CANADA

NATIONAL ADVISORY COMMITTEE ON RESEARCH IN THE GEOLOGICAL SCIENCES

SECOND ANNUAL REPORT 1951-52

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Department of Mines and Technical Surveys

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Ottawa, Ontario,
July 1, 1952.

The Honourable George Prudham,
Minister of Mines and Technical Surveys,
Ottawa, Ontario.

Sir:

I have the honour to submit to you the Second Annual Report of the National Advisory Committee on Research in the Geological Sciences.

In submitting this report may I, on behalf of the members of the Committee, express to you our sincere appreciation of the interest and support you have given the Committee and its work.

Respectfully submitted,

W. A. Bell

W. A. Bell,
Chairman.

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MEMBERS OF COMMITTEE

Dr. W. A. Bell (Chairman)	Geological Survey of Canada, Ottawa, Ont.
Dr. P. E. Auger	Laval University, Quebec, Que.
Col. P. D. Baird	Arctic Institute of North America, Montreal, Que.
Dr. H. H. Beach	Texaco Exploration Co. Limited, Calgary, Alta.
Dr. G. M. Brownell	University of Manitoba, Winnipeg, Man.
Dr. A. E. Cameron	Nova Scotia Technical College, Halifax, N.S.
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Dr. J. E. Gill	McGill University, Montreal, Que.
Dr. H. C. Gunning	University of British Columbia, Vancouver, B.C.
Dr. George Hanson	Geological Survey of Canada, Ottawa, Ont.
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Dr. J. F. Walker	Dept. of Mines, Victoria, B.C.
Dr. J. T. Wilson	University of Toronto, Toronto, Ont.
Dr. J. F. Henderson (Secretary)	Geological Survey of Canada, Ottawa, Ont.

Meetings:

June 1-2, 1951, National Museum, Ottawa.
January 19-20, 1952, National Museum and Chateau Laurier, Ottawa.

EXECUTIVE COMMITTEE

Dr. W. A. Bell (Chairman)	Geological Survey of Canada, Ottawa, Ont.
Dr. J. E. Gill	McGill University, Montreal, Que.
Dr. George Hanson	Geological Survey of Canada, Ottawa, Ont.
Dr. J. E. Hawley	Queen's University, Kingston, Ont.
Dr. J. F. Henderson (Secretary)	Geological Survey of Canada, Ottawa, Ont.

Meetings:

January 3, 1951, National Museum, Ottawa.
September 21, 1951, National Museum, Ottawa.
May 20, 1952, National Museum, Ottawa.

FOREWORD

The National Advisory Committee on Research in the Geological Sciences has a threefold purpose: (1) to co-ordinate geological research carried on in Canada; (2) to suggest worthy research projects that should receive attention; and (3) to aid in having these projects undertaken. The Committee itself does not carry on research; its function is to stimulate research by the universities, Federal and Provincial geological surveys, and other organizations equipped for the job. A study of this report will show that in this objective the Committee is attaining some degree of success. However, only a start has been made; much remains to be done. The active and successful functioning of the Committee depends not only on its members and the members of its subcommittees, but on the support and co-operation of all those in Canada interested in the geological sciences. It is primarily from them that must come suggestions as to problems and projects most urgently in need of study. The Committee hopes that those who read this report will think of the Committee as their Committee and be eager to contribute their suggestions and criticisms to its members.

The report is divided into two parts. Part I contains a summary of the work of the Committee in the past year. It includes a brief statement of the action that has been taken on the recommendations in the First Annual Report[1], an account of the special projects and problems that are now under study, and a summary statement of the work of the subcommittees. Part II contains the subcommittee reports. These reports are surveys prepared by the chairmen of the subcommittees that cover the different fields in the geological sciences, with suggestions as to problems in need of study in these fields.

[1] First Annual Report (1950-51) National Advisory Committee on Research in the Geological Sciences, published by Geol. Surv., Canada, March 1951.

PART I

THE YEAR IN REVIEW

ACTION ON PAST RECOMMENDATIONS

In the First Annual Report (1950-51)[1] of the Committee, we

[1] Op. cit.

stressed the need for more basic or fundamental research in Canada. It was pointed out that the ore deposits that form our present reserves were comparatively well exposed; their discovery required no profound knowledge of geological principles. Our ore deposits of the future will not be found as easily. Their discovery will require new geological and geophysical techniques and a greater knowledge of the factors that control ore deposition. We must, therefore, place greater stress on field and laboratory research that will lead to the development of new methods of exploration for ore deposits, and to new data on their origin. This means more emphasis on fundamental types of research involving exploration and experimentation to extend our knowledge of general principles. It is from research of this type that new techniques will be developed for the finding of our ore deposits of the future.

It was further concluded that the facilities and technical personnel for such basic research are, at present, inadequate in Canada. The first step must be to increase them. Our specific recommendations were directed in large part to this end. These recommendations were:

(a) an expansion of the research laboratories and increase in technical staff of the Geological Survey of Canada and provision of a suitable permanent building to house the Geological Survey and its laboratories.

(b) the provision of funds for the stimulation and support of fundamental geological research in Canadian universities.

The first of these recommendations, dealing with the expansion of the research facilities of the Geological Survey of Canada, has been carried out in part. A fluorescence analysis unit has been installed in the National Museum building and is now in use in the study of radioactive ores. Equipment for an excellent spectrographic laboratory has been purchased and set up temporarily in the National Museum building. Equipment for a sedimentology laboratory is on order and will be set up temporarily in the Ottawa Auditorium building. Purchase of a mass spectrometer for geological age determinations is planned in the near future. Hence, definite progress can be reported in the implementation of this recommendation.

However, the expansion and proper functioning of the research laboratories of the Geological Survey is badly handicapped by the lack of a suitable building in which to house them. The Geological Survey presently has no building of its own, but is housed in parts of four widely separated buildings in different parts of Ottawa. The present quarters are regarded as temporary, pending the erection of a permanent building. The present quarters are not suitable for laboratories - they are primarily office buildings. We again stress the need of a permanent building to house the Geological Survey and its research laboratories. Without such a building, the further expansion of the research laboratories and, indeed, the efficient functioning of the Survey as a whole is most difficult.

The second specific recommendation of the Committee was that funds be provided for the stimulation and support of fundamental geological research in our universities. This recommendation has been fully carried out. In 1951, $10,000 was provided to the Geological Survey of Canada for grants-in-aid to Canadian universities for geological research. This amount was increased to $20,000 for 1952-53. Applications for grants, which are submitted to the Director,

Geological Survey of Canada, by members of the staffs of the universities, are reviewed by the National Advisory Committee and the grants awarded by the Geological Survey on the basis of recommendations by this Committee. Twenty projects in eight universities are currently being supported by these grants (See Appendices I and II for general conditions governing award of grants and details of grants awarded 1951-52).

These grants allow many workers with different viewpoints and considerable freedom to work on widely diversified problems. In addition to providing new knowledge, much of which is of a fundamental nature, the grants provide training in research for a number of graduate students employed as technicians in carrying out the projects. The Committee considers the grants are an important stimulus to research and hopes that funds for them will continue to be provided.

The Committee in its first report recommended that a survey of current geological research in Canada be made and published annually by the Geological Survey of Canada. This project has been carried out. For each of the past 2 years all available information has been assembled and published on research in progress in Canada by the universities, Federal and Provincial departments of mines, mining and oil companies, and other institutions that carry on geological and mineralogical research[1]. This compilation is of

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[1] Henderson, J. F.: Current Research in the Geological Sciences in Canada 1951-52, Geol. Surv., Canada, 1952.

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interest to all geologists, and of especial value in the co-ordination of geological research in Canada.

SPECIAL PROJECTS AND PROBLEMS

A summary of the reports of the permanent subcommittees covering the different fields of the geological sciences is given

in succeeding pages and the reports in full are included in Part II of this report. In addition to the projects and problems covered by the subcommittee reports, certain special projects and problems that do not fall within the fields of the permanent subcommittees are under study by the Committee. A brief account of these follows.

Geological and Geophysical Studies of Kemano-Tahtsa Lake Tunnel

At the June 1951 annual meeting of the Committee, the geological study of the Kemano-Tahtsa Lake tunnel was discussed. This tunnel, which is under construction by the Aluminum Company of Canada, is being driven through the Coast Range of British Columbia for a distance of 10 miles, from Kemano on the coast to Tahtsa Lake. The Committee was in agreement that the opportunity should not be lost to make geological and geophysical studies of the magnificent continuous section of rocks that will be exposed along the tunnel. A subcommittee composed of Dr. H. C. Gunning and Dr. J. E. Gill was appointed to approach the Aluminum Company of Canada and find out what geological work was planned by the Company and the willingness of the Company to co-operate in any detailed geological study and collection of data and specimens that might be undertaken. Mr. McNeely DuBose, Vice-President, expressed the willingness of the Aluminum Company of Canada to co-operate in such a project.

At the January 1952 meeting of the Committee, Dr. J. F. Walker was added to the Kemano Tunnel Subcommittee, and the Subcommittee was asked to continue to explore means of having geological and geophysical studies undertaken. In April 1952, a Vancouver Committee was formed, with Dr. Gunning as Chairman, Dr. W. E. Cockfield representing the Geological Survey of Canada, Mr. R. W. Kraft representing the Aluminum Company of Canada, and Dr. H. Sargent representing the British Columbia Department of Mines. Largely through the work of these Committees, the British Columbia Department

of Mines is undertaking detailed geological mapping of the tunnel and the surface area over the tunnel, and collection of specimens for laboratory studies. The Geological Survey is carrying on standard 1 inch to 4 mile geological mapping of a 1- by 2-degree quadrangle including the Kemano tunnel site. All data collected in the tunnel area will be supplied to the Provincial Department. In addition, thermal measurements will be made under the supervision of Dr. A. D. Misener of the University of Western Ontario, to determine the heat flow from the rocks transected by the tunnel. Dr. Misener will receive a grant of $1,000 from the Geological Survey of Canada in support of this project.

Supply of Geologists in Canada

The present inadequate supply of geologists in Canada, and the small and apparently decreasing number of geological students in our universities was the subject of discussion at the 1952 meeting of the Committee. It was felt that every effort should be made to attract more of the best type of student to the geological professions. One of the many suggestions made was that means should be found to interest high school boys in geology as a profession. This might be done by the publication of a booklet on the secondary school level describing what geology is about and its attractions as a profession, by radio broadcasts to the schools about geology, and by educational and vocational guidance film strips for the high schools. It was also suggested that an annual survey be made of the number of geological students in our universities, no accurate data at present being available; possibly a parallel survey should also be made of the prospective demand for geologists by mining and oil companies, government organizations, and in the academic field.

The Subcommittee on Scholarship and Research Training and Dr. J. E. Thomson were asked to study these and other suggestions that were made and to explore the possibility of carrying out those considered desirable.

On the recommendation of the Subcommittee, the National Advisory Committee has since asked the Geological Survey of Canada to carry out an annual survey of Canadian geological students attending Canadian universities and graduate schools in the United States. The Subcommittee is giving further study to means of interesting high school and university students in geology as a profession and the need for a booklet about geology to interest more high school students in the subject.

Publication of Results of Geological Research

The limited outlets in Canada for the publication of the results of geological research have been under consideration by the Committee. This problem is not serious for those in government organizations with their own publications. However, it becomes a real problem for geologists in universities and industry who must depend on the small number of Canadian learned societies that publish articles on geological and mineralogical research.

A subcommittee under the chairmanship of Dr. J. E. Hawley has been appointed to study the field of geological publications in Canada.

Study of Batholiths

The reports of the Subcommittees on Structural Geology and Petrology, Mineralogy, and Chemistry have stressed the need for comprehensive studies of batholiths. Batholiths are important elements in the earth's crust, mark outstanding events in earth history, and are believed to give rise to many types of economically

important deposits, yet most of our knowledge of these masses is based on rather superficial observations made in the course of areal field mapping. The Subcommittees have recommended that detailed field studies should be made of certain batholiths, including some with associated ore deposits and some without. Not only should the structure be carefully mapped, but the batholiths should be systematically sampled and material collected for petrographic, chemical, spectrographic, radioactivity, and other studies. Such projects might well be co-operative between Federal or Provincial geological surveys and the universities.

The National Advisory Committee at its January 1952 meeting expressed full agreement with the need for more comprehensive studies of batholiths. It was realized that such studies would transgress the fields of several of the subcommittees. Therefore, a subcommittee composed of Dr. Gill and Dr. MacKenzie was appointed to inquire into and suggest specific lines of research in regard to studies of batholiths and similar granitic intrusions.

It is worthy of note that two comprehensive studies of batholiths are being initiated this field season (1952). In British Columbia, the British Columbia Department of Mines is beginning the detailed geological study of the Kemano-Tahtsa Lake tunnel, which is being driven through several miles of the Coast Range batholith. In northwestern Quebec the Geological Survey of Canada is beginning a systematic study of the La Corne batholith in La Corne and Preissac townships.

Co-operative Research Projects

Means of promoting co-operative research projects sponsored jointly by industry (mining and oil exploration companies) and government organizations is under study by the Committee. It is felt

that many general geological problems are of direct economic interest to the mining and oil exploration companies; that much of the data and material essential for their solution have been accumulated by the companies; and that the companies would not only be anxious to have investigations undertaken, but would also like to participate in the support of the research involved. The National Advisory Committee might well act as a co-ordinating agent between the mining and oil companies and the government or university research laboratories that are available for carrying out these investigations.

The Committee has appointed Dr. D. R. Derry and Dr. H. H. Beach as a subcommittee to study ways and means by which the National Advisory Committee may promote co-operative geological research projects of this type, sponsored jointly by government and industry. This Subcommittee will welcome suggestions from mining and petroleum geologists and others who are interested as to projects that would lend themselves to such co-operative research.

CHANGES IN PERSONNEL OF COMMITTEE

Several changes have occurred in the personnel of the Committee since publication of the First Annual Report. Dr. A. L. Washburn resigned from the Committee in January 1951 and Dr. J. D. Allan in July 1951. Dr. Washburn represented the Arctic Institute of North America and was the energetic chairman of the Pleistocene Subcommittee. Dr. Allan represented the Manitoba Department of Mines and Natural Resources and took an active interest in the work of the Committee. Col. P. D. Baird, Director of the Montreal office of the Arctic Institute, and Dr. G. H. Charlewood, Chief Geologist, Manitoba Department of Mines and Natural Resources, have been appointed to the Committee to replace Dr. Washburn and Dr. Allan. Col. Baird also succeeds Dr. Washburn as Chairman of the Pleistocene Subcommittee.

The Committee, as originally set up, did not include geologists from the mining and petroleum industries. In November 1951, Dr. D. R. Derry, Chief Geologist, Ventures Limited, was appointed as a representative of the mining industry, and Dr. H. H. Beach, Assistant Manager, Texaco Exploration Company, as a representative of the petroleum industry.

The Committee suffered the loss of one of its most active members in the sudden death of Dr. R. L. Rutherford in January 1952. Dr. Rutherford was keenly interested in the work of the Committee and was Chairman of the Subcommittee on Non-metallic Deposits, Industrial Minerals, Coal, and Oil. He contributed much to the deliberations of the Committee by his wise counsel, his ready wit, and his unfailing sense of humour. He will be greatly missed.

