CANADA

# NATIONAL ADVISORY COMMITTEE ON RESEARCH IN THE GEOLOGICAL SCIENCES

## FOURTH ANNUAL REPORT
## 1953-54

(Including Survey of Current Research in the Geological Sciences in Canada, 1953-54)



Price 50 cents

OTTAWA

Published, December 1954, by the Geological Survey of Canada,
Department of Mines and Technical Surveys

# NATIONAL ADVISORY COMMITTEE ON RESEARCH IN THE GEOLOGICAL SCIENCES

## FOURTH ANNUAL REPORT

## 1953-54

(including Survey of Current Research in the Geological Sciences in Canada, 1953-54)

Ottawa, Canada,
October 15, 1954

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

Sir:

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

Respectfully submitted,

George Hanson

George Hanson,
Chairman.

## CONTENTS



## FOURTH ANNUAL REPORT



## CURRENT RESEARCH IN GEOLOGICAL SCIENCES IN CANADA, 1953-54

## MEMBERS OF COMMITTEE

| | |
|---|---|
| Dr. George Hanson (Chairman) ..... | Geological Survey of Canada, Ottawa, Ont. |
| Dr. P. E. Auger ..... | Laval University, Quebec, Que. |
| Dr. D. M. Baird ..... | Dept. Mines and Resources, St. John's, Newfoundland. |
| Col. P. D. Baird ..... | Arctic Institute of North America, Montreal, Que. |
| Dr. H. H. Beach ..... | Texaco Exploration Co., Ltd., Calgary, Alta. |
| Dr. G. M. Brownell ..... | University of Manitoba, Winnipeg, Man. |
| Dr. A. E. Cameron ..... | Nova Scotia Technical College, Halifax, N.S. |
| Dr. G. H. Charlewood ..... | Dept. Mines and Natural Resources, Winnipeg, Man. |
| Dr. D. R. Derry ..... | Rio Canadian Explorations, Ltd., Toronto, Ont. |
| Dr. J. E. Gill ..... | McGill University, Montreal, Que. |
| Dr. H. C. Gunning ..... | University of British Columbia, Vancouver, B.C. |
| Dr. J. E. Hawley ..... | Queen's University, Kingston, Ont. |
| Dr. I. W. Jones ..... | Dept. of Mines, Quebec, Que. |
| Dr. C. S. Lord ..... | Geological Survey of Canada, Ottawa, Ont. |
| Dr. G. S. MacKenzie ..... | University of New Brunswick, Fredericton, N.B. |
| Dr. J. B. Mawdsley ..... | University of Saskatchewan, Saskatoon, Sask. |
| Dr. H. Sargent ..... | Dept. of Mines, Victoria, B.C. |
| Dr. J. E. Thomson ..... | Dept. of Mines, Toronto, Ont. |
| Dr. P. S. Warren ..... | University of Alberta, Edmonton, Alta. |
| Dr. J. T. Wilson ..... | University of Toronto, Toronto, Ont. |
| Dr. J. F. Henderson, Secretary ..... | Geological Survey of Canada, Ottawa, Ont. |

Meetings:

April 24, 1954, Victoria Memorial Museum, Ottawa, Ont.

## EXECUTIVE COMMITTEE

| | |
|---|---|
| Dr. George Hanson (Chairman) ..... | Geological Survey of Canada, Ottawa, Ont. |
| Dr. J. E. Gill ..... | McGill University, Montreal, Que. |
| Dr. J. E. Hawley ..... | Queen's University, Kingston, Ont. |
| Dr. C. S. Lord ..... | Geological Survey of Canada, Ottawa, Ont. |
| Dr. J. F. Henderson (Secretary) ..... | Geological Survey of Canada, Ottawa, Ont. |

Meetings

May 31, 1954, Victoria Memorial 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 work.

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 suggestions must come 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.

GEORGE HANSON,
Chairman

# THE YEAR IN REVIEW

## INTRODUCTION

Most of Canada, including large regions in the northern part of the Precambrian Shield, the Arctic Islands, northern British Columbia, and Yukon Territory, is as yet geologically unmapped. Consequently, the efforts of our federal and provincial geological surveys and the geologists of many of the larger mining and oil companies have been directed primarily to geological mapping to find out the distribution of the rocks and thus the most favourable areas in which to seek mineral deposits and reservoirs of oil and gas. The geological mapping of our country is basic research of the first order and has deserved and will continue to deserve the highest priority. However, in the past few years with the use of modern aircraft a remarkable change has occurred in the rate of the geological mapping of Canada.

Ten years ago only 11 per cent of Canada had been geologically mapped, and at that time it was pointed out[1] that with no increase in the speed of mapping it would take 800 years to map the remaining 89 per cent. But within the past 3 years, by the combined use of conventional aircraft and helicopters, areas of 57,000 and 67,000 square miles in our northern barren grounds have been geologically mapped in single field seasons of 4 months by only four geologists[2] — areas that might have required 25 to 30 years to map in comparable detail by conventional ground methods. These projects have demonstrated that we now have a method whereby the geological mapping of a vast region difficult of access can be completed within a few years and, because somewhat similar methods will be applicable to many other regions of Canada, we can now foresee completion of the preliminary geological mapping of Canada, not in hundreds of years but in a few decades; and it will be accomplished by a much smaller number of geologists than would have been possible by older methods.

[1] Chipman, K.G., and Hanson, George: Mapping by the Bureau of Geology and Topography; Trans. Can. Inst. Min. and Met., vol. XLVII, 1944, p. 108.

[2] Lord, C.S.: Operation Keewatin, 1952: A Geological Reconnaissance by Helicopter; Trans. Can. Inst. Min. and Met., vol. LVI, 1953.

The preliminary geological mapping of Canada is our primary objective, but it must be accompanied and followed by detailed studies of a more basic and fundamental nature. We have been engaged mainly in finding out the distribution of the rocks that underlie our country; with the collection of observed facts from which we have formed hypotheses largely unbacked by detailed studies and experimental data. Now that our primary objective is in sight we can and must devote more effort to detailed field studies of specific problems backed by accompanying laboratory research. Only by such studies, using many of the techniques newly probided by the physical sciences, can we hope to solve many fundamental problems, such as how granites and other igneous, metamorphic, and sedimentary rocks are formed and how mountains and continents are built; only by such studies can we hope to find out more about the factors that control the formation of mineral deposits and oil and gas reservoirs and to develop new geological and geophysical techniques to aid in finding them. Therefore, in this report as in our previous ones we stress the need for greater emphasis on fundamental field and laboratory research by the federal and provincial geological surveys, by our universities, and by mining and oil companies.

## RESEARCH FACILITIES OF THE GEOLOGICAL SURVEY OF CANADA

As one important and specific means of increasing the facilities for more basic and fundamental geological research, this Committee has, from its inception, urged expansion of the laboratories of the Geological Survey of Canada, including provision of a suitable building to adequately house it. Since 1950 considerable progress has been made in provision of equipment and personnel to carry out the more fundamental types of research so much needed to supplement field studies; and we believed that construction of a new building would start in 1954. The delay in provision of the building is a matter of keen disappointment to the Committee. At present, dispersal of personnel and laboratories in seven widely separated buildings seriously impairs efficiency. Different phases of laboratory investigation must be carried on in buildings miles apart, with consequent inconvenience and loss of time to personnel. Most important, discussion of common problems among the geologists is hampered, full use of library facilities is difficult, and complete co-ordination and efficient over-all administration is practically impossible.

It is our hope that plans for the building quickly reach fruition and that its construction will be started early in 1955.

## RESEARCH GRANTS TO UNIVERSITIES

For the past 4 years, at the instigation of this Committee, funds have been provided by the Federal Government to the Geological Survey of Canada for grants-in-aid to stimulate and support fundamental geological research in our universities. In 1951, $10,000 was provided, and this amount was increased to $20,000 in 1952 and $25,000 in 1953 and 1954. Applications for grants, which are submitted to the Director, Geological Survey of Canada, are reviewed by the National Advisory Committee and the grants are awarded by the Geological Survey on the basis of these recommendations. Twenty-eight research projects in nine universities are currently being supported; twelve additional projects have been completed.

Summary reports on completed projects and progress reports on continuing and uncompleted projects that are achieving results of interest are given in an Appendix to this report (p.48). Also given in an Appendix (p. 58 ) are grants awarded in 1954, with descriptions of the projects they are supporting.

As seen from the reports on projects initiated in 1951 and 1952 (p.48), the grants are not only achieving their purpose of stimulating research and providing training in research in our universities, but are already producing results of real interest and value. Thus, biogeochemical research at the University of British Columbia has given us a new prospecting tool that is being widely used in Canada by many of our major mining companies and is already credited with finding ore orebodies. At the University of Toronto two new methods of age determination of common lead and potassium minerals have been developed; in addition, several hundred age determinations of minerals have been made that make necessary considerable revision of our earlier concept of Precambrian time. At the University of Manitoba considerable success is being attained in the use of induced radiation to identify and quantitatively measure the proportions of certain elements in rocks, ores, and minerals; a method that requires little preparation of the material and is extremely fast. Several other projects have achieved equally successful and interesting results.

Each year the number of applications and the aggregate amount applied for have increased. Thus, in 1954 the applications totalled more than $45,000. It is apparent that a larger sum than the $25,000 presently available could be well and efficiently spent in support of worth-while projects.

## ANNUAL SURVEY OF CURRENT RESEARCH

On the recommendation of the National Advisory Committee, the Geological Survey of Canada for each of the past 3 years has compiled and published the results of an annual survey of current research in the geological sciences in Canada[1]. This compilation includes available information on geological research in Canada by the universities, the federal and provincial departments of mines, some mining and oil companies, and other institutions that do geological, geophysical, and mineralogical research. In addition, an annual survey of Canadian geological students attending Canadian universities and post-graduate schools in the United States was started in 1952 to indicate, over a period of years, 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.

[1] Current Research in the Geological Sciences in Canada, 1950-51, 1951-52, 1952-53; Geol. Surv., Canada.

The separate publication of the annual survey of current research and the report of the National Advisory Committee has resulted in some duplication of material. The National Advisory Committee, therefore, recommended that the survey of current research be included in the Annual Report. This recommendation has been followed and "Current Research in the Geological Sciences in Canada, 1953-54" makes up the second part of this report (p. 65 ). The delay of 6 to 8 months in publication of the survey of current research, which is completed in the spring of each year, is more than compensated for by the convenience of having the two reports in one volume.

## SUBCOMMITTEE REPORTS

(Summary Statement)

The reports of the subcommittees, which cover the different fields of the geological sciences in Canada, are given in full in a later section (p. 7 ). They include brief reviews of geological research in these fields and suggestions as to problems particularly in need of study. The reports were presented by the subcommittee chairmen at the annual meeting of the National Advisory Committee (1954) where they formed the basis for much of the discussion.

Summaries of the reports follow.

The Subcommittee on Physical Methods Applied to Geological Problems summarizes the developments that have taken place in 1953 in the physical study of the earth, with special reference to Canada -- a year probably more productive in progress than any in the past. It includes brief accounts of advances in geophysical prospecting, seismology, gravity, age of the earth, age of rocks, carbon - 14 ages, studies of non-radiogenic

isotopes, temperatures and thermal history of the earth, and theories of mountain building.

The report notes that although nature operates according to laws that are universal, there is a tendency to divide Natural Science into a number of smaller sciences and erect artificial barriers between them. This is especially true of the study of the earth, where the sciences of geology, geodesy, and geophysics each proceed largely indeperiently of the others. Growth of knowledge has brought these studies to the point where they must be considered together. This more general, combined attack has already proved fruitful and must be continued. If geology is to remain truly the science of the study of the earth, it must expand its horizons. By so doing it will be placed on a sounder scientific basis and a much fuller grasp of the nature and operation of the earth will be obtained.

In discussing the report at the annual meeting (1954), members of the Committee remarked on the excellent work in progress on gravity and seismic research at the Dominion Observatory, which is outlined in the report; this research is of great interest to geologists. Mention was also made of the valuable physical research in progress at the University of Toronto, particularly that on determination of the age of rocks.

The Subcommittee on Metallic Mineral Deposits discusses briefly a few of the more general of the 80 projects being carried on in Canada that are directly concerned with metallic mineral deposits. An increased interest is apparent in the development and application of geochemical and biogeochemical methods of prospecting for copper, zinc, lead, and nickel. A number of research projects are suggested and discussed. These include further studies of the fifteen major bodies of ultrabasic rocks in Newfoundland; further study of the copper deposits in Pennsylvanian sandstones in New Brunswick along the Bay of Fundy; and a thorough investigation of the feasibility of using geochemical and biogeochemical prospecting methods in the permafrost regions of northern Canada.

The Subcommittee on Structural Geology briefly reviews the more important structural studies in progress in Canada in 1953. These include: an extensive program of geological mapping in the Arctic Islands; the study of the stratigraphy and reef structures in the eastern Rocky Mountains; the stresses causing "bumps" and related phenomena in the deeper coal mines of Nova Scotia and Alberta; long term structural studies of the "Grenville Front" and of the structure of the Eastern Townships in Quebec; study of the Salmo-Pend'Oreille lead-zinc-tungsten belt in British Columbia; and in Ontario, detailed studies of the Whitewater series of the Sudbury Basin, and of the structure and stratigraphy of the Porcupine area and of the north shore of Lake Huron. Progress is reported on the geological study of the Kemano-Tahtsa tunnel and on the compilation of the structural map of British Columbia, both of which projects are nearing completion. In the Maritime Provinces a large amount of structural and other data is becoming available as a result of the widespread search for sulphide deposits following discovery of those in the Bathurst area. The report recommends prompt action on the part of the provincial governments to have this information recorded, before it is lost.

The report recommends further detailed studies of individual folds and faults and experimental research to produce them in the laboratory. Other projects suggested include further detailed studies of the Rocky Mountain Trench, detailed mapping of the area between the Porcupine and Kirkland Lake gold belts, detailed study of the granites of the Burin Peninsula, Newfoundland, and associated fluorite deposits, and detailed structural studies of the Grenville Province in Ontario. Further study of aeromagnetic maps in relation to exposed bedrock is recommended so that they may be of greater use in the interpretation of geology beneath drift-covered areas.

In the discussion of this report at the annual meeting (1954) the Chairman, in reply to a question on the policy of the Geological Survey in selecting areas for aeromagnetic mapping, stated that when an area has been demonstrated to be of sufficient interest for private enterprise to do aeromagnetic work, no further work of this type is done there by the Geological Survey. Thus, in the Bathurst area of New Brunswick, the preliminary aeromagnetic mapping was done by the Survey, but when commercial orebodies were found, subsequent aeromagnetic work was left to private enterprise.

In regard to the correlation of geology with aeromagnetic maps, Dr. Thomson stated that the Ontario Department of Mines had assigned geologists to correlate aeromagnetic with detailed geological maps and known regional structures. Large discrepancies between the two had been found and, on the whole, attempts at correlation had not been too successful. However, he and other members agreed that this only emphasized the need for more research to find out the reasons for these discrepancies.

The Subcommittee on Petrology, Mineralogy, and Chemistry reviews briefly a few of the more general of the more than 100 projects being carried on in Canada in these branches of geology. The importance of age determinations of rocks and minerals is stressed and the program of age determination research recently initiated by the Geological Survey is outlined. Some important additions to laboratory equipment for geological research in Canada in 1953-54 are noted. Ten additional research problems are listed as being worth investigation and, in addition, several more general projects are suggested, including the assembly, in a central file, of all available rock analyses in Canada.

In the discussion of this report at the annual meeting (1954) it was agreed that a central file of all rock analyses would be useful, but difficulties were foreseen in assembling the analyses and it was felt not enough was known of the magnitude of the task. Dr. G.S. MacKenzie, with the aid of Dr. K.R. Dawson, Geological Survey of Canada, was asked to look into the project more fully, including consultation with the federal and provincial geological surveys and the universities.

The Subcommittee on Pleistocene Geology reviews the work accomplished across Canada in 1953. In discussing the projects that should be undertaken, mention is made of the slow progress in compilation of a Pleistocene map of Canada, a project recommended by the Subcommittee in 1951. It is suggested that greater use might be made of glacial geology in prospecting for ore deposits beneath areas covered by glacial drift and forest. Further work is suggested on sedimentation processes involved in the deposition of varves.

The Subcommittee on Non-Metallic Mineral Deposits, Industrial Minerals, Coal, and Oil discusses the supplies of gravel, sand, and clay in Western Canada and describes the current program of fundamental research on coal by the Research Council of Alberta. The production of sulphur in Alberta is discussed. Applied research on industrial minerals at the Mines Branch, Ottawa, is described, and it is suggested that geological research on the origin of anhydrite, gypsum, kyanite, and vermiculite should be undertaken. Work in the past year on non-metallic minerals in British Columbia is reviewed, and, in conclusion, recent developments in the oil fields of the Prairie Provinces are briefly described.

The report of the Subcommittee on Stratigraphy and Palaeontology is divided into two sections, one covering activities in these branches of geology in Canada in 1953 and the other outlining some additional problems that require attention. The additional projects suggested include: further study of the pre-Carboniferous and Carboniferous formations of New Brunswick to assess the possibility of finding further deposits of metallic and non-metallic minerals in these rocks; subsurface investigation of the pre-Utica Ordovician succession in southwestern Ontario to make possible a more intelligent evaluation of the oil and gas possibilities of these rocks; and studies of Precambrian sedimentation, of the siliceous shales of eastern Saskatchewan and Western Manitoba, of the oil-shales of the Colorado series, and of the volcanic ash deposits of southwestern Saskatchewan.

The Subcommittee on Scholarship and Research Training again urges the preparation and publication of a vocational guidance brochure on geology as a profession. Figures on the registration of geological students in Canada are discussed, and it is concluded there is a good prospect of ample student help for government and industrial geological field work by 1955. The problems involved in training for the Bachelor of Science degree in geology are considered. It is concluded that the broad field of training for students with an end point at the Bachelor degree should be restudied.

## SUBCOMMITTEE REPORTS

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

Presented by Dr. J. T. Wilson

### Members of Subcommittee

| | |
|---|---|
| Dr. J. T. Wilson (Chairman) | - University of Toronto, Toronto, Ont. |
| Dr. H. Carmichael | - Atomic Energy of Canada, Ltd., Chalk River, Ont. |
| Dr. J. H. Hodgson | - Dominion Observatory, Ottawa, Ont. |
| Dr. M. J. S. Innes | - Dominion Observatory, Ottawa, Ont. |
| Dr. A. D. Misener | - University of Western Ontario, London, Ont. |
| Dr. G. D. Garland | - Dominion Observatory, Ottawa, Ont. |

No previous year has been more productive of advances in physical study of the earth than 1953. Some of these developments are recorded below, with special reference to Canada.

### RESEARCH IN GEOPHYSICAL PROSPECTING

Seismic surveys in Western Canada continued to employ more than 150 crews at a cost of perhaps $40,000,000 a year (Eckhardt, 1953). This is probably the major part of all expenditures in the earth sciences in Canada. Some research in petroleum exploration has been started in Canada but little has been published about it.

The Geological Survey introduced the airborne magnetometer in Canada several years ago, and continues to publish maps of magnetic surveys at a rapid rate. Most of these can be readily related to geological maps. The problem of aeromagnetic surveys near the Auroral Zone has been discussed by Morley (1953).

In electromagnetic and magnetic prospecting for minerals there has been more activity than ever before, especially in New Brunswick. Many papers have been read but few have yet been published (Hammond, 1952, Seigel, 1952, and Ward, 1953). J. R. Wait (1953 a,b,c, and others) has been extremely active in publishing theoretical papers.

New airborne eletromagnetic prospecting devices have been developed by research in Canada. However, nothing has been published about these instruments except the patent application, although they are in active use (Cartier et al, 1953).

Great credit is due to the companies who have developed electro-magnetic prospecting methods to their present state of usefulness. In spite of their work the following comments of a well-known geologist are of interest:

"There certainly is room for much more research in electro-magnetic methods. As you know, we try out most new equipment as it becomes available and there are still possibilities for improvement in definition and range of the equipment and techniques presently in use. In fact, I sometimes am concerned that the use of electro-magnetic methods may result in currently passing up more potential areas because of negative indications, than are suggested as favourable zones of exploration through definite anomalies."

It is difficult to know to what extent this is true but it is clear that not enough research is being done and not enough of what is being done is being published.

Great credit is due to the Canadian Exploration Geophysicists Society of Toronto, to the Prospectors and Developers Association, and to the Northern Miner for the preparation and publication of articles and seminars on geophysical exploration for prospectors (Canadian Exploration Geophysicists, 1954).

The Dominion Observatory has developed a three-component airborne magnetometer of the accuracy required for charting rather than prospecting.

Important work has been done in methods of prospecting for, and analyzing radioactive ores (Eichholtz, G. G., Hillborne, J. W., and McMahon, 1953). Counters are being carried in aeroplanes and helicopters to prospect for radioactive deposits. A radioaltimeter is used to correct for variations in height. The best results are obtained from heights of less than 200 feet but regional radioactivity can be plotted from 1,000 feet altitude. Lundberg (1953) holds that oil fields can be discovered in this manner.

## SEISMOLOGY

The first estimate has been published by the Dominion Observatory (Hodgson, 1953) of the thickness of the Canadian Shield down to the ultrabasic mantle - about 20 miles (of gneisses?). This agrees with estimates in Europe, the United States, and Africa. Similar studies of the crust are being made in British Columbia by W. G. Milne. Preliminary measurements indicate about the same thickness there as beneath the Shield.

It is now apparent that the continents are quite different from the ocean floors. On the ocean floors a variable but usually thin layer of mud and about 3 miles of basalt overlie the ultrabasic mantle (Ewing, 1953). The Grand Banks off Newfoundland have been investigated (Press and Beckmann, 1953) and Bullard (1954) organized a thorough discussion about the floor of the Atlantic Ocean, which has been reviewed by Hill (1953).

A detailed plot of earthquakes near Vancouver has been published by Milne (1953). Some of them can be correlated with faults mapped by Clapp and by Buckham (1947). The Division of Building Research, National Research Council, has recently issued a National Building Code, which takes account of earthquake risks and includes an earthquake probability map.

A twelve channel set of refraction seismographs for long range work has been developed by the Dominion Observatory. The stations transmit by shortwave to a central recording station. This is being used in Ontario and Quebec to investigate two or three circular depressions a few miles across, which may be large meteoric craters. The same apparatus can be used for studying variations in crustal thickness and composition.

A method for determining the strike, dip, and direction of movement along fault planes of distant earthquakes has been developed and is being applied (Hodgson and Allan, 1954, a and b, Hodgson and Bremner, 1953, and Hodgson and Storey, 1953, 1954).

Gussow (1953) has published important results of geological and geophysical surveys in New Brunswick made by the Shell Oil Company. Competition has restricted publication of results of similar surveys by oil companies in Western Canada.

Rockbursts in Ontario mines are no longer being investigated by government agencies, but seismic studies have been started of rockbursts in coal mines in Nova Scotia and along the Alberta-British Columbia boundary.

Some further work on model seismology has been published (Northwood and Anderson, 1953).

The Dominion Observatory continues to publish the Bibliography of Seismology semi-annually (Smith, 1954).

## GRAVITY

Garland (1953a) has used the University of Cambridge pendulums to establish gravity stations from Mexico City to Fairbanks, Alaska. These pendulum base stations are necessary for accurately calibrating gravimeters. Innes and Thompson (1953) have established many other bases.

Gravity anomaly maps of six provinces have been published (Garland, 1953b, and Innes, 1953 a, b, and c). These show many striking correlations with geology. Thus the New Ross granite of Nova Scotia is said to be at least 18 miles deep and may extend through the crust. It is becoming apparent that the state of isostatic equilibrium prevailing over most of Canada is not as good as might have been supposed.

The fact that granite batholiths are nearly always negative shows that the whole crust is not made up of granite, but of something heavier (sedimentary gneisses?). Ewing (1953) has suggested a mechanism for incorporation of the sediments into the continents.

Gravimeters have been used by J. E. Blanchard, Nova Scotia Research Council, to investigate coal, salt, and gypsum deposits. Detailed gravity maps of the Sudbury and Ottawa areas have been published by the Dominion Observatory (Millar, 1954, and Saxov, 1954). Miller and Innes (1953) have investigated gravity in mines.

A study relating gravity anomalies to geology near Parry Sound has been published (Oldham, 1954). Additional work along the same lines is being analysed, using the FERUT electronic computer and mathematical methods devised by a Canadian (Grant, 1954). It seems likely that three quite different types of causes of gravity anomalies can be commonly distinguished. These are: (1) anomalies due to variations in the sedimentary cover, such as salt domes or folds that may indicate the presence of oil and gas; (2) anomalies due to changes in composition of the basement, such as the New Ross granite in the Meguma series; and (3) anomalies due to crustal warping, that is, variations in crustal thickness, such as have been described in India by Glennie (1951).

Anomalies in Canada caused by crustal warping have been found by Fitzpatrick in the Eastern Townships. The very large positive gravity anomalies found there are almost certainly due to the mantle breaking through the crust. Cooke's (1937) description of the geology had suggested some such uplift and airborne magnetometer maps show deep-seated as well as shallow effects. The asbestos deposits have probably resulted from this uplift the ultrabasic rocks.

The understanding of many such problems would be greatly helped if seismic, gravity, magnetic, and geological surveys were combined in the same areas and interpreted together.

## THE AGE OF THE EARTH

Baade has led astronomers to a revision that approximately doubles Hubble's estimate of the distance of the extra galactic nebulae, and this has increased the probable date of origin of the universe to 5 ± 1 billion years (Hubble, 1937; Struve, 1953; McVittie, 1953; Shapley, 1953).

Recent studies of lead isotopes in meteorites, rocks, and ores have led to new estimates of the age of the earth averaging 4.5 ± 0.5 billion years (Patterson et al, 1953, and Russel, Ph.D. thesis, University of Toronto) instead of 3.5 billion years (Collins et al, 1953). It is not clear whether the earth is appreciably younger than the universe or not.

The oldest minerals yet dated are about 2.9 ± 0.1 billion years (Allan et al, 1953, and Holmes, in press). They come from the Keewatin type rocks of Rhodesia and Transvaal and dates from all other areas of Keewatin type rocks are only a little younger. The abundance of volcanic rocks that mark Keewatin type areas suggests a hotter earth at that time. It may well be that during some of the period from 4.5 to 3 billion years ago the earth was generating enough radioactive heat to be partly molten near the surface and hence no rocks of that period were permanently preserved.

The most important division in geological time in all continents seems to be marked by the close of Keewatin time, about $2 \times 10^9$ years ago. There is much recent evidence that Archaean and Proterozoic refer to types of rocks rather than rocks formed at two different periods.

## AGE OF ROCKS

The Geological Survey of Canada is continuing the valuable work on age determinations started by the late Dr. H.V. Ellsworth, and has provided a suite of 35 carefully selected radioactive ores to three laboratories for age determinations. This intercomparison will undoubtedly lead to a general reconsideration and improvement of techniques by all concerned. The Geological Survey is installing a mass spectrometer for age determinations.

The Geological Association of Canada held a symposium in Precambrian correlation and dating for which abstracts have been published (Derry and Jolliffe, 1953).

Lead-210 (Kulp et al, 1953) and radon loss measurements are being added to the standard chemical and isotopic studies of uranium and thorium ores. The output of results may seem slow and uncertain to geologists, but there is no doubt that present efforts will lead to reliable and consistent dating of an increasing number of radioactive occurrences within the next few years. Isotopic lead analysis has been speeded by development of better techniques (Collins et al, 1954).

Because the number of uranium occurrences is relatively small, the development of the lead ore (Allan et al, 1953, Russell, R.B., et al, 1954) and potassium methods is of great value. Both methods show promise of being practicable. Papers dating many Canadian sulphide occurrences will be published shortly (Cummings et al, in press). The many difficult problems involved in establishing the potassium-argon method for determining the age of such common minerals as feldspar and mica seem now to be capable of solution. Russell et al (1953) gave a recent account, but their results need some modification (Shillabeer et al, 1954). Fleming and Thode (1953) have investigated the isotopic composition of argon. The great ages recently published from rubidium-strontium determinations are now doubted by the authors, who are continuing work on the method (Nicolaysen et al, 1953, and personal communication from Nicolaysen).

## CARBON-14 AGES

Several Canadian universities are working with this method or propose to do so, and age determinations are being made regularly, at the University of Saskatchewan. At University of Manitoba a method of incorporating the carbon to be tested in a liquid scintillation counter promises to improve efficiency. In England a similar method using acetylene gas has been proposed. These methods will be of great help in dating late-glacial and post-glacial materials, and archaeological events (Libby, 1952).

## STUDIES OF NON-RADIOGENIC ISOTOPES

This subject has important implications in geology and has recently been reviewed by Ingerson (1953) and by Marble (1953 and in press).

In Canada, Allenby (1954) and Hogg have studied the isotopic ratios of silicon and titanium respectively in a number of minerals in the hope that the relative abundance of silicon and titanium isotopes might reflect the geological and chemical histories of the rocks containing them. A maximum variation of 1.3 per cent has been detected in the ratio $Si^{28}/Si^{30}$; no variations were found for the isotopes of titanium.

In the last 3 years the investigation of natural variations in the relative abundance of the sulphur isotopes has been actively continued at McMaster University under the direction of Professor H.G. Thode. Thode and his colleagues have shown that there are no significant differences between the ratio $Si^{32}/Si^{34}$ in meteorites and terrestrial igneous rocks. The $Si^{32}/Si^{34}$ ratio in samples of native sulphur varies by as much as 4.5 per cent depending on whether the sulphur is of organic or volcanic origin. It is now believed possible to determine the origin of sulphur deposits from the isotopic composition of the sulphur (Macnamara et al, 1951 and 1952).

Thode has also investigated the isotopic fractionation occurring when sulphates are reduced to sulphides by sulphur bacteria under anerobic conditions (Thode et al, 1951). This process, which represents part of the natural sulphur cycle, has been reproduced in controlled laboratory experiments, and some fractionation by bacteria has actually been observed.

## THE TEMPERATURES AND THERMAL HISTORY OF THE EARTH

Heat flow at the Kemano tunnel in British Columbia and temperatures within the earth have been investigated at the University of Western Ontario (Uffen, 1952, and Uffen and Misener, 1952 and 1954). New methods of measurement have been devised by Blackwell (1953 and 1954).

For the past 40 years years it has been known that beneath 2,900 km. of solid rock mantle the earth contains a liquid core. This had generally been supposed to be liquid nickel iron, but about 1940 Ramsay suggested it might be silicate that had undergone a change of state. It is now doubtful if this proposal fits the requirements entailed for other planets and the theory of an iron core has no serious rival at present.

In 1947 seismologists discovered evidence of a small, central, solid inner core within the liquid core. Jacobs (1953 and 1954) has made the ingenious suggestion that the inner core is merely a part of the core frozen by greater pressures near the centre of the earth. He has used a well-founded theory of Simon's to find the melting point of iron at the pressure ($3.2 \times 10^6$ atm.) prevailing at the depth of the core-inner core boundary; it is $3,900 \pm 100^{\circ}C$. The temperature at the base of the mantle can then be placed at about $3,600^{\circ}C$. These estimates of internal temperatures, which agree with those made independently by Uffen and Misener (1952), are by far the most precise yet made and have important implications in petrology, seismology, terrestrial magnetism, and tectonics.

Meanwhile, Allan has embarked on a major program of calculations suggested by Urry (1949) and made possible by using the FERUT electronic computer. He has assumed a layered model of the earth in which various amounts of three radioactive elements can be assigned to each layer. Account is taken of the decay of the radioactive elements with time. Tables are being prepared which will enable temperatures at various depths in the earth at various times in the past to be found for any assumed distribution of radioactivities.

This research will enable statements about the earth's thermal history to be checked. Enough may be known of the earth's age and present internal temperatures to fix its past thermal history within fairly close limits.

