CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

Economic Geology Series No. 16

CANADIAN DEPOSITS OF URANIUM AND THORIUM

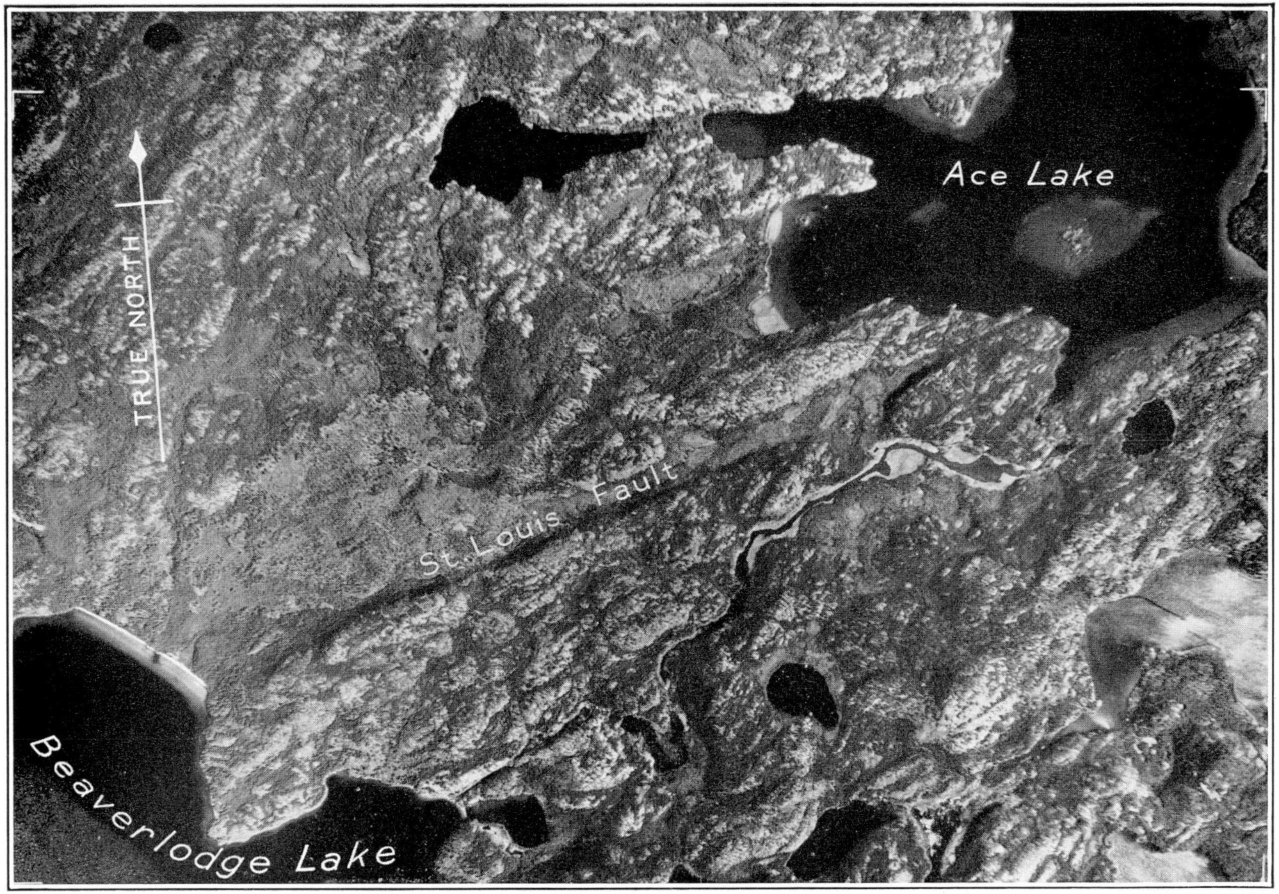
(Interim Account)

BY

A. H. Lang

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1952

Price, $1. No. 2504



Air photograph of part of St. Louis fault, between Beaverlodge and Ace Lakes. *See also* Figures 6, 7, 8. (Photo courtesy Royal Canadian Air Force.) (A 8022, 13.) (Page 71.)

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PREFACE

This report is a summary of information on Canadian deposits of uranium and thorium, up to the end of 1950. The report is timely because of the interest now being taken in uranium deposits, the amount of prospecting, and the large number of deposits being tested. Because the report is issued during this period of great activity, it can only be an interim one that outlines the present state of knowledge on problems that are receiving much attention, and which contains descriptions of some properties that will have been advanced greatly even during the time between the writing of the report and its publication.

In some respects this report is a sequel to No. 11 of the Economic Geology Series, entitled "Rare-element Minerals of Canada", by H. V. Ellsworth. That volume, published in 1932 and now out of print, dealt at length with the principles of radioactivity, and with both radioactive minerals and minerals containing the rare earth elements. Discoveries of radioactive minerals, containing uranium or thorium, are now so numerous that they form a topic for a single volume; the present report, therefore, does not deal with the principles of radioactivity, nor with minerals that contain rare earths without also containing uranium or thorium.

The report is published with the approval of the Atomic Energy Control Board, for whom the Geological Survey acts as official agent in matters pertaining to the resources of radioactive materials. Most of the information it contains appeared in mimeographed form, as Paper 51-10, in August 1951. In its present form, a few additions and corrections have been made, and several illustrations have been added. Some of these contain information obtained in 1951.

GEORGE HANSON,
Chief Geologist, Geological Survey of Canada

OTTAWA, October 31, 1951

Canadian Deposits of Uranium and Thorium

(Interim Account)

PART I

INTRODUCTION

GENERAL STATEMENT

The widespread search for uranium in Canada during the last few years has resulted in numerous discoveries in many parts of the Dominion, from British Columbia to Nova Scotia. Several other deposits have been known for some time, and extensive exploratory work has now been done by mining companies on several properties.

Under regulations of the Atomic Energy Control Board, discoverers and companies have been required to furnish information to the Geological Survey of Canada for confidential records. Much information has accumulated, therefore, from these records and from field and laboratory studies made by officers of the Federal and Provincial Governments. This report has been prepared with the approval of the Atomic Energy Control Board, to make available a summary of as much of this information as the property owners are willing to have published, excepting data on production and ore reserves. Descriptions of thorium deposits have been included, but the report deals mainly with uranium deposits.

The report is in three parts. Part I is an introduction, including acknowledgments; an outline of the history of prospecting and mining for uranium in Canada; a summary of regulations of the Atomic Energy Control Board applicable to prospecting and mining; and a statement of usages adopted for this report. Part II contains generalizations concerning the mineralogy of uranium and thorium deposits; the types of occurrences; their geological setting and geographical distribution; the economics of uranium mining; and suggestions for prospecting. Part III contains short accounts of the principal regions in which uranium deposits occur, and short descriptions of the individual occurrences and properties.

In some respects this report is a revision of earlier, shorter papers by the writer. The information has been brought up to date to the end of 1950, additional general topics are discussed, and short descriptions are included for all known occurrences or properties that have yielded assays of 0·05 per cent or more of uranium or thorium oxides, except for a few that the discoverers do not wish mentioned. About one-half of the individual descriptions are based on examinations by the writer or other representatives of the Geological Survey, supplemented by information supplied by the owners; the remainder have been prepared from reports of provincial governments, property owners, and discoverers. Some of the individual descriptions contain essentially all that is known about an occurrence; in other instances details have been omitted to prevent the report from being too lengthy, references being given if additional information has been published elsewhere.

This report should be regarded as an interim one on subjects and properties that are changing rapidly. Many problems regarding the geology of the deposits, and their economic possibilities, have still to be solved.

ACKNOWLEDGMENTS

The Geological Survey, and the writer personally, wish to express appreciation to the discoverers and company officials who have supplied information and consented to its publication. The writer is also greatly indebted to many of these gentlemen for courtesies extended in the field. The large number precludes mentioning them individually.

The writer thanks H. V. Ellsworth, of the Geological Survey, for suggestions and assistance. Ellsworth's memoir on "Rare-element Minerals of Canada", which is out of print, is in some ways a forerunner of this report. Thanks for suggestions are also made to B. S. W. Buffam and E. B. Gillanders, who served with the writer on a geological committee established by the Atomic Energy Control Board.

The writer acknowledges with gratitude information that he has obtained from J. S. Stevenson then of the B.C. Department of Mines; J. B. Mawdsley of the University of Saskatchewan; A. G. Horton of the Saskatchewan Department of Mines and Natural Resources; E. W. Nuffield of the University of Toronto; D. F. Hewitt of the Ontario Department of Mines, and officers of the Quebec Department of Mines; M. H. Haycock and S. Kaiman of the Mines Branch; and F. Q. Barnes, Donald A. W. Blake, E. J. Brooker, A. M. Christie, K. R. Dawson, W. E. Hale, S. C. Robinson, S. M. Roscoe, R. B. Rowe, and H. R. Steacy of the Geological Survey. Where a mineral is of special interest, the name of the identifier has been included in the text, but it is not practical to do this for all identifications.

The writer is indebted to D. J. Dewar and G. M. Jarvis, respectively, Scientific Adviser and Secretary of the Atomic Energy Control Board, for suggestions on the section dealing with the regulations of the Board; and to W. F. James and A. Thunaes for suggestions on the section on economic considerations. Some of the information on ages of mineralization was kindly supplied by C. B. Collins and J. T. Wilson of the University of Toronto.

PREVIOUS WORK

Much mineralogical and geological work has been done on deposits of radioactive minerals in Canada and in other countries. The published Canadian work, and some of the work done elsewhere, is referred to throughout the text of this report and in the list of references, therefore, it is unnecessary to list it here. Although the writer has examined about one hundred uranium properties, and has revisited some each year since 1948, his first-hand knowledge is slight in comparison with the wealth of information that has accumulated from the work of many engineers, geologists, and mineralogists. During the past 3 years he has compiled, condensed, and made deductions from this information, for an annual, confidential "Inventory of Canadian Deposits of Uranium and Thorium", for the use of the Atomic Energy Control Board. This report is a summary of the non-confidential parts of that inventory.

HISTORY

Pitchblende has been known to occur in Europe since 1727. The element "uranium" was isolated from pitchblende and described in 1789. Curiosity regarding the marked difference between the amount of radioactivity emanating from specimens of pitchblende and samples of pure uranium led to the discovery of the element "radium" in 1898.

The history of Canadian uranium mining is bound inseparably with that of radium, because the two elements, uranium and radium, occur together in pitchblende and other minerals and are only separated in the refining process. The amount of radium is minute compared with that of uranium, the ratio being about 1 to 3,000,000. Until the discovery of atomic fission, uranium was largely a worthless by-product of radium mining, although some uranium could be marketed for use in pigments and chemical reagents.

The first Canadian uranium discovery was made on the shore of Lake Superior, and short descriptions of it were published in 1847, 1849, and 1857 (LeConte, Whitney, Genth)[1], but the location was described vaguely. Summarized accounts of this occurrence were given in four reports of the Geological Survey published at various times from 1863 (Logan, 1863; Malcolm, 1914; Ellsworth, 1932, 1935), and efforts to find it were made. It was also brought to the attention of prospectors by interviews and correspondence, but because of the indefiniteness of the original account, the general locality was not rediscovered until 1948, by a prospector who studied the above-mentioned reports and who was aided by a Geiger counter.

A uranium mineral was found in Quebec in 1904 (Obalski, 1904). Soon after, several discoveries of unaninite and other radioactive minerals were made in pegmatite deposits in the southern part of the Canadian Shield in Quebec and eastern Ontario, but none of these was in sufficient quantity to be of commercial interest at that time (Ellsworth, 1921, 1922, 1932). Interest in the deposits of this region was revived recently.

In 1914, interest in radium caused the governments of Ontario and British Columbia to offer cash bonuses for discoveries of radioactive minerals in commercial quantities (Brunton, 1915, p. 91). The rewards were unclaimed and the offers were withdrawn in 1937 and 1938 respectively.

In 1930, Gilbert LaBine and E. C. St. Paul flew to Great Bear Lake to investigate an occurrence of cobalt reported by J. Mackintosh Bell, who made a reconnaissance there for the Geological Survey in 1900 (Bell, 1902); Camsell (1950) states that LaBine was interested in the possible association of silver with the cobalt. They found native silver, pitchblende, and cobalt at the locality mentioned, and staked the discovery for Eldorado Gold Mining Company, which LaBine had previously organized to develop a gold property in Manitoba. The discovery at Great Bear Lake became known as the Eldorado mine, and was brought into production in 1933. Much pioneering was necessary, as the mine is in a remote region, only 30 miles south of the Arctic Circle. The name of the company was changed later to Eldorado Mining and Refining Limited. Before production from the Eldorado mine was begun the world's radium market was controlled by the Belgian Congo, where radium deposits were found in 1913 and brought to large-scale production in 1924. Some radium was also derived from deposits in Czechoslovakia, the United States, and other countries. The radium from the Eldorado mine ended, to a large degree, the Belgian monopoly. By 1940, when work ceased temporarily, the mine had produced large amounts of silver, radium, uranium, copper, and cobalt. At first, it was essentially a silver-radium mine, but the amount of silver decreased with depth. The Eldorado discovery soon caused several other finds of silver and pitchblende in the region, one of which produced pitchblende on a small scale.

Early in World War II advances in atomic fission made it desirable to establish a large source of uranium on this continent, so the Eldorado company was asked, in 1942, to reopen the mine without publicity.