WORK OF THE SUBCOMMITTEES

The eight subcommittees that cover the different fields in the geological sciences play a most important role in the work of the National Advisory Committee. It is their function to maintain a continuous survey of the needs and developments in their particular fields, and to advise the National Committee as to the problems most urgently in need of investigation. The reports of the subcommittees, prepared and presented by the subcommittee chairmen, form the basis for much of the discussion and many of the conclusions reached at the meetings of the National Advisory Committee.

The subcommittees carry on by correspondence only; no funds are provided for travelling expenses of subcommittee members. The active functioning of the subcommittees by correspondence alone is not easy; yet, their reports are a testimony to the energy and enthusiasm of the chairmen and members in carrying out a difficult task.

In past years each of the chairmen has collected data on developments and needs in the field covered by his subcommittee. At the January 1952 meeting of the Committee, at the suggestion of the late Dr. R. L. Rutherford it was agreed that more pertinent information could be assembled with less duplication of effort if data on all fields of the geological sciences were collected in geographical districts by designated members of the National Advisory Committee and sent as reports to the Secretary. The Secretary in turn will send copies of these reports to the chairmen of the subcommittees to aid them in the preparation of their reports. It was further agreed that the members responsible for the collection of this information and the preparation of reports embodying it would be as follows for the districts designated;

Dr. H. C. Gunning	- British Columbia
Dr. R. L. Rutherford	- Alberta
Dr. J. B. Mawdsley	- Saskatchewan
Dr. G. M. Brownell	- Manitoba
Col. P. D. Baird	- Northwest Territories and Yukon
Dr. J. E. Hawley	- Ontario
Dr. P. E. Auger	- Quebec
Dr. G. S. Mackenzie	- New Brunswick and Prince Edward Island
Dr. A. E. Cameron	- Nova Scotia
Mr. C. K. Howse	- Newfoundland

Subcommittee Reports

The reports of the subcommittees make up Part II of this report. The subcommittee on Physical Methods Applied to Geological Problems stresses the need for wider realization of the changes taking place in methods of study of the earth owing to the rapid development of geophysics, and to the effect that these are having on modern prospecting. It is pointed out that in 1951 more than $29,000,000 was spent in Canada in the search for petroleum alone by geophysical methods; this compares with annual expenditure of only $1,200,000 or less on these methods prior to 1947.

Although geologists and geophysicists have the same objectives it is felt that somewhat of a barrier exists between the two professions and that each group tends to underestimate the other. Specific suggestions are offered to help break down this barrier by changes in the courses leading to degrees in geology and geophysics in our universities.

The Subcommittee on Metallic Mineral Deposits reports progress on two of the recommendations of its previous report. Geothermal studies of vein minerals are being carried on by the Geological Survey of Canada and by the Mines Branch; these will serve to critically evaluate techniques recently developed at the University of Toronto. On the recommendation of the Committee, important biogeochemical research in progress at the University of British Columbia is being supported by a Geological Survey of Canada research grant. Current research in Canada concerned with metallic mineral deposits is reviewed. Several additional problems in need of study are suggested.

The Subcommittee on Structural Geology directs attention to the need for detailed studies of faults, folds, rock cleavage, joint systems and breccias. Particular stress is laid on the need for comprehensive studies of batholiths. Also stressed is the opportunity afforded for a study of the Coast Range batholith during the driving of the Kemano-Tahtsa Lake tunnel by the Aluminum Company of Canada (See p. 4 of this report).

The Subcommittee on Petrology, Mineralogy, and Chemistry discusses the facilities for research in this field in Canada, and the parts played by the universities, Federal and Provincial departments of mines, and other research organizations. This is followed by a review of current research in petrology, mineralogy, and chemistry in Canada. Finally, a number of problems are suggested that should receive

attention. These include intensive studies of batholiths and other igneous rocks, the metamorphic rocks, and means of standardizing mineralogic data obtained in different laboratories in Canada. In the discussion following presentation of this report, Dr. H. H. Beach mentioned a number of additional mineralogical and chemical problems that were of present vital concern to the petroleum industry including (1) the relationship between primary anhydrite and reef structure (2) radioactivity studies in relation to X-ray, gamma ray, and neutron logging (3) the geological significance of the variation of chemical properties of oils (the isotopes of sulphur might be used to determine the migration of oil), (4) a study of oil field waters and (5) the origin of dolomite and its relation to the creation of porosity in rocks.

Col. P. D. Baird was appointed chairman of the Pleistocene subcommittee in January 1952, succeeding Dr. Washburn who resigned early in 1951. Col. Baird, in the short interval since his appointment, has prepared an interim report. This report notes that some of the recommendations of the First Annual Report of the Committee (1950-51) in regard to Pleistocene work by the Geological Survey of Canada have been carried out and that others are planned to be undertaken in the near future. Several of the more pressing Pleistocene problems in which work should be initiated are outlined. These include (1) a study of spores and pollen grains to aid in the dating of Pleistocene deposits and the interpretation of climatic conditions (2) further use of C-14 for accurate dating of Pleistocene and recent materials and (3) comprehensive investigations of the larger glacial lake basins in Canada and of the glacial history and deposits of the St. Lawrence Lowlands.

The Subcommittee on Non-metallic Mineral Deposits, Industrial Minerals, Coal and Oil notes the large amount of research

being carried on by the oil companies and well servicing organizations in Western Canada and suggests that it would be highly advantageous if some organization such as the National Advisory Committee could bring about the co-ordination of these investigations. Mention is made of the large amount of geologic data, particularly in regard to coal, from numerous shallow test and seismic holes that is available, but is not being collected in Western Canada. Likewise, no effort has been or is being made to examine the glacial and recent deposits exposed along the continuous trenches dug for pipelines in the Prairie Provinces.

In discussing this report the Committee expressed agreement that all available data on coal deposits and the Pleistocene of the western plains should be collected. However with the present lack of trained personnel, no satisfactory suggestion was offered as to how this could be done. This problem will be reviewed again at future meetings of the Committee.

The Subcommittee on Palaeontology and Stratigraphy reports on the progress made on research projects under way in 1950 and 1951. The large amount of research being sponsored by industry is noted, particularly by the rapidly expanding oil industry and in the search for, and development of Precambrian sedimentary iron deposits in Quebec and Ontario. The results of much of this research are not being divulged but it may be confidently expected that most, if not all this information will eventually be made available; in fact some important results of research sponsored by the oil industry have already been published.

A number of suggestions are also made as to projects that should be initiated; these include (1) palaeontological and stratigraphic studies of Palaeozoic, Mesozoic, and Tertiary rocks of the Canadian Arctic, (2) study of micro and semi-micro fossils in the

Siluro-Devonian of the Quebec Lowlands and Gaspe (3) development of new methods for correlating sections of thick formations without fossils or other distinguishing features, and many others.

The Subcommittee on Scholarship and Research Training makes several suggestions in regard to the annual survey of current research in the Geological Sciences in Canada. The need for greater emphasis on the study of sedimentary rocks in Canadian universities is stressed.

PART II

SUBCOMMITTEE REPORTS

THE REPORT OF THE SUBCOMMITTEE ON PHYSICAL METHODS APPLIED TO GEOLOGICAL PROBLEMS

Presented by Dr. J. T. Wilson

Members of Subcommittee

Dr. J. T. Wilson (Chairman)	- University of Toronto, Toronto
Dr. H. Carmichael	- National Research Council, Ottawa
Dr. H. V. Ellsworth	- Geological Survey of Canada, Ottawa
Dr. J. H. Hodgson	- Dominion Observatory, Ottawa
Dr. M. J. S. Innes	- Dominion Observatory, Ottawa
Dr. A. D. Misener	- University of Western Ontario, London
Mr. George Shaw	- 261 Somerset Street West, Ottawa
Dr. G. D. Garland (Secretary)	- University of Toronto, Toronto

DEVELOPMENTS IN GEOPHYSICS

Geophysical Methods of Prospecting

Last year the first annual report of this subcommittee reviewed the chief physical methods of prospecting employed in Canada. The report mentioned the enormous increase in activity in these fields during the past 5 years. This activity has continued to grow.

On November 26, 1951, Dr. Oliver Hopkins speaking in Toronto stated that there were then 155 geophysical crews at work in Western Canada. A reliable source has estimated that during the whole of 1951 a total of $29,900,000 will have been spent in Canada in the search for petroleum alone by geophysical methods. Prior to the discovery of oil at Leduc in 1947 there were only a handful of parties and annual expenditures averaged $1,200,000. Geophysical prospecting is, in fact, a new industry that has grown up in Canada in the past 5 years. It is still expanding. The history of prospecting for oil

in the past 25 years in the United States and the increasing use of physical methods in many other industries clearly indicate that this is no temporary boom, but that geophysical methods will continue to be used on a large scale in the search for petroleum.

The Federal Government continues to operate its airborne magnetometer, and already has conducted geophysical surveys over large parts of Canada. Provincial surveys have shown an active interest in this work. Mining companies, too, have been operating airborne surveys by magnetic, electro-magnetic, and radioactivity methods, and have been prospecting for ore deposits on the ground or in drill-holes with magnetometers, gravimeters, radioactivity counters, and electromagnetic devices. Several companies have been formed in Canada during the past few years for the purpose of manufacturing, selling, or operating geophysical instruments.

For many years it has been recognized that geological field methods are useful in locating mineral deposits, but until recently no physical methods were known that were of much practical help in that search. During the past 25 years the situation has been altered by the rapid development and useful application of physical methods of prospecting. Some of the most useful methods are listed below, with the approximate dates of their first widespread application.

Refraction seismic methods	1920
Reflection " "	1930
Geiger counters	1930
Gravity meters	1935
Airborne magnetometers	1945
Airborne electromagnetic gear	1950
Airborne radioactive counters	1950

A few methods, notably the magnetometer, are much older; others, like electromagnetic methods and devices to operate in drill-holes, have been under continuous development and improvement for many years.

Prospectors are practical men. Methods of seismic prospecting for oil and radioactivity counting for locating uranium have proved themselves invaluable. Many other geophysical methods have proved to be economical and useful. They will not replace geological field methods, although their objectives are the same, but they will supplement them and in future all economic geologists will have to regard geophysical methods as powerful partners to the methods to which they are already accustomed.

Physics of the Earth

In addition to its service in prospecting, geophysics has a branch dealing with more general problems concerning the earth as a whole.

During the past century geologists have made at least a reconnaissance survey of the surface of the earth. Results of this tremendous task are being summarized at the present time by the compilation and publication of excellent maps and reports that cover whole countries and entire continents. But geologists can only describe what they can see; they have had to speculate on the nature of the subsurface and the ocean floors.

The power of physical methods, in spite of difficulties of interpretation, lies in their ability to make measurements at a distance, even to the centre of the earth. By use of these methods the nature of the inaccessible interior is disclosed, and the task of interpreting geological history, and discovering the causes of geological activity, is thus being made possible. The geophysical methods include the study of earthquakes, gravity, heat flow, and radioactivity.

No one knew much about the nature of the interior of the earth until a geologist, Milne, organized a world-wide system of

seismological observatories. The data compiled by these observatories began to be usefully interpreted about 1910. Other important advances in the use of physical methods for exploring the earth are listed below, with approximate dates.

Discovery of discontinuities between earth's core, mantle, and crust	1910
First measurements of gravity at sea	1925
Discovery of deep focus earthquakes	1930
Gravity meters introduced	1935
First accurate isotopic radioactive age determinations	1940
First accurate measurements of amounts of radio-activity in the crust	1940
First accurate measurements of heat flow from the earth	1940
Good maps of distribution of earthquakes in three dimensions made available	1950
Plans for world-wide gravity survey started	1950

The growing interest in physical methods was indicated at the Ninth General Meetings of the International Union of Geodesy and Geophysics held in Brussels in the summer of 1951. These meetings were attended by 1,050 delegates and guests representing 30 countries. Matters of geodetic and geophysical interest (other than prospecting) were discussed for 2 weeks. Thirteen Canadian geophysicists attended.

NEEDS IN GEOPHYSICS

Among the prime needs in geophysics are:

(1) a need for wider realization of the profound change that is now taking place both in the study of the earth and in prospecting methods because of the rapid development of geophysics;

(2) a need for adjustments both in the training and thinking of geologists in regard to geophysics.

If there are any who still believe that physical methods are not useful or constitute a temporary boom, they should reflect that the petroleum industry in 1950 spent more than $300,000,000 on

geophysical prospecting. The Society of Exploration Geophysicists is now 17 years old and has 2,500 members. The study of geophysics and especially the physics of the earth is so new and has been of such rapid growth that books describing it are few in number and it is difficult to find simple, up-to-date and easily read reviews of the subject. Most geophysicists are physicists or electrical engineers; although they study the earth, many of them know no geology, and they tend to write in mathematical language with which few geologists are familiar. Thus, somewhat of a barrier exists between two professions devoted to the same objectives - the location of oil and ore and elucidation of the nature of the earth. By reason of lack of understanding, each group tends to underestimate the contributions of the other. Geophysicists tend to oversimplify or neglect geological knowledge and geologists fail to realize the full value that can be obtained from the use of appropriate physical methods.

To help break down this barrier between geologists and geophysicists more emphasis on geophysics is needed in the training of geological students in our universities. Students can scarcely be burdened with additional courses; what is required is a suitable pruning of existing courses so that time can be found to teach students the nature and achievements of all fields before they specialize in one or two of them. It is perhaps not necessary for palaeontologists to learn calculus, but they should be taught the broad aspects and applications of geophysics. Geophysicists in turn should be taught what palaeontologists have achieved and what they are able to do. Areal geologists likewise need training in geophysics in order to broaden their outlook and familiarize them with the tools that may help solve areal geological problems.

In most fields in the natural sciences a division is made between those men concerned with immediate practical problems that

can be solved by standard methods (engineers) and those concerned with research (pure scientists). Thus, in the same fields there are chemical engineers and chemists, agriculturalists and botanists, electrical or mechanical engineers and physicists.

It is suggested that such a division might be useful in the earth sciences or might be made sharper where one already exists. At present most geologists claim to be pure scientists, but the fact of the matter is that most of them are much more interested in assisting prospecting than in discovering the nature of the earth for its own sake. This is highly laudable. There is need for many more practical geologists than research men, but let us admit in our training that most geologists have more in common with engineers than with pure scientists.

To make a specific recommendation, it is suggested that the four courses below might be suitable for training undergraduates:

	More Mathematical	Less Mathematical
Arts	Physics and Geology (To provide research men in both geology and geophysics)	Geology (Palaeontologists, mineralogists, stratigraphers, men to do areal mapping, etc.)
Engineering	Engineering Physics, Geophysics Option (The chief source of economic geophysicists)	Mining Geology (The chief course for economic geologists)

The two more mathematical courses should include a large part of the work in mathematics and physics given to honour students in those courses plus enough geology to enable graduates to do geological field work. The two less mathematical courses should include more descriptive geology than the others; some physics, chemistry, and mathematics to enable students to understand established methods of geophysical prospecting; and a course on the physics of the

earth. To men with a good grounding in physics and in geology, geophysics presents little that is new and can be taught in the fourth year at university.