## THEORIES OF MOUNTAIN BUILDING

Jacobs (1953a) has concluded that if his estimates of temperatures in the core are correct no convection currents are necessary in the mantle and that the earth is cooling; therefore, the contraction theory is probably valid. Scheidegger has reviewed and greatly strengthened his account of the contraction theory (1953a) by extending it (1953b) to explain the difference between Appalachian and Cordilleran types of mountain structures with their attendant graben in one case and zwischengebirge and lineaments in

the other. Wilson (in press) has endeavoured to relate the physical theory to geology. Heaps (1953) has made a theoretical analysis of the stresses arising in the crust of the earth due to a surface load, such as an ice-cap. Much recent geophysical work in Canada and the United States has been reviewed by Woollard (1953).

## CONCLUSIONS

Scientists assume that nature operates according to laws that are universal, but the limitations of human capacity force each one of us to consider only some small part of the whole. A natural unity among those who consider the same small fragments has led to the convenient but misleading concept that there is not one natural science but rather a number of smaller sciences. Administrative convenience, diversity of techniques, the herd instinct, and great lacunae in our knowledge has deepened these artificial barriers within science.

Even a single subject is often divided for historical and practical reasons into several parts. This has been especially true of the study of man and his abode, the earth. In ancient times the earth was considered by travellers, miners, and surveyors and navigators each in their own way and the facets they observed developed into the subjects of geography, geology, geodesy, and geophysics, respectively. The last three are all physical sciences but until recently the development of each proceeded largely independently of the others. The gaps in our knowledge were so great that no one could, for example, state the precise relation existing between the geologist's studies of mountain building, the geophysicist's studies of the earth's thermal history, and the geodesist's studies of changes in the shape o the earth; yet it was obvious that all three were intimately related.

As late as 1952 Jeffreys could write a book with the title "The Earth, its Origin, History and Physical Constitution" and scarcely mention any geology, and geological text-books, although defining geology as the "general science of the earth", omitted all reference to such vital aspects of its study as, say, terrestrial magnetism. Until last year most astronomers believed that the present universe could not be more than two billion years old in spite of the fact that this age could not be reconciled with well-dated occurrences of minerals that seemed to have been deposited in the rocks at least half a billion years earlier.

These contradictions and omissions were inevitable during the growth of the subject; they were the best that men could do at the time. But the growth of knowledge in all branches of geology, geophysics, and geodesy has inevitably brought these subjects to the point where they must be considered together. The present may yet be remembered as the time when the general study of the earth first became possible by a combination of the physical sciences.

In many ways the isolated approach was neat, easy, and convenient; and there will continue to be need for individuals to specialize in each of many fields. There will continue to be need for palaeontologists, mineralogists, and many other specialists; but our science has broadened. The new and more general approach to study of the earth is going to be more difficult and will require more members to a team and many may regret the demise of geology as an independent science. But because such a general and combined attack has already proved so fruitful, it must be continued.

The change need not be as drastic as might be imagined. In the field of geology no men are experts in every branch, but a stratigrapher at least knows what a mineralogist can do and when to solicit his services. Similarly, in future the field geologist should have at least as great a knowledge of what the seismologist and geomagnetician can do and how they can help him. The rewards for having such knowledge are likely to be great. They may also be satisfying to the ego of the earth scientist for the following reason.

A century ago geology was of little economic use, but in the eyes of the general public it was a most exciting science because the great controversies about evolution and the interpretation of the biblical story of creation and of the flood were being fought out. At that time chemistry and particularly physics had scarcely started the rise in public interest which later followed the development of organic chemistry, the discovery of radioactivity, and the invention of methods of generating and controlling electric power. Since then geology has been gaining steadily in value as an applied science but has been losing ground as a pure science and in public interest. As King Hubbert (1940) has so forcefully pointed out, its scope has been diminishing.

However, in the last few years a reversal of this trend has occurred because other scientists have realized that geology has much to offer pure science. In mass and linear dimensions the earth is intermediate between galaxies and atoms and hence rather uninteresting; but in respect to time and the history of the universe, geology gives more information than all the rest of nature. A knowledge of time is basic to relativistic science and the sorting out of Precambrian time is as vital to the progress of the most fundamental aspects of pure science as it is to prospecting for metals in Canada.

The heart of the problem now facing us may be summarized in this way. Much field mapping remains to be done; many more surveys using physical devices are needed. But already for some areas in Canada there exist geological, aeromagnetic, gravity, seismic, and air photo interpretation maps. Each gives some information not provided by the others; interpreted together they can give more information than the sum of the results achieved by interpreting them separately. No one man can be expert in all fields; the problem is to discover how we can best train students and organize work and manpower to make the maximum use of the abundant methods and data now available for studying the earth and its mineral deposits. If geology is to remain truly the science of the study of the earth it must seize the opportunity for expanding its horizons. We have the opportunity of combining what is good in present geological practice with other branches of the physical sciences. By so doing we will expand the study of geology, place it on a much sounder scientific basis, and, for the first time, obtain a full grasp of the nature and operation of the earth. It is most important that this be done.

## References

Allan, D. W., Farquhar, R. M., and Russell, R. D.: Science, 1953, V. 118, P. 486.

Allenby, R. J.: Geochem. et Cosmochem. Acta, 1954, V. 5, P. 40.

Blackwell, J. H.; Can. Jour. Phys., 1953, V. 31, P. 472.

Blackwell, J. H.: Jour. Appl. Phys., 1954, V. 25, P. 137.

Buckham, A. F.: Can. Inst. Min. Metal. Trans., 1947, V. 50, P. 460.

Bullard, E. C., et al: Proc. Roy. Soc., A, 1954, V. 222, P. 237.

Canadian Exploration Geophysicists, Handbook of Geophysical Methods, Northern Miner Press, Toronto, 1954.

Cartier, W. O., McLaughlin, G. H., Robinson, W. A., and Wise, E. M.: Geophysics, 1953, V. 18, P. 459.

Collins, C. B., Farquhar, R. M., and Russell, R. D.: Can. Jour. Phys., 1953, V. 31, P. 402.

Cooke, H. C.: Memoir 211, Geol. Surv., Canada, 1937; Bull. Geol. Soc. Amer., 1954, V. 65, P. 1.

Cumming, G.L., Farquhar, R. M., Russell, R. D., and Wilson, J. T.: Proc. Geol. Assoc. Canada (in preparation).

Derry, D. R., and Jolliffe, A. W.: Program Geol. Soc. Amer. Annual Meetings, 1953, p. 16.

Eckhardt, E. A.: Geophysics, 1953, V. 18, P. 501.

Ewing, M.: Bull. Geol. Soc. Amer., 1953, V. 64, P. 1419.

Fleming, W. H., and Thode, H. G.: Phys. Rev., 1953, V. 80, P. 857.

Garland, G. D.: Proc. Roy. Soc., A, 1953(a), V. 219, P. 215.

_____: Pubs. Dominion Obs., Ottawa, 1953(b), V. 16 (7), P. 185.

Glennie, E. A.: Mon. Not. Roy. Astron. Soc., Geophys. Suppl., 1951, V. 6, P. 167.

Grant, F. S.: Geophysics, 1954, V. 19, P. 23.

Gussow, W. C.: Bull. Amer. Assoc. Pet. Geol., 1953, V. 37, P. 1713.

Hammond, P.: Econ. Geol., 1952, V. 47, P. 634.

Heaps, H. S.: Trans. Roy. Soc., Canada, 1953, V. 47, (4), P. 17.

Hill, M. N.: Nature, 1953, V. 171, P. 857.

Hodgson, J. H.: Pubs. Domin. Obs., Ottawa, 1953 (a), V. 16, P. 113.

_____: Pubs. Domin. Obs., Ottawa, 1953 (b), V. 16, (6).

Hodgson, J. H., and Allan, J. F. S.: Pubs. Domin. Obs., Ottawa, 1953 (c), V. 16, (10).

Hodgson, J. H., and Allan, J. F. S.: Pubs. Domin. Obs., Ottawa, 1953 (d), V. 16, (11).

Hodgson, J. H., and Bremner, P. C.: Bull. Seism. Soc. Amer., 1953, V. 43, P. 121.

Hodgson, J. H., and Storey, R. S.: Bull. Seism. Soc. Amer., 1953, V. 43, P. 49.

_____: Bull. Seism. Soc. Amer. 1953, V. 44, P. 57.

Holmes, A.: Nature (in press).

Hubbert, M. K.: Amer. Inst. Min. Eng., Symposium on Education 1940.

Hubble, E.: The Observational Approach to Cosmology, Oxford, 1937.

Ingerson, Earl: Bull. Geol. Soc. Amer., 1953, V. 64, P. 301.

Innes, M. J. S.: Gravity Anomaly Map of Manitoba; Domin. Obs., Ottawa, 1952.

_____: Gravity Anomaly Map of Saskatchewan; Dom. Obs., Ottawa, 1952.

_____: Gravity Anomaly Map of Alberta; Domin. Obs., Ottawa, 1952.

Innes, M. J. S., and Thompson, L. G. D.: Pubs. Domin. Obs., Ottawa, 1953, V. 16, (8).

Jacobs, J. A.: Trans. Roy. Soc., Canada, 1953 (a), V. 47, (4), P. 33.

_____: Can. Jour. Phys., 1953 (b), V. 31, P. 370.

_____: Nature, 1953 (d), V. 172, P. 297.

_____: Nature, 1954, V. 173, P. 258.

Jeffreys, H.: The Earth (3rd ed.), 1953, Cambridge Univ. Press.

Kulp, J. L., Broecker, W. S., and Eckelmann, W. R.: Nucleonics, 1953, V. 11, P. 19.

Libby, W. F.: Radiocarbon Dating; Chicago Univ. Press, 1952.

Lundberg, H., and Isford, G.: World Petroleum, 1953, V. 24, P. 40.

Marble, J. P.: Report of Committee on Measurement of Geologic Time, N.R.C., Washington 1953 and 1954.

Macnamara, J., Fleming, W., Szabo, A., and Thode, H. G.: Can. Jour. Chem. 1952, V. 30, P. 73.

Macnamara, J., and Thode, H. G.: Research, 1951, V. 4, P. 582.

McVittie, G. C.: Astron. Jour., 1953, V. 58, P. 129.

Miller, A. H.: Pubs. Domin. Obs., Ottawa, 1954, V. 18 (1).

Miller, A. H., and Innes, M. J. S.: Pubs. Domin. Obs., Ottawa, 1953, V. 16, (4).

Milne, W. G.: Pubs. Domin. Obs., Ottawa, 1953, V. 16, (9), P. 313.

Morley, L. W.: Trans. Amer. Geophys. Un., 1953, V. 34, P. 836.

Nicolaysen, L. O., Aldrich, L. T., and Doak, J. B.: Trans. Amer. Geophys. Un., 1953, V. 34, P. 342.

Northwood, T. D., and Anderson, D. V.: Bull. Seismol. Soc. Amer., 1953, V. 43, P. 239.

Oldham, C. H. G.: Geophysics, 1954, V. 19, P. 76.

Patterson, C., Tilton, G., and Ingham, M: Bull. Geol. Soc. Amer., 1953, V. 64, P. 1461.

Press, F., and Beckmann, W.: Bull. Geol. Soc. Amer., 1954, V. 65, P. 299.

Russell, R. D., Shillibeer, H. A., Farquhar, R. M., and Mousuf, A. K.: Phys. Rev., 1953, V. 91, P. 1223.

Russell, R. D., Farquhar, R. M., Cumming, G. L., and Wilson, J. T.: Trans. Amer. Geophysical Union, 1954, V. 35, P. 301.

Saxov, S. F.: Pubs. Domin. Obs., 1954, V. 18, P. (2).

Scheidegger, A. E.: Bull. Geol. Soc. Amer., 1953 (a), V. 64, P. 127.

_____: Can. Jour. Phys., 1953 (b), V. 31, P. 1148.

Seigel, H. O.: Geophysics, 1952, V. 17, P. 907.

Shillibeer, H. A., Russel, R. D., Farquhar, R. M., and Jones, E. A. W.: Phys. Rev., June 1954.

Shapley, H.: Astron. Jour., 1953, V. 58, P. 47.

Smith, W. E. T.: Pubns. Domin. Obs., Ottawa, 1954, V. 14, (13 and 14).

Struve, O.: Sky and Telescope, 1953, V. 12, pp. 203 and 238.

Thode, H. G., MacNamara, J., and Fleming, W. H.: Geochem. et Cosmochem. Acta. 1953, V. 3, P. 235.

Uffen, R. J.: Trans. Amer. Geophys. Un., 1952, V. 33, P. 893.

Uffen, R. J., and Misener, A. D.: Proc. Phys. Soc. London, B, 1952, V. 65, P. 742.

_____: Nature, 1954, V. 173, P. 239.

Urry, W. D.: Trans. Amer. Geophys. Un., 1949, V. 30, P. 171.

Wait, J. R.: Geophysics, 1953 (a), V. 18, P. 138.

_____: Geophysics, 1953 (b), V. 18, P. 416.

_____: Trans. Amer. Geophys. Un., 1953 (c), V. 34, P. 185.

Wait, J. R.: Can. Jour. Phys., 1953, V. 31, P. 670.

_____: Can. Jour. Technol., 1954, V. 32, P. 1.

_____: Geophysics, 1953, V. 18, P. 138.

_____: Def. Res. Telec. Est., Proj. Report 18-0-2, 1953.

_____: Def. Res. Telec. Est., Proj. Report 18-0-3, 1953.

_____: Proc. Inst. Radio Eng., 1953, V. 41, P. 1664.

_____: Proc. Inst. Radio Eng., 1953, July, pp. 9-11.

_____: Jour. Appl Phys., 1953, V. 24, P. 646.

_____: Jour. Appl. Phys., 1953, V. 24, P. 341.

_____: Def. Res. Telec. Est., Proj. Report 18-0-6, 1953.

_____: Geophysics, 1953, V. 18, P. 416.

_____: Trans. Amer. Geophys. Un., 1953, V. 34, P. 185.

Wait, J. R., and Campbell, L. L.: Jour. Geophys. Res. 1953, V. 58, P. 21.

_____: Jour. Geophys. Res. 1953, V. 58, P. 167.

_____: Can. Jour. Phys., 1953, V. 31, P. 456.

Ward, S. H.: Geophys. 1953, V. 18, P. 434.

Wilson, J. T.: Chapter 4 in The Earth as a Planet (ed. G. P. Kuiper); Univ. of Chicago Press (in press for publishing August 1954).

Woollard, G. P.: Trans. Amer. Geophys. Un., 1953, V. 34, P. 281.

# REPORT OF THE SUBCOMMITTEE

# ON METALLIC MINERAL DEPOSITS

Presented by Dr. G. M. Brownell

## Members of Subcommittee

| | |
|---|---|
| Dr. G. M. Brownell (Chairman) | - University of Manitoba, Winnipeg, Man. |
| Dr. D. R. Derry | - Rio Canadian Explorations, Ltd., Toronto, Ont. |
| Dr. A. H. Lang | - Geological Survey of Canada, Ottawa, Ont. |
| Dr. G. B. Langford | - University of Toronto, Toronto, Ont. |
| Dr. C. E. Michener | - International Nickel Company of Canada, Copper Cliff, Ont. |
| Dr. G. H. Charlewood | - Manitoba Mines Branch, Winnipeg, Man. |

## CURRENT RESEARCH

Some 80 projects directly concerned with metallic mineral deposits are listed in the compilation of Current Research in the Geological Sciences in Canada (p.63 ) and need not be repeated here. However, a few of the more general projects are discussed briefly.

### Cobalt

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

### Columbium, Tantalum, Lithium, Beryllium, and Molybdenum

The Geological Survey of Canada is carrying out studies of the columbium deposits near North Bay, Ontario and the lithium-beryllium pegmatites of southeastern Manitoba and western Quebec. Eventually a full report on Canadian occurrences is planned as one of the Economic Geology series.

The Geological Survey is completing field and laboratory studies of the Preissac-Lacorne batholith in western Quebec, and, as part of the same project, a spectrographic study of the trace elements has been completed at Queen's University. These studies should aid in the understanding of, and search for, deposits of lithium and molybdenum.

Quantitative studies of tantalum, niobium, uranium, and thorium in ores from eastern Canada are being made at Queen's University by X-ray fluorescence methods. They are being made principally on mill products and concentrates and will be extended to include rare earth elements also present in the ores.

At McGill University Dr. J. S. Stevenson has developed a method of analysis of $Cb_2O_5$ by fluorescent analysis. Research is continuing to improve the method.

## Chromite

The Geological Survey of Canada in 1951 began a study and inventory of chromite deposits in Canada but was unable to continue this work in 1953. However, field work is almost completed although the report is not fully written. A separate study of the chromite deposits of western Newfoundland was completed in 1952 and a bulletin is being prepared.

## Copper, Zinc, Lead, and Nickel

The Quebec Department of Mines is sponsoring detailed studies of the wall-rock alteration associated with base metal deposits in the Eastern Townships, Gaspe, and western Quebec. The laboratory work in connection with these studies is being carried on in large part at McGill University. The Department is also investigating the distribution of base metals in soils and waters near lead-zinc deposits in Gaspe north county.

The Geological Survey of Canada is continuing a geochemical study of the silver-lead-zinc ores and the country rocks of Mayo mining camp, Yukon Territory. This will include an investigation of the metals in soils and waters near the deposits in the hope that their distribution may give some clues in the search for more ore-bearing veins in drift-covered areas.

In New Brunswick, geochemical surveys for lead, zinc, and copper were carried out over the Brunswick and Anacon-Leadridge ore-bodies by St. Joseph Lead Company. Soil samples at varying depths were tried. It is worthy of note that the finding of the Anthonian base metal deposits in the Bathurst area is credited to a geochemical survey, combined with the tracing of a boulder train in the drift.

Biogeochemical methods in conjunction with geophysical methods are being used by a mining company in prospecting for nickel and copper in northern Manitoba. The methods have been used mainly in areas of no outcrop where magnetic and conductive anomalies coincide. In these areas the presence of the copper and nickel in the underlying bedrock may be detected by analysis of the ash derived from various types of foliage. More work is needed to find out if it is possible to estimate from metallic content of the ash the abundance of these metals in drift-covered deposits.

The discovery of nickel ore in the St. Elias Mountain front, Yukon Territory, during 1952 led to much prospecting, followed, during 1953, by diamond drilling and airborne magnetometer surveys. Much useful experience is being gained from this pioneer work in geophysical prospecting in an area of great relief. Kluane map-area, which is traversed by the nickel-bearing belt, is being mapped by the Geological Survey of Canada and a number of the basic intrusions with which the nickel mineralization is associated have been delineated.

## Iron

The rapid expansion of iron mining in Canada is directing increased attention to problems relating to iron ore deposits. The Geological Survey of Canada, the Quebec Department of Mines, and several mining companies are carrying on broad scale and detailed investigations of the stratigraphy and structure in relation to the origin and distribution of the iron deposits of the Labrador Trough, New Quebec and Labrador. The Geological Survey is also carrying out a study of the iron deposits of eastern Ontario and western Quebec and a general study of iron ores of Canada.

## Tungsten

Field work and most of the office work has been completed for a report on tungsten deposits of Canada to be published as one of the Geological Survey's Economic Geology series.

The British Columbia Department of Mines is making detailed field studies of the lead-zinc-tungsten belt in the Salmo-Pend'Orielle River area which will extend over several seasons. Similar studies are being made around the Red Rose tungsten mine near Hazelton.

## Uranium

Because of the widespread interest in uranium the Geological Survey of Canada which acts as the official agency of the Atomic Energy Control Board, assigned three officers to field studies of uranium deposits. Several others were occupied wholly or partly on laboratory investigations relative to uranium deposits and on geological mapping of areas of known or possible importance for uranium. Much work was also done in summarizing and filing reports on uranium properties. The confidential inventory of Canadian deposits of uranium and thorium was brought up to date for 1952, when it comprised digests on 645 properties or unstaked occurrences, and progress was made on the inventory for 1953.

The stratigraphy, structure, and mineralization of the Blind River area where important uranium deposits are being developed is under investigation by the Ontario Department of Mines. At Queen's University the radioactive ores from this region are being studied by use of a recently installed X-ray fluorescence unit.

An interesting occurrence of radioactive material was discovered in New Brunswick in the summer of 1953. The radioactive constituent is in anthraxolitic material filling fractures related to a fault involving carbonaceous or bituminous beds of the Albert formation of Mississippian age. The nature of the material and its possible derivation from the Albert shale invite investigation, and preliminary work is being done by the Geological Survey of Canada.

## GENERAL COMMENTS

Early prospecting in Newfoundland was marked by an almost complete absence of detailed geological information. In many places the rocks are spotted at the surface with small occurrences of sulphide mineralization. It is believed that there is the possibility of finding orebodies at many places where sulphides occur and that these places warrant further investigation. About fifteen major bodies of ultrabasic rocks are known in Newfoundland, very few of which have been investigated. They offer an excellent opportunity for research.

In New Brunswick recent work on the copper (chalcocite) deposits in the Pennsylvanian sandstones, and of bornite-chalcocite veins along the Bay of Funday indicates the need for further study of the deposits, particularly in regard to their age and genesis.

The Geological Survey did no further reconnaissance mapping by helicopter in 1953. The helicopter reconnaissance project of 1952 ("Operation Keewatin") was supplied entirely by airlift but it was decided that future operations should be supplied by boat a year in advance to obtain maximum economy. Plans and operations have been made for "Operation Baker, 1954" and "Operation Thelon, 1955", the former to map 60,000 square miles of the central District of Keewatin, and the latter to explore more of the geologically unmapped area of the District of Mackenzie south of the 65th parallel. During 1953, in preparation for the 1954 project, about 100 tons of aviation fuels were delivered by boat, mainly to Baker Lake, Northwest Territories, a contract was signed for the use of two helicopters and a Norseman aircraft, and preliminary arrangements were completed during an aerial tour of the reconnaissance area. Negotiations have been started for another shipment of fuels to go to Fort Reliance during the summer of 1954 for use in 1955. Thus if plans now in hand materialize, the reconnaissance mapping of the Canadian Shield from Hudson Bay to Great Slave Lake, and between the 60th and 65th parallels, should be virtually completed by September 1955. This will supply basic geological information about a vast, potentially favourable and largely unprospected region of the Canadian Shield. It is a pleasure to record that all reports from the field speak well of the accuracy of the published geological maps from "Operation Keewatin", 1952; there is every reason to expect that the results of operations "Baker" and "Thelon" will be equally satisfactory.

Practically all the great region being geologically mapped by these helicopter operations is north of the tree line in the barren grounds. Detailed prospecting of the scattered outcrops within the barren grounds is a hopelessly inadequate means of finding ore deposits that in most instances probably lie beneath the intervening drift areas. Despite the glacial origin of most of the overburden there is good reason to believe that traces of buried ore minerals have reached the upper drift, the vegetation rooted in it, or drainage water. The feasibility of using geochemical prospecting methods within the barrens should, therefore, be investigated.

# REPORT OF THE SUBCOMMITTEE

# ON STRUCTURAL GEOLOGY

Presented by Dr. J.E. Gill

## Members of Subcommittee

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

## CURRENT RESEARCH

A listing of projects currently in hand in structural geology is given in the compilation of "Current Research in the Geological Sciences", which is included with this report (p. 63).

In the Northwest Territories the discovery of piercement domes by officers of the Geological Survey of Canada is of special interest to petroleum geologists. Studies along the north coast of Ellesmere Island indicate that orogeny may have occurred at three different times.

The British Columbia Department of Mines is sponsoring detailed structural studies of the Salmo-Pend'Oreille lead-zinc-tungsten belt, the Cariboo district, and the Red Rose tungsten mine area near Hazelton. Bulletins 31 and 33 of that Department on the Sheep Creek area south of Nelson and the Crowsnest Pass coal basin are distinct additions to our knowledge of the structure of the province.

The preliminary compilation of the structural map of British Columbia at the University of British Columbia on a scale of 8 miles to 1 inch is essentially complete. There remains the checking of the manuscript and the addition of unpublished information to be obtained from companies and individuals.

The geological investigation of the Kemano-Tahtsa tunnel, British Columbia, is almost complete. Final detailed examination of the tunnel will be completed by the spring of 1954 by A. Smith and R. A. Stuart of the British Columbia Department of Mines.

In an attempt to explain the origin of the Rocky Mountain Trench detailed mapping near Canal Flats was commenced by the Geological Survey in 1953. This area promises to afford critical information in that it is one of the few containing reasonably satisfactory outcrops across the valley floor.

In Alberta, Saskatchewan, and Manitoba a large amount of structural data continues to accrue from the intensive search for petroleum and natural gas. The Geological Survey of Canada continues the study of the Devonian and Carboniferous stratigraphy and reef structures where exposed in the eastern part of the Rocky Mountains. The results of this work should assist materially in interpreting drill-hole data from the plains.

A structural project of interest is the investigation of the character, distribution, and cause of the stresses that result in "bumps" and related phenomena in the deeper workings of the coal mines in Nova Scotia and the Crowsnest area of Alberta. This is a co-operative project in which the Mines Branch, Geological Survey, and Dominion Observatory are participating.

Among projects of the Ontario Department of Mines involving structure are investigations of the structure and correlation of the Whitewater series in the Sudbury basin, and the structure and stratigraphy of the Porcupine area and the north shore of Lake Huron.

Research on the strength of rocks is under way at the University of Toronto.

The Quebec Department of Mines continued mapping in many parts of the province. Long term structural studies worthy of special note are proceeding in the Eastern Townships of Quebec and along the "Grenville Front".

At Laval University, studies of the area around Quebec City are being continued.

At McGill University experimental studies of fracture patterns are well started and 14 investigations of map-areas and mines involving structure are in progress.

The discovery of important new sulphide deposits in the Bathurst area of New Brunswick has led to widespread search in the Maritime Provinces utilizing geological mapping, geophysical surveys, and chemical testing of soils and vegetation. Much new structural information is being made available. A large part of this will be lost unless the provincial governments take prompt steps to have it recorded by competent technically trained employees.

It should be noted that the large amount of areal mapping done annually by the Geological Survey of Canada, the provincial departments of mines, and by mining companies continues to provide important basic structural data.

## SUGGESTED PROJECTS

The Subcommittee recommends further detailed field studies of individual folds and faults in various environments, and scale model experiments designed to produce folds, faults, and joints under various conditions.

H. C. Gunning urges that detailed study of the western Rocky Mountains and the Rocky Mountain Trench be continued.

J. W. Ambrose suggests the publication of a supplement to the Canadian Institute of Mining and Metallurgy volume, "Structural Geology of Canadian Ore Deposits". This project is under active consideration by the Geological Division of the Institute and this subcommittee wishes to record its approval and support of the project.

W. A. Jones suggests that the section of country between the Porcupine and Kirkland Lake gold belts should be mapped on a scale of 1 inch to 1,000 feet to aid in the better understanding of these well-studied and economically important belts. He also advocates more detailed studies of batholiths and of the distribution of diabase dykes.

D. M. Baird suggests a detailed study of the St. Lawrence granite mass of Burin Peninsula, Newfoundland, and the fluorite deposits associated with it. This would entail much more than a structural study.

J. E. Hawley suggests structural studies of the Grenville subprovince in Ontario and the compilation of structural sections between the St. Lawrence River and the Sudbury area.

Aeromagnetic maps are being produced in large numbers. The study of these maps in relation to known exposed bedrock and structure is needed as a guide to the interpretation of maps of drift-covered areas.

## REPORT OF THE SUBCOMMITTEE ON

## PETROLOGY, MINERALOGY, AND GEOCHEMISTRY

Presented by Dr. G. S. MacKenzie

### Members of Subcommittee

| | |
|---|---|
| Dr. G. S. MacKenzie (Chairman) | - University of New Brunswick, Fredericton, N.B. |
| Dr. J. E. Hawley | - Queen's University, Kingston, Ont. |
| Dr. W. W. Moorhouse | - University of Toronto, Toronto, Ont. |
| Dr. F. F. Osborne | - Laval University, Quebec, Que. |
| Dr. S. C. Robinson | - Geological Survey of Canada, Ottawa, Ont. |
| Dr. H. V. Warren | - University of British Columbia, Vancouver, B.C. |

### CURRENT RESEARCH

Research in petrology, mineralogy, and geochemistry in the field and the laboratory was widespread across Canada in 1953. The inclusion in this report (p. 63) of the compilation "Current Research in the Geological Sciences in Canada" makes any detailed review unnecessary.

Many of the more than 100 projects listed under "Petrology and Petrography", "Mineralogy", and "Geochemistry" involve more than routine field and microscopic studies. Among these are the spectrographic studies of trace elements in granite batholiths at Queen's University where curves for the determination of some 20 elements will soon be completed. Research on the spectrographic determination of the major constituents of igneous rocks is also in progress. At McMaster University trace elements are being studied in relation to the metamorphism of pelitic sediments to find out if transfer of material takes place. Work at McGill University includes experimental research on the geologic role of heat exchanges during metamorphism, and on rock melting. A new method of rock and ore analysis is being developed at the University of Manitoba by neutron bombardment of the specimen and measurement of the induced radiation thus produced from the different elements.

Biogeochemical methods are being used to an increasing extent in exploration for base metals across Canada and in particular, with some success, in British Columbia and New Brunswick. Research to develop new techniques continues at the University of British Columbia and Dr. H. V. Warren reports on recent work that "Investigations on calcium, magnesium, iron and manganese have been interesting but have not produced results of direct significance as aids in prospecting. However, molybdenum and nickel findings have been satisfactory and should prove to be of material aid to those seeking extra tools for mine finding".

The effects of high temperatures and pressures on quartz and quartzite under hydrothermal conditions are being studied at the University British Columbia. Research on decrepitation methods of determining the temperature of formation of minerals continues at the University of Toronto with emphasis on the metamorphic and igneous rocks and minerals; similar work on the temperature of formation of hydrothermal minerals continues at the Mines Branch, Ottawa.

A geochemical study of the Yellowknife gold mining camp, Northwest Territories, has been completed by the Geological Survey of Canada and publication of the results is planned. A similar geochemical investigation of the Mayo mining camp, Yukon Territory, is under way. Many studies of radioactive minerals are in progress, particularly at the University of Saskatchewan, University of Toronto, and the Geological Survey and Mines Branch, Ottawa. An interim report by the Geological Survey on the interesting pyrochlore deposits in the North Bay district has been completed, and a thorough field and laboratory study of radioactive deposits of the Blind River and Bancroft districts of Ontario will be undertaken in 1954.

## GEOLOGICAL AGE DETERMINATIONS

Recent developments in techniques of geological age determinations are described in the present and past reports of the subcommittee on "Physical Methods Applied to Geological Problems". The importance of the work has been stressed in the reports of this and other subcommittees. The program of age determinations to be undertaken by the Geological Survey is most welcome. In this connection, Dr. S.C. Robinson states:

"At first we intend to make use of uranian and thorian minerals and to determine their ages by a combination of chemical analysis for total uranium, thorium, and lead, and of isotopic analysis of the lead. Insofar as possible we wish to give priority to syngenetic minerals such as uraninite, monazite, zircon, and other less common radioactive minerals. At first we shall calibrate on the simple minerals that contain adequate amounts of radiogenic lead, but we propose to initiate work on such minerals as zircon, in which we may use the 'spiking' technique to achieve analysis of very small amounts of uranium and lead by the mass spectrometer.

Other methods of age determination and other applications of isotopic chemistry to geological problems will be taken up subsequently."

## EQUIPMENT FOR RESEARCH

The result of a survey of research equipment in government departments and universities in Canada was given in last year's annual report of the National Advisory Committee. The laboratories of some mining and industrial companies are also well equipped. However, many company geologists lack equipment such as petrographic microscopes, to carry out laboratory studies to supplement their field work. Every effort should be made to convince the companies of the value of such studies.

Notable additions to laboratory equipment in the past year include a spectrophotometer at the University of Saskatchewan and a Philips X-ray Fluorescence unit and a flame photometer at Queen's University. A 10-inch, 90 degree sector type mass spectrometer capable of resolution of 1 mass

unit in 300 has been designed for the Geological Survey by Professor H.G. Thode of McMaster University. The instrument has been constructed by Dr. R.K. Wanless who has joined the staff of the Survey. The instrument will be installed and in operation by the summer of 1954. The rock analysis laboratory of the Geological Survey has been reorganized by Dr. J.A. Macwell who joined the staff of the Survey in November 1953. The laboratory has been completely re-fitted and modernized and is now in operation.