[1] Names and/or dates in parentheses are those of references at end of this report.

In September 1943, Orders in Council were passed reserving to the Crown all new discoveries of radioactive minerals in the Yukon and Northwest Territories. Staking and mining for these minerals by private individuals and companies was banned, as was publication of information on uranium occurrences. Some of the provinces took similar action. In 1944 the Government acquired the shares of the Eldorado company, as a security measure, and the undertaking was transferred to a Crown company, called Eldorado Mining and Refining (1944) Limited. The Crown company asked the Geological Survey to assist in searching for new ore and making geological studies at the Eldorado mine and in other parts of Canada. This work was begun in 1944 by sending three parties to Great Bear Lake, as well as parties to other districts. Many radioactive occurrences were found and investigated by Eldorado and Geological Survey parties.

In 1934, interest in the Box gold discovery at Lake Athabasca[1], in northern Saskatchewan, had caused the Geological Survey to re-study the region. The resulting report (Alcock, 1935, pp. 36-37) recorded two occurrences of pitchblende at a gold-copper prospect called the Nicholson, but this information was not then of great interest. The Box mine produced gold from 1939 to 1942, after which the town of Goldfields that had grown nearby was abandoned. In 1944, when all known uranium deposits were being studied, R. Murphy of the Crown company and A. W. Jolliffe of the Geological Survey visited the Nicholson claims, which were in good standing although no work had been done on them since the decline of the Goldfields camp. These geologists advised the Eldorado company to acquire claims in the neighbourhood. Large blocks of claims were, accordingly, staked. Systematic prospecting was begun, and more detailed geological mapping was done. This soon resulted in the discovery of about one thousand pitchblende occurrences or radioactive indications. Several of the more promising deposits were tested by surface trenching and diamond drilling, and underground work has now been done on three deposits on claims held by Eldorado.

The passing of the Atomic Energy Control Act in 1946 vested control of matters pertaining to atomic energy in Canada in a board called the Atomic Energy Control Board. This Board did not establish separate technical staffs, but instead, it makes use of existing government agencies. Thus, the National Research Council continues to investigate the industrial and medical uses of atomic energy; the Mines Branch of the Department of Mines and Technical Surveys continues research on the concentration and extraction of uranium ores; and the Geological Survey of the same Department continues research on the mineralogy and geology of radioactive occurrences, makes geological maps of favourable areas, and receives and compiles the data supplied by prospectors and companies in compliance with the regulations of the Board.

Late in 1947, the Government, on the advice of the Atomic Energy Control Board, decided to permit and to encourage private prospecting and mining for uranium. The restrictions on staking in Federal territories were removed, and a minimum price for uranium oxide was guaranteed for 5 years. The Provincial Governments concerned removed the restrictions in their respective provinces. The Eldorado company continues to be operated by the Federal Government. The price for uranium oxide was increased in 1950, and the guarantee was extended to March 31, 1958. Payment of an additional "development allowance" of $1.25 per pound of uranium oxide during the first 3 years of production, was authorized in March 1951. At the same time the guarantee was extended to April 1, 1960.

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[1] The spelling of the name of this geographical feature has recently been changed from "Athabaska" to "Athabasca".

Much prospecting and staking for uranium by private individuals and companies were done in 1948 and subsequent years, in many parts of Canada. Numerous discoveries resulted, and many of these merited exploratory work in the form of stripping and trenching, and diamond drilling. Underground exploration has been done on eight of them. Work has been concentrated in the Lake Athabasca region of Saskatchewan, the Lake Superior region of Ontario, and in the Northwest Territories. In March 1951, the Eldorado company announced plans for beginning production on a substantial scale at its main property in the Lake Athabasca region.

REGULATIONS OF THE ATOMIC ENERGY CONTROL BOARD

The administration of the regulations of the Atomic Energy Control Board is designed to give all possible encouragement to prospecting and mining by the public. The reporting of information is required, but restrictions apply only to the removal of bulk samples, the disposal of ores and concentrates, release of certain information on ore treatment, and figures on production and ore reserves of producing mines. The reporting of information is essential to enable the Government to build up an inventory of Canada's uranium resources and to organize geological information on uranium occurrences for the benefit of prospectors and mine operators. The necessity for controlling the destination of shipments and the publication of figures on the production and ore reserves of producing mines is obvious.

Full information on the regulations and on the services available to prospectors and mining companies can be obtained from the Atomic Energy Control Board, the Geological Survey of Canada, or the Mines Branch. The following is a summary of the essential points in the regulations that apply to prospecting and mining. It is included here as an added means of circulating the information as widely as possible, in the hope of clarifying certain points about which there appears to be a misunderstanding. Particular note should be taken of the correct way to address letters and reports, as incorrect addresses lead to delay in replies and cause wider circulation of confidential data.

The regulations do not replace the laws governing prospectors' licences, staking of claims, mine safety, etc. Control of these matters is vested in the Provincial Governments and in the administration of the Northwest Territories and Yukon. Information on these subjects, for the respective jurisdictions, can be obtained from the Departments of Mines of the provinces concerned, and from the Development Services Branch, Department of Resources and Development, Ottawa. A summary of these laws, for all Canada, called "The Mining Laws of Canada", can be obtained from the Mines Branch, Ottawa. The regulations of the Atomic Energy Control Board, summarized below, are additional to the provincial and territorial laws.

No special permission from the Board is needed to authorize prospecting for uranium.

No special permission is required for the removal, or shipping within Canada, of the following: uranium-bearing hand specimens; specimens of reasonable size and number for display purposes; grab samples; chip samples; or channel samples. Shipments of specimens and samples to other countries require export permits, for which forms and information can be obtained from all Collectors of Customs.

Anyone who has reason to believe that he has found a deposit containing 0·05 per cent or more of uranium or thorium must report the particulars, including the exact location, to the Director, Geological Survey of Canada, Ottawa. A reasonable time to permit staking, usually 1 month, is allowed before sending this information. The information is treated as confidential until it is released by the discoverer or claim owner. Any desired publicity may be given to a discovery after the Geological Survey has been notified.

To ensure receipt of information on discoveries and development work, all assayers and analysts are required to submit copies of all reports of radiometric tests and chemical analyses showing 0·05 per cent or more of uranium or thorium. If a sample is sent to the Geological Survey for radiometric test or mineralogical identification, time and trouble may be saved by sending the information on locality and type of deposit at the same time.

A little stripping or trenching may be done on claims containing uranium or thorium without special permission from the Board. Permits are required, however, for work that goes beyond the stage of ordinary prospecting. In general, work will be considered as going beyond the prospecting stage if it includes diamond drilling, underground work, removal of bulk samples, systematic traversing with Geiger counters or other geophysical instruments, or trenching to the extent of more than 300 man-days. Such permits are issued readily and promptly, free of charge, their main purpose being to ensure receipt of the information needed to keep the inventory of uranium resources up to date and to increase as rapidly as possible the geological information available to prospectors and operators. Applications for permits should be made to the Secretary, Atomic Energy Control Board, Ottawa, and should give the following information:

1. The full name and address of the applicant, and, if the applicant is a corporation, the manner of its incorporation and the names and addresses of all of its directors and officers.
2. The name and address of the person who will be in charge of the work on the ground.
3. A complete and accurate description by claim number, district, and province, or by lot and concession number, township, county or district, and province, of all property intended to be covered by the permit.
4. A general description of the work contemplated.
5. The names and addresses of all persons to whom it is proposed to send samples for assay and analysis or for mill tests.

A permit stipulates that complete and accurate monthly reports showing the work done at the property, and its results, must be sent promptly to the Director, Geological Survey of Canada, Ottawa. Such reports are treated as confidential until released by the property owner. The property owner is free to publish his results, after having notified the Geological Survey.

If work is stopped temporarily for seasonal or other reasons, the Geological Survey should be notified so that monthly reporting may be suspended, and it should again be notified when resumption of work is planned. These notifications are necessary because failure to send monthly reports may invalidate a permit. The Geological Survey should also be notified if abandonment of the property is planned.

No further permit is required until the property nears production, when a special permit will be required to provide for the control of material and information.

Full precautions are taken by the Geological Survey to ensure that notifications of discoveries and reports of work are kept confidential and are known to a minimum of personnel, unless the senders consent to wider disclosure. All envelopes should be addressed to the Director, Geological Survey of Canada, Ottawa, with the words "Attention Radioactivity Division" in the lower left-hand corner.

No provision is made to have notifications of discoveries or reports of work accepted or forwarded by Mining Recorders or Resident Geologists, but these officials are glad to advise regarding the correct procedure.

It will be seen from the foregoing summary that most of the confidential files of the Geological Survey are confidential because of the business interests of the discoverers or property owners, and not because of secrecy related to atomic energy.

The operator of a property that has not reached the production stage is free to disclose any information regarding the property. However, when a property nears production, a special permit from the Board will be required. This will state the limits on publication of information on ore reserves and amount of production, but arrangements will be made for the furnishing of necessary information to shareholders.

USAGES ADOPTED FOR THIS REPORT

Several principles had to be followed in the preparation of this report, to aid in deciding which properties should be included, and how they should be described.

The report is designed both for prospectors and for engineers and geologists. Technical terms are avoided where possible, but terms that are familiar to experienced prospectors are used.

The object of the report has been to include short descriptions of all Canadian deposits from which assays or other information showing 0·05 per cent or more of uranium or thorium have been reported. The quantity "0·05 per cent" was chosen because the Regulations define a radioactive substance, for official purposes, as one containing 0·05 per cent by weight of uranium or its equivalent. Actually, the content "0·05 per cent U_3O_8" has been used in selecting occurrences, because chemical analyses and radiometric tests are reported in terms of U_3O_8. The compound "U_3O_8" contains about 85 per cent of uranium, therefore, 0·5 per cent U_3O_8 represents about 0·04 per cent of uranium. Thus, by using the value "0·05 per cent U_3O_8" occurrences that are slightly below the official minimum have been included.

Descriptions of thorium deposits have been included, partly because, for many occurrences, the only quantitative results are from radiometric tests that did not distinguish between uranium and thorium; and partly because thorium deposits, although not in particular demand now, may be of more interest at some future time.

No purpose would be served by listing the many hundreds of occurrences from which samples that showed less than 0·05 per cent U_3O_8 or ThO_2 have been sent to the Geological Survey or to other agencies. A few such occurrences are described, however, because of publicity concerning them or because they are unusual types of deposits. Some occurrences are known because of mineral identifications that were not accompanied by quantitative analyses or radiometric tests; these have been included if the pure mineral, as described in standard texts, contains 0·05 per cent U_3O_8 or ThO_2, or more. Some radioactive occurrences are known only from reports of above-normal reactions obtained in the field with Geiger counters without supporting evidence obtained from tests on samples. Such reactions are generally called "anomalies". These occurrences are not included in this report unless the anomalies are known to have been strong enough to suggest the presence of radioactive minerals in quantities equivalent to 0·05 per cent U_3O_8. A few reported occurrences, for which the information is uncertain, have been omitted.

Many properties contain two or more separate radioactive occurrences, and some contain many occurrences. As it is not practical to list these occurrences separately, the property has been taken as the unit. The word "occurrence" is used in referring to the individual deposits on some properties, or to refer to properties that are not known to contain more than one deposit, or to describe discoveries that are not known to have been staked.

Copies of the descriptions of occurrences or properties were sent to the discoverers or owners concerned, to learn whether they approved of publication. Approval was granted in almost all cases, but a few asked that publication be withheld, and a few others asked that certain information be omitted. Several property owners failed to reply, and the writer has not felt free to include the descriptions of these properties. In all, about 10 per cent of the known occurrences or properties are undescribed.

A few occurrences may be described twice under different names, because two persons sent samples from a single occurrence without supplying adequate information on the locality, but it is believed that the submission of descriptions to the persons from whom the samples were received has virtually avoided such errors.

If a property has a definite name, such as a particular mine or group of claims, that name has been used. If not, a geographical name, such as a township or nearby lake, has been used, if available. This has been done because geographical names are permanent, whereas the ownership of claims is subject to change. If no other name is known, the name of the property owner or of the person from whom samples were received has been adopted.

The individual descriptions in Part III are necessarily brief because of the large number of occurrences or properties. Greatest space has been allotted to properties where underground work for uranium has been done. Shorter descriptions are included for those properties that have been diamond drilled. Properties and occurrences that have only been explored on the surface are described briefly.

Occurrences and properties are arranged according to the regions in which they occur, instead of by mineralogical or geological types, because the writer believes that most readers will find that arrangement convenient. The regional sections, including short regional descriptions, are arranged in a general west-to-east and north-to-south order, and the individual descriptions for each region are arranged alphabetically.

Addresses of individual discoverers or property owners are included, but addresses of companies are omitted because they can be obtained readily from handbooks.

To conserve space, a short way of reporting the results of chemical analyses and radiometric tests has been devised. For example, "0·17 C" stands for "0·17 per cent U_3O_8, determined by chemical analysis"; and "0·17 R" stands for "0·17 per cent U_3O_8 equivalent, determined by radiometric test". An ordinary radiometric test gives a close approximation of the total amount of uranium or thorium oxide, or both, in a sample, but it does not distinguish between uranium and thorium. Radiometric tests that measure separately the amounts of beta and gamma rays provide close approximations of the separate amounts of uranium and thorium oxides in a sample, because the ratios of beta to gamma radioactivities caused by uranium and thorium differ. Tests of this kind are mentioned specifically.