It may be held that biology and chemistry are basic sciences and, therefore, are as important and as much in need of more time as geophysics. Biology is essential for palaeontologists, and for them a special undergraduate course may be needed, but biology is not of great value to other geologists.

Geochemistry and petrology are fields in which there is need and great scope for research, but at present the answers to the basic problems in these fields are not known. For example, what is the origin of granite, or how are ores emplaced? Likewise, the geochemistry of trace elements may eventually provide a sure method of prospecting, but it is still in the development stage. Research should be devoted to establishing the method as quickly as possible, but in the meantime it is more important to train undergraduates in the elements of geophysics because $30,000,000 was actually spent on geophysical prospecting in the past year in Canada. To understand geophysical work a knowledge of at least elementary mathematics and physics is essential.

A century ago there was no science known as geophysics, but Lyell devoted a third of his Principles of Geology (7th ed., 1847) to topics that would now be classed as geophysics, including seismology, volcanology, climatology, ocean currents, and changes in the level of the land. Since then these fields have been somewhat neglected by geologists but they have attracted the interest of some physicists, most of whom have had little training in geology. To reunite geology and geophysics and utilize both to the best advantage, geologists must give more consideration to training in geophysics and more support to research in the application of physical methods to geology.

There is need for more men trained in geophysics. The employment of an additional 150 new geophysical parties in Canada in the last 5 years has meant new jobs for more than 500 geophysicists. Many of these men have been brought from the United States; those that are Canadian are electrical engineers or physicists. At the present time the Geological Survey of Canada, Dominion Observatory, all large petroleum companies, and many large mining companies are trying to find geophysicists. Practically every university in Canada gives some courses or at least some lectures in geophysics (Canadian Mining and Metallurgical Bulletin, No. 473, pp. 636-639, September 1951), but only one university has yet granted many degrees in geophysics and its output has not been adequate to meet the demand. Fortunately, a number of other universities are increasing their interest, training facilities, and staff in geophysics. The demand is particularly great for men who have a fairly good understanding of both physics and geology with which to make interpretations of physical surveys.

The shortage of technical men of all kinds is acute in Canada; it is not confined to geophysicists. Some means must be found of carrying back to the high schools the need for men in science and engineering.

RESEARCH PROBLEMS IN GEOPHYSICS

The subcommittees are charged with responsibility for reviewing research that should be undertaken but at present geophysics is developing so rapidly that everyone engaged in this field can think of far more problems than they can undertake. Therefore, no useful purpose would be served at the present time in outlining additional problems.

CONCLUSIONS

For many years geologists found mathematics and physics of little use in observational methods of field geology and were not trained in these subjects. The development of geophysics has been comparatively recent and has been brought about by physicists. In their hands geophysics has developed to the point where it is now used in exploration for mineral deposits to approximately the same extent as geology. A continuation of the division between the two sciences is clearly undesirable; a greater unification of geophysics and geology is needed.

It will be held that no man can learn so many things. That is true, but no geologist now learns all the specialities in mineralogy, petrography, palaeontology, and so forth, although each knows what can be done with the other fields. Let us treat at least those parts of geophysics that deal with the solid earth on the same basis as we treat the existing branches of geology; let us give undergraduates a broader and more basic knowledge from which they can specialize.

At present a great deal of time in geology courses is devoted to discussing speculations about unsolved problems such as the origin of glacial periods, ore deposits, or granites. Perhaps undergraduates devote more time than necessary to learning the names and characteristics of rare minerals, unusual rocks, and local fossils. By reducing these topics, time can be found to devote to the study of physics. With the addition of these techniques to the geologist's existing tools more of the speculative matters will be solved. As a tentative basis four undergraduate courses have been suggested. Further specialization should be left to graduate work.

All geologists cannot be mathematical geniuses, but let us teach geological students enough physics so that they can understand how geophysical methods can help them and so that more of them can use these methods effectively.

Some may object that these suggestions are too radical; that geology is progressing very well; that the present interest in geophysical prospecting in Western Canada will not last; and that sweeping changes in the training of geological students is not justified. To them one can only say that the great significance of the change in the earth sciences has been recognized elsewhere. Professor W. H. Bucher, Chairman, Department of Geology, Columbia University, recently stated "Geology is in a period of unprecedented discovery. ------In the search for answers to fundamental questions there is an atmosphere of fascinated suspense today such as has always marked the high points on the growth curve of a science" (Scientific America, p. 33, May 1950). Professor J. C. Jaeger, a physicist, discussing a program of geophysical work in Australia, writes "The word 'geophysics' now suggests to many people only the prospecting side, while in fact there has been almost as large an advance in the more fundamental branches so that the whole subject is in as exciting a state, and developing as rapidly, as quantum physics in its early days" (Australian Journal of Science, 1951).

We must face the fact that in the past few years many powerful physical techniques have been introduced; that in Canada hundreds of physicists are now using these methods to search for oil and for ore and to study the earth; and that a consolidation of geological and geophysical work is needed. To achieve it we must reorient our thinking and our training.

Down with the study of geophysics as a separate study without training in geology! Up with a return to Lyell and the broad study of the earth by all possible means, including modern physical tools!

REPORT OF THE SUBCOMMITTEE ON METALLIC MINERAL DEPOSITS

Presented by Dr. G. M. Brownell

Members of Subcommittee

Dr. G. M. Brownell (Chairman)	- University of Manitoba
Dr. D. R. Derry	- Ventures Limited, Toronto, Ontario
Dr. A. H. Lang	- Geological Survey of Canada
Dr. G. B. Langford	- University of Toronto
Dr. C. E. Michener	- International Nickel Company of Canada, Copper Cliff, Ontario

PROGRESS ON RECOMMENDED PROJECTS

The First Annual Report of this Subcommittee recommended a number of research projects, two of which were specific, whereas the others were more general. The Subcommittee is pleased to report progress on the two specific projects, and a beginning on one of the general projects.

Geothermal Studies of Vein Minerals

It was recommended that the results obtained by Dr. F. Gordon Smith at the University of Toronto in his geothermal studies of vein minerals were of such significance that they should be the subject of an independent investigation to critically evaluate his technique and to check results.

The Geological Survey of Canada had previously assigned R. W. Boyle to make detailed geothermal studies of the gold ore-bodies in the Yellowknife camp. Mr. Boyle reports as follows:

> "During the field season of 1950 the Negus and Rycon Mines were sampled for decrepitation work on 25' centres both horizontally and vertically. Horizontal control was good but vertical control on 25' centres was restricted since many ore shoots have been almost completely removed.

"The preliminary results of the quartz decrepitation are inconclusive. There seems to be a faint pattern between ore shoots and barren portions of the veins. In the ore shoots the recorded decrepitation temperatures are generally higher than in barren portions. The writer has been informed that Dr. Haycock of the Mines Branch found a similar pattern at Eldorado. At Yellowknife, temperature gradients do not seem to be present between ore shoots and barren portions of the veins.

"Pyrite samples were collected in a similar manner to that of the quartz samples. The results of the pyrite temperature determinations indicate that in the ore shoots the pyrite has a low temperature whereas in the walls and certain barren quartz veins the temperatures recorded are higher. The reason for this is not clear. Temperature gradients are not apparent.

"During the field season of 1951 specific ore shoots and barren areas in the Negus, Rycon, Con, and Giant mines were studied in great detail and a grid of pyrite and quartz samples were obtained to check in greater detail the faint patterns and to correlate if possible the various temperature readings with ore values. The writer proposes also to check the effect of minor elements in the pyrite by spectrographic work and to attempt a correlation of these results with the pyrite temperatures. It is also proposed to do some work on the heating stage when this apparatus becomes available, to determine the temperature of filling of the liquid inclusions. It is thought that this type of work may produce valuable results and solve some of the problems encountered in this research."

Likewise, Dr. M. H. Haycock of the Mines Branch, Ottawa, has made geothermometric studies at the Eldorado mine, but these are not yet completed and the results are not available. Also, he has done some work on specimens from the Malartic mine collected by Mr. P. Black; the data have not yet been related to structure and petrology though the determinations have been of assistance in confirming the interpretation of the paragenesis of the minerals. The latter application has been the most helpful one to date and Dr. Haycock believes that such studies, when used with discretion, can be very useful. These studies are being made with a decrepitatograph in the laboratory of the Division of Mineral Dressing and Process Metallurgy of the Mines Branch.

At Queen's University, spectrographic studies have been made of specimens of pyrite from the Porcupine district that were obtained through Dr. F. G. Smith. Variations in the trace elements indicate definitely that two types of pyrite are present. A pyrite that gives low temperature readings contains different quantities and ratios of cobalt and nickel compounds from a pyrite that gives high temperature readings. The low temperature pyrite also contains more arsenic and gold than the high temperature type[1].

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[1]Hawley, J. E.: Spectrographic Studies of Pyrite on some Eastern Canadian Gold Mines; Econ. Geol., vol. 47, p. 260 (1952).

The present state of research on inclusion thermometry in the University of Toronto is reported by Dr. Smith as follows:

"a) Equipment. The published description of our electronic decrepitation ratemeter is due for revision, because we have made substantial improvements in the heating device, temperature fiducialing, and pre-amplification. Also, we have recently added an electronic scaler and automatic recording counter to the ratemeter circuit. I plan to publish a description of the new features as soon as the latter two devices are fully tested.

"b) Calibration. Suitable means of calibration for the principal types of temperature and time lags have been worked out and applied. The sensitivity is now of the order of 3°C for a stage of decrepitation that starts abruptly.

"c) Minerals being studied. The research is principally in two divisions. The first is concentrated on a study of two-phase fluid inclusions in quartz of Canadian gold deposits, sphalerite of all types of zinc deposits, and cassiterite of all types of tin deposits.

"The second division is a study of solid inclusions in metamorphic minerals, principally garnet from all types of metamorphic and pyrometasomatic rocks.

"d) Miscellaneous. Data concerning the conditions of deposition of a large number of minerals has accumulated and several important relations have been derived. These are being prepared for publication. A complete history of inclusion thermometry is now ready for publication. The data on P-V-T relations of water, CO_2, and of the system H_2O-CO_2 are being recalculated, compiled, and prepared in graphical form. Three papers have been submitted to the A.I.M.E. for publication."

On the recommendation of the National Advisory Committee, a grant of $256 has been made by the Geological Survey of Canada to assist in Dr. Smith's research.

Biogeochemical Studies

On the recommendation of the National Advisory Committee, the Geological Survey of Canada granted $1,750 to Dr. H. V. Warren and Dr. R. N. Delavault of the University of British Columbia, to assist their research in biogeochemistry. Their latest development is the successful application of acetonic dithizone to field technique with consequent advantages in simplicity of "make-up", longer lasting solutions, and lighter weight field kit. During the past summer the methods of Warren and Delavault have been applied in the field by several prospecting organizations in British Columbia, Saskatchewan, and Quebec.

Mineral Inventories

Work that has been begun on the various inventories of metals, as described later in this report, also provides a beginning on the general problem of outlining metallogenetic provinces, which was recommended in our report for 1950-51.

REVIEW OF CURRENT RESEARCH, AND RECOMMENDATIONS FOR ADDITIONAL WORK

The remainder of this report contains a summary of current work related to metallic mineral deposits, and recommendations for additional research. We believe that most geological mapping in regions favourable for the occurrence of metal deposits is a type of research. Therefore, such work is discussed, as well as special field and laboratory studies.

Most of the reviews and recommendations are listed according to certain of the principal metals. Much of our information has been obtained from officers of the Geological Survey who are specializing in these metals. The work of the Geological Survey is stressed partly because that organization is doing much work on these subjects, and partly because we have obtained more information on the work of the Geological Survey than on the work of other organizations.

The Saskatchewan Department of Natural Resources is now setting up a Geological Laboratory in Regina to carry out research on problems related to metallic mineral deposits. This laboratory will be a welcome addition to the existing laboratories maintained by several of the other Provincial Departments of Mines.

Iron

The Geological Survey of Canada had four parties in the Labrador iron belt, under J. M. Harrison, in 1951. The Iron Ore Company of Canada had fifteen parties in the field last summer, seven of which were engaged in mapping on 1,000 feet to 1 inch. Dr. Harrison believes that there are many problems on the genesis of iron that will require laboratory study, and that as a rule the field mapping should be done before the problems can be properly outlined. A beginning has been made on a study of iron ores and associated rocks by differential thermal analysis. In this study, the field work is being done by J. M. Harrison and the laboratory work by S. A. Forman of the Mines Branch. Dr. Harrison believes that another problem that should be tackled is a study of the role of colloidal chemistry in the formation of the iron deposits.

Laval University has also undertaken research on the iron formations and iron ores of Labrador and New Quebec. According to Dr. P. E. Auger, there is, in this field, much to learn because

research that has been done on the somewhat similar iron ores of the Lake Superior region does not seem to answer all the questions in the Labrador area.

Professor W. W. Moorhouse of the University of Toronto is undertaking a comparative study of the petrology of the Gunflint and Biwabik iron formations. The objective of this study is to determine significant differences in the two formations that may account for the absence of important secondary concentrations in the Gunflint. On the recommendation of the National Advisory Committee a grant of $400 has been made by the Geological Survey of Canada to assist in this research.

Copper

Several years ago the Geological Survey began work on a volume on Copper Deposits of Canada, for its Economic Geology Series. The project was dropped, and there is no comprehensive geological report on our copper deposits. Such a report, summarizing what is known about Canadian copper deposits, would be most useful and point the way to future research. The recently published report on "The Copper Resources of Canada", by W. R. McClelland of the Mines Branch, is a useful compilation that will assist any future geological studies of Canadian copper resources.

Lead and Zinc

The Geological Survey published a volume of the Economic Geology Series on lead and zinc in 1930. It would be desirable to bring out a new edition of this volume.

Among the more important exploration programs for lead and zinc of the past 2 years are those in northern Quebec and on the Pine Point concession on the south shore of Great Slave Lake. The Pine

Point concession, which is within 30 miles of the western edge of the Canadian Shield, is underlain by Devonian rocks. It is in a region of few rock exposures, and exploration has been mainly by diamond drilling on a grid system. If satisfactory results are obtained, further exploration will be undertaken on present holdings and will probably extend over a wide area where the geology is more or less similar. There will doubtless be a demand for detailed studies of the deposits found; for geological studies of the rest of the region; for geophysical studies to find further deposits or favourable structures; and for other types of work to aid prospecting in a region where outcrops are scarce. It is probably too early to formulate plans for such work, but if present exploration is successful research of this type should be undertaken.

Antimony

In 1951 C. S. Lord, of the Geological Survey, began a study and inventory of Canadian antimony deposits. This work, and the similar work described below for other strategic minerals, is intended to provide unpublished inventories for government agencies responsible for defence production, etc.; to lead eventually to publications of the Economic Geology Series; and to prepare the way for further studies and prospecting for these minerals by summarizing what is already known about occurrences and pointing to problems that should be investigated. This project has not yet reached a stage where Dr. Lord can suggest specific problems related to antimony.

