CANADA

NATIONAL ADVISORY COMMITTEE ON RESEARCH IN THE GEOLOGICAL SCIENCES

THIRD ANNUAL REPORT 1952-53

OTTAWA

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Department of Mines and Technical Surveys

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Ottawa, Canada,
October 15, 1953.

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

Sir:

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

Respectfully submitted,

W. A. Bell

W. A. BELL,
Chairman.

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MEMBERS OF COMMITTEE

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Meetings:

January 19-20, 1952, National Museum and Chateau Laurier, Ottawa, Ont.
April 11-12, 1953, Macdonald Hotel, Edmonton, Alta.

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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:

May 20, 1952, National Museum, Ottawa, Ont.
May 22, 1953, National Museum, Ottawa, Ont.

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 research projects that should receive attention; and (3) to aid in having these projects undertaken.

The Committee does not carry on research; its function is to stimulate research by the universities, the Federal and Provincial geological surveys, and by other organizations equipped for the job.

Again, as in our earlier reports, we emphasize that 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 the problems and projects most urgently in need of study. We hope that those who read this report will be eager to contribute their suggestions and criticisms to our 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 progress on past recommendations and a summary statement of the work and reports of the subcommittees. Part II contains the subcommittee reports. These include the reports of the eight standing subcommittees covering the different fields in the geological sciences; they give brief reviews of research in progress and suggestions as to problems particularly in need of attention in their particular fields. In addition, there are the reports of three subcommittees appointed to inquire into special problems.

W. A. BELL,
Chairman.

PART I

THE YEAR IN REVIEW

The First and Second Annual Reports of the Committee have stressed the need for more basic or fundamental geological and geophysical research in Canada. Canada has been and still is singularly fortunate in having many hundreds of thousands of square miles of largely unexplored and unprospected country underlain by rocks potentially favourable for the finding of mineral deposits and oil and gas. Most of our producing mines are mining orebodies that were exposed at the earth's surface and were found by prospectors armed only with a pick, a good physique, and plenty of optimism. These are still essential, but the modern prospector has, in addition, new tools to aid him in his search. He is armed with geological and aeromagnetic maps that guide him to the more favourable areas; with geiger counters, magnetometers, and other physical machines that help him find certain ores when he walks over them, even though they are covered with soil and overburden; with chemical kits that allow him to make quick tests of doubtful minerals and to track down ore deposits by testing for the trace amounts of metals derived from them, which may occur in the overlying or nearby soils, in the vegetation, or in streams. Likewise, and to an even greater degree, the finding of structures favourable for the accumulation of oil and gas is no longer solely dependent on mapping of exposed rock strata; today the location of such structures depends largely on the geological interpretation of seismic, gravity, magnetic, and other geophysical data that reveal the structure of the strata many thousands of feet below the surface.

As our northern frontier is pushed back our unexplored, unprospected areas became less and less and the potential number of exposed and easily found orebodies fewer. We will become increasingly dependent on new geological and geophysical techniques that aid us in finding concealed mineral deposits impossible to find by search with pick and shovel alone. Many such techniques now in use were unknown a few years ago, others are in the experimental stage; and

we may confidently expect that many others are yet to be developed. The development of these new techniques and the perfection of those we are already using is dependent on increasing knowledge of the factors that control the formation of ore deposits and gas and oil reservoirs. Increasing knowledge of these factors can only be obtained by basic and fundamental field and laboratory research; by research involving exploration, experimentation, and the full use of many new tools available from the physical sciences.

In order that the facilities and technical personnel for such research may be increased in Canada, the Committee has recommended:

(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.

Progress in the fulfilment of the first recommendation, dealing with expansion of the research facilities of the Geological Survey of Canada, was outlined in the Second Annual Report (1951-52). Some further progress can be reported in the past year. The spectrographic laboratory has been compeleted and is providing qualitative analyses; preliminary calibration for making quantitative analyses is also being carried on when time is available.

Arrangements have been made to have a modern mass spectrometer built at McMaster University for the Geological Survey laboratories and a physicist has been employed to assist in the building of this spectrometer and to operate it when completed. An isodynamic magnetic separator has been added to the mineral separation equipment and several modern microscopes and ancillary equipment have been purchased. The X-Ray fluorescence analysis unit has been modified to permit its use as a spectrogoniometer. An old laboratory has been renovated for use as a rock and mineral analysis laboratory and equipment for it is on order.

A qualified chemist has been appointed to take charge of the laboratory.

The lack of a proper building to house the Geological Survey and its laboratories continues to be a major problem. The Geological Survey is at present housed in parts of six buildings in widely separated parts of Ottawa. The efficient functioning of the Survey and the expansion of its laboratories is most difficult under these conditions. However, $50,000 has been included in the 1953-54 appropriations of the Department of Mines and Technical Surveys for the preparation of plans for a new building for the Geological Survey. It is hoped that not only will the plans be completed but that a start may be made in laying the foundation of the building within the next year.

The recommendation that funds be provided for stimulation and support of fundamental geological research in our universities has been fully implemented. 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 and $25,000 for 1953. Applications for grants are submitted to the Director, Geological Survey of Canada, by members of the staffs of the universities. The applications are reviewed by the National Advisory Committee and the grants are awarded by the Geological Survey on the basis of the recommendations of the Committee. Twenty-nine research projects in ten universities are currently being supported; three additional projects have been completed. (See Appendices I and II for general conditions governing the award of grants and details of grants awarded in 1952-53 and 1953-54.)

The grants fulfil a twofold purpose. They allow many workers with widely different points of view to work with complete freedom on problems of their own choosing. It is under such conditions that fundamental research thrives best, and we may look forward with confidence to important contributions to our knowledge. In addition, the grants stimulate interest and provide training in research for graduate students employed as technicians in carrying out the projects, and thus add to the pool of trained research workers in Canada.

As recommended by the Committee, the Geological Survey of Canada continues to make and publish the results of an annual survey of current geological research in Canada[1]. This compilation includes available

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[1] Current Research in the Geological Sciences in Canada, 1952-53; Geol. Surv., Canada, 1952.

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information on geological research in Canada by the universities, Federal and Provincial departments of mines, some mining and oil companies, and other institutions that carry on geological and mineralogical research.

On the further recommendation of the Committee the Geological Survey will also make an annual survey of Canadian geological students attending Canadian universities and post-graduate schools in the United States. No accurate information on their number has been available in the past. The survey supplies this information and, over a period of a few years, should indicate the trend in the number of students specializing in geology and thus aid in forecasting the supply of geologists to be expected in the future. The result of the survey for 1952-53 is given in the report of the Subcommittee on Scholarship and Research Training (page 95).

On the recommendation of the Committee the Geological Survey of Canada in 1952 made a survey of the equipment available for geological research in Canadian universities and government departments. A table giving the result of this survey is contained in Appendix III of this report.

WORK OF THE SUBCOMMITTEES

Eight standing subcommittees cover the different fields in the geological sciences and play a most important role in the work of the National Advisory Committee. The Chairman of each subcommittee is a member of the National Committee and a specialist in the particular field of the subcommittee that he heads. The members of the subcommittees who are specialists in their fields are not necessarily members of the National Committee. The function of the subcommittees is 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 are prepared by the subcommittee chairmen and presented at the annual meeting of the National Advisory Committee, where they form the basis for much of the discussion.

To aid the chairman of the subcommittees in the collection of data on developments and needs in the fields of their subcommittees, designated members of the National Advisory Committee collect data in all fields of the geological sciences in geographical districts. The information so collected is sent as reports to the Secretary, who in turn sends the parts of these reports pertaining to the field of each subcommittee to the respective subcommittee chairmen. The members of the National Advisory Committee responsible for the collection of this information are as follows for the districts designated:

Dr. H. C. Gunning	-	British Columbia
Dr. P. S. Warren	-	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
Dr. D. M. Baird	-	Newfoundland

In addition to the eight standing subcommittees covering the different fields in the geological sciences, four subcommittees have been appointed to inquire into and report on the following special problems: (1) geological and geophysical studies of the Kemano-Tahtsa Lake tunnels; (2) geological publications in Canada; (3) study of batholiths; and (4) co-operative research projects.

SUBCOMMITTEE REPORTS

(Summary Statement)

The reports of the subcommittees, including those of the eight standing subcommittees and three special subcommittees, make up Part II

of this report. The reports of the standing subcommittees include brief reviews of research in progress. These reviews are designed to give a general picture of geological research in Canada, but for details on any of the projects mentioned reference should be made to "Current Research in the Geological Science in Canada, 1952-53" published by the Geological Survey of Canada. The reports also include suggestions as to problems particularly in need of study in the field of each subcommittee.

Summaries of the reports follow.

Standing Subcommittees

The Subcommittee on Physical Methods Applied to Geological Problems reviews some of the past achievements, some aspects of the present state, and some probable future trends in geology. It is pointed out that, although in the past 100 years geologists have contributed much to the discovery of ore deposits and gas and oil fields and have mapped most of the land surface of the earth, progress in fundamental research and solution of major problems has been negligible. However, great advances in the science appear to be in the offing, and some of them, with particular reference to those of a physical nature, are discussed, including geophysical prospecting, age determinations of rocks and minerals, natural variations of the non-radiogenic isotopes and their geological implications, gravity and seismic studies, geothermometry, tectonic theories, and geological exploration of the sea floor.

It is concluded that geology will continue to be the best way to study the surface of the earth, but that in order to understand the earth's history and behaviour, physical methods must be used. In the past, geology has been halted at the stage of collecting observed facts and making hypotheses, but because these hypotheses could not be related to natural laws little progress has been made. Now, through geophysics, we have the prospect of finding the causative process of geology, which can be precisely defined by relating it to natural laws. When this is accomplished a precise

tool will be available for a satisfactory interpretation of geological history.

The report of the Subcommittee on Metallic Mineral Deposits is divided into two parts. The first reviews geological research on the metals and their ore deposits carried on in 1952. The second suggests and discusses a number of research projects and concludes with some general comments and recommendations. The research projects suggested include development of new prospecting techniques for finding deposits of asbestos and chromite with particular reference to large areas of favourable ultrabasic rocks in Newfoundland; a study of the Notre Dame Bay sulphide mineral belt and of the structure of the iron-bearing rocks of Conception Bay, Newfoundland; the geological mapping of the coastal area of British Columbia, the western Rocky Mountains, and the Rocky Mountain Trench; an investigation of the floor of the Sudbury basin by seismic or other geophysical methods; and geochemical and isotope studies to determine the source of gold and other elements in hydrothermal veins. The Subcommittee notes that "Operation Keewatin" by the Geological Survey of Canada has demonstrated that a method is now at hand for geological reconnaissance of the northern barren grounds of Canada by helicopter; continuation of this method of mapping is strongly recommended. The Subcommittee records its strong support of research in laboratory methods that promise to increase the accuracy of age determinations of rocks, or make these determinations more readily applicable. It notes that the Geological Survey of Canada and some provincial surveys are making special studies related to mineral deposits in addition to the usual geological mapping; it recommends that such studies be continued and increased to learn, in particular, more about the genesis of ore deposits, controls of mineralization, and metallogenetic provinces.

The report of the Subcommittee on Structural Geology reviews the special structural studies in progress in Canada in 1952. These include geologic studies of the Kemano-Tahtsa Lake tunnels in northern British Columbia, compilation of a structural map of British Columbia, compilation of a tectonic and geological map of Nova Scotia, and other structural studies at Toronto, McGill, and Queen's Universities. Mention is made of the great amount of valuable structural data available from the bore-holes drilled for oil and gas throughout Canada and which it is hoped are being recorded and compiled by the various Federal and Provincial departments concerned. A number of desirable projects are suggested, including the systematic study of the Rocky Mountain Trench, the compilation of a geological map of the Alberta and British Columbia Foothills area, and structural studies of the Pennsylvanian basin of central New Brunswick.

In discussing this report at the annual meeting (1953) members of the Committee stressed the importance of not only collecting samples and records of wells drilled for oil and gas in Canada but of compiling and interpreting the data so obtained. It was unanimously agreed that letters should be sent to the Federal and Provincial ministers of mines expressing the concern of the Committee in the matter and urging that the various government departments concerned obtain and retain the requisite personnel to study the samples, well cores, and records from oil and gas wells drilled in Canada, and to compile and correlate the information obtained.

The Subcommittee on Petrology, Mineralogy, and Chemistry reports fewer research projects initiated in 1952 as compared with 1951. This is thought to be related to the decline in the number of geological graduate students in the universities. A brief review is given of research in progress in Canada in igneous, metamorphic, and sedimentary petrology, mineralogy, and geochemistry. It is concluded

that, although too commonly the selection of problems is haphazard and determined by the area in which the worker happens to be doing field work, there is some sign of increased attack on the broader type of problem involving over-all planning and co-operation by several different organizations. A number of problems are suggested that should receive attention.

The report of the Subcommittee on Pleistocene Geology reviews the status of recommendations by the Subcommittee in the First Annual Report of the National Advisory Committee. Progress has been made in carrying out several of these recommendations. More attention is being given the teaching of Pleistocene geology in Canadian universities than heretofore, the staff of Pleistocene geologists of the Geological Survey of Canada has been increased, and a district division of "Pleistocene and Engineering Geology" established in its organization. However, no progress has been made on the compilation of a Pleistocene map of Canada, nor has the compilation of such a map been made an official project of the Survey. Pleistocene work carried out in Canada in 1952 and planned for 1953 is reviewed.

The Subcommittee on Non-metallic Mineral Deposits, Industrial Minerals, Coal, and Oil discusses the supplies of gravel, sand, and clay in western Canada, and current mapping and research on these deposits. Current geological research on industrial minerals is briefly reviewed and several problems worth study are suggested. The fundamental research on coal being carried on by the Coal Petrography Laboratory, at Sydney, Nova Scotia, the Research Council of Alberta, and at Queen's University is outlined. The problem of rock bursts in the coalfields of Nova Scotia and current research on this problem by the Department of Mines and Technical Surveys, the Research Foundation of Nova Scotia, and at McGill University is discussed. In regard to oil and gas in the western plains it is noted that the major research is being carried on by the larger producing oil companies. Although the results of much of this research are reserved by the companies, some have been published; a list of such

publications over the past 2 years is given. The conclusion is reached that the oil companies may best be given assistance by research of broad and general application. Thus, studies of sections in the Rocky Mountains where the oil-bearing strata of producing areas in the plains are exposed are of great value. Studies of an even broader nature that are prerequisite to an understanding of the geology of the Foothills are suggested; these include the structure of the Rocky Mountains, which is known only in part, and of the Rocky Mountain Trench, which must be the key to much of the history of the mountain area. Another study demanding immediate attention is the stratigraphy of the Rocky Mountains north of Peace River.

In the discussion following presentation of this report it was brought out that in the preceding report of the Subcommittee (1952) reference was made to the large amount of available information on coal from numerous bore-holes for oil and gas in western Canada. It was stated incorrectly in the report that the data were not being collected. In point of fact the Geological Survey of Canada began in 1951 an investigation to find out the usefulness of electric and radioactivity logs in detecting and correlating coal seams penetrated by the bore-holes drilled for oil in Alberta. Radioactivity logs were found unsatisfactory and the investigation has been limited to electric logs, from which the exact depths and an indication of the thickness of the seams can be obtained. As this information accumulates it will be used to find out the thicknesses and lateral distribution of coal seams throughout central Alberta.

The report of the Subcommittee on Stratigraphy and Palaeontology reviews activities in these branches of geological science in each of the provinces and territories of Canada in 1952. The concluding section of the report suggests and outlines a number of projects in stratigraphy and palaeontology that should be undertaken. These include detailed study of the sedimentation sequences in the coal measures of Nova Scotia adjacent to seams in which rock bursts are

occurring, study of the stratigraphy and structure of the Pennsylvanian basin of central New Brunswick, study of the Mississippian formations of southwestern Manitoba in which commercial oil pools occur, further investigation of the Lower Cretaceous(?) formations in the Foothills and Plains of western Canada, stratigraphic and palaeontological studies of the Rocky Mountains and the Mesozoic stratigraphy of the Peace River area, and further study of the late Mesozoic and Tertiary basins of the Gulf of Georgia, Graham Island, and the west coast of Vancouver Island.

The report of the Subcommittee on Scholarship and Research Training discusses the present inadequate supply of geologists in Canada and means of attracting students to the profession. It is concluded that there is need for a booklet outlining geology as a profession and designed to interest students in the secondary schools. It is suggested that such a booklet should be published by the Geological Survey of Canada. The supply and employment of geologists in Canada is briefly discussed. In regard to scholarship and training at the university level, the Subcommittee concludes that the geology departments of the universities in Canada should closely examine their program of studies for the Master's degree. They should guard against any tendency to make work for the degree largely lecture courses and laboratory instruction with only minor emphasis on original or thesis work. The possession of the degree should be evidence that the student has shown aptitude for original work and thinking; it should be recognition of distinct achievement beyond the baccalaureate. Only if it is so considered by the universities can it be expected to have any significance in the outside world.

In the discussion following presentation of this report members representing Federal and Provincial geological surveys stressed the difficulty of obtaining student assistants for field parties. All members agreed that experience as student assistants on survey field parties is an important part of the training of young geologists in Canada. However, at the present salary scale such a large differential

exists between the salaries offered student assistants by government surveys and by mining and oil exploration companies that the students cannot afford to make the financial sacrifice involved in working on a government field party. It was decided that letters should be sent to the Federal and Provincial ministers of mines expressing the concern of the Committee at the sharp decrease in the number of geological students seeking employment in government field parties and suggesting that salaries be increased to approach those being offered by private industry.

Special Subcommittees

The Subcommittee on Geological and Geophysical Studies of the Kemano-Tahtsa Tunnels was appointed in 1951 to explore means of having such studies undertaken. No formal report has been prepared, but Dr. H. C. Gunning, Chairman of the Subcommittee, gave an oral report of progress at the 1953 annual meeting of the National Advisory Committee. He stated that during the 1952 field season D. Roy Stuart, graduate student in geology at Princeton University, was stationed at Kemano by the British Columbia Department of Mines, his room and board being supplied by the Aluminum Company of Canada. Dr. Duffell of the Geological Survey of Canada continued standard geological mapping on the scale of 1 inch to 4 miles at the Tahtsa end of the tunnel. Dr. J. H. Blackwell of the University of Western Ontario, with the assistance of a grant of $1,000 from the Geological Survey of Canada, visited Kemano in July 1952 and made plans for thermal measurements of the wall-rocks along the tunnel to obtain data on the heat flow from the earth in this region.

In September 1952 the "Vancouver Committee", consisting of Dr. Gunning and representatives of the Aluminum Company of Canada, the British Columbia Department of Mines, and the Geological Survey of Canada, met to hear progress reports by Messrs. Duffell and Stuart and to consider plans for future work. Mapping of the part of the

tunnels driven up to the time of their departure from the field in September 1952 had been completed and a large number of specimens for laboratory study had been collected. Copies of these maps have been supplied to the Aluminum Company of Canada and have proved of practical value. During the winter of 1952-53 Mr. G. G. L. Henderson of the British Columbia Department of Mines made periodic visits to Kemano to bring the geological studies up to date as the tunnels advanced. Mr. Stuart will return for the British Columbia Department of Mines in the summer of 1953 to continue geological mapping and study of the tunnels.

Holes are being drilled in the walls of the tunnels for thermal measurements, and Mr. Blackwell has left instruments and instructions for making the measurements. He will return in the summer of 1953 to complete the collection of the thermal data.

It is felt by all concerned that the geological field studies have been placed on a satisfactory basis and there is every reason to hope they will continue to a satisfactory conclusion in the autumn of 1953. At this time further consideration will be given the laboratory study of the data and specimens collected.

The report of the Subcommittee on Geological Publications includes a statistical study of geological publications in Canada over the period 1947 to 1951 inclusive. On the suggestion of the Subcommittee, the editors of the Canadian Mining Journal have agreed to publish abstracts of Master's and Doctor's geological theses to the number of ninety-six abstracts a year. Such a service makes possible the publication of results of research that might otherwise remain buried in university libraries.