Where results of several samples are listed, the widths across which the samples were taken are given in parentheses.

So far as possible, the writer's opinions are confined to the generalizations contained in Part II, the descriptions in Part III being written objectively, without stating opinions on the merits of individual properties. The descriptions of properties are believed to be authentic, but the writer does not assume responsibility for information supplied by others.

PART II

GENERALIZATIONS

MINERALOGY

GENERAL STATEMENT

Much detailed mineralogical information has accumulated, in Canada and in other countries, from research on ores containing uranium and on minerals containing uranium or thorium. This information is necessary for a full understanding of deposits of these minerals and for investigations concerning the treatment of their ores. The subject cannot be treated fully in this report, however, so the following is only a summary of the main features that apply to known Canadian occurrences. Further work may cause revision of some of the information given.

Minerals that contain uranium or thorium are commonly called radioactive minerals because they give off alpha, beta, and gamma rays. The principles of radioactivity are beyond the scope of this report, and are described in many other publications. Uranium and thorium are the main radioactive elements, but minerals containing uranium also contain a little radium and other disintegration products of uranium. There are no separate radium minerals, distinct from those of uranium. Also radioactive are certain isotopes of potassium, rubidium, and other elements; atoms of isotopes have the same chemical properties as the typical atoms of a particular element, but have different physical properties. Minerals that contain potassium possess enough of the radioactive isotope of potassium to be slightly radioactive, and may cause misleading results to be obtained with Geiger counters (Senftle, 1948). For the purposes of this report, however, radioactive minerals are considered to be those that contain uranium or thorium.

One of the facts learned from the intensive search for, and study of, uranium deposits in Canada is that many primary deposits contain uranium dispersed so finely that uranium minerals cannot be seen by eye, and that their detection by laboratory methods may be difficult or impossible. Samples from some such deposits have yielded very fine-grained uraninite and other radioactive minerals, but samples from a few other deposits, which showed significant contents of uranium by chemical analysis, have defied the most modern identification techniques. Work on these problems is being continued.

CANADIAN RADIOACTIVE MINERALS

More than one hundred minerals containing uranium are known, but most of these contain small amounts of the element. Several additional minerals contain thorium without significant amounts of uranium. Table I lists the twenty-nine uranium or thorium minerals that have been identified from Canadian occurrences. It shows their contents of uranium and thorium oxides, and the number of occurrences or properties from which identifications have been reported. A few additional identifications may have been made at universities and elsewhere before reporting of this information was required, but the numbers listed are believed to be substantially correct.

Table I

CANADIAN RADIOACTIVE MINERALS

Name	Composition	U_3O_8[4] %	ThO_2[4] %	Occurrence[1]	Number of properties[2]	
						?
Allanite	Silicate of rare earths and thorium	....	1–3	P	32	5
Autunite	Hydrous phosphate of uranium and calcium	60	....	S	......	1
Becquerelite	Hydrous oxide of uranium	....	....	S	1	......
Betafite	Columbate of uranium, etc	up to 27	....	P	1	......
Carnotite	Hydrous vanadate of uranium and potassium	50–55	....	S	1	......
Cuprosklodowskite	Hydrous silicate of copper and uranium	65	....	S	1	......
Curite	Hydrous oxide of uranium and lead	....	....	S	1	......
Cyrtolite	Zirconium silicate with uranium	up to 1·5	less than 1	P	10	2
Euxenite-polycrase series	Titano-tantalo-columbate of rare earths, uranium, etc	up to 20	0–5	P	20	6
Lyndochite[3]	High in calcium and thorium, low in uranium	....	....	P	2	......
Fergusonite	Columbate of rare earths	up to 8	....	P	8	1
Gadolinite	Silicate of rare earths, thorium, etc	....	up to 0·9	P	1	......
Gummite	Hydrous silico-uranate of lead, calcium, etc	40–80	0–25	S	27	......
Kasolite	Hydrous silicate of lead and uranium	49	....	S	1	......
Liebigite	Hydrous carbonate of calcium and uranium	....	....	S	1	......
Monazite	Phosphate of rare earths and thorium	....	2–15	P	18	3
Pyrochlore-microlite series	Titano-columbate of calcium, rare earths, uranium, etc	up to 20	0–5	P	3	......
Ellsworthite	High in uranium	....	....	P	4	3
Hatchettolite	High in uranium	....	....	P	1	1
Samarskite	Tantalo-columbate of uranium, rare earths, etc	9–18	0–4	P	1	1
Calciosamarskite	With calcium	....	....	P	2	1
Thorianite	Thorium dioxide	....	38–93	P	......	1
Thorite	Hydrous silicate of thorium	0–22	50–90	P	4	......
Thucholite	Hydrocarbon with uranium, etc.	2–8	10–12	V and P	8	5
Toddite	Tantalo-columbate of iron, uranium, etc	11	0·47	P	......	1
Torbernite	Hydrous phosphate of uranium and copper	60	....	S	1	1

Table I.—*Con.*

Name	Composition	U_3O_8[4] %	ThO_2[4] %	Occurrence[1]	Number of properties[2]	
						?
Uraconite	Hydrous sulphate of uranium, copper, and calcium	....	....	S	1	......
Uranophane	Silicate of calcium and uranium	67	0–3	P	1	......
Uranothorite	Silicate of thorium and uranium	up to 20	40–60	P	9	7
Uranothorianite	Thorium oxide, with some uranium	variable	....	P	......	1
Uraninite	Uranium oxide	65–85	2–14	P	40	15
Pitchblende	Uranium oxide	50–80	less than 1	V	67	34
Zeunerite	Hydrous arsenate of copper and uranium	56	....	S	1	......
Zippeite	Hydrous uranium sulphate	up to 68	....	S	2	......

[1] Refers to the type of deposit in which the mineral is found. P=pegmatitic type; S=secondary type; V=vein type.

[2] The number of properties from which a particular mineral has been reported is listed here. Many properties contain several occurrences, but only one is counted for each property. The first column lists definite identifications, and the column headed by "?" lists doubtful identifications.

[3] Names indented are those of varieties of the preceding species.

[4] Compositions are taken from standard references and do not neccssarily represent analyses of Canadian specimens.

URANINITE AND PITCHBLENDE

Pitchblende is the most important source of uranium, because it is relatively abundant, and because it contains a large percentage of uranium. Most mineralogists regard pitchblende as a variety of the definite mineral species "uraninite". Some mineralogists believe that the name "pitchblende" should no longer be used. However, because the type of uraninite generally called pitchblende has many separate characteristics, and because the name is well established, pitchblende is here used as the name of a variety of uraninite.

Uraninite and pitchblende consist essentially of uranous oxide (UO_2), but, because of radioactive disintegration and resulting oxidation, some of it is changed to uranic oxide UO_3. The amount of UO_3 increases slowly with the age of the mineral. Actual compositions of specimens of uraninite and pitchblende lie between UO_2 and UO_3. Although chemical analyses and radiometric tests are computed in terms of uranosic oxide (U_3O_8), this oxide is not known to exist as such in natural minerals. Typical uraninite is crystalline, and is found as cubes or octahedra. The variety pitchblende is cryptocrystalline; it is found in masses, some of which are botryoidal, banded, or colloform. Typical uraninite usually contains significant amounts of thorium and rare earths, whereas pitchblende generally contains very little of these elements. Pitchblende from different localities may show wide variations in composition. Some specimens contain so much hematite or silica, or both, that they cannot be regarded as true uraninite or pitchblende, but they are loosely called pitchblende; they are mixtures containing pitchblende, and, if they occur in commercial quantities, an appropriate name for them is "pitchblende ore".

THUCHOLITE AND RELATED COMPOUNDS

Substances classed as "thucholite" are carbonaceous compounds or mixtures that have been found in several Canadian pegmatite deposits and in a few vein deposits. The name thucholite was coined by Ellsworth (1928) from the chemical symbols "Th, U, C, H, O" to describe an occurrence from the Parry Sound region of Ontario. Recent work by Davidson and Bowie (1950) indicates that the material classed as thucholite "is not a true mineral but a complex of uraninite with hydrocarbon of hydrothermal origin, resulting from a polymerization or condensation of hydrocarbon fluids effected by radiations from uranium ore". These writers have also shown that "thucholite" is an important constituent of the uranium ores associated with some of the Witwatersrand gold deposits of South Africa. Material classed in early reports as uranium-bearing anthraxolite probably belongs to the thucholite group. Some material previously classed as thucholite has been shown to be sooty pitchblende. Robinson (1950, p. 13) tentatively classed some of the radioactive material at the Nicholson property in Saskatchewan as "uraniferous opal", a compound or mixture of silica and uranium oxide. Specimens were later identified as hisingerite by S. H. U. Bowie, of the Geological Survey of Great Britain (personal communication). Hisingerite is a non-radioactive, hydrous, iron silicate, and the radioactivity of the specimens was caused by minute inclusions of pitchblende.

TYPES OF RADIOACTIVE MINERALS

Radioactive minerals are of three main types: those found in pegmatites and related types of deposits formed at high temperatures; those found in veins and related types of deposits; and secondary minerals formed at or near the surface, from the alteration of minerals of one or other of the foregoing types. Table I indicates the types to which each of the minerals listed belongs.

Pegmatitic Minerals. Radioactive minerals of the pegmatite class occur as distinct crystals or small masses, commonly scattered irregularly in bodies of pegmatite. Table I shows that allanite, minerals of the euxenite-polycrase series, and uraninite are the radioactive minerals most commonly identified in samples from Canadian pegmatites. Many uranium-bearing minerals of the pegmatite type are members of solid-solution series, such as the euxenite-polycrase series, and their compositions, accordingly, vary widely between arbitrary limits. The most common minerals that consist essentially of thorium rather than uranium are allanite and monazite. Radioactive minerals of this class are most commonly associated with feldspar, quartz, mica, beryl, lithium minerals, columbite-tantalite minerals, and minerals containing the rare earths. In a special type of pegmatite deposits found in southeastern Ontario, uraninite is associated with fluorite; Emmons (1950) has suggested that uranium may be associated genetically with fluorine.

Hydrothermal Minerals. The only uranium-bearing mineral that occurs commonly in veins and related types of deposits is uraninite of the variety called pitchblende. Table I shows that pitchblende has been reported from one hundred and one properties in Canada. It is commonly associated with hematite, cobalt-nickel minerals, native silver, copper minerals, and selenide minerals. The only other uranium 'compounds' recognized in Canadian deposits of this kind are thucholite and hisingerite, and they have been found at few localities. Crystalline uraninite occurs in several vein-type deposits in British Columbia, which appear to be of such high-temperature origin that they have some of the characteristics of both pegmatite and vein deposits. Here the most common mineral associates are cobalt minerals, gold, silver, and molybdenite. No minerals containing significant amounts of thorium have been reported from Canadian deposits of the vein type.

Secondary Minerals. Uranium minerals are fairly unstable in the presence of water; therefore, secondary minerals commonly occur at or near the outcrops of pegmatite, vein, and other types of deposits. Many secondary uranium minerals, which are usually yellow or orange in colour, have been named and described. Those that have been identified from Canadian deposits are listed in Table I, gummite being the most abundant. It should be noted, however, that almost all Canadian deposits of uranium contain small amounts of secondary uranium minerals at or near the surface, but in relatively few instances have the secondary mineral or minerals been identified. Definite identifications generally require laboratory work, and, because deposits of secondary uranium minerals are not likely to be economically important in Canada, this work is seldom necessary on prospectors' samples. It is generally sufficient in this country to refer to them collectively as "uranium stain" or "secondary uranium minerals". Some prospectors wrongly refer to all yellow secondary uraniferous material as 'carnotite'.

Cuprosklodowskite, kasolite, and zeunerite were identified recently by E. W. Nuffield and D. Hogarth at the University of Toronto, in specimens from the Nicholson property (Nuffield, personal communication). From the same property they also identified uranophane, which had previously been reported from an occurrence in Quebec by the Quebec Department of Mines.

Minerals containing thorium without significant amounts of uranium do not form secondary minerals to the extent that uranium minerals do, probably because thorium compounds are more stable. This probably accounts for the common occurrence of minerals like allanite and monazite in placers, whereas uranium minerals have rarely been reported from placer deposits.

TYPES OF DEPOSITS

Deposits that contain radioactive minerals can be classified in different ways, such as by their importance; their contained minerals; their geological origin; and their form, such as stringers, stock-works, veins, or disseminations. No single classification will satisfy all requirements. The writer believes that the following classification, which is mainly genetic, but also based to some extent on mineralogy and form, is the most practical one for known Canadian deposits. Certain individual deposits are border-line examples that lie between two of the types in the classification, but this would probably be a fault of any classification.

Types of Canadian Radioactive Deposits

(1) Granitic deposits

(2) Pegmatitic deposits
- A. Granite pegmatites
- B. Pegmatitic schist deposits, migmatites, etc.
- C. Diorite pegmatite, etc.
- D. Calcite and calcite-fluorite pegmatites

(3) Hydrothermal deposits
- A. Uraninite-bearing veins
- B. Pitchblende-bearing veins, stringer-systems, etc., with simple mineral associations
- C. Pitchblende-bearing veins, stringer-systems, etc., with complex mineral associations
- D. Disseminated or replacement deposits

(4) Sedimentary deposits

(5) Secondary deposits

(6) Placer deposits

GRANITIC DEPOSITS

Many bodies of granite and related rocks contain about 0·003 per cent uranium or thorium oxide, and contents up to 0·01 per cent occur more rarely. A few have shown contents above 0·05 per cent, but the average content would not likely be that great, and possibly the samples came from small pegmatitic concentrations within the intrusion. Allanite, monazite, and thorite are known to occur as minor original constituents of granitic rocks, and small amounts of uraninite and other uranium minerals probably occur in this way as well. Some uranium may also occur as an impurity in other rock-forming minerals. At present it appears that pink-coloured granitic rocks are slightly more radioactive than the grey types, but this may be caused by the radioactivity of potassium, rather than by greater contents of uranium or thorium.