## SUGGESTIONS FOR FUTURE RESEARCH

Research projects that have been suggested include:

(1) The study of gabbro-metagabbro relations and criteria for distinguishing meta-intrusives, meta-volcanics, and meta-sediments in North Hastings and Renfrew counties and further study of the Grenville-Hastings problem in Hastings county, Ontario (D.F. Hewitt).

This project will be undertaken by Dr. Hewitt, Ontario Department of Mines, who will also review, in co-operation with New York State geologists, problems of Grenville correlation, classifications, and nomenclatures. The Department of Geological Sciences of Queen's University will co-operate in this project by trace element studies of granite batholiths.

(2) The study of problems in the Porcupine area, including the relation of a granite stock to sediments in Bristol township, the nature and composition of the feldspars in the acid intrusions, and detailed studies of the basic sills (S.A. Ferguson).

(3) Detailed studies of the basic sills of the Port Arthur area and of the relation between the copper, lead, and zinc deposits and degree of metamorphism of the host rocks in the Thunder Bay district of Ontario (E.G. Pye).

(4) Direct geochemical dating of Precambrian carbonate sediments as a key to the stratigraphy (J.E. Thomson).

(5) A structural and petrographic investigation of the diabase sills and stocks of the Nipigon and Fort William areas and of the Sault Ste. Marie-Blind River area; they may have been connected at one time. The sills near Pigeon River southwest of Fort William have coarse textures with some chalcopyrite, pyrrhotite, and pentlandite; petrographic study might show a differentiation from diabase to norite (W.A. Jones).

(6) A study of zones of metamorphism in the Grenville sub-province, especially in relation to the Grenville-Timiskaming boundary, which, on tectonic grounds, is believed to be an old mountain chain. If so, some relation might be expected between intensity of metamorphism and structure (D. M. Shaw).

(7) More quantitative data is needed on the amounts of minor elements in common rocks, especially sediments. For example, the possible concentration of uranium in black shales makes a study of minor elements in these rocks important, and knowledge of the distribution of elements such as gold, silver, copper, lead, and zinc in Precambrian rocks has a vital bearing on the origin of economic deposits of these metals (D.M. Shaw).

(8) The isotopic composition of lead from basalts and their coarse-grained equivalents should be determined in the hope that such analyses can be used for correlating these rocks (R.W. Boyle).

(9) A comprehensive study of Canadian pegmatites should be made (R.B. Rowe).

(10) Fundamental research on the genesis of pitchblende-hematite-calcite deposits should be undertaken to establish (a) the state in which constituents of these deposits were transported and (b) the environment favourable to their deposition from the transporting medium (S.C. Robinson).

## GENERAL COMMENTS AND RECOMMENDATIONS

Consideration of the work of the past year indicates that several of the projects suggested in our previous reports have been undertaken. The granitic rocks, basic intrusions, pegmatites, and some igneous and metamorphic complexes are being studied locally and there are some larger, co-ordinated projects employing several techniques. The problems in petrology, mineralogy, and geochemistry are clearly enough defined but there seems some lack of organized co-operative attempts to solve them; each man tends to work on his own local problem. Perhaps geologists need to develop a greater appreciation of the value of teamwork in the attack on major problems, such teamwork as is common in the fields of chemistry and physics, particularly in European universities.

In recent years Canadian universities have suffered from over-worked and inadequate staffs. Some improvement is now apparent with more time available to staff members to undertake broad scale, long range projects. It is noteworthy that most university geology departments are now staffed with relatively young men.

In recent years demands from industry have deterred many able students from taking graduate work. These demands are decreasing and there is also a growing awareness on the part of industry that graduate studies make their prospective employees of greater value.

No action has been taken on the suggestion in our report last year regarding the compilation of available rock analyses, and new analyses as they are made. K.R. Dawson has suggested the use of a punch card system by which chemical analyses and other data could be recorded for each rock type or specimen analysed. A central filing agency would collect and distribute the information.

This subcommittee in its annual reports has attempted to briefly review current research in the field and to suggest specific and general projects. It has been suggested that there should also be a critical annual assessment of what has been accomplished that would include a review of the literature and of parallel research outside Canada. The problem might be met by having experts in the subfield concerned (geochemistry, mineralogy, and petrology) prepare papers on recent research. Different men could be called on in successive years or at longer intervals.

The suggestion has come from several quarters that a volume comparable to the "Structural Geology of Canadian Ore Deposits" be assembled on the mineralogy and wall-rock alteration of Canadian ore deposits. Such a project, which would be of more direct concern to the subcommittee on 'Metallic Mineral Deposits' but also of interest to this subcommittee, is now under consideration by the Geology Division of the Canadian Institute of Mining and Metallurgy. This subcommittee strongly approves the proposal.

The work of this and other subcommittees of the National Advisory Committee must be done by correspondence. If meetings of the subcommittees were possible, suggestions could be more fully explored, ideas would flow more freely, and better solutions be achieved. This subcommittee recommends that attempts be made to hold meetings of the subcommittees and others interested in the fields concerned, even if at only 2- to 3- year intervals. Such meetings might well be held at the same time as those of the larger learned and professional societies.

## 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. |

### WORK ACCOMPLISHED IN 1953

There appears to have been increased activity in Pleistocene geology throughout Canada in 1953. Nearly 50 projects are listed under "Pleistocene Geology and Water Supply" in the compilation of "Current Research in Canada", to which the reader is referred (p.100).

The Geological Survey of Canada had fifteen field parties engaged in Pleistocene projects in nine provinces of Canada. Most of these parties were mapping the glacial deposits and investigating the water supply of definite map-areas. Among the more general problems were a field study of the Labrador ice centre in New Quebec and Labrador and of the deposits and Pleistocene fauna of the Champlain sea in the Montreal-Ottawa area. The mapping of the bedrock and unconsolidated deposits of Prince Edward Island was started.

In the Maritimes the Research Foundation of Nova Scotia continued to map the Pleistocene of the province and has prepared a number of new map-sheets for final compilation on the scale of 1 inch to 2 miles. The value of Pleistocene mapping as an aid in finding water has been well demonstrated in the Kennetcook area of Hants county, Nova Scotia, where artesian and bedrock water are largely contaminated by salt. Determination of the location and extent of gravel beds in the Pleistocene deposits has resulted in the development of abundant supplies of first quality water at various points as needed.

A thesis study completed at Clark University by E. J. C. de Jonge on "Glacial Water levels in the St. John River Valley" presents new data and some controversial conclusions. The thesis postulates the one-time existence of a hitherto unrecognized glacial lake extending 75 miles from Grand Falls up the St. John River Valley to Lake Temiscouta, and places the upper limit of the late glacial marine submergence at Grand Falls at a maximum elevation of 563 feet. The post-glacial deposits of the St. John Valley have been drilled for water at Fredericton and the data obtained are being studied at the University of New Brunswick.

The Arctic Institute, under contract with the Defence Research Board, continued the plotting of glacial and structural features from the study of air photographs of Canada. A paper resulting from these studies on the aerial interpretation of glacial features of Quebec was presented at the meetings of the Geological Society of America in Toronto, November 1953.

The physiographic survey by the Ontario Research Foundation of the Lake Algonquin plain east and north of Georgian Bay is nearing completion. A paper on an outlet of this glacial lake at Fossmill, Ontario, was presented at the meeting of the Geological Society of America in Toronto, November 1953. The paper suggests some changes should be made in our conception of the later stages of the lake.

An active program of research on the Pleistocene deposits of the London area continues at the University of Western Ontario, with particular reference to the stratigraphy and the Huron and Erie lobes of the ice-sheet.

The work of the British Columbia Department of Mines on Pleistocene deposits included reconnaissance studies of the white silts of the Kamloops and Okanagan areas. These widespread Pleistocene deposits in the centre of the province are of great importance as agricultural lands and also present problems in engineering projects. In the latter respect the expert evidence presented to the Royal Commission on the damaging slide at the Whatshaw hydro-electric plant (Arrow Lakes) is of great interest to engineers and geologists. Compilation of the record of drilled wells in the farming district immediately north of Vanderhoof indicates the existence of a deep valley filled with silts and clays, which are overlain by glacial till. The deepest well recorded is the Vanderhoof municipal well at an elevation of 2,096 feet. The well is reported to have drilled to a depth of 582 feet without encountering solid rock, and although it is not certain that the sequence passed through is entirely Pleistocene, all of the material is completely unconsolidated. This deeply buried valley is of interest in any study of the history of the Fraser River drainage system.

Glaciological research was carried out on northern Ellesmere Island by a field party of the Defence Research Board. In particular, the ice shelf region was investigated from which most of the polar basin "ice islands" are believed to originate; initial findings show that in most places the ice shelf is now separated from the source of supply.

The Baffin Island Expedition of the Arctic Institute carried out work on the Penny ice-cap and also studied exhaustively the geomorphology of Pangnirtung Pass.

The Kaskawulsh area in Yukon, which is being mapped by the Geological Survey is one of the finest areas in North America for the study of valley glaciation. All varieties of valley glaciers occur, from the great winding branching system of the Kaskawulsh glacier, to small cirque glaciers. A number of markers and permanent instrument stations have been established and photographs taken recording the present positions and forms of some of the glaciers. It is planned to continue this work.

It was announced near the end of 1953 that the villages of Aklavik and Coppermine, Northwest Territories, were to be moved to new sites. In the former case the high ice-water content of the soil, which is causing slumping, is the prime reason for the move. The staff of the Permafrost Research Station of the Division of Building Research, National Research Council, was mainly responsible for the soil survey leading to this decision. To date their activities have been limited to the summer season, but in the near future winter projects will be initiated. At present this Division is studying the development of site selection methods, and compilation of design data on building foundations on permafrost areas. It is continuing general studies of permafrost, including mapping of the northern boundary of permafrost in Canada. Its Soil Mechanics Section continued work on the study of varved clays at Steeprock Lake, Ontario.

The Section collected considerable information on the properties of Leda clay in the Ottawa area in a study of the settlement of buildings.

## RESEARCH PROBLEMS

Some of the research projects listed in the First Annual Report have been undertaken (1950-51) but the main problems still stand. The Pleistocene map of Canada evolves slowly; the data sheets for the glacial map for the Atlas of Canada are complete but have yet to be compiled on a base map.

From the Rocky Mountains to Ellesmere Island, the study of Canadian glaciers has progressed well. Some general correlation of the data collected by individual expeditions is now required.

The Permafrost Station of the Division of Building Research, National Research Council at Norman Wells, N.W.T., and other research by the Division in Ottawa on permafrost bids fair to cover much of the field of ground frost phenomena in Northern Canada.

We are in need of new and improved prospecting methods for finding orebodies beneath glacial drift and forest cover. Geophysical and geochemical prospecting methods are being constantly improved and coming into greater use, but more attention should also be given to prospecting for orebodies by tracing boulder trains in drift-covered areas. A detailed study of the boulder train from the Steeprock Lake iron deposits has recently been completed by A. Dreimanis, University of Western Ontario, as an example of how the method may be used.

As pointed out in a recent paper, (Economic Geology, vol. 48, No. 7, 1953) on the varved clays at Steeprock Lake, Ontario, there is need for further research on the sedimentation processes involved in the deposition of varves. This might well be carried out at some Canadian university where the necessary laboratory facilities are available. Such work should be supplemented by detailed field studies to broaden our knowledge of the occurrences, and the differences in varved deposits from place to place.

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

Presented by Dr. P. S. Warren

Members of Subcommittee

| | |
|---|---|
| Dr. P. S. Warren (Chairman) | - University of Alberta, Edmonton, Alta. |
| Dr. G. H. Charlewood | - Department of Mines and Natural Resources, 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

An annual report on geological research on any subject relating to the geological sciences is best considered as a progress report. Research on the various projects listed for review is never finished so long as there is a demand for the product undergoing investigation. Projects that may be listed under the term "fundamental research" will probably never be concluded. It is necessary, however, due to rapid changes in the demand for various products, to review each year projects under investigation and to recommend new fields of research to satisfy fresh demands of industry.

## GRAVEL, SAND, AND CLAY

In general, gravel and sand for road metal and for building purposes are in good supply in Western Canada, and especially in Alberta. The "river cities", that is the cities situated on the main rivers, obtain their supplies from bench gravels along the valleys and from the "Saskatchewan gravels", a formation of sand and gravel lying on bedrock and below the glacial till.

Away from the rivers, sand and gravel from drumlinoid hills as well as outwash fans from terminal or recessional moraines are in much use, and interglacial sands have been utilized in some areas. The continuance of the Pleistocene survey by the Geological Survey of Canada and the Research Council of Alberta is much to be desired. The Pleistocene surveys should be directed so as to give the greatest help to highway engineers and soil surveyors.

The Research Council of Alberta has now obtained the necessary equipment for its clay laboratory, including X-ray diffraction and differential thermal analysis units. It will, therefore, be in a position to make very exact analyses of the various clays, limestones, and dolomites present in the province.

## COAL

Fundamental research on Alberta coal is being continued by the Research Council of Alberta in co-operation with the Department of Mines and Technical Surveys, Ottawa. Such research will be given considerable impetus in the near future as much more commodious quarters will be provided in the Research Council building, being financed by the Alberta Government and to be erected in the university area. This building will provide room for the Coal Research Laboratory, the Bituminous Sand Research Laboratory, the Clay Laboratory, the Geological Investigation Laboratory, the Pleistocene Laboratory, the Pleistocene Survey Laboratory, and the Soil Survey Laboratory.

Mr. W.A. Lang of the Research Council of Alberta, reports the following work being carried on:

"The currently severe, and undoubtedly continuing, competition against coal by oil and natural gas has caused a shift in emphasis in the coal research program of the Research Council of Alberta. Instead of confining its investigations to applied problems related to the preparation, processing and utilization of coal, the work has been extended to include fundamental studies of the origin and constitution of coal. Included are (a) a paleobotanical study of the flora and biological origin of Alberta coal measures, (b) investigations into the chemical and colloidal structure of coals, and (c) explorations of possible new chemical uses of coal. Continuing investigations include: analysis of channel samples of coal taken from newly opened mines and from established mines in which operation has extended to a new and hitherto unopened working area; improvements in the determinations used for the physical and chemical testing of coal and coal products; studies of the cleaning of fine coal; combustion studies of the suitability of Alberta coals for use in domestic stokers; and problems related to the briquetting and carbonization of coals of various ranks."

## INDUSTRIAL MINERALS

Dr. R. E. Folinsbee reports on sulphur in Alberta, as follows:

"Two plants in Alberta are currently producing sulphur commercially -- the Royalite plant at Turner Valley (about 10,000 tons per year) and the Shell plant at Jumpingpound (currently 10,000 tons per year, stepping up to 25,000 tons per year by 1955).

This sulphur production is a by-product of the cleaning of natural gas. In general, the natural gas of fields in southern Alberta and the foothills belt is high in hydrogen sulphide -- this is particularly true of the undeveloped Pincher Creek, Okotoks, and Olds fields. The gas associated with the reef fields of the Edmonton area is generally low in hydrogen sulphide; the dry gas of the Viking fields is very low in sulphur content.

"Certain oil wells in Alberta have encountered native sulphur during drilling operations -- Bailey Olds, for example. The depth at which this sulphur-bearing zone of the Devonian is encountered is too great for recovery of the native sulphur by the Frasch process, and wells drilled for sulphur on the shallower part of the platform (Sunbeam No. 1 and 2 wells, Dominion Tar and Chemical Company) have not encountered sulphur in commercial amounts.

"Sulphur in the crude oils of the reef fields is locked up in troublesome mercaptan compounds, and these are flared at the refineries. It appears unlikely that these crudes will become a major source of sulphur."

Dr. D.M. Baird reports from Newfoundland the difficulties in finding large magnesium-free limestones to supply the cement plant and the steel industry and suggests research that might reveal a quick field test to distinguish limestones that range from 97 to 100 per cent pure $CaCO_3$. He also suggests research into a rapid field test of the gypsum-anhydrite ratio in assessing gypsum deposits.

Dr. G.M. Mackenzie reports an occurrence of kaolinized tuff breccia of Mississippian age in southern New Brunswick. The material is refractory and a large tonnage is present as shown by bore-holes to the depth of 50 feet. At that depth alteration and leaching are just as intense as at the surface, so the process seems to be more than a surface phenomenon. The matter calls for investigation.

Dr. Donald J. McNeil, Antigonish, N.S., reports that at a meeting of the Nova Scotia Mining Society, acting as host to the A.I.M.E. and the C.I.M.M. at Antigonish in 1953, the following papers of interest as relating to industrial minerals, were read:

Industrial Minerals in the Chemical Industry, by J. R. Donald.

Geology and mining of Nova Scotia Gypsum, by N. R. Goodman and and C. B. Hume.

Petrology and Industrial Minerals, by Ian Campbell.

Fluorspar Resources of Newfoundland, by G. F. Carr.

Phosphate Rocks as an Economic Source of Fluorine, by W. H. Hill and K. D. Jacob.

Some Geologic Features of a Potash Deposit, by C. L. Jones.

Importance of Water in Industry, by J. F. L. Thomas.

Barites Resources of Nova Scotia, by C. O. Campbell.

Kyanite in Canada, by V. A. Haw.

Methods of Proving Worth of Clay and Shale Deposits, by J. F. McMahon and W. Brownell.

Mr. M. F. Goudge of the Industrial Minerals Division, Mines Branch, Ottawa, reports as follows:

"The Industrial Minerals Division is currently doing applied research on a great variety of industrial minerals such as, anhydrite, apatite, asbestos, barite, bentonite, brucite, diopside, fluorspar, gypsum, industrial waters, kyanite, magnesite, mica, nepheline, syenite, perlite, potash minerals, serpentine, sodium sulphate, spodumene, tourmaline, and vermiculite.

"Most of our work is directly connected with the utilization of these minerals and of finding out the influence of minor amounts of impurities on their usefulness. However, some of our work is very closely related to geological research inasmuch as knowledge of the origin and occurrence is generally necessary in our work on beneficiation and conversion of the physical and chemical characteristics of certain minerals to those required in industry as, for instance, in changing carbonates to oxides, and sulphates to sulphides. Our work on asbestos may be taken as an illustration of the type of work we are engaged in. In addition to extensive milling tests to separate the fibre from the rock and to open it up so that it can be used by industry, we are undertaking an exhaustive study of asbestos fibres and associated rocks from various deposits in Canada with the object of finding out why some fibre is soft and silky and some is harsh. In this work we use the Chevenard thermal balance, X-ray diffraction, the spectrograph, differential thermal analysis, and also, of course, ordinary quantitative analysis. We hope, in addition to obtaining our immediate objective, to obtain leads on the origin of asbestos and on the possibilities of making it synthetically.

"As to geological research projects that might be undertaken, I would suggest research on the origin of anhydrite, gypsum, kyanite, and vermiculite. I suggest these four minerals because some authoritative information on their origin and conditions of formation would greatly help us in the work we now have in hand. There are plenty of theories, but very little real research has apparently been done in this field."

Dr. H. Sargent, Chief, Mineralogical Branch, Department of Mines, Victoria, reports on non-metallic minerals in British Columbia in 1953:

"Ralph Thrall (Summit Lime Works, Lethbridge, Alberta) has been experimenting with talc and hydrophyllite from British Columbia for use as insecticide carrier. He has also been trying to find a use for red shale from Cranbrook.

"Harold Englund of Princeton Properties has had some experimental work done on the Princeton bentonite by Prof. Hauser at M.I.T. and by a paper company at Everett, Washington. So far, no market has been found for the Princeton bentonite which is believed to be present in large quantity; it is of the 'calcium' type.

"Port Haney Brick Company has had Mueller of the University of Washington doing experimental work on the bloatability of their clay. The Clayburn Brick Company has done a small amount of shale-bloating testing.

"Interest in perlite rock has not died out and we are still hoping that a deposit will be found within economic range of market.

"J. W. McCammon of the British Columbia Department of Mines collected samples of shale from Vancouver Island, the Lower Fraser Valley and the Princeton area, and is now testing the shale samples for bloatability.

"Use of the sulphur content of Sullivan mine tailings in the manufacture of fertilizer has been started in a plant built at the concentrator. This operation will yield substantial quantities of iron oxide residue and of synthetic gypsum. The nearness of the Crowsnest Pass coal deposits suggests possibilities for economic use of the fertilizer plant waste products. Use of the phosphate deposits of the Crosnest Pass area seems nearer."

## OIL

The McMurray formation in Alberta, generally known as the Tar Sands, has lately been subject to investigation by several oil companies. A drilling program was instituted with the hope of obtaining information relating to the richness of the oil sands at different horizons in various areas. The information obtained by the companies is, of course, confidential. The Geological Section, Research Council of Alberta, obtained permission to examine many of the drill cores and they are being shipped to the Research Council for sedimentary analysis. This is being undertaken at the present time and later, combined with further field work, will be the subject of a Master's thesis by Barry Mellon, a graduate student at the University of Alberta.

The discovery of gas and oil in the eastern pinch-out of the Cardium sandstone of the Alberta shale in the Pembina area, west of Edmonton, was the result of an accurate sedimentary and stratigraphic analysis of the formation by research geologists of various oil companies. This research will be repaid to the extent of probably a billion barrels of oil in one of the biggest oil fields on the Continent.

A marine sandstone at the base of the Belly River series (variously known as the Solomon, Chinook, or Basal Belly River sandstone) is also being investigated and has proved productive in much the same area. Limestone of Missippian age is proving productive in the same general area. Mississippian limestones are productive in the Turner Valley field and this horizon is the principal producer of light oil on the Canadian side of the Williston Basin. Recent discoveries and extensions at known fields in Saskatchewan and Manitoba make it probable that these two provinces will become exporters rather than importers of crude oil. Mississippian limestones are petroliferous in the Liard basin, but so far no production has been obtained.

The Mississippian strata in the Rocky Mountains should be thoroughly investigated by competent geologists who are well acquainted with Carboniferous faunas. Two quite widely separated Mississippian sections in the Liard area, from which fossil collections have been obtained, are the subject of study for Master's theses at the University of Alberta at present.

Continuation of the study of the Rocky Mountain Trench is a necessary item of research. The relationship of this structural feature to the mountain masses to the east and west should be assessed.

# 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

This report deals with research projects in stratigraphy and palaeontology, one section covering the activities in these branches in 1953 and the other outlining some of the additional problems that require attention.

In the section dealing with the considerable activity in these branches of geological science across Canada in 1953, little is said of the large amount of valuable work being done by geologists engaged by the many oil and mining companies conducting intensive investigations in many parts of the country.

In the second section, only a few of the many problems requiring attention are mentioned. There seemingly is no end to the list that could be compiled.

## CURRENT RESEARCH

More than 80 projects are listed under the headings "Stratigraphy and Palaeontology", "Palaeontology", and "Sedimentation" in the compilation of "Current Research in the Geological Sciences" on page 105 of this report. Only a few of the more general projects are dealt with here.

Stratigraphical, palaeontological, and related structural problems in the Maritime Provinces were studied by several parties of the Geological Survey of Canada. In Newfoundland, there was mapping of the Twillingate, Argentia, and St. George areas; in Nova Scotia, studies of the Joggins and Springhill coal fields were made and there was mapping of the Stewiacke and Baddeck areas; a program of mapping Prince Edward Island geologically was begun; and in New Brunswick the study of Silurian stratigraphy and palaeontology was continued, and there was mapping of the Tetagouche and Coldstream areas. Notable contributions resulted also from investigations carried out under the auspices of the Summer School in Geology of the Massachusetts Institute of Technology at "Crystal Cliffs", Antigonish County, N.S. In this work, post-graduate students prepared theses for masters' and doctors' degrees from studies of the Horton (Mississippian) group, of the Canso (Carboniferous) group, and of the Canso, Cape George, and Chedabucto Bay areas.

The Palaeozoic formations of southern Quebec received increased attention by 6 parties of the Quebec Department of Mines. In Gaspe peninsula one of these parties continued the study of Lower and Middle Ordovician rocks of the northern part of the peninsula and another began a detailed study of Lower Devonian rocks of Holland township where large copper deposits have been developed. East and south of Quebec City two parties studied the Cambrian(?) and Devonian(?) formations, and farther southwest another continued the mapping of Lower and Middle Palaeozoic rocks of the Eastern Townships. The scarcity of fossils and the disturbed nature of the rocks in these areas make the correlation and determination of ages of the formations difficult, but with the present program of systematic investigation, progress will be made in solving the many problems. The sixth party continued study of the little disturbed Ordovician rocks of the St. Lawrence north of Montreal.

Study of the lowlands on both sides of the St. Lawrence River between Montreal and Quebec City is now about completed and thus in Quebec, there remains to study in the lowlands only the relatively small area west and southwest of Montreal.

Parties of the Quebec Department of Mines studied the stratigraphy of early Precambrian rocks in the southern part of Quebec in the Grenville subprovince. Farther north, in the interior of the Shield, southwest and southeast of Chibougamau Lake, two parties studied the relations between rocks of the so-called Timiskaming and Grenville. They found, as has been observed in other parts of the Chibougamau region, that the gneisses that used to be considered as Grenville and as overthrust northwestward onto rocks of Keewatin and Timiskaming types are actually metamorphic facies of the Keewatin and Timiskaming types, and that the contact between the two "subprovinces", in this region at least, is one of gradational metamorphism rather than a major fault.

One party of the Quebec Department of Mines investigated an area 60 miles west of the south end of Ungava Bay. This area is on the eastern side of the Labrador Trough and the rocks are predominently quartzites of late Precambrian age with concordant gabbro sills. Six other field parties - four in the western Quebec mining belt and two in the Chibougamau district - made detailed studies directed primarily to problems of economic and structural geology, but at the same time gathered information to add to our knowledge of Precambrian stratigraphy.

Five of the six Geological Survey of Canada field parties in Quebec in 1953 studied areas underlain mainly by Late Precambrian formations in and near the Labrador Trough. Much geological work was also done on this sedimentary iron-bearing belt by company geologists, notably those of the Iron Ore Company of Canada, Labrador Mining and Exploration Company, Norancon Exploration Ltd., Quebec Labrador Development Ltd., Fenimore Iron Mines Ltd., Atlantic Iron Ores, Ltd., and International Iron Ores, Ltd., the last two being newcomers to the region west of Ungava Bay.

A paper of considerable interest was published early in 1953 by T.H. Clark and D.A.W. Blake on "Ordovician Fossils From Waswanipi Lake, Quebec" (Canadian Field Naturalist, vol. 66, No. 5, Sept.-Oct. 1952). These fossils, gathered by the junior author during field work for the Quebec Department of Mines, were from limestones found well within the interior of the Canadian Shield. The finding of Ordovician strata here and at two or three other widely separated places suggests that much of the Shield, in Quebec, at least, was covered by early Palaeozoic seas.

In Ontario, the Geological Survey of Canada extended its studies of the Silurian formations of the Niagara escarpment to Manitoulin Island, continued mapping of the Ordovician between the Canadian Shield and Lake Ontario, and made subsurface stratigraphical studies from wells drilled for oil and gas in southwest Ontario.

Field projects of the Ontario Department of Mines concerned particularly with stratigraphy included: (1) studies of the stratigraphy and structural relations of Precambrian rocks along the north shore of Lake Huron; (2) study of the structure and correlation of the Whitewater series of the Sudbury Basin; and (3) study of the stratigraphy and structure of the Porcupine area.

The Ontario Department of Mines made a distinct contribution to stratigraphy and palaeontology by publication, at the close of 1953, of a comprehensive report on the James Bay Lowland area. This well illustrated, 157-page report (published by the Department as volume LXI, part 6, 1952) is also outstanding because of its pooling of information derived from the work of the geologists of Shell Oil Company of Canada and from that of its own geologists. In giving the results of surface and subsurface investigations undertaken over a period of years the authors deal with the stratigraphy, palaeontology, and petroleum possibilities of the Silurian, Devonian, and Cretaceous formations of this extensive, hitherto little known, region.

The study of Precambrian sediments and sedimentation has been in progress for several years at the University of Toronto, with attention so far directed mainly to the Proterozoic iron formations of Ontario and Quebec. The work includes conventional petrographic studies and spectrochemical and X-ray mineralogical investigation of the iron formations and associated rocks. It is planned to supplement these with bulk chemical analyses and differential thermal analysis studies of the iron silicates. This will be followed by a spectrochemical, chemical, and petrographic study of representative Archaean and Proterozoic greywackes, argillites, and tillites of the Timiskaming-Kirkland Lake-Malartic area.

A trace element study of coal from Cape Breton Island has been completed at Queen's University and a full report is in preparation. Samples of single seams taken a mile apart correpond well in trace elements, but over greater distances the lateral variation prevents much use of these elements for identification and correlation of seams.

The Manitoba Mines Branch is sponsoring a study of the Mississippian of Manitoba, the only oil-producing formation to date in the province. It does not outcrop and the study is being made from well cuttings and cores.

The Geological Survey of Canada continues to study the stratigraphy and palaeontology of the Jurassic, Mississippian, and Devonian where they outcrop in the foothills and Eastern Rockies to gather basic information useful in the search for petroleum.

The Zoology Section of the National Museum of Canada made studies of vertebrate fossils in Saskatchewan and Alberta. In Saskatchewan, in co-operation with the Royal Ontario Museum of Zoology and Palaeontology, it completed the field work and laboratory preparation dealing with Tertiary mammalian faunas and is continuing scientific studies on them. In a study of the Cretaceous vertebrates of Alberta, it undertook field work during 1953 in the Oldman formation of Red Deer River Valley. Preparation and study of the specimens collected are in progress.

Four Geological Survey of Canada parties operating in widely separated areas in the Arctic Islands in 1953 obtained much information of stratigraphic interest. One party working out of the meteorological station at Alert on the north coast of Ellesmere Island found evidence of three periods of orogeny, and found metamorphic and intrusive rocks in the Cape Columbia region. Another party working out of the Isachsen meteorological station continued 1 inch to 8 mile mapping of parts of Ellef Ringnes Island, which is 300 miles west of Ellesmere Island. Cretaceous and younger strata to a thickness of 5,000 feet were mapped. A circular structure that had been noted on air photos was found to be a piercement dome with upturned strata at the rim and a core of gypsum with fragments of Palaeozoic limestone and masses of basic intrusive rocks. A third party continued the reconnaissance study of Cornwallis Island and neighbouring Bathurst Island, where twenty thousand feet of Palaeozoic strata were mapped and some of the Silurian facies were found to be petroliferous. A Tertiary lignite was found. The fourth party made a geological reconnaissance in the Hudson Strait region, completing a study of the coast and neighbouring areas of Baffin Island.

## SUGGESTED RESEARCH

In addition to the numerous problems calling for solution that are listed in the previous reports of this subcommittee, the following are presented:

(1) A comprehensive memoir is needed on the pre-Carboniferous of southern New Brunswick, though many problems yet remain to be settled. Regional palaeontological and stratigraphical studies under way by the Geological Survey of Canada should help to solve some problems of correlation and structure. Radioactive age determinations should help in fixing ages of some intrusive and volcanic rocks and determining the Archaean or younger age of the Green Head and other formations (G.S. MacKenzie).

(2) The pre-Carboniferous of New Brunswick needs study with modern concepts of geosynclinal types in mind. Such studies might be helpful in estimating the possibility of finding orebodies in these rocks. The Carboniferous formations should also receive detailed and regional study to assist in assessing coal, petroleum, natural gas, gypsum, and salt possibilities. The Triassic, although limited in extent, also offers interesting features for study (G.S. MacKenzie).