Beryllium, Niobium, Tantalum, Lithium

In 1951 R. B. Rowe, of the Geological Survey, began a study, and an inventory, of deposits of these metals. He spent the past season (1951) studying pegmatites containing these metals in the

Yellowknife region. He used the method of detailed mapping of internal structures, recently developed by the U.S. Geological Survey, and in which he has been trained. He concluded that the known occurrences are uneconomic at present prices with the transportation costs prevailing in this rather remote region, but that so many unprospected pegmatites occur that further prospecting is warranted. Similar studies of pegmatites in less remote regions may be warranted.

In connection with beryllium, the Subcommittee desires to draw attention to a deposit of helvite in a contact metamorphic zone that has been under investigation in the United States. Helvite is a mineral containing about 14 per cent BeO, which closely resembles garnet and is generally found in contact metamorphic deposits in limestone. It should be kept in mind that deposits of this mineral may also occur in Canada.

Chromite

In 1951 H. A. Quinn, of the Geological Survey of Canada, began a study and inventory of chromite occurrences in Canada. He is not yet in a position to suggest specific research related to chromite deposits.

The North American continent is dependent upon overseas deposits of high-grade chromite for commercial use. Known deposits of chromite in Canada may be too small or too low grade for production in normal times, but should supplies of this material be cut off during any emergency it would be necessary to use domestic ores. The Bird River, Manitoba, chromite can be easily concentrated and used in the manufacture of chrom-X. Also, both the Mines Branch and the Hudson Bay Mining and Smelting Company have developed methods by which concentrates can be beneficiated to raise the chrome-iron ratio to the level required by the steel industry, should it be necessary to do so.

Cobalt

For some years, the greater part of Canada's cobalt production has been obtained as a by-product in the refining of nickel from mines in the Sudbury district. Cobalt will also be obtained as a by-product from the Lynn Lake nickel-copper ores of Manitoba when production from that mine begins.

The balance of Canada's cobalt production is from mines in the Cobalt area of Ontario; most of which is smelted and refined at Deloro, Ontario. The resident geologist for the Ontario Department of Mines at Cobalt, Dr. R. Thomson, is making a detailed study of the geology and mineral deposits of the Cobalt area, and his report will be published in due course.

M. E. Eriskevitch completed in 1952 a Ph.D. thesis on the famous Nipissing diabase sill of the Cobalt area, in which he dealt with the course of crystallization and behaviour of elements such as Ni, Co, V, Cr, and Cu. The spectrographic studies for this research were carried out at Queen's University.

Molybdenum

In 1951 G. M. Wright, of the Geological Survey of Canada, began a study and inventory of molybdenum occurrences in Canada. The work has not proceeded to the stage where specific projects have been suggested.

Tungsten

In 1951 Dr. H. W. Little, of the Geological Survey of Canada, began a study and inventory of tungsten occurrences in Canada. The reopening of the Emerald and Red Rose mines in British Columbia has eased the shortage in supply of this metal. Dr. Little spent most of the field season of 1951 in a detailed study of the Emerald mine.

Uranium

For several years the Geological Survey has been keeping up to date a complete inventory of occurrences of uranium and thorium, because the Survey acts as the official agent of the Atomic Energy Control Board in matters dealing with raw materials. Condensed versions of the descriptions of properties contained in the inventory have been published in Geological Survey Paper 51-10 entitled "Canadian Deposits of Uranium and Thorium".

Concerning recent work and problems for future attention, A. H. Lang reports as follows:

> "Because of the interest in uranium the Geological Survey has been able to do a good deal of mapping and to make special studies, but this was by no means everything that could have been done. Last season one party devoted part-time to some of the main uranium occurrences in British Columbia; this party made an interesting new discovery of uranium. In the Northwest Territories one party did 1-mile mapping in one of the most interesting uranium areas there, and studied the deposits. Two parties did 1-mile mapping in the Goldfields region; one mineralogist made a special mineralogical study at Goldfields, Black Lake, and Charlebois Lake; one geologist studied wall-rock alteration at Goldfields; and one geologist reported on properties in the Goldfields, Black Lake, and Charlebois Lake regions. I examined properties in the Northwest Territories, Saskatchewan, Ontario, and Quebec, and supervised other parties. In addition to the foregoing work by the Geological Survey, Eldorado financed one thesis project at Goldfields, the Saskatchewan Government engaged Dr. J. B. Mawdsley to map and study properties at Charlebois Lake, and the Ontario Government engaged Dr. E. W. Nuffield to map and examine properties in the Sault Ste. Marie region.
>
> "For 1952 the Geological Survey plans to have at least one party doing 1-mile mapping in a uranium area in the Northwest Territories; at least one party doing 4-mile mapping in a part of the Northwest Territories that is favourable in a general way for uranium; and at least one party doing 1-mile mapping at Goldfields. The Survey also plans to begin detailed mapping, and structural and other studies, of the most important part of the Goldfields region - an important project that will probably require 5 years to complete.
>
> "The most immediate requirements are, therefore, pretty well in hand, but there is more that should be done. The Geological Survey does not have sufficient men to examine more than about a third of the discoveries reported to us, and so must choose those that seem most worthy. In so doing some important discoveries may be overlooked, and in any case, the discoverers and property owners think that they are being neglected. Also, there are more areas that should be mapped but they are second-priority areas.

"For long-range research, the situation is very different. We are just able to keep pace with the most immediate requirements, and can do practically nothing about long-range work, except to list low-grade discoveries and problems that occur to us. We should be doing some work to try to find new pitchblende areas; to learn whether any of the non-pitchblende types of deposits are mineable at present prices (a beginning has been made on this at Charlebois Lake); to try to find uranium in by-product quantities at producing gold and base metal mines (a good deal has been done on this, without results, but there is much more that could be done); and studies of known low-grade deposits so that information will be available if needed at some future time or if cheap methods of extraction should be developed. Known placer occurrences of uranium and thorium in British Columbia should be studied to learn whether any are of importance and whether it may be worth while to prospect for such placers at some future time. Beach placers along the British Columbia coast should be studied to learn whether they contain significant amounts of monazite.

"I believe that support should be given to projects for making age determinations, so that the validity of existing methods can be checked, and so that many additional determinations can be made by existing methods, if satisfactory, or by improved methods. The rubidium-strontium method is believed to have many possible applications to the study of mineral deposits in general and to stratigraphy."

Pyrrhotite "Dykes"

Dr. Bruce Wilson has suggested that many magnetic anomalies recorded have, upon investigation, turned out to be due to barren pyrrhotite "dykes". The question arises as to whether or not such "dykes" have any relation to base metal ore deposits. He suspects that pyrrhotite dykes are not a product of normal hydrothermal solutions and, if this assumption is correct, their presence is no indication of favourable prospecting territory. An effort towards the solution of this problem is being made by Wilson in his current research on the origin of pyrrhotite dykes, at the University of Manitoba. On the recommendation of the National Advisory Committee, the Geological Survey of Canada has provided a grant of $450 to the University of Manitoba for support of this project.

Altered Zones Around Sulphide Mineralization

Mr. J. E. Riddell, McGill University, is making a study of rock alteration associated with base metal deposits in northwestern Quebec. Mr. P. E. Eakins has carried out similar studies in the Malartic district in relation to gold ores. The field work and analyses for both investigations were paid for by the Quebec Department of Mines.

On the recommendation of the National Advisory Committee the Geological Survey of Canada has made a grant of $2,030 to McGill University for further research by Mr. Riddell on samples collected for the above investigations. The samples will be analysed for Ca, Na, K, Fe, Mg, and the base metals. The earlier work indicated that a redistribution of these elements has taken place around base metal deposits in such a manner, and to a degree, that would make its study useful in the search for other deposits.

Genesis of Copper and Nickel Ore

Dr. J. S. Stevenson, McGill University, is attacking the general problem of the partition of nickel and copper between silicates and sulphides under various conditions.

Low-grade deposits

We suggest that more attention should be paid to low-grade deposits and that information on such deposits should be included in any inventories that may be made. As better deposits become exhausted, mining of very low-grade deposits will eventually be begun. Research is being done on the treatment of such "ores", by methods such as ion exchange. We believe that records should be kept of Canadian deposits that might eventually be important, either as primary sources or as by-products of mines that work

higher grade deposits of other metals. We also believe that field studies along these lines should be made, that more spectrographic tests should be made on samples collected incidentally to other work, and that tests should be made on the numerous samples of oil-well cuttings stored by the Geological Survey.

Research Division

The establishment of a Research Division within the Geological Survey will greatly stimulate research in the geological sciences throughout Canada. Until this division is assured, however, it seems premature to propose specific problems for its attention.

REPORT OF THE SUBCOMMITTEE

ON STRUCTURAL GEOLOGY

Presented by Dr. J. E. Gill

Members of Subcommittee

Dr. J. E. Gill (Chairman)	- McGill University, Montreal, Que.
Dr. J. W. Ambrose	- Queen's University, Kingston, Ont.
Dr. M. F. Bancroft	- Acadia University, Wolfville, N.S.
Dr. D. R. Derry	- Ventures Limited, Toronto, Ont.
Dr. H. C. Gunning	- University of British Columbia, Vancouver, B.C.
Dr. T. A. Link	- 25 King St. W., Toronto, Ont.
Dr. J. B. Mawdsley	- University of Saskatchewan, Saskatoon, Sask.
Dr. C. H. Stockwell	- Geological Survey of Canada, Ottawa, Ont.

Structural investigations in Canada have proceeded along normal lines in connection with areal studies. This work, done largely under the auspices of the Geological Survey of Canada and the Provincial Departments of Mines, is a major and most important part of structural research in Canada.

Exploration for petroleum proceeded at an increased pace. The large amount of structural data accumulating is under close study by private organizations, and we assume that records are being preserved in government files.

A few special studies relating to ore deposits, the geometry of folds and regional structures were in progress and some useful results accrued from these during the year.

An outstanding event was the publication of a Tectonic Map of Canada prepared by a committee of the Geological Association of Canada headed by Dr. D. R. Derry, and published by the Geological Society of America. This map is remarkably good, considering the relatively short period of compilation. Although not complete or entirely accurate in every respect, it provides for the first time a broad and reasonably accurate view of the major structural features of the country as at present known. One of its main features will undoubtedly be the stimulation of workers in many parts of the country to new efforts directed toward filling in blank spots, and investigation of doubtful or disputed points. Such projects are even now afoot. Dr. Gunning has written suggesting that this committee support the preparation of a more precise and detailed map, starting with the Geological Association of Canada map as a base. Plans are already laid at the University of British Columbia to revise the British Columbia section. This project will receive the support of most geologists in Canada.

Dr. Ambrose again directs attention to the item in last year's report relating to the study of faults; also detailed study of well-exposed areas exhibiting various types of folds, rock cleavage, joint systems, and breccias. These are outlined on pages 64 and 65 of the Annual Report of the National Advisory Committee on Research in the Geological Sciences for 1950-51.

Dr. Stockwell has mentioned study of faults in the Kirkland-Malartic belt as worth special consideration, and he would like to see a more vigorous attack made on the structure of the Grenville province, especially along its northwest border.

Dr. Stockwell's own work on folds illustrates the type of basic investigation to which this committee thinks more attention should be given.

Mention was made in our last report of batholith studies. Structural studies of batholiths are desirable, but it appears unlikely that any really systematic or comprehensive study of this type will be undertaken in the near future except as part of a broader project to include chemical and mineralogical investigation. This has led us to suggest a project involving co-operation between the Geological Survey, Provincial Departments of Mines, and universities. Those of us who have been dealing with batholiths have been constantly aware of the poor quality of our information about the composition of these masses. They are important elements in the earth's crust, mark outstanding events in earth history, and are believed to give rise to many types of economically important deposits, yet our knowledge of these masses is based on rather superficial observations on a few traverse lines supplemented by study in thin section and, rarely, by chemical analysis of a few grab samples. This is not good enough. We propose that field parties be assigned to map structure and sample systematically certain batholiths, some with associated ore deposits and some without. Enough material should be collected so that petrographic, chemical, spectrographic, and radioactivity studies could be carried out.

The Federal or Provincial surveys could finance field parties and do part of the laboratory work. Much detailed study of rocks and minerals could be carried out by graduate students in university departments. This project could be started in a small way and, if the results warrant it, should continue until a groundwork of precise information about intrusives has been attained. The results should be of great scientific interest and probably also of great practical value in the selection of prospecting areas.

It is realized that this project cuts across the fields of several of the subcommittees, but we feel that the major problems

in geology can only be dealt with satisfactorily by co-operative attack. We, therefore, submit it for discussion by the Committee as a whole and any subcommittees that may be interested.

Early in the year, Dr. Gunning called attention to the exceptional opportunity for study of part of the Coast Range batholith during the driving of the Kemano tunnel by the Aluminum Company of Canada. This matter was discussed at the June 1951 meeting of the National Advisory Committee and inquiries have been made in British Columbia and at the head office of the Company at Montreal as to the best way to supplement the Company's own work to further the interests of science. There is reason to hope that a practical co-operative scheme can be worked out between the Company and the British Columbia Department of Mines whereby a complete mapping job can be done and ample material collected for supplementary laboratory studies. This means that oriented specimens should be collected systematically and, in addition, ample material for petrographic, chemical, spectrographic, and radioactivity studies. Measurement of rock temperatures and other physical data may also be undertaken (See also page 4 of this report).

REPORT OF THE SUBCOMMITTEE ON PETROLOGY, MINERALOGY, AND CHEMISTRY

Presented by Dr. G. S. MacKenzie

Members of Subcommittee

Dr. G. S. MacKenzie (Chairman) - University of New Brunswick, Fredericton, N.B.

Dr. J. E. Hawley - Queen's University, Kingston, Ont.

Dr. W. W. Moorhouse - University of Toronto, Toronto, Ont.

Dr. F. F. Osborne - Laval University, Quebec, Que.

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

Dr. H. W. Warren - University of British Columbia, Vancouver, B.C.

INTRODUCTION

Canada by virtue of its size and variety of geological formations and mineral deposits offers splendid opportunities for field and laboratory studies in petrology, mineralogy, and geochemistry. Much field study has been accomplished despite obstacles imposed by geography. However, field study has not been followed by as much laboratory investigation of a quantitative nature as is desirable, largely because of limited personnel and equipment. Experimental investigations have been restricted for similar reasons. Some alleviation of the situation has been achieved by grants by the Geological Survey of Canada for geological research in Canadian universities.

A deterrent to research, noted in the first report of this subcommittee, is the difficulty of obtaining routine chemical analyses of rocks and minerals (and waters) that the average worker has not the time or equipment to make. Coupled with this is a need for more

specialized spectroscopic, X-ray, thermal, and isotopic studies calling for equipment and technical skill not generally available. The carrying out of the first three recommendations of the First Annual Report of the National Advisory Committee would go far to relieve this situation. In addition, establishment of laboratories of the size and character recommended would allow types of research to be undertaken that are beyond the scope of most university laboratories.