All known deposits of this class contain too little uranium to be of commercial interest at present. Some of them might become important at some future time if the demand for uranium should be sufficiently great and if cheap methods of mining and treatment should be available, but none is considered to be worth staking at present. Study of them might also lead to the discovery of more important uraniferous pegmatite or hydrothermal deposits. The type has been described here largely for the sake of completeness, and to show one of the reasons why low and unimportant reactions are so commonly obtained with Geiger counters.

Few granitic deposits have as yet been investigated in Canada for radioactive minerals; therefore, it is probable that many more examples occur than are listed in Table II.

PEGMATITIC DEPOSITS

General. Radioactive pegmatites are so common in many parts of Canada that it is not surprising that deposits of this kind represent about 40 per cent of known Canadian radioactive occurrences or properties. By no means all pegmatites contain radioactive minerals, but many of them do carry one or more of the pegmatitic minerals listed in Table I. Many more such occurrences could doubtless be found if there should be a demand for them.

Ordinary pegmatite is found in segregations, lenses, or dykes in granite or closely related plutonic rocks, or in the invaded rocks nearby. Pegmatite of this kind is properly called "granite pegmatite"; use of the word pegmatite alone usually implies that the granite type is meant.

Several occurrences of pegmatitic radioactive minerals have been found in zones of banded pegmatite and schist, or in schist near granitic intrusions. These are called migmatites and pegmatitic schists.

Special types of pegmatites that contain considerable calcite or calcite and fluorite have been described by Ellsworth (1932, pp. 113-114).

Another special type of uranium-bearing pegmatite has recently been found associated with diorite in the Northwest Territories. This type is tentatively called "diorite pegmatite".

Pegmatite deposits have been classified in different ways by several specialists, some by mineral content, some by the rocks with which they are associated, and some by the form of the deposits. The above-mentioned types are used as the basis of the classification employed in this report.

Granite Pegmatites. About 90 per cent of the known occurrences of radioactive pegmatite in Canada are granite pegmatites. Typical granite pegmatite consists chiefly of potash feldspar and quartz. Page (1950), in summarizing the world-wide occurrence of uranium in pegmatites, states: "In summary, the uranium minerals in foreign pegmatites, as well as in the United States, appear to be most common in those bodies that contain an abundance of potash feldspar. Uraninite shows a close association with muscovite and biotite; betafite and allanite with biotite; euxenite and monazite with beryl and in a few deposits with muscovite; and samarskite with columbite and fergusonite". Ellsworth (1932, pp. 117-118) considered that two main types of uranium-bearing pegmatites occur in Canada: (1) those containing uraninite, which also contain an unusual amount of quartz and muscovite, and are the type sought and worked for mica; and (2) those containing euxenite, which contain a normal amount of quartz, tend to have the quartz and fieldspar well segregated, and are sought and worked for feldspar.

Many deposits of granite pegmatite, and other kinds of pegmatite, contain zones of different textures or different mineralogical contents. In deposits worked for mica, etc., mapping of such zones separately, on a fairly broad scale, has been practised in Canada for many years. A technique for detailed mapping and study of such zones, developed recently in the United States (Cameron, 1949), may have wide application if it should be shown that granite pegmatites, or other kinds of pegmatites, are mineable for uranium in Canada. In summary, Cameron and his associates have found that: "The structural and lithologic units that differ in mineralogy, texture, or both have been designated as: (1) fracture fillings—tabular units that fill fractures in previously consolidated pegmatite, (2) replacement bodies—units formed primarily by replacement of pre-existing pegmatite, and (3) zones—successive shells, complete or incomplete, around an innermost unit or core that reflect to varying degrees the shape and structure of the pegmatite body".

Pegmatitic Schist Deposits, Migmatites, etc. Several deposits of radioactive minerals consist of thin, parallel bands of granite pegmatite, and schist or gneiss that commonly contain much biotite. In some of these occurrences the bands of pegmatite are so thin and such an integral part of the rock mass that the name "migmatite" is applicable. Elsewhere the deposits consist of wider, parallel or *en échelon* lenses or dykes of granite pegmatite, with intervening schist or gneiss. At still other localities, masses of biotite schist occur in granitic rocks, and appear to be altered inclusions. Deposits of one or other of these types have been found north of the East Arm of Great Slave Lake, in the Black Lake and Charlebois Lake areas of Saskatchewan, and in the Grenville region of Ontario. The minerals most commonly identified have been uraninite and uranothorite. In some instances the radioactive minerals are more abundant in the schist than in the pegmatite itself, perhaps indicating that biotite acts as a precipitant for uranium. Some occurrences suggest possibilities for considerable tonnage of uranium-bearing rock.

Diorite Pegmatite, etc. Any type of plutonic rock may have pegmatites associated with it, and it is customary to call them syenite pegmatite, diorite pegmatite, etc. (Johannsen, 1932, p. 73). The compositions of such pegmatites are analogous to those of the plutons to which they are related.

The deposits at the Rex property in the Northwest Territories occur in diorite, and are believed by the writer to represent uranium-bearing diorite pegmatite. Fractures are filled mainly with coarsely crystalline, fibrous actinolite, and smaller amounts of calcite, magnetite, apatite, uraninite, and fluorite.

Calcite and Calcite-fluorite Pegmatites. Many of the pegmatites in the Grenville region of Ontario contain large amounts of calcite as well as feldspar and quartz. Some, such as the MacDonald mine, which was worked extensively for feldspar, contained minor amounts of radioactive minerals.

Several deposits in the Wilberforce area contain considerable fluorite, perhaps in commercial quantities. Most or all of these occurrences contain calcite as well, and several of them contain uraninite and other radioactive minerals.

Attempts have and are being made to develop some of the occurrences as fluorite producers, with production of uranium as a by-product. Two theories have been advanced by Ellsworth (1932, p. 216) to account for the abundance of calcite in these pegmatites. One theory postulates that ordinary pegmatitic solutions reacted with limestone country rock, and dissolved more calcium carbonate than could be assimilated by chemical combination, calcite crystallizing from the excess. The other theory assumes that the calcite-bearing pegmatite formed from inclusions of limestone in a granite magma, and that typical pegmatite minerals were introduced into the limestone by replacement.

HYDROTHERMAL DEPOSITS

The term 'hydrothermal' is generally used to define the types of mineral deposits believed to have been deposited from hot solutions, regardless of theories on the nature and origin of such solutions. Pitchblende deposits of this class, usually in the form of veins or stringer-systems, have been the most important sources of uranium in Canada, the Belgian Congo, and Europe. The Canadian deposits placed in this group are subdivided mainly on the basis of mineralogy.

Uraninite-bearing Veins. Several deposits in British Columbia, particularly in the Bridge River and Hazelton camps, consist of veins and related forms containing crystalline uraninite in gangue that has some pegmatitic characteristics. These deposits also contain cobalt-nickel arsenides, molybdenite, or other metallic minerals in quantities that appear to be too great to allow classing the deposits as true pegmatites. They are probably high-temperature hydrothermal deposits in which some of the minerals may have been deposited under pegmatitic conditions.

Pitchblende-bearing Veins with Simple Mineral Associations. Many pitchblende deposits consist of veins, stringers, lenses, or pods, composed of relatively few minerals. Some consist of pitchblende alone, but most contain hematite, and quartz, chlorite, or carbonate minerals. These gangue minerals may be in minor amounts, or the deposits may consist chiefly of gangue, with a little pitchblende. Small amounts of sulphides or other metallic minerals may also be present. Most deposits are complex zones of mineralized lenses, stringers, and streaks within a much larger volume of altered rock; at some deposits the rock contains pitchblende in both disseminated and concentrated forms.

Most of the pitchblende deposits in northern Saskatchewan and in the Sault Ste. Marie region of Ontario are of this relatively simple mineralogical type.

The 'giant quartz veins' of the Northwest Territories are classed as a special type within this group of deposits. They are large stock-works composed of quartz stringers and silicified wall-rocks, generally occupying major fault zones. Some are several hundred feet wide and are traceable for several miles. Some of them contain, in places, streaks and pods of pitchblende and specular hematite.

Pitchblende-bearing Veins with Complex Mineral Associations. Other veins and related types of deposits contain pitchblende associated with many other minerals, such as hematite, native silver, cobalt-nickel minerals, pyrite, chalcopyrite, selenide minerals, vanadium minerals, gold, and platinum. Common non-metallic minerals are calcite, other carbonate minerals, and quartz. Examples of this type are the Eldorado mine and the Contact Lake deposit in the Northwest Territories, and the Nicholson and one of the Fish Hook Bay deposits in Saskatchewan.

Replacement or Disseminated Deposits. A few deposits whose origin has not yet been proved are classed tentatively as replacement or disseminated deposits. An example is the Breton property in the Sault Ste. Marie region.

SEDIMENTARY DEPOSITS

A few, very low-grade, radioactive occurrences are typical sedimentary deposits in which the uranium or thorium is almost certainly an original constituent of the sedimentary rocks in which it occurs. For example, certain phosphatic beds in the Fernie formation of the Rocky Mountains are slightly radioactive, and uranium-bearing nodules have been found in the Sibley series near Nipigon, Ontario (Tanton, 1948, pp. 69-74). The McLean Bay deposit at the east arm of Great Slave Lake appears to be a sedimentary deposit. The possibility that workable sedimentary deposits may be found in Canada should not be overlooked.

SECONDARY DEPOSITS

Known deposits of secondary uranium minerals in Canada are relatively small, but it is possible that deposits of secondary uranium minerals in gravels, such as the one mentioned in the description of the Bolger property in the Goldfields region of Saskatchewan, will be salvaged if a primary uranium deposit is being mined nearby. Larger deposits, in bedrock or in overburden, may be found.

PLACER DEPOSITS

Samples of concentrates from several placer deposits in British Columbia and Yukon Territory, and from one small placer in the Northwest Territories, have shown significant radioactivity. Most of these contained thorium minerals such as allanite and monazite. Chemical analyses showed that a few of these samples, from British Columbia, contained significant amounts of uranium, but the uranium-bearing minerals have not been isolated.

The possibility of finding radioactive placers containing recoverable amounts of monazite, or, possibly of uranium minerals, should not be ignored, particularly in the Cordilleran region. Most uranium minerals decompose fairly readily in the presence of water, and placers are more likely to contain thorium than uranium. Some hydrated uranium oxides are only sparingly soluble, however. Consequently, the discovery of even small amounts of uranium in placers might lead to the discovery of the lodes from which the uranium in the placer was derived.

DISTRIBUTION OF DEPOSITS

RELATIVE ABUNDANCE OF URANIUM

Uranium and thorium are fairly common elements. Estimates of the average uranium content of the earth's crust are 0·0002 per cent (Anderson, 1942), 0·0004 per cent (Goldschmidt, 1938), and 0·0009 per cent (Fersman, 1932). The discrepancies in these figures are not significant, as the orders of magnitude are similar. Senftle and Keevil (1947) estimated that granitic rocks contain an average of 3·963 grammes of uranium a ton. Goldschmidt estimated that uranium is less abundant in the earth's crust as a whole than are copper, lead, or zinc, but more abundant than gold or silver; he also estimated that thorium is about three times as abundant as uranium. However, the estimate that uranium is more plentiful than gold does not necessarily imply that mineable uranium deposits will be found to be as abundant as gold mines, because rocks containing minute amounts of uranium occur in large quantities and probably account for most of the uranium in the earth's crust. The estimates do indicate, however, that uranium is a fairly common metal, and that mineral deposits containing uranium should also be fairly common.

In Canada, uranium or thorium in amounts over 0·05 per cent were reported from four hundred and ninety-one properties or unstaked occurrences up to the end of 1950. Most of them contain uranium, but their exact number is not known because some of the information is based on radiometric tests that did not distinguish between uranium and thorium. Many properties contain several individual occurrences of radioactive minerals, or high anomalies that doubtless represent unexposed radioactive minerals; the total number of these occurrences in Canada was estimated to be about three thousand two hundred at the end of 1950.

GEOGRAPHICAL DISTRIBUTION

Fifty per cent of the properties from which samples have shown 0·05 per cent or more of uranium or thorium oxide are in Ontario. This high percentage is attributable partly to the large number of pegmatitic occurrences in the region between Georgian Bay and Ottawa River, and partly to numerous pitchblende occurrences in the Sault Ste. Marie region. Saskatchewan contains only 20 per cent of the properties, but this province has the largest number of known individual occurrences, because several properties in the Goldfields region each contain more than 100 individual occurrences. The Northwest Territories contains about 14 per cent of the properties; Quebec contains about 7 per cent; and British Columbia, about 6 per cent. A few occurrences have been found in Manitoba, Nova Scotia, and Yukon Territory.

In Table II, the properties or occurrences are listed by provinces or territories and according to types of deposits. The type is not always known, because of incomplete reports; in such cases the writer has included the probable type in a column headed by "?".