The report concludes that there is need in Canada for additional outlets for geological articles, particularly those dealing with the results of geological research. Expansion of the publication facilities in the Transactions of the Royal Society of Canada and the Proceedings of the Geological Association of Canada is recommended.

The report of the Subcommittee on Batholiths reviews current research in progress and outlines in some detail the systematic study that is being made of the Lacorne batholith in northwestern Quebec. The Subcommittee recommends that the present program of batholith studies be continued and expanded and that the provincial geological surveys and the universities initiate other studies and also assist those at present under way.

The Subcommittee on Co-operative Research Projects was appointed in 1952 to study ways and means by which geological research projects sponsored jointly by government, the universities, and industry may be promoted. Separate reports have been prepared by the members of this Subcommittee. One, by Dr. H. H. Beach, discusses co-operative research and the petroleum industry; the other, by Dr. D. R. Derry, discusses co-operative research as applied more particularly to the mining industry. Dr. Derry discusses means of raising funds for co-operative projects and suggests some problems that might be suitable for co-operative attack.

Dr. Beach in his report defines co-operative research, discusses the contributions that might be expected by the participating universities, governmental bodies, and oil companies, and suggests a number of specific problems that would be suitable. He concludes that the oil industry could be attracted to co-operative effort in research with the universities and governmental scientific bodies and suggests that the Canadian Petroleum Association be invited to express its views on the matter.

In the discussion of these reports at the annual meeting (1953) the National Advisory Committee unanimously agreed that the Canadian Petroleum Association should be invited to express its views on the possibility of carrying out co-operative research projects along the lines suggested in Dr. Beach's report.

PART II

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, Ont.

Dr. H. Carmichael - Atomic Energy of Canada, Ltd., Chalk River, Ont.

Dr. J. H. Hodgson - Dominion Observatory, Ottawa, Ont.

Mr. M. J. S. Innes - Dominion Observatory, Ottawa, Ont.

Dr. A. D. Misener - University of Western Ontario, London, Ont.

Dr. G. D. Garland (Secretary) - Dominion Observatory, Ottawa, Ont.

INTRODUCTION

This report is an attempt to review some of the past achievements, some aspects of the present state, and some probable future trends in geology from a general and philosophical point of view. The physical aspects will be especially stressed.

PAST ACHIEVEMENTS IN GEOLOGY

Geologists may find much cause for satisfaction in past achievements. They have contributed to the discovery of many ore deposits and oil and gas fields, and in recent years this has been widely recognized by mining and oil companies. Many occupy important positions and most are well employed. The importance of their work in aiding construction engineers, soil experts, and hydrologists has everywhere come to be recognized.

Geologists have accomplished the great task of mapping most of the land surface of the earth at least in reconnaissance; they have compiled general maps and reports on the geology of the principal countries of Asia and of each of the other continents. The rate of geological mapping has been speeded remarkably by better

means of transport, including airplanes and helicopters. Fundamental concepts of stratigraphy and palaeontology have been proved sound and given to the world the idea of evolution. In other branches of the science, such as mineralogy and the search for oil and ores, new techniques are constantly being introduced although many of the instruments are borrowed from chemists and physicists.

All of this should give geological surveys and societies of geologists much cause for satisfaction. Geologists are giving taxpayers and companies valuable returns for their expenditures and are themselves able to combine travel and outdoor life with scientific work, and, in general, lead pleasant and prosperous lives.

However, in regard to fundamental research the picture is less good. It can be fairly said that during the last 100 years no other major branch of science has made less progress. Most of the other sciences have altered their techniques and ideas profoundly, but this is not true of geology if we except the techniques borrowed from chemistry and physics. A hundred years ago geology had new and exciting ideas. Evolution and the geological processes were new and of great interest to the general public, and many countries were establishing geological surveys, which were the first scientific organizations formed by many governments. Today geology has lost its popular appeal. Although a great many more facts are known they are largely undigested; the great problems of a century ago remain unanswered. For example, who can answer any of the important problems of how mountains and continents are formed, of how granites form, of how oil and metallic ores are formed and concentrated.

This need not depress us. Progress in any science proceeds in fits and starts and the recent lack of progress may well herald great advances in the near future. We can already see

the start of great changes. Some of them will be described in this report, with particular emphasis on the changes of a physical nature. The subject is vast and is not easy to cover thoroughly. The writer has drawn on many sources but realizes that much has been omitted.

TEACHING OF GEOPHYSICS

Important additions have been made to the staffs of Canadian universities giving courses in geophysics. Dr. J. E. Blanchard has joined the staff of the Department of Physics, Dalhousie University, and is also attached to the Nova Scotia Research Foundation. Dr. D. J. McNeil and students of St. Francis Xavier University collaborate with the summer school of the Massachussetts Institute of Technology, Department of Geology and Geophysics.

At McGill University, Dr. V. A. Saull has been added to the staff teaching geophysics; for many years Professor H. G. L. Watson has given courses in geophysics in the Department of Physics. The Universities of Laval and Montreal have long shown an interest in geophysics and given courses but no recent changes are reported.

At Queen's University, M. M. Fitzpatrick has joined the Department of Geological Sciences to teach geophysics; J. E. Hawley's spectroscopic work and A. W. Jolliffe's interest in age determinations have long been well known. At University of Western Ontario Dr. R. J. Uffen is giving courses in geophysics; he is in the unusual position of being a member of both the Geology and Physics Departments. Professors A. D. Misener and J. H. Blackwell have both been working on geothermometry.

At McMaster University Dean H. G. Thode's laboratory is the centre for mass spectrometry in Canada. In addition to much work of other kinds, Dean Thode has studied the isotopes of sulphur and the natural fission of uranium, both of which bear on age determinations. Other work on age determinations is being carried on by Mr. Tomlinson

in the Department of Geology under Dean H. S. Armstrong. Dr. Dennis Shaw is carrying out spectrographic research on trace elements in rocks.

At University of Toronto P. N. O'Brien has replaced G. D. Garland; a temporary vacancy due to illness was filled by lectures and supervision of graduate work by Professors C. Barnes, R. W. MacKay, J. A. Jacobs, and C. B. Collins. During the past 3 years sixteen Ph.D. degrees have been given in the Department of Physics on geophysical subjects. Figures published for 1951 and 1952 show that this was many more than at any other university in North America.

At the University of Manitoba the fruitful co-operation of geologists and physicists in developing improved scintillation counters or scintillometers is well known. In the Departments of Chemistry and Physics a new type of Carbon-14 counter is being developed. The Carbon-14 from the carbon-bearing material is introduced into a complex organic molecule corresponding to the materials in use for liquid scintillation studies. The subsequent liquid scintillator analysis of the Carbon-14 is expected to give an accuracy at least ten times greater than that obtained by former methods.

At the University of Saskatchewan, Professor B. W. Currie, the new head of the Physics Department, is a well known geophysicist, but his interests lie chiefly in study of the atmosphere and ionosphere. In the Chemistry Department construction of a new Carbon-14 counter is under way.

At the University of Alberta no changes have been reported. At the University of British Columbia courses in geophysics are given by Professor A. R. Clark of the Physics Department.

TEXT-BOOKS ON GEOPHYSICS

Several important text-books on geophysics were published in the past year. Outstanding are "Introduction to Geophysical Prospecting" by Milton Dobsin, which is an excellent, non-mathematical

introduction to all methods, and a completely new edition of "The Earth" by Sir Harold Jeffreys, which is a recognized work on the physics of the earth.

GEOPHYSICAL PROSPECTING

New methods of geophysical prospecting continue to be important, and have been partly or wholly responsible for several recent discoveries of mineral deposits. The search for oil and gas now chiefly depends on them.

By use of an airborne magnetometer the Geological Survey of Canada in 1951 and 1952 mapped and published seventy-six aeromagnetic map-sheets on the scale of 1 inch to 1 mile. These maps cover perhaps $\frac{1}{2}$ of 1 per cent of the total area of Canada and demonstrate that aeromagnetic surveys can be made much more rapidly than geological surveys on the same scale. Although the resulting aeromagnetic maps are not geological maps, they do indicate much about the geology, not all of which can be observed on the ground; more than one orebody has been found by their aid. Only one geologist has been employed by the Geological Survey in the aeromagnetic work, with a staff of airmen, technicians, and compilers. The work could, therefore, easily be speeded up if desired. Geological maps are issued with a report or notes describing and interpreting the geology, but no interpretations of the aeromagnetic maps are given. This is no doubt due to shortage of skilled staff. Methods for making such interpretations have been given by Vacquier et al.

Geiger counters, scintillation counters, and many electromagnetic devices are now widely used, and all are being used in aircraft for aerial surveys. No doubt much research is being carried on in these fields but not all of it has as yet been described.

The holding of the meeting of the Eastern Section of the Society of Exploration Geophysicists in Toronto in October 1952 is

an indication of the growing interest in geophysical prospecting in Canada. More than one hundred attended and several members came from as far away as California, Colorado, Texas, and Calgary. Seventeen papers were presented chiefly devoted to mining geophysics. The Society is a large and long established one with an important branch in Calgary.

The third meeting of the European Section of the Society of Exploration Geophysicists was held in Hanover, Germany, in December 1952. A report in "Nature" on the meetings includes the tantalizing statement "Few people outside Germany are aware of the remarkable progress which has been made by geophysical firms in that country in the application of seismic methods underground in mines. The location of faults, metalliferous veins, and the accurate mapping of sinuous or faulted veins are problems on which considerable work is being done".

A bibliography of recently published papers on geophysical prospecting and on the subjects discussed in subsequent sections of this report is appended. Emphasis is placed on Canadian papers and papers by Canadians, but many other general papers are included, especially those of a review nature.

AGE DETERMINATIONS

In 1952 a joint paper by officers of the Geological Survey of Canada and the University of Toronto Geophysical Laboratory added fifty age determinations of Canadian Shield rocks to the handful previously available. At the University of Toronto C. B. Collins, R. M. Farquhar, and R. D. Russell have found large variations in the isotopic composition of lead ores. This seems likely to throw light on the origin of the ores. Russell and Farquhar are developing methods by which to find out the approximate age of common potash minerals such as orthoclase, muscovite, and sylvite, and many lead ores. The quantities required are small, ranging from a few

milligrams of lead to some ounces of feldspar. In order that the methods may be calibrated and compared specimens are needed from the same locality of any two of lead, uranium, potassium, or rubidium minerals.

At the Universities of Saskatchewan and Manitoba Carbon-14 counters for age determinations have been built. These will be of great value to Pleistocene geologists in Canada.

Several university departments of physics have spectrographs that could be used for making age determinations of rocks and minerals by the rubidium-strontium method. As yet this method has not been studied or applied in Canada.

NATURAL VARIATIONS IN NON-RADIOGENIC ISOTOPES

At McMaster University, Dean H. G. Thode has played a leading role in the study of natural variations in non-radiogenic isotopes. In particular, his research on the isotopes of sulphur and boron is of great geological significance. He has shown that the isotopic composition of sulphur varies with its source, which throws light on the origin of life, the origin of petroleum, and on the age of some deposits.

At the University of Toronto some work has been done on the isotopes of silicon and titanium. In the United States geologically important variations have been shown in the isotopic ratios of oxygen and carbon and variations have also been found in the isotopic ratios of hydrogen, helium, nitrogen, argon, and germanium. Magnesium and chlorine do not appear to have been investigated although variations in the isotopic ratios are to be expected in them. Unlike lead and other heavy elements, which require special instruments to analyse isotopically, the light elements can be studied by any mass spectrometer.

The study of isotopic variations is just beginning; it opens a field of study comparable with geochemistry in scope and perhaps in

importance. Thus, evidence reported by Silverman from a study of oxygen isotopes, and also data in preparation by Allanby and Grant on silicon, make it seem unlikely that any of the granite samples so far examined formed by differentiation from more basic magma. This agrees with much other recent evidence on the importance of granitization.

GRAVITY SURVEYS

The Dominion Observatory is about to issue gravity maps of six provinces, which reflect information about the geology and make it possible to draw certain conclusions about the nature of the earth's crust. These maps are compiled from surveys chiefly by A. H. Miller, M. J. S. Innes, and G. D. Garland.

M. M. Fitzpatrick is completing a combined gravity and geological study of ultrabasic rocks in the Eastern Townships, Quebec, and C. H. G. Oldham has made a study of gravity and rock densities across a wide strip from Parry Sound to Kaladar, Ontario. B. B. Sutherland is extending this work across the Ottawa-Bonnechère graben. A gravity survey of the Sudbury basin by A. H. Miller is almost finished.

SEISMIC STUDIES

Papers by J. H. Hodgson of the Dominion Observatory on a study of rock bursts near Kirkland Lake and their use in the interpretation of crustal structure have gone to press. A start has been made on a large program designed to study the direction of movement in selected large earthquakes occurring along fault planes all over the world. W. G. Milne is using three stations in British Columbia to plot epicentres of earthquakes along the Pacific coast. Some may occur along known faults. In eastern Canada a study of local earthquakes and their relation to faults is under way.

The Dominion Observatory has done much to open new seismic stations and re-equip old ones. P. Willmore is installing eight new seismic stations in the British West Indies for the British Government as part of a warning scheme for volcanic eruptions.

It has been suggested by Dr. H. J. Fraser that seismic surveys of the Sudbury Basin be undertaken; this is being considered but as yet no action has been taken.

The seismic survey continues to be the chief method of searching for oil pools in western Canada.

GEOTHERMOMETRY

Arrangements have been made to measure temperature gradients, conductivities, and heat flow in the Kemano tunnel, British Columbia. This has been possible through the remarkably good co-operation of all concerned. Professor J. H. Blackwell of University of Western Ontario is in charge of the work, but many measurements are being made by local engineers (See also page 12).

T. H. Leith has published further thermal measurements made at Kirkland Lake mining camp. This work, like that of J. H. Blackwell and R. J. Uffen was started under Professor A. D. Misener's guidance.

Professors J. A. Jacobs and R. J. Uffen, University of Toronto, have been working upon thermal properties and temperatures within the earth. These are probably much less than 5,000°C. and thus lower than had been supposed. They are using Bullen's estimate of densities within the earth to obtain elastic constants at various depths from measured seismic velocities and then applying the theory of the solid state to convert these to thermal properties. J. A. Jacobs suggests that convection currents are unnecessary in the mantle, and has pointed to reasons for believing that the inner solid core (within the liquid core) is probably composed of solidified iron.

OTHER PHYSICAL LABORATORY METHODS

The importance of geochemistry has long been recognized, but in the past the emphasis has been placed on the study of major constituents of rocks by chemical analysis. The application of a physical instrument, the spectrograph (not to be confused with the mass spectrometer), has made the accurate study of trace elements possible. J. E. Hawley, H. D. B. Wilson, and D. Shaw have done outstanding work, and have recently published their latest results. Geochemistry is dealt with in the report of another subcommittee (See page 50).

Other physical techniques now widely used involve x-rays and thermal analysis.

TECTONIC THEORIES

In an important paper J. E. Gill has summarized his views on mountain building and subdivisions of the Canadian Shield. The present classification of the Precambrian has often been attacked, but it is one thing to suggest weaknesses and another to recommend a new system of classification. Gill has tackled the larger problem and made constructive suggestions.

At a time when so many and such varied theories of mountain building are being advanced, it is inevitable that some of them contradict others. Scheidegger of Imperial Oil Limited has presented a useful paper indicating how known laws of physics can control speculation in this field. Recent data suggest that convection currents are unimportant and that contraction is probably the sole cause of mountain building.

GEOLOGICAL EXPLORATION OF THE SEA FLOOR

In July 1952 a geological investigation of the sea floor of the lower Gulf of St. Lawrence was carried out by the Atlantic Oceanographic Group in association with the Nova Scotia Centre for

Geological Sciences. Also associated in the field work were members of the staff of the Wood's Hole Oceanographic Institute and the Massachusetts Institute of Technology. The main purpose was to map the extension of continental faults under the sea in an area where faulting is a prominent feature and of considerable fundamental as well as economic importance.

Submarine gravity surveys in the Bay of Fundy and submarine seismic work over the coastal shelf of Nova Scotia and the Grand Banks were carried out by a group from Columbia University under Professor M. Ewing. This group also investigated evidence that turbidity currents started by a Newfoundland earthquake had been the cause of cable breaks off the Atlantic coast.

New bathymetric charts of the Gulf of Alaska show a ridge of seamounts that indicate an extension of the faults of the Strait of Georgia far out to sea. Bathymetric, seismic, and geological work all suggest a great rift running northwest from near Vancouver. It is subparallel with the San Andreas rift, the Rocky Mountain Trench, and the Hawaiian Islands. All seem likely to be wrench (strike-slip) faults.

THE FUTURE OF GEOLOGY AND ITS RELATION TO GEOPHYSICS

These advances have been mostly in geophysics, which may or may not be regarded as distinct from geology, and they have been accompanied by some fairly drastic criticisms of geology itself. King Hubbert has pointed out the diminishing scope of geology. Gill is the latest and most explicit in a succession of those who have attacked the usual subdivision of the Precambrian. Walter Link, Chief Geologist of Standard Oil Company, has stated: "From the Drake discovery until the 'twenties surface geology was the scientific method used most extensively. Geophysics started to develop in the early 'twenties, and today is the most common tool in the United States and Canada. There

are 810 geophysical crews of all categories in North America, and seismic work alone costs about $130,000,000 per year. The surface geological parties have dwindled to around 100, and the yearly expenditure for seismic work is probably as much as was spent on surface work for the past thirty years".

Does this suggest that geology as we have known it is to be replaced by geochemistry and geophysics? In the opinion of this subcommittee this will not happen. There will continue to be a large and proper sphere for geology as well as these newer fields; geology will continue to be the best way to study the surface of the earth. However, if we are to understand the earth's history and behaviour, physical methods must be used to find out the ages and more about the properties of the surface rocks and also what lies below the surface.

It is useful to recall the three steps by which logical reasoning proceeds. These are: (1) the collection of observed facts; (2) the forming of several likely but competitive hypotheses; and (3) the selection of one preferred hypothesis on the basis of its agreement with natural laws. Quite apart from their precision or usefulness the branches of science fall into an order based on the nature of the things studied. Thus, physics is the most general science because it is concerned with the relations of mass and energy. Geology is only concerned with a small part of this field; this explains why it is possible to study the earth from the point of view of physics as well as geology.

From the point of view of physics and disregarding the details of geology, the earth is a heat engine. Only recently was enough discovered about the interior of the earth to enable any idea to be formed of how that engine works. The operation of the engine can be observed today. The facts observed are physical, not geological; they are concerned with earthquarkes, heat flow, etc. These facts

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are amenable to precise treatment by the natural laws of elasticity, thermal conductivity, etc.; this is not true of geological observations. We can have every confidence that we will soon know fairly precisely the manner in which the earth is working and has worked. The establishment of that physical hypothesis is important for geology because geology is the surface record of how that engine has worked. When we know how the engine has worked we will be able to interpret the geological record far more accurately.

When we realize that geology is the record of a process that could not be studied heretofore we see why geology has been unable to digest its facts. Geology has been halted at the stage of collecting observed facts and making hypotheses; but these hypotheses could not be tied to natural laws, therefore, little progress was made. Now, however, we have the prospect of finding the causative process of geology, which can be quite precisely defined by relating it to natural laws. This is the role of geophysics. When that is accomplished we will have the precise tool needed to make a satisfactory interpretation of geological history, and particularly of Precambrian history.

It follows, therefore, that the training of geologists should include study of the nature of the earth's process (physics of the earth) as well as study of the history of the effects of the process (geology). The subjects are distinct but both should be part of a geologist's training.

APPENDIX

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REPORT OF THE SUBCOMMITTEE ON METALLIC MINERAL DEPOSITS

Presented by Dr. G. M. Brownell

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This report is divided into two parts, the first being a review of geological research on different metals and their ore deposits carried on in 1952, and the second consisting of comments and recommendations.