(3) A subsurface investigation of the pre-Utica Ordovician succession in southwestern Ontario should be undertaken. These strata underlie younger Palaeozoic rocks throughout most of the Ontario peninsula from Georgian Bay to Lake Erie. They outcrop on the north side of Manitoulin Island and in the area between Lake Simcoe and the Frontenac axis. This succession has been penetrated by about 135 wells between Lake Erie and the Bruce Peninsula, and although encouraging "shows" of oil and gas have been obtained at widely separated localities, commercial production has been obtained at only two places. Recent detailed mapping of these rocks where they outcrop has established several lithological subdivisions not hitherto recognized in well cutting examinations. It is felt that detailed logging of cuttings from recently drilled wells and a restudy of cuttings from the older wells in the light of the outcrop mapping is anecessary approach to an intelligent evaluation of the oil and gas possibilities of these rocks. Such a project would also include preparation of structure contour and isopachous maps and a study of any facies changes that may occur (J.F. Caley).

(4) Studies of Precambrian sedimentation are needed. The work of Pettijohn on Archaean sedimentation should be expanded and applied to areas other than those he has studied and discussed in more detail. Trace element studies of sedimentary rocks should be made to gain some idea of the probable changes in the composition of sea water during the Precambrian. It is possible that these studies might develop into a technique for the relative dating of Precambrian marine sediments. The chemistry of greywackes and argillites should be much more extensively investigated, especially in conjunction with trace element studies. The sources of sediments and the form and distribution of basins and troughs of deposition should be investigated.

Such a large project calls for a co-ordinated program of research in which the field work might well be carried out or sponsored by the provincial departments of mines and the Geological Survey of Canada and much of the laboratory work by the universities (W.W. Moorhouse).

(5) Studies of the relation of siliceous shales (Odanah) of eastern Saskatchewan and western Manitoba; of the oil-shales of the Colorado series; of the volcanic ash deposits of southwestern Saskatchewan (J.B. Mawdsley).

(6) With so much of the northern territories essentially unknown, geological reconnaissance of the bedrock and Pleistocene deposits is still the prime basic research requirement (C.S. Lord).

# 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 committee has not been able to meet throughout the year but has continued its study on training in geology by correspondence. It wishes to express its thanks for assistance rendered by the Secretary of the National Committee, and by Dr. J.E. Thompson of the Department of Mines of Ontario.

## VOCATIONAL GUIDANCE

Preparation of a vocational guidance brochure by the Geological Survey as recommended at the annual meeting of the Advisory Committee in Edmonton in 1953 appears to have gone full circle. The Secretary of the Advisory Committee has reported to the subcommittee that "a spokesman for the Treasury Board passed on the word that the preparation and publication of such a booklet was quite beyond the province of the Geological Survey. Booklets of this type are the business of the Department of Labor which has a Canadian Vocational Branch". Dr. Thompson reports that in March 1952 he asked the Department of Labor, Ottawa, if a booklet on geology could be published by that Department in its "Canadian Occupations" series. The Department reported: "We appreciate the fact that the material published on geologists and geophysicists in our 'careers' booklet is of a somewhat general character but considered it adequate for the purposes intended". However, the Director added that the Department would welcome suggestions for a more complete coverage.

The subcommittee is fully convinced that this brochure should be prepared by the Geological Survey and published either by the Survey or by the Department of Labor, whichever Department is better equipped and financed to undertake the publication. The subcommittee would prefer to have the booklet a definite publication of the Geological Survey.

## SUPPLY AND EMPLOYMENT OF GEOLOGISTS

The Department of Labour, Ottawa, reports that, as of 1953, there were 1,400 persons employed as geological engineers and scientists in Canada[1]. Its survey of Canadian firms[2] indicates requirements of 35 to 40

[1] Dymond, Dr. R. W.: Utilization of Specialized Manpower in Canada; A.A.A.S., Boston, Dec. 1953.

[2] Technical Personnel, Quarterly Bulletin, Oct. 1953, Table 1.

geological engineers and geologists each year for the period 1953 to 1956.

The Secretary of the National Committee has submitted the results of his survey on Canadian geological students attending universities in Canada and graduate schools in the United States in 1953-54 (p.116). The summary clearly indicates an upswing in students who will finish in geology at the Bachelor level in 1955. At the same time fewer candidates are apparently proposing to continue in post-graduate study. This potential swingover to the Bachelor degree as a final degree in geology points up the problem, considered later in this report, of the training for geology to the Bachelor level.

The Engineering Journal summary of undergraduate registrations in geological engineering in Canada[3] shows a total of 159 students. Many

[3] Engineering Journal, Dec. 1953, p. 1626.

of these will want summer employment during the balance of their academic years and permanent employment as geologists upon completion of their Bachelor course. The report of the Secretary of the National Committee (p.116) gives figures for the third and final years only, but those for arts and sciences added to those for engineering indicate there should be ample student help available for government and industrial field work in 1954 and 1955.

The report of the subcommittee for 1952-53, supplemented by the figures of registration supplied by the Secretary's inquiry and the Engineering Journal survey, indicated a decrease in interest in geology as a profession. This is certainly not borne out by the figures now available.

## BACHELOR'S DEGREE

The subcommittee has given some thought to the problems involved in the proper training for the degree of Bachelor of Science in geology. The figures clearly indicate an increasing interest in geology as a profession. The prevalent idea is that a professional geologist must have a Ph.D. degree. Certainly the government services seem to expect field party chiefs to be at least candidates for that degree, a possible reason being that, by restricting the work to such persons, the field party "make-up" will be continuous for the period of training. However, there is much geological work that does not require a doctorate degree. Some mining and oil companies prefer to hire the younger, less well-trained man and prepare him in their own way for their needs. The question arises "what fundamental topics should be covered in a 4-year course leading to a degree of Bachelor of Science in geology?".

The subcommittee feels that the development of a useful Bachelor degree graduate requires, besides suitable courses in geology a sound foundation in mathematics, physics, chemistry, and a good working knowledge of surveying. The average employer is interested in facility in the use of compass, transit and chain, level and plane-table, and drawing instruments and in map preparation. Proper interpretation of geological structure requires a knowledge of descriptive geometry, mechanics, and dynamics. Petrology and economic geology involve quantitative analysis and assay. The Bachelor graduates in geology will soon encounter geophysical interpretations and thus a knowledge of the field methods and results of geophysical exploration is essential. He need not know all the intricacies of geophysical instrument design, although some knowledge of the electromagnetic circuits involved is desirable.

Some knowledge of the modern devices and techniques such as scintillation counter, mass spectrometer, X-ray crystallography, thermal analysis, etc., might be helpful but the advanced mathematics and physics necessary for their proper use can be left to the few who carry on to post-graduate studies.

The foundation courses in geological sciences, i.e., general geology, including physical and historical, and some palaeontology, petrology and mineralogy, and structural and economic geology, can remain much as presently given. Emphasis on map reading and interpretation of geological maps, including geophysical maps, is desirable. An undergraduate thesis to train the student in assembly of data and interpretation, and in the essentials of report writing is a "must". It follows that the undergraduate course work must include sound training in English composition. Cultural subjects such as history, literature, modern languages, etc., can be included as the time-table permits.

The subcommittee believes that the foregoing would meet the requirements for basic training for geology as a profession, and the foundation subjects suggested are available at most Canadian universities. Possibly the profession of geology requires a break-down into "branches" just as that of engineering does. Field geology, mining geology, petroleum geology, coal geology, mineralogy, and palaeontology offer fields of usefulness and endeavour of sufficient importance to the study and utilization of the mineral resources of the country to form a sound stepping stone for professional advancement. Just as the engineer frequently diverges from the particular branch in which he was trained, so the professional geologist could diverge as his experience expands.

The subcommittee suggests that the broad field of training for the profession of geology with an end-point at the Bachelor degree should be restudied on the lines outlined above.

## APPENDIX I

### GEOLOGICAL SURVEY OF CANADA RESEARCH GRANTS — SUMMARY REPORTS ON PROJECTS INITIATED IN 1951 AND 1952

Summary reports on projects supported by grants in 1951 and 1952 that have been completed or are achieving results of interest are given below. No statements on projects iniated subsequent to 1952 are included.

### Project 1-51 - Geological Age Determinations

Under direction of Dr. J. T. Wilson, University of Toronto
Grants: 1951 - $1,350; 1952 - $2,100; 1953 - $3,220; 1954 - $3220

Approximately 300 isotopic age determinations of lead, uranium, and potassium minerals have been made, of which about half have been published and the rest are in press. Two new methods of age determination have been developed that promise to be particularly useful because they require only common lead and potassium minerals. The lead method also provides information on the source and history of many sulphide ores.

Published papers recording the results of this research include:

The Maximum Age of the Elements and the Age of the Earths Crust, C.S. Collins, R.D. Russell, and R.M. Farquhar; Can. Jour. Physics, vol. 31, pp. 402-418 (1953).

A Note on the Lead Isotope Method of Age Determinations; D.W. Allan, R.M. Farquhar, and R.D. Russell; Science, vol. 118, No. 3069, pp. 486-488 (1953).

Branching Ratio of Potassium 40; R.D. Russell, H.A. Shillibeer, R.M. Farquhar, and A.K. Mousouf; Phys. Rev., vol. 99, pp. 1223-1225 (1953).

Isotopic Constitution of Radiogenic Leads and the Measurement of Geologic Time; C.B. Collins, R.M. Farquhar, and R.D. Russell; Bull. Geol. Soc. America, vol. 65, pp. 1-22 (1954).

### Project 3-51 - Sandstones of the Medina Formation, Ontario

Under direction of Dr. H.S. Armstrong, McMaster University

Grant: 1951 - $350

The chief problem is delimiting the Grimsby and Thorold sandstones. Studies made of sandstones considered to belong to the Grimsby have suggested that this 'unit' represents a deltaic deposit in a sea in which shales were forming elsewhere. The work has pointed out the difficulties of recognizing the overlying Thorold. By the time the project is completed in 1955 a good knowledge should be obtained of the various sandstones between the Queenston shale and the Reynales dolomite. A part of the results of this study is recorded in the publication listed below and it is hoped to publish a paper on sedimentation in early Silurian times in this area in the near future.

Geology of Part of Niagara Peninsula of Ontario; J.S. Armstrong; Guide Book Field Trips 4-5, Meeting of Geol. Soc. Amer. and Geol. Assoc. Canada, Toronto, 1952.

## Project 4-51 - Spectrochemical Study of Trace Element Behaviour During Metamorphism of Argillaceous Rocks

Under direction of Dr. D.M. Shaw, McMaster University

Grants: 1951 - $760; 1952 - $1,200; 1953 - $1,850

In all, more than 1,000 analyses have been made, each in triplicate, on a suite of metamorphic rocks from the Littleton formation, New Hampshire. This work is described in two papers under the title "Trace Elements in Pelitic Rocks - Part 1, Variation During Metamorphism, and Part 2, Geochemical Relations". These papers will appear shortly in the Bulletin of the Geological Society of America. A third has been written entitled "Statistical Methods Applied to Geochemistry" arising out of statistical problems encountered in the course of the analytical work.

Active research is continuing on the analysis of metamorphic minerals; analysis of rocks for barium; and investigation of point counter methods in metamorphic petrography.

## Project 5-51 - Biogeochemical Research

Under direction of Dr. H.V. Warren, University of British Columbia

Grants: 1951 - $1,750; 1952 - $1,750; 1953 - $1,800; 1954 - $3,325

The manganese, iron, and magnesium content of vegetation has been studied to find out if the variation in the content of these elements can be used in prospecting for buried orebodies. It has been found that the biogeochemistry of iron and manganese is much more complex and not as likely to be of use in the search for ore as is that of copper and zinc. Nevertheless, on occasion, iron and manganese do show anomalies that can be related to ore occurrences.

The biogeochemistry of molybdenum, cobalt, and nickel is being studied. If more detailed work confirms the preliminary studies, molybdenum will be an important 'path-finder' element in biogeochemical exploration for copper and possibly for tungsten and uranium. Preliminary studies indicat that the content of cobalt and nickel in the vegetation varies with presence of either or both in the rocks under the overburden. Biogeochemical anomalies of cobalt and nickel in the vegetation are expected to prove fully as useful as those of copper, zinc, and molybdenum. Laboratory work is in progress to develop methods of making routine analyses for cobalt and nickel simple enough to be used by non-technical personnel in the field.

Recent published papers recording the results of this research include:

Acetonic Dithizone in Geochemistry; Harry V. Warren, Robert E. Delavault, and Ruth I. Irish; Econ. Geol., vol. 48, No. 4, pp. 306-311 (1953).

Water Testing for Minerals - A New Tool for Prospectors; Harry V. Warren and Robert Delavault; Western Miner and Oil Review, vol. 26, No. 7, pp. 38-43 (1953).

Geochemical Prospecting Finds Widespread Application in British Columbia; Harry V. Warren and Robert E. Delavault; Mining Engineering, vol. 6, No. 10, pp. 980-981 (1953).

Preliminary Studies of the Biogeochemistry of Molybdenum; Harry V. Warren and Robert E. Delavault; Trans. Roy. Soc., Canada, sec. IV, vol. XLVII, pp. 71-75 (1953).

Geochemical Prospecting in British Columbia; Harry V. Warren and Robert E. Delavault; Western Miner and Oil Review, vol. 27, No. 5, pp. 48 (1954).

Geology and Health, H.V. Warren; Scientific Monthly, vol. 78, No. 6, pp. 339-349 (1954).

## Project 7-51 - Formation of Sulphides in Rock by Reaction with Gases

Under direction of Dr. H. D. B. Wilson, University of Manitoba
Grant: 1951 - $450

A Barrell tube furnace has been used to test the reaction of gases or silicate minerals and rocks at elevated temperatures. It has been found that pyrrhotite is produced at temperatures as low as 613°C. when $H_2S$ is passed over silicate minerals that contain iron and that the iron content of a mineral affects the temperature of pyrrhotite formation. Considerable information has been obtained on the structure of the mineral residue after pyrrhotite formation by X-ray analysis. Other experiments have shown that copper silicate minerals are converted to copper sulphides by $H_2S$ at high temperatures; copper-iron sulphides are formed if iron is present; and that nickel sulphides form in a similar manner from nickel silicates.

The publication of the results of the work has been delayed until completion of the second part of the problem, which includes field and microscopic study of natural occurrences. The study of material from three areas is now complete and there remains only the laboratory study from two other additional areas to complete the project.

## Project 8-51 - Corundum Deposits of Renfrew County, Ontario

Under direction of Dr. J. E. Hawley, Queen's Unifersity

Grant: 1951 - $640

The study of the origin of these deposits has been completed and the results are embodied in the doctorate thesis of H. D. Carlson (Ph.D. thesis, Queen's University, 1953, 149 p., 2 maps, ill.). The results are summarized in the abstract of the thesis, which follows:

"Corundum, in Renfrew County, occurs as an erratically distributed constituent of a banded complex of scapolite, andeclase and nepheline-rich rocks, but is much more abundantly developed, and more generally distributed, in contact zones between this banded complex of rocks and a younger hybrid alkaline syenite.

"The scapolite-andeclase-nepheline gneiss complex may have formed either, (a) by the metasomatic alteration and replacement of intercalated calcareous and aluminous metasediments, or (b) by the intrusion of sill-like masses of an anorthositic magma into intercalated calcareous and aluminous metasediments. No positive evidence definitely supporting either one of these hypotheses over the other has been obtained in the present study. In both hypotheses, corundum is assumed to have formed by the transformation of portions of the metasediments, locally rich in alumina, into corumdum-bearing rock, either by a process of metasomatic replacement or by magmatic assimilation.

"The hybrid alkaline syenite appears to have developed by metasomatic replacement of the rocks of the earlier complex. In this process potash and silica were added to, and lime, soda, and alumina were released from the scapolite, andeclase, and nepheline rocks. The development of much corumdum in the contact zones between the older and the younger rocks is attributed to the crystallization here of some of the alumina released from the former during their transformation into syenite. Some of this alumina may have migrated, with the hydrothermal solutions responsible for the metasomatism, to loci favourable for the development of corundum-rich pegmatitic facies of the hybrid alkaline syenite."

## Project 9-51 - Spectrographic Analysis of Ash from Nova Scotia Coals

Under direction of Dr. J. E. Hawley, Queen's University

Grants: 1951 - $460; 1952 - $330; 1953 - $280

The ash from samples of 10 coal seams has been prepared and analysed spectrographically. Quantitative analyses of 185 samples have been obtained for 13 to 15 elements and intensity ratios for an additional 12 to 14 elements. A large number of calculations have been completed and weighted averages obtained.

Individual seams show what are considered to be significant differences, which should assist in their distinction one from the other. Lateral variation within individual seams indicates that to be of value in correlation work each seam would require extensive sampling throughout its length and depth.

This project has been completed and the full results will be presented in a final report being prepared.

Project 10-51 - Petrographic Comparison of Iron Formations of Port Arthur, Ontario, and the Mesabi Range, Minnesota, and Differentiation and Assimilation in the Logan Sills, Port Arthur, Ont.

Under direction of Dr. W. W. Moorhouse, University of Toronto

Grants: 1951 - $400; 1952 - $1,500; 1953 - $800

Nearly 200 thin sections of various phases of the iron formation of Port Arthur and of the Mesabi Range have been examined. The project has been broadened to include a study of the trace elements, particularly chromium, cobalt, nickel, vanadium, and boron, in the iron formations and associated rocks. The trace elements of representative samples of recent fresh and marine sediments of an argillaceous nature have also been studied to determine if the ancient iron formations were deposited in fresh or marine waters. The distribution of elements, especially chromium, vanadium, and boron is considered to indicate fairly clearly that the iron formations were deposited in marine water.

A paper entitled "Significance of Some Trace Elements in the Animikie Iorn Formation and Associated Argillite", which summarizes the results of this study was presented by B. A. Bradshaw at the meetings of the Geological Society of America in Toronto in 1953. A full report on the project is being prepared.

The study "Differentiation and Assimilation in the Logan Sills" has been completed and the results are embodied in the doctorate thesis of R.G. Blackadar (Ph.D. thesis, Univ. of Toronto, 1954, 119 pp., 10 plates). The abstract of the thesis, which follows, summarizes the results:

"Studies were made of the relative importance of the processes of differentiation and assimilation as evidenced in the rocks known as the Logan sills, which outcrop in the district west and north of Lake Superior.

"A detailed petrographic study was made of 7 diabase sills in the Lakehead district by means of Rosiwal analyses. Chemical analyses were also carried out on selected rocks from the sills. The variation in volume per cent of certain minerals, the average grain size, the specific gravity of the specimens, and the composition of the plagioclase feldspar were plotted against the position of the specimens above the lower contact of the sills. The erratic nature of the curves obtained from these data, especially those illustrating such critical features as the percentage of olivine and the grain size, has led the writer to postulate that many of the sills may be the result of multiple intrusion. It is unlikely that the thickness of a single intrusion exceeded 50 feet, and thus no well defined lithologic changes, such as are found in the Palisade sill on the Hudson River, are present in the Logan sills.

"Twenty chemical analyses of various rock types are presented; of these 17 were carried out by the writer. The results of 9 of these, being analyses of diabase from the various sills, have been plotted on two diagrams and the differentiation trends noted. The problem of iron enrichment as a product of the differentiation in a basaltic magma is considered and the conclusion reached that in the crystallizing magmas of the Logan sills, enrichment in iron occurred until very near the close of the crystallization sequence, at which time there was a rapid increase in the alkali content. Mineralogical evidence, derived mainly from the study of the olivine group, supports the conception of iron enrichment.

"Both assimilation and differentiation have been considered to be the processes whereby the hybrid rocks found at the top of many diabase sills originated. In the study of the "red-rock" associated with the Logan sills, the former process appears to have been by far the more important. The physical conditions under which such a process would be possible were considered and the conclusion reached that assimilation could have given rise to the hybrid rocks. The process of differentiation was found by a critical study to be incapable of giving rise to rocks having the observed chemical composition of the hybrid rocks."

## Project 11-51 - An Attempt to Identify Source of Radioactivity in Surface and Near Surface Sediments

Under direction of Dr. G. M. Brownell, University of Manitoba

Grant: 1951 - $700

Radioactivity surveys over sedimentary areas in Western Canada have shown that in some cases there is an apparent relation between the radioactivity pattern and oil fields. The Redwater field, Alberta, in particular shows a distinctive radioactive pattern above the oil-producing section with highs around its margin. To obtain some further data on this radiation, including its nature, distribution near the surface, and, if possible, its relation to underlying concentrations of petroleum and natural gas, the radioactivity was measured and 87 soil samples taken along a line crossing the Redwater field where repeated flights had shown a definite variation in radioactivity. Radioactivity measurements of the samples were made and the source (whether radiu, uranium, thorium, or potassium) determined.

No conclusions have been reached as to the relation, if any, between variations in radioactivity intensity and underlying concentrations of petroleum. However, the study shows a relatively great variation in radioactivity readings at the surface and that these variations decrease progressively with increasing depth to about 4 to 5 feet where the readings become fairly uniform. The erratic surface readings are probably due to variable moisture content, local differences in top soil composition, leaching effects, etc. It is concluded that airborne radioactivity surveys are more accurate and satisfactory than ground surveys because a larger area is scanned and a recording obtained that conforms fairly closely with readings that would be obtained at a depth of about 5 feet.

The final report on this project, which was completed in April 1953, entitled "An Attempt to Identify Source of Radioactivity in Surface and Near Surface Sediments as Recorded by an Airborne Scintillometer" (13 pp., 2 figs., 2 ill.) is available in the Library, Geological Survey of Canada, Ottawa.

## Project 12-51 - Microscope Heating Stage Construction

Under direction of Dr. F. G. Smith, University of Toronto

Grant: 1951 - $256

Construction of a horizontal microscope with attached heating stage has been completed. The purpose of the stage is to examine inclusions in minerals at elevated temperatures. The instrument functions reasonably well and is useful in research on the temperatures of formation of minerals. Studies have been made of quartz, sphalerite, fluorite, topaz, cassiterite, garnet, and diamond.

## Project 13-52 - Geochemistry of the Platinum Minerals in Sulphides and Ores

Under direction of Dr. J. E. Hawley, Queen's University

Grants: 1952 - $264; 1953 - $170

This is the continuation of an investigation to determine as accurately as possible the distribution of the platinum metals in various sulphides and ores, by spectrographic analysis of fire assay beads made from ores and minerals and by chemical methods involving solution, reduction with mercury, and finally spectrographic analysis of recovered solutions of the metals by the copper spark method.

As a fundamental part of the investigation some of the tellurides of palladium, platinum, rhodium, iridium, ruthenium, and osmium, the arsenides of rhodium and iridium, and the dibismuthide of platinum have been synthesized and studied by X-ray crystallographic methods and by mineralographic techniques to determine their parameters and mineralographic characteristics.

This project will be completed by the summer of 1954.

Publications recording the results of this research include:

Spectrographic Study of Platinum and Palladium in Common Sulphides and Arsenides of the Sudbury District, Ontario; J. E. Hawley, C. L. Lewis, and W. J. Wark; Econ. Geol., vol. 46, pp. 149-162 (1952).

Lead Bead Method of Spectrographic Analysis of the Platinum Metals, Gold, Silver and Bismuth in Sulphide and Uranium Ores; J. E. Hawley, Y. Rimsaite, and T. V. Lord; Trans. Can. Inst. Min. and Met., vol. LVI, pp. 19-26 (1953).

Platinum Metals in Some Canadian Uranium and Sulphide Ores; J. E. Hawley and Y. Rimsaite; Amer. Mineralogist, vol. 38, no. 5/6, pp. 463-475 (1953).

## Project 14-52 - Trace Element Studies of Granite Batholiths, Preissac-Lacorne Area, Quebec

Under direction of Dr. J. E. Hawley, Queen's University

Grants: 1952 - $308; 1953 - $3,227

This research forms part of a co-operative investigation initiated by the Geological Survey of Canada. The trace element study of the batholiths has been completed and the results are embodied in a thesis by L. B. Halferdahl (M.Sc. thesis, Queen's University, 125 pp., 8 pls., 9 figs.). A copy of the thesis is also available in the Library, Geological Survey of Canada. The results are summarized in the abstract of the thesis, which follows:

"Twenty-eight trace elements have been detected or determined by spectrographic methods in Early Precambrian microcline-bearing granitic rocks that outcrop in three batholiths and associated stocks in the Preissac-Lacorne area of Quebec. These rocks are distinguished from other granitic rocks in northwestern Quebec by: (1) pegmatites and veins containing economic concentrations of molybdenite, bismuthinite, spodumene, and beryl; and (2) a higher $K_2O$: $Na_2O$ ratio. Features indicating a magmatic origin, some differentiation, and alterations produced by late magmatic fluids in these batholiths and stocks are described.

Generally these rocks contain average concentrations of V, Cr, Ni, Co, Cu, Zr, Mn, Pb, and Ba. The concentrations of Zn and Sr are somewhat higher than average. Be, Li, W, Ag, and Bi are erratically distributed throughout all the batholiths. Mo appears to be concentrated mostly outside the borders of the batholiths. The distribution of the trace elements is explained by the principles first suggested by V.M. Goldschmidt, and with reference to the petrography.

"The three batholiths and all the stocks but one have been correlated by the presence of similar rocks with similar trace element suites.

"The fact that the Lacorne batholith contains more zinc than average suggests that the magma from which this arose may have been the source for the zinc ore at the Barvue mine and for other nearby mineralization."

## Project 18-52 - Fracture Patterns in Heterogeneous Rocks

Under direction of Dr. J. E. Gill, McGill University

Grant: 1952 - $790

The purpose of this investigation is to obtain more knowledge of the origin of fracture systems such as those that control the formation of many ore deposits. Because the conditions in nature are too complex to be dealt with by mathematical theory, the problem is being investigated by producing fracture patterns experimentally in the laboratory.

Several materials that might be suitable for model experiments have been tried, including various transparent plastics, gelatin, clay, and patching plaster mixed with oil, of which the last two have so far proved most satisfactory. In order to see the internal fractures caused by compression, the clay is frozen and then cut with a sharp knife. In this way the fractures are preserved so that they can be examined and plotted. A method of defining the positions of shear surfaces in soft clays after slicing has been developed and a series of experiments carried out with homogeneous and non-homogeneous blocks. The results of this work form part of a thesis by A. T. Avison (B.Sc. thesis, McGill University, 1954).

Additional experiments are needed to define with greater accuracy the boundary effects on blocks and to investigate the variation of fracture patterns with different block shapes and with materials of different strengths. This project will continue.

Project 20-52 - Study of Induced Radiation in Minerals, Rocks, and Ores

Under direction of Dr. G. M. Brownell, University of Manitoba

Grants: 1952 - $2,600; 1953 - $1,500; 1954 - $1,600

This is an investigation of the possibility of using induced radiation to identify and quantitatively measure the proportions of certain elements in rocks, ores, and minerals. The first phase was the construction and assembly of equipment, which was in operation in March 1953. The first experiments were to find which elements give an appreciable induced radioactivity. Preliminary measurements were then made on shales, sandstones, and limestones to learn something of their relative reactions to radiation. These tests tended to confirm the hope that rocks can be classified and certain constituents analysed by induced radiation. Following this specific tests were made on materials with known quantities of manganese, sodium, and silver. It was found that in mixtures containing 1 per cent or more manganese the amount can be measured with an accuracy within 0.05 per cent; likewise the silver content of a silver concentrate checked to within 0.9 per cent of the known content. Further experiments on the elements aluminium, magnesium, and silicon were likewise carried out with promising results.

The results of the preliminary studies are described in a thesis by Kelvin Bramadat entitled "Preliminary Investigation of Activation Analysis" (M.Sc. thesis, University of Manitoba, 1954), a copy of which is available in the Library, Geological Survey of Canada, Ottawa.

A second report covering subsequent work on aluminium and silicon is in preparation. The project will continue.

Project 22-52 - Thermal Measurements in Kemano Tunnel, British Columbia

Under direction of Dr. A. D. Misener, University of Western Ontario

Grants: 1952 - $1,000; 1953 - $1,910

The Kemano tunnel, which was driven 10 miles through part of the Coast Range of British Columbia, offered an opportunity to measure the heat flow from the earth in this region. Measurements of equilibrium rock temperatures and of the thermal properties of the rocks in situ at intervals along the tunnel have been completed. Check measurements on thermal

properties of the rocks in the laboratory will also be made. The computation of the heat flow from this data is well advanced and will be completed shortly.

A paper recording the results of this investigation was presented by Dr. Misener at the meetings of the International Union of Geodesy and Geophysics in Rome, Italy, in September 1954.

## APPENDIX II

## GEOLOGICAL SURVEY OF CANADA RESEARCH GRANTS TO CANADIAN UNIVERSITIES 1954

### UNIVERSITY OF BRITISH COLUMBIA

#### Biogeochemistry of Cobalt and Nickel

Applicant - Dr. H. V. Warren — Amount - $3,325

Biogeochemical research at the University of British Columbia has been supported by Geological Survey grants for the past 3 years. To date this research has demonstrated that trace amounts of some base metals increase in the vegetation over buried orebodies, and chemical kits, developed at the University of British Columbia for use by the prospector in the field, are now available and in use by many prospectors in the search for deposits of copper, lead, and zinc. Research is being continued on cobalt and nickel to find out if the content of these metals in the vegetation also reflects buried mineralization (See also p. 49 ).

### UNIVERSITY OF MANITOBA

#### Analysis of Rocks by Induced Radioactivity

Applicant - Dr. G. M. Brownell — Amount - $1,600

This project has been supported by Geological Survey grants for the past 2 years. It is an investigation of the possibilities of using induced radiation to identify, and quantitatively measure, the proportions of certain elements in rocks, ores, and minerals. The method is based on the formation of radioisotopes by bombardment of the elements with neutrons. The radioisotopes are unstable and return to stability by emission of beta and gamma rays. The induced radioactivity and decay time are characteristic of each radioisotope and the intensity of the induced activity is proportional to the quantity of the element present.

So far good results have been obtained in the analysis of the aluminium and silicon content of rocks by this method. Research will now be continued on the analysis of sodium and other elements. The possible applications of this extremely rapid method of activation analysis are numerous and important (See also p. 56 ).

### MCGILL UNIVERSITY

#### Silicate and Sulphide Phase Relationships

Applicants - Drs. J. E. Gill, V. A. Saull, and E. H. Kranck — Amount - $3,600

This project involves the construction of a high temperature-pressure furnace in which experiments will be carried out on:

(1) the immiscibility of sulphides and silicates; this has application to the origin of base metal deposits such as copper, nickel, lead, and zinc (the sulphides) and their relation to the rocks in which they occur (the silicates).

(2) The melting of natural rocks to find out the order of melting of the rock-forming minerals under different conditions of temperature and pressure; this is fundamental research on how rocks are formed, including the origin of the granitic rocks which are believed to be the source of many ore deposits.

Enthalpy Changes in Metamorphism

Applicant - Dr. V. A. Saull — Amount - $1,000

This project was initiated in 1953. It involves fundamental research on the changes (metamorphism) that rocks undergo when they are deeply buried beneath the earth's surface. The objective is to develop accurate methods of measuring the enthalpy changes in geologically important chemical reactions of this type.

Apparatus has been constructed that will measure accurately the heat developed in any solution process that can be made to occur in a closed system. This data will be used to determine heats of reactions, and surface and strain energy of geologic materials. Refinements and some additions will also be made to the apparatus.

MCMASTER UNIVERSITY

Geochemical Studies of Metamorphic Rocks

Applicant - Dr. D. M. Shaw — Amount - $1,800

For the past 3 years the Geological Survey has supported a program of spectrochemical research at McMaster University on the distribution of minor elements in metamorphic rocks. This project has now been completed and a report recording the results is in press (See also p. 49 ).

Further spectrographic work will be carried out on the manner of distribution of minor elements among the minerals of the rocks and to find out if these elements influence the stability relations between kyanite and related minerals.

Geochemical Studies of Deep Sea Manganese Nodules

Applicant - Dr. Z. L. Sujkowski — Amount - $1,540

This investigation, which was initiated in 1953, involves the study of rare elements in the nodules. To date more than 20 rare elements have been identified and methods for quantitative spectroscopic analysis of most of them have been worked out. Work on the remainder will be continued and study of samples of the bottom sediments from which the nodules came will be carried out. It is hoped that our knowledge of the chemical balance of sea water may be increased by this research.