DISTRIBUTION WITH RESPECT TO AGES AND KINDS OF ROCKS

Canadian Shield. About 93 per cent of the properties are in the Canadian (Precambrian) Shield, and, with few exceptions, they are in the western and southern margins of the Shield. They have been found in a zone that is generally less than 100 miles wide, extending southward from the east side of Great Bear Lake to Lac la Ronge, thence eastward through the Flin Flon, Lake of the Woods, and Lake Superior regions, and ending in the Grenville sub-province. The Grenville sub-province is a division of the Shield that extends from Georgian Bay to the Gulf of St. Lawrence, and which is characterized by the presence of crystalline limestone, much gneiss, and abundant pegmatite.

At the present stage of prospecting, it is impossible to state the extent to which the distribution of known uranium occurrences in the Shield is attributable to accessibility and the tendency to prospect in the regions where deposits have already been found, and the extent to which the distribution is related to geological conditions. The writer believes that accessibility and geological conditions are each partly responsible. Most of the early discoveries were made near large lakes and rivers that formed natural travel routes; these occurrences attracted prospectors and other discoveries were made nearby. Therefore, it may be that when the entire Shield has been thoroughly prospected for uranium, the pattern of discoveries will be quite unlike what it is today. On the other hand, it is well known that different metals tend to occur in particular parts of the earth's crust called metallogenetic provinces, and these provinces are believed to be related, at least in part, to differences in the metal content of the underlying source rocks or source magmas from which the mineral deposits were derived. Another consideration is that most of the pitchblende occurrences are in or near belts of Proterozoic mountain building, so there may be a time relationship between the age of at least some of the pitchblende mineralization and the Proterozoic folding and faulting.

Table II

DISTRIBUTION OF PROPERTIES BY TYPES (1950)

—	Granitic		Pegmatitic		Hydrothermal veins, etc.		Replacement		Sedimentary		Placer	Totals		
		?		?		?		?		?	?		?	
Yukon											1	1		1
British Columbia			5		14	3		2			5	24	5	29
Northwest Territories			7	3	33	24				1		40	28	68
Saskatchewan		5	13	9	62	11						75	25	100
Manitoba			4	1								4	1	5
Ontario	7	1	121	50	43	24		4				171	79	250
Quebec	1		21	10	2	2						24	12	36
Nova Scotia			1	1								1	1	2
Totals	8	6	172	74	154	64		6		1	6	340	151	491

NOTE. Columns headed by "?" list properties for which there is incomplete information, and which are only thought to be of that particular type.

The main uranium regions, and the distribution of deposits within them, are discussed in Part III of this report. Below, only the broadest generalizations concerning rock types are discussed.

Pegmatite deposits are commonly associated with granites and related rocks, and, as these are widespread in the Canadian Shield, it seems likely that radioactive pegmatites will be found in many parts of the Shield. Whether or not the granites and associated pegmatites of certain parts of the Shield contain more

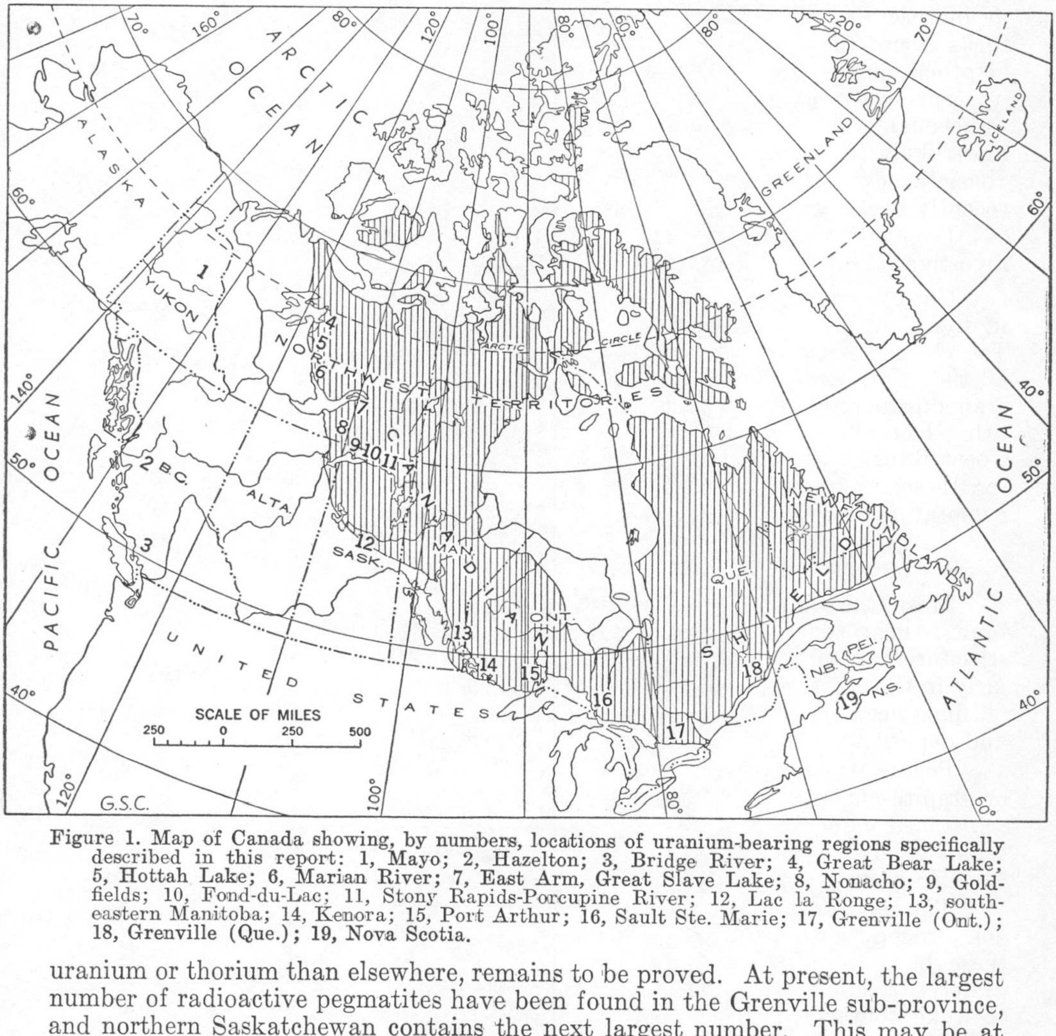


Figure 1. Map of Canada showing, by numbers, locations of uranium-bearing regions specifically described in this report: 1, Mayo; 2, Hazelton; 3, Bridge River; 4, Great Bear Lake; 5, Hottah Lake; 6, Marian River; 7, East Arm, Great Slave Lake; 8, Nonacho; 9, Goldfields; 10, Fond-du-Lac; 11, Stony Rapids-Porcupine River; 12, Lac la Ronge; 13, southeastern Manitoba; 14, Kenora; 15, Port Arthur; 16, Sault Ste. Marie; 17, Grenville (Ont.); 18, Grenville (Que.); 19, Nova Scotia.

uranium or thorium than elsewhere, remains to be proved. At present, the largest number of radioactive pegmatites have been found in the Grenville sub-province, and northern Saskatchewan contains the next largest number. This may be at least partly because of intensive prospecting in these regions, but, on the other hand, the Grenville sub-province has long been known as a region containing an unusually large number of pegmatites that carry radioactive and rare-element minerals, so it appears to be a metallogenetic province.

In determining the location of pitchblende deposits, structural conditions seem to have been more important, in most areas, than were rock types, but where favourable structures existed, favourable wall-rocks were commonly important in determining the exact locus of mineralization. As explained in more detail later, the favourable wall-rocks at the Eldorado mine are altered sediments and diabase, whereas porphyry is unfavourable. Many of the more important pitchblende deposits found to date in the Goldfields region are in basic rocks, such as amphibolite and basalt. Most of the pitchblende occurrences in the Sault Ste. Marie region occur in diabase dykes. Pitchblende deposits show a tendency, therefore, to occur in basic rocks; but this is not always the case, probably because, if uranium-bearing solutions penetrated favourable structures and no basic rocks were available, precipitation would occur eventually regardless of the type of wall-rock. The tendency for uranium to be deposited in a basic environment is found also in many pegmatite deposits, where uraninite or other minerals occur in concentrations of biotite in massive pegmatite, or in biotitic bands in migmatite. The common affinity of uranium for basic rocks is not fully understood because of incomplete knowledge of the solutions or other sources from which the minerals were precipitated. Broadly, however, it seems reasonable to assume that the solutions were derived from "acid" (siliceous) material and were "acid" solutions, therefore, precipitation would be most likely to occur where chemical equilibrium was destroyed by contact with "basic" rocks. A theory for this relationship in the case of lamprophyres has recently been formulated by R. C. Emmons, but his views are as yet unpublished.

Deposits of types other than pegmatitic or hydrothermal have not yet been investigated sufficiently to permit generalizations on their distribution.

Cordilleran Region. With the exception of phosphate rocks, the discoveries in the Cordilleran region are in the part lying west of the Rocky Mountain Trench, and most of them are in the southern half of British Columbia. Most of the discoveries classed as high-temperature hydrothermal deposits are in granodiorite or closely related rocks, in the eastern part of the Coast Range batholith. Deposits of other types are in the Interior belt, which lies between the Coast Range batholith and the Rocky Mountain Trench; generalizations regarding these occurrences are not possible at the present stage of prospecting and exploratory work.

DISTRIBUTION WITH RESPECT TO STRUCTURES

Most Canadian uranium deposits are related to geological structures, chiefly faults, shear zones, fracture systems, and contacts with igneous rocks. These structures are important guides for prospecting and exploratory work, particularly in the cases of hydrothermal deposits. Only the broadest generalizations are outlined here, the details being reserved for the descriptions of individual regions and deposits.

Pegmatite deposits are most abundant near the contacts of bodies of granite or granite-gneiss with other rocks. At some localities, radioactive pegmatite or schist lies immediately at such contacts; at others it is most abundant within a mile or so of the contacts, and may be found in fractures in the granitic or in the invaded rocks.

The relationship of most known pitchblende occurrences to belts of Proterozoic orogeny within the Canadian Shield has already been mentioned. Within these belts, most of the principal pitchblende deposits are related to northeasterly trending fault zones at Great Bear Lake and northern Saskatchewan, and to dyke contacts in the Sault Ste. Marie region. At the Eldorado mine, the deposits lie in fault zones that contain much sheared and fractured rock; and, in places, the distribution of pitchblende shoots within these zones is controlled by "noses" of porphyry masses. In the Goldfields region, a few deposits have been found within large fault zones, but most of the principal ones are in zones of minor faults, crushed zones, or tension fractures near major faults; this is also the mode of occurrence at the Nisto property east of Goldfields. The Sault Ste. Marie region is characterized by swarms of diabase dykes. Most of the numerous pitchblende discoveries in this region are in fractures and shear zones in such dykes, commonly near the walls; a few occurrences have been found in granitic rocks at or near contacts with diabase dykes.

AGES OF MINERALIZATION

There are two ways of estimating the age of a mineral deposit. One is based on the age of the rock in which the deposit occurs, and the other is based on the age of radioactive minerals, if any, in the deposit.

Sedimentary deposits are of the same age as the sedimentary rocks in which they occur. Pegmatites and hydrothermal deposits are younger than the rocks in which they occur, and, therefore, although a general idea of the maximum age of a pegmatite or hydrothermal deposit may be gained from knowledge of the geology, this usually gives little or no information on the amount of time that may have elapsed between the formation of the host rock and the emplacement of the deposit. Furthermore, the age of the rock is usually estimated only in terms of geological eras or periods. The ages of eras and periods are imperfectly known; information available at present suggests that Archæan time ended about 1,000,000,000 years ago; Proterozoic time about 510,000,000 years ago; Palæozoic time, about 182,000,000 years ago; and Mesozoic time about 58,000,000 years ago (Holmes, 1947). Methods of dating rocks based on the rate of disintegration of rubidium to strontium, and on related phenomena, have recently been investigated, and it is hoped that these methods may provide fairly accurate means of dating rocks. Age determinations of rocks, by the helium ratio method have been made by N. B. Keevil and others but these have been questioned because of the possibility of escape of helium from the rocks.

The age of a radioactive mineral can be estimated on the basis of radioactive disintegration, both uranium and thorium yielding series of "daughter" elements, lead being the end member of both the uranium series and the thorium series. Because the rates of disintegration are known, the age of a sample can be calculated if the amounts of two members of the series occurring in the sample are known; the method most commonly used is based on the amounts of uranium and lead. The lead derived from the decay of uranium differs from ordinary lead because it is a particular isotope called "uranium lead"; similarly, thorium produces "thorium lead". In making accurate age determinations by this method it is, therefore, necessary to work with a sample that is known to contain no ordinary lead, such as would occur if any galena were present, or to separate the uranium lead by means of a mass-spectrometer or related device. A further possible source of error lies in the fact that some of the products of radioactive disintegration may have been removed from the sample by natural processes. Additional research on age determinations may cause revision of some of the estimates already made, and of the ages assigned to geological eras and periods.