The status of scientific research in general in Canada has been ably reviewed in the Report of the Royal (Massey) Commission on the Arts, Letters, and Sciences. Research in petrology, mineralogy, and geochemistry fits into the general pattern of scientific research outlined in the Massey report. It might be noted in passing that the geological sciences should be of particular importance relative to other sciences because of Canada's geography, mineral resources, and stage of development. Mineral wealth is useful only when it has been located and developed. It is obvious that the chances of finding mineral deposits exposed at the surface are decreasing, and that geophysical methods must be used more and more. Most of these methods, due to their cost, are applicable to only relatively small areas. Much of the research in petrology, mineralogy, and geochemistry may be directly applied to delineation of areas where such intensive prospecting is justified.

Any review of research in petrology, mineralogy, and geochemistry in Canada, must mention the important role played by the Geological Survey of Canada. Areal mapping across Canada by the Geological Survey provides the background data for much of the geological research in Canada. The areal mapping is frequently followed by more intensive field and laboratory research by members of the Survey staff, by university workers, and others. Research

throughout the country is also stimulated and aided by provision of thesis areas and topics to graduate students in the universities. Further background information, and service to research workers is provided by the Mineralogy and Radioactivity Division of the Geological Survey and the laboratories of the Mines Branch. Given the necessary personnel, equipment, and space, the Geological Survey has indicated eagerness to increase its aid to research in every way possible and to embark on new research projects of its own.

Several of the Provincial Governments are providing similar valuable services to research workers through Department of Mines, Research Foundations, or Resources Development Boards. These services fulfil a real need, and their number and scope could be increased.

The National Research Council, though only indirectly concerned with research in petrology, mineralogy, and geochemistry, performs a valuable service in providing new data, equipment, techniques, and theory through research work in physics and chemistry. The Council also supports research in petrology, mineralogy, and geochemistry by grants-in-aid to university staffs and provision of scholarships, studentships, and bursaries to graduate students.

Some research is carried on by mining and industrial companies and much aid is given to government and university workers by the companies. The aid provided takes such forms as access to properties, provision of specimens, and the granting of scholarships and financial help to universities.

The burden of pure research falls largely on the universities. Much of this research, particularly of the more advanced or specialized type, is concentrated in the larger institutions because they have staffs with the necessary training

and time, as well as the equipment. More research would be attempted in both the larger and smaller institutions if the staffs were not overburdened with teaching duties. Many instructors would prefer to work on research problems, but are forced to spend their summers in remunerative routine work because of the low salaries they receive. The correction of this situation seems equally or more important than provision of funds for research equipment.

It is encouraging to note that several geology departments in Canadian universities have increased their staffs and equipment and extended their graduate teaching and research in recent years. This expansion has been largely in the field of mineralogy, but geochemistry, and to a lesser degree petrology, are also receiving increased attention. More stress than heretofore is being placed on experimental investigations and mineral synthesis.

The limited number of outlets in Canada for publication of results of research in petrology, mineralogy, and geochemistry is a serious problem. The recently established bulletin of the Geological Association of Canada is a welcome addition to the publications covering these fields.

The specific projects in petrology, mineralogy, and geochemistry currently in progress are listed in "Current Research in the Geological Sciences in Canada, 1951-52". No complete listing is, therefore, attempted in this report but a general summary of current research in each of these fields follows. This is followed by a section in which problems and projects are discussed that the Subcommittee considers particularly deserving of further study.

SURVEY OF CURRENT RESEARCH

Petrology

Research in petrology of the igneous rocks is receiving attention along several lines. In the Kirkland Lake area, the granitic and related minor intrusions are being studied in the field, with complementary chemical and petrographic laboratory studies at the University of Toronto. A part of the Coast Range batholith in British Columbia is being studied. Three related studies of parts of the southern batholith of New Brunswick are being made at the University of New Brunswick.

Granite, syenite, and corundum pegmatites of several areas in Ontario and Quebec are being studied at Queen's University and the University of Toronto. The granites and radioactive pegmatites of the Charlebois Lake area, northeastern Saskatchewan, are being studied at the University of Saskatchewan. The petrology of the diabase sills of Port Arthur is being studied at the University of Toronto, and spectrographic analyses of the Nipissing diabase of Cobalt are being made at Queen's University. The relatively undisturbed and widespread rhyolitic and volcanic rocks of the Carboniferous of New Brunswick are receiving some field and petrologic, as well as stratigraphic, study at the University of New Brunswick.

Of a more general nature are studies at the University of Toronto of accessory minerals and textures in igneous rocks, with particular attention to basic complexes. At Laval University, experimental research is in progress on gas explosion effects in magmas believed to result in the development of "pillowed" aplites.

Much work on metamorphic rocks is in progress. At McGill University the gneisses of two areas in Baffin Island and of an area on the coast of Labrador are being studied. Also at McGill,

two thesis studies are being made of Grenville type gneisses of the north shore of the St. Lawrence River. At Laval University several studies of metamorphic rocks from the Grenville and Appalachian regions are under way. At Queen's University nepheline bearing gneisses are being studied. At the University of Toronto the Keewatin meta-diabase and rocks from areas in the Granville of south-eastern Ontario are under investigation. At the University of Saskatchewan the petrology and radioactive content of lime rich metamorphosed sediments of northern Saskatchewan are being studied. At McGill University experimental research on rheomorphism is in progress.

Several studies of iron formations overlap the fields of metamorphism and sedimentary petrology. At Laval University high temperature and high pressure experimental work is under way on the origin of jasper and chert. At the University of New Brunswick comparative studies are being made of the Precambrian iron formations of Ungava and the Ordovician and Silurian iron formations of New Brunswick. At the University of Toronto the petrology of the Gunflint and Biwabik iron formations is being compared. Correlation of slaty beds associated with the iron formations of Labrador by their spectrographic, thermal, and chemical properties is an example of the use of new techniques in the study of metamorphic rocks. A spectro-chemical study of trace element behaviour in the slates of Labrador was made at Queen's University and a study of trace element behaviour in the metamorphism of argillaceous rocks is being carried out at McMaster University.

Studies in the field of sedimentary petrology are limited. The Medina formation of the Niagara peninsula is being studied at McMaster University, and the sedimentary petrology of the Cretaceous of Saskatchewan is being studied at the University of Saskatchewan.

Work on the petrography of reef structures in the Devonian rocks near Great Slave Lake is contemplated at the University of Toronto. Some study is being given the petrography of the Carboniferous formations in the Maritimes by the Geological Survey of Canada and others.

Mineralogy

Most of the field studies in mineralogy have been incidental to examination of mineral deposits and pegmatites. In recent years special attention has been given the radioactive minerals. Field and laboratory studies in this field are a chief concern of the Radioactivity Division of the Geological Survey of Canada. At the University of Toronto, the apatite deposits of the Ottawa Valley are being studied.

Laboratory and experimental studies are receiving increased attention in the universities. Determinations of mineral structures by X-ray is continuing at Queen's University, with present work centred on the niobate-tatalates and the lollingite-safflorite series. Additions are being made to X-ray powder data on the ore minerals. A noteworthy accomplishment at this institution was the synthesis of zippieite, a basic uranium sulphate; crystals suitable for X-ray study were produced for the first time. Thorite and huttonite were also synthesized. This work is a real contribution to the study of the radioactive minerals.

A research program on uranium-bearing minerals begun a few years ago at the University of Toronto with the aid of a National Research Council grant has resulted in several intensive mineralogical studies. These studies include the torbernite group of phosphates, vandenbrandeite, gummite, and U_3O_8, pitchblende and the metamict state, and the uranium silicate minerals. Research on

the ore minerals is continuing, with the completion of descriptions of cuprobismutite, parkerite, shandite, and the manganese minerals crednerite, lithiophorite, jacobsite, hetaerolite, hydrohetaerolite, hollandite, cryptomelane, and coronadite. Papers on cuprobismutite and jacobsite are in press. Systematic morphological and X-ray studies initiated by the late Dr. M. A. Peacock are being continued. The Department of Geological Sciences at Toronto has purchased a Buerger Precession X-ray goniometer and has had built to its own specifications a second X-ray diffraction unit utilizing a Machlett tube. The goniometer and X-ray diffraction laboratories have been completely renovated.

Geochemistry

The Mineralogy-Radioactivity Division of the Geological Survey of Canada has under way a plan for systematic geochemical studies, mainly aimed at outlining geochemical provinces. The Quebec Department of Mines has completed a compilation of nearly three thousand analyses of minerals and rocks. The laboratories of this department are continuously accumulating data from spectrographic and other analyses, and carry out trace element determinations for the Department's geologists and university workers. The presence of nickel in the pyrite of the recently found nickeliferous pyrite deposit in Montmagny county in the Province of Quebec was first established by X-ray diffraction analysis and spectrographic analyses made in these laboratories.

A great impetus to interest in biogeochemistry in Canada has been given by the outstanding work of Dr. H. V. Warren and colleagues at the University of British Columbia over the past several years. Techniques developed by this group are being applied by mining companies across Canada in prospecting for base metals.

Additional research, using these techniques, is being carried on by other universities. Research along these lines is being extended to include studies of the distribution of trace and common elements in bedrock formations, particularly in relation to ore deposition. The motive behind much of this work is to develop new prospecting tools, but in addition much data of theoretical value are being obtained.

Research projects in geochemistry include: studies in biogeochemistry and hydrogeochemistry at the University of British Columbia; at McGill University an investigation of copper and zinc in indigenous trees in southeastern Quebec; studies of trace and major elements in metasomatic zones associated with the copper-zinc sulphide deposits of northwestern Quebec; and research on the distribution of Ca, Na, K, Mg, and Fe in metasomatic and metamorphic zones around base metal deposits.

At Queen's University several projects allied to geochemistry are in progress that will supply geochemical data. These include: spectrographic analysis of minerals in sulphide deposits containing the platinoids and of ash from Nova Scotia coals; spectrographic analyses of the Nipissing diabase; and the correlation of slaty formations in Labrador by spectrographic, thermal, and chemical properties. The study of trace element behaviour in the metamorphism of argillaceous rocks at McMaster University should also be mentioned.

In discussing geochemistry, the chemistry of the hydrosphere and atmosphere should be included but this Subcommittee has not assessed the work being done in these fields. Some data have been accumulated on the composition of underground lake and river waters. Sampling of coastal marine waters is being carried out under the Joint Committee on Oceanography of Canada. The latter group welcome the interest and co-operation of geologists not only in chemical studies but in studies of submarine sedimentation and topography.

SUGGESTED PROJECTS

A number of research projects that should receive attention were listed in the first report of this Subcommittee. Several of these have been initiated; others have not yet been started.

Dr. S. C. Robinson, a member of this Subcommittee has listed the following general fundamental problems to whose solution the fields of petrology, mineralogy, and geochemistry must make the main contribution:

1. The genesis, differentiation, and emplacement of batholiths, their apophyses, and the mineral deposits related to them.

2. The delineation of petrographic and mineralogical provinces in Canada.

3. The processes and conditions responsible for the deposition of the various types of mineral deposits in Canada. This includes critical appraisal of the relationship of pegmatites to hydrothermal mineral deposits, the theories of magmatic differentiation and lateral secretion, the mechanics of replacement, and the relative importance of structural and chemical control by host rocks.

4. The determination of the age of rocks and mineral deposits in Canada. This should include correlation of various methods of determining age; by radioactive decay of certain elements, field evidence of succession, and by palaeontology.

5. The extent and development of progressive metamorphism in various districts and geological provinces.

6. The association of rock alteration with deposits of economic minerals.

7. Appraisal of criteria for distinguishing between granites of magmatic and metasomatic origin.

In addition to the general problems mentioned above, more specific problems dealing with the study of batholiths, metamorphic rocks, and the standardization of mineralogic data are discussed below.

Batholiths and Other Igneous Bodies

The Subcommittee on Structural Geology has suggested that more attention should be given the study of batholiths. This is a problem that crosses the fields of several of the subcommittees, but is of particular interest to petrologists. It has received attention heretofore by a committee of the Royal Society of Canada and a subcommittee of the National Research Council of the United States. However, much remains to be learned about batholiths, and Canada provides unexcelled opportunities for their study.

The problem can be approached on a regional and chronologic basis; it should include studies of Canadian Shield, Acadian and Appalachian, and Cordilleran batholiths. Aspects to be studied include external and structural relationships, internal structure and variations, related intrusions, and mineral deposits. Such broad scale studies may help solve the problem of the origin of granite and whether or not mineral deposits are associated with granitic rocks produced by granitization or only with those of true plutonic origin.

Two intensive studies of batholiths are being initiated this year (1952). The British Columbia Department of Mines is undertaking the geological study of the Kemano-Tahtsa Lake tunnel. This tunnel, which is under construction by the Aluminum Company of Canada, is being driven through part of the Coast Range batholith for a distance of 10 miles. The geology along the tunnel and on the surface will be mapped in detail and specimens collected for laboratory research. In addition, thermal measurements will be made to determine the heat flow from the rocks along the tunnel.

The Geological Survey of Canada is beginning an intensive study of a batholith in Preissac and La Corne townships in northwestern Quebec. It is planned to include in this project studies

of the petrography and variations in composition, of the distribution of trace elements and radioactivity, of the accessory minerals, and of inclusions in constituent minerals.

In addition to the study of granite batholiths, there is need for further research on basic intrusive bodies. Some gabbroic rocks are associated in the field, and apparently in origin, with granites; others are apparently unrelated to granites. A broad study of these rocks might bring out features of petrogenic significance. The peridotites likewise offer an interesting field for for wide-scale investigation and comparative study.

Metamorphic Rocks

In the first report of this Subcommittee mention was made of the need for more exact definition of the amphiboles and pyroxenes, particularly in the metamorphic rocks. Such studies are of special concern in Canada because of the abundance of rocks containing these minerals, particularly in the Canadian Shield.

Mineralogy

In the field of mineralogy several projects have been suggested by Dr. Robinson that were not mentioned in our earlier report. The first of these is that a survey be made of the laboratory facilities and equipment for geological and mineralogical research in Canadian universities and government departments. Data on the main problems for which the equipment is being used should also be gathered. The Subcommittee recommends that such a survey be made.

Dr. Robinson further suggests that in order that data obtained in one laboratory may be compared with that from others throughout Canada, study should be given to developing some system of standardization. He states:

"In spectrographic laboratories, the two standard rock powders prepared by the United States Geological Survey (Bulletin No. 980, 1951) should be analysed as an indication of the reproducibility of the results. Similar standards of known composition to represent other groups of elements should also be prepared for the same purpose.

"In the field of X-ray diffraction, it is probable that various laboratories have mounts or spindles of known minerals that could be loaned to other laboratories where a 'library' of reference patterns is being assembled. If this were done, questionable mineral species or specimens would be readily detected. The alternative method of exchanging actual patterns is less satisfactory owing to the use of powder cameras of varying radius and X-radiation of different wave length in the various laboratories. In order to facilitate the loan of spindles, it is recommended that a master list of spindles available in all laboratories be compiled and distributed.