QUEEN'S UNIVERSITY

Mineralogy of the Sudbury Ores

Applicant - Dr. J. E. Hawley — Amount - $1,000

Dr. Hawley has acquired an extensive collection of the ores of this important mining camp over the past 20 years and, with his students, has completed several syntheses of minerals found in them. The work to be undertaken will include some further analyses of individual minerals, the investigation of major and minor trace element components, a paragenetic study of polished sections, and the assembly of all available physical-chemical data on the ore minerals.

Granites of the Grenville Province and Sudbury Areas

Applicant - Dr. J. E. Hawley — Amount - $3,600

In 1952-53, with the support of Geological Survey grants, spectrographic methods for the analysis of major and minor constituents of silicate rocks have been developed and a study of the Lacorne-Preissac granite bodies of northern Quebec has been completed. Studies of granite bodies in the Grenville province and in the Sudbury area will now be carried out in co-operation with geologists of the Ontario Department of Mines. In the Sudbury area the granite rocks will be examined to explore the possible use of trace element content as a means of correlating and distinguishing the different bodies. In the Grenville province the origin of the granites - whether magmatic or the product of granitization - is of special interest, particularly where they contain uranium such as the Centre Lake and Croft deposits. It is hoped that clues may be found as to the distinctive features that characterize uranium-bearing granites.

UNIVERSITY OF SASKATCHEWAN

Petrology of Radioactive Pegmatites, Granites, and Metamorphic Rocks of Northern Saskatchewan

Applicant - Dr. J. B. Mawdsley — Amount - $1,600

This project includes studies of the relation between the composition of the feldspars and the radioactive content of the pegmatites and between degree of metamorphism and radioactive content.

UNIVERSITY OF TORONTO

Studies of Precambrian Sediments

Applicant - Dr. W. W. Moorhouse — Amount - $300

For the past 3 years the Geological Survey has been supporting research on the sedimentary iron formations of the Port Arthur area. This study will now be expanded to include a petrographic and chemical study of Precambrian sediments. The objectives will be: (1) to provide more exact information on the character of Precambrian argillaceous sediments; (2) to obtain some indication of the variation of composition of the sea water with time; and (3) to find out more about the source and conditions of deposition of Precambrian sediments.

Geological Age Determinations

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

The age of the rocks of the Canadian Shield is a major problem and this project gives promise of enabling geologists to determine the age of the granitic rocks, and sedimentary and volcanic rocks isolated within them.

This project has been supported by Geological Survey grants for the past 3 years. More than 300 isotopic age determinations of lead, uranium, and potassium have been made, practically all of which have been published or are in press. Of the samples used, nearly 100 were supplied by officers of the Geological Survey. Two new methods of age determination have been developed which give promise of being extremely useful because they require only common lead and potassium minerals (See also p. 48).

This grant is to carry on this work and to improve the accuracy of the methods.

UNIVERSITY OF WESTERN ONTARIO

Pleistocene Stratigraphy Along Lakes Erie and Huron

Applicants - Profs. G. A. Reavely and A. Dreimanis Amount - $600

The applicants have been carrying on studies of glacial deposits in the immediate vicinity of London, Ontario for several years. This grant will allow them to extend their work along the north shore of Lake Erie and the southeast shore of Lake Huron and to correlate it with that now in progress immediately to the south in the United States. This project should contribute much to our knowledge of the history of the Great Lakes region in glacial times and of the deposits that were left that now form the arable land, are the sources of sand and gravel, and contain the groundwater that supplies most of the wells of the area.

Study of Interstadial Peat from Markham Gravel Pit, Ontario

Applicant - Prof. A. Dreimanis Amount - $250

This project will include a complete pollen analysis, a C-14 age determination, and a field investigation of a peat block, probably deposited during an inter-glacial period, that is exposed in a gravel pit 90 feet below the surface. The results of this study will contribute to our knowledge of the Pleistocene stratigraphy of southern Ontario.

UNIVERSITY OF WESTERN ONTARIO

Scale Model Experiments of Airborne Electromagnetic Prospecting

Applicant - Dr. R.J. Uffen Amount - $1,000

Airborne electromagnetic prospecting devices have recently been developed in Canada. They are already in active use by some of the

larger mining companies and more general use will follow. The interpretation of the field results is most difficult.

It is proposed to construct scale models of typical geological structures and find out, experimentally, the response to be expected. The first work will be measurements of the response, as a function of the transmitter and receiver heights, above tabular "orebodies" that are good conductors.

# CURRENT RESEARCH IN THE GEOLOGICAL SCIENCES IN CANADA, 1953-54

Compiled by J. F. Henderson

CONTENTS

## INTRODUCTION

The annual bibliography of current geological research in Canada was published formerly as separate reports by the Geological Survey of Canada. This year, on the recommendation of the National Advisory Committee on Research in the Geological Sciences, it is included with the Annual Report of the Committee.

The lists of research projects in the bibliography have been obtained from the universities, federal and provincial departments of mines, and other institutions carrying on geological and mineralogical research in Canada. The larger mining and oil companies were also canvassed but the response was not too great because most of their research is directly concerned with exploration for oil and ore deposits and, consequently, many of them consider any announcement of its nature might be detrimental to their interests.

The bibliography is useful in: (1) indicating the lines of geological research receiving the greatest attention, and by inference, those being neglected; and (2) in enabling research workers to see who are working in similar fields and on similar problems. It also serves as a record of the large number of research projects undertaken as graduate student theses in our universities, many of which are available only in manuscript form in university libraries.

An appendix gives the results of a survey of the number of Canadian geological students in our universities and in post-graduate schools in the United States. This annual survey, which was started in 1952-53, should indicate over a period of a few years 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.

Success in assembling project titles for a bibliography such as this depends on the response of institutions and individual research workers. Acknowledgment is made in particular to those who assembled and forwarded data on research projects in institutions under their direction. However, in spite of general excellent co-operation, many projects, on which no information was received, have not been recorded. So that succeeding compilations may be more complete, any reader doing research projects or knowing of projects that have been omitted, is requested to send information on them to the Secretary, National Advisory Committee on Research in the Geological Sciences, Victoria Museum, Ottawa.

### Use of the Bibliography

In the bibliography projects are grouped under main headings that cover the different branches of the geological sciences. The reader can thus readily determine the research in progress in any field in which he is interested. Many projects that seem to fall equally well under more than one heading will be found repeated under these headings. An author index lists after each author the numbers of the projects, as listed in the bibliography, on which he is currently engaged. Thus by reference to the author index, the fields of research and projects of any worker can be readily found.

## AREAL GEOLOGY

### Alberta

1. Collins, G. A. and Swan, A. G., Research Council of Alberta:
   Detailed Studies of Precambrian Areas Staked for Uranium in Northeastern Alberta, 1953.
2. Douglas, R. J. W., Geol. Surv., Canada:
   Revision for Final Publication of Geology of the Brazeau, Bighorn River, Wawa, Wapiabi Creek, Pembina Forks, and Grave Flats Map-areas, Central Foothills, Alberta, 1 inch to 1 mile, 1953-54.
3. Irish, E. J. W., Geol. Surv., Canada:
   Kvass Flats Map-area, 1 inch to 1 mile, 1952-53.

### British Columbia

4. Aitken, J. D., Geol. Surv., Canada:
   Atlin Map-area, 1 inch to 4 miles, 1951-55.
5. Armstrong, J. E., Geol. Surv., Canada:
   Geological Study and Mapping of the Geology and Groundwater Supply of the Vancouver Area, 1 inch to 1 mile, 1948-54.
6. Bacon, W. R., B.C. Dept. of Mines:
   Studies of Coast Mountain Geology, 1950-53.
   Includes studies in the McKay Lake - Leduc Glacier-area, on Quadra Island, and in the Pender Harbour - Sechlelt Inlet area.
7. Brown, A. Sutherland, B.C. Dept. of Mines:
   Detailed Structural Studies of Wells - Roundtop Mountain Area, Cariboo District, 1 inch to 1000 feet, 1951-53; Ph.D. thesis, Princeton Univ.
   Detailed Mapping in Vicinity of Red Rose Stock, Rocher de Boule Mountain, Hazelton, B.C.
8. Christie, R. L., Geol. Surv., Canada:
   Bennett Map-area, 1 inch to 4 miles, 1949-53.
9. Duffell, S., Geol. Surv., Canada:
   Terrace Map-area, 1 inch to 4 miles, 1953-55.
10. Eastwood, G. E. P., B.C. Dept. of Mines:
    Detailed Studies Near Ferguson and Trout Lake, Lardeau Area, 1953-55.
11. Fyles, J. T., B.C. Dept. of Mines:
    Detailed Study in the Salmo-Pend d'Oreille River Area, 1 inch to 1000 feet, 1951-55. The study involves tracing and determining structure of the lime-bearing series.
    Geology of the Cowichan Lake Area, Vancouver, B.C., 1951-54; Ph.D. thesis, Columbia Univ.
12. Gabrielse, H., Geol. Surv., Canada:
    McDame Creek Map-area, 1 inch to 4 miles, 1949-54.
13. Leech, G. B., Geol. Surv., Canada:
    Canal Flats Map-area, 1 inch to 1 mile, 1953-55.
14. Little, H. W., Geol. Surv., Canada:
    Kettle River Map-area, 1 inch to 4 miles, 1952-55.
15. Reesor, J. E., Geol. Surv., Canada:
    Lardeau Map-area, 1 inch to 4 miles, 1953-56.
16. Roddick, J. A., Geol. Surv., Canada:
    Coquitlam Map-area, 1 inch to 4 miles; 1953-56.
17. Root, Samuel, Univ. of Manitoba:
    Stratigraphy in the Canal Flats Map-area, 1953-54; M.Sc. thesis.

18. Stuart, R. A., B.C. Dept. of Mines:
Geological Study of the Tahtsa Lake - Kemano River Tunnel, 1952-54.

19. Tipper, H. W., Geol. Surv., Canada:
Nechako Map-area, 1 inch to 4 miles, 1949-54.

Manitoba

20. Allen, C. M., Manitoba Mines Branch:
Geological Study of Area between Longitudes 55° and 55°20' and Longitudes 96°30' and 96°55', 1 inch to $\frac{1}{8}$ mile, 1953-54.

21. Davies, J. F., Manitoba Mines Branch:
Geology of the West Hawk Lake Area, 1 inch to 1000 feet, 1953-54.

22. Hunter, H. E., Manitoba Mines Branch:
Tow Lake Intrusive, 1 inch to 500 feet, 1953-54; Ph.D. thesis, Univ. of California.

23. Milligan, G. C., Manitoba Mines Branch:
Geology of Eastern Utik Lake Area, 1 inch to $\frac{1}{8}$ mile, 1952-54.

24. Moorhouse, M. D., Manitoba Mines Branch (part time):
Geology of Part of California Lake Area, Pt. 2, 1953-54; M.Sc. thesis, Univ. of Manitoba.

25. Moorhouse, M. D., and Shepherd, J. H., Manitoba Mines Branch:
Geology of the Prostick Lake Area, 1 inch to $\frac{1}{8}$ mile, 1953-54.

26. Quinn, H. A., Geol. Surv., Canada:
Nelson House Map-area, 1 inch to 4 miles, 1953.

27. Shepherd, J. H., Manitoba Mines Branch (part time):
Geology of Part of California Lake Map-area, Pt. 1, 1953-54; M.Sc. thesis, Univ. of Manitoba.

New Brunswick

28. Anderson, F. D., Geol. Surv., Canada:
Coldstream Map-area, 1 inch to 1 mile, 1953-54.
Geology of the Woodstock - Millville Area; Ph.D. thesis, McGill Univ., 1954.

29. Hachey, P. Osmund, Univ. of New Brunswick:
Geology and Groundwater of the Fredericton City District, 1953-55; M.Sc. thesis.

30. Jackson, W. H., Univ. of Toronto:
Rocky Brook Area, 1953-54; M.A.Sc. thesis.
A petrologic study of metamorphism of lavas and sediments.

31. Skinner, R., Geol. Surv., Canada:
Tetagouche Map-area, 1 inch to 1 mile, 1953-54.

Newfoundland and Labrador

32. Baird, D. M., Newfoundland Dept. Mines and Resources:
Geological Map of Newfoundland, 1952-54.
Structure of the Carboniferous Belt of the West Coast of Newfoundland, 1952-54.

33. Barnes, F. Q. and Riley, G. C., Geol. Surv., Canada:
St. Georges Map-area, 1 inch to 4 miles, 1952-53.

34. Belshe, John, Newfoundland Dept. Mines and Resources (part time):
Christopher Lake - Minipi Lake Area, Newfoundland, 1953-54.

35. Fritts, C. E., Newfoundland Dept. Mines and Resources (part time):
Ossokmanuan Lake Area, Western Labrador, 1953-54.

36. Frarey, Murray J., Geol. Surv., Canada:
Willbob Lake Area, Labrador, 1951-54; Ph.D. thesis
Univ. of Michigan.

37. Jenness, S. E., Newfoundland Dept. Mines and Resources (part time):
Geology of the Gander River Ultrabasic Belt,
1952-54; Ph.D. thesis, Yale Univ.
Geology of Newman Sound Area, Bonavista Bay,
Newfoundland, 1953-54.
An investigation of the natural resources of a
proposed National Park site.

38. Lee, Burdett W., Newfoundland Dept. Mines and Resources (part time):
Geology of the Red Wine Mountains, Labrador,
1953-54; Ph.D. thesis, McGill Univ.

39. McCartney, W. D., Geol. Surv., Canada:
Argentia Map-area, Newfoundland, 1 inch to 1 mile,
1953-54.

40. Podolsky, T., Newfoundland Dept. Mines and Resources (part time):
Geology of an Area Between Goose River and Dominion
Lake, Labrador, 1953-54.

41. Patrick, T. O. H., Geol. Surv., Canada (part time):
Twillingate Map-area, Newfoundland,
1 inch to 1 mile, 1953-54.

42. Smith, C. H., Geol. Surv., Canada:
Mount St. Gregory Map-area, Newfoundland,
1 inch to 1 mile, 1953.

## Northwest Territories

43. Blackadar, R. G., Geol. Surv., Canada:
Geological Exploration Along the North Coast of
Ellsmere Island, 1953-

44. Brown, I. C., Geol. Surv., Canada:
Detailed Geological Study and Mapping of the
Yellowknife Greenstone Belt, 1 inch to
500 feet, 1946-54.

45. Heywood, W. W., Geol. Surv., Canada (part time):
Geological Reconnaissance of Parts of
Ellef Ringnes Island, 1952-53;
M.Sc. thesis, Univ. of Washington.
An investigation of the stratigraphy and
peculiar circular structures visible in aerial
photographs.

46. Kidd, Donald J., Arctic Institute of North America (part time):
Geology of a Portion of Cumberland Peninsula,
Baffin Island, 1953-54.

47. Prusti, B. D., Geol. Surv., Canada (part time):
Geology of O'Connor Lake Map-area with Special
Reference to the Mineral Deposits, 1952-53;
Ph.D. thesis, McGill Univ.

48. Riley, G. C., Geol. Surv., Canada:
Cumberland Sound Area, Baffin Island; Ph.D. thesis,
McGill Univ., 1952-54.

49. Thorsteinsson, R., Geol. Surv., Canada:
Cornwallis Island and Vicinity, 1950-53.

## Nova Scotia

50. Bird and Walker, Massachussetts Institute of Technology:
Stratigraphy and Structure of an Area Along the South Shore of Chedabucto Bay; M.Sc. theses.

51. Cameron, H. L., Nova Scotia Research Foundation (part time); Acadia Univ:
Geological and Tectonic Map of Nova Scotia, 1943-53.

52. Hilton, Richard, Massachussetts Institute of Technology:
Stratigraphy and Structure of the Strait of Canso Area; M.Sc. thesis.

53. Huppi, Rodney, Massachussetts Institute of Technology:
Geology of the Cape George Area, Antigonish; M.Sc. thesis.

54. Kelley, D. G., Geol. Surv., Canada (part time):
Baddeck Map-area, 1 inch to 1 mile, 1952-54.

55. Smith and Dick, Massachussetts Institute of Technology:
Geology of the Canso (Carboniferous) Group Along the Pomquet and Black Avon Rivers, Antigonish County; M.Sc. theses.

56. Stevenson, I. M., Geol. Surv., Canada:
Shubenacadie Map-area, 1 inch to 1 mile, 1953-54.
Geology of the Truro Map-area, 1952-54; Ph.D. thesis, McGill Univ.

## Ontario

57. Abraham, E. M., Ont. Dept. Mines:
Gladstone Township, District of Algoma, 1 inch to $\frac{1}{2}$ mile, 1953.

58. Armstrong, H. S., Ont. Dept. Mines (part time), McMaster Univ:
Glamorgan Township, Haliburton County, 1 inch to 1 mile.

59. Bartley, M. W., Consultant, Development Dept., Canadian Pacific Railway:
Geological Mapping of Small Areas in Northwestern Ontario, 1951-
Small areas are mapped within convenient reach of the Canadian Pacific Railway that may not, as yet, have been mapped in detail. Results are not published in full but are available for distribution on request.

60. Hewitt, D. F., Ont. Dept. Mines:
Carlow and Mayo Townships, Hastings County, 1 inch to 1 mile, 1952-53.

61. Irvine, T. N. and Fletcher, G. L., Ont. Dept. Mines (part time):
Emo Area, Rainy River District, 1 inch to 1 mile, 1953; M.Sc. theses, Univ. of Manitoba.

62. Lawton, K. D., Ont. Dept. Mines (part time):
Boston Township, Temiskaming District, 1 inch to 1000 feet, 1952-54.

63. Satterly, J., Ont. Dept. Mines:
Lount Township, Parry Sound District, 1 inch to $\frac{1}{2}$ mile, 1953.

64. Thomson, R., Ont. Dept. Mines:
Cobalt Area, Temiskaming District, 1 inch to 1000 feet, 1948-

65. Thomson, J. E., Ont. Dept. Mines:
Sudbury Basin, District of Sudbury, 1953-

66. Walker, J. W. R., Ont. Dept. Mines (part time):
Jackfish-middleton Area, District of Thunder Bay, 1 inch to 1 mile, 1953.

67. Wilson, J. T., Ont. Dept. Mines (part time), Univ. of Toronto:
Geology of Sudbury - Cobalt District, 1947-

68. Winder, C. G., Geol. Surv., Canada (part time) Univ. of Western Ontario:
Geological Study and Mapping of Early Palaeozoic Formations of Southern Ontario East of Longitude 70°30' to the Frontenac Axis, 1951-53.
An investigation of the stratigraphy and palaeontology to assist subsurface correlations in the productive oil and gas fields of southwestern Ontario.

## Prince Edward Island

69. Prest, V. K., Geol. Surv., Canada:
Geological Study and Mapping of Prince Edward Island, 1953-56.
An investigation of the character, extent distribution and origin of the bedrock formations and glacial and post-glacial deposits.

## Quebec

70. Allard, Gilles, Quebec Dept. Mines (part time):
McKenzie Township (Southeast Quarter), Abitibi - East County, 1 inch to 1000 feet, 1953-54; Ph.D. thesis, John Hopkins Univ.

71. Averill, E. L., McGill Univ:
Geology of the Campbell Chibougamau Mine and Adjacent Areas, 1953-56; Ph.D. thesis.

72. Beland, J., Quebec Dept. Mines:
Rosaire - St. Pamphile Area, Montmagny and L'Islet Counties, 1 inch to 1 mile, 1953-54.

73. Bergeron, R., Quebec Dept. Mines:
Study of the Quebec - Labrador Iron Belt Between Hematite South Lake and Larch River, 1951-54; D.Sc. thesis, Université Laval.
Lake Gerido Area, New Quebec, 1 inch to 1 mile, 1953-54.

74. Blais, R., Quebec Dept. Mines:
Wacouno River Area, Saguenay County, 1 inch to 1 mile, 1953-54.
Geological Reconnaissance Along the Lower Thirty-two Miles of Marguerite River, Saguenay County, 1953-54.
An examination of the part of the river banks to be flooded in 1954.

75. Brummer, J. J., Quebec Dept. Mines (part time):
Holland Township (Northwest Quarter), Gaspe North County, 1953-55; Ph.D. thesis, McGill Univ.
A detailed geological investigation of the area, Gaspe Copper Mines Ltd., and other properties.

76. Clark, T. H., Quebec Dept. Mines (part time), McGill Univ.:
Laurentides Area (Palaeozoic Section), Montcalm, L'Assomption and Terrebonne Counties, 1 inch to 1 mile, 1953-54.
Part of a continuing program of investigation of the geology of the St. Lawrence Lowland.

77. Cooke, H. C., Quebec Dept. Mines (part time), Univ. of Montreal:
Warwick Area (West Half), Arthabaska, Richmond, and Wolfe Counties, 1 inch to 1 mile, 1953-54.

78. Deland, A. N., Quebec Dept. Mines (part time):
Surprise Lake Area, Abitibi - East County, 1 inch to 1 mile, 1953-55; Ph.D. thesis, Yale Univ.

79. Dugas, J., Quebec Dept. Mines:
Cadillac Township (Northwest Quarter), Abitibi - East County, 1 inch to 1000 feet, 1953-54.

80. Fahrig, W. F., Geol. Surv., Canada:
Herodier Lake Map-area, 1 inch to 4 miles, 1953-54.

81. Frarey, Murray J., Geol. Surv., Canada:
Thompson Lake Map-area, 1 inch to 1 mile, 1952-53.

82. Gilbert, J. E., Quebec Dept. Mines:
Compilation of Geology of the Western Quebec Mining Belt, Rouyn - Noranda District, 1 inch to 1000 feet, a continuing program.

83. Gorman, W. A., Quebec Dept. Mines (part time):
Ste. Justine Area, Bellechasse and Dorchester Counties, 1 inch to 1 mile, 1953-54; Ph.D. thesis, McGill Univ.

84. Harrison, J. M., Geol. Surv., Canada:
Geological Reconnaissance in Ungava Between Hudson and Ungava Bay, 1953.
An investigation of the bedrock formations to outline the areas in which mineral deposits are most likely to occur and the northern extension of the Quebec - Labrador iron belt.
Detailed Geological Study and Mapping of the Labrador - Quebec Iron Belt, 1949-56.

85. Johnston, W. G., Geol. Surv., Canada:
Opasatica Lake Map-area, 1 inch to 1 mile, 1953-54.

86. Kavanagh, P. M., Princeton Univ.:
Geology of the Hyland Lake Area, New Quebec, 1953-54; Ph.D. thesis.

87. Klugman, M. A., Quebec Dept. Mines (part time):
Charpeney - Coopman Area, Saguenay County, 1 inch to 1 mile, 1953-55; Ph.D. thesis, McGill Univ.

88. Latulippe, M., Quebec Dept. Mines:
Lacorne Township (Northeast Quarter), Abitibi East County, 1 inch to 1000 feet, 1953-54.

89. Mauffette, Pierre, Ecole Polytechnique:
Geology of Bellechasse - Montmagny District, 1952-

90. McGerrigle, H. W., Quebec Dept. Mines:
Grande Vallée Area, Gaspé North County, 1 inch to 1 mile, 1953-54.

91. Neale, E. R. W., Quebec Dept. Mines (part time):
Dollier - Charron Area, Abitibi - East and Roberval Counties, 1 inch to 1 mile, 1953-54.

92. Owens, O. E., McGill Univ.:
The Labrador Trough South of Leaf Bay, Northern Quebec, 1952-54; Ph.D. thesis.

93. Perrault, G. G., Univ. of Toronto:
Geology of Western Margin of the Labrador Trough, 1952-54; Ph.D. thesis.
A geological, petrological, and mineralogical investigation of the iron formation on the west side of the Labrador Trough with particular attention to the identification of the iron silicates by X-ray and other methods.

94. Roscoe, S. M., Geol. Surv., Canada:
Cambrian Lake Map-area, 1 inch to 4 miles, 1953-54.

95. Sabourin, R. J. E., Quebec Dept. Mines (part time):
Onslow - Masham Area, Pontiac and Gatineau Counties, 1 inch to 1 mile, 1953-54; D.Sc. thesis, Université Laval.

96. Slipp, R., McGill Univ.:
Geology of the Marymac Map-area, New Quebec, 1952-55; Ph.D. thesis.

97. Smith, J. R., Quebec Dept. Mines (part time):
McKenzie Township (Northeast Quarter) Abitibi - East County, 1 inch to 1000 feet, 1953-54; Ph.D. thesis, Princeton Univ.

98. Tiphane, M., Quebec Dept. Mines (part time), Univ. of Montreal:
La Tuque Area (East Half), Laviolette County, 1 inch to 1 mile, 1953-54.

## Saskatchewan

99. Budding, A. J., Sask. Dept. Mineral Resources:
Settee Lake Area, East Half, 1 inch to 1 mile, 1953-54.

100. Fraser, J. A., Geol. Surv., Canada:
Milliken Lake Map-area, 1 inch to 1 mile, 1953.

101. Hale, W. E., Geol. Surv., Canada:
Black Bay and Camsell Portage Map-areas, 1 inch to 1 mile, 1951-53.

102. Tremblay, L. P., Geol. Surv., Canada:
Detailed Geological Study and Mapping of the Beaverlodge Area, Athabasca Lake, 1 inch to 1000 feet, 1952-57.

## Yukon Territory

103. Campbell, R. B., Geol. Surv., Canada:
Glenlyon Map-area, 1 inch to 4 miles, 1949-54.

104. Christie, R. L., Geol. Surv., Canada:
Teepee Lake Map-area, 1 inch to 4 miles, 1953-54.

105. Green, L. H., Geol. Surv., Canada:
Mayo Lake Map-area, 1 inch to 1 mile, 1952-54.

106. Kindle, E. D., Geol. Surv., Canada:
Keno Hill Map-area, 1 inch to 1 mile, 1952-54.

107. Muller, J. E., Geol. Surv., Canada:
Kluane Lake Map-area, 1 inch to 4 miles, 1950-54.

108. Mulligan, R., Geol. Surv., Canada:
Teslin Lake Map-area, 1 inch to 4 miles, 1950-53.

109. Poole, W. H., Geol. Surv., Canada:
Wolf Lake Map-area, 1 inch to 4 miles, 1951-54.

110. Roots, E. F., Geol. Surv., Canada (part time):
Geological Reconnaissance in the Headwaters Region of Hyland and South Nahanni Rivers, 1953.

111. Tozer, E. T., Geol. Surv., Canada:
Geological Study and Mapping of the Triassic Formations in the Laberge Map-area, 1953.

112. Wheeler, J. O., Geol. Surv., Canada:
Kaskawulsh Map-area, 1 inch to 4 miles, 1953-55.
Plutonic Rocks of the Whitehorse Map-area, 1951-55; Ph.D. thesis, Columbia Univ.

GEOCHEMISTRY

113. Abbey, S., Champ, W. H., Robinson, S. C., Traill, R. J. and Wanless R. K., Geol. Surv., Canada:
Determination of Geological Age of Various Minerals, Ores and Rocks, 1953-
This research will combine chemical, spectrochemical and mass spectrometric analyses with mineralogical investigations in attempts to date minerals, ores and rocks by various methods.

114. Blais, R. A., Quebec Dept. Mines:
Petrology and Its Relationship to Decrepitation Studies of the Quartz Veins of O'Brien Mine, Quebec, 1952-54; Ph.D. thesis, Univ. of Toronto.

115. Boyle, R. W., Geol. Surv., Canada:
Study of the Lead Ores of the Mayo Mining Camp, Yukon Territory, 1953-56.
An investigation of the nature, geochemistry, origin and mode of formation of the silver-lead ores.

116. Brooker, E. J., Hawley, J. E., Lord, T. V., Queen's Univ.:
X-Ray Fluorescence Methods of Analysis of Ores Containing Tantalum, Niobium and Rare Earths, 1953-55.

117. Clayton, Robert N., California Institute of Technology:
Distribution of Stable Oxygen Isotopes in Silicate Rocks and Minerals, 1952-55; Ph.D. thesis.

118. Cornwall, F. W., Quebec Dept. Mines (part time):
Wall-rock Alteration in Vicinity of Lead-Zinc Deposits, Quebec (Anacon, New Calumet, and Golden Manitou Mines), 1953-56; Ph.D. thesis, McGill Univ.

119. Forman, S. A., and Bright, N. F. H., Mines Branch, Dept. Mines and Technical Surveys:
Synthesis of Titanium Oxides and Titanates, 1952-54.
The lower oxides of titanium and the titanates of iron and magnesium are being synthesized for use as X-ray and chemical standards. The investigation concerns the constitution of titania slags.

120. Fraser, J. A., Geol. Surv., Canada:
Hydrothermal Syntheses of Epidotes and Garnets and their Stabilities, 1951-54; Ph.D. thesis, Univ. of Minnesota.

121. Groeneveld Meijer, J. O. W., (grad. Student) and Hawley, J. E., Queen's Univ.:
Geochemistry of the Platinum Metals in Sulphides and other Ores, 1952-54.
Chemical methods of concentrating platinum metals from ores in contrast to fire-assay methods are being examined and tested in order to recover maximum amounts of platinum metals. Spectrographic analyses of recovered solutions are used for determination of quantities present. A part of the investigation is to include a synthesis of platinum metal tellurides and study of their mineralographic properties.

122. Halferdahl, L. F., Queen's Univ.:
Trace Element Study of Granite Batholiths, 1952-54; M.Sc. thesis.
A trace element study of the Lacorne and Preissac granite-masses, northern Quebec with which molybdenum-bismuth mineralization and lithium bearing pegmatites are associated.

123. Haycock, M. H., Mines Branch, Dept. Mines and Technical Surveys:
Investigation of Decrepitation Methods for the Determination of Temperature of Formation of Hydrothermal Minerals, 1950-

124. Harrison, W. D. (grad. Student) and Shaw, D. M., McMaster Univ.:
Geochemical Studies in Regional Metamorphism, 1953-54.
The point counter will be used to determine the composition of metamorphic rocks. Different sections will be cut from each specimen in an effort to prove or disprove variance in chemical analyses.

125. Hawley, J. E. and MacDonald, Graham (research assistant) Queen's Univ.:
Spectrographic Analysis of Major and Minor Constituents of Igneous Rocks, 1953-54.
A variety of spectrographic methods for determining major constituents in igneous rocks have been tried out but difficulties have been encountered in obtaining constant ratios for silicon and aluminum. Current research is going forward using air jet forcooling electrodes as designed by Dr. J. B. Stallwood.

126. Johns, R. W., Dominion Gulf Company, Toronto:
A Study of the Relationship of Metasomatism to Ore Occurrences, 1952-54.
The study employs X-ray diffraction analysis to determine mineral assemblage of samples. Association with ore occurrences is determined by analysis of samples collected over large regional areas.

127. Jones, R. E., Univ. of Toronto:
A Critical Study of Phase-Relations at the Pegmatite Stage, 1952-54; Ph.D. thesis.

128. Knutson, Robert A., Univ. of Manitoba:
Application of Induced Radiation to Rock Analysis, 1953-54; M.Sc. thesis.

129. Lepp, Henry, Univ. of Minnesota:
An Experimental Study of Interconversions Among Iron Carbonates, Oxides and Sulphides, 1950-53; Ph.D. thesis.

130. Macpherson, H. G., Univ. of Toronto:
A Chemical and Petrographic Study of Precambrian Sediments, 1953-55; Ph.D. thesis.
This project involves a study of the spectrochemistry, bulk chemistry, and petrography of typical sediments from type Precambrian areas in hope of obtaining more detailed information regarding (1) the characteristics of the classical Precambrian sedimentary formations (2) possible variations in the composition of sea water in the Precambrian and (3) a possible method of correlation.

131. Moore, T. H., McGill Univ.:
Heat Exchanges in Certain Metamorphic Reactions, 1951-54; Ph.D. thesis.

132. Mueller, G. V., McGill Univ.:
Experimental Work Bearing on the Origin of Hydrous Nickel-Magneseum Silicate Minerals, 1952-55; Ph.D. thesis.

133. Murray, L. G., Quebec Dept. Mines (part time):
Wall-rock Alteration in the Vicinity of Base Metal Sulphide Deposits in the Eastern Townships of Quebec, 1950-54; Ph.D. thesis, McGill Univ.