AGES OF PEGMATITE DEPOSITS

About fifty age determinations were made on samples from pegmatites in the Canadian Shield by H. V. Ellsworth. Some of these results have been published (1932, p. 105), and others are quoted by courtesy of H. V. Ellsworth. The determinations were made in the first instance by the lead ratio method, that is, the ratio of lead to the uranium or thorium or both, if present; but Ellsworth saved the leads recovered in the analyses and a number of them were later subjected to isotope analysis by Professor Nier in the United States by means of the mass-spectrometer. The atomic weights of some of them were also determined in the chemical laboratory of Harvard University. By these means the age of each mineral could be checked in several different ways. The amounts of common lead found by the isotope analyses were practically negligible. These determinations showed wide variations, ranging from 2,211,000,000 years (Huron claim, Manitoba) to 94,000,000 and 154,000,000 years for two samples of ellsworthite from the MacDonald mine in the Grenville region. The ages were divisible into three main groups: one group representing deposits formed in Archæan time; one representing deposits formed in Proterozoic time; and a smaller group suggesting Palæozoic ages for a few pegmatite deposits that intrude Precambrian rocks.

A recent determination on a sample from the Wilberforce district, made by C. B. Collins, J. R. Freeman, and J. T. Wilson with the aid of a mass-spectrometer at the University of Toronto, indicates an age of 1,010,000,000 years (Collins *et al.*, 1951).

No age determinations have been made on samples from pegmatites in British Columbia and Nova Scotia. The occurrences in British Columbia are associated with intrusive rocks that are probably Mesozoic or Tertiary in age.

AGES OF HYDROTHERMAL DEPOSITS

Two determinations made by J. P. Marble on pitchblende from the Eldorado mine at Great Bear Lake indicated ages of 1,333,000,000 and 1,347,000,000 years, and one made by A. C. Lane indicated 1,277,000,000 years. A recent determination by Collins, Freeman, and Wilson (Collins *et al.*, 1951) indicated 1,470,000,000 years. These determinations are fairly consistent, and they suggest an Archæan age for the mineralization. This presents a problem, because most geologists now believe that the rocks in which the Eldorado deposits occur are of Proterozoic age (Henderson, 1948). There are three possible explanations, namely: that the deposits are Archæan, in which case the rocks must also be Archæan; or that the age determinations are unreliable; or that the time ranges assigned to the Archæan and Proterozoic Eras require revision.

A determination made on pitchblende from the Contact Lake mine, about 9 miles from the Eldorado mine, showed 623,000,000 years, suggesting Proterozoic age. This was confirmed by a determination made by Ellsworth on material from the same mine; this showed a ratio of 0·093, which suggests a Proterozoic age.

Four determinations made on pitchblende from Hottah Lake indicated 328,000,000, 350,000,000, 388,000,000, and 422,000,000 years. These suggest that the mineralization at Hottah Lake is of early Palæozoic age.

Two determinations made by Kroupa several years ago on material from the Nicholson mine at Lake Athabasca gave conflicting results, one indicating 1,414,000,000 years, and the other, 590,000,000 years. One made by Ellsworth on material from the Nicholson or Fish Hook Bay property showed 583,000,000 years; and one made by Ellsworth on a sample from the Gil property at Lake Athabasca indicated 764,000,000 years. Ellsworth states that the analyses were made on crude materials as received as a preliminary to further work on more carefully selected fractions of the same material. Both samples were from the surface and much altered and no isotopic analyses of the leads were made, hence too much importance should not be attached to the age results. Several of the pitchblende deposits near Lake Athabasca occur in rocks that are classed with little doubt as Proterozoic, indicating that the age of mineralization is probably late Precambrian or early Palæozoic. Recently, however, Collins, Freeman, and Wilson (1951) made seven determinations on pitchblende from properties near Lake Athabasca. These were made by determining, with a mass-spectrometer, the ratio of the leads from the isotopes U^{235} and U^{238}; the results ranged from 1,400,000,000 to 1,680,000,000 years. These determinations raise the same problem as mentioned above in connection with the deposits at Great Bear Lake.

A determination made by Collins, Freeman, and Wilson on pitchblende from the Sault Ste. Marie region indicated an age of 1,150,000,000 years. Most of the deposits in this region occur in diabase dykes considered to be Keweenawan in age.

Age determinations have not yet been made on samples from hydrothermal deposits in parts of Canada outside the Canadian Shield. The deposit known to occur in Gaspe is in rock believed to be Devonian in age, and the deposits in British Columbia are associated with intrusions of Mesozoic or Tertiary ages.

The foregoing summary shows that much remains to be learned about the ages of Canadian radioactive deposits. It is hoped that increased use of age determination techniques will clarify some of the anomalies outlined above, and will indicate whether radioactive mineralization occurred at several distinct times in any one region, and whether it is related to widespread metallogenetic epochs. At present, the only broad generalization that can be made is that many pitchblende deposits occur in Proterozoic rocks, or in Archæan rocks that were affected by pre-pitchblende folding and faulting that also affects nearby Proterozoic rocks; and that many of the age determinations suggest mineralization in Proterozoic time.

Several additional age determinations have recently been made by Collins on samples from the Goldfields region and from other deposits in the Canadian Shield. These results will probably be published soon.

ORIGIN OF MINERALIZATION

PEGMATITE DEPOSITS

The extensive literature on the origin of pegmatite has been summarized by Ellsworth (1932, pp. 120-124); the principles are mentioned only briefly here, for the general reader. The principle generally accepted is that granitic rocks crystallize at depth, from molten material. As crystallization proceeds, the still-molten material is believed to acquire concentrations of metals and of fluxing compounds or elements such as water, carbon dioxide, fluorine, and sulphur. These fluxes are thought to keep a certain amount of quartz and feldspar molten until after the main granitic mass has crystallized and become fractured; then this remaining quartz and feldspar, together with some of the metallic and other rarer constituents of the original melt, would migrate into fractures in the outer part of the granite mass, or beyond it in the invaded rocks. The fluxes would permit slow, and, therefore, coarse, crystallization as pegmatite. Some investigators believe that much pegmatite is formed from the same kind of material as described above, but by replacement and reaction with other rocks, instead of simply filling fractures. Pegmatites are formed at high temperatures and at considerable depths below the land surface at the time of their formation; their occurrence at or near the present land surface indicates deep erosion.

More basic types of pegmatite, such as the pegmatite described in connection with the Rex property at Great Slave Lake, are doubtless formed in a manner analogous to that outlined above, but from material containing less silica and alkalis, and more ferromagnesian constituents.

HYDROTHERMAL DEPOSITS

It is generally accepted that veins and other types of the broad class of deposits called 'hydrothermal' are, like pegmatites, derived from igneous material but that the mineralizing material migrated, in the form of solutions, beyond the zones favourable for pegmatitic crystallization into cooler rocks where they formed quartz veins and other types of deposits. This theory is corroborated in two ways: by the fact that many hydrothermal deposits are found in the outer parts of stocks or batholiths, or in the invaded rocks nearby; and by the fact that some pegmatite dykes have been observed to change gradually and upwards, into quartz veins. Although some details of the mode of origin of veins and related types of deposits are in doubt, the general theory as outlined above is so widely accepted that, where a deposit cannot be associated genetically with an exposed body of plutonic rock, such a body is assumed to underlie the region at depth.

Because uranium-bearing pegmatites are associated with granitic rocks in many parts of the world, it is generally assumed that most, if not all, pitchblende deposits were also derived ultimately from granitic magmas. Most pitchblende deposits, however, show evidence of having been deposited at moderate or low temperatures and accordingly at considerable distance from the source of the solutions. In most districts, therefore, it is impossible to demonstrate that pitchblende deposits are related genetically to any exposed granitic rocks. This subject is discussed in more detail in the descriptions of regions and properties. Only the general conclusions for the main pitchblende-bearing regions of Canada are mentioned below.

The deposits at Great Bear Lake are believed to have been formed at several stages, the pitchblende being deposited at an early stage, at moderate temperatures. Granodiorite, granite, and diabase are exposed in the district. The pitchblende may have been derived from one of these intrusions, but no direct evidence has been found; the uranium-bearing solutions may, therefore, have come from an intrusive source that is not exposed.

The pitchblende deposits in the Goldfields region show evidence of formation at moderate temperature and shallow depth. Many of the deposits are in rocks of the Athabasca series, and there is no evidence that any of the granitic rocks exposed in the region are as young as this series. There is a slight possibility that some of the granitic rocks of the region could have been intruded in Athabasca or later time, but it appears to be more probable that the pitchblende was derived from granitic rocks younger than those exposed. The association of uranium-bearing pegmatites with some of the granites exposed in the area leads to speculation as to whether the pitchblende deposits were not also derived from these granites, but as no other supporting evidence has been found, present opinion is that the pegmatites belong to an earlier period of mineralization.

The pitchblende deposits of the Sault Ste. Marie region are in and near late diabase dykes. There, the pitchblende mineralization may be related to the same igneous source as the diabase, and in that case represent a later phase introduced after the crystallization and fracturing of the diabase, or it may be related to a much later period of mineralization. Radioactive pegmatites occur in granite near some of the pitchblende deposits, but this granite appears to be much older than the diabase and the pitchblende.

The above summary indicates the incompleteness of knowledge regarding the origin of pitchblende mineralization. Studies of the temperature of formation of minerals associated with pitchblende, and accurate age determinations, may prove useful means of attacking these problems.

WALL-ROCK ALTERATION

Red alteration products of the wall-rocks of hydrothermal uranium deposits are common, but by no means universal. Where the deposits themselves consist partly of rock, as in stock-works and disseminations, this rock is commonly altered in the same way. This red alteration product is characteristic of many deposits at Great Bear Lake and Goldfields, and of the dolomitic radioactive deposits at the east arm of Great Slave Lake. It is not conspicuous at the Nisto property in Saskatchewan, nor at the main pitchblende occurrences in the Sault Ste. Marie region of Ontario.

In the regions where this type of alteration is characteristic, the rocks close to the pitchblende deposits are commonly brick coloured because of abundant hematite, and in some places are hard and known locally as jasperoid. The red alteration presents an important problem that has been studied by several workers, whose conclusions are summarized in the following paragraphs.

Murphy (1946, p. 432) described the alteration at the Eldorado mine as follows:

"The envelope of reddish 'jasperoid' enclosing the veins is the most intense form of alteration. Within four or five feet of the vein there are seldom even recognizable remnants of the wall-rock. Although the width of the altered zone is roughly proportional to the width of the vein, there are examples of unusual penetration, probably on numerous small mineralized fractures. The red alteration may mark areas in which veins are concealed and is therefore a useful guide in exploration."

Christie (1949, p. 31) described the red alteration in the Goldfields region as follows:

"Hematite, specular hematite, or red hematite stain has been reported from all the pitchblende occurrences, and the carbonate of the mineralized veins is usually at least in part, stained red or brown by hematite. In the gneisses in the vicinity of radioactive anomalies, the feldspars are stained red. A good example of this was seen at the southwest corner of Neely Lake, where a radioactive fissure in white granite-gneiss is flanked for a distance of a few feet by a granite-gneiss that is red, due to the staining of the feldspars.

"Over most of the map-areas this effect is more difficult to observe because the feldspars of the granites and granite-gneisses are pink or red, probably due to the large amount of iron in the intruded sedimentary formations. This earlier stain may mask the later introduction of hematite or stain associated with the pitchblende deposits; however, in several places, as was mentioned in the case of the Box orebody, a deeper-than-normal brick-red stain is associated spatially with the pitchblende occurrences.

"Another important type of alteration is what has been called 'red cherty alteration' of wall-rock near pitchblende-bearing veins. This may occur in any type of rock, but is most conspicuous and most important in the fine-grained mafic rocks (chlorite-epidote type), as at the Ace Lake property. It may be due to silicification, the silica being accompanied by iron stain, or it may be due to introduction of fine-grained, red-stained feldspar, or to both."

Conybeare and Campbell (1951) studied the red alteration in the Goldfields region, particularly near the St. Louis fault. Their conclusions were as follows:

"Zones of deep-red rocks, shown by petrographic study to be mylonites have been observed to be more radioactive than others in the Goldfields and Great Bear Lake areas of western Canada. For the Goldfields area, this relationship is considered a result of the following sequence of events all of which took place in Precambrian time:

(1) Partial replacement of a bedded series by the minerals of albite granite.

(2) Mylonization during early movements along the St. Louis and related fault zones.

(3) Deposition of finely-divided hematite in feldspar porphyroclasts and groundmass, from solutions migrating along the mylonite zones.

(4) Widespread recrystallization of feldspar and quartz and introduction of calcite, penninite, specularite, and pitchblende."

In 1950, K. R. Dawson studied the red alteration in the Goldfields district for the Geological Survey. His results have not yet been published[1], but he kindly supplied the following synopsis for inclusion in this report:

"It appears that 'red alteration' is the only general term that can be applied safely as there are objections to the use of either hematitic alteration or mylonitized zones in that sense. There are also objections to the use of the term jasperoid. Of the last three, hematitic seems the best, but its use may obscure the fact that the alteration is considerably more complex. Mylonitized zones are significant at the Eagle, Ace, and probably the Donaldson, but certainly not at Martin Lake. The rôle these zones play is uncertain, but the term is not generally applicable. Jasperoid commonly applies in American geological literature to cherty replacements of limestone in such sulphide deposits as the Mississippi type lead-zinc deposits. With the possible exception of the Ura and some barren veins in Martin Lake there is little cherty silica and in neither place are the conditions met for the use of the term jasperoid.

1 Since this was written, a preliminary report (Paper 51-24) has been published by the Geological Survey of Canada.

"I believe the colour is due to finely divided and disseminated hematite, but hematite present in much smaller amounts than we thought earlier. Martin Lake and Fish Hook Bay are two exceptions, and Ace and Donaldson are typical examples. In the last two, it is unlikely that there is more hematite present than would be found in a red granite. The visible grains of specularite are clustered along the veins rather than disseminated throughout the host rock.