CURRENT RESEARCH

A large part of the regional geological mapping done by the Federal and Provincial geological surveys is related to the discovery and understanding of metallic mineral deposits. The importance of such basic research in the development of Canada's mineral industry cannot be overestimated. However, it is not possible to refer to such work in detail in this report. What follows is confined to a brief summary of special projects of the Federal and Provincial surveys and the universities and is arranged alphabetically according to specific metals. This is followed by discussion of a few general projects.

Chromite

The Geological Survey of Canada began a study and inventory of Canadian chromite deposits in 1951. All field work and most of the office work has now been completed and publication

as a volume of the Economic Geology Series is planned. The Geological Survey is also carrying on a special study of the basic and ultrabasic rocks of Newfoundland with particular attention to associated deposits of chromite and copper.

Cobalt

The Geological Survey has completed the study and inventory of the cobalt deposits of Canada. It is planned to publish the report, which is almost finished, as one of the Economic Geology Series.

The Ontario Department of Mines is continuing the detailed study of the geology, structure, and mineralization of the Cobalt camp.

Columbium, Tantalum, Lithium, and Beryllium

Investigations of pegmatites and related rocks containing these metals were made by the Geological Survey in northern Quebec and in the Ross Lake area, Northwest Territories, in 1952; similar studies will be continued in Manitoba in 1953. The geologist in charge of this work has had special training in the mapping of the internal structures of pegmatites.

Copper, Nickel, Lead, and Zinc

The Geological Survey is engaged in the detailed mapping of the Mayo camp, Yukon Territory; a special comprehensive mineralogical and geochemical study will begin in the spring of 1953.

At McGill University several studies are in progress of the rock alteration about base metal deposits in Quebec. The deposits being studied include some in the Eastern Townships, and the Barraute and Noranda areas. The partition of nickel sulphides and silicates is also being investigated.

At Queen's University the chlorites developed near copper orebodies in the Noranda area have been studied. A comparative study of the copper deposits of the Chibougamau area is also being made.

Studies at the University of Toronto include the structure and stratigraphy of the Waite-Amulet area; the metamorphic facies at the New Calumet mine in Quebec, and of the ore deposits of the Keno camp, Yukon Territory.

Field studies by the British Columbia Department of Mines in the Stanford Range east of Windermere, B.C., are of exceptional interest in relation to the lead-zinc possibilities of the area.

Research in biogeochemistry continued at the University of British Columbia, special attention being given to the development of methods for detecting trace amounts of manganese and molybdenum, nickel, and cobalt. Geochemical field studies in British Columbia were greatly increased and resulted in two or more drilling programs that found mineralization beneath heavy overburden.

At the University of Manitoba experimental research on the formation of sulphides in rocks by reaction with gases is continuing, and pyrrhotite has been synthesized by the action of hydrogen sulphide on iron-bearing minerals such as hornblende, olivine, etc. The distribution of base metals in ores and related rocks is also being studied.

Iron

The Geological Survey is continuing the study of the stratigraphic succession in the Labrador Trough, mainly to learn the origin of the structural basin in which the iron was deposited. In co-operation with the Mines Branch, differential thermal analysis studies are being made as a means of correlating different shale horizons. The origin of the chert is also under investigation. The magnetic iron ore deposits of eastern Ontario and Quebec are being studied.

At Laval University research on iron deposits includes a study of the iron belt in New Quebec between South Hematite Lake

and Larch River, the nature and distribution of manganese minerals in the iron formation of the Ungava Bay district, the genesis of hydrothermal "iron formation" in the Grenville subprovince, and a general study of the texture and genesis of iron formations.

At McGill University the iron deposits of the Michipicoten district of Ontario and the Leaf Bay district of New Quebec are being studied.

At University of Toronto petrographic, spectrographic, and mineralogical investigations of the Port Arthur, Mesabi, and Labrador iron formations are continuing.

At Queen's University research includes studies of the sedimentational and volcanic history of part of the Labrador Trough, the foot-wall rocks of the Steep Rock iron deposits, and the magnetic iron ores of eastern Ontario and Quebec.

Gold

The Geological Survey is placing little emphasis on the study of gold deposits at the present time. However, a detailed field and laboratory investigation of the gold deposits of the Yellowknife greenstone belt, started in 1946, is nearing completion. The project includes detailed mapping of the belt and field and extensive laboratory study of the mineralogy and geochemistry, including temperature of formation of the vein minerals by decrepitation studies.

Studies of the structure and mineralogy of the gold deposits of the Yellowknife area were also carried on at Queen's University and of the wall-rock alteration at Western University.

Studies of the gold deposits of the Malartic district, Quebec, and of the Bridge River district, British Columbia, continued at McGill University.

At University of Toronto petrologic and decrepitation studies of the gold-quartz veins of the O'Brien mine, Quebec, were continued, as were the spectrographic studies of the Round Lake batholith and its satellitic intrusions in the Kirkland Lake area, Ontario.

The Manitoba Department of Mines completed a study of the gold deposits of the Rice Lake area, southeastern Manitoba, in which the structure and the relation of porphyry to the gold-bearing veins is given special attention.

Tungsten

The Geological Survey began a study and inventory of tungsten occurrences in Canada in 1951. All field and most of the office work has now been completed; it is planned to publish the report as a volume of the Economic Geology Series.

Uranium

The Geological Survey has confined most of its recent work on uranium to northern Saskatchewan because of the great amount of prospecting and exploration going on there, and because men were not available for much work elsewhere. In 1952 two geologists studied deposits in relation to their economic possibilities and the detailed study of the mineralogy of the Goldfields camp continued; this study will be completed in 1953. Detailed geological mapping and study of the main part of the Goldfields area was begun in 1952. This project, which will probably require about five field seasons, will include detailed structural analysis of the area and the plotting of several thousand known radioactive occurrences.

The uranium possibilities of the sedimentary rocks underlying the Great Plains were briefly investigated in 1952. This study was made desirable because of the increasing use of radioactive logging of oil and gas wells. It did not yield encouraging results

but a system for recording and sampling the more radioactive beds encountered in the bore-holes was established with the co-operation of the Calgary office of the Geological Survey.

The confidential inventory of Canadian deposits of uranium and thorium, which is compiled for the Atomic Energy Control Board, was kept up to date. More than 700 properties are recorded in the inventory, many of which are undergoing exploration, which is reported in detail monthly by the companies to the Geological Survey for summarizing in the inventory.

At the University of Toronto a study is being made of the inclusions in minerals associated with pitchblende in the Great Bear-Great Slave Lake region.

At the University of Saskatchewan petrographic and radiometric studies of the Tazin meta-sediments were carried on.

General

An outstanding accomplishment in 1952 was "Operation Keewatin" in which one Geological Survey of Canada field party mapped 57,000 square miles in the Northwest Territories west of Hudson Bay in adequate detail for publication at 8 miles to 1 inch. The operation disclosed about 14,000 square miles of Precambrian sedimentary and volcanic rocks ranging in age from Archaean to Upper Proterozoic, most of which may be regarded as favourable ground for the discovery of metallic mineral deposits. About 7,600 square miles of this area are underlain by Archaean greenstones - probably more greenstone than has been found by all 4-mile mapping done by the Geological Survey in the Northwest Territories to date.

This work was accomplished in a field season of 113 days, including the spring break-up period. A conventional ground party mapping at 4 miles to 1 inch, would have required 25 years to map the same area. Aerial geological observations were made from two helicopters flying at

about 300 feet; these observations were checked by more than 1,700 landings and about an equal number of low, slow, aerial examinations. Logistical support was provided by a Norseman aircraft on skis or floats. Combined helicopter and Norseman flying time approximated 1,000 hours. More than 100 square miles were mapped per helicopter hour and about 815 square miles were examined on each day that both helicopters operated. The operation cost about $215,000 or about $3.80 per square mile mapped.

As a result of the past season's trial use of helicopters we now have, for the first time, a proven method whereby an acceptable geological reconnaissance of the northern Barren Grounds part of the Canadian Shield can be contemplated within the foreseeable future.

The Geological Survey began a comprehensive study of the Lacorne batholith in northern Quebec in 1952. Mineral deposits of several types are associated with the batholith and it is hoped that the study, which includes the dispersion pattern of trace elements, radioactivity, heavy accessory minerals, and structure, will give clues for further prospecting.

The Ontario Department of Mines is preparing a mineral map of the province.

SUGGESTED RESEARCH PROJECTS

In addition to the suggested research projects listed in the earlier reports of this Subcommittee the following have been received:

(1) New prospecting techniques for asbestos and chromite (D. M. Baird)

Research is needed to develop new or better prospecting techniques for asbestos and chromite. Thus in Newfoundland, with several large areas of favourable ultrabasic rocks, ordinary mapping techniques have proved disappointing in indicating deposits of these minerals. It is realized that there is no substitute for detailed mapping of such bodies as a background for prospecting, but further

research is needed to extend our knowledge of how and why asbestos is formed. It would seem that the Geological Survey of Canada should undertake such a study.

(2) Study of the Notre Dame Bay sulphide mineral belt, Newfoundland (C. K. Howse)

The upper limit of all ore deposits is the surface. On the other hand the bottoms of the deposits are unknown but the hope is to find workable extensions in depth of the many pods and lenses of sulphides that were worked close to the surface between 1860 and 1920. In this respect the history of the Buchans mine is encouraging because deeper ore shoots of great value are now being discovered and developed. The Buchans mine now provides a vertical range of 3,000 feet for study and comparison with other deposits. Such a study might reveal a systematic change that would indicate whether or not deeper mineralization can be expected. Changes with depth in mineralization, wall-rock alteration, trace element composition and proportion, microcrystal relations, structures of walls and ore shoots, isotopic composition and proportion are only a few of the possible avenues of approach.

(3) Structure of Iron-bearing rocks, Conception Bay, Newfoundland (D. M. Baird)

One of Canada's largest reserves of iron ore is thought to underlie the waters of Conception Bay, Newfoundland; yet the structure of the rocks beneath the bay is not well known. The Geological Survey of Canada has been mapping near the area and is providing some information on the structure of the adjacent rocks, but little has been done on the structure of the iron-bearing sedimentary series. The possibility that these rocks, which form a syncline beneath Conception Bay, may also form a hidden syncline under St. Mary's Bay to the south is intriguing. Every effort should be made to explore thoroughly means of getting information on the subject.

The development of some system of submarine exploration seems necessary. The application of geophysical techniques to submarine areas should be attempted; magnetic methods, gravity methods, and submarine seismic methods are possibilities. Much has been accomplished in recent years with submarine sampling devices, but they seem largely confined to soft bottom corers and are not well adapted to taking samples of bedrock from the ocean bottom. Research is needed on methods of obtaining bottom samples and information on structure.

(4) Geological Mapping of the Coastal Area of British Columbia, the Western Rocky Mountains, and the Rocky Mountain Trench (H. C. Gunning)

Reconnaissance mapping of the coastal area of British Columbia was carried out by the Geological Survey of Canada during and prior to the 1920's. Recent studies in more detail by the Geological Survey, the British Columbia Department of Mines, and others have produced results that show that here is an excellent field readily accessible by thousands of miles of incomparable waterways for long range investigations of scientific and economic problems. These problems are not limited to the "hard rock" field; little is known of the detailed geology and genetic history of the late Mesozoic and Tertiary basins of the Gulf of Georgia, Graham Island, and the west coast of Vancouver Island. Mining activity is on the increase in the coastal areas and oil companies are interested in the sedimentary basins.

The western Rocky Mountains and Rocky Mountain Trench are deserving of continued geological mapping. For most of the area immediately east of the Rocky Mountain Trench through the entire length of British Columbia no adequate geological maps are available and little is known of the stratigraphy and structure. This is an area potentially favourable for the finding of metallic and non-metallic ore deposits. A long-range plan for the mapping of this part of British Columbia should be drawn up beginning in the southern or central part.

(5) An investigation of the floor of the Sudbury Basin using seismic or other geophysical methods (D. R. Derry)

Either the top of the micropegmatite or the bottom of the norite, or both, might be investigated as a means of learning more about the structural control of associated orebodies.

(This project was originally suggested by Dr. H. J. Fraser, Falconbridge Nickel Mines, Ltd., to the Committee on Geological Research of the Canadian Institute of Mining and Metallurgy. The Dominion Astronomer reports that gravimetric observations have been made in the Sudbury area but it is not at all clear that seismic studies would yield satisfactory results. Some further consideration should be given this problem in view of the far-reaching importance of the area.)

(6) Geochemical and isotope studies to determine the source of gold and other elements in hydrothermal veins (F. G. Smith)

That gold and other elements have all come from igneous magmas is being questioned by serious students of economic geology. New techniques are now available and should be applied in the investigation of this fundamental problem.

GENERAL RECOMMENDATIONS

"Operation Keewatin" has shown that a method is now at hand for geological reconnaissance mapping of the northern Barren Grounds of the Canadian Shield within the near future. A continuation of this method of survey is strongly recommended.

The Subcommittee notes with approval the attention given the mapping of the Pleistocene geology in "Operation Keewatin". It is hoped that in future similar operations comparable study will be given the Pleistocene deposits, which may well prove to be of considerable economic as well as purely scientific value both as regards the deposits themselves and in the prospecting for ore deposits by tracing glacial float.

A major problem in geology in Canada is the long distance correlation of granitic rocks or of bodies of sedimentary and volcanic rocks isolated within granitic rocks. Research in laboratory methods that promise to increase the accuracy of age determinations, or to make these determinations more generally applicable, warrant strong support.

The Subcommittee notes with approval that the Geological Survey of Canada and some provincial surveys are making special studies related to metallic mineral deposits in addition to the usual geological mapping. It recommends that such studies be continued and increased, particularly to learn more about the genesis of ore deposits, controls of mineralization, clues for prospecting, and metallogenetic provinces.

The Geological Survey of Canada has a special responsibility to the Atomic Energy Control Board for studying uranium deposits; it is recommended that every effort be made to deal adequately with this subject. At present the money being spent for research on uses of atomic energy in Canada seems greatly out of proportion to that being spent on research on the raw materials.

One of the greatest problems is that of implementing worthwhile projects. It is easier to plan work that should be done than to obtain funds and suitable personnel to carry it out. This is particularly true of research on metallic mineral deposits because men who specialize in economic geology are at present being attracted to operational work for mining and oil companies. Two things may be done to help this situation. One is the careful selection of the most worthwhile projects so that the men and funds available are used to the best advantage. The other is for the main Committee and this Subcommittee to do their utmost to spread the conviction that although Canada is a young country with

probable large and as yet undiscovered mineral resources, the search for them requires all the aids that geological research can supply. If such research is to be undertaken it is essential that adequate funds be made available and that salaries for research workers be comparable to those paid in industry.

In attempting to allocate different fields of geological research to separate subcommittees there is bound to be considerable overlapping. Thus many projects discussed in the reports of the subcommittees on "Petrology, Mineralogy, and Chemistry", "Structure", and "Geophysics" are of vital concern to this Subcommittee and might equally well be discussed in this report. They are not so discussed to prevent duplication, but this Subcommittee wishes to record its interest in and support of such projects.

REPORT OF THE SUBCOMMITTEE ON STRUCTURAL GEOLOGY

Presented by Dr. J. E. Gill

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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.

Areal mapping is being carried on on a broad scale by the Geological Survey of Canada and the mines departments in the various provinces. In addition, a large amount of surface and subsurface mapping for commercial purposes is being done and all of these produce important structural information. In the review that follows only those items appear that are not of a routine nature and may, therefore, be classed as special structural studies.

CURRENT RESEARCH

Geologic studies of the Kemano-Tahtsa Lake tunnels being driven by the Aluminum Company of Canada in northern British Columbia have proceeded satisfactorily. By about October 1953 the break through will have been made and the main tunnel will be washed down and floored before water is turned through. A period of a few weeks will be available then for detailed studies of structures, and it is hoped that a specialist on "Granite Tectonics" may be found for this work.

Work on a new structural map of British Columbia is continuing at the University of British Columbia. Most of the preliminary plotting on an 8 mile scale will be completed next spring. After completion of this stage it will be necessary to study the data and distribute copies to other geologists for corrections and additions. Final compilation would be the last step.

In Alberta and adjacent parts of British Columbia the search for oil and natural gas goes on apace. Much valuable structural information is being secured, mostly by private companies. Provincial government representatives are in close touch with this work and it is to be hoped that as much as possible of the geological data are being recorded and compiled.

In southern Saskatchewan success attained by oil companies started a great surge of activity, resulting in the drilling of over 500 wells in 1952. The information produced is being collected by the Provincial Geological Survey and subsurface geological laboratory. A considerable amount of geological mapping has been done by the government and private companies in northern Saskatchewan in direct connection with the search for base metal and uranium deposits. Detailed studies of the origin and structure of the Kisseynew gneisses in Flin Flon and adjacent areas and of the granites of northern Saskatchewan are long term projects already started at the University of Saskatchewan.

In Manitoba, structural studies during the year were mainly related to the search for petroleum and natural gas. Seventy-five wells were completed during the year. A detailed study of the Sickle sediments has been started in the Lynn Lake area.

In Ontario and Quebec there was much structural study incidental to government mapping and investigation by mining and oil companies. Laval University reports special studies of the Appalachians between Levis and Charny, Quebec, and study of structures in the Quebec City

formation. Some petrofabric work on Grenville rocks near Shawbridge, Quebec, is being done at McGill.

In New Brunswick and Newfoundland the need for more geological mapping is keenly felt. Up to now the structures are known in only a very sketchy fashion. Studies by the Shell Oil Company, summarized in a recent paper by W. C. Gussow, have suggested new problems and Dr. MacKenzie advocates a study of the whole Pennsylvanian basin of central New Brunswick as a worthwhile major project from which valuable scientific and economic results should accrue.

In Nova Scotia, work on a tectonic and geological map of the province, sponsored by the Nova Scotia Research Foundation, has been completed and the manuscript is now ready for publication.

In the Northwest Territories studies of Ellesmere Island by Dr. J. C. Troelsen of Copenhagen during 1952 has given for the first time positive evidence of late Silurian or post-Silurian and pre-Middle Carboniferous folding. The extremely interesting experiment by the Geological Survey in mapping an area of 57,000 square miles in the Keewatin District west of Hudson Bay using helicopters resulted in much needed broad scale structural information.

Structural studies not related to particular areas include studies of structural control of ore deposition at the University of Toronto, experiments on the deformation of soft sediments at Queen's University, stress-strain theory applied to fracture patterns, and fracture patterns in non-homogeneous media at McGill University, and a statistical method of determining the attitudes of cylindrical folds at Princeton University.

Finally, it should be noted that geophysical work is in progress in many parts of Canada to help in the solution of broad scale structural problems.

SUGGESTED PROJECTS

Projects newly proposed or re-submitted are:

(1) Systematic study of the Rocky Mountain Trench (H. C. Gunning, D. R. Derry). Dr. Derry's report on the Structural Map of Canada, and the map itself drew attention to the Rocky Mountain Trench and contributed some new interpretations and conclusions on origin, all admittedly based on very incomplete evidence. Additional field studies guided by compilations from maps and aerial photographs are badly needed before we can begin to understand the significance of this major physiographic element.

(2) Compilation of mapping in the Alberta and British Columbia Foothills area (T. A. Link). Dr. Link has suggested that a composite map of the Foothills belt of Alberta and British Columbia would be a useful contribution, especially in view of the current interest in that area as a source for natural gas. Much mapping has been done by the Geological Survey of Canada in this area, but no comprehensive map is at present available.

(3) Further study of the Grenville Front where exposures are good (D. R. Derry, J. E. Gill). Dr. Derry mentions the area near Mount Wright as of special interest. Some good work has been done, particularly by the Quebec Department of Mines, but more is needed.

(4) Study of the Pennsylvanian basin of central New Brunswick (G. S. MacKenzie).

(5) More detailed study of the Conception Bay and nearby submarine areas, in Newfoundland both geologically and by geophysical methods.