134. Prince, A. T., Mines Branch, Dept. Mines and Technical Surveys:
Liquidus Relationships in the 10 per cent Magnesia Plane of the System CaO - MgO - $Al_2O_3$ - $SiO_2$, 1952-53.
This work concerns the chemistry of blast furnace slag, rock wool, and refractory materials. A number of common rock forming minerals are encountered in crystalline phases in the quenching experiments.

135. Riddell, J. E., Quebec Dept. Mines (part time), McGill Univ.:
Distribution of Base Metals in Soils and Waters in Vicinity of Lead-Zinc Deposits in Lemieux Township, Gaspe North County, Quebec, 1953-54.

136. Saull, Vincent, Alexander, McGill Univ.:
Geologic Role of Heat Exchanges in Metamorphic Processes, 1953-54.

137. Schmidt, R. C., McGill Univ.:
A Study of the Dispersion of Certain Base Metals in Soils Under the Influence of Weathering, 1953-55; M.Sc. thesis.

138. Shaw, D. M. and Pearson, G. R. (grad. Student), McMaster Univ.:
Geochemical Studies in Regional Metamorphism (A) Rocks, 1951-
A continuation of earlier work on Devonian metamorphic rocks from New Hampshire. The schists, shales, and gneisses are being analysed for barium and will probably be analysed for uranium and thorium with co-operation of the University of Wisconsin. The major elements are also being studied by gravimetric and modal analyses to ascertain whether any changes in composition took place during metamorphism.
Geochemical Studies in Regional Metamorphism (B) Minerals, 1953-
Investigation of minor elements in the kyanite-sillimanite-andalusite group has been started to find out whether the polymorphic relations between these minerals are influenced by "foreign" elements.

139. Smith, F. G., Univ. of Toronto:
Decrepitation Geothermometry, 1948-
Current research is on decrepitation of metamorphic and igneous rocks and minerals.

140. St. Pierre, P. D. S., Mines Branch, Dept. Mines and Technical Surveys:
The System Tricalcium Phosphate-Anorthite-Silica, 1952-53
The Role of CaO - MgO Flux Ratio in the Burdening of Blast Furnaces, 1953-54.
This work is being done mainly to assist blast furnace operators. Many common mineral compounds are encountered in the course of this study.

150. Warren, H. V., Delavault, R., Univ. of British Columbia:
Geochemical Investigations of Molybdenum, 1952-54.
New Techniques for Determining Small Amounts of Nickel and Cobalt, 1952-54.

150-a. Whyte, W. H., Univ. of British Columbia:
Stability of Minerals under Hydrothermal Conditions, 1952-54.

## GEOPHYSICS

### Electrical

151. Blanchard, J. E., Nova Scotia Research Foundation:
Theoretical Investigation of Problems in Potential Theory which Have Application to Geophysical Exploration, 1948-

152. Bjarnason, Bjarni S., and Robinson, William J., Lundberg Explorations Ltd., Toronto:
Electromagnetic Ground-Airborne Method, 1952-53.
The exciting source is located on the ground and the detecting apparatus is carried in a suitable aircraft. In conducting a survey the aircraft, with detecting apparatus, is flown along pre-determined profiles.

153. Patkau, B., Univ. of Toronto:
Comparison of Theoretical Results and Experimental Results with Models in Response Obtained from a Cylindrical Conductor Situated in an Electromagnetic Field, 1952-53; M.A. thesis.

154. McClure, M. E., Univ. of Western Ontario:
Application of Geophysical Methods to the Determination of Bedrock Surfaces in the Pleistocene Deposits of the London Area, Ontario, 1952-54; M.Sc. thesis.
Resistivity methods have been employed and the results are being correlated with well logs.

155. Muir, W., Univ. of Western Ontario:
Electromagnetic Modelling of Air-borne Methods, 1953-55; M.Sc. thesis.
It is proposed to construct a scale model simulating an air-borne electromagnetic survey in order to obtain response curves over typical geologic structures.

## Gravity

156. Garland, G. D., Dominion Observatory:
Gravity Measurements in Vicinity of Malagash, N.S., 1953-54.
This study includes a regional survey of a considerable portion of the Cumberland Basin of northern Nova Scotia, and a detailed investigation of the Malagash salt deposit.

157. Innes, M. J. S., Dominion Observatory:
Gravitational Investigations in the Vicinity of Brent, Ontario, 1953.
This work is part of a co-operative investigation by the Division of Seismology and Terrestrial Magnetism and the Geological Survey of Canada of a feature that may be a meteor crater.

158. Innes, M. J. S. and Thompson, L. D. G., Dominion Observatory:
Gravitational Investigation of the Canadian Shield, 1947-
The general study of the Shield is continued from year to year.

159. Oldham, C. H. G., Dominion Observatory (part time):
Gravity Surveys Between Georgian Bay and Bancroft, Ont. and Across the Coast Range, B.C., 1952-54; Ph.D. thesis, Univ. of Toronto.
Study of Gravity Anomalies Along the Alaska Highway, 1953-54.
A fairly complete profile across the northern Cordillera is provided by this study. A number of samples have been collected for density measurements.

160. Sutherland, D. B., (grad. student) Univ. of Toronto:
Gravity Survey Across the Ottawa Graben, Ont., 1953-54.
A survey of 600 gravity stations has been made across the Ottawa graben near Renfrew and Pembroke. The densities of several hundred specimens of rocks have been measured. No gravity anomaly due to the graben was found but there are others related to changes in rock densities.

## Magnetic

161. Jacobs, J. A., Univ. of Toronto:
Analysis of Canadian Geomagnetic Data, 1953-55.
The data collected over the past century at Canadian government magnetic observatories are being analysed by use of the electronic computer.

162. Morley, L. W. and DuVernet, F. P., Geol. Surv., Canada:
Geophysical Surveys with the Airborne Magnetometer of Areas in Nova Scotia and Newfoundland, 1953.
In Nova Scotia the area covered includes about 5000 square miles between latitudes 45°15' and 46° and longitude 62° on the west and the Atlantic Ocean on the east. In Newfoundland the area covered includes about 20,000 square miles covering the whole width of the Island between latitudes 48° and 49°. For experimental purposes an airborne scintillation counter was operated during both surveys.

163. Rutledge, Donald W., Univ. of New Brunswick:
Contact Phenomena of the Pokiok Granite, New Brunswick, 1953-55; M.Sc. thesis.
Project includes consideration of the aeromagnetic pattern.

## Radioactivity

164. Abbey, S., Champ, W. H., Robinson, S. C., Traill, R. J., and Wanless, R. K., Geol. Surv., Canada:
Determination of Geological Age of Various Minerals, Ores and Rocks, 1953-
This research will combine chemical, spectrochemical and mass spectrometric analyses with mineralogical investigations in attempts to date minerals, ores and rocks.

165. Blanchard, J. E., Nova Scotia Research Foundation and Carter, A. L., (grad. student), Dalhousie Univ:
Carbon - 14 Age Determinations, 1953-

166. Farquhar, R. M., (grad. student), Univ. of Toronto:
Ages by Isotopic Analysis of Lead Extracted from Uranium-bearing Minerals and Lead Ores, 1948-
About 100 ages of uranium-bearing minerals and about 100 ages of galenas have been measured and published or are in the process of publication.

167. Gretener, P., Research Assistant, Univ. of Toronto:
Continental Structure and Age Determinations in South Africa, Australia, India and Europe, 1953-54.
A study of all available age determinations including recent ones from the Geophysical Laboratories, Univ. of Toronto, in relation to continental structure for areas other than North America.

168. Hogg, J., (grad. student), Univ. of Toronto:
Natural Variation of Isotopic Ratios of Titanium from Different Sources, 1953-54.

169. Harper, H. G., Univ. of Toronto:
Radioactivity of the Rocks Associated with Lake Athabasca Pitchblende Deposits, 1952-54; Ph.D. thesis.

170. House, Richard, Northwestern Univ.:
Radioactivity in the Falcon Lake Stock, Southeastern Manitoba, 1953-54; M.Sc. thesis.

171. Jones, E. A., (grad. student), Univ. of Toronto:
Comparison of Methods of Age Determination, 1953-
The uranium, lead, potassium, and rubidium methods of age determination are being checked one against the other.

172. Knutson, Robert A., Univ. of Manitoba:
Application of Induced Radiation to Rock Analysis, 1953-54; M.Sc. thesis.

173. Russell, R. D., (grad. student), Univ. of Toronto:
Radon Leakage from Uranium-bearing Minerals, 1953-54.

174. Roulston, Alan M., Roulston, K. I., Pringle, R. W., Brownell, G. M., Lundberg Explorations Ltd., Toronto:
Airborne Gamma Ray Spectrometer, 1953-54.
The purpose of this investigation is to obtain charts which will separate the radiations given off by different elements such as uranium, thorium and potassium.

175. Shillibeer, H. A., and Sturm, J., (grad. students), Univ. of Toronto:
Potassium-argon Method of Age Determination, 1950-
Nearly all work to date has been concerned with checking the accuracy and seeking possible errors in this method which now looks promising.

176. Wilson, J. T. and Cumming, G. L. (grad. student), Univ. of Toronto:
Continental Structure and Age Determinations in North America.

## Seismic

177. Hodgson, J. H., and Allen, J. F. J. (part time), Dominion Observatory:
Fault Plane Project, 1949-
It is possible from seismic records alone to determine the strike and dip of faults involved in long earthquakes and direction of motion in the fault. Tables, analogous to map projection tables, have been sent to press and a large number of earthquakes have been analysed. The project will continue indefinitely.

178. Mailhot, J., (grad. student), McGill Univ.:
Seismic Investigations of Part of the St. Lawrence Lowland, South of Montreal, 1953-56.

179. Milne, W. G., Dominion Observatory:
Seismicity of Southern British Columbia, 1951-
Using stations at Victoria, Alberni, and Horseshoe Bay earthquakes in the area of the stations are located.
Strata-Stress Project, 1953-54.
Three stations at Fernie, B.C. and Coleman and Turner Valley, Alta. have been set up to locate earthquakes in the vicinity of coal fields. The purpose is to determine whether rock bursts in the mines are due to mining operations or whether residual stresses are present.

180. O'Brien, P. N. S., Lecturer, and Patterson, N., (grad. student), Univ. of Toronto:
Model Seismology, 1952-
The investigation of the passage of seismic waves through single and multi-layered models.

181. Willmore, P. L., Dominion Observatory:
Development of Field Instruments, 1952-54.
A twelve-channel set of refraction seismographs for long range work is being developed. The stations will transmit by short wave to a central recording station. A three-channel prototype has been field tested and the remaining nine channels are being built. The instruments will be used in crustal studies and for investigating large geological features.
Seismic Studies of the Crater near Brent, Ontario, 1953.

182. Woo, D. A., (grad. student), Univ. of Toronto:
Construction and Testing of a Shaking Table, 1952-53.
A shaking table for testing geophones has been constructed and used.

## General Problems

183. Blanchard, J. E., Nova Scotia Research Foundation:
Investigations Relating to the Application of Methods of Geophysical Exploration to Exploration for Gypsum, 1950-54.
Geophysical Investigations of the Carboniferous Sedimentary Areas of West Hants County, N.S., 1952-54.

184. Betz, J., (grad. student), Univ. of Toronto:
Measurements of Conductivity and Susceptibility of Rocks and Minerals, 1952-54.
Instruments for measuring these properties have been constructed and are being tested.

185. Blackwell, J. H., Univ. of Western Ontario:
Geothermal Measurements at Kemano, British Columbia, 1952-54.
Rock temperature and thermal conductivity measurements are being made along the tunnels through the Coast Range of the Aluminum Company of Canada's Kitimat project. Calculation of conductivities and heat flow has commenced.

186. Jacobs, J. A., and Allan, D. W., Univ. of Toronto:
Geothermal History of the Earth, 1952-
A sufficient amount is known about the earth's interior and history so that upper and lower limits may be placed, with some confidence, on its age, layering, radioactivity, and original and present temperatures at various depths. Using various combinations of these possible figures many possible models of the earth can be postulated. This is being done and the thermal history of each model is being calculated on the electric computer to see which models are possible and reasonable. It is hoped to relate the results to the geological history of the Precambrian.

186-a. Meen, V. B., Royal Ontario Museum of Geology and Mineralogy:
Origin of the Chubb Crater, Ungava, Que., 1950-54.
Origin of Crater near Hebron, Labrador, 1953-55.

187. Uffen, Robert J., Univ. of Western Ontario:
Investigations of the Internal Constitution of the Earth, 1950-
The application of the solid state theory and seismic data is being used in an attempt to determine the state of the earth's interior.

## MINERALOGY

### X-Ray, Crystal Structure, Specific Minerals

188. Abesque, Frederic, Quebec Dept. Mines:
X-Ray Identification of Metamict Allanites, 1953.

189. Byrne, P. J. S., Research Council of Alberta:
Comparative Study of Bentonites, 1952-53;
Ph.D. thesis, Univ. of Illinois.

190. Ferguson, R. B., Univ. of Manitoba:
Crystal Structure of Albite, 1950-54.

191. Forman, S. A., Mines Branch, Dept. Mines and Technical Surveys:
Studies of Shales Associated with the Quebec-Labrador Iron Deposits, 1952-54.
This work is being done in co-operation with the Geological Survey as an aid in problems of stratigraphic correlation.

192. Forman, S. A. and Bright, N. F. H., Mines Branch, Dept. Mines and Technical Surveys:
Properties of Iron Ore Minerals, 1953-54.
A supplementary investigation to the Quebec-Labrador shale study.
Synthesis of Titanium Oxides and Titanites, 1952-54.
The lower oxides of titanium and titanites of iron and magnesium are being synthesized for use as X-ray and chemical standards.

193. Forman S. A. and Lindsey, June M., Mines Branch, Dept. of Mines and Technical Surveys:
Carbonate Minerals Associated with the Steeprock Iron Deposits, 1952-53.

194. Gillet, L. B., McGill Univ.:
Quantitative Determination of Niobium by X-Ray Spectroscopy, 1953-55; M.Sc. thesis.

195. Patrick, T. O. H., Univ. of Wisconsin:
Sericite in Granitic Feldspar, 1952-54; Ph.D. thesis.

196. Mueller, G. V., McGill Univ.:
Experimental Work Bearing on the Origin of Hydrous Nickel-Magnesium Silicate Minerals, 1952-55; Ph.D. thesis.

197. Rolnick, L. S., Massachusetts Institute of Technology:
The Gypsum-Anhydrite Problem; Ph.D. thesis.
Nova Scotia is one of several areas in North America from which specimens were collected for this investigation.

198. Swan, A. G., Research Council of Alberta:
Differential Thermal Analysis of Carbonate Rocks, 1952-53; M.Sc. thesis, Univ. of Alberta.

### Radioactive Minerals

199. Abbey, S., Geol. Surv., Canada:
Chemical Work Related to Research on Radioactive Minerals, 1952 —
A modern laboratory is planned in which will be made chemical analyses of radioactive minerals and other materials, and chemical separations of material for age determinations.

200. Gorman, D. H., Lecturer, Univ. of Toronto:
X-Ray Study of the Uranium Silicate Minerals, 1952-54.

201. Haycock, M. H., Mines Branch, Dept. Mines and Technical Surveys:
Mineralogical Study of the Ores of the Eldorado Mine, Northwest Territories, 1950-55.

202. Kaiman, S., and Hughson, M. R., Mines Branch, Dept. Mines and Technical Surveys:
Mineralogical Reports on Radioactive Ore Samples.
These reports cover the mineralogical composition of radioactive ores and mill products. Their main purpose is to supply mineralogical information that will assist the ore-dressing engineers in the treatment of ore.

203. Langford, G. B. and Nuffield, E. W., Univ. of Toronto:
Mineralogy of Radioactive Minerals and Compounds, 1952-56.
This project has as its objective -
(1) to secure definitive data on all radioactive minerals and compounds,
(2) to study the natural decomposition of radioactive minerals,
(3) to study the paragenesis of radioactive minerals and the zoning in radioactive deposits.

204. Robinson, S. C., Geol. Surv., Canada:
Mineralogy of the Goldfield's Area, Sask., 1949-54.
The project involves study of the geology and genetic relationships of the uranium-bearing ores of the Goldfields Mining Area. Knowledge of the mode of occurrence of vein deposits of uranium-bearing minerals so gained will aid in the search for further deposits of a similiar nature.

205. Robinson, S. C., Traill, R. J., and Sabina, A. P., Geol. Surv., Canada:
Preparation of a Reference Collection of X-Ray Powder Photographs of Radioactive and Other Minerals, 1949-
The objective is to have at hand the most efficient means for identification of radioactive and other minerals. The preparation of such a collection requires the accurate identification of the type material by chemical or other means, as well as the development of new techniques in powder photography.

206. Robinson, S. C., and Traill, R. J., Geol. Surv., Canada:
Investigation of the Variation in the Lattice Parameter of Specimens of Pitchblende and Uraninite from Various Localities, 1949-
The objective of this project is to ascertain whether the variations can be attributed to any of the following (1) different mineralogical provinces (2) age of deposits (3) variations in solid solution series.

207. Steacy, H. R., Geol. Surv., Canada:
Reclassification of the Geological Survey Collection of Radioactive Minerals, 1952-
This project includes the checking of identifications by modern methods and adding to the present collections.

## General Problems

208. Abbey, S., Champ, W. H., Robinson, S. C., Traill, R. J., and Wanless, R. K., Geol. Surv., Canada:
Determination of Geological Age of Various Minerals, Ores and Rocks, 1953-
This research will combine chemical, spectrochemical, and mass spectrometric analyses with mineralogical investigations in attempts to date minerals, ores and rocks by various methods.

209. Butler, Roy, (grad. student), Univ. of Manitoba:
Some Aspects of the Geology and Mineralogy of the Madsen - Red Lake Mine, Ont., 1953-54.

210. Das Gupta, S. K., Univ. of Toronto:
Paragenesis and Composition of Crustified Sulphide Ores, 1953-55; Ph.D. thesis.
A study of the paragenetic, compositional, decrepitometric characteristics of banded sulphide ores, with the objective of determining reasons for their variations.

211. Mauffette, Pierre, Ecole Polytechnique:
Magnetite, Titaniferous Magnetite and Ilmenite, 1952-

212. Podolsky, T., Lecturer, Queen's Univ.:
X-Ray Investigation of Rock Fabric, 1952-54; Ph.D. thesis, Massachusetts Institute of Technology.

213. Pollock, D. W., McGill Univ.:
Mineralogy of the Eastern Metals Nickel - Copper Deposits, Quebec, 1953-55; M. Sc. thesis.

# MINERAL DEPOSITS

## Precious Metals

214. Blais, R. A., Quebec Dept. Mines:
The Petrology and Its Relationship to Decrepitation Studies of the O'Brien Mine Quartz Veins, Quebec, 1952-54; Ph.D. thesis, Univ. of Toronto.

215. Black, P. T., McGill Univ.:
Geology of the Malartic Gold Fields Mine, 1950-54; Ph.D. thesis.

216. Butler, Roy, Univ. of Manitoba:
Some Aspects of the Geology and Mineralogy of the Madsen Red Lake Mine, Ontario, 1953-54; M.Sc. thesis.

217. Groeneveld Meijer, J. O. W., and Hawley, J. E., Queen's Univ.:
Geochemistry of the Platinum Metals in Sulphides and Other Ores, 1952-54.
Chemical methods of concentrating platinum metals from ores, in contrast to fire assay methods, are being examined and tested in order to recover maximum amounts of platinum metals. Spectrographic analyses of recovered solutions are used for determination of quantities present. A part of the investigation is to include synthesis of platinum metal tellurides and study of their mineralographic properties.

## Base Metals

218. Assad, R. J., McGill Univ.:
The Formation of Certain Granite-like Rocks in the Foot-wall of the Sudbury Norite Northwest of the Sudbury Basin, Ontario, 1953-54; M.Sc. thesis.

219. Averill, E. L., McGill Univ.:
Geology of the Campbell Chibougamau Mine and Adjacent Areas, 1953-56; Ph.D. thesis.

220. Blais, R., Quebec Dept. Mines:
Preliminary Study of the Nickel - Copper Deposit of Eastern Metals Corp. Ltd., Montmagny County, Quebec, 1952-53.

221. Boyle, R. W., Geol. Surv., Canada:
Study of the Lead Ores of the Mayo Mining Camp, Yukon Territory, 1953-56.
An investigation of the nature, geochemistry, origin and mode of formation of the silver-lead ores of the Camp.

222. Brummer, J. J., Quebec Dept. Mines (part time):
Holland Township (Northwest Quarter) - Gaspe North County, Quebec, 1953-56; Ph.D. thesis, McGill Univ.
A detailed geological investigation of the area and of Gaspe Copper Mines Ltd., and other mining properties.

223. Copeland, J. G., Univ. of Toronto:
Structure and Stratigraphy of the Waite-Amulet Area, Quebec, 1952-54; Ph.D. thesis.
A detailed re-study of the stratigraphy of the flows in the vicinity of the Waite-Amulet mine and a re-interpretation of the structure on this basis.

224. Cornwall, F. W., Quebec Dept. Mines (part time):
Wall-Rock Alteration in Vicinity of Lead-Zinc Deposits of the Anacon Mine, New Calumet Mine, and Golden Manitou Mine, Quebec, 1953-56; Ph.D. thesis, McGill Univ.

225. Cunningham-Dunlop, P. K., Univ. of Toronto:
Structural Geology of Ontario Pyrites Deposits, Sudbury, Ont., 1953-54; M.A.Sc. thesis.

226. Graham, A. R., Dominion Gulf Company, Toronto:
Partition of Nickel Between Sulphides and Silicates in Ultrabasic Bodies, 1953-55.

227. Mitra, R., Univ. of Toronto:
A Study of the Metamorphic Facies at the New Calumet Mine, Quebec, 1952-54; Ph.D. thesis.
An attempt to apply Eskola's facies principle to a particularly complex series of schists, gneisses, and amphibolites that have been mapped in considerable detail.

228. Mueller, G. V., McGill Univ.:
Experimental Work Bearing on the Origin of Hydrous Nickel-Magnesium Silicate Minerals, 1952-55; Ph.D. thesis.

229. Murray, L. G., Quebec Dept. Mines (part time):
Wall-Rock Alteration in Vicinity of Base Metal Sulphide Deposits in the Eastern Townships of Quebec, 1950-54; Ph.D. thesis, McGill Univ.

230. Pollock, D. W., McGill Univ.:
Mineralogy of the Eastern Metals Nickel-Copper Deposits, Quebec; 1953-55; M.Sc. thesis.

231. Riddell, J. E., Quebec Dept. Mines (part time), McGill Univ.:
Wall-Rock Alteration Associated with Base Metal Deposits; 1949-
Distribution of Base Metals in Soils and Waters in the Vicinity of Lead-Zinc Deposits in Lemieux Township, Gaspe North County, Quebec, 1953-54.

232. Scott, Barry, Queen's Univ.:
The Diorite Complex Beneath the Sullivan Orebody and Its Associated Alterations, Kimberly, B.C. 1953-54; M.Sc. thesis.

233. Smith, John C., Univ. of New Brunswick:
Geology of the Keymet Mine, Elmtree, New Brunswick, 1953-54; M.Sc. thesis.

234. Smith, C. H., Geol. Surv., Canada:
Investigation of Ultrabasic and Basic Intrusive Rocks and their Contained Chromite and Copper Deposits, Western Newfoundland, 1951-53.

235. Stewart, Keith J., Univ. of New Brunswick:
Geology of the No. 1 Orebody, Brunswick Mining and Smelting Corp., Bathurst, N.B., 1953-54; M.Sc. thesis.
A study of the petrology, mineralogy, wall-rock alteration and structure of the orebody.

236. Wolofsky, Leib, McGill Univ.:
Geology of the Candego Mine, Gaspe North County, Quebec, 1953-55; M.Sc. thesis.

## Ferrous Metals

237. Bergeron, R., Quebec Dept. Mines:
Study of the Quebec-Labrador Iron Belt Between South Hematite Lake and Larch River, 1951-54.
Iron Formation of the Labrador Trough, 1951-54; D.Sc. thesis, Université Laval.

238. Bradshaw, B. A., (grad. student), and Moorhouse, W. W., Univ. of Toronto:
Petrological Comparison of Lake Superior Iron Formations, 1951-54.
This investigation has involved a petrographic and spectrographic study of the iron ores of the Gunflint and Mesabi ranges. Mr. Bradshaw has completed his part of the work; further investigations by Dr. Moorhouse are continuing.

239. Dreimanis, A., Univ. of Western Ontario:
Study of Boulder Train of Iron Ores South of Steeprock Lake, Ontario, 1953-54.
The study of the boulder train from the Steeprock ore deposits will serve as an example for prospecting for ore deposits by boulder trains.

240. Evoy, E. F., Queen's Univ.:
The Iron Formations of Mistassini Lake, Northwest Quebec, 1953-54; M.Sc. thesis.

241. Forman, S. A., Mines Branch, Dept. Mines and Technical Surveys:
Studies of Shales Associated with the Quebec-Labrador Iron Deposits, 1952-54.
This work is being done in co-operation with the Geological Survey as an aid in problems of stratigraphic correlation.

242. Forman, S. A., and Bright, N. F. H., Mines Branch, Dept. Mines and Technical Surveys:
Properties of Iron Ore Minerals, 1953-54.
A supplementary study to the Quebec-Labrador shale study.

243. Forman, S. A., and Lindsay, June M., Mines Branch, Dept. Mines and Technical Surveys:
Carbonate Minerals Associated with the Steeprock Iron Deposits, Ont., 1952-53.

244. Gross, Gordon A., Univ. of Wisconsin:
A Study of Highly Metamorphosed Iron Formations in Matonipi Lake Area, Quebec, 1952-55;
Ph.D. thesis.

245. Howell, J. E., Univ. of Wisconsin:
Silicification in the Fleming Formation of the Knob Lake Group, Labrador, 1952-54;
Ph.D. thesis.

246. Owens, O. E., McGill Univ.:
The Labrador Trough South of Leaf Bay, Northern Quebec, 1952-54; Ph.D. thesis.

247. Perrault, G. G., Univ. of Toronto:
Geology of the Western Margin of the Labrador Trough, 1952-54.
A geological, petrological and mineralogical investigation of the iron formation on the west side of the Labrador Trough, with particular attention to the identification of the iron silicates by X-ray and other methods.

248. Rose, E. R., Geol. Surv., Canada:
Geological Study of the Iron Deposits of Eastern Ontario and Western Quebec, 1952-54.
An investigation of the character, origin, size and economic possibilities of the deposits.

249. Tanton, T. L., Geol. Surv., Canada:
General Investigation of the Iron Ores of Canada, 1940-55.
An investigation of the nature, origin, and age of the iron-bearing formations, and their relationships to the contained iron deposits.

## Radioactive Minerals

250. Abraham, E. M., Ont. Dept. of Mines:
Examination of Radioactive Deposits, Blind River Area, Ontario, 1953.

251. Arnold, Ralph G., Univ. of Toronto:
Petrology of the Blind River Conglomerate, Blind River, Ontario, 1953-54; M.A. thesis.
A study of the petrology and geology of the uranium-bearing conglomerate and associated sediments with special reference to the Quirke Lake section and including investigation of the conditions of sedimentation and their relationship to uranium deposition.

252. Campbell, Douglas D., California Institute of Technology:
Geology and Ore Controls, Eldorado Mine, Port Radium, N.W.T., 1952-55; Ph.D. thesis.

253. Collins, G. A. and Swan, A. G., Research Council of Alberta:
Detailed Studies of Selected Precambrian Areas in Northeastern Alberta Staked for Uranium, 1953.

254. Harper, H. G., Univ. of Toronto:
Radioactivity of the Rocks Associated with Lake Athabaska Pitchblende Deposits, 1952-54; Ph.D. thesis.

255. Haycock, M. H., Mines Branch, Dept. Mines and Technical Surveys:
Mineralogical Study of the Ores of the Eldorado Mine, Northwest Territories, 1950-55.
Study of Temperature of Formation of the Ores of the Eldorado Mine, Northwest Territories, 1950-54.

256. Kaiman, S. and Hughson, M. R., Mines Branch, Dept. of Mines and Technical Surveys:
Mineralogical Reports on Radioactive Ore Samples.
These reports cover the mineralogical composition of radioactive ores and mill products. Their main purpose is to supply mineralogical information that will assist the ore-dressing engineers in treatment of ore.

257. Kermeen, J. S., Univ. of Saskatchewan:
Investigation of Radioactive Mineralization in the Athabasca Sandstone Near Stony Rapids, Sask., 1953-54; M.Sc. thesis.

258. Lang, A. H., and Staff, Geol. Surv., Canada:
Filing of Information on Deposits of Radioactive Substances and Laboratory Investigation of Samples, 1945-
The objective of this project is to maintain a complete inventory of all occurrences of uranium and thorium in Canada and to aid in the discovery and explortation of deposits by supplying information gained from laboratory investigation.

259. Lang, A. H., Geol. Surv., Canada:
Field Studies of Uranium Deposits, 1948-
The investigation of the geology, structure, mineralogy, origin, age and economics of uranium and other radioactive deposits in Canada.

260. Langford, G. B. and Nuffield, E. W., Univ. of Toronto:
Mineralogy of Radioactive Minerals and Compounds, 1952-57.
The objective of this project is, (1) to secure definitive data on all radioactive minerals and compounds, (2) to study the natural decomposition of radioactive minerals and (3) to study the paragenesis of radioactive minerals, and zoning in radioactive deposits.

261. MacLaren, A. S., Geol. Surv., Canada:
Examination of Radioactive Deposits in the Goldfields Area, Sask., 1953.

262. Rotherham, D. C., (grad. student), Univ. of Saskatchewan:
Investigation of Radioactive and Non-Radioactive Granites and Related Pegmatites in Northern Saskatchewan, 1953-54.

263. Silman, J. F. B., Queen's Univ.:
Structural Control of Pitchblende-Bearing Fractures at Nesbitt-Labine Uranium Mine, Sask., 1952-54; M.Sc. thesis.

264. Roulston, Alan M., Roulston, K. I., Pringle, R. W., and Brownell, G. M., Lundberg Explorations Ltd., Toronto:
Airborne Gamma Ray Spectrometer, 1953-54.
The purpose of this investigation is to obtain charts that will separate the radiations given off by different elements such as uranium, thorium, and potassium.

265. Tremblay, L. P., Geol. Surv., Canada:
Detailed Geological Study and Mapping of the Beaverlodge Area, Athabasca Lake, Sask., 1952-57.

## Industrial Minerals

266. Allen, C. M., Univ. of Toronto:
Geology of the Gooderham Nepheline Pegmatite, Gooderham, Ont., 1950-54; Ph.D. thesis.
A petrographic and field investigation of the environment and origin of the nepheline pegmatite and gneiss of the Tory Hill - Gooderham area.

267. Antoniuk, Stephan A., Univ. of Alberta:
Sedimentation Study of the Saskatchewan Sands and Gravels, 1953-54; M.Sc. thesis.

268. Baird, D. M., Newfoundland Dept. Mines and Resources:
Anhydrite-Gypsum in the Ship Cove Limestone of the Basal Carboniferous of Southwestern Newfoundland, 1953-54.

269. Baird, D. M. and McKillop, J. K., Newfoundland Dept. Mines and Resources:
Sand and Gravel Deposits of the Avalon Peninsula, Newfoundland, 1953-54.

270. Blanchard, J. E., Nova Scotia Research Foundation:
Investigations Relating to the Application of Geophysical Methods to Exploration for Gypsum, 1950-54.

271. Bourret, P. E., Quebec Dept. Mines:
Industrial Minerals Investigations
A continuing program of investigation with the purpose of advising owners as to the value of industrial mineral deposits and to furnish information regarding the developing, mining, milling, and marketing of their product.

272. Byrne, P. J. S., Research Council of Alberta:-
A Comparative Study of Bentonite, 1952-53; Ph.D. thesis, Univ. of Illinois.