"For X-ray diffraction patterns of metamict minerals it is usual to induce crystallinity by heat treatment either in vacuum or in an inert gas. If powder patterns of such minerals are to be standardized, a uniform method of heat treatment must be employed. Some progress in such standardization is being made by an international committee on radioactive minerals. It is recommended that the method decided upon by this Committee should be promulgated to all Canadian X-ray diffraction laboratories.

"Similar methods of standardization should be established for thermal analysis, some aspects of chemical analysis, and other procedures, on a trial basis."

Dr. Robinson in commenting on the recommendation of the National Advisory Committee that the laboratories of the Geological Survey of Canada be expanded, an expansion in part to allow for an increased number of rock and mineral analyses, points out the advantage of the newly developed spectrochemical method of rock analysis, and of the X-ray fluorescence unit for complex ores, minerals, and chemical or mechanical concentrates.

REPORT OF THE SUBCOMMITTEE

ON PLEISTOCENE GEOLOGY

Prepared by Col. P. D. Baird[1]

Members of Subcommittee

Col. P. D. Baird (Chairman)	- Arctic Institute of North America, Montreal
Dr. H. S. Bostock	- Geological Survey of Canada, Ottawa
Mr. L. J. Chapman	- Ontario Research Foundation, Toronto
Dr. R. F. Flint	- Yale University, New Haven, Conn.
Dr. A. Leahey	- Experimental Farm Service, Ottawa
Mr. R. F. Legget	- National Research Council, Ottawa

This report must be accepted as an interim one only. It comprises notes prepared by Dr. H. S. Bostock and Dr. V. K. Prest of the Geological Survey of Canada, and the writer.

Dr. Bostock has prepared a brief account of the state of Pleistocene research in the Geological Survey of Canada. It is gratifying to note that several recommendations of this Subcommittee in the First Annual Report of the National Advisory Committee (1950-51) have been carried out and that action is planned on others. Dr. Bostock's notes are as follows:

> "The Geological Survey is developing a Pleistocene and Engineering Geology Division. To obtain staff for this Division, the Geological Survey has found it necessary to assist selected students in their post-graduate studies in the universities. This plan has been satisfactory and a nucleus of some ten specialists in Pleistocene Geology and water supply has been built up over the past few years.
>
> "Every effort is being made to broaden the field and research program. Some twelve field parties were engaged in

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[1]Col. Baird was appointed Chairman of the Pleistocene Subcommittee at the January 1952 meeting of the National Advisory Committee. This interim report has been prepared by Col. Baird since that time.

Pleistocene and water supply work in the season of 1951. A laboratory for the study of Pleistocene materials and sedimentology is being established.

"More study is being given Pleistocene deposits by Geological Survey field parties engaged primarily in mapping bedrock geology. This is particularly true in the Yukon and northern British Columbia where field parties are giving special attention to glacial and geomorphological features.

"Some special studies have been made of existing glaciers in the Rocky Mountains.

"Using two helicopters and support aircraft, a Geological Survey field party is mapping an area of 50,000 to 75,000 square miles in the Northwest Territories between Great Slave Lake and Hudson Bay in the one field season of 1952. This vast, largely unexplored area is of particular interest to Pleistocene geologists because it includes the Keewatin centre of glaciation. It is thought that this area will be covered with a thoroughness at least comparable to that of conventional 1 inch to 8 miles and may approximate that of 1 inch to 4 miles geological maps. The five geologists carrying out this project include a specialist in Pleistocene geology who will be responsible for the interpretation and correlation of the unconsolidated materials and the production of a Pleistocene map of the area.

"The Geological Survey plans on preparing a geomorphic map of Canada on a small scale for the forthcoming Atlas of Canada. Larger scale geomorphic maps of the Cordilleran region are at present being compiled, and the compilation of similar maps of the Appalachian region is planned.

"The compilation of a Pleistocene map of Canada is planned to begin this autumn (1952)."

Dr. Prest has prepared the following statement, which, he stresses, is complementary to the report of this Subcommittee in the First Annual Report of the National Advisory Committee (1950-51):

"The most pressing work that should be undertaken in Canada is the study of spores and pollen grains as an aid in the dating of Pleistocene deposits and the interpretation of climatic conditions. This study will require personnel well versed in botanical matters and familiar with Pleistocene geology. Laboratory facilities necessary for the convenient handling of various types of sample will be necessary. In addition, the problem will require the close co-operation of the National Herbarium or some such organization where adequate collections of modern flora are stored and available for comparative studies.

"Spore and pollen analyses may well prove to be the most useful tool available in the dating and proper understanding of Pleistocene events. They are especially important in Canada where buried soil profiles are generally lacking.

"Work on C-14 should be carried out in Canada. The accurate dating of Pleistocene and Recent materials is of great importance to Pleistocene geologists, to archaeologists, and to soil scientists. We are still dependent on American research centres and personnel for the occasional determination that absolutely must be done. Although there are now several centres in the United States where such work may be carried out for us, the process of having the work done tends to be involved and work is on a priority basis. The necessity of going outside our own country for the answer to our problems is a great deterrent to efficient work.

"Work is reported to be in progress on a C-14 laboratory at the University of Saskatchewan. It is doubtful, however, if university laboratories, designed specifically for research problems, will be able to handle the routine analyses that are bound to follow in the wake of renewed interest in the Pleistocene history of Canada.

"Comprehensive investigations of the basins of glacial Lakes Barlow and Ojibway should be speeded. The geological study of the deposits and history of these lakes is a prerequisite to proper soil, forestry, botanical, and other studies. The great lack of geological information on the Pleistocene deposits of these lake basins has already forced botanical and agricultural scientists to make broad surveys of the regions themselves, prior to tackling their own specific problems. Surely this state of affairs should not exist. Although these scientists have accomplished a great deal, much still remains to be learned about Pleistocene chronology that will be of service to various interests.

"The lake basins should be accurately mapped and the position and elevations of the strand lines determined. The character of the deposits should be noted, the outlets determined, and data obtained on warping of strand lines. The problem of the Ojibway-Barlow overlap and of the southern 'shore' of Barlow, and the 'Cochrane' glacial advance might then be satisfactorily solved. Air photos of the whole region make the problem ripe for action. The problem is especially important because this great northern clay belt will be the farm land of the future. Although much of it is being farmed today great tracts are undeveloped. Much remains to be learned about proper land usage. Geological mapping is the forerunner of the full development of this area.

"Similar work to the above should be undertaken on the north strand lines of glacial Lake Algonquin and on its drainage history.

"As already suggested in the First Annual Report of the National Advisory Committee, work should be pushed along on the glacial history and deposits of the St. Lawrence Lowlands. The limits of the marine submergence should be determined in detail along with work on the raised beaches, terraces, etc. There is great need for a thorough study of the faunal record of this seaway -- now recognized as a multiple invasion in some parts of the lowlands. A comprehensive study of the fauna and of the stratigraphy is long overdue.

"The major end moraine systems in Canada should be mapped by the use of air photos plus certain ground check work. Great tracts of end moraines are as yet unmapped and even unknown. They will provide fascinating studies for students of Pleistocene geology for years to come. Such studies will throw more light on the waning of the Wisconsin glaciers, afford a better broad scale picture of the Wisconsin age, and lead us more quickly to key points of interest across Canada.

"Soils engineers are today carrying out comprehensive tests on soils to properly understand their behaviour in engineering projects, but there is a wide field of research on Pleistocene materials that might well be undertaken by geologists. Pleistocene geologists should take a more active interest in the products of glaciation. Studies of the clay minerals are especially important. The geologists' work should be complementary to that of mineralogists and soils engineers.

"Pleistocene geologists might well take a more direct interest in the field of perma-frost studies.

"Detailed Pleistocene studies of every city and large town in Canada should be started as soon as possible. Much data are daily being lost as construction spreads in all urban areas. Only the geologist can properly correlate such information and make it available in future years for engineers, geologists, and others. Soils engineers may well co-operate in this work but universities and Provincial departments should delegate personnel to keep current track of developments and broaden our knowledge of the Pleistocene by their detailed studies. Such 'knots' of detail will also serve to link up reconnaissance or more general work in neighbouring areas."

The Arctic Institute of North America has recently established a Research Committee to review the status of research in northern regions and to make recommendations on the priority of investigations in various fields. Six main fields are discussed in its report and Nos. 1 and 4 are reproduced here:

"1. Studies on the Northern Ice Caps and Glaciers

"Significant work has already been done in the Seward icefield in the St. Elias Range in the Alaskan-Yukon boundary region. Outside Greenland there are few ice-caps in the North American Arctic. They occur in Baffin Island, Ellesmere Island, Axel Heiberg Island, and Devon Islands. There are several ice-caps in northern U.S.S.R. territory.

"Studies should be made to determine whether the accretion of snow compensates for the loss by ablation and otherwise, to examine the character of the surface ice, and to obtain data on the variation of temperature on the surface and depth. The significance of these studies climatologically in relation to similar studies in Europe should be explored. This project will require continuous study over several years.

"4. Arctic Geological Processes as Related to Northern Engineering

> "The low temperatures that prevail in the north have a specific effect on rock disintegration and movement, and on soil development. The ordinary temperate weathering processes do not apply, and considerable rock movement takes place through solifluction. Permafrost, extending downwards for hundreds of feet, presents problems in foundations, in drilling, and in water supply. With the indications of northern development now ahead, there are engineering problems, due to the special geological conditions of the north, that demand study and solution."

In connection with Item 1, the Arctic Institute is in a particularly adequate position to contribute. Mr. Wood, the Director of the New York Office, has been responsible for the extensive investigations of the Seward-Malaspina system in the years 1948-49 and 1952, and the writer organized investigations in the Baffin Island area in 1950 and intends to return to another area of Baffin ice in 1953. The Institute and McGill Univesity are supporting two projects during the summer of 1952. The first of these is the glaciological investigation of the Saskatchewan Glacier being carried out under the direction of Dr. R. P. Sharp, California Institute of Technology, who has been the senior scientist with the "Snow Cornice" expeditions. The second project is being undertaken by two students from McGill University, J. H. Mercer and W. Blake, who are investigating the Grinnell Glacier in southern Baffin Island.

The Arctic Institute would be in a position to prepare a map of existing glaciers in Canada as a full time project, using the now extensive existing air photograph coverage.

With reference to the projects suggested by this Subcommittee in the First Annual Report of the National Advisory Committee (1950-51), one of great interest to the Arctic Institute is the determination of the outer limit of glaciation in Arctic Canada (Item E, page 27 of the Report).

REPORT OF THE SUBCOMMITTEE ON NON-METALLIC MINERAL DEPOSITS, INDUSTRIAL MINERALS, COAL, AND OIL

Presented by Dr. R. L. Rutherford

Members of Subcommittee

Dr. R. L. Rutherford (Chairman) - University of Alberta, Edmonton, Alberta

Dr. J. D. Allan - Winnipeg, Manitoba

Mr. M. F. Goudge - Dept. of Mines and Technical Surveys, Ottawa, Ontario

Dr. D. J. MacNeil - St. Francis Xavier University, Antigonish, N.S.

Dr. H. Sargent - Dept. of Mines, Victoria, B.C.

INTRODUCTION

The main topics listed in the title of this subcommittee are oil and coal. It is almost impossible to discuss geological research in respect to them without transgressing the fields of at least five other subcommittees because nearly all fundamental research in respect to oil and coal pertains to topics of stratigraphy, palaeontology, petrography, structural geology, and geophysics. Discussion of all research problems involving these topics and connected with the search for oil and coal would make the report of this Subcommittee extremely repetitive and redundant. However, certain problems might be mentioned.

OIL AND GAS

Much of the geological research in Western Canada is being carried on in the private laboratories of the operating oil exploration companies and well-servicing organizations. For example, detailed studies of structure, palaeontology, stratigraphy, and sedimentation are being carried on by all the major oil companies.

This means much duplication of effort because there is little, if any, intercorrelation of results by these companies. It would be highly advantageous if some such organization as the National Advisory Committee could bring about the co-ordination of these investigations. This is most difficult to accomplish because the research of these companies is directly related to the search for oil, and in such a highly competitive industry each company is loath to disclose data that might be of use to a competitor. Nevertheless, the co-ordination of the results of the research of these companies might result in the solution of several general problems.

Turning now to specific problems, the mode of formation of dolomite and anhydrite is challenging and in need of continued research. Such research should be not only petrographical and chemical but also geophysical because the study of electro and radioactive logs of bore-holes may prove important in the solution of these problems.

Metallic sulphides and fluorite have been found in the cores of some wells in Western Canada. Mineralogical and petrographical research is needed on the occurrence of these minerals.

Native sulphur has been found in cores from widely spaced wells. Its origin and occurrence present problems in chemistry and mineralogy calling for further research. The composition of oil field waters is also important and in need of further study.

COAL

Coal for many years has been one of the main contributors to the mineral production of Western Canada, but with the competition of oil, it has, in some instances, suffered a major setback. Such competition has stimulated the coal industry to find new and cheaper

methods of production, and it might be assumed that some of this effort would be directed to fundamental research. However, this has not been the case in Western Canada up to the present; most of the effort has been directed toward finding coal that can be strip-mined because this offers the best immediate solution to the problem.

We are apparently missing a very valuable opportunity at the present time to make geological studies of coal of the plains areas of Western Canada. Large areas have been perforated with numerous shallow holes made for seismic and structure test work in the search for oil and gas. The only use made of the coal seams intersected in this work is for correlation; no observations are made on the nature of the seams encountered in such drilling. Many hundreds of shallow-hole electrologs are taken that give valuable data on the distribution and lateral variation in the nature of the coal seams. So far as known, no attempt has been made by the coal industry or any governmental agency to collect and make use of this information. In the not too distant future such information may become very important because large reserves of comparatively accessible, low rank Tertiary coal are probably present.

Coal research is being conducted on an intensified basis in the Maritime regions. The over-all results of this investigation have not been published in detail as yet, excepting that information presented in advance reports of progress.

NON-METALLIC AND INDUSTRIAL MINERALS

Any survey of the field of research in respect to these deposits transgresses the fields of several of the subcommittees. Various organizations, both Federal and Provincial, are conducting research on these materials.

In Western Canada one of the most urgent needs is a program of research in respect to clay minerals and limestones suitable for industrial uses. Fully equipped laboratories for fundamental research on clay minerals are lacking at present, although some are planned. It is to be hoped that these plans reach fruition and that well-equipped laboratories for the work will soon be in operation.

In the western plains areas, the distribution of the clay minerals is mainly associated with the Pleistocene and Recent deposits. As in the case of coal, a valuable opportunity is being missed to assemble important data from the many test and seismic shot holes that are being drilled over large areas of Western Canada.

No geological examination was made of the continuous trench that was dug from Edmonton to Winnipeg in the construction of the interprovincial pipeline for the transport of crude oil to the east. Its study would have added much to our knowledge of the glacial and recent deposits of the plains. Soon another such trench will be dug from Edmonton towards the Pacific. It is to be hoped that the opportunity to study the Pleistocene section exposed along it will not be missed. Periodically, other shorter pipelines are built on the plains. The excavations for these lines should also be examined.