"The width of the altered zone does not appear to bear any consistent relationship to occurrences of pitchblende. In the Martin Lake workings, the alteration was effective for the same uniform width along barren fractures as along radioactive veins. At the Ace, it bears a closer relationship to the St. Louis fault than to the occurrence of the pitchblende, as though the alteration preceded the pitchblende mineralization. The veins in that mine occur in shatter zones within the zones of strong red alteration, unaccompanied by any additional alteration. I do not believe a general rule regarding the width of the alteration relative to the occurrence of pitchblende will be found to apply to the camp as a whole.

"It is also noteworthy that there are numerous zones of 'red alteration' in the area around Goldfields, which are megascopically identical with those carrying pitchblende but which are barren. I hope to get more information on this problem."

Hematitic alteration is not the only type associated with hydrothermal deposits. The wall-rocks at the Eldorado mine contain considerable magnetite, and some of the shear zones contain much talc and chlorite. The wall-rocks of some of the deposits in the Goldfields region contain much chlorite, which is believed to be of hydrothermal origin. Hriskevich (1949, p. 21), in describing the Nisto property, states that where the wall-rocks are of basic types, such as gabbro, they are markedly bleached for as much as a foot from pitchblende veins, whereas acidic wall-rocks show little or no alteration. His studies showed that the bleaching was caused partly by decoloration of biotite in the rock, and partly by alteration of biotite to chlorite.

ECONOMIC CONSIDERATIONS

GENERAL PRINCIPLES

Exploration and mining for uranium differ only in details from similar work on deposits of other metals. The general economic principles of mining are, therefore, applicable. Numerous requests for information on this subject indicate that many persons who are unfamiliar with mining in general are interested in the commercial possibilities of uranium deposits, and that a short discussion of the basic principles is desirable in this report. The following outline is intended, therefore, for the layman rather than for mining geologists or engineers.

The fundamental economic principles affecting mining are: (1) mining is subject to the same laws of supply and demand that control other industries; (2) a mine is a 'wasting asset' that cannot be reproduced; (3) only a small proportion of mineral discoveries are suitable for mining; (4) mines may ship ore in the form in which it is mined, or after it has been sorted by hand; or they may be large enough to have their own treatment plants; (5) metals that occur in relatively small amounts may be recovered as by-products of mining for other metals.

Supply and Demand, etc. All markets and prices are subject to the law of supply and demand, but governments may control markets and prices, as in the case of uranium. The Government, through the Eldorado company, is the only authorized buyer of uranium ores and concentrates, and has guaranteed a base price for uranium oxide until April 1, 1960. Up to that time, the Eldorado company will buy any acceptable ores or concentrates containing 10 per cent or more by weight of U_3O_8, at a base price of $2.75 per pound of contained U_3O_8; the Eldorado company will also pay the costs of rail transportation and refining. This price includes all radioactive elements in the shipment, but arrangements will be made for valuing any other constituents that can be recovered commercially. To encourage the mining and milling of lower grade ores, the Government has offered to pay a milling allowance of $7.25 per ton of ore milled, on the basis of a maximum price for mill heads of 0·25 per cent U_3O_8 and a minimum extraction of 70 per cent (the terms 'mill heads' and 'extraction' are explained later). The price payable is determined as follows:

The price per pound to be paid for the U_3O_8 content of acceptable concentrates containing 10 per cent or more by weight of U_3O_8 shall be the product obtained by multiplying the average number of pounds of U_3O_8 per ton of mill feed by $2.75 a pound, adding to this a milling allowance of $7.25 per ton of ore milled, and dividing the sum of the two by 70 per cent of the average number of pounds of U_3O_8 per ton of mill feed.

On the above basis, the price payable for the U_3O_8 content of concentrates produced from ore averaging 0·25 per cent U_3O_8 is $6 a pound; from an ore averaging 0·5 per cent, $4.95 a pound; and from an ore averaging 0·75 per cent, $4.62 a pound. In addition, it was announced, in March 1951, that a special development allowance of $1.25 per pound of U_3O_8 will be paid during the first 3 years of production, or any part thereof.

Markets and prices for thorium are not guaranteed in any part of the world. Thorium is not in particular demand at present, but monazite, one of the thorium minerals, is in demand because of its content of rare earth elements. Almost the entire world supply of monazite comes from large placer deposits in India, Brazil, and Australia. In 1951, the price in the United States for monazite concentrates containing 65 per cent rare-earth oxides including thorium oxide and cerium oxide was about 17 cents a pound, f.o.b. Atlantic ports. Monazite is stated to occur at several places in the United States, and several companies there have been reported to be considering recovery of monazite as a by-product.

A mine is considered to be a wasting asset because it cannot be reproduced, in contrast with agriculture and forestry, in which crops can be reproduced annually and forests can be regrown after many years. Obviously, when an orebody has been mined it has been exhausted for all time. Capital invested in developing and equipping a mine is, therefore, lost unless it is repaid from profits or from sale of the property or plant.

Proportion of Successful Properties. Before discussing this subject it is necessary to define some terms that are commonly used loosely or incorrectly. A *prospect* is defined as a mineral property that has not yet been proved by exploration to be worthy of development (Peele, 1948, pp. 10-30). *Exploration* is work done to gain knowledge of the size, shape, and content of a deposit. *Development* is the driving of openings to and in a proved deposit, for mining and handling the product economically. *Ore* is a metal-bearing mineral or aggregate of minerals, generally mixed with barren material called *gangue,* capable of being mined at a profit. An unproved body of mineral is usually called a *mineral occurrence* or a *mineral deposit;* the terms 'orebody' or 'ore deposit' should not be used until a mineral deposit has been shown by exploration to be capable of profitable mining.

It is an accepted fact that prospects are common, but relatively few prove large or rich enough to be economically mineable. Because mineral deposits are rarely exposed sufficiently in their natural state to reveal their dimensions, much exploration is usually required to 'prove' an ore deposit. The sequence of events generally begins with prospectors doing a little stripping or digging on 'showings' that they have found. They will discard some as being obviously unimportant, and do additional stripping and trenching on others to expose them sufficiently to facilitate examination by an engineer. Engineers and geologists examine many such prospects each year, and recommend further exploratory work on those that may prove to be of sufficient size and grade. The results of such work may be unfavourable, or they may indicate that still further work is advisable. Exploration thus proceeds by stages, a few producing mines resulting from a much larger number of prospects. Many of the factors involved in deciding whether to recommend work on a prospect can only be estimated; therefore, some properties become producers although previously reported on unfavourably. Such situations may arise from unforeseen conditions for which no one could be held responsible, or from improved metal prices, transportation, or treatment methods. Cases of this kind are not, however, sufficiently common to alter the general principle that there are far more unimportant prospects than orebodies.

No accurate statistics for the relationship between unsuccessful prospects and producing mines are available, but authorities generally estimate that, for gold and base-metal mining in Canada, much less than 1 per cent of prospects become producing mines. This condition will probably be true also for uranium occurrences, and the proportion of unimportant occurrences may be even greater because the use of Geiger counters probably results in detection of many small or low-grade uranium occurrences, whereas analogous types might be missed in prospecting for gold or other non-radioactive metals. The large proportion of unimportant occurrences should not deter prospecting for uranium, or exploratory work on those that seem to offer promise, because it has not prevented the establishment of important gold and base-metal industries. The subject has been discussed at some length only because many persons who are unfamiliar with mining in general have in the last few years become unduly excited about very meagre occurrences of uranium. Nothing that has been said is meant to discourage prospecting for uranium, but to indicate that caution should be exercised until a deposit of fair size and content has been revealed.

Shipping Ore. Some small gold, silver, or base-metal mines ship ore as it comes from the mine, or after it has been sorted by hand. This may be done because the ore is of very high grade and does not warrant treatment at the mine, but more often it is because the deposit is too small to justify the expense of a plant. According to the Minerals Yearbook (1948, p. 1274) some of the uranium ore from mines in the Belgian Congo is shipped as untreated ore. It seems likely that some of the higher grade uranium occurrences that are too small to warrant the building of individual treatment plants could ship sorted ore to the refinery, or perhaps to plants that might be built on other nearby properties or as central buying plants. Some deposits contain a large amount of low-grade material and, also, smaller amounts of better grade; in such cases it would be unwise to mine and ship the higher grade material if there is any likelihood that it could be blended with that of lower grade to form an orebody that would warrant its own treatment plant.

Treatment Plants. The treatment of uranium ores is a large subject, about which detailed information may be obtained from the Mines Branch. A full discussion of the subject would be out of place in this report, but short mention should be made because treatment may be an important consideration in deciding whether a mineral deposit can be worked economically.

If a deposit is large enough, it will generally be more profitable to treat the ore at the mine than to ship, because of the saving in freight. For mining in general, small plants with capacities of 25 or 50 tons a day are occasionally built at relatively small, high-grade properties, but plants usually have capacities of 100 tons or more a day, and some mines have plants with capacities of 1,000 tons or more. In general, there is a relationship between the size of plant and the grade of ore mined and treated, larger plants permitting lower grade operations because the overhead is spread over a larger volume of business. The valuable content or 'grade' of the ore reaching a plant, expressed in percentage or dollars, is called the 'mill head', and the percentage of valuable material extracted by the plant is called the 'recovery', the remainder passing out as 'tailings', which may be stored for possible re-treatment. Inquiries from the public have shown that the terms 'extraction' and 'recovery', as used in connection with the prices for uranium concentrates, are not well understood, so the following explanation may be useful. Chemical analyses will show the exact amount of valuable metal in an ore. Theoretically, a plant could be built that would be capable of obtaining by chemical methods all the metal in the ore, but the process would be very costly. In practice, as much metal is recovered as can be done economically, and the remainder, which would cost more to recover than it would be worth, is sent to waste with the tailings. The ratio between the amount recovered and the amount in the mill heads is called the recovery or extraction. These two words have slightly different technical meanings but they are almost synonymous; when used in connection with the treatment of uranium ores, 'recovery' is used customarily to refer to the percentage of uranium oxide obtained by gravity concentration, as explained below, and 'extraction' is used when referring to the percentage obtained by chemical methods. The milling allowance offered for uranium ores was based on a recovery or extraction of 70 per cent because it was thought that this figure would be about what could be expected. It would be to the owner's advantage to obtain a recovery above this, however, as he would then have more uranium to sell.

A plant for the treatment of uranium ores would probably contain equipment for some or all of the following processes: sorting, milling, crushing, gravity concentration, and leaching. Very high-grade material would probably be sorted by eye or by electronic equipment based on the radioactivity of the ore. This material might be sent directly to the refinery because pitchblende is brittle, and if large pieces of it are crushed and ground some of the mineral will be finely powdered and difficult or impossible to save by gravity methods. The ore that was not removed by sorting would be crushed and ground; the part of a plant used for this purpose is properly called a mill, but the word 'mill' is sometimes used loosely to refer to the entire plant. After grinding, some types of ores are suitable for concentration by what are called 'gravity methods', which are based on the weight of pitchblende. Thus a large part of the pitchblende in the ore would be separated from the lighter, worthless constituents. Ores that are unsuitable for gravity concentration would probably be treated in a leaching plant, where the uranium would be dissolved from the ground ore, and then precipitated. A leaching plant would be more expensive than a gravity plant to build and to operate; for this reason, certain types of ore might be treated partly by gravity methods and the tailings from the gravity equipment might then be treated in a leaching plant.

By-product Production. Metals that occur in relatively small amounts in ore mined essentially for some other metal are sometimes recovered as by-products. For example, uranium minerals might be recovered from a pegmatite deposit worked essentially for feldspar or fluorite, although the amount of uranium in the deposit was too small to permit mining for uranium alone. As a general rule, it is sometimes estimated that a metal can be recovered as a by-product if it occurs in one-tenth the content necessary to permit mining for that metal alone. For example, if it should be estimated that a deposit would require an average grade of 0·3 per cent U_3O_8 to permit it to be mined for uranium alone, and if it was being worked in any case for some other metal, uranium might be recovered as a by-product if the deposit contained as little as 0·03 per cent U_3O_8. The reason for this assumption is that the mining, milling, and overhead would be paid for by sale of the principal metal or mineral, and only a little extra expenditure for equipment, supplies, and supervision might be necessary in order to recover at least some of the uranium. No uranium is being produced as a by-product in Canada at present, but some properties are being investigated as possible by-product producers.

ESTIMATION OF SIZES OF DEPOSITS THAT WOULD JUSTIFY PLANTS

The valuation of a mineral property, and the decision to build a treatment plant and begin production, are involved subjects that require expert work. The problems are made difficult by such facts as the following: no orebodies are identical, so experience of other mines is only a general guide to the conditions that may be expected at the one under consideration; production may be begun before sufficient ore is blocked out to assure repayment of the entire cost of the plant, so that the life expectancy of the mine is based partly on opinion that geological conditions are favourable for the finding of additional ore; mining and treatment costs can only be estimated, particularly because costs of labour, supplies, and transportation are subject to change. This report attempts to deal with these subjects only so far as to give the general reader an idea of the kinds of deposits that might warrant their own treatment plants. Because few plants have been built in Canada for the treatment of uranium ores, much of the discussion is based on experience at gold and other mines.