(6) Exhaustive structural studies of well-exposed areas of high grade, medium, and low grade metamorphism to help solve foliation problems (J. E. Gill, D. R. Derry).

REPORT OF THE SUBCOMMITTEE ON PETROLOGY, MINERALOGY, AND CHEMISTRY

Presented by Dr. G. S. MacKenzie

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RESEARCH AND RELATED ACTIVITY DURING 1952

New projects in the fields of petrology, mineralogy, and geochemistry are not as numerous as in 1951; much of the work reported is a continuation of that started in 1951 or earlier. This situation is probably related in part to the decline in the numbers of graduate students in the universities.

General

Studies of the rocks transected by the Kemano-Tahtsa tunnel in British Columbia and of the Preissac-Lacorne batholith in Quebec made progress in 1952. Both studies are discussed elsewhere in this report. (pages 12 and 99)

Progress has been made in the acquisition of equipment and facilities in the laboratories of the Geological Survey of Canada. The spectrographic laboratory has been completed and is providing qualitative analyses. Preliminary calibration for quantitative analysis is being carried out when time is available. This work would be greatly expedited if another spectrographer were appointed.

Arrangements have been made to have a modern mass spectrometer built at McMaster University for the Geological Survey laboratories. A physicist has been employed to assist in the building of the spectrometer and to operate it when completed. The laboratory accommodation for the assembly of the spectrometer is now completed.

An isodynamic magnetic separator has been added to the mineral separation equipment and several modern microscopes and ancillary equipment have been purchased. The X-Ray fluorescence analysis unit has been modified to permit its use as a spectrogoniometer. Various instruments and other equipment have been purchased for the chemical laboratory although lack of adequate space imposes a severe handicap in the service the laboratory can supply. A qualified rock analyst has been added to the staff.

At the University of Toronto a decrepitometric study of metamorphic and igneous rocks has been made by Dr. F. G. Smith. The results of this research indicate that temperature of crystallization can be measured by the misfit that develops around foreign solid inclusions when the minerals are heated above the maximum temperature previously experienced.

Igneous Petrology

Current research in the petrology of igneous rocks includes many projects. Officers of the Geological Survey of Canada are carrying out studies of the ultrabasic rocks of western Newfoundland and of the Atlin district of British Columbia; of the pegmatites of the Ross Lake-Redout Lake area in the Northwest Territories; and of the Lacorne batholith in northern Quebec.

At Queen's University petrographic studies include the diabase dykes in the Michipicoten area, the hybrid rocks around a granite stock in Godfrey township, the beryl pegmatites of Renfrew county,

and the nepheline gneisses of York River near Bancroft, Ontario. A noteworthy development at Queen's University is the setting up in the spectrographic laboratory of working curves for the determination of major constituents of igneous rocks. Chemically analysed samples of granite and diabase supplied by the United States Geological Survey and National Bureau of Standards will be used.

At the University of Toronto research continued on the study of differentiation and assimilation of the Logan Sills, Port Arthur; the Round Lake batholith and its satellitic intrusions in the Kirkland Lake area; and the petrology and environment of the alkaline rocks of the Blue Mountain and Gooderham areas, Ontario. More general studies included the texture of differentiated basic igneous rocks and a critical study of the phase relations at the pegmatitic stage.

At McGill University petrographic studies included the peridotites of Quebec and the Brome and Shefford intrusive masses. At Laval University the study of the Meach Lake pseudo-conglomerate of the Wakefield area continued. At McMaster University study of the gabbros of Glamorgan township, Haliburton county, Ontario, continued. At the University of New Brunswick petrographic study of the Devonian intrusive and Carboniferous volcanic rocks of New Brunswick is continuing. At the University of Saskatchewan a study of the petrology of the granites and pegmatites of the Charlebois Lake area, northern Saskatchewan, was completed.

Metamorphic Petrology

At Laval University studies of the Grenville rocks of the Wakefield area are in progress. At McGill University studies of the Baffin Island gneisses, the petrology of the Michipicoten iron formations, and experimental research on rheomorphism are continuing. At the University of Toronto research includes a petrological comparison of the Lake Superior iron formations and a

study of the metamorphic facies of the New Calumet mine, Quebec. At the University of Western Ontario a study of the metamorphic rocks around the Madoc talc deposits is under way. At Queen's University the metamorphism of siderite, iron formation, and pyroclastics is being investigated, with particular attention to the oxidation of siderite to magnetite. At the University of Saskatchewan a study of the Tazin metasediments of the Charlebois Lake area, northern Saskatchewan, has been completed.

Sedimentary Petrology

The Geological Survey of Canada research laboratory at Sydney, Nova Scotia, is contributing much to our knowledge of coal and coal petrography. At McGill University sedimentary petrographic studies include work in the Potsdam sandstone near Montreal, the "Intermediate Siltstone" of Kimberly, British Columbia, certain Ordovician limestones of Quebec, and on the silicification of fossils. At Laval University a study of the Charny formation of the Quebec group is in progress. At the University of Alberta the petrology of the Methye dolomite, McMurray area, Alberta, and the Aldridge formation, St. Mary Lake area, British Columbia, is being studied.

Mineralogy

The Geological Survey of Canada has made considerable progress in the development of methods and techniques for X-Ray fluorescence analysis of minerals and ores. The library of X-Ray diffraction powder patterns has been much enlarged, largely through the courtesy of Dr. Frondel of Harvard University and Dr. Rabbitts of the United States Geological Survey.

The Geological Survey has completed a report on the wall-rock alteration associated with uranium deposits in the Goldfields district. Another report on the mineralogy of the district, including consideration of origin and age of the deposits is to be completed in 1953.

At Queen's University X-Ray studies of ore minerals for the "Atlas of X-Ray Data of the Ore Minerals" is continuing. This work includes studies of the sulpharsenides of lead, columbate and tantalate minerals, argentopyrite, the safflorite-loellingite minerals, and others. Additional X-Ray measurements are being made of the safflorites and will be correlated with their chemical compositions. At the University of British Columbia similar studies for the same volume are continuing. Among the minerals being investigated are argyrodite, terrestrial nickel iron, uranoan, thorianite, meta-torbernite, gersdorffite, owyheeite, cassiterite, stannite, and skutterudite. Here also studies are being made of the columbium-tantalum-uranium minerals of the Blue River district, British Columbia, and of the Kluane Nickel deposits, Yukon Territory.

The Mineralogical Branch of the Quebec Department of Mines has been carrying on investigations of new physical methods of determining brucite in ores; mineralogical studies of two varieties of kornerupine from Lake St. Marie, Quebec, and studies of the thermal behaviour of kornerupine; and on the nickel-bearing minerals from Montmagny county, Quebec.

At Laval University research on the refinement of approximate optical data is being carried on, which it is hoped will be of great help in the identification of metallic minerals and the study of solid solutions. In addition, secondary nickel minerals are being studied and research on the hydrothermal synthesis of minerals is continuing. At McGill University mineralogical studies include work on the origin of the Sudbury erruptive and on the magnesium silicates. The study of the uranium minerals continues at the University of Toronto and a new investigation of inclusions in cassiterites and associated minerals has begun.

At the University of Manitoba the study of the atomic structure of low temperature albite by X-Ray diffraction continues; and research on high temperature albite initiated at the University of Manitoba was continued at Queen's University.

Geochemistry

The Geological Survey of Canada will complete the geochemical and mineralogical study of the gold deposits of the Yellowknife area in 1953. At Queen's University spectrographic study of trace elements of the Lacorne batholith in northern Quebec is in progress and forms part of a comprehensive study of the batholith being undertaken by the Geological Survey. The Ontario Department of Mines is also investigating the use of trace elements in correlating the intrusive rocks between Elk and Kirkland Lakes, Ontario.

At McGill University the chemistry of wall-rock alteration near sulphide orebodies is being studied, with special attention to the distribution of alkalis by use of flame spectrophotometric techniques. The alkali content of the feldspars from Brome and Shefford mountains, Quebec, is also being studied.

At the University of British Columbia studies in geochemistry and biogeochemistry include studies of trace element provinces; a systematic study of the geochemistry of germanium; methods for detection of trace amounts of iron, manganese, and molybdenum; biogeochemical investigations of the distribution of various elements, including cobalt, uranium, cadmium, silver, and nickel; and experimental research on the stability of minerals under hydrothermal conditions. At the University of Saskatchewan some biochemical and geochemical research in the Amisk Lake and Flin Flon areas has been completed. At the University of Toronto the geochemistry of the formation of diamond is being investigated.

General Comments on Current Research

The above brief review of the research under way suggests a somewhat haphazard choice of problems. Their selection is too commonly determined by the area in which the worker happens to be doing field work, which in turn is determined by the need for remunerative field work. The time available for research and aptitudes of university personnel are other important factors.

However, attack on the broader type of problem with over-all planning and co-operation of different organizations show signs of increase. Examples are the program of study of radioactive minerals by the Geological Survey of Canada and the universities, and co-operative studies by several universities in preparation of the "Atlas of X-Ray Data of Ore Minerals". Other noteworthy examples of co-operative projects are the research on coal at the laboratories in Sydney, Nova Scotia, sponsored by the Geological Survey of Canada and the Nova Scotia Department of mines, with Queen's University contributing to trace element studies, and the geological and geophysical study of the Kemano tunnel in which the British Columbia Department of Mines, the Geological Survey of Canada, and the universities of British Columbia and Western Ontario are participating, with the full co-operation of the Aluminum Company of Canada.

The comprehensive studies of the Lacorne batholith, and of the mineralogy and geochemistry of Yellowknife, Goldfields, and Mayo mining camps are the broad and fundamental types of investigation that are particularly desirable.

SUGGESTED PROJECTS

In direct connection with the work of this Subcommittee Dr. S. C. Robinson has suggested:

(1) That membership of the subcommittee, if not of the National Committee, be rotated to ensure vitality, critical examination, and

spread of the work involved.

(2) That work in each of the fields of petrology, mineralogy, and geochemistry be appraised each year by preparation of an annual digest of work completed or in progress. Each field might be assigned to one member of the Subcommittee.

A number of specific projects have been suggested, in addition to those listed in previous reports of this Subcommittee:

(1) Study of the origin and structure of the Kisseynew gneisses in the Flin Flon and adjacent areas of northern Saskatchewan and Manitoba (J. B. Mawdsley).

(2) Collection of data on the nature of the granites of northern Saskatchewan (J. B. Mawdsley).

(3) Study of the "metagabbros" and related plutonics of northeastern Ontario (H. S. Armstrong).

(4) Determination of the age of the granites and other intrusions in the Northern Cordillera and Peace River basin regions (P. S. Warren).

(5) Much time in research is spent in working out mechanical details already done by others, as for example, preparation of X-Ray spindles from thin and polished sections, methods of using and preparing autoradiographs, removal of cover glasses from thin sections. Compilation and publication of data resulting from experience in Canadian laboratories might be considered (Dr. S. C. Robinson).

(6) A large number of rock analyses are made in connection with theses and other petrologic research in Canada each year. It is suggested that a card index of such rock analyses should be kept by some central agency. In this way information would be accumulated for statistical studies of rock associations and rock types (W. W. Moorhouse).

(7) Experimental investigation is needed of the solubility of water in intermediate, basic, and ultrabasic rocks and the determination of the solubility of sulphide melts in wet and dry magmas produced by the melting of normal basalt, norite, and granite (W. W. Moorhouse).

Some problems in petroleum geology suggested by Dr. H. H. Beach that in part overlap the fields of the other subcommittees are as follows:

(1) The relation between primary anhydrite and reef structure.

(Much might be learned of the relation of anhydrite and limestone by study of the Windsor group of Mississippian age in the Atlantic provinces. The whole question of gypsum and anhydrite genesis, interchange, and occurrence is of practical importance.)

(2) Radioactivity studies in relation to X-Ray, gamma ray, and neutron logging to find out what determines the response of specific rocks.

(3) The geological significance of variation in the chemical properties of oils; is migration a factor?; would study of the isotopes of sulphur in the oils be fruitful?

(4) The origin of dolomite and its relation to the creation of porosity in rocks.

REPORT OF THE SUBCOMMITTEE

ON PLEISTOCENE GEOLOGY

Presented by Col. P. D. Baird

Members of Subcommittee

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

No meeting of the rather widely flung members of the Subcommittee was held during the year under review. This report has been compiled mainly from extracts concerning the Pleistocene given in the reports of members of the National Advisory Committee on various regions of Canada.

STATUS OF RECOMMENDATIONS BY THE SUBCOMMITTEE IN THE FIRST ANNUAL REPORT, 1950-51

Much has been done by the Geological Survey to implement some of the recommendations of this Subcommittee in the first annual report of the Committee. With regard to the recommendations referring to the encouraging and training of geology students in Pleistocene geology some progress has been made. As an outcome of our recommendations the National Advisory Committee sent a letter to the presidents and principals of Canadian universities stressing the need for more attention to the teaching of Pleistocene geology. The report of this Subcommittee with a covering letter was also sent to the heads of departments of geology. Several universities have since added Pleistocene geologists to their teaching staffs, and there is little doubt that the subject is being given more attention in Canadian universities than heretofore.

The Geological Survey, in accordance with our recommendation, is continuing to encourage its officers to devote more time to Pleistocene geology in the course of field mapping of bedrock geology. Several Pleistocene geologists have been added to the staff of the Survey in recent years and a distinct division for Pleistocene and Engineering Geology has been set up within its organization.

No progress has been made with the Pleistocene map of Canada and bibliography, mainly as a result of lack of personnel. A "glacial" geology map on a small scale is in preparation for the Atlas of Canada, but it has not been possible to start compiling data for a map of the character recommended in the first report of this Subcommittee nor has compilation of such a map been made an official project of the Survey. A geomorphic map of Canada on a small scale is in preparation for the Atlas of Canada.

Good progress has been made at Laval University on a glacial map of the province of Quebec. The project includes a careful survey of the published literature and compilation of the extracted data on the Department of Lands and Forests provincial map of Quebec. The map is nearly completed and does comprise for Quebec alone the type of map recommended by the Subcommittee for the whole of Canada.

WORK ACCOMPLISHED IN 1952

In the 1952 field season the Geological Survey of Canada had some nine parties engaged in Pleistocene work, which varied in scope from detailed studies of value to construction engineers to broad-scale mapping to fill in areas where information was meagre or lacking. Three parties were assigned to studies of ground-water resources to gather basic data on available supplies of ground-water in specific areas where the information is of vital importance.

A Pleistocene geologist was attached to "Operation Keewatin" for the sole purpose of studying the deposits and features left by

"Keewatin Centre" glaciers. An area of 57,000 square miles in the Northwest Territories west of Hudson Bay was covered by use of helicopters and a good concept of the Wisconsin glacial period was obtained. Three substages of the Wisconsin period are indicated, a glacial lake has been partly mapped, and the area of marine overlap accurately defined. It is planned to include a Pleistocene geologist on a similar air reconnaissance project in the area north of that covered by "Operation Keewatin". This major project, called "Operation Baker", is scheduled for the field season of 1954.

The sedimentology laboratory of the Geological Survey of Canada was finally brought into operational condition in 1953 and the services of a trained technician were obtained. Sedimentation problems, the character of tills, heavy mineral suites, etc., will now be studied to further our knowledge of Pleistocene geology in Canada.

The Division of Building Research, National Research Council, established a permafrost research station at Norman Wells, Northwest Territories, in 1952.

The investigations of J. C. Troelsen on Ellsmere Island, Northwest Territories, have indicated a marine beach 465 feet above sea-level; marine shells prove post-glacial submergence of the low plains of the Fosheim Peninsula. Glacial till overlying marine sediments along the foothills of the Sawtooth Range indicates a late re-advance of the glaciers.

At McGill University J. D. Campbell has presented a thesis entitled "A Palaeobotanical-Stratigraphical Study of the 'Muck' Deposits of the Klondike". Some useful conclusions on the local Pleistocene geology are reached in it.

In British Columbia investigations of the Pleistocene geology and ground-water supply were made in the Vanderhoof, Prince George-Quesnel, and Peace River areas. W. H. Mathews, University

of British Columbia, in co-operation with the Institute of Oceanography, collected bottom samples from glacier-fed Garibaldi Lake. Detailed studies of the Pleistocene geology in relation to engineering structures were made recently at the Nechako dam sites, the Capilano dam of the Vancouver Water Board, the Pend Oreille dam, and along the new line of the Pacific Great Eastern Railway.

In Ontario, a study by the Ontario Department of Mines of Pleistocene stratigraphy and bedrock topography in relation to ground water is almost complete for the Toronto area and well advanced in Peel and York counties. The Ontario Research Foundation is carrying on a physiographic survey east and north of Georgian Bay and much information is being gained about shorelines and eastward outlets of Lake Algonquin.

In Nova Scotia, H. L. Cameron and R. H. MacNeil of Acadia University and W. A. Hogg of Dalhousie University, continued their studies of the Pleistocene geology of the western part of the province on behalf of the Nova Scotia Research Foundation.

Investigations in the field of glaciology during 1952 included a reconnaissance survey of the Grinnell Ice Cap in Baffin Island by two students from McGill University and detailed study of the Saskatchewan Glacier directed by Dr. R. P. Sharp of the California Institute of Technology. The Saskatchewan Glacier has been selected for this study because of its accessibility; it is hoped this project will continue.

WORK PLANNED FOR 1953

The Geological Survey of Canada will field ten Pleistocene parties in the season of 1953. One of these parties will begin a study of the Labrador centre of glaciation. Three parties will continue their work on ground-water resources.

The Ontario Department of Mines will continue surveys of the Pleistocene stratigraphy and bedrock topography in relation to ground water in southwestern Ontario.

The Arctic Institute of North America under contract with the Defence Research Board is carrying out a preliminary survey of glacial features of northern Canada by study of aerial photographs in Ottawa. The territory to be examined includes all Ungava and parts of Keewatin and Franklin districts. Detail will be drawn on 8 mile to the inch topographic maps.

The Arctic Institute of North America is sponsoring an expedition in the summer of 1953 to the Penny Highland district of Baffin Island. Glaciology and glacial geology will form the main part of its scientific program.

Age Determinations

A laboratory for age determinations by the C-14 method has recently been established at the University of Saskatchewan. Another laboratory, which it is hoped to have operating by the middle of 1953, is being set up at the University of Manitoba. This laboratory is designed to analyse C-14 by a liquid scintillation process, which it is hoped will give more accurate data than the Libbey counting method.

Initial discussions are also taking place for the establishment of a C-14 laboratory at McGill University. There is as yet no available space for the setting up of such a C-14 laboratory by the Geological Survey in Ottawa.

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

By Dr. P. S. Warren

Members of Subcommittee

Dr. P. S. Warren (Chairman)	- University of Alberta, Edmonton, Alta.
Dr. J. D. Allan	- Winnipeg, Man.
Mr. M. F. Goudge	- Department of Mines and Technical Surveys, Ottawa, Ont.
Dr. D. J. MacNeil	- St. Francis Xavier University, Antigonish, N.S.
Dr. H. Sargent	- Department of Mines, Victoria, B.C.

INTRODUCTION

Due to the death of Dr. Ralph L. Rutherford on January 29, 1952, the present writer has been asked to replace him on this Subcommittee. This replacement was acceded to with a certain amount of reluctance as the writer is fully aware that Dr. Rutherford's interest in and knowledge of oil exploration and production in the western plains area was unique in its thoroughness and broadness, and his approach to any problem related thereto was strictly scientific. The writer had the advantage of close co-operation with him at all times with reference to the exploitation of the non-metallic resources of the plains area and feels a certain degree of competence in making various suggestions as to the fields of research that would be most helpful to the development of the non-metallic resources of the area.

GRAVEL, SAND, AND CLAY

Gravel and sand for road metal and construction purposes is in fairly good supply in most parts of western Canada. The present building boom in the larger cities and the extensive program of road making by provincial governments has led to prospecting for the necessary materials in local areas. Most of the material for this

purpose is obtained from Pleistocene deposits and from Saskatchewan gravels that are usually considered pre-glacial in age. The supply of Saskatchewan gravels is local and occurs as benches in pre-glacial valleys that headed in the mountains.