PUBLICATION

One of the more general problems in respect to research in geology in Canada, is the difficulty in having the results of research published. This is not as serious for those in governmental organizations with their own means of publication. It is, however, a real problem for geologists in universities and

private organizations who must depend on the limited number of Canadian societies that publish articles on geological research. Anything the Committee can do to alleviate this situation will be most beneficial to geological research in Canada.

REPORT OF THE SUBCOMMITTEE

ON STRATIGRAPHY AND PALAEONTOLOGY

Presented by Dr. I. W. Jones

Members of Subcommittee

Dr. I. W. Jones (Chairman)	- Dept. of Mines, Quebec, Que.
Dr. W. A. Bell	- Geological Survey of Canada, Ottawa, Ont.
Dr. T. H. Clark	- McGill University, Montreal, Que.
Dr. F. H. Edmunds	- University of Saskatchewan, Saskatoon, Sask.
Dr. Edward Leith	- University of Manitoba, Winnipeg, Man.
Dr. V. J. Okulitch	- University of British Columbia, Vancouver, B.C.
Dr. L. S. Russell	- National Museum, Ottawa, Ont.
Dr. P. S. Warren	- University of Alberta, Edmonton, Alta.
Dr. J. B. Webb	- Anglo-Canadian Oil Co., Calgary, Alta.
Dr. W. J. Wright	- Provincial Geologist, Fredericton, N.B.

INTRODUCTION AND GENERAL REMARKS

In the last report of the Subcommittee on Stratigraphy and Palaeontology, more than twenty topics of research were indicated as requiring attention. Several others had been listed in earlier publications, notably in the compilation made by Dr. J. E. Hawley of problems suggested by geologists across the country("Research in the Geological Sciences in Canada"; Bull., C.I.M.M., July 1947, pp. 351-370) and by Dr. F. J. Alcock ("Problems of New Brunswick Geology"; Roy. Soc., Canada, Trans., vol. 23, sec. 4, 1948, pp. 1-15). During the present year, members of this Subcommittee were canvassed again for any further suggestions and comments on problems for research.

Two of the conclusions that may be drawn from these surveys of needs in research in stratigraphy and palaeontology are:

1. There are a great many problems that require research and solution. Almost every one of the few geologists approached was able to suggest problems; many more problems would probably be brought to light if still more workers in these fields were questioned.
2. Many of the already suggested problems have not as yet been undertaken.

From these conclusions, the question arises as to whether it would now be appropriate to concentrate efforts on finding ways and means to resolve as many as possible of the indicated problems rather than on attempting to add to the already imposing list of research subjects that require attention. In this respect, it is hoped that the lists of projects are being given wide circulation among possible research workers, particularly students in post-graduate schools. Finding workers who would be interested in a particular problem, or any one of problems of a certain type, would constitute a useful forward step; from such a start, it then may be possible to present concrete cases to those institutions that may be in a position to further that research.

In stating that relatively few of the many listed possible projects have been attacked, it is not intended to convey the thought that little is being done. Indeed, it might be said that notable progress is being made by the few workers in the fields of palaeontology and stratigraphy in the government geological services -- both federal and provincial -- with, in many cases, the co-operation of university staffs or of the facilities offered by universities to postgraduate students. It is also true that valuable

contributions in research are being made by some members of university staffs independent of aid from or co-operation with other institutions.

Until recently, it was mainly from governmental and university organizations that contributions were made to research in Canadian stratigraphy and palaeontology. It is to be noted that now, however, much and very useful research in these fields is being sponsored and effected by industry, and by geologists in the employ of companies as well as by many in consulting practice. This is particularly the case in the rapidly expanding oil industry and in the considerable work that is being done in the search and development of sedimentary iron deposits of early and late Precambrian ages in Quebec and Ontario. It is true, and understandable, that much new information and results of research are not being divulged by workers engaged in private, competitive enterprise, but it may be confidently expected that most, if not all, such information eventually will come to light. In fact, important results of painstaking research through private enterprise are already being made available through publications and by presentation of papers before various scientific societies. It is gratifying, in this respect, to draw attention to the contributions being made, especially since a year or so, by such organizations as The Geological Association of Canada, The Alberta Society of Petroleum Geologists, and The American Association of Petroleum Geologists.

As an indication of the contributions being made by geologists in the oil industry, the following are titles of papers that appeared in the Bulletin of the American Association of Petroleum Geologists, vol. 35, No. 11, November 1951: Geological History of Plains of Western Canada, by J. B. Webb; Folded Faults in Rocky Mountain Foothills of Alberta, Canada, by J. C. Scott;

Useful Blairmore Microfossil Zone in Central and Southern Alberta, Canada, by D. M. Loranger; Regional Stratigraphic Analysis of Devonian System in Wyoming, Montana, Southern Saskatchewan, and Alberta, by John M. Andrichuk; Stratigraphic Reconnaissance along Upper South Nahanni River, Northwest Territories, Canada, by Dave R. Kingston.

In respect to sedimentary iron formations, less information perhaps has as yet been made public, but it should not be long before the results of research in this field will be available. Special mention may be made of the fact that several theses for master's and doctorate degrees have been, and are being, prepared on subjects relating to the nature and origin of iron deposits and their accompanying sedimentary formations. Such companies as the Iron Ore Company of Canada offer investigators facilities to study the problems in the field, and universities such as Laval, McGill, Queen's, and Toronto afford them opportunities for further research and attainment of degrees. Many of the theses, if not published, at least will be available for consultation at these universities.

RESEARCH PROJECTS

A. PROGRESS REPORT ON 1950-51 PROJECTS

This section gives a report on the progress made on projects that were under way during 1950 and 1951. Some of the projects were listed in the Committee's report for 1950; others are additional projects that were initiated. To avoid repetition and to keep down the length of the present report, no mention is made here of the possible projects that were listed in the 1950 report, or in earlier publications, and on which, apparently, no work has yet been done. To ascertain these projects, the reader is referred to the previously published lists.

Newfoundland

No report obtained.

Prince Edward Island

No report obtained.

Nova Scotia

1. Cambrian Stratigraphy and Palaeontology of Southern Cape Breton Island - G.S.C.; R. D. Hutchinson, Ph.D. thesis for University of Wisconsin; carried forward to, and completed, in 1950.

New Brunswick

1. Correlation of the Silurian Fauna of Southern New Brunswick - This is project No. 1 of the list of possible projects submitted by Dr. W. J. Wright (See Ann. Rept. of National Committee, 1950). In November 1951, Dr. G. S. MacKenzie, reporting on behalf of Dr. Wright, states that he made some fossil collections during the course of his mapping in southern New Brunswick and that he is sending the collections to Miss Ruth A. Reed, a graduate of Mount Allison University in 1951, who is now taking post-graduate work at the University of Toronto. Miss Reed is interested in the problem and it is expected that she will make a thesis out of it. The problem might be extended to include a comparison with the Bay of Chaleur syncline and even to the question of the reality of the New Brunswick geanticline.

2. Vulcanism in Carboniferous time in New Brunswick (Project 5 of Dr. Wright's 1950 list) - W. H. Laughlin, a graduate student at the University of New Brunswick, worked on the problem, under Dr. G. S. MacKenzie, during the 1950-51 session; he is writing a master's thesis on it. Dr. MacKenzie states that there is still room for more work on the subject.

3. Petrography of Pennsylvanian Sediments in New Brunswick (Project 6 of Dr. Wright's list) - Bud Cumming, in the spring of 1951, submitted his thesis to the University of New Brunswick on the heavy mineral study of the Coal Measures of the Minto Basin. J. D. McAllary is completing an M.A. thesis at Toronto (with the G.S.C.) on the stratigraphy and sedimentary petrography of the Pennsylvanian in the Bathurst area.

Quebec

1. Palaeontology of Silurian and Lower Devonian of Gaspe, Que. G.S.C., L. M. Cummings, Ph.D. thesis, University of Wisconsin; initiated in 1950, continued in 1951; a project originally suggested by I. W. Jones (See Hawley, J. E. - C.I.M.M. Bulletin, July 1947).

2. Lithology and Relations of Lower and Middle Devonian Formations in Interior Gaspe, Que. - Que. Dept. Mines, C. Carbonneau; initiated in 1950, continued in 1951; also research toward Ph.D. thesis at McGill University 1950-51.

3. Regional geological map of Gaspe - Que. Dept. Mines, H. W. McGerrigle; in 1950 continued mapping key sections, manuscript map well advanced.

4. Lower and Middle Ordovician of northern Gaspe - Que. Dept. Mines, H. W. McGerrigle; continuing project, 1948-49-51.

5. Lower Palaeozoic of the Appalachian Disturbed Belt, Eastern Townships, Que. - Que. Dept. Mines, H. C. Cooke; continuing project; 1949 - Coaticook area; 1950 - Granby area; 1951 - Orford area.

6. Ordovician of St. Lawrence Lowlands, Que. - Que. Dept. Mines, T. H. Clark; continuing project, 1938 to date.

7. In addition to the above, considerable stratigraphic research is being done on sedimentary rocks of various Precambrian ages by several investigators of the Que. Dept. Mines, Geological Survey of Canada, Iron Ore Company of Canada, Fenimore Iron Mines Limited, Quebec Labrador Development Limited, Fort Chimo Mines Limited, and Norancon Limited (the work of these companies is on the iron formations of Ungava).

Ontario

1. Palaeontology and Stratigraphy of Ordovician of Lake Simcoe Region, Ontario - G.S.C. (No. 13 of Dr. W. A. Bell's list of continuing projects in Committee's 1950 report); this project, begun by B. A. Liberty as a Ph.D. thesis, University of Toronto, is reported as having its completion deferred. It was to be extended in 1951 by C. G. Winter (See next).

2. Ordovician in Belleville, Peterborough, and Port Hope Areas - G.S.C., C. G. Winter; Ph.D. thesis; beginning 1951.

3. Stratigraphy of Silurian along Niagara Escarpment - G.S.C., T. Bolton; Ph.D. thesis; initiated in 1950, continuing in 1951.

4. Stratigraphy of Devonian of S.W. Ontario, west of London - G.S.C., E. W. Best; Ph.D. thesis; initiated in 1950.

Manitoba

1. Palaeozoic Palaeontology of Manitoba (No. 1 of Dr. W. A. Bell's proposed 1950 projects in the 1950 report) - G.S.C., C. W. Stearn; Ph.D. thesis, Yale University; initiated in 1950, continued in 1951.

2. Ordovician Stratigraphy and Palaeontology of Knife and Churchill Rivers region, Manitoba - G.S.C., S. J. Nelson; Ph.D. thesis, initiated in 1950, continued in 1951 (No. 2 of Dr. W. A. Bell's proposed 1950 projects in the 1950 report).

3. Palaeozoic Stratigraphy of Manitoba - being investigated by the Manitoba Department of Mines and Natural Resources.

4. Bird's Hill so-called Esker Deposit, Manitoba - graduate student under Prof. Edward Leith, University of Manitoba, 1950-51.

5. Palaeontological and Petrological Study of the Winnipeg Sandstone, Manitoba - a graduate student under Prof. Edward Leith, University of Manitoba, 1950-51.

Saskatchewan

1. Stratigraphy of the Reservoir Rocks in the Lloydminster Oil Field - J. S. Ambler, M.Sc. thesis, University of Saskatchewan, 1950-51.

2. Sub-surface Stratigraphy and Palaeontology of the Devonian in the Northern Part of the Saskatchewan Prairies - D. E. Powley, M.Sc. thesis, University of Saskatchewan, 1950-51.

3. Oil companies are actively engaged in valuable research on various geological problems in Saskatchewan, but details as to the nature and results of the research are not yet available to everybody.

Alberta

1. Devonian Succession and Correlation in Rocky Mountains, Banff to Jasper, Alberta - G.S.C.; No. 2 of Dr. W. A. Bell's list, in the 1950 report, of projects under way; palaeontology - D. J. McLaren,

Ph.D. thesis, University of Michigan, completed; stratigraphy - R. deWit; project continued in 1951 by both deWit and McLaren, and expanded to include other parts of the Rocky Mountains.

2. Carboniferous Stratigraphy and Palaeontology near Banff, Alberta - G.S.C.; No. 3 of Dr. Bell's 1950 list of projects under way; P. Harker, Ph.D. thesis at University of Michigan, completed, the project continued in 1951 and expanded to include other parts of the Rocky Mountains.

3. Carboniferous Stratigraphy and Palaeontology, Southern Rocky Mountains - G.S.C., No. 4 of Dr. Bell's above mentioned list; F. W. Beales, Ph.D. thesis at University of Toronto, completed; project continued by P. Harker as part of 2 above.

4. Correlation of Lower Cretaceous in Peace and Athabasca Valley areas - G.S.C., No. 11 of Dr. Bell's 1950 list; R. T. D. Wickenden, paper completed for publication.

5. Cretaceous and Early Tertiary Non-marine Faunas of Alberta - G.S.C., No. 12 of Dr. Bell's 1950 list; E. T. Tozer, in part Ph.D. thesis, University of Toronto; project continued in 1951 and expanded to include Lower Cretaceous non-marine faunas.

6. Devonian Stratigraphy of Rocky Mountains, Jasper Park to Liard River - G.S.C., No. 4 of Dr. Bell's proposed 1950 projects; R. deWit; begun in 1950, continued in 1951.

7. Jurassic and early Lower Cretaceous South of Peace River, Alberta - G.S.C., No. 5 of Dr. Bell's proposed 1950 projects; H. Frebold; project begun in 1950, continued in 1951.

8. The oil companies are doing considerable and important research on the stratigraphy and palaeontology of Alberta. Although much of the results is not yet available to everybody, it is gratifying to note the appearance of several articles on these subjects by geologists of the oil industry.

9. Dr. P. S. Warren, in drawing attention to the large number of problems requiring attention in the Prairie Provinces, mentions that the main ones concern the big sedimentary basin and the accumulation of oil in it at different horizons ..... He further states that, during the 1950-51 session, eleven Master's theses were presented at the University of Alberta, each containing a small piece of research on these problems.

British Columbia

1. Triassic of Northeastern British Columbia - G.S.C., No. 5 of Dr. W. A. Bell's 1950 list of projects under way; F. H. McLearn; project continued in 1951, paper on part of project published as supplement to G.S.C. Paper 46-1.

2. Late Jurassic and Early Cretaceous of West Coast Vancouver Island - G.S.C., No. 6 of Dr. Bell's above-mentioned list; J. A. Jeletsky; project continued in 1951; field work to be completed in 1952.

3. Oil company geologists are doing research on the stratigraphy and palaeontology of various areas in British Columbia.

Palaeontology, Unclassified as to Geographic Location

1. Species of Aucella and their Stratigraphic Significance - G.S.C., No. 7 of Dr. W. A. Bell's 1950 list of projects under way; J. A. Jeletzky; project continued in 1951.

2. Evolution of the Genus Inoceramus - G.S.C., No. 8 of Dr. Bell's above-mentioned list; F. H. McLearn; project continued in 1951.

3. Evolution of the Family Trigoniadae - G.S.C., No. 9 of Dr. Bell's 1950 list; F. H. McLearn; project continued in 1951.