273. Freeman, P. V., McGill Univ.:
Petrographic Study of the "A" Orebody of the Monroe Asbestos Mine, Matheson, Ont., 1953-54; M.Sc. thesis.

274. Garland, G. D., Dominion Observatory:
Gravity Measurements in the Vicinity of Malagash, N.S., 1953-54.
This study includes a regional survey of a considerable portion of the Cumberland Basin of northern Nova Scotia and a detailed investigation over the Malagash salt deposit.

275. Girault, Jean, Quebec Dept. Mines:
Magnetic Susceptibility of Spodumene from Lacorne Twp., Quebec and its Magnetic Separation from Gangue Minerals, 1952-53.

276. Goodman, Nordau R., and Pendle, Yvette, Nova Scotia Dept. Mines:
Study of Evaporites in Carboniferous Areas in Nova Scotia, 1953-54.

277. Hestor, Brian W., Univ. of Toronto:
Geology and Economics of Limestone, 1953-54; M.A. thesis.

278. Hilchey, Gordon R., Univ. of Toronto:
Geology and Economics of Graphite, 1953-54; M.A. thesis.

279. Hoadley, J. W., Geol. Surv., Canada:
Investigation of Kyanite Deposits in Eastern Ontario, 1953-54.
An investigation of the character, structural control, and economic possibilities of the kyanite deposits of this region.

280. Matthews, J. G., Development Div., Canadian Pacific Railway:
Mineral Inventory of Alberta, 1949-
The project consists of recording data on all known industrial mineral deposits, the making of detailed field surveys, the sampling of new deposits, and laboratory testing by commercial or government organizations.

281. McCammon, J. W., B.C. Dept. of Mines:
Investigation of the Shale Deposits on Vancouver Island, the Lower Fraser Valley, and Princeton Area in Search for Material Suitable for Bloating for Lightweight Aggregate, 1953-54.

282. Maurice, O. D., Quebec Dept. Mines:
Building Stones of the Province of Quebec, 1950-
The continuation of a study begun in 1950, of the building stone industry in the Province.

283. Pearson, W. J., Ont. Dept. Mines (part time):
Kyanite Occurrences, Districts of Sudbury and Nipissing, Ontario, 1953; Ph.D. thesis, Queen's Univ., 1953-55.

284. Sandomirsky, Peter, Univ. of Western Ontario:
Geology of the Henderson and Conley Talc Mines, Madoc, Ont., 1952-54; M.Sc. thesis.
In addition to studying the local geology in considerable detail this investigation seeks to explain the origin of the talc and whether and how it is related to the regional metamorphism.

285. Waddington, G. W., Quebec Dept. Mines (part time), Université Laval:
Investigation of Marl Deposits in Gaspe Peninsula, Quebec, 1953-54.

## Coal and Peat

286. Copeland, M. J., Geol. Surv., Canada (part time):
Geological Study of the Coal Seams of the Cumberland Coal Area, N.S., 1953.

287. Girard, H., Quebec Dept. Mines:
Investigation of Peat Bogs in the Province of Quebec.
A continuing program with the results being published from time to time.

288. Hacquebard, P. A., Geol. Surv., Canada:
Research on Petrography and Spore Analysis of Nova Scotia Coals, 1948-
Investigations of the character and correlation of the various coal seams in Nova Scotia such as will aid in their development.

289. Hawley, J. E. and Rimsaite, Y., Queen's Univ.:
Spectrographic Analysis of Ash from Nova Scotia Coals, 1952-54.
The spectrographic analyses of more than 200 coal ash samples have been completed and the results are being calculated, averaged, and studied.

290. Ignatieff, A. et al., Mines Branch, Dept. of Mines and Technical Surveys:
Investigation of Restrictive Effect of Excessive Strata Pressures and Sudden Relief of Stress in Coal Mining at Depth, 1950-55.
A co-operative project of Mines Branch and Geological Survey by a team of mining engineers, physicists and geologists under the direction of Mr. Ignatieff, to obtain a better understanding of the character, cause and distribution of stresses that result in 'bumps', 'outbursts' and related phenomena in deep workings, and alternately to establish criteria that will assist in establishing safe and economical deep mining practices.

291. Ignatius, H., Quebec Dept. Mines:
The Napierville Peat Bog, Napierville, Quebec, 1953-54.

292. King, Lewis, Massachusets Institute of Technology:
Spontaneous Combustion of Nova Scotia Coals, 1953-54; Ph.D. thesis.

293. Latour, B. A., Geol. Surv., Canada:
Coal Reserves of Western Canada, 1950-
Collection of data relative to coal mines, coal prospects and coal occurrences in Western Canada, so that up-to-date records are available for use in computing coal reserves.
Investigation of the Use of Electro-Logs as a Means of Detecting and Correlating Coal Seams Penetrated by Bore-Holes Drilled for Oil and Gas in Alberta.
Investigation of Germanium Content of Canadian Coals, 1953-
Some 300 samples of coals from British Columbia, Alberta, and Saskatchewan have so far been tested; the project will continue.

294. Norris, D. K., Geol. Surv., Canada:
Detailed Study of the Structure and Stratigraphy at, and in Vicinity of International Coal and Coke and McGillivary Colliers, Coleman, Alberta, 1951-53.
The purpose is to obtain a better understanding of the character, cause, and distribution of the stresses that result in 'bumps', 'outbursts' and related phenomena in deep workings.

295. Rouse, Glen E., Ohio State Univ.:
Palaeobotanical Analysis of Fossil Plant Remains Associated with Canadian Lower Cretaceous Coal Measures, 1952-55; Ph.D. thesis.

296. Warren, H. V., and Delavault, R., Univ. of British Columbia:
Germanium in British Columbia Coals, 1953-54.

## General Problems

297. Brooker, E. J., Hawley, J. E., and Lord, T. V., Queen's Univ.:
X-Ray Fluorescence Methods of Analysis of Ores Containing Tantalum, Niobium, and Rare Earths, 1953-55.
A new X-ray fluorescence unit has been obtained and a variety of analytical problems will be investigated with it.

298. Brown, A. Sutherland, B.C. Dept. Mines:
Detailed Mapping in Vicinity of Red Rose Stock, Rocher de Boule Mountain, Hazelton, B.C. 1953.
The area is of interest as a present and prospective source of tungsten ore.

299. Cornwall, F. W., Quebec Dept. Mines (part time):
Examination of Mining Properties, Chibougamau District, Quebec, 1952.

300. Das Gupta, S. K., Univ. of Toronto:
Paragenesis and Composition of Crustified Sulphide Ores, 1953-55; Ph.D. thesis.
A study of the paragenetic, compositional, and decrepitometric characteristics of banded sulphide ores with the objective of determining reasons for their variations.

301. Emery, D. J., (grad. student), Queen's Univ.:
Structure and Mineralization Adjacent to the Round Lake Batholith, Boston Creek, Ont., 1953-54.

302. Folinsbee, R. E., Univ. of Alberta:
Preparation of Reference Suite of Polished Sections of Ore Minerals.

303. Gilbert, J. E., Quebec Dept. Mines:
Examination of Mining Properties and Development in Western Quebec.
A continuing program being carried out in the western Quebec mining region.

304. Gill, J. E., McGill Univ.:
Ore Deposits of Malartic District, Quebec, 1948-

305. Grenier, P. E., Que. Dept. Mines:
Examination of Mining Properties and Development in Southern Quebec, 1953-

306. Gross, W. H., Univ. of Toronto:
Cross Folding as a Guide to Ore, 1948-54.

307. Haycock, M. H., Mines Branch, Dept. Mines and Technical Surveys:
Investigation of Decrepitation Methods for the Determination of Temperature of Formation of Hydrothermal Minerals, 1950-

308. Ingham, W. N., Quebec Dept. Mines:
Compilation of the Geology of the Western Quebec Mining Belt, Val d'Or District, 1 inch to 1000 feet.
Examination of Mining Properties and Development in Western Quebec.

309. Johns, R. W., Dominion Gulf Co., Toronto:
A Study of the Relationship of Metasomatism to Ore Occurrences, 1952-54.
This study employs X-ray diffraction analysis to determine mineral assemblage of samples. Association with ore occurrences is determined by analysis of samples collected over large regional areas.

310. Maurice, O. D., Quebec Dept. Mines:
Examination of Mining Properties and Development in Southern Quebec, 1951-

311. Prusti, B. D., McGill Univ.:
Geology of O'Connor Lake Map-area, N.W.T., with Special Reference to the Mineral Deposits, 1952-55; Ph.D. thesis.

312. Rowe, R. B., Geol. Surv., Canada:
Geological Study of the Lithium-Beryllium Pegmatites of Manitoba and Ontario, 1953.

313. Smith, F. G., Univ. of Toronto:
Decrepitation Geothermometry, 1948-
Current research is on decrepitation of metamorphic and igneous rocks and minerals.

314. Stevenson, J. S., McGill Univ.:
Study of Certain Phases of the Sudbury Irruptive, 1952-

315. Thomson, J. E., Ontario Dept. Mines:
Sudbury Basin, Ont., 1953-

## MINERAL INVENTORIES

316. Gooch, W. B., Geol. Surv., Canada:
Economic Geology Files, 1940-
The objective of this project is to file all published authentic geological information on all Canadian occurrences of economic metals or minerals; to cross index these files so that the information is readily accessible; to file all geological maps; and to prepare for publication maps and reports showing distribution and mode of occurrence of specific metals or minerals.

317. Lang, A. H., and Staff, Geol. Surv., Canada:
Filing of Information on Deposits of Radioactive Substances and Laboratory Investigation of Samples, 1945-
The objective of the project is to maintain a complete inventory of all occurrences of uranium and thorium in Canada and to aid in the discovery and exploitation of deposits by supplying information gained from laboratory investigations.

318. Matthews, J. G., Development Dept., Canadian Pacific Railway:
Mineral Inventory of Alberta, 1949-
This project includes recording data on all known industrial mineral deposits, the making of detailed field surveys, the sampling of new deposits, and laboratory testing by commercial or government organizations.

## PALAEOBOTANY

319. Bell, W. A., Geol. Surv., Canada:
Lower Cretaceous Floras of Western Canada, 1953-54.

320. Fry, Wayne L., Geol. Surv., Canada:
Palaeobotanical Studies of the Jurassic Floras of British Columbia, 1954-
Palaeobotanical Studies of the Tertiary Floras of British Columbia, 1954-

321. Lowther, J. Stewart, Univ. of Michigan:
Fossil Flora of the Arctic Slope of Alaska, 1953-55; Ph.D. thesis.

322. Rouse, Glenn E., Ohio State Univ.:
Palaeobotanical Analyses of Fossil Plant Remains Associated with Canadian Lower Cretaceous Coal Measures, 1952-55; Ph.D. thesis.

## PALAEONTOLOGY

323. Clark, T. H., McGill Univ.:
Palaeontology of the Ordovician Rocks of Quebec, 1925-

324. Copeland, M. J., Univ. of Michigan:
Arthropods of the Carboniferous of Nova Scotia, 1952-55; Ph.D. thesis.

325. Frebold, Fred, Univ. of British Columbia:
Study of the Mississippian Faunas of the Rocky Mountains of Canada, 1953-54; M.Sc. thesis.

326. Frebold, Hans, Jeletzky, J. A., McLaren, D. J., Harker, P., Tozer, E. T., Bolton, T. E., Cumming, L. M., Wagner, Frances J. E., and Staff, Geol. Surv., Canada:
Maintenance of Geological Survey Collections of Fossil Invertebrates and Plants, Particularly of Canadian Type Specimens.
The project includes (1) cataloguing, labelling, and preparation of existing and incoming collections (2) examination and description of collections, and (3) exchange with other palaeontological institutions elsewhere.
Examination of Fossil Collections from Oil and Mining Companies, Provincial Government Departments, Officers of the Geological Survey, and Private Individuals.
Includes examination and stratigraphic reports on fossil collections from all parts of Canada.

327. Fortesque, John, Univ. of British Columbia:
Some Brachiopoda from the Upper Devonian of the Rocky Mountains, 1953-54; M.Sc. thesis.

328. Fritz, Madeleine A., Univ. of Toronto:
A Genus of Stromatoporoid from the Upper Abitibi River Limestone, 1952-54.

329. Husain, B. R., McGill Univ.:
Semi-Micro Fossils of the Black River and Trenton Formations of Quebec, 1951-54; Ph.D. thesis.

330. Jeletzky, J. A., Geol. Surv., Canada:
Scaphitoid Ammonites of the Bearpaw Formation, Alberta and their Stratigraphic Importance, 1949-57.
Belemnites of the Colorado Group of the United States, 1950-54.
Aucellas of Canada and their Stratigraphic Importance, 1949-56.
Callovian Ammonite Faunas of the West Coast of Vancouver Island and their Stratigraphic Importance, 1949-57.

331. Lindblad, G. E. and Russell, L. S., National Museum of Canada:
Fossil Vertebrates of the Cretaceous of Alberta, 1953-55.
This is a re-exploration of the badlands of the Red Deer River. The results of one season's field work include discovery of new reptiles.

332. MacGregor, A. R., McGill Univ.:
Chazyan Reefs and Reef Builders, 1953-54; M.Sc. thesis.

333. Mawdsley, James C., Univ. of Alberta:
Middle Devonian Palaeontology, Norman Wells Area, Northwest Territories, 1953-54; M.Sc. thesis.

334. McLearn, F. H., Geol. Surv., Canada (retired):
Jurrassic Pelecypods of Skidegate, B.C., 1933-54.
Ammonoidea of the Upper Triassic Pardonnet Beds, Peace River Foothills, 1937-55.
A preliminary paper on this project was published in 1953 (Geol. Surv., Canada, Paper 53-21).
Evolution of Inoceramus, 1942-56.

335. Okulitch, V. J., Univ. of British Columbia:
Archaeocyatha from the Cambrian of Northern and Eastern British Columbia, 1952-54.

336. Patton, W. J. H., Univ. of Alberta:
Carboniferous Fauna of the South Nahanni Area, Northwest Territories.

337. Procter, R. M., Univ. of Manitoba:
Palaeontology of the Stony Mountain Formation, 1953-54; M.Sc. thesis.

338. Russell, L. S., National Museum of Canada:
Tertiary Mammals of Saskatchewan, 1948-55.
Tertiary Mammals of British Columbia, 1950-.
So far this project has been concentrated in the Flathead Valley of southeastern British Columbia, but will be expanded in the summer of 1954. In addition to fossil mammals, new faunas of Mollusca have been obtained, as well as important data on the geological history of the region.

339. Thomlinson, A., Univ. of British Columbia:
Devonian Corals from the Rocky Mountains of Canada, 1953-54; M.Sc. thesis.

340. Thorsteinsson, Raymond, Geol. Surv., Canada:
Graptolites from Silurian of Cornwallis Island, Northwest Territories, 1952-54;
Ph.D. thesis, Univ. of Kansas.

341. Usher, John L., Queen's Univ.:
Upper Cretaceous Pelecypods from Vancouver Island, B.C., 1953-

342. Wall, John H., Univ. of Missouri:
Jurassic Microfaunas of Saskatchewan, 1954-57;
Ph.D. thesis.

343. Wilson, Alice E., Geol. Surv., Canada (retired):
Ordovician and Silurian Fauna of Cornwallis Island, Northwest Territories, 1950-56.

344. Wagner, Frances J. E., Geol. Surv., Canada:
Pleistocene Champlain Sea Faunas, Southeastern Ontario and Southern Quebec, 1953-56.

345. Wickenden, R. T. D., Geol. Surv., Canada:
Lower Cretaceous Foraminifera from Peace River, Alberta, 1949-54.

## PETROLOGY AND PETROGRAPHY

### Alberta

346. Burwash, Ronald A., Univ. of Minnesota:
The Precambrian Under the Central Plains of Alberta, 1953-55; Ph.D. thesis.

### British Columbia

347. Christie, R. L., Geol. Surv., Canada:
Plutonic Rocks of the Coast Range Batholith in the Bennett Area, B.C., 1953-55; Ph.D. thesis, Univ. of Toronto.
This investigation will involve a petrographic study of the variations in composition horizontally and vertically through a section of the Coast Range batholith near its northern end.

348. Gabrielse, H., Geol. Surv., Canada:
Structure and Petrogenesis of the McDame Ultramafic Belt, B.C., 1953-55; Ph.D. thesis, Columbia Univ.

349. Scott, Barry, Queen's Univ.:
The Diorite Complex Beneath the Sullivan Orebody Kimberly, B.C. and its Associated Alterations, 1953-54; M.Sc. thesis.

350. Souther, J., Geol. Surv., Canada (part time):
Study of Granitic Rocks in the Terrace Map-area, B.C., 1953-55.
An investigation of the nature, origin and structure of the granitic rocks and the relationship between them and mineral deposits of possible economic importance; Ph.D. thesis, Princeton Univ.

351. Hunter, H. E., Univ. of California:
Geology of Basic Intrusive Bodies in Northern Manitoba, 1949-54; Ph.D. thesis.

### New Brunswick

352. Jackson, W. H., Univ. of Toronto:
Rocky Brook Area of New Brunswick, 1953-54; M.A.Sc. thesis.
A petrologic study of metamorphism of lavas and sediments.

353. Rutledge, Donald W., Univ. of New Brunswick:
Contact Phenomena of the Pokiok Granite, New Brunswick, 1953-55; M.Sc. thesis.
The investigation includes consideration of the aeromagnetic pattern.

### Newfoundland and Labrador

354. Howell, J. E., Univ. of Wisconsin:
Silicification in the Fleming Formation of the Knob Lake Group, Labrador, 1952-54; Ph.D. thesis.

355. Jenness, S. E., Newfoundland Dept. Mines and Resources (part time):
Geology of the Gander River Ultrabasic Belt, Newfoundland, 1952-54; Ph.D. thesis, Yale Univ.

356. Smith, C. H., Geol. Surv., Canada:
Ultrabasic and Basic Intrusive Rocks and Their Contained Chromite and Copper Deposits, Western Newfoundland, 1951-53.

357. Spina, D., McGill Univ.:
Petrography of the Igneous Rocks of the New Bay and Loon Bay Areas, Newfoundland, 1952-54; M.Sc. thesis.

## Ontario

358. Allen, C. M., Univ. of Toronto:
Geology of the Gooderham Nepheline Pegmatites, Gooderham, Ont., 1950-54; Ph.D. thesis.
A petrographic and field investigation of the environment and origin of the nepheline pegmatites and gneisses of the Tory Hill-Gooderham area.

359. Arnold, Ralph G., Univ. of Toronto:
Petrology of the Blind River Conglomerate, Blind River, Ont., 1953-54; M.A. thesis.
A study of the geology and petrology of the uranium-bearing conglomerate and associated sediments with special reference to the Quirke Lake section; it will include investigation of conditions of sedimentation and their relation to uranium deposition.

360. Assad, R. J., McGill Univ.:
The Formation of Certain Granite-like Rocks in the Foot-wall of the Sudbury Norite, Northwest of Sudbury Basin, Ontario, 1953-55; M.Sc. thesis.

361. Blackadar, R. G., Geol. Surv., Canada:
Differentiation and Assimilation in the Logan Sills, Port Arthur, Ontario, 1952-54; Ph.D. thesis, Univ. of Toronto.
A detailed chemical and petrographic study of the sills particularly with regard to evidence of vertical variations in mineral and chemical composition.

362. Bradshaw, B. A., (grad. student) and Moorhouse, W. W., Univ. of Toronto:
Petrological Comparison of Lake Superior Iron Formations, 1951-54.
This investigation has involved a petrographic and spectrographic study of iron ores from the Gunflint and Mesabi Ranges. Further studies will be carried on by Dr. Moorhouse.

363. Eisenbrey, E. H., Univ. of Toronto:
Petrology of Metamorphic Rocks of Fishtail Lake, Harcourt Township, Ont., 1953-54; M.A. thesis.
A mineralogic and petrologic description of the cordierite gneiss of the area.

364. Emery, D. J., (grad. student), Queen's Univ.:
Structure and Mineralization Adjacent to the Round Lake Batholith, Boston Creek, Ontario, 1953-54.
The relation of the copper-iron sulphide mineralization to the batholith is of particular interest.

365. Freeman, P. V., McGill Univ.:
Petrographic Study of the "A" Orebody, Monroe Asbestos Mine, Matheson, Ont., 1953-54; M.Sc. thesis.

366. Friedman, G. M., Univ. of Cincinnati:
Petrography and Petrology of the Mamainse Complex Near Batchwana, Algoma District, Ont.

367. Harding, W. D., Ont. Dept. Mines:
Contact Relationships Between Granite and Anorthosite Bodies in Southeastern Ontario, 1953.

368. Lawton, K. D., Univ. of Toronto:
The Round Lake Batholith and Its Satellitic Intrusions, Kirkland Lake, Ont., 1948-54; Ph.D. thesis.
A chemical and petrographic study of the batholith and associated stocks based on considerable field work.

369. Peach, Peter A., Univ. of Toronto:
Metamorphism in the Grenville Related to Pegmatite Intrusion, 1952-
A study of the formation of pink gneisses and migmatites relative to pegmatite intrusions near Kaladar, Ont.

370. Phipps, C. V. G., Univ. of Toronto:
Petrology and Environment of Alkaline Rocks of the Blue Mountain Area, Ont., 1952-55; Ph.D. thesis.
A field and petrographic re-study of an interesting and unique occurrence of nepheline syenite.

371. Reavely, G. H. and Dreimanis, A., Univ. of Western Ontario:
Regional and Petrographic Studies of the Pleistocene of the London Area, 1950-

372. Speers, E. C., Queen's Univ.:
The Breccias of the Sudbury Area, 1953-55; Ph.D. thesis.
Breccias of several types have been studied and mapped in the field and will be investigated as well by laboratory methods.

373. Stevenson, J. S., McGill Univ.:
Study of Certain Phases of the Sudbury Irruptive, 1952-

374. Walker, J. W. R., Queen's Univ.:
Origin of Granophyre and Alteration of Gabbro and Andesites, Godfrey Township, Ont., 1953-54; M.Sc. thesis.

375. Wrigglesworth, L. A., McMaster Univ.:
Petrographic Study of Limestone Drill Core, Simcoe, Ont., 1953-54.
The core comes from a water well accompanying drill hole number three of the U.S. Steel Co.'s Simcoe project. A physical, microscopical and partly chemical study will be carried out. Inclusions and structures such as chert nodules and styolites will also be studied in detail.

376. Weaver, John F., Univ. of Cincinnati:
Petrology of the Caribou Lake Intrusive near Loring, Ont., 1953-54; M.Sc. thesis.

## Quebec

377. Allard, Gilles, Johns Hopkins Univ.:
The Chibougamau Gabbro-Anorthosite Complex, 1954-55; Ph.D. thesis.

378. Blais, R. A., Quebec Dept. Mines:
The Petrology and Its Relation to Decrepitation Studies of the O'brien Mine Quartz Veins, Que., 1952-54; Ph.D. thesis, Univ. of Toronto.

379. Cornwall, F. W., Quebec Dept. Mines (part time):
Wall-rock Alteration in Vicinity of the Lead-Zinc Deposits of the Anacon, New Calumet, and Golden Manitou Mines, Que., 1953-55; Ph.D. thesis, McGill Univ.

380. Dawson, K. R., Geol. Surv., Canada:
A Comprehensive Geological Study of the Preissac-Lacorne Batholith, Abitibi County, Quebec, 1952-53.
An investigation of the size, shape, and mode of emplacement of the batholith, and its relation to associated mineral deposits.

381. Eadie, D. A., McGill Univ.:
The Metamorphic Collar in the Sediments Around Mount Royal, Que., 1952-54; M.Sc. thesis.

382. Emo, W. B., McGill Univ.:
The Gneisses of the Walouno River District, Que., 1953-55; M.Sc. thesis.

383. Halferdahl, L. F., Queen's Univ.:
Trace Element Study of Granite Batholiths, 1952-54; M.Sc. thesis.
A trace element study of the Lacorne and Preissac masses, Quebec, with which molybdenum-bismuth mineralization and lithium bearing pegmatites are associated.

384. Hannah, Raymond, Université Laval:
Study of the Macquereau Formation, Gaspe, Que., 1953-54; D.Sc. thesis.
This project includes study of the petrology and structure of the formation.

385. Jackson, G. D., McGill Univ.:
Petrographic Study of Part of the Potsdam Drill Core from Mallet Well, Ste. Therese, Que., 1952-54; M.Sc. thesis.

386. Mitra, R., Univ. of Toronto:
Study of the Metamorphic Facies at New Calumet Mine, Que., 1952-54; Ph.D. thesis.
An attempt to apply Eskola's facies principle to a particularly complex series of schists, gneisses and amphibolites which have been mapped in considerable detail.

387. Morin, Marcel, Université Laval:
Study of Some Conglomerates from Southeastern Quebec, 1953-54; M.Sc. thesis.
Conglomerates from several map areas are being examined in detail.

388. Murray, L. G., Quebec Dept. Mines (part time):
Wall-rock Alteration Around Sulphide Deposits in the Eastern Townships of Quebec, 1952-54; Ph.D. thesis.

## Saskatchewan

389. Rotherham, D. C., (grad. student), Univ. of Saskatchewan:
Radioactive and Non-Radioactive Granites and Related Pegmatites in Northern Saskatchewan.

## General Problems

390. Harrison, W. D., (grad. student), and Shaw, D. M., McMaster Univ.:
Geochemical Studies in Regional Metamorphism-Modal Analysis, 1953-54.
The point counter will be used to determine the composition of metamorphic rocks. Different sections will be cut from each specimen in an effort to prove or disprove variance in chemical analyses.

391. Hawley, J. E., and MacDonald, Graham, (grad.,student), Queen's Univ.:
Spectrographic Analysis of Major and Minor Constituents of Igneous Rocks, 1953-54.
A variety of spectrographic methods for determining major constituents in igneous rocks have been tried out but difficulties have been encountered in obtaining constant ratios for silicon and aluminum. Current research is going forward using an air jet for cooling the electrodes.

392. Hewlett, C. G., Univ. of Wisconsin:
Significance of Optical Variations of Potash Feldspars, 1951-54; Ph.D. thesis.

393. Knutson, Robert, A., (grad. student), Univ. of Manitoba:
Application of Induced Radiation to Rock Analysis, 1953-54.

394. Macpherson, H. G., Univ. of Toronto:
A Chemical and Petrographic Study of Precambrian Sediments, 1953-55; Ph.D. thesis.
A study of the spectrochemistry, bulk chemistry, and petrography of typical sediments from type Precambrian areas in the hope of obtaining more detailed information regarding (1) the characteristics of the classical Precambrian sedimentary formations (2) possible variations in the composition of sea water in the Precambrian and (3) a possible method of correlation.

395. Patchett, J. E., Univ. of Toronto:
Distribution of Accessory Minerals as a Criterion of the Origin of Gneisses, 1953-54; M.A. thesis.
An investigation of the possibility of identifying the origin of gneisses (whether igneous or sedimentary) by the statistical association of accessory minerals with the essential constituents of the gneisses. Gneisses of sedimentary origin should have a more uniform statistical association.

396. Patrick, T. O. H., Geol. Surv., Canada (part time):
Sericite in Granitic Feldspar, 1952-54;
Ph.D. thesis, Univ. of Wisconsin.

397. Podolsky, T., Queen's Univ.:
X-Ray Investigation of Rock Fabric, 1952-54;
Ph.D. thesis, Mass. Inst. Technology.

398. Rowe, R. B., Geol. Surv., Canada:
Geological Study of the Lithium-Beryllium Pegmatites of Manitoba and Ontario, 1953.
An investigation of the distribution, nature, age, and origin of the pegmatites and of concentrations of lithium and beryllium minerals contained in them.

399. Saull, V. A., McGill Univ.:
Geologic Role of Heat Exchanges in Metamorphic Processes, 1953-54.
A partly experimental and partly mathematical investigation.

400. Shaw, D. M. and Pearson, G. R., (grad. Student), McMaster Univ.:
Geochemical Studies in Regional Metamorphism
(A) Rocks, 1951 -
A continuation of earlier work on Devonian metamorphic rocks from New Hampshire. The schists, shales, and gneisses are being analysed for barium and will probably be analysed for uranium and thorium with co-operation of the University of Wisconsin. The major elements are also being studied by gravimetric and modal analyses to ascertain whether any changes in composition took place during metamorphism.

Geochemical Studies in Regional Metamorphism
(B) Minerals, 1953 -
Investigation of minor elements in the kyanite-sillimanite-andalusite group has been started to find out whether the polymorphic relations between these minerals are influenced by "foreign" elements.

PHYSIOGRAPHY

401. Bird, J. B., Geographical Branch, Dept. Mines and Technical Surveys:
Physical-Ecological Survey of Wager Bay Area, N.W.T., 1952-54.

402. Chapman, L. J., Ontario Research Foundation:
Physiographic Survey of Algonquin Lake Plane East and North of Georgian Bay, Ont., 1949-54.

403. Fraser, J. K., Geographical Branch, Dept. Mines and Technical Surveys:
Physical-Ecological Survey of Spence Bay Area, N.W.T., 1953-55.

404. Gadbois, P., and Laverdiere, C., Geographical Branch, Dept. Mines and Technical Surveys:
Physical-Ecological Survey of the Alert Area, N.W.T., 1952-53.

405. MacKay, J. R., Geographical Branch, Dept. Mines and Technical Surveys:
Physical-Ecological Survey of Darnley Bay Area, N.W.T., 1951-54.

406. Thompson, H. R., Arctic Institute of North America:
Geomorphology of Pangnirtung Pass, Baffin Island, N.W.T., 1953-54; Ph.D. thesis, McGill Univ.

PLEISTOCENE GEOLOGY AND WATER SUPPLY

Alberta

407. Bayrock, L. A., Univ. of Alberta:
Mineralogical Analysis of the Tills of East Central Alberta, 1953-54; M.Sc. thesis.

408. Craig, B. G., Geol. Surv., Canada:
Pleistocene Geology of the Drumheller Region, Alberta, 1951-54; Ph.D. thesis, Univ. of Michigan.

409. Stalker, A. M., Geol. Surv., Canada:
Geological Study and Mapping of the Quaternary Geology of the Beiseker Map-area, 1 inch to 4 miles, 1952-53.

410. Warren, P. S., Univ. of Alberta:
Studies of the Pleistocene Geology of the Plains Area of Alberta.

British Columbia

411. Armstrong, J. E., Geol. Surv., Canada:
Geological Study and Mapping of the Geology and Groundwater Supply of the Vancouver Area, 1 inch to 1 mile, 1948-54.

412. Fyles, John G., Geol. Surv., Canada:
Superficial Deposits and Groundwater Resources of the Horne Creek and Parksville Map-areas, Vancouver Island, 1950-53; Ph.D. thesis, Ohio State Univ.

413. Mathews, W. H., Univ. of British Columbia:
Glaciation in British Columbia
A continuing study of air photographs and literature, supplemented by field work with the object of determining directions of movement, upper limits, and nature of retreat of the Cordilleran ice sheet in British Columbia.

414. Nasmith, H. W., B.C. Dept. of Mines:
Reconnaissance of Thick Silts in Kamloops and Okanagan Areas with Some Attention to Particle Size and Field Density, 1953.
This study of Dawson's "white silts" was undertaken because of the problems they present in foundations and in engineering construction.
Investigation of Feasibility of Using an Earth Auger in Prospecting for Water in an Agricultural Area South of Prince George, B.C., 1953.
This project was undertaken in co-operation with the District Agriculturist and supplements groundwater studies made in 1951 and 1952. The results indicate that it is possible to avoid digging unsuccessful wells; the results are also useful in determining a suitable site for a farm water storage dugout.
Groundwater Studies in the Duncan Area, B.C., 1953.

## Manitoba

415. Halstead, E. C., Geol. Surv., Canada:
Groundwater Supply of Brandon Area, 1 inch to 4 miles, 1946-54.

## New Brunswick

416. Lee, H. A., Geol. Surv., Canada:
Geological Study and Mapping of the Overburden (Pleistocene and Recent) of the Fredericton Map-area, 1 inch to 1 mile, 1951-53.