Investigation of the Pleistocene deposits in Western Canada has been carried on fairly extensively in recent years by the Geological Survey of Canada and by the Research Council of Alberta, and a knowledge of the later geological history of the area is gradually being obtained and the resources of sand and gravel being investigated.

Clays for brick and tile are used fairly extensively in the area, the source of supply being from Cretaceous beds and from Pleistocene and post-Pleistocene lake deposits. In order to investigate the supply of clays more intensively, the Research Council of Alberta is in process of setting up a clay laboratory with fully qualified personnel in charge. This laboratory will also have in charge the testing of various limestones and dolomites from the mountains and from Palaeozoic formations beneath the plains area.

The Manitoba Department of Mines and Natural Resources carried on in 1952 a study of the clays and shales of the province with the aim of finding deposits that might have industrial uses such as the making of light-weight aggregates, rock wool, etc.

INDUSTRIAL MINERALS

In the field of non-metallic mineral deposits, projects of the Geological Survey of Canada include an inventory and field study of mica deposits in Canada. Field work has been completed and the report, which is well advanced, will be published as one of the Economic Geology Series. A similar study and inventory of kyanite deposits in Canada was begun in 1953.

In Quebec, projects of the Quebec Department of Mines include study of the graphite deposits of the Buckingham district and the

feldspar deposits of the Johan Beetz area; a study of the building stone industry in the province; and research on a new physical method of determining brucite in ores.

In Ontario, projects of the Ontario Department of Mines include the gathering of information on ultrabasic rocks and exploration for asbestos in Reeves township and east of Matheson; a detailed study of a belt of sediments and nepheline-bearing rocks in Glamorgan township, Haliburton county; and a study of the pegmatites and corundum-bearing rocks in Carlow-Monteagle townships. At Queen's University studies were made of the beryl and corundum pegmatites of Renfrew county and of the nepheline gneisses near Bancroft, Ontario. At the University of Toronto the geology of the Gooderham nepheline pegmatites was studied.

In Nova Scotia the Department of Trade and Industry sponsored a geological investigation of limestone and salt deposits near Antigonish harbour. A systematic program of exploration revealed adequate limestone and salt in close proximity for a proposed soda-ash plant.

Suggested Research

A number of research projects directly concerned with industrial minerals have been suggested. They include the following:

(1) Newfoundland now supplies most of Canada's production of fluorite. Recent months have seen tremendous activity in prospecting and a great rise in interest in the Newfoundland fluorite areas. The fluorite occurs as fissure filling and veins in and about certain granites in the Burin Peninsula and nearby parts of Newfoundland. Research should be initiated on the possibilities of finding the relationship between fluorite-rich areas and the igneous parent rocks. Some

system of prediction might be worked out to find whether specific granites are favourable or unfavourable prospecting grounds. Detailed studies of structures formed in the late magmatic stages plus bulk analyses might give this information. Trace elements and other lines of investigation used in the study of batholiths and stocks might reveal why fluorite occurs where it does, and thus, the most likely areas in which to prospect (D. M. Baird).

(2) Evaluation of the data collected in the search for the potash salt basin of Saskatchewan (J. B. Mawdsley).

(3) A study of the volcanic ash deposits of southwestern Saskatchewan (J. B. Mawdsley).

(4) Further reconnaissance mapping on the American Nepheline property northeast of Peterborough. The property shows a folded structure and the relationship of the nepheline syenite to contiguous limestone or limy beds (D. R. Derry).

COAL

The use of Alberta coals either within the Plains area or for shipment to more distant markets is largely a matter of economics. Coal is present in flat-lying seams under the Plains and also in the disturbed area of the Foothills. The supply is plentiful but the market is limited owing to the increasing use of natural gas in urban areas. There is little likelihood of the supply becoming exhausted in the foreseeable future. The necessity of surveys to assist the coal operators in finding new supplies of coal, except in very local areas, is not pressing.

In the past, the Research Council of Alberta has devoted a considerable part of its program to coal, both through geological surveys and through many thousands of analyses collected from various seams in different parts of the province. The data so obtained have

provided a good picture of the nature and composition of Alberta coals, and serve as a basis for assessing their suitability for various uses. The data were used in international studies of classification. Recently a co-operative program of fundamental research has been designed to study the origin and constitution of coal. A three-way approach will be made—paleobotanical, physical-chemical, and organic-chemical. Such approach, it is hoped, will provide information that will assist in a more efficient utilization of coal by newer techniques.

The Coal Petrography Laboratories at Sydney, Nova Scotia, housed and maintained by the Provincial Department of Mines, equipped by the Research Foundation of Nova Scotia, and staffed by the Geological Survey of Canada, is an outstanding example of co-operative effort, and is making a notable contribution to the knowledge of coal petrography in general as well as the specific interpretation of the coal seams. Detailed study of petrographic and chemical constituents of coal and detailed mapping of the variations in these is producing factual information of great value in the extension of the coal mine operations; study of the plant micro-fossils (micro-spores) of the seams is also under way. This work has shown that petrographic and micro-fossil studies of coal seams can establish correlations over considerable areas. The value of geological studies applied to coal mining operations, as shown by the work of this laboratory, has resulted in the appointment of a full-time geologist to the engineering staff of the Dominion Coal Company.

At Queen's University a trace element study of Cape Breton coals is being made. Some 200 samples from 9 seams are being analysed qualitatively for more than 30 elements. By the use of rhodium as an internal standard comparable intensity ratios are

being obtained, and for twelve elements, including germanium, actual quantities will be determined. It is hoped the study will yield data that will be of assistance in coal seam correlation and in the petrographic classification of individual parts of the seams.

Rock bursts or "mine bumps" have been a major source of trouble and danger in the Springhill coalfields of Nova Scotia for many years and with the extension of coal mining operations to depth in the Sydney area the problem is developing there. Several groups are working on this problem or on problems closely allied to it. The Fuels Division, Department of Mines and Technical Surveys, commenced a systematic study of rock movements by establishment of fixed points under ground and the taking of repetitive measurements on them as the working faces advance. This is a long term project and for its success depends upon the close co-operation of the mine surveyors. The Research Foundation of Nova Scotia has physicists investigating the physical and mechanical properties of rock-types from the stratigraphic sequence adjacent to the seams, and it and the Department of Mines are sponsoring investigations at the Nova Scotia Technical College on the mechanical properties of structures, using the principles of photo-elasticity. A fourth investigation is under way at McGill University on the mechanical properties of rocks under compression, tension, and shear, the work including rock-types from the Springhill field. An outstanding need in these investigations is detailed studies of the sedimentation sequence in the stratigraphy of the coal measures, particularly those adjacent to the seams in which the bumps or bursts are occurring. Relatively minor variations in rock-types within a single stratum may cause fundamental differences in the physical and mechanical properties of the rock itself and profoundly influence the incidence of rock bursts.

Petrographic studies in relation to spontaneous combustion of coal are continuing at the Massachusetts Institute of Technology

with particular reference to the Lloyd Cove seam of the Sydney coalfield. The Lloyd Cove seam makes up one of the more important reserves of the field, but is mined on only a small scale because of its tendency to spontaneous combustion even in small storage piles. These studies have shown that spontaneous combustion is not caused by composition of the coal but is related to the particle size of the sulphides.

GAS AND OIL

There is little to add to last years report on research in respect to oil and gas in the western plains. The larger producing companies are still doing the major research, both in the immediate oil-producing fields and also, in a broader way, over the whole area. The results of such studies are usually reserved for private use only. Some companies have research departments capable of doing first class work, both in the finer detail of the producing zones and over a broad area. Some of the results of this research have already been published and some are in the process of being published. The usual vehicle of publication is the Bulletin of the American Association of Petroleum Geologists; a list of such publications over the last 2 years follows:

Published in the Bulletin, American Association of Petroleum Geologists:

1. Possible Future Petroleum Provinces of North America - Western Canada, Alberta Society of Petroleum Geologists, February 1951.

2. Tectonics of East Side of Cordillera in Western Canada, A. J. Goodman, April 1951.

3. Geology of Turner Valley Oil and Gas Field, Alberta, Canada, W. B. Gallup, April 1951.

4. Devonian Stratigraphy of Rocky Mountains and Foothills Between Crowsnest Pass and Athabaska River, Alberta, Canada, F. G. Fox, April 1951.

5. Structural Interpretation of Loci of Petroliferous Parts of Devonian Reefs in Edmonton Area, Alberta, Canada, Ralph L. Rutherford, April 1951.

6. Source of Oil in "Tar Sands" of Athabaska River, Alberta, Canada, Theo. A. Link, April 1951.

7. Stettler Oil Field, Alberta, Canada, R. P. Lockwood and O. A. Erdman, April 1951.

8. St. Mary River Formation in Spring Coulee-Magrath Area, Alberta, Canada, E. P. Williams, April 1951.

9. Review of Exploration and Developments in 1950 - Western Canada, John O. Galloway, June 1951.

10. Geological History of Plains of Western Canada, J. B. Webb, November 1951.

11. Folded Faults in Rocky Mountain Foothills of Alberta, J. C. Scott, November 1951.

12. Useful Blairmore Microfossil Zone in Central and Southern Alberta, Canada, D. M. Loranger, November 1951.

13. Regional Stratigraphic Analysis of Devonian System in Wyoming, Montana, Southern Saskatchewan and Alberta, John, M. Andrichuk, November 1951.

14. Stratigraphic Reconnaissance Along Upper South Nahanni River, Northwest Territories, Canada, Dave R. Kingston, November 1951.

15. Review of Exploration and Developments in 1951, Western Canada, A. J. Goodman, June 1952.

Published in Proceedings, Athabasca Oil Sands Conference, September 1951:

1. The McMurray Formation and Its Relation to Oil Occurrence, J. C. Sproule.

2. Stratigraphy of McMurray Formation, W. L. Falconer.

3. Geology of the Bituminous Sand Deposits of the McMurray Area, Alberta, F. A. Kidd.

4. Regional Correlations of the Lower Cretaceous Formations of the McMurray Oil-sand area, R. T. D. Wickenden.

5. Some Stratigraphic Features of the Upper Devonian Sequence of the Canadian Western Plains, P. S. Warren.

6. Source of Oil in Oil Sands of Athabasca River, Alberta, Canada, T. A. Link.

7. Possible Lower Cretaceous Origin of Bitumen in Bituminous sands of Alberta, G. S. Hume.

8. On the Origin of Athabasca Oil, D. S. Montgomery.

Assistance may best be given the oil industry in the search for oil and gas by studies of broad and general application. Most of the oil-bearing strata of the producing areas and of the areas being actively prospected are exposed in the Rocky Mountains to the west and along the flanks of the Canadian Shield to the east. These sections are readily accessible. Their thorough study should be undertaken by competent geologists who are especially equipped to study definite stratigraphic horizons. An example is the recently completed "Carboniferous Stratigraphy and Palaeontology in the Mount Greenock Area, Alberta", published by the Geological Survey of Canada as Memoir 264. This report should be of great value to oil company geologists working in the Peace River basin. Another report, entitled "Notes on the Subsurface Stratigraphy and Oil and Gas Geology of the Lower Cretaceous Series in Central Alberta", published as Preliminary Paper 52-11 by the Geological Survey of Canada, though an excellent report in itself, is of less value to exploring and producing companies as they are accustomed and equipped to collect, assemble, and correlate such data themselves.

Studies of even broader nature should also be undertaken. Fundamental studies of foothills geology cannot be properly carried out without a reasonable knowledge of the main structural history of the Rocky Mountains. This is known only in part. Thus a great physiographic feature like the Rocky Mountain Trench has not as yet yielded to any interpretation that can be reasonably accepted by geologists studying Foothills and Rocky Mountain structure. This great feature must hold the key to much of the structural history of our mountain area. Investigation by a competent geologist or group of geologists over a period of years will be necessary to arrive at satisfactory conclusions as to the significance of the feature. Probably such a study could be undertaken only by the Geological Survey of 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. M. A. Fritz	University of Toronto, Toronto, Ont.
Prof. 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 Company, Calgary, Alta.
Dr. W. J. Wright	Fredericton, N.B.

INTRODUCTION

The information in this report has been obtained from a canvass of the members of the Subcommittee and from the reports of those members of the main National Advisory Committee who were delegated by the Committee to report on developments and needs with respect to all branches of the geological sciences in their respective provinces or major divisions of the country.

The report deals with research projects in stratigraphy and palaeontology: one section covering the activities in these branches in 1952, and the other outlining some of the additional problems that require attention.

As the report shows, there was considerable activity in 1952 across all Canada in these branches of geological science. There remains much to do, however. The problems listed as requiring attention in the second section of this report are relatively few, but to them must be added the many problems listed in the two preceding annual reports, and undoubtedly there are many other needs that have not been listed.

CURRENT RESEARCH

As most of the activities lend themselves to a geographical classification, the developments are listed province by province; thus a picture is obtained of what has been taking place during 1952 from one end of Canada to the other.

Newfoundland

A notable development in Newfoundland in 1952 was the expansion of geological survey activities by the government of this newest province of Canada. Mr. C. K. Howse, who almost alone had been looking after matters pertaining to geology in so far as the provincial government was concerned, was promoted to the rank of Deputy Minister of Mines and Resources and Dr. D. M. Baird was appointed to succeed him as Provincial Geologist. The building up of a provincial geological service will bring increased contributions to the knowledge of the stratigraphy and palaeontology of Newfoundland.

The Newfoundland Department of Mines and Resources carried on, in 1952, detailed stratigraphical studies on the presumed oil-bearing Ordovician strata on the west coast of Newfoundland.

The Geological Survey of Canada continued stratigraphic and palaeontological studies in the eastern part of the province. This work was additional to that of seven field parties engaged in areal geological mapping in Newfoundland and Labrador.

Nova Scotia

At the research laborties at Sydney the Geological Survey of Canada continued in 1952 the detailed petrographic study of the coals in the Sydney and Mabou areas, including the study of the micro-fossils (micro-spores) that they contain. These studies are proving most useful in the correlation of faulted coal seams over considerable areas. Detailed mapping and study of the coal areas of western Cape Breton Island and detailed mapping of the Baddeck area was begun.

Work on a tectonic and geological map of Nova Scotia sponsored by the Research Foundation of Nova Scotia has been completed and the manuscript is now ready for publication.

At St. Francis Xavier University a thesis was prepared on the geology of the Windsor (Mississippian) rocks of the Antigonish area.

A group of twenty students from the Massachusetts Institute of Technology attended summer school at "Crystal Cliffs", the Nova Scotia centre for geological sciences, and continued detailed studies of Antigonish county and adjacent areas. Two theses are being prepared in connection with these studies, namely, "Provenance of Horton Sediments of Cape George Area" and "Metamorphic Rocks of the Cape George Area".

New Brunswick

The field projects of the Geological Survey of Canada in New Brunswick in 1952 included the 1 inch to 1 mile mapping of the Woodstock and Bathurst map-areas and the study of the palaeontology and stratigraphy of the Silurian strata of southern New Brunswick.

The publication, in 1952, of a paper by W. C. Gussow summarizing the results of recent extensive geological and seismic work in New Brunswick by the Shell Oil Company of Canada is a valuable contribution to our knowledge of the stratigraphy and structure of the Carboniferous formations of New Brunswick. The report was published by the New Brunswick Department of Lands and Mines and in the Bull. Am. Ass. Pet. Geol., vol. 37, No. 7, (July 1953).

Dr. R. H. Denison, Curator of Fossil Fishes, Chicago Natural History Museum, spent some weeks in the province exploring Silurian fossil fish localities in southern New Brunswick.

Quebec

Among the field projects and connected research being carried out by the Quebec Department of Mines are: (1) a study of the lithology and relations of Lower and Middle Devonian formations in interior Gaspe; (2) preparation of a regional geological map of Gaspe, which is now completed and ready for printing; (3) the mapping and study of the Lower and Middle Ordovician of northern Gaspe; (4) the Lower and Middle Palaeozoic of the Appalachian Disturbed Belt, Eastern Townships; (5) the Lower and Middle Palaeozoic of the Appalachian Disturbed Belt, southeast of Quebec city; and (6) the Ordovician of the St. Lawrence Lowlands.

At Laval University intensive research on the Cryptolithidae of Quebec is continuing. Already several papers have appeared and others are planned.

At McGill University research projects include study of the core of a deep well near Noyan, southern Quebec, stratigraphy and palaeontology of the Silurian of Manitoba, the study of semi-micro-fossils of the Trenton rocks of Quebec, study of the Potsdam sandstone in the core of the Mallet well, Ste. Therese, Quebec, the Ghost River formation between Athabasca and Smoky Rivers, Alberta, and study of the "intermediate siltstone" of Kimberly, British Columbia.

In the past, studies of Precambrian areas have been considered as problems of petrography and structure, but increasing attention is being given research on sedimentation and other problems of stratigraphy in the areas where much of the rock is of sedimentary origin. In Quebec, during 1952, the Geological Survey of Canada continued studies of the Late Precambrian sedimentary rocks in the southern part of the Labrador geosyncline, and the Quebec Department of Mines continued studies of the same rocks in the northern part, near Ungava bay. Considerable geological work in various sections of this sedimentary, iron-bearing belt was also carried out in 1952 by Iron Ore Company of Canada, Fort Chimo Mines Limited

(subsidiary of Frobisher Limited), Quebec Labrador Development Limited, and Fenimore Iron Mines Limited.

Precambrian stratigraphy was also studied by eleven geological parties of the Quebec Department of Mines and two parties of the Federal Geological Survey in other, widely separated areas in the Precambrian Shield of Quebec.

Ontario

At the University of Toronto palaeontological and stratigraphic research in 1952 included study of the Bryozoa of the Ottawa limestone, the Stromatoporidae of the Abitibi River limestone, the coral fauna of the Abitibi limestone, plants from the Sextant formation including spore analysis, a study of the genus Atrypa of western Canada, the Silurian stratigraphy and palaeontology of the Niagara escarpment, the Trenton and Black River formations in southeastern Ontario west of Longitude 78°30', the structure and stratigraphy of the Grenville in the vicinity of the Elzevir batholith, Ontario, and of the western margin of the Labrador trough, Quebec.

At Queen's University a study of the ammonite fauna of the Upper Cretaceous rocks of Vancouver Island was completed and study of the pelecopod fauna of the same area was begun. The corals of Lower Ordovician age in the Georgian Bay area, Ontario, are also being studied. A stratigraphic study of southeastern Cape Breton Island, N.S., was completed.

At McMaster University research included studies of the sandstones of the Medina formation and of the Grimsby sandstone of the Niagara Peninsula, and the Precambrian stratigraphy of Glamorgan township, Haliburton county.

The Ontario Department of Mines assigned eight field parties to the geological mapping of Precambrian areas in Ontario. As is true in Quebec and elsewhere, these parties studied the stratigraphy of the sedimentary and volcanic rocks that they mapped. In addition to the program of areal mapping, several special stratigraphic problems were studied. These included a detailed study of the structure and stratigraphy of the Precambrian rocks of the north shore of Lake Huron, the mapping and correlation of the Gunflint formation between Fort William and the International Boundary, the bearing of granitization and grade of metamorphism on the lithologic and genetic classification of rocks in the Grenville subprovince of Ontario, and the geology and stratigraphy of the James Bay lowland.

Stratigraphical and palaeontological projects of the Geological Survey of Canada in Ontario included the continuation of the mapping of the Ordovician strata between the Canadian Shield and Lake Ontario and longitudes 77° and 78°30', and the completion of a study of the stratigraphy and palaeontology of the pre-Hamilton Devonian strata of southwestern Ontario. In addition, collection of data on the elevations of wells drilled for oil and gas in southwestern Ontario was continued; from this data bedrock contour and drift thickness isopach maps of the area are being prepared.