4. Pleistocene Fauna of Canada - G.S.C., No. 6 of Dr. Bell's proposed 1950 projects; F. J. Wagner; Ph.D. thesis; project begun in 1950 by collecting Pleistocene fauna of Moosonee area, Ontario; project continued in 1951 by study of Pleistocene faunas of Vancouver area, B.C.

Note

The reader is referred to "Current Research in the Geological Sciences in Canada 1950-51", G.S.C. compilation by J. F. Henderson, for the titles of other research projects in stratigraphy and palaeontology.

B. FURTHER SUGGESTIONS FOR RESEARCH IN STRATIGRAPHY AND PALAEONTOLOGY

In addition to the projects suggested in the 1950-51 report (See First Annual Report of National Committee on Research in the Geological Sciences - Subcommittee on Stratigraphy and Palaeontology), the following projects and comments have been received from a canvass of subcommittee members during the current year:

Dr. W. A. Bell, Geol. Surv., Canada (Nov. 26, 1951)

1. A restudy of G. F. Mathew's type specimens in the Royal Ontario Museum. These include the types of a great many common species, and the lack of adequate published descriptions and

photographs is a serious hindrance to further work in this field. This problem would make a suitable Ph.D. thesis for a graduate student at University of Toronto.

2. Cambrian stratigraphy of northwest Newfoundland. This study would be of particular interest; for, if the source area of the sediments could be determined, it might be possible to prove or disprove the existence of the so-called "New Brunswick geanticline". Would be a suitable Ph.D. thesis or could be done by the Geological Survey of Canada.

3. Cambrian stratigraphy of Western Canada. This problem is so vast that more specific projects cannot be given. What is needed is a general account of the stratigraphy and distribution of these rocks, together with detailed study of the sequence of their faunas.

4. Detailed palaeontological and stratigraphic study of the Upper Palaeozoic foraminfera of Western Canada.

5. Palaeontological and stratigraphical studies of the Mesozoic of the Canadian Arctic. Occasional collections recently made by non-geologists on some of the Canadian Arctic islands and the Arctic coast have shown a much wider distribution of the Mesozoic than was known before. The necessity for a systematic investigation of the Canadian Arctic, both from a stratigraphical and palaeontographical point of view, is obvious. It can be expected that many faunistic and stratigraphical problems in other parts of Canada will find their solution by studies in these regions, and it is possible that the Mesozoic of the Canadian Arctic may prove of economic interest. The Mesozoic of the Canadian Arctic is very little known in comparison with other Arctic regions, e.g., Greenland, Spitzbergen, Novaya Zemlya, and even northern Siberia. These studies could perhaps be best undertaken by the Geological Survey.

6. The Palaeozoic of the Canadian Arctic has the same interest as the Mesozoic. One specific problem is research on the Cambrian stratigraphy and fauna of Ellesmere Island. There are suggestions of a mingling of Atlantic and Pacific faunas, and a study of this area might unravel the relationship between the two faunal realms.

7. A restudy of the Tertiary of the Canadian Arctic is needed, as there are indications that rocks mapped as Tertiary may really belong to the Mesozoic.

Dr. T. H. Clark, McGill University (Nov. 28, 1951)

Suggested Special Problem in Quebec
Stratigraphic Palaeontology

Use of Micro and Semi-micro-fossils in Correlation Problem:

The Ordovician rocks of the Quebec lowlands and the Siluro-Devonian rocks of Gaspe abound in micro- and semi-micro-fossils. These belong for the most part to the bryozoa, ostracods, scolecodonts, and conodonts. There is also the possibility that foraminifera may turn up in these rocks. With hardly an exception, all of these types of fossils have great diagnostic stratigraphic value but, because of the highly specialized technique involved in their preparation and study, it is rarely practicable to do a first class job on any of these in the course of routine work. Hence, there is a pressing need for a palaeontologist with the training and time required for the study of these groups of fossils.

Procedure and Personnel:

The field work for the Quebec Department of Mines has resulted in the accumulation of a large study collection of fossils and sedimentary rocks of the Ordovician, Silurian, and Devonian periods.

With proper training the present collections could be scanned for the fossils concerned and the study and identification of the latter ought to be completed in about 2 years. Thereafter, with that work done, new collections coming in ought not to take more than 2 months annually for their proper study along these lines.

Value of Results:

All who have studied these semi-micro-fossils have agreed as to their great stratigraphic value. We would have upon the completion of this work a complete reference set of all the species that occur in Quebec. This in itself would immeasurably reduce the time involved in making even approximate identifications and contribute very greatly to our exact understanding of stratigraphy and correlation in the Palaeozoic rocks of Quebec.

Location:

This work should be undertaken at one of the large institutions in Quebec, that is, the Department of Mines, Laval University, University of Montreal, or McGill University. Among these the logical place would be McGill, where the present collections made by and for the Department of Mines are housed.

Dr. F. H. Edmunds, University of Saskatchewan (May 25, 1951)

A considerable amount of confusion is likely to occur in the nomenclature of the Palaeozoic rocks of the plains area - due to the fact that individual companies are establishing their own terms and new names are being introduced with almost every well that is drilled. To avoid some unnecessary duplication of names in the literature, I think that the matter of nomenclature might be taken up with the local geological organizations, for example, the branches

of the A.A.P.G. and C.I.M.M. in Alberta and the Saskatchewan Geological Society in Regina. Establishment of a committee with representatives of the bodies interested, along with representatives of Federal and Provincial surveys might do useful work in the matter. In my opinion it is important that enough concern is aroused so that members of these organizations do not rush into print with new names that have not been given due consideration.

Two students here have carried out research projects of a fundamental nature during the past session - J. S. Ambler on the Stratigraphy of the Reservoir rocks in the Lloydminster Oil Field and D. E. Powley on the Devonian subsurface Stratigraphy of the northern part of the Saskatchewan prairies.

There is no shortage of research problems but there is difficulty in retaining suitable men against competition of the oil companies.

Dr. I. W. Jones, Quebec Department of Mines

An important contribution from research would be the finding of some way to correlate sections traversed by oil-drilling operations in thick formations where there are, at present, few or no criteria for establishing correlation. Particular cases are being encountered in Gaspe peninsula where, through lack of fossils or other distinguishing features, it seems almost impossible to establish the stratigraphic position of well cuttings within such thick and monotonous series as the Gaspe Sandstones (Middle Devonian), Grand Greve (Lower Devonian), Bon Ami (L.D.), St. Alban (L.D. or Sil), and Silurian formations. Each of the formations is from 2,000 to more than 4,000 feet thick. In addition to the difficulty of determining just where within one of these formations a drilling operation might be, there are some cases where it is

difficult to know to which of the formations the rocks belong. It is a problem of not only scientific but of immediate economic importance.

The suggestion that Differential Thermal Analysis may be used to advantage in the absence of data from other known techniques is contained in a recent note by D. B. O'Neill in the A.I.M.E. publication, Petroleum Geology, vol. III, No. 10, October 1951, p. 14.

Dr. V. J. Okulitch, University of British Columbia (Nov. 19, 1951)

It seems to me that, in general, stratigraphic and structural studies in the Cordilleran section of Canada should be continued and expanded ..... More specifically:

1. I think that the Cambrian as exposed along the Banff-Jasper Highway and west of it has been neglected. The only recent work is that of Dr. Rasetti in the Field area and the field work by Mr. Dick Hughes in the Sunwapta Pass region. The older and very sketchy work by C. D. Walcott does not begin to show the actual picture.

2. The structure of the rocks should be considered in the light of increased knowledge of the Devonian and Mississippian. Extensive overthrusting and nappes are indicated.

3. The palaeogeography of the Cordilleran geosyncline should be worked out. Positions of ancient shorelines, the origin of sediments, and the distribution of reefs are particularly important.

4. The sequence of geological events within the Rocky Mountain geosyncline and adjacent mountainous areas to the west have not been worked out satisfactorily. Is Cascadia a reality, or could this concept be modified in the light of recent hypotheses of island arcs or the "igneous blister" hypothesis of Professor Rich?

It is probable that the best organization to do the work is the Geological Survey of Canada, but much advanced work could be done by Ph.D. candidates given thesis areas by the Survey or by provision of adequate research fellowships, which would permit both field and office work. It should be remembered that the work in the mountains is expensive, so that the fellowships should be high enough to pay both field and office work for 12 months. A tentative figure of $3,000 a year would not be too high. Supervision of such Ph.D. work could be carried out by officers of the Survey familiar with the general areas and by at least some of the professors of western universities.

Dr. L. S. Russell, National Museum of Canada (Nov. 17, 1951)

Dr. Russell suggests the setting up at some centre of a laboratory for the determination of geological ages by the carbon 14 method. Dr. Russell has recently seen such a laboratory and is convinced that the equipment could be installed with the facilities available in Canada. Although the determinations by this method do not extend very far back in geological time, they should be of great value in work on water supply and superficial geological deposits. These would also be of interest to the archaeologist. He suggests that such a laboratory could be set up as a co-operative effort between the National Research Council and the Geological Survey of Canada without any great difficulty.

Dr. P. S. Warren, University of Alberta (Nov. 17, 1951)

There are many problems that should be resolved but few people capable of doing them. The main problems in this field concern the big sedimentary basin and the accumulation of oil in it at different horizons. It is a problem calling for many researchers. Various facets

are being tackled by geological survey parties, both from official surveys and private surveys. It will yield in time when we have accumulated sufficient data.

We had eleven Master's theses last year presented to this Department, each containing a small piece of research on this problem. This is a good way to attack the problem, but the weakness is that graduate students have not the financial backing to go out to the field and investigate the problems. Financial backing from your Committee would help in this regard.

THE REPORT OF THE SUBCOMMITTEE ON SCHOLARSHIP AND RESEARCH TRAINING

Presented by Dr. Alan E. Cameron

Members of Subcommittee

Dr. A. E. Cameron (Chairman)	- President, Nova Scotia Technical College, Halifax, N.S.
Dr. H. S. Armstrong	- McMaster University, Hamilton, Ont.
Dr. P. E. Auger	- Laval University, Quebec, Que.
Dr. L. S. Russell	- National Museum, Ottawa, Ont.

Following the meeting of the National Committee in June 1951, Dr. H. S. Armstrong, Professor of Geology, McMaster University, Hamilton, was asked and kindly consented to act as a member of the Subcommittee.

Before 1951, data on student theses in Canadian universities were compiled each autumn by Dr. H. S. Armstrong. This information was subsequently incorporated in the bibliography of current geological research compiled by the Geological Survey of Canada. This Subcommittee has recommended that in future all data on current research, including that on student theses, be collected and compiled by the Geological Survey. This recommendation is now being followed.

Dr. Armstrong has suggested that the annual compilation of current geological research should be extended to include American universities where Canadian students are doing graduate research on Canadian problems. The Subcommittee agrees that the bibliography of research projects would be more complete and useful if it included this work. The Subcommittee also believes that the compilation must be published annually, otherwise it will lose its usefulness.

In inter-member correspondence, both Dr. Russell and Dr. Auger have stressed the need for greater emphasis on the geology of sedimentary rocks. Dr. Russell suggests that the time has come for Canadian universities to take a much greater interest in this branch of our science. It is neglected in Canada in contrast with the emphasis on it in the United States, although it is fundamental to our rapidly developing petroleum industry.

Dr. Auger reports that his department has several students working on various aspects of the iron ore deposits and allied formations, and that the more work done, the more there appears to do. Dr. Cameron points out that the excellent work of Doctors Hacquebard and Haites in the research laboratories at Sydney, Nova Scotia, shows that detailed studies on sedimentation problems are as of much interest to coal geologists as to petroleum geologists.

The Subcommittee on Scholarship and Research Training strongly recommends that the universities of Canada give serious consideration to "soft rock" geology and its application to the mineral resources of Canada.

APPENDIX I

GENERAL CONDITIONS GOVERNING THE AWARD OF GRANTS FOR RESEARCH TO CANADIAN UNIVERSITIES

1. Grants are made to stimulate and support geological research in Canadian universities on the basis of recommendations made by the National Advisory Committee on Research in the Geological Sciences.
2. Consideration will be given only to applications from members of university staffs. Such applications must be signed by the head of the department concerned and the executive head of the university.
3. Grants are made only for the actual expenses of the investigation. They are not to support a member of the university staff in carrying out the investigation, but may be used in whole or part for the payment of assistants.
4. Grants may provide for purchase of special apparatus essential for the proposed investigation but not for the purchase of apparatus that a well-equipped laboratory should possess.
5. The applicant shall furnish all information requested on the application form provided[1].
6. Grants are made for a specific purpose and are to be used for that purpose only. If the grantee desires to change, in any manner, the subject of his investigation, he must make application for approval to have the grant made available for the altered investigation.
7. A report of progress is to be made semi-annually and whenever requested by the Geological Survey of Canada.

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[1]Application forms may be obtained from the Director, Geological Survey of Canada, Ottawa, Ontario.

8. The grantee shall provide to the Geological Survey of Canada a full report of the completed investigation. He shall in any paper arising out of the investigation, make due acknowledgment of the assistance received from the Geological Survey of Canada.

9. Equipment purchased out of moneys provided under a Geological Survey of Canada grant is to be used for the particular project for which the grant is provided. An annual report is required on the equipment so purchased stating its condition and the use that is being made of it. On completion of the project, the equipment may be required to be returned to the Geological Survey of Canada.

10. Funds shall be administered through the business office of the university. A certified statement of expenditures against each grant shall be furnished annually to the Geological Survey of Canada by the university.

APPENDIX II

GEOLOGICAL SURVEY OF CANADA RESEARCH GRANTS - 1951-52

UNIVERSITY AND APPLICANT(S)	PROJECT	AMOUNT
University of Toronto		
J. T. Wilson, C. B. Collins	Isotopic Lead Method for Geological Age Determinations	$1,350
W. W. Moorhouse	Differentiation and Assimilation in Logan Sills, Port Arthur, Ont. Comparison of Petrology of the Gunflint and Biwabik Iron Formations	400
F. G. Smith	Microscopic Heating Stage Construction	256
McGill University		
J. E. Riddell	Distribution of Ca, Na, K, Fe, and Mg in Altered Zones Around Concentrations of Sulphide Mineralization	2,030
Queen's University		
L. G. Berry	Chemical and X-ray Study of Saffloríte-Lollingite	815
J. E. Hawley	Corundum Deposits of Renfrew County, Ontario	640
	Spectrographic Analysis of Ash from Nova Scotia Coals	460
University of Manitoba		
G. M. Brownell	Source of Radioactivity in Surface and near Surface Sediments over Oil Fields in Alberta	700
H. D. B. Wilson	Formation of Sulphide Deposits in Rocks by Reaction with Gases	450
University of British Columbia		
H. V. Warren	Improvements in Biogeochemical and Hydrogeochemical Techniques	1,750
McMaster University		
H. A. Armstrong	Study of the Sandstones of the Medina Formation of the Niagara Peninsula	350
D. M. Shaw	Spectrochemical Study of Trace Element Behaviour during Metamorphism of Argillaceous Rocks	760