417. Hachey, P. Osmund, Univ. of New Brunswick:
Geology and Groundwater of the Fredericton City District, N.B., 1953-55; M.Sc. thesis.
Includes new data from recent drilling in St. John River valley.

## Newfoundland

418. Baird, D. M. and McKillop, J. K., Newfoundland Dept. Mines and Resources:
Sand and Gravel Deposits of the Avalon Peninsula, Newfoundland, 1953-54.

419. Henderson, E. P., Geol. Surv., Canada:
Geological Study and Mapping of Glacial and Recent Deposits in Labrador and New Quebec, 1953-55.

## Nova Scotia

420. Cameron, H. L. and MacNeil, R. H., Nova Scotia Research Foundation and Acadia Univ.:
Pleistocene Geology of Nova Scotia, 1949-53.

421. Hughes, Owen L., Univ. of Kansas:
Pleistocene Geology of Nova Scotia, 1952-55; Ph.D. thesis.

## Ontario

422. Caley, J. F. and Sanford, B. V., Geol. Surv., Canada:
Studies of Drift Thickness and Bedrock Topography in Southern Ontario, 1948-
The objective is to determine the pre-Pleistocene topography of the bedrock and thickness of overlying drift by data obtained from bore holes. From these studies the pre-glacial drainage may be deduced and the probable location of reservoirs of groundwater determined.

423. Chapman, L. J., Ontario Research Foundation:
Physiographic Survey of Algonquin Lake Plane East and North of Georgian Bay, 1949-54.

424. Dreimanis, A., Univ. of Western Ontario:
Pleistocene Stratigraphy Along the North Shore of Lake Erie Between Tyrconnell and Port Stanley, 1952-54.
Studies of Late Wisconsin Ice Flow Directions at St. Mary's Ont., 1952-54.
A Boulder Train of Iron Ores South of Steeprock Lake, Ont., 1953-54.
The study of the train from the Steeprock ore deposits will serve as an example for prospecting by use of boulder trains.

425. Gravenor, C. P., Geol. Surv., Canada (part time), Univ. of Alberta:
Geological Study and Mapping of the Glacial Deposits of Lindsay Map-area, 1 inch to 1 mile, 1953.

426. Legget, R. F. and Eden, W. J., Div. of Building Research, National Research Council:
Varved Clays at Steeprock Lake, 1948-
A paper dealing with soil conditions in general has been published (Economic Geology, Vol. 48, No. 7, 1953). A second paper dealing with a detailed laboratory study of varved clays is in preparation.

427. McClure, M. E., Univ. of Western Ontario:
Application of Geophysical Methods to the Determination of Bedrock Surfaces in the Pleistocene Deposits of the London Area, Ont., 1952-54; M.Sc. thesis.
Resistivity methods have been employed and the results are being correlated with well logs.

428. Owen, E. B., Geol. Surv., Canada:
Groundwater Survey and Geological Mapping of Overburden (Pleistocene and Recent) in Gloucester and Nepean Townships, Carleton County, 1 inch to 1 mile, 1951-53.

429. Reavely, G. H. and Dreimanis, A., Univ. of Western Ontario:
Differentiation of the Lower and Upper Till Along the North Shore of Lake Erie, 1952-53.
Comparison of Huron and Erie Lobes by Heavy Mineral Studies, 1952-54.

430. Schriever, W. R., Div. of Building Research, National Research Council:
Toronto Subway Research, 1949-53.
A complete soil profile was made along the subway from an engineering and geological aspect. This work was done in co-operation with an advisory committee of interested Pleistocene geologists in the Toronto area. Correlation of the mechanical properties of the samples obtained with local glacial stratigraphy has yet to be carried out.

431. Wagner, Frances J. E., Geol. Surv., Canada:
Geological Study and Mapping of the Unconsolidated Deposits Laid Down by the Champlain Sea in Ontario and Quebec, 1953-57.

432. Watt, A. K., Ont. Dept. Mines :
Pleistocene and Groundwater Survey, Peel County, Ont.

Quebec

433. DeBlois, R., Quebec Dept. Mines:
Groundwater Investigations in Quebec, 1949-
A long term program of investigation of water supply problems in various parts of the province and accumulation of information on surface geology that will be useful for engineering and other purposes.

434. Gadd, N. R., Geol. Surv., Canada:
Glacial and Recent Deposits of Aston Map-area, 1 inch to 1 mile, 1953-54.
Pleistocene Geology of Becancour Map-area, 1950-54; Ph.D. thesis, Univ. of Illinois.

435. Henderson, E. P., Geol. Surv., Canada:
Geological Study and Mapping of Glacial and Recent Deposits in Labrador and New Quebec, 1953-55.

436. Neilson, J. M., Quebec Dept. Mines (part time), Michigan College of Mining and Technology:
Late Pleistocene Glaciation in North Central Quebec.

437. Pollitt, E. I. K., Geol. Surv., Canada:
Groundwater Survey of Montreal Area, 1951-53.

Saskatchewan

438. Craig, B. G., Geol. Surv., Canada:
Geological Study and Mapping of the Overburden (Pleistocene and Recent) in the North Battleford Map-area, 1 inch to 4 miles, 1952-54.

439. Elson, J. A., Geol. Surv., Canada:
Geological Study and Mapping of the Glacial and Recent Deposits of Souris Map-area, 1 inch to 4 miles, 1953-54.

General Problems

440. Blanchard, J. E., Nova Scotia Research Foundation and Carter, A. L., (grad. student) Dalhousie Univ.:
Carbon - 14 Age Determinations, 1953-

441. Brown, R. J. E., Div. of Building Research, National Research Council:
Mapping of Southern Boundary of Permafrost in Canada, 1953-56.
A search of the literature on permafrost occurrences in Canada is being made. A questionaire will be sent out to people living in the north regarding occurrences of permafrost. Field investigations will then be carried on and finally a set of maps will be made showing the occurrences of permafrost.

442. Crawford, C. B., Div. of Building Researoh, National Research Council:
Study of Building Settlements, 1949-
A paper covering an investigation of the engineering properties of the Leda clay and interpretation of the results with reference to the performance of the National Museum Building, Ottawa has been published

(Proc. Third International Conference on Soil Mechanics and Foundation Engineering, Aug.,1953). Other buildings are under observation on different types of soil and records will eventually be published.

Ground Temperature Studies, 1947-

This project covers a widespread investigation of the variation of ground temperatures with depth and time. A number of recording thermometers and other temperature recording devices have been installed at about a dozen localities in Canada including the far north.

443. Pihlainen, J. A., Johnson, G. H. and Brown, R. J. E., Div. of Building Research, National Research Council:
Permafrost in Canada, 1950-

This project is a long term study of permafrost in the north of Canada. Although directed with the special interests of building in mind, the scientific problems associated with permafrost are also being studied. This investigation has already developed many facets. Its progress in 1954 is being somewhat impeded due to diversion of staff to study of the new site for Aklavik, N.W.T.

444. Wilson, J. T., Douglas, Mary C. V., Ruddell, Joan and Drummond, R. N., Arctic Institute of North America and Defence Research Board:
Study of Air Photographs of Canada - a continuing project.

Air photographs of Canada are being studied in the National Air Photo Library, Ottawa and glacial and structural features plotted. About 1,000,000 square miles have now been examined chiefly in Labrador, Ungava and Northwest Territories.

## SEDIMENTATION

445. Antoniuk, Stephen A., Univ. of Alberta:
Sedimentation Study of the Saskatchewan Sands and Gravels, 1953-54; M.Sc. thesis.

446. Armstrong, H. S., McMaster Univ.:
Study of the Sandstones of the Medina Formation in the Niagara Peninsula, Ontario, 1951-54.

447. Beales, F. W., Univ. of Toronto:
Conditions of Deposition of the Carboniferous Rocks of Southwestern Alberta, 1948-54.

448. Cameron, R. A., McGill Univ.:
An Experimental Study of the Compaction of Sediments, 1953-56; Ph.D. thesis.

449. Clark, T. H., McGill Univ.:
Geology of Chert, 1951-

450. Glaister, R. Perry, Univ. of Alberta:
Sedimentary Study of the Viking Sandstone in the Camrose Area, Alberta; M.Sc. thesis.

451. Lemon, R. R. H., Univ. of Toronto:
The Upper Devonian Limestones of Southwestern Alberta; 1953-55; Ph.D. thesis.

452. Mathews, W. H., Univ. of British Columbia:
Sedimentation in Garibaldi Lake, B.C., 1952-54.

453. Macpherson, H. G., Univ. of Toronto:
A Chemical and Petrographic Study of Precambrian Sediments, 1953-55; Ph.D. thesis.
A study of the spectrochemistry, bulk chemistry, and petrography of typical sediments from type Precambrian areas in the hope of obtaining more detailed information regarding (a) the characteristics of classical Precambrian sedimentary formations and (b) possible variations in the composition of sea water in the Precambrian and (c) a possible method of correlation.

454. McDermott, A. A., Univ. of Toronto:
Conditions of Deposition of the Crinoidal Limestones of the Carboniferous Rocks of Southwestern Alberta; 1953-55; M.A.Sc. thesis.

455. Sujkowski, Z. L., McMaster Univ.:
Diagenetic Changes in the Sedimentary Rocks, 1953-
Spectroscopic and Other Investigations of Deep Sea Manganese Nodules, 1953-
The problem is to find the relation between the rare elements present in the nodules and surroundings, depth of deposition, type of water (marine, lacustrine) and other conditions of deposition.

456. Sutterlin, Peter G., McMaster Univ.:
The Thorold Sandstone in the Niagara Peninsula, Ont., 1953-54; M.Sc. thesis.
A field and petrographic study to attempt to determine the origin, conditions of deposition, and relation to other rocks in the district.

457. Tuffy, F., McGill Univ.:
Chert in the Ordovician Rocks of Southern Quebec, 1953-55; M.Sc. thesis.

## STRATIGRAPHY AND PALAEONTOLOGY

### Precambrian

458. Antrobus, E. S. A., McGill Univ.:
A Study of the Witwatersrand System; Ph.D. thesis.

459. Burwash, Ronald A., Univ. of Minnesota:
The Precambrian Under the Central Plains of Alberta, 1953-55; Ph.D. thesis.

460. Copeland, J. G., Univ. of Toronto:
Structure and Stratigraphy of the Waite-Amulet Area, Quebec, 1952-54; Ph.D. thesis.
A detailed re-study of the stratigraphy of the flows in the vicinity of the Waite-Amulet mine and a reinterpretation of the structure on this basis.

461. Wilson, M. E., Geol. Surv., Canada (retired):
Early Precambrian Rocks of the Temiskaming Region and their Relationship to Those of the Grenville Region, 1939-54.

### Cambrian to Silurian

462. Armstrong, H. S., McMaster Univ.:
A Study of the Sandstones of the Medina Formation in the Niagara Peninsula, Ont., 1951-54.

463. Bolton, T. E., Geol. Surv., Canada:
Silurian Fauna and Stratigraphy of Southwestern Ontario Mainland, 1950-55.
Silurian Fauna and Stratigraphy of Manitoulin Island, Ont., 1953-56.
Ordovician and Silurian Fauna and Stratigraphy of British Columbia, 1954-

464. Byrne, A. W., McGill Univ.:
The Beekmantown Group in the St. Lawrence Lowland of Quebec, 1953-56; Ph.D. thesis.

465. Carter, G. F., McGill Univ.:
The Dunham Dolomite in St. Armand Township, Quebec, 1953-55; M.Sc. thesis.

466. Clark, T. H., McGill Univ.:
Ordovician Palaeoclimatology, 1946-
Senigon Well, Noyan, Que., 1953
The log of a well, 30 miles southeast of Montreal, diamond drilled to a depth of 2296 feet through Utica shales and Trenton shales and limestones.

467. Cumming, L. M., Geol. Surv., Canada:
Silurian Stratigraphy and Palaeontology of Southwestern New Brunswick, 1952-54.
The study involves subdivision of a thick succession of Silurian volcanic and sedimentary rocks; the mapping of the stratigraphic units; and a description of their invertebrate faunas. Two phases that will receive special attention are (1) correlation of the four separate New Brunswick Silurian areas with that of Eastport Maine and (2) description of Charlotte County Silurian structural geology as related to the Quoddy power project.

468. Liberty, B. A., Geol. Surv., Canada:
Stratigraphic Studies of the Ordovician System in Central Ontario, 1949-53; Ph.D. thesis, Univ. of Toronto.

469. MacGregor, A. R., McGill Univ.:
Chazyan Reefs and Reef Builders, 1953-54; M.Sc. thesis.

470. Stearn, Colin W., McGill Univ.:
Stratigraphy and Palaeontology of the Silurian of Southern Manitoba, 1950-54.

471. Sutterlin, Peter G., McMaster Univ.:
The Thorold Sandstone in the Niagara Peninsula, Ont., 1953-54; M.Sc. thesis.
A field and petrographic study to attempt to determine its origin, conditions under which it was deposited and its relation to other rocks in the district.

472. Tuffy, F., McGill Univ.:
Chert in the Ordovician of Southern Quebec, 1953-55; M.Sc. thesis.

473. Winder, G. C., Geol. Surv., Canada (part time), Univ. of Western Ontario:
Early Palaeozoic Formations of Southern Ontario between Longitude 78°30' and Frontenac Axis, 1951-53.
An investigation of the stratigraphy and palaeontology to assist subsurface correlations in the productive oil and gas fields of southwestern Ontario.

474. Wrigglesworth, Lorne Albert, McMaster Univ.
Petrographic Study of Limestone Drill Core, Simcoe, Ont., 1953-54.
The limestone core is from a water well accompanying # 3 hole of the U.S. Steel Co.'s Simcoe project. A physical, microscopic and partly chemical study will be carried out including detailed study of inclusions and structures such as chert nodules and styolites.

## Devonian to Permian

475. Beales, F.W., Univ. of Toronto:
Conditions of Deposition of the Carboniferous Rocks of Southwestern Alberta, 1948-54.

476. Belyea, Helen R., Geol. Surv., Canada:
Subsurface Study and Correlation of Upper Devonian Formations of Central Alberta.

477. Brady, William Blake, Johns Hopkins Univ.:
Mississippian Stratigraphy in the Central Foothills of Alberta, 1953-56; Ph.D. thesis.

478. Douglas, R. J. W., Geol. Surv., Canada:
Carboniferous Stratigraphy of the Southern Foothills of Alberta, 1952-
A study of the Carboniferous stratigraphy of the surface exposures and correlation with subsurface stratigraphy from study of well cuttings.

479. Harker, P., Geol. Surv., Canada:
Carboniferous Stratigraphy and Palaeontology of Alberta Rocky Mountains, 1949-55.
Carboniferous Stratigraphy, Snake Indian River Region, Alberta, 1953-54.
Description and Study of Carboniferous and Permian Stratigraphy and Faunas of Canada, 1950-

480. Howard, Ronald A., Univ. of Alberta:
Examination and Correlation of the Rundle Formation, Alberta, 1953-54; M.Sc. thesis.

481. Lemon, R. R. H., Univ. of Toronto:
Upper Devonian Limestones of Southwestern Alberta, 1953-55; Ph.D. thesis.

482. MacLean, D. W., McGill Univ.:
Ghost River and Related Formations between Athabasca and Smoky Rivers, Alberta, 1951-54; M.Sc. thesis.

483. McCabe, Hugh R., Manitoba Mines Branch (part time), Northwestern Univ.:
Mississippian Stratigraphy of the Williston Basin Area, 1953-56; Ph.D. thesis.

484. McDermott, A. A., Univ. of Toronto:
Conditions of Deposition of the Crinoidal Limestones of the Carboniferous Rocks of Southwestern Alberta, 1953-55; M.A.Sc. thesis.

485. McLaren, D. J., Geol. Surv., Canada:
Stratigraphy of the Devonian System in the Alberta Rocky Mountains, 1949-55.
Description of the Brachiopod Fauna and Stratigraphy of the Devonian of Western Canada, 1950-

486. Murray, Bruce, Massachussetts Institute of Technology:
Geology of the Horton (Mississippian) Group of Nova Scotia; Ph.D. thesis.

487. Norris, A. W. and Lemon, R. R. H., Univ. of Toronto:
Stratigraphy and Palaeontology of the Williams Island Formation on the Abitibi River, Ont., 1953-54.

## Triassic to Cretaceous

488. Francis, David R., Northwestern Univ.:
Jurassic-Stratigraphy of the Williston Basin Area, 1953-56; Ph.D. thesis.

489. Frebold, Hans, Geol. Surv., Canada:
Palaeontological and Stratigraphic Study of the Fernie Group of the Rocky Mountains and Foothills, 1952-53.
An investigation of the character, structure, thickness, diagnostic fossil content, and geological history of the Fernie group, as representative of Jurassic time in Western Canada.
Jurassic Stratigraphy and Palaeontology of the Alberta Rocky Mountains and Foothills, 1950-55.
Description of Jurassic Faunas and Stratigraphy of Canada, 1950-

490. Glaister, R. Perry, Univ. of Alberta:
Sedimentary Study of the Viking Sandstone in the Camrose Area, Alberta, 1952-54; M.Sc. thesis.

491. Jeletzky, J. A., Geol. Surv., Canada:
Study of the Mainly Lower Cretaceous Stratigraphy and Palaeontology of the West Coast of Vancouver Island, 1949-53.
An investigation of the character, stratigraphy and fossil content of the Lower Cretaceous formations, with special attention to their contact with underlying Jurassic rocks.

492. Magdick, F. S., Univ. of Saskatchewan:
The Cretaceous Viking Horizon in Saskatchewan, 1953-54; M.Sc. thesis.

493. Stelck, C. R., Univ. of Alberta:
Mesozoic Stratigraphy of Alberta with Special Reference to the Peace River Area.

494. Stott, D. F., Univ. of Manitoba:
Jurassic Strata of Manitoba, 1953-54; M.Sc. thesis.

495. Tozer, E. T., Geol. Surv., Canada:
Geological Study and Mapping of the Triassic Formations in Laberge Map-area, Yukon Territory, 1953.
Triassic Palaeontology and Stratigraphy of Vancouver Island, 1953-56.
Description of Triassic Faunas and Stratigraphy of Canada, 1953-

496. Wickenden, R. T. D., Geol. Surv., Canada:
Clearwater Formation on Athabasca River, 1952-54.

## General Problems

497. Heywood, W. W., Geol. Surv., Canada (part time):
Geological Study and Reconnaissance Mapping of Parts of Ellef Ringnes Island, Northwest Territories, 1952-53; M.Sc. thesis, Univ. of Washington.
An investigation of the stratigraphy and peculiar circular structures visible in air photographs of the island.

498. Hilton, Richard, Massachussetts Institute of Technology:
Stratigraphy and Structure of the Strait of Canso Area, N.S.; M.Sc. thesis.

499. McGerrigle, H. W., De Blois, R. and Clark, T. H., Quebec Dept. Mines:
Deep Borings Investigations in Province of Quebec.
A continuing programme of the logging of deep borings for oil and gas in various parts of the Province.

500. Price, L. L., Geol. Surv., Canada:
Subsurface Study from Well Borings of Sedimentary Formations of Southwestern Manitoba and Southern Saskatchewan.

501. Rolnick, L. S., Massachussetts Institute of Technology:
The Gypsum-Anhydrite Problem; Ph.D. thesis.
Nova Scotia is one of several areas in North America from which specimens were collected for this investigation.

502. Root, Samuel, Univ. of Manitoba:
Study of Stratigraphy in Canal Flats Map-area, B.C., 1953-54; M.Sc. thesis.

503. Sanford, B. V., Geol. Surv., Canada:
Establishment of Elevations of Wells Drilled for Oil and Gas in Southwestern Ontario, 1951-
To assist in interpretations of the structure and stratigraphy of the productive oil and gas formations.

504. Stelck, C. R., Univ. of Alberta:
Stratigraphy of the Oil Fields of Alberta and Northeastern British Columbia.

505. Sujkowski, Z. L., McMaster Univ.:
Diagenetic Changes in Sedimentary Rocks, 1953-

506. Warren, P. S., Univ. of Alberta:
Studies of the Stratigraphy and Structure of the Rocky Mountains.
Studies of the Palaeozoic Strata Underlying the Plains Area of Western Canada.

## STRUCTURAL GEOLOGY

### Alberta

507. Folinsbee, R. E., Univ. of Alberta:
Structural Research in the Foothills Belt of Alberta.

508. Norris, D. K., Geol. Surv., Canada:
Detailed Study of the Structure and Stratigraphy at and in Vicinity of the International Coal and Coke McGillvary Colliers, Coleman, Alberta.
To obtain a better understanding of the character, cause, and distribution of stresses that result in 'bumps', 'outbursts' and related phenomena in deep workings.

509. Warren, P. S., Univ. of Alberta:
Studies of the Stratigraphy and Structure of the Rocky Mountains.

### British Columbia

510. Brown, A. Sutherland, British Columbia Dept. of Mines:
Detailed Structural Studies of Wells - Round Top Mountain Area, Cariboo District, 1951-53; Ph.D. thesis, Princeton Univ.

510a. Gabrielse, H., Geol. Surv., Canada:
Structure and Petrogenesis of the McDame Ultramafic Belt, B.C., 1953-55; Ph.D. thesis, Columbia Univ.

## Ontario

511. Cunningham-Dunlop, P. K., Univ. of Toronto:
Structural Geology of the Ontario Pyrites Deposits, Sudbury, Ont., 1953-54; M.A.Sc. thesis.

512. Emery, D. J., (grad. student), Queen's Univ.:
Structure and Mineralization Adjacent to the Round Lake Batholith, Boston Creek, Ont., 1953-54.
The relation of the copper-iron sulphide mineralization to the batholith is of particular interest.

513. Speers, E. C., Queen's Univ.:
The Breccias of the Sudbury Area, 1953-55; Ph.D. thesis. Breccias of several types have been studied and mapped in some detail in the field and will be investigated by laboratory methods.

514. Thomson, J. E., Ont. Dept. Mines:
Sudbury Basin, Ontario, 1953-

## Quebec

515. Cooke, H. C., Quebec Dept. Mines (part time), Univ. of Montreal:
Some Structures of the Eastern Townships.

516. Copeland, J. G., Univ. of Toronto:
Structure and Stratigraphy of the Waite-Amulet Area, 1952-54.
A detailed re-study of the stratigraphy of the flows in the vicinity of the Waite-Amulet Mine and a re-interpretation of the structure on this basis.

517. Neale, E. W. R., Quebec Dept. Mines (part time), Univ. of Rochester:
The Grenville Front in the Bethoulat Lake Area.

## Saskatchewan

518. Kirkland, S. J. T., Queen's Univ.:
Faulting in the Flin Flon Area, 1953-54; Ph.D. thesis.

519. Silman, J. F. B., Queen's Univ.:
Structural Control of the Pitchblende-bearing Fractures at Nesbitt-Labine Uranium Mine, Sask., 1952-54; M.Sc. thesis.

## General Problems

520. Avison, A. T., McGill Univ.:
An Experimental Investigation of Fracture Patterns in Heterogenesis Materials, 1953-55; M.Sc. thesis.

521. Gill, J. E., McGill Univ.:
Precambrian History.

522. Gretener, P., Research Assistant, Univ. of Toronto:
Continental Structure and Age Determinations in South Africa, Australia, India and Europe, 1953-54.
A study of all available age determinations including new ones made at Geophysical Laboratories, Univ. of Toronto, in relation to continental structure for areas other than North America.

523. Gross, W. H., Univ. of Toronto:
An Indirect Method of Mapping Fold Structures in Precambrian Areas, 1948-54.
Strength Changes in Rocks Due to Rise in Temperature, 1948-54.
Cross Folding as a Guide to Ore, 1948-54.
Some Uses of Schistosity, 1948-54.

524. Hodgson, J. H. and Allan, J. F. J., Dominion Observatory:
Fault Plane Project, 1950-
It is possible from seismic records alone to determine the strike and dip of faults involved in large earthquakes and direction of motion in the fault. Tables, analogous to map projection tables, have been sent to press and a large number of earthquakes have been analysed. The project will continue indefinitely.

525. Ignatieff, A. et al., Mines Branch, Dept. Mines and Technical Surveys:
Investigation of Restrictive Effect of Excessive Strata Pressures and Sudden Relief of Stress in Coal Mining at Depth, 1950-55.
A co-operative project of the Mines Branch and Geological Survey both in mine and laboratory by a team of mining engineers, physicists and geologists.

526. Laurin, André, Quebec Dept. Mines (part time):
The Problem of the Boundary between Grenville and Keewatin-Temiskaming Provinces, 1953-55; D.Sc. thesis, Université Laval.

527. Milne, W. G., Dominion Observatory:
Strata-Stress Project, 1953-54.
Three stations at Fernie B.C., and Coleman and Turner Valley, Alta. have been set up to locate earthquakes in the vicinity of the coal fields. The purpose is to determine whether bursts in mines are due to mining operations only, or whether residual stresses are present.

528. Wilson, J. T., Univ. of Toronto:
Mountain Building Processes, 1947-
Data from various sources are being correlated.

529. Wilson, J. T., Douglas, Mary C. V., Ruddell, Joan and Drummond, R. N., Arctic Institute of North America and Defence Research Board of Canada:
Study of Air Photographs of Canada - a continuing project.
Air photographs of Canada are being studied in the National Air Photo Library in Ottawa and glacial and structural features plotted. About 1,000,000 square miles have now been examined chiefly in Labrador, Ungava and Northwest Territories.

530. Wilson, J. T. and Cumming, G. L., (grad. student), Univ. of Toronto:
Continental Structure and Age Determinations in North America - a continuing project.

531. Wilson, M. E., Geol. Surv., Canada (retired):
Early Precambrian Rocks of the Temiskaming Region and their Relationship to the Grenville Rocks, 1939-54.

# AUTHOR INDEX

# APPENDIX

## SURVEY OF CANADIAN GEOLOGICAL STUDENTS ATTENDING UNIVERSITIES IN CANADA AND GRADUATE SCHOOLS IN THE UNITED STATES - 1953-54

### SUMMARY

#### Canada

| Undergraduates - | Arts and science | Engineering | Total |
|---|---|---|---|
| Expected to graduate 1954 | 64 | 35 | 99 |
| Expected to graduate 1955 | 139 | 52 | 191 |
| Graduates - | | | |
| Master's degree candidates | 64 | 26 | 90 |
| Ph.D. degree candidates | | | 55 |

#### United States

| | | | |
|---|---|---|---|
| Graduates - | | | |
| Master's degree candidates | | | 7 |
| Ph.D. degree candidates | | | 46 |

### GEOLOGICAL STUDENTS IN CANADIAN UNIVERSITIES, 1953-54

#### Undergraduates

| University | Arts and Science | | Engineering | |
|---|---|---|---|---|
| | 3rd year (graduate 1955) | 4th year (graduate 1954) | 3rd year (graduate 1955) | 4th year (graduate 1954) |
| | Number | Number | Number | Number |
| Acadia | 3 | 10 | | |
| Alberta | 32 | 2 | | |
| British Columbia | 30 | 10 | 7 | 10 |
| Ecole Polytechnique | | | 6 | 2 |
| Laval | | | 3 | 4 |
| Manitoba | 12 | 6 | 2 | 2 |
| McGill | 10 | 11 | | |
| McMaster | 12 | 6 | | |
| Montreal | 2 | 3 | | |
| Mount Allison | 2 | 0 | | |
| New Brunswick | 11 | 5 | | |
| Queen's | 3 | 0 | 8 | 5 |
| Saskatchewan | 10 | | 17 | 8 |
| St. Francis Xavier | 7 | 6 | | |
| Toronto | 1 | 1 | 9 | 4 |
| Western Ontario | 4 | 4 | | |
| | 139 | 64 | 52 | 35 |

## Graduate Students

| University | Masters (Arts and Science) | | Masters (Engineering) | | Ph.D. | | |
|---|---|---|---|---|---|---|---|
| | Expect to receive degree | | Expect to receive degree | | Expect to receive degree | | |
| | 1954 | 1955 | 1954 | 1955 | 1954 | 1955 | 1956 |
| Alberta | 6 | 2 | 1 | | | | |
| British Columbia | 7 | 2 | 7 | | | | |
| Laval | | | 1 | | 3 | 1 | |
| Manitoba | 9 | | | | | | 1(?) |
| McGill | 9 | 7 | | | 6 | 13 | 3 |
| McMaster | 3 | 1 | | | | | |
| New Brunswick | 5 | 6 | | | | | |
| Queen's | 1 | 1 | 6 | 1 | 3 | 3 | 3 |
| Saskatchewan | | 1 | 3 | 2 | | | |
| Toronto | 2 | | 5 | | 16 | 3 | |
| Western Ontario | 2 | | | | | | |
| | 44 | 20 | 23 | 3 | 28 | 20 | 7 |

## 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 | | |
|---|---|---|---|---|---|---|
| | 1954 | 1955 | 1956 | 1954 | 1955 | 1956 |
| Calif. Inst. Technology | | 2 | | | | |
| Univ. of Calif. | 1 | | 1 | 2 | | |
| Colorado School of Mines | | | | | 2 | |
| Columbia Univ. | 1 | 3 | | | | |
| Harvard Univ. | | | 1 | | | |
| Univ. of Illinois | 1 | | | | | |
| John's Hopkins Univ. | | 3 | 1 | | | |
| Univ. of Kansas | 1 | 2 | | | | |
| Mass Inst. Technology | 2 | 3 | 1 | | | |
| Univ. of Michigan | 2 | 2 | | | | |
| Univ. of Minnesota | 2 | 1 | | | | |
| Univ. of Missouri | | | 1 | | | |
| Northwestern Univ. | | | 2 | | | |
| Ohio State Univ. | 1 | 1 | 1 | | | |
| Princeton Univ. | 1 | 1 | | | | |
| Washington Univ. | | | | 1 | | |
| Univ. of Wisconsin | 3 | 2 | | 2 | | |
| Yale Univ. | 2 | 1 | | | | |
| | 17 | 21 | 8 | 5 | 2 | |

| University | Candidates for Doctorate degree | | | Candidates for Master's degree | | |
|---|---|---|---|---|---|---|
| | Depart to receive degree | | | Depart to receive degree | | |
| | 1954 | 1955 | 1956 | 1954 | 1955 | 1956 |
| Alberta | 6 | 2 | 1 | | | |
| British Columbia | 7 | 2 | 7 | | | |
| Laval | | | 1 | | | 1 |
| Manitoba | 9 | | | | | 1(?) |
| McGill | 9 | 7 | | | 8 | 13 5 |
| McMaster | 3 | 1 | | | | |
| New Brunswick | 5 | 6 | | | | |
| Queen's | 1 | | 6 | 1 | 3 | 3 3 |
| Saskatchewan | 1 | 1 | 3 | 2 | | |
| Toronto | 2 | | 5 | | 16 | 8 |
| Western Ontario | 2 | | | | | |
| | 44 | 20 | 23 | 3 | 26 | 20 7 |

| University | Candidates for Doctorate degree | | | Candidates for Master's degree | | |
|---|---|---|---|---|---|---|
| | Depart to receive degree in | | | Depart to receive degree in | | |
| | 1954 | 1955 | 1956 | 1954 | 1955 | 1956 |
| Calif. Inst. Technology | | | | | | |
| Univ. of Calif. | 1 | | 1 | | | |
| Colorado School of Mines | | | | | | |
| Columbia Univ. | | | | | | |
| Harvard Univ. | | | | | | |
| Univ. of Illinois | | | | | | |
| Johns Hopkins Univ. | | | | | | |
| Univ. of Kansas | | | | | | |
| Univ. of Minnesota | | | | | | |
| Mass. Inst. Technology | | | | | | |
| Univ. of Missouri | | | | | | |
| Univ. of Nebraska | | | | | | |
| Univ. of New Mexico | | | | | | |
| Univ. of Oklahoma | | | | | | |
| Penn. State Univ. | | | | | | |
| Univ. of Pittsburgh | | | | | | |
| Princeton Univ. | | | | | | |
| Univ. of Rochester | | | | | | |
| Stanford Univ. | | | | | | |
| Univ. of Texas | | | | | | |
| Univ. of Utah | | | | | | |
| Yale Univ. | | | | | | |