Manitoba

At the University of Manitoba research projects included studies of the stratigraphy and palaeontology and of the sedimentation of the Winnipeg formation, a detailed study of the Red Beds in southwestern Manitoba and an attempt to work out criteria for their correlation, and a study of the Swan River group of Manitoba and of the basal quartz sand of the Leduc area, Alberta. In addition a study of the Bird Hill Pleistocene gravel deposit has shown that the gravel formed as a delta in Lake Agassiz between ice walls rather

than as an esker. Another locality for the Saxicava fauna in Manitoba was found by Professor G. A. Russell at Long Lake west of Hudson Bay; a paper is in preparation describing the occurrence and the fauna.

Much interest has been shown by oil exploration companies in the stratigraphy of Manitoba. Papers presented at the Western Annual Meeting (1952) of the Canadian Institute of Mining and Metallurgy included "The Sub-surface Stratigraphy of Southwestern Manitoba" by J. Ower, and "The Palaeozoic Outcrop Section in Manitoba and some Suggested Interpretations" by Andrew Baillie. Both papers will be published and should prove of great value to geologists interested in the stratigraphy and sedimentational history of the Williston Basin.

Saskatchewan

The many oil and gas companies carrying on active exploration in Saskatchewan have done much subsurface geological work and correlation but as yet much of this data is confidential.

The Provincial subsurface geological laboratory has recently been moved from Saskatoon to Regina. However, the cores, samples, and logs not on the confidential list are available to students and staff of the University of Saskatchewan for research purposes.

Projects of the Saskatchewan Department of Natural Resources in 1952 included an investigation of the bituminous sands of western Saskatchewan; and a combined surface and subsurface study of the Ordovician and Silurian stratigraphy of east-central Saskatchewan was completed. A useful annotated bibliography of geological literature dealing with Saskatchewan was published in 1952.

Geological Research at the University of Saskatchewan included a study of the subsurface stratigraphy of the Jurassic in Saskatchewan and of the Devonian stratigraphy of southern Saskatchewan.

The National Museum of Canada continued the collecting of Oligocene fossil mammals from the Cypress Hills formation on Calf Creek near Eastend. The collection obtained by this expedition is being studied along with previously collected material. The work of the Provincial Museum of Saskatchewan on the fauna of the Cypress Hills Oligocene is worth mentioning.

The Geological Survey of Canada commenced the 4 mile to 1 inch mapping and study of the drift cover in the North Battleford area; three other parties were engaged in mapping Precambrian areas in Saskatchewan.

Alberta

The Geological Survey of Canada continued detailed studies of Mississippian, Devonian, and Jurassic palaeontology in the foothills of Alberta to provide basic data for oil exploration. Detailed mapping was continued in the northern foothills in the vicinity of Kvass flats on the scale of 1 inch to 1 mile. The Calgary office of the Geological Survey continued: (1) the study of subsurface samples from the Devonian of north-central Alberta; (2) the study of well cuttings from Saskatchewan and Alberta with particular reference to correlation of the formations; and (3) the study of micro-fossils and correlation of Lower Cretaceous strata.

At the University of Alberta the following geological research has been completed in the past 2 years in theses for the M.Sc. degree:

Microfauna of the Joli Fou Formation, Athabasca River, Alberta.
A Study of the Aldridge Formation, St. Mary Lake area, British Columbia.
The Precambrian under the Central Plains of Alberta.

Sediments Associated with the Knee Hills Tuff in the Edmonton Area.
Some Analyses of Pleistocene Deposits in the Edmonton Area.
The Petrology and Palaeontology of the Methye Dolomite, McMurray Area, Alberta.
Studies in Radioactivity Well Logging.
Some Cutanized Microfossils from Western Canada.
A Lower Microfauna of the Loon River formation, northern Alberta.
Cenomanian Microfauna from the Upper Fort St. John Strata, British Columbia.
Cenomanian-Turonian Foraminifera of the Kaskapau Formation, Peace River Area, Western Canada.

British Columbia

The British Columbia Department of Mines continued stratigraphic and structural field work in the Windermere area. This work is of outstanding importance because it has a bearing on the relationship of Devonian reefs and presumably lagoonal deposits of gypsum. It may also throw light on the Devonian paleogeography and the presence or absence of suspected Middle Devonian in the southern Rocky Mountains. Other projects of the British Columbia Department of Mines included stratigraphic and structural studies of the Cariboo area and a largely stratigraphic and structural study of the Cambrian and possibly Ordovician strata of the zinc belt in the Salmo area.

At the University of British Columbia geological research included completion of an inventory of the Cambrian trilobites from the Lower Cambrian near Cranbrook, a study of the sediments in Bute Inlet, of Pleistocene and recent sediments in Garibaldi Lake, and of the Archaeocyatha from Sinclair Mills on Fraser River and from the McDame area. Work was begun on the preparation of an illustrated card catalogue of Devonian fossils from the Rocky Mountains.

The program of the Geological Survey of Canada in British Columbia included the study of the Cretaceous stratigraphy and palaeontology on the west coast of Vancouver Island and areal geological mapping in the Vancouver, Atlin, Bennett, Nelson, and Kettle River areas.

A field party from the National Museum of Canada studied and collected fossils in the Kishenehn formation in the Flathead Valley. The results of this study will permit a more accurate dating of these early Tertiary deposits.

Yukon Territory

Of the seven Geological Survey of Canada field parties in Yukon Territory in 1952, four were engaged in the study and mapping of areas on the scale of 1 inch to 4 miles, two did more detailed work in the Mayo mining district, and one carried out an exploration traverse. A similar program is planned for 1953 but, in addition, a special study will be begun of the Mesozoic stratigraphy in south-central Yukon.

Two parties from the United States did some geological work in Yukon Territory. One party, led by Mr. Dudley Bolyard and Howie Martin, of the Yale Mountaineering Club, explored an area on the northeast flank of the Logan Mountains and obtained some knowledge of the general geological features. Another expedition organized by Mr. Robert M. Shamp of Washington, D.C., went into an area somewhat north of that of the Yale party, mainly to study the flora but also to collect geological information. In addition, an expedition from the University of Alaska collected vertebrate palaeontological material in the Old Crow Plain region.

Northwest Territories

Stratigraphic and palaeontological studies in the Northwest Territories, in 1952, were largely confined to those of officers of the Geological Survey of Canada. The study of the stratigraphy of Mesozoic formations beyond the Parry Island folded belt was started at Isachson on Ellef Ringnes Island. The lowermost Cretaceous forms found there together with those collected by other expeditions at

Eureka and on Prince Patrick Island are being studied; they indicate a widespread Early Cretaceous sea. The study of the stratigraphy of Cornwallis Island continued. The formations there extend from Ordovician to Devonian with many thousands of feet of Silurian strata occurring in three facies. Research on an outstanding collection of Silurian graptolites of European affinity from the Island is in progress. The coastal exploration of the southern part of Baffin Island was completed. The geology is interesting not only for its Grenville type stratigraphy but also because it displays, among many metamorphic facies, widespread distribution of variable charnockitic gneisses and rocks of presumably granulitic facies similar to those on the Labrador coast and middle west coast of Greenland.

Geological notes of observers on expeditions to Hudson Bay and Foxe Basin in 1949 and on the joint American-Canadian Resupply Mission along the coast of parts of Ellesmere and Devon Islands were published in 1952 as Geological Survey Papers 52-25 and 52-32.

The Stratigraphic Palaeontology Division of the Geological Survey is presently attempting to compile a summary of its knowledge of Arctic faunae and of the problems connected with these faunae.

A Geological Survey party using helicopters for aerial reconnaissance mapped a large area to the west of Hudson Bay in 1952. About 57,000 square miles were mapped in adequate detail for publication at 1 inch to 8 miles; about 14,000 square miles of this area are underlain by Precambrian sedimentary and volcanic rocks ranging in age from Archaean to Upper Proterozoic.

In the field season of 1953, Geological Survey field parties will explore further the geology of Ellef Ringnes Island, southern Baffin Island, and Cornwallis Island, and possibly will

visit Bathurst Island. A geologist will also take part in a joint expedition with the Defence Research Board to the north coast of Ellesmere Island.

Dr. J. C. Troelsen, University of Copenhagen, studied the geology of the region around and to the east of Eureka station, Ellesmere Island, in 1952. His report has been published in "Arctic", vol. 5, No. 4, December 1952.

SUGGESTED RESEARCH

A considerable number of research projects in stratigraphy and palaeontology have already been suggested in the two previous annual reports of the Subcommittee. A start has been made on only a few of them. The reader is referred to these reports (contained in the First and Second Annual Reports of the National Advisory Committee on Research in the Geological Sciences). The following additional suggestions have been submitted, as indicated, by members of the Subcommittee and other workers:

Dr. D. M. Baird, Newfoundland Geological Survey

A complete list of stratigraphic and other geological names came into use in Newfoundland prior to confederation with Canada in 1949. Some of these are parallel with terms that can be extended from the mainland geology, notably that of Nova Scotia. Other formations were named by pioneer workers in areas not previously explored. Some system should be devised by which original names are respected where they can be and discarded where they are unnecessary or merely duplicate others of more widespread usage. The same problem exists in other parts of Canada but is aggravated in Newfoundland because of its geographical position and the history of geological work.

Much has been accomplished in recent years on submarine sampling devices but they seem largely confined to soft-bottom

corers and are not well adapted to taking samples from bedrock on the ocean bottom. Research on methods of obtaining bottom samples and some information on structure would be most useful. How else can the structure of the Tertiary of the Grand Banks be solved so that oil exploration can be directed intelligently? Perhaps some sort of electrically driven gyro-oriented portable drilling rig for taking very short cores could be devised to sample areas of bedrock at the sea bottom.

Dr. G. S. MacKenzie, University of New Brunswick

The recent paper by Dr. W. C. Gussow on "Carboniferous Stratigraphy and Structural Geology of New Brunswick" (See page 63) points the way to unanswered and new problems such as the correlation of red and other non-fossiliferous beds. Broad study of the whole Pennsylvanian basin of central New Brunswick to determine the stratigraphy and structure remains a major project. The Mississippian and Pennsylvanian formations offer an excellent opportunity for studies of sedimentary petrography and genesis. Many problems remain in Precambrian and pre-Carboniferous Palaeozoic stratigraphy, correlation, and structure.

Dr. G. M. Brownell, University of Manitoba

Southwestern Manitoba is structurally part of the northeast flank of the Williston Basin. The Palaeozoic and Mesozoic formations present are Ordovician, Silurian, Devonian, Mississippian, Jurassic, and Cretaceous. The Mississippian formations vary in thickness from 0 to 1,000 feet with an average of 320 feet at the Daly field. All of the commercial oil in Manitoba comes from the upper unit of the Mississippian, tentatively called the Madison.

The most immediate need for research appears to be a study of the Mississippian formations, particularly the subdivisions of the Madison. Oil accumulation seems to be influenced

by both stratigraphic and structural control. Research should include insoluble residue, textural, and palaeontological studies.

Dr. J. B. Mawdsley, University of Saskatchewan

(1) A detailed stratigraphic study of the Tertiary coal-bearing strata in southern Saskatchewan.

(2) The evaluation of data collected in search of the potash salt basin.

(3) Volcanic ash deposits in southwestern Saskatchewan.

(4) Petrology and stratigraphic relationships of the siliceous (Odanah) shales of eastern Saskatchewan and western Manitoba.

(5) Study of the oil-shales of the Colorado series.

Dr. P. S. Warren, University of Alberta

X (1) Investigation of the Lower Cretaceous(?) formations in the Foothills and under the Plains of western Canada. This investigation has been under way for a considerable time, both by the Geological Survey of Canada and the University of Alberta, but it is particularly important to give impetus to the study at this time.

(2) Investigation of the Rocky Mountain Trench and its relation to:

(a) The edge of the Canadian Shield
(b) The Rocky Mountains to the east
(c) The mountains to the west

(3) Investigation of the Rocky Mountains between Peace and Liard Rivers. This must be done before the structures of the Peace River basin to the east can be evaluated.

Most of these research problems would have to be undertaken by the Geological Survey of Canada.

Dr. H. C. Gunning, University of British Columbia

Concerning the coastal area of British Columbia, Dr. Gunning states, "We know far too little of the detailed geology and genetic history of the late Mesozoic and Tertiary basins of the Gulf of Georgia, Graham Island, and the west coast of Vancouver Island".

Dr. Gunning also says "... for the bulk of the area immediately east of the Rocky Mountain Trench through the entire length of British Columbia we have no adequate geologic maps and

little or no idea of the stratigraphy and structure ..... We should have an adequate long-range campaign for mapping this part of British Columbia (the western Rockies and Rocky Mountain Trench areas), starting in the southern or central part. Both regions (the Coastal and the Rockies and Trench areas) contain many problems that would be excellent for Ph.D. thesis studies. Some of the studies would yield maps and reports suitable for publication by the Geological Survey or B. C. Department of Mines. Others would yield fundamental information on stratigraphy, structure or petrogenesis of interest to the petroleum or mining industry .....".

Dr. V. J. Okulitch, University of British Columbia

It is desirable that the Geological Survey of Canada sponsor the study of the Mesozoic stratigraphy in the Peace River area. This would co-ordinate and make public information of potential economic importance that otherwise will remain scattered in the files of private companies.

It is also desirable to continue stratigraphic and palaeontological studies, coupled with structural studies, of the Rocky Mountains. The work begun by the Geological Survey north of Jasper should be pushed both north and west to provide additional east-west sections of the mountains. Particular attention should be paid to the facies changes in the Cambrian, Middle (?) and Upper Devonian, and Mississippian strata.

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.

INTRODUCTION

The National Advisory Committee at its meeting in Ottawa in January 1952, discussed the present inadequate supply of geologists in Canada and heard many suggestions regarding means of attracting suitable students to the profession. It asked the Subcommittee on Scholarship and Research Training and Dr. J. E. Thomson of Toronto to study these and other suggestions and explore the possibility of carrying out those advisable.

Certain specific suggestions included publication of a booklet at secondary school level, radio broadcasts to schools about geology, and educational and vocational guidance film strips for the high schools. The Committee felt that an annual survey should be made of the number of students studying geology in our universities and that also a study should be made of the prospective demand for geologists by mining and oil companies, government organizations, and in the academic field.

It was decided that the Secretary of the National Advisory Committee should make the annual survey of students in the universities at the same time that he circulates the request for information on research in hand. The Subcommittee on Scholarship and Research Training was asked to investigate the suggestions regarding interesting high school students, and Dr. J. E. Thomson of Toronto

was requested to co-operate with the Subcommittee in these and other investigations.

The Sub-committee is pleased to be able to report some progress in these matters and wishes to express its thanks to the Secretary of the National Advisory Committee and to Dr. Thomson who were largely responsible for the progress made. The Secretary's report on the registration of students in geology in the universities is attached hereto. In part, through his efforts, also, a vocational guidance film strip on geology is being prepared by the National Film Board for the Department of Mines and Technical Surveys. Dr. Thomson has contributed most of the section on Vocational Guidance.

VOCATIONAL GUIDANCE

The Canadian Legion Educational Services have published a pamphlet that contains a section on "geologists" and there are other similar pamphlets available from the United States. A well written and illustrated 75 page booklet has recently been published by the Boy Scouts of America as one of their Merit Badge Series. It covers the origin of the earth, rock weathering, the different kinds of rocks, ore deposits, and the development of life on the earth, and has a final chapter on geology as a profession. This booklet, however, is not available to Canadian Boy Scouts.

Many professional bodies have prepared attractive informational pamphlets or booklets for vocational guidance of teachers, but little has been done to popularize geology. The Canadian Department of Labour, Ottawa, has published a booklet in the Canadian Occupation series entitled "Careers in Natural Science and Engineering" and this includes three pages on the geologist. The "Profession of Engineering in Canada" prepared by the Engineering Institute of Canada mentions mining geology as a branch of mining engineering. These books treat all professions on an equal basis and do not pretend to popularize geology or answer the many questions a young man would ask before choosing

geology as a profession.

There is a real need for a booklet or pamphlet outlining the possibilities of geology as a profession in Canada along somewhat the same lines as the booklet on geology recently published by the Boy Scouts of America. To be attractive to the secondary school student it should be brief, non-technical, well illustrated, and emphasize the living and working conditions in the different areas of geological specialization. The different phases of geological endeavour such as petroleum; metal exploration and mining; government surveys; teaching; research, and other specialties, should be enumerated. Geophysics could be included unless the geophysicists wish to prepare a separate publication. Inasmuch as geology and geophysics are so closely allied in the practical field, any booklet on geology should include at least a section on geophysics.

The Subcommittee suggests that the gathering of information for such a booklet should be undertaken as a co-operative effort on the part of the members of the National Advisory Committee, with compilation by the Secretary or an alternate named by the Geological Survey of Canada. The Geological Survey appears to be the best body to publish such a booklet.

The Subcommittee, therefore, suggests that the National Advisory Committee recommend the preparation by the Geological Survey of Canada of a booklet on "Geology as a Profession" with the purpose of interesting young Canadians in geology. The publication should be so designed that it will be useful for vocational guidance teachers in the secondary schools.

Because geology and mineralogy are not taught in secondary schools, the teachers are less appreciative of geologists and their work and so cannot be expected to emphasize the career possibilities in this field. "Open-house nights" for high school students at

universities; "career-nights", with talks by geologists at high schools, as well as the vocational guidance film strips already mentioned, are obvious and practical methods for advancing an interest in geology. Many of the mining industries make special efforts to interest the high school students within their communities by visits to mine or industrial plants and talks to the high school students. The Subcommittee suggests that the geologists on the staffs of these industries can play a major part in student guidance to geology in these areas.

SUPPLY AND EMPLOYMENT OF GEOLOGISTS

The survey of Canadian geological students by the Secretary of the National Advisory Committee has been referred to and is attached to this report. The Engineering Institute of Canada makes an annual report on student enrolment in engineering at Canadian universities. At the request of the Chairman of this Subcommittee the Institute has included a survey of students in geology and mineralogy. The survey for 1952-53 can be found in the "Engineering Journal", vol. 35, No. 12, December 1952, p. 1326.

The two surveys, particularly at the undergraduate level, are worth consideration. The survey by the Secretary covers registration of geology students in only the last 2 years of course work but includes both Arts and Science, and Engineering geology students. It shows a possible total of 254 geology graduates by 1954 of which 186 are Arts and Science and 66 are Engineering students.

The survey by the Engineering Institute covers only the Engineering geology students but includes those in the first 2 as well as last 2 years. It shows a total of 119 prospective engineering geology graduates by 1956. As the other survey indicates 66 prospective graduates by 1954, a decrease in graduates after 1954 is indicated. Similar figures for Arts and Science geology students are not available, but if comparable it would seem that interest in geology as a

profession is decreasing rather than increasing.

This Subcommittee has been able to give only casual consideration to the large problem of possibilities for employment for geologists. In general, it can be said that there are ample opportunities for summer employment and considerable opportunity for permanent employment in the Dominion and Provincial Government departments. All report that more work would have been done if more staff had been available. To what extent lack of applicants has been due to salary offerings is hard to determine but it is generally true that the government services pay much less than the going rate offered by industry to undergraduates and recent graduates.

Significant figures are not available for industrial or educational needs. It is worth noting, however, that British Columbia reports that "the current decline in market value of lead and zinc, has led to the closure of several producing mines in British Columbia, and to a serious curtailment in the activities of a number of exploration companies. This, in addition to the continued unsatisfactory condition of the gold mining industry has thrown a number of geologists out of work at a time of year when seasonal activities are normally at a low ebb. Fortunately, this condition is off-set somewhat by continued expansion in the petroleum industry, particularly in northeastern British Columbia".

MASTER'S DEGREE

Although the foregoing topics formed the major subjects for consideration by this Subcommittee during the past year some thought has been given the question of scholarship and training at the university level.

The Subcommittee believes that the departments of geology of the universities of Canada should closely examine their program of studies for the Master's degree. The Subcommittee feels the

universities should guard against any tendency to make work for the degree largely lecture courses and laboratory instruction with only minor emphasis on original or thesis work. This Subcommittee would be the first to admit that much new "geological science" cannot be covered in the undergraduate courses. Nevertheless, Master's work is "training for research" and an appreciable part should be research, i.e., original investigation. If the Master's degree were only preliminary to the Ph.D. degree a pure study course might be best because the student needs the information and will have the chance for research later. However, the Master's degree completes the professional training for many students and its possession should be evidence that the student has shown aptitude for original work and thinking.

The Subcommittee believes it is dangerous to consider the Master's degree as only a way-station on the main line to a Ph.D. degree. Care should also be taken that it is not given as a substitute for a Ph.D. degree to a man who does not quite measure up to Ph.D. standards. The Master's degree can and should be recognition of distinct achievement beyond the baccalaureate; only if it is so considered by the universities can it be expected to have any significance in the outside world.

It is worthy of note that the Master's degree has a definite sales value today. At the Defence Research Board and the National Research Council starting salaries for holders of Master's degrees are $450. a year higher than those paid holders of Honours Bachelor degrees. This is recognition of added worth arising from the previous experience in research or original investigation that the new employee is assumed to possess. The Subcommittee believes that to justify this increased salary the product of the university at the Master's level should have spent an appreciable time at, and shown aptitude and initiative in, original work.

APPENDIX

SURVEY OF CANADIAN GEOLOGICAL STUDENTS ATTENDING UNIVERSITIES IN CANADA AND GRADUATE SCHOOLS IN THE UNITED STATES - 1952-53

SUMMARY

Canada

	Arts and Science	Engineering	Total
Undergraduates			
Expected to graduate 1953	83	29	112
Expected to graduate 1954	98	38	135
Graduates			
Candidates for Master's degree 1953	29	12	41
Candidates for Master's degree 1954	37	9	46
Candidates for Master's degree 1955	2		
Ph.D. candidates 1953			27
Ph.D. candidates 1954			19

United States

Graduates	
Candidates for Master's degree 1953	3
Candidates for Master's degree 1954	1
Ph.D. candidates 1953	31
Ph.D. candidates 1954	19
Ph.D. candidates 1955	15

GEOLOGICAL STUDENTS IN CANADIAN UNIVERSITIES, 1952-53

Undergraduates

University	Arts & Science		Engineering	
	3rd year (graduate 1954)	4th year (graduate 1953)	3rd year (graduate 1954)	4th year (graduate 1953)
	Number	Number	Number	Number
Acadia	8	5		
Alberta	16	13		1
British Columbia	13	13	10	8
Dalhousie				
Ecole Polytechnique			4	3
Laval			4	1
Manitoba	5	10	2	5
McGill	15	12		
McMaster	7	5		
Montreal	3	3		
Mount Allison	4	4		
New Brunswick	9	5		
Queen's	3	2	5	4
Saskatchewan	3		8	2
St. Francis Xavier	7	7		
Toronto	1	1	5	5
Western Ontario	4	3		
	98	83	38	29

Graduate Students

University	Master's (Arts and Science)			Master's (Engineering)			Ph.D		
	Expect to receive degree			Expect to receive degree			Expect to receive degree		
	1953	1954	1955	1953	1954	1955	1953	1954	1955
Alberta	3	9	2						
British Columbia	4	5		1	1				
Dalhousie	1	2							
Laval				1			1	2	
Manitoba	3	9							
McGill	7	6					11	9	3
McMaster	1								
New Brunswick	4								
Queen's	2	2		4	6		4	4	2
Saskatchewan	2	1		3	2				
Toronto	4			3			11	4	
Western Ontario		3							
	29	37	2	12	9		27	19	5

GEOPHYSICS STUDENTS IN CANADIAN UNIVERSITIES, 1952-53

Undergraduates

University	Geophysics (Arts and Science)		Geophysics (Engineering)	
	3rd year	4th year	3rd year	4th year
	Number	Number	Number	Number
Toronto	3	1	—	1

Graduate Students

University	Master's (Arts and Science)		Master's (Engineering)		Ph.D		
	Expect to receive degree		Expect to receive degree		Expect to receive degree		
	1953	1954	1953	1954	1953	1954	1955
Toronto	4				2	3	2
British Columbia	3	5					

CANADIAN GEOLOGICAL STUDENTS ATTENDING GRADUATE SCHOOLS IN THE UNITED STATES

University	Candidates for Doctorate degree Expect to receive degree in			Candidates for Master's degree Expect to receive degree in		
	1953	1954	1955	1953	1954	1955
Calif. Inst. Technology	1	2	1			
Univ. of California	2	1	2			
Univ. of Chicago	3					
Colorado School of Mines	1			1		
Columbia Univ.		2				
Cornell Univ.	2					
Harvard Univ.		3	1			
Univ. of Illinois	2			1		
Indiana Univ.	1					
Mass. Inst. Technology	2	2	4			
Univ. of Michigan	2	1				
Univ. of Minnesota	3	1				
Northwestern Univ.	1			1	1	
Ohio State Univ.		1				
Pennsylvania State	2(?)	1(?)				
Princeton Univ.	2	1	4			
Washington Univ.	1					
Univ. of Wisconsin	6	2	2			
Yale Univ.		2	1			
	31	19	15	3	1	

REPORT OF THE SUBCOMMITTEE ON STUDY OF BATHOLITHS

Presented by Dr. G. S. MacKenzie

INTRODUCTION

The need for comprehensive studies of batholiths has been stressed by the Subcommittees on Structural Geology and Petrology, Mineralogy, and Chemistry. The National Advisory Committee at its January 1952 annual meeting expressed agreement that such studies are needed, and as they transgress the fields of several subcommittees a special subcommittee composed of Dr. J. E. Gill and Dr. G. S. MacKenzie was appointed to inquire into and suggest specific lines of research to do with batholiths and similar granitic intrusions.

CURRENT AND RECENT WORK

Two comprehensive studies of batholiths were initiated in 1952. In British Columbia the British Columbia Department of Mines began the detailed mapping of the Kemano-Tahtsa tunnel that is being driven through several miles of the Coast Range batholith. This and a parallel geothermal study of the tunnel are outlined elsewhere in this report (page 12).

In northwestern Quebec the Geological Survey of Canada began a systematic study of the Lacorne batholith. The project is under the supervision of Dr. K. Dawson, who gives the following outline of its scope.

(1) Field investigation and collection of specimens.

(2) Laboratory work

Trace elements

Identification and distribution

Distribution of zirconium

Structural data

In country rocks

In batholith

Magnetic data

Study of available magnetometer data

Determination of magnetism of specimens

Contact metamorphism

Specific gravity data

Petrology

Description

Modal distribution of quartz and K-feldspar

Colour index

Heavy accessories

Radioactivity

Alpha scintillation counts

Nuclear track plate counts

Chemistry

Mineralogy

Dr. Dawson reports that all the above aspects are being investigated with the exception of the heavy accessory minerals, which it is hoped to begin in 1954. Work on the trace element distribution is being done at Queen's University.

It is hoped tho path of the late hydrothermal solutions in the magma may be traced by the distribution of the zirconium and the radioactivity. This would indicate where the wall-rocks are theoretically most likely to contain orebodies, and hence the best prospecting areas.

During the field season of 1953, the structural features of the batholith will be investigated more fully. It is hoped to publish in 1953 a preliminary paper with a map showing the effect of the batholith on the earth's magnetic field.

Dr. Dawson mentions the problem involved in storing the suites of specimens for such studies. Five hundred or more rock specimens have been collected from the Lacorne batholith alone. These specimens

are available for study of other aspects not covered by the present project by workers in universities or other research organizations.

In addition to the two studies mentioned above, other research on batholiths includes the study of trace elements of the batholiths of the Kirkland Lake area by the Ontario Department of Mines and at the University of Toronto and of the granites and pegmatites of the Charlebois Lake area, Saskatchewan, at the University of Saskatchewan. In New Brunswick a study of the Devonian intrusions of the southern part of the province is under way at the University of New Brunswick. Studies of the St. Stephen basic and nearby granite masses, the southern and eastern part of the main batholith, and of a dioritic pluton east of the main batholith have been completed. During the summer of 1953 it is hoped to extend the study of the northern and central intrusions and expand the scope of the work, and to correlate the intrusions with the results of aeromagnetic surveys.

RECOMMENDATIONS

Only a limited number of batholiths can be comprehensively studied; therefore, they should be selected with care. It is most desirable that those selected be as varied as possible in age, in geological and structural relations, in depth of erosion, complexity of composition, number and diversity of apophyses and related intrusions, in associated mineral deposits, and in kind and degree metamorphism. The comparative study of batholiths of apparently igneous origin with those of metamorphic origin should be undertaken. Do batholiths of diverse origin vary from each other in content and distribution of trace elements, magnetic properties, and in many of the other aspects mentioned above?

This Subcommittee recommends:

(1) That present programs of study of batholiths be continued and expanded. Batholiths to be studied in the future

should differ from those presently being studied along the lines mentioned above. Suitable batholiths would be a metamorphic batholith in the Grenville subprovince, a Mesozoic Cordilleran batholith, an Acadian or Appalachian batholith in southeastern Quebec, Gaspe, New Brunswick, Nova Scotia, or Newfoundland. The study of a Newfoundland batholith might particularly stress all aspects of the relation of the fluorite deposits to it.

(2) That the provincial geological surveys, the universities, and other provincial research organizations initiate other studies of batholiths and also assist those at present under way.

REPORT OF THE SUBCOMMITTEE ON GEOLOGICAL PUBLICATIONS

Presented by Dr. J. E. Hawley

At the 1952 annual meeting of the National Advisory Committee on Research in the Geological Sciences, a subcommittee was appointed to make a survey of geological publications in Canada, with especial reference to the outlets for publication of papers embodying results of research on geological problems as opposed to descriptive areal studies of either a regional or local character, which bulk large in the reports of various Provincial and Federal geological surveys. However, because the latter contain the results of both field and laboratory study that add greatly to our knowledge, they are included in the following brief statistical study of geological publications in Canada over the 5 year period of 1947 to 1951 inclusive.

PUBLICATIONS IN CANADIAN PERIODICALS

Canadian outlets for publication of papers on geological research include particularly the Transactions of the Canadian Institute of Mining and Metallurgy, the Transactions of the Royal Society of Canada, and the Proceedings of the Geological Association of Canada, the latter dating only from 1947. Cessation of publication of Contributions to Canadian Mineralogy, University of Toronto Press, in 1948 was unfortunate, but its place has been taken by a Canadian number in the American Mineralogist, the Journal of the Mineralogical Society of America.

Articles of a more general geological nature that apply particularly to mining and exploitation of our natural resources are published in at least four magazines, including the Canadian Mining Journal, the Precambrian, and the Western Miner.

A summary of the number of geological papers published in Canada over the 5 year period 1947-51 is given in Table I. The total yearly average of eighty papers appears impressive but the number dealing with specialized research in the geological sciences is not great; it probably does not exceed forty a year.

TABLE I

Geological Publications in Canadian Transactions, Journals, and Magazines
(1947 - 1951)

	Years	Total	Average per year
Roy. Soc. Canada (Sec. IV)	1947-51	43	8.6
	(1950-52)	17	5.4
Geol. Assoc. Canada	1947-51	26	5.2
Cont. Can. Mineralogy Univ. Toronto	1946-47	21[v]	10.2
Can. Inst. Min. Met.	1947-51	109[*]	21.8
Can. Min. Jour.	1947-51	116	23.3
Precambrian Mag.	1947-51	28	5.6
			80.1

* Including articles of general geological interest and on industrial minerals and geophysics.

v Ceased publication in Canada - See Table II, American Mineralogist.

The Transactions of Section IV (Geological Sciences) of the Royal Society of Canada, because of high costs of printing, has in recent years handled an average of about only five papers a year, though many more have been available for publication. If changes were made in the format and paper, some savings could be made and the number of articles considerably increased.

The Proceedings of the Geological Association of Canada over the 5 year period of its existence, has contained an average of only five papers a year. This Association might well expand the Proceedings as rapidly as possible and formulate a more positive policy on publication of papers on research in the geological sciences in Canada.

The Transactions of the Canadian Institute of Mining and Metallurgy, serving as it does so many divisions other than geology, has long maintained an excellent record of geological publications. It has a wide circulation and will no doubt continue as a very desirable medium for publication, but because of the demands of the other divisions of the Institute it is doubtful if much increase in the number of geological papers can be expected.

The Canadian Mining Journal publishes a large number of papers of a geological nature, not a few of which embody results of original research. On the suggestion of this Subcommittee, the editors of this Journal have agreed to publish during the coming year abstracts of unpublished Master's and Doctor's theses to the number of 96 abstracts of 150 words each. Such a service makes possible the publication of results of research that otherwise might remain buried in university libraries. It will be of value both to geologists engaged in research and to field geologists who find it difficult to keep posted on new advances in the sciences.

Geological papers of considerable interest and merit have appeared from time to time in the Precambrian and Western Miner magazines. Such papers are primarily devoted to geological discussions relating directly to the search for ores.

GEOLOGICAL PUBLICATIONS BY CANADIANS IN FOREIGN PERIODICALS

A survey of nine foreign geological and mineralogical publications, seven of which are published in the United States, shows that they contain over the 5 year period a yearly average of thirty-two papers and notes by Canadian authors (Table II). The greater number of these papers are on mineralogical topics and economic and petroleum geology. Canadians cannot but be grateful for the assistance so rendered by the American Mineralogist (supported by the Geological Society of America), the Journal of the Society of Economic Geologists, and the American Association of Petroleum Geologists.

TABLE II

Geological Papers by Canadians in Foreign Journals

(1947-1951 inclusive)

	Years	No.	Average
Bull. Geol. Soc. Amer.	1947-51	11	2.2
Amer. Jour. Sci.	1947-51	11	2.2
American Mineralogist	1947-51	49 papers 8 notes	11.4
Journal of Geology	1947-51	2 papers 2 notes	0.8
Economic Geology	1947-51	32	6.4
Am. Geophys. Union	1947-51	11	2.2
Am. Assoc. Petrol. Geol.	1947-51	35	7.
Mineralogical Magazine	1947-51	2	0.4
Geological Magazine	1947-51	0	0
			32.6

It is highly desirable that Canadian geologists continue to publish papers in foreign journals to at least some extent. However, Canadians are making a real and increasing contribution to the geological sciences and the time may come when they will need to share more adequately in the cost of the publication of the results of their research. It is clear that at present the facilities are quite inadequate in Canada for the yearly publication of the thirty odd papers that Canadians send elsewhere.

It is to be noted with some regret that publication by Canadians in British geological journals has now dwindled to an insignificant figure.

GOVERNMENT GEOLOGICAL PUBLICATIONS IN CANADA

To complete the survey of publications of geological articles of various types data have been gathered from the Geological Survey of Canada and the provincial surveys on the number of reports, memoirs, bulletins, and miscellaneous papers that have appeared over the 5 year period of 1947-51. These are listed in Table III.

TABLE III

Government Geological Publications 1947-51

Government	Memoirs or geological reports	Preliminary reports	Bulletins, misc.	Total	Yearly average
Geol. Surv., Canada	16	142	17	175	35.0
Newfoundland			7	7	1.4
Nova Scotia			39	39	7.8
New Brunswick			8	8	1.45
Quebec	23	56	2	81	16.35
Ontario	29	33	4	66*	13.2
Manitoba		29	2	31	6.2
Saskatchewan			21	21	4.2
Alberta			9	9	1.8
British Columbia			18	18	3.6
				455	91.

* Not included - 16 articles by Ontario Dept. Mines in Canadian Mining Journal 1950.

No lengthy comment on governmental geological publications is necessary. Much may be said for the issuing of preliminary reports each year so that results of new surveys and maps are made quickly available to the mining industry. Memoirs and bulletins of the Geological Survey and provincial surveys have always maintained an exceptionally high standard, which it is hoped will continue. The total yearly average of over ninety publications issued by the Geological Survey of Canada and the provincial surveys is indeed impressive.

SUMMARY

	Yearly average
Geological papers and notes published in transactions or proceedings of Canadian societies and in Canadian magazines	80
Geological papers published by Canadians in foreign periodicals	32
Geological publications by Canadian government departments	91

The number of geological papers published in Canada over the

past 5 years is considerable, but this study shows that there is need for additional outlets for articles dealing particularly with results of geological research. The publication by Canadians of some thirty papers a year in foreign journals does not place an undue burden on them, and such papers are probably welcomed, but the time will no doubt soon come when many of these should be published in Canada with Canadian funds. Expansion of publication facilities in the Transactions of the Royal Society of Canada and the Proceedings of the Geological Association of Canada is recommended.

The editors of the Canadian Mining Journal are to be commended for their co-operation in offering to publish abstracts of the geological theses of Canadian graduate students.

REPORTS OF THE SUBCOMMITTEE ON CO-OPERATIVE RESEARCH

The National Advisory Committee is anxious to promote co-operative research projects sponsored jointly by industry (mining and oil exploration companies), the universities, and government organizations. At the January 1952 meeting of the Committee Dr. H. H. Beach and Dr. D. R. Derry were asked to study ways and means by which the Committee might promote geological research projects of this type.

Dr. Beach and Dr. Derry prepared separate reports, which were presented at the April 1953 meeting of the National Advisory Committee. In these reports Dr. Beach deals with co-operative research as it applies particularly to the petroleum exploration companies and Dr. Derry as it applies to the metal mining companies. The reports follow.

CO-OPERATIVE RESEARCH AND THE PETROLEUM INDUSTRY

By Dr. H. H. Beach

The remarks that follow were formulated after discussions with many persons representing a cross-section of the exploratory divisions of petroleum industry. The writer accepts full responsibility for the interpretations drawn.

Co-operative Research

Co-operative research might be defined as the uniting of organizations of diverse major interests to investigate some natural phenomenon with the expectancy that the results attained will be mutually beneficial. Such research must be purposeful, not "research for research's sake". To be effective, research projects should be assigned periodic deadlines, when interim results are reported, permitting, where desirable, re-orientation of the scope of the problem.

There seems a general concensus that the oil industry could be attracted to co-operative effort in research with universities and governmental scientific bodies provided that:

(1) A satisfactory solution of the problems investigated can have some practical application to the oil industry as a whole;

(2) The results in whole, or in part, are reported in usable form at specific intervals of not more than 6 months, and the results be made available simultaneously to industry as a whole.

Universities and governmental bodies could be expected to provide:

(1) Research personnel and technical and administrative supervision

(2) Laboratory and library facilities

(3) Means of publication

(4) A part of the funds required to pursue the research

Oil companies could be expected to provide:

(1) Preliminary analyses of problems worth investigation

(2) Consultation in the direction the inquiry should take

(3) Basic data, specimens, samples, and other material necessary for the research

(4) Facilities for field study

(5) Part of the funds required

Funds for Co-operative Projects

Most of the points listed are readily appreciated and need no elaboration. The matter of funds, so vital to such ventures, needs amplification. It seems desirable that certain all too prevalent misconceptions be clarified. Few industries require such prodigious amounts of capital in the prosecution of business as oil exploration. The man on the street "just knows" that the profits are likewise enormous. There is probably not a single major oil company exploring in western Canada that could today come within $10,000,000 of showing a profit on its exploratory ventures. This is despite operations extending over periods as long as 35 years. It is economically possible to carry on in the red year after year only when such losses are absorbed in successes of total operations spread continent-wide or throughout the world. This is not a cry of poverty. Western Canada offers excellent potentialities for finding oil in commercial quantities. With reasonable success a company has good prospects of ultimately operating at a profit there.

Manifestly, little or no research could be accomplished if the funds required were to come from profits at the present time. Thus, managements of oil companies owe it to the shareholders, which are an appreciable percentage of the general public, to allot funds only if some tangible benefit to the organization can be expected. Companies must regard contributions of funds to co-operative research on the basis of sound investment, not on sentimental or altruistic grounds.

In the matter of aid to governmental bodies that might co-operate in research, the general feeling seems to be that fulfilment of the first four provisions is all that can reasonably be expected of industry for most projects. The heavy taxes paid by the companies should provide funds for most government sponsored research projects.

It is appreciated that universities would require that a fairly large percentage of the funds for any specific worth-while project be provided by industry. This might be accomplished either through individual

company contributions or through some form of general assessment levied by some such organization as the Canadian Petroleum Association. The latter course has many advantages in that committees of that body, representing as it does virtually the entire petroleum industry in western Canada, could recommend worth-while projects and arrange realistic co-operation in providing basic data and study material. Under such a setup a few worth-while projects could be devised each year and the lists presented to universities for consideration.

In like manner, governmental research bodies could be made aware of desirable research projects.

These generalities can be emphasized by a few specific examples.

Co-operation with Governmental Research Groups

For many years the Geological Survey of Canada was universally recognized in western Canada as the body most competent to rule upon desirable stratigraphical nomenclature and in matters related to geological age and correlation of strata. Concomitant with greatly increased geological activity in the West, the Survey has seemed content to let this task be assumed largely by local geological societies and even individual companies and sample service organizations. The urgency of obtaining a desirable formation nomenclature undoubtedly justified to some extent non-governmental organizations stepping into this role. Continuation of such practice is dangerous and could easily lead to a terminology that will not stand the test of time. This condition happened in the early days of Turner Valley with the use of such terms as "Dakota", "Benton", and "Madison"; all are acceptable names in Montana, but unjustified in Alberta. If the Geological Survey would again assume the role of disinterested arbitrator in such matters, the co-operation of the industry would almost certainly be forthcoming. Every geological system and, indeed, nearly every formation is in dire need of careful definition and description.

The need of a lexicon of geological names for western Canada is apparent. Its preparation could be accomplished in reasonable time if the task of basic research were apportioned out to all organizations employing mature geologists.

There are scores and probably hundres of maps issued in past years by governmental bodies that are not generally known to practicing geologists, because they have never been catalogued in readily usable form.

Co-operation with Universities

As examples of projects that could be tackled by universities with financial and practical assistance from the oil industry, the following merit consideration. The problems are legion, however, and the oil industry needs the solutions. It only remains to effect a practical liaison between the fully competent scientific institutions of Canada and its petroleum industry. It is not implied that all or even any of the projects outlined by the writer would meet with universal appeal from industry. Any such selection must await the creation of a disinterested body capable of co-ordinating diverse opinions of operators.

Examples:

(1) The process of dolomitization of limestone reefs

(2) The palaeo-ecology of reefs

(3) The origin of chert and its environmental implications

(4) The mechanics of sand lens disposition in predominantly marine environments

(5) The major facies changes in different geological systems

(6) The origin and deposition of primary and secondary anhydrite

(7) The geological significance of anhydrite in carbonate rocks

(8) Criteria for the determination of the age of earth fluids relative to their reservoirs

Conclusion

It is suggested that the Canadian Petroleum Association be invited by the National Advisory Committee to express its views on the feasibility of participating in co-operative research projects along the lines suggested in this report.

CO-OPERATIVE RESEARCH

By Dr. D. R. Derry

It should be realized at the start that many of the larger oil and mining companies carry out research on geological problems and that in many cases this research goes beyond problems of direct commercial application. Such cases, however, are not within the scope of the present investigation, because although the companies may permit publication of some of the results, such research is entirely their own. The National Advisory Committee is interested in promoting the type of research that would not normally be undertaken by any one company but that might be of interest to them as a co-operative project, particularly if the personnel and/or part of the cost were supplied by a research organization.

One suggestion might be that a special research fund be raised, to which both companies and the government should subscribe and which would be available for investigating broad problems affecting several companies. It is felt, however, that such a fund would not receive wide support from most companies because of the uncertainty as to how and on what problems the money would be spent. It must be remembered that those who make the decisions in budget matters in mining and oil companies are rarely geologists. Therefore the company geologist must act as advocate and have strong specific arguments to obtain support for a project. A specific problem is much more likely to get financial support from a company than a general program of research, especially if it is pointed out that a governmental organization is paying part of the cost.

It is obvious that if a governmental organization is paying part of the cost the problem selected should be one that is of interest to more than one company, otherwise criticism of a political nature is apt to arise. Having selected a problem of interest to several companies a geologist must be found who is interested enough in the problem to personally sell it to the companies likely to benefit. A circular letter would not have the d.sired result.

It would seem that the first step would be for the National Advisory Committee to go on record as favouring such co-operative projects.

The following are types of problems of interest to mining companies that might be suitable for co-operative effort:

(1) A study of the depth and attitude of the buried parts of the Sudbury eruptive, by investigation of both the bottom of the norite and the top of the micropegmatite by geophysical methods and structural studies.

(2) A study of the Rocky Mountain Trench, its attitude, origin, and relation to the centres of mineralization along the west side.

(3) Problems connected with the Coast Range batholith, the "roof pendants" within it, and the associated ore deposits.

APPENDIX I

GENERAL CONDITIONS GOVERNING AWARD OF GRANTS FOR GEOLOGICAL 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 TO CANADIAN UNIVERSITIES 1952-53

UNIVERSITY OF BRITISH COLUMBIA

Biogeochemistry of Manganese, Iron, and Magnesium

Applicant - Dr. H. V. Warren — Amount - $1,750

Stability of Minerals under Hydrothermal Conditions

Applicant - Dr. W. H. Whyte — Amount - $1,000

UNIVERSITE LAVAL

Refinement of Approximate Optical Data

Applicants - Dr. P. E. Auger and Dr. F. F. Osborne — Amount - $2,000

UNIVERSITY OF MANITOBA

Induced Radiation in Rocks, Minerals, and Ores and Radioactivity Distribution about Manitoba Batholiths

Applicants - Dr. G. Brownell and Dr. H. D. B. Wilson — Amount - $2,600

MCGILL UNIVERSITY

Investigation of the Origin of Fracture Patterns in Heterogeneous Media

Applicant - Dr. J. E. Gill — Amount - $ 790

Distribution of Ca, Na, K, Fe, and Mg in Altered Zones around Sulphide Mineralization

Applicant - Dr. J. E. Riddell — Amount - $ 770

Assimilation of Copper, Zinc, and Lead by Trees and Lesser Plants in Eastern Canada

Applicant - Dr. J. E. Riddell — Amount - $ 300

MCMASTER UNIVERSITY

Relative Importance of Micro-fossils, Tree and Non-tree Type, In Recent Deposits

Applicant - Dr. A. Radforth — Amount - $1,410

Spectrochemical Investigations of Trace Element Distribution

Applicant Dr. D. M. Shaw — Amount - $1,200

QUEEN'S UNIVERSITY

Chemical and X-Ray Study of Safflorite-Loellingite

Applicant - Dr. L. G. Berry — Amount - $ 600

Correlation of Coal Seams of Cape Breton Island by Trace Element Study

Applicant - Dr. J. E. Hawley — Amount - $ 330

Trace Element Studies of Granite Batholiths

Applicant - Dr. J. E. Hawley — Amount - $ 308

Geochemistry of Platinum Metals

Applicant - Dr. J. E. Hawley — Amount - $ 264

Spectrographic Analysis of Major and Minor Constituents of Igneous Rocks and Minerals

Applicant - Dr. J. E. Hawley — Amount - $1,200

UNIVERSITY OF TORONTO

Technical Assistance in Geological Age Determinations

Applicant - Dr. J. T. Wilson — Amount - $2,100

Petrographical Comparison of Iron Formation of Port Arthur and Mesabi Range

Applicant - Dr. W. W. Moorhouse — Amount - $1,500

UNIVERSITY OF EST RN ONTARIO

Heat Flow Measurements in Kemano Tunnel, British Columbia

Applicant - Dr. A. D. Misener — Amount - $1,000

GEOLOGICAL SURVEY OF CANADA RESEARCH
GRANTS TO CANADIAN UNIVERSITIES
1953-54

UNIVERSITY OF BRITISH COLUMBIA

Geological Investigation of Kemano Tunnel, British Columbia

Applicant - Dr. H. C. Gunning — Amount - $1,494

This tunnel, which is being driven through part of the Coast Range of British Columbia, gives a fine cross-section of part of the Coast Range granite batholith and its contact zone. The study of the geology of the tunnel will also be of interest from the engineering point of view. The study is being undertaken by the British Columbia Department of Mines and the University of British Columbia with the co-operation of the Aluminum Company of Canada.

Biogeochemistry of Cobalt and Nickel

Applicant - Dr. H. V. Warren — Amount - $1,800

Preliminary work has demonstrated that the cobalt and nickel content of vegetation varies greatly. There is some evidence that this content may also vary in such a way that it may be used in prospecting for buried orebodies. The project will explore this possibility.

DALHOUSIE UNIVERSITY

Comparison of Nova Scotian and Death Valley Borate Deposits

Applicant - Dr. N. R. Goodman — Amount - $ 650

Mr. Goodman has spent much time in the study of the Nova Scotia deposits. The purpose of this grant is to allow him to visit and study the Death Valley deposits in the United States, which are somewhat similar. It is hoped that the comparison of the two deposits may aid in solving the origin of the Nova Scotian deposits.

UNIVERSITY OF MANITOBA

Study of Induced Radiation in Minerals, Rocks, and Ores

Applicant - Dr. G. M. Brownell — Amount - $1,500

This is an investigation of the possibility of using induced radiation to identify and quantitatively measure the proportions of certain elements in samples of rocks, ores, and minerals. It is hoped to establish new and rapid methods of quantitative analysis for these elements by this means.

McGILL UNIVERSITY

Enthalpy Changes in Metamorphic Reactions and their Geologic Significance

Applicant - Dr. V. A. Saull — Amount - $1,500

It is probable that many important reactions in progressive metamorphism of rocks are exothermic. The objective of this project is to develop an accurate method of measuring enthalpy changes in geologically important chemical reactions of this type.

MCMASTER UNIVERSITY

Relative Importance of Micro-Fossils, Tree and Non-tree Type

Applicant - Dr. N. W. Radforth Amount - $1,610

Using techniques developed in recent months, attention will be directed more towards micro-fossils in mineral strata than in organic debris. From micro-fossil populations isolated from these, comparisons will be made with populations in buried peats and other submerged and trapped masses of organic debris. Results of these comparisons will be utilized in interpreting paleo- and recent physiographic phenomena in sedimentary formations.

Geochemical Studies in Regional Metamorphism

Applicant - Dr. D. M. Shaw Amount - $1,850

This project involves the study of the chemical compositions of sedimentary rocks and their changes when metamorphosed or altered. The data obtained will give information on the composition variation during metamorphism, and will have a bearing on the origin of ores and minerals.

Spectrographic Investigation of Deep Sea Manganese Nodules

Applicant - Dr. Z. L. Sujkowski Amount - $ 975

This investigation involves determination of the rare elements in deep sea manganese nodules and a comparison with nodules found in Canadian Lakes. This work was started by Dr. Sujkowski a few years ago in the Mineralogical Department of the British Museum and the microscopical and colourometric - chemical part of the research is finished. Dr. Sujkowski has now left England to join the Geological Department of McMaster University and this grant is to allow him to complete the project.

QUEEN'S UNIVERSITY

Spectrographic Study of Cape Breton Coals

Applicant - Dr. J. E. Hawley Amount - $ 280

This project has a threefold purpose:

(1) To aid in the correlation of individual coal seams, which is of great interest in the development and mining of the coal.

(2) To determine the relation between trace element distribution and the petrographic divisions of the seams.

(3) To determine the distribution of germanium in the seams, which is of possible economic importance.

In this study Dr. Hawley and his assistants are working in co-operation with the Sydney office of the Geological Survey.

Geochemistry of the Platinum Metals in Sulphides

Applicant - Dr. J. E. Hawley — Amount - $ 170

This study has been under way for some time, and methods of spectrographic analysis for these metals have been developed. The objective is to further study the distribution of Pt, Pd, Rh, Ir, Ru, and osmium in metallic sulphides and determine concentrations in ores. Practically no data are at present available on the latter four metals.

(1) Trace Element Study of Preissac-Lacorne Batholiths

Applicant - Dr. J. E. Hawley — Amount for (1), (2) and (3) - $3,227

This is part of a complete study of these batholiths being sponsored by the Geological Survey of Canada. It is hoped to establish the individual characteristics of the batholiths with respect particularly to associated ores of molybdenum and lithium.

(2) Analyses of Major Constituents in Silicate Rocks

The spectrochemical analysis of silicate rocks offers a much more rapid and in some respects more accurate method than straight chemical analysis. This project involves research to further perfect the method that was first developed by the Mass. Inst. Technology and the United States Geological Survey.

(3) Study of Secondary White Micas and their Alkali Content

These micas are commonly associated with ore deposits. Their study is most important in relation to ore deposits and also to regional metamorphism.

Upper Cretaceous Pelecypods from Vancouver Island, B.C.

Applicant - Dr. J. L. Usher — Amount - $ 400

This is a palaeontological study and will supplement a stratigraphical and structural investigation of the coalfields of the Island. It will bring up-to-date, information on the palaeontology, stratigraphy, and the correlation of this important series of rocks.

UNIVERSITY OF SASKATCHEWAN

Spectrophotometric Determination of the Composition of Minerals Associated with Uraninite-bearing Deposits of Charlebois Lake Area, Saskatchewan

Applicant - Dr. J. B. Mawdsley — Amount - $2,565

This project includes:

(1) A study of the apparent relationship between composition of the feldspars and radioactive content of the pegmatites.

(2) Study of the relation between the degree of metamorphism and the radioactive content of the pegmatites, that is, the over-all temperature control in the formation of the deposits.

Several other problems to do with metamorphism petrology, and radioactive content of granites, wall-rock alteration associated with the sulphides in the Flin Flon area, and the determination of calcium, magnesium, etc., in carbonate sediments, will also eventually be investigated.

UNIVERSITY OF TORONTO

(1) Petrographic Comparison of the Iron Formations of the Mesabi Range and the Port Arthur Region

Applicant - for (1) and (2)
Dr. W. W. Moorhouse — Amount - $ 800

This project has as its objective an attempt to establish the difference between the iron formations in the Mesabi and Port Arthur areas in order to evaluate the economic possibilities of the Port Arthur area and to determine the conditions of deposition of the iron-bearing rocks.

(2) Differentiation and Assimilation on the Logan Sills, Port Arthur

This project involves a chemical and petrographic study of these intrusions to determine the relative importance of differentiation and assimilation in the origin of the different phases of these rocks.

Construction of Microscope Cooling Stage

Applicant - Dr. F. G. Smith — Amount - $ 400

There is need for temperatures far below room temperature while examining fluid inclusions in minerals under the microscope. This grant will be used to build apparatus so that these low temperatures may be obtained. The study of the fluid inclusions may lead to a reliable method of determining the temperatures at which the minerals were formed, which is of the greatest importance in the study of ore deposits.

Air Photo Study of Foothills and Eastern Rockies

Applicants - Drs. Beales and Tovell — Amount - $ 130

Both applicants for this grant have mapped in parts of the region. Much of the belt, however, has never been geologically studied. The purpose of the air photo study is an attempt to arrive at a structural and stratigraphic synthesis of the region.

Geological Age Determinations

Applicant - Dr. J. T. Wilson — Amount - $3,220

This research is primarily concerned with determining the abundance ratios of isotopes of lead extracted from radioactive ores of uranium and thorium, in order to measure the time since

the minerals were deposited. The age of the older rocks of the Canadian Shield is a major problem and research of this type gives promise of solving it and enabling us to determine the age of the granitic rocks and of the sedimentary and volcanic rocks isolated within them.

UNIVERSITY OF WESTERN ONTARIO

A Boulder Train of Iron Ores South of Steeprock Lake, Ontario

Applicant - Dr. A. Driemanis Amount - $ 500

The major part of this boulder train was studied by Dr. Driemanis for a mining company in 1951. It was thought the ore boulders came from the area west of Steeprock Lake, but it was found that changes in ice flow direction were responsible for an abnormal form of the boulder train. It was concluded the boulders came from the Steeprock deposit and the study was stopped 4 to 5 miles north of Steeprock Lake.

The present grant will allow Dr. Driemanis to add the 20 to 25 square miles needed to complete the study, which will serve as an example for prospecting for ore deposits by boulder trains. Although this prospecting method has been used with success in Norway, Finland, and Sweden, it is not popular in Canada. A description of a local example may stimulate its application.

Thermal Measurements in Kemano Tunnel, British Columbia

Applicant - Dr. A. D. Misener Amount $1,910

The Kemano tunnel presently being driven through part of the Coast Range of British Columbia offers an opportunity to measure the heat flow in the earth in this region. If we are to understand the earth and its fundamental processes, such as mountain building, more data are required about its properties. Heat flow in the earth is some of the basic information that is required and a tunnel through a mountain range offers an excellent opportunity to get a good average value for this region.

APPENDIX III

EQUIPMENT AVAILABLE FOR GEOLOGICAL RESEARCH IN CANADIAN UNIVERSITIES AND GOVERNMENT LABORATORIES 1953

	Acadia Univ.	Univ. of Alberta	B.C. Dept. Mines	Univ. of B.C.	Dalhousie Univ.	Ecole Polytechnique	Geol. Surv., Canada	Univ. Laval	Manitoba Mines Br.	Univ. of Manitoba	McGill Univ.	McMaster Univ.	Univ. of Montreal	Mt. Allison Univ.	Univ. of N.B.	Newfoundland Dept. of Mines and Resources	Ontario Dept. Mines	Quebec Dept. Mines	Queen's Univ.	Saskatchewan Dept. Natural Resources	Univ. of Sask.	St. Francis Xavier Univ.	Univ. of Toronto	Univ. of Western Ontario
Microscopes																								
Petrographic	2	10	3	22	5	6	40	9	3	18	25	8	3	2	12	2	3	8	20	4	15	2	53	10
Mineralographic		4	1	15	4	a	8	3		22	10	6	2		1			2	20		1	1	10	10
Research	a	2	1	3		a	4	3		2	4	2	1		2			1	9		1	1	13	1
Binocular	a	10	4	3	1	3	34	5	2	8	4	5	1		1	1	2	5	2	4	5	1	12	1
Electron											a												a	
Photomicrographic equip.		x	x	x	x	x	x	x		x	x	a	x		x			x	x		x	x	x	x
Thin section preparator			x	x	x	x	x		x	x	x	x	x		x			x	x		x		x	x
Rel. fluorescence analysis unit							x				x													
Spectrographic equip.		a	x	x	a	x	x	a		a	a	x			a		x	x	x		a	a	a	
Mass spectrometer							(x)	a				a											x	
Thermal equip., furnaces, etc.	a	a	x	x		a		x		x	x							x	x		a		x	x
Differential thermal analysis	a	a				a					x							x			a		(x)	
Radioactivity lab.		a					x	a		a							x	x			a		x	a
Geiger counter			x	x		x	x	a			x	a		x	a	x	x	x	x	x	x	x	x	
Optical equip.																								
Univ. stage			x	x	x		x	x		x	x	x			x			x	x		x		x	
Refractometer	a		x	x	x	a	x	x		x	x	x			x			x	x		x	x	x	
Monochrometer			x	x			x			x	x	a						x	x			x	x	a
Geophysical equip.																								
Magnetometer				a			x				x				a	x	x	x	x				x	x
Dip needle	a		x	x		x	x	a		x	x		a		a	x	x	x	x	x			x	a
Electrical		a						a		x						x			x				x	
Gravimeter								a															a	
Assaying lab.		a	x	a			a	a	x		a				a		x	x	a		a		a	
Infrasizer				x			x	a			a							x	a				a	
Superpanner				x			x	a			a							x	a				a	
Magnetic separator				x		a	x	a			(x)							x	x				a	
Diamond or Di-Met saw		x	x	x	x	x	x	x	x	x	x	x	x		x	(x)		x	x		x		x	x
Machine shop		a	a	a		a	x	a		a	a	a	x					x	a		a		x	
Flame photometer											x								(x)		(x)			

x - Equipment on hand (x) - Equipment on order a - Equipment available