To obtain an idea of the grades of uranium ore that might be economically mineable, the writer tabulated figures for a number of producing gold and other mines in Canada. The figures are chiefly for the year 1949, and costs have since risen. Most of the examples chosen are gold mines, because their grades are quoted in dollars, whereas figures for base-metal mines are difficult to compare because of fluctuation in metal prices. Thirteen mines with plants of 88 to 290 tons capacity had average grades ranging from $8.76 to $31.39. The average for all thirteen mines is $15.23, which is equivalent to about 0·2 per cent U_3O_8 at 70 per cent recovery. Twenty-three mines with capacities between 300 and 600 tons a day mined ores with average grades ranging from $4.27 to $19.00, but the two mines with lowest grades showed net losses. The average grade for all the mines in this class is $10.83, which is equivalent to about 0·15 per cent U_3O_8 at 70 per cent recovery. Fifteen mines with plants of 600 to 2,000 tons capacity mined ores with average grades ranging from $3.22 to $19.00, two of the lower grade mines showing losses. The average for all fifteen mines is $7.06, which is equivalent to about 0·1 per cent U_3O_8 at 70 per cent recovery. The foregoing figures do not include the development allowance of $1.25 per pound of U_3O_8, payable for the first 3 years. Averages of this kind are far from conclusive, and too close an analogy with gold mining should not be made because of government assistance paid to gold mines. The figures serve to give a rough idea of the grades of uranium ores that would probably be mineable in operations of appropriate size, but the details of each property would have to be considered separately for a proper estimate.

Buffam and Gillanders (1951, p. 11) have estimated that an orebody 4 feet wide and 400 feet long, with an average grade of 0·25 per cent U_3O_8, would have a value of about $5,000 per vertical foot at present prices.

As a preliminary step in valuing a property, some engineers estimate whether it contains enough ore to offset the cost of a treatment plant. Although smaller plants might be built at high-grade deposits, most plants would probably have capacities of 100 tons a day or more. Costs of plants will vary according to the kind of ore, distance from transportation, etc., but it has been reliably estimated that the cost of a gravity plant for uranium ores, for a district where transportation is not an exceptional problem, would be roughly $1,500 per ton of capacity, and that a leaching plant would be considerably more costly. On this basis, a 100-ton gravity plant would cost $150,000, and, if the average grade of the ore were 0·25 per cent U_3O_8, about 7,000 tons would be required to equal $150,000 at the present price of uranium oxide and at a recovery of 70 per cent. This, however, would represent the gross value of the ore; if operating and other costs were considered, a much larger tonnage would be required to offset the cost of the plant.

It is generally considered to be sound practice to build a treatment plant if ore for 3 years has been proved and if the geology, particularly the structural conditions, are favourable for the probable development of considerably more ore. Few orebodies are rich enough to permit paying for a plant, showing a profit, and closing at the end of 3 years. Many mines are, however, capable of having additional ore developed from year to year, and it is sound practice to keep 3 or more years' ore ahead of mining. It may be useful, therefore, to estimate the requirements for 3 years' ore at, say, 100 tons a day. This would be 109,500 tons. Weights of ore vary, but this tonnage would be equal to about 1,314,000 cubic feet. If the orebody had an average width of 3 feet and was half as deep as it was long, its depth would be roughly 450 feet and its length roughly 900 feet; if it were twice as wide, one of the other dimensions could be halved, and so on. Actual orebodies are, of course, irregular in shape. They may also contain parts that are of insufficient grade for mining. Some mines are operated on several relatively small orebodies that are spaced sufficiently closely to be classed as parts of a single mine.

RATINGS OF PROPERTIES

Rating the economic possibilities of uranium properties can only be done inadequately at present because most of them are in early stages of exploration. The writer has estimated the possibilities of each property, but these estimates are only his personal opinion, often based on very incomplete information, and they are subject to change. It would be unfitting to discuss the ratings of individual properties, but a summary of the results is given below.

'Class A Prospects' are those that the writer believes have sufficient promise to warrant full expenditure to prove or disprove their possibilities. Considerable exploratory work has already been done on them, and this has yielded enough encouragement to suggest that exploratory work should be continued on a fairly large scale. It is impossible to know whether they will become producing mines until this has been done. Thirteen properties, most of them in northern Saskatchewan, were given this rating in 1950.

'Class B Prospects' are, mainly, deposits that the writer believes warrant limited expenditure on exploratory work, i.e., prospects on which a few thousand dollars might be spent on preliminary diamond drilling, or on additional trenching, or on bulk sampling. Some Class B prospect deposits are now known to be sufficiently large to provide at least a few tons of shipping ore, and no further exploration appears to be warranted on them. Seventy-three properties contained deposits rated as Class B prospects in 1950, and some of these properties contained more than one individual Class B prospect. Most of the prospects in this class are pitchblende deposits, but several are large pegmatitic deposits. Most of the Class B prospects are in northern Saskatchewan, but several are in other parts of the country.

Most of the remaining known occurrences appear to be too small or of too low average grade to warrant substantial expenditure, but a few may warrant a little trenching or sampling in the hope of revealing additional information that would permit them to be classed as "B". A few are large low-grade deposits that may be of value at some future time if it should be practical or become necessary to mine and treat such deposits.

PROSPECTING AND EXPLORATION

Success in prospecting often results from luck, intuition, or persistence, despite seemingly unfavourable conditions, but as easily found deposits become more and more scarce, prospectors depend increasingly on geological guidance. Prospecting and exploratory work for uranium do not differ basically from similar work for other metals, the main difference being that the radioactivity of uranium minerals allows the use of detecting instruments such as Geiger counters. The writer does not pretend to any special knowledge of prospecting or exploratory work, but he has had an opportunity to see some of this work and its results. He has included the following sections because they may be of interest to inexperienced prospectors and companies, or to those who have had experience with prospecting and exploration for other metals but not for uranium. Booklets on prospecting and exploratory work in general, and on uranium minerals, can be obtained from the Geological Survey and other sources. The following notes are intended mainly to supplement that information.

SELECTION OF REGION FOR PROSPECTING

Some persons prospect only in the region in which they live. If they are not familiar with geological principles, they may be content to test with a Geiger counter any rocks or mining dumps they encounter. This type of prospecting is not disparaged, because there is always a chance that deposits may be found under conditions not previously known to be favourable. However, most professional prospectors, and companies engaged in prospecting, select a region for their operations.

A particular region may be selected because it is a centre of attraction at the time, or a more reasoned selection may be made by deciding first on a type of deposit to search for, and then choosing an area that is known to contain, or is thought likely to contain, such deposits. On the basis of present knowledge, pitchblende deposits are the most favourable type of uranium deposits, and special kinds of pegmatites are probably the next most favourable. The regions known to contain deposits of these types are described elsewhere in this report. Also, it is not impossible that important deposits of other types may be found, and some prospectors may wish to test these possibilities.

It is often stated that the best place to find a mine is where one has been found before. This is at least partly true, because the general conditions will be favourable, and there may be additional orebodies that do not outcrop. These may occur on the same property as a producing mine, or in other parts of the area. Much preliminary prospecting will probably have been done in the area, however, so the search for ore in established camps is largely a matter for geologists and engineers. Many articles on this subject, not specifically related to uranium but applicable in a general way, have been published. Because of the amount of previous prospecting, and because the ground for some distance around a producing mine or promising prospect will probably have been staked, the individual prospector will probably have to select a locality on the fringes of an established mining camp; or select a less well-known region where the deposits of the kind he is looking for have been reported, or a region where the geology has been described as being somewhat similar to that of a region where deposits of the type in which he is interested have been found; or he may select an area on the basis of some personal theory or intuition. He will be wise to select an area that is not too far from cheap transportation, unless he is prepared to gamble on making an exceptional discovery, or to wait for transportation facilities to be improved.

METHODS OF PROSPECTING

In areas where there is much activity, prospectors may stake first and then investigate the claims, or companies may acquire ground that has already been staked. In such cases, detailed prospecting would probably commence at once, as described later. As a rule, however, a prospector who has arrived in the region that he has selected will first undertake reconnaissance in order to choose a smaller area for detailed prospecting, or he may select such an area on the advice of resident geologists or other prospectors, or from published geological information or air photographs.

One of the first matters to be decided in prospecting for uranium is the extent to which radioactivity detectors should be used. Some prospectors rely on them entirely, but in so doing they spend much time at places that are not likely to be favourable. A few prospectors do not use detectors at all, chiefly because of their cost or because the one they have is out of order. Radioactivity detectors are very useful aids in prospecting for uranium, and it is advisable for a prospector to have one, and to have a spare one if he is in a remote place. It is best to use them in conjunction with a certain amount of geological knowledge, thus using the instrument most intensively at places that are theoretically favourable.

Except in cases of detailed prospecting of ground that has already been staked, a prospector will probably first undertake a 'roving survey' by going from outcrop to outcrop in the part of the area that he has selected for the day's work. Except where overburden is deep, he will walk slowly with his detector turned on, and listen for higher-than-average counts while looking for favourable signs. If he obtains a favourable reaction with his instrument, or sees favourable signs, he will search the vicinity more closely, either by testing slowly all the rock that appears to be favourable, or by making a radioactivity or 'grid' survey as explained below. Some stripping or picking into rock with a grub-hoe or pick may be desirable. It used to be stated that counts of twice the background count, or more, were worth investigating, but it is now known that a double count is too low unless one is interested in very low-grade deposits. Conditions are so variable that no definite rule can be made, but, in general, an important count will be several times background, or even a continuous 'buzz' in the earphones. If a discovery seems important, the prospector will take a few samples to be sent for testing or analysis. He should learn to recognize pitchblende and uranium stain, and be able to distinguish uranium stain from molybdenum stain, as he may thereby be able to judge whether a discovery is radioactive because of uranium or thorium, and thus be able to decide whether to stake or do additional work, without having to wait for a report on his samples. Because uranium stain may be washed or dissolved by rain from the immediate surface of an outcrop, it may be necessary to pick into the rock for an inch or so along fractures before finding it. The primary minerals may be completely missing from an outcrop.

In special cases, it may be desirable for prospectors to learn the methods, and have the equipment, for making fluorescent bead tests for uranium, as described in handbooks, and for making quantitative tests on samples by the method described by Senftle (1949).

In searching for mines from which uranium might be obtained as a by-product, producing mines may be investigated by the operators, and the dumps or workings of abandoned properties may be tested by prospectors; if radioactivity is detected or suspected, representative samples should be sent for analysis. Samples of mill heads from practically all producing mines in Canada have been tested for uranium by the Geological Survey and the Mines Branch, without encouraging results. This does not exhaust the possibilities, however, as uranium might be associated with, or occur in parts of, an orebody not represented by the samples tested. As mentioned elsewhere, uranium has been found associated with the ores of several partly developed properties and former small producers.

Geological Guides to Mineralization. The places that are theoretically favourable for the occurrence of uranium deposits are those where conditions are somewhat similar to those at known uranium occurrences. Such conditions are described in many parts of this report, but the main features applicable to know pitchblende deposits are reviewed as follows. The main areas that contain pitchblende deposits are those that contain belts of folded Proterozoic rocks. The extent to which this relationship is accidental is not yet known. The principal structures with which pitchblende deposits are associated are large faults and shear zones in the northwestern part of the Canadian Shield, and contacts of diabase dykes in the Sault Ste. Marie region. More pitchblende deposits have been found in basic rocks such as amphibolite, basalt, diabase, or gabbro, than in siliceous rocks. The mineral with which pitchblende is most commonly associated is hematite, which may occur as a vein mineral and also as 'red alteration' of the adjacent rock. Other minerals with which pitchblende may be associated are native silver, cobalt-nickel minerals, and copper minerals, but many deposits containing these minerals have been tested unsuccessfully for uranium. Prospecting for uranium has only been done intensively in Canada during the last few years, so complete dependence on the foregoing generalizations is probably not warranted. Important pitchblende deposits may be found under other conditions, and deposits of other types may prove to be important.

Air Photographs. Air photographs are being used increasingly in connection with prospecting in Canada because they may show rocks and structures favourable for prospecting and because they show topographical details that have to be omitted from maps. Most of Canada has now been photographed from the air. If the serial numbers of the prints desired are known, they may be ordered from the National Air Photographic Library, Department of Mines and Technical Surveys, Ottawa. The price is 50 cents each, in advance. Enlarged prints for detailed work can be obtained at higher cost. If the serial numbers are not known, the best way to obtain prints is to outline on a map the exact area for which prints are desired, and send the map to the National Air Photographic Library; the sender will then be notified of the number of prints involved and the cost. Vertical photographs are taken with a large overlap to permit use with a stereoscope. A stereoscope is useful but not essential, and if one is not to be used, the cost of a set of prints can be reduced by specifying that stereoscopic coverage is not required. A pamphlet on the use of air photographs in prospecting can be obtained from the Geological Survey.

Radioactivity Detectors. Detailed information on the types of radioactivity detectors, their principles, use, and care, and lists of dealers, can be obtained from the Radioactivity Division of the Geological Survey of Canada. Only a few points about which questions are frequently asked are discussed here.

In general, radioactivity is shielded by about 3 feet of overburden, water, or wet snow, and by lesser amounts of rock. Discoveries have been made occasionally where overburden was a few feet deeper than this, and most of these finds have probably been made because the overburden contained fragments of a uranium mineral or deposits of secondary uranium minerals. There is another possibility, however. Radioactive radiations include a small proportion of high-energy rays that will penetrate more overburden or other material than most of the rays; therefore, especially efficient instruments may be used to search for such high-energy rays in special types of prospecting. Claims for great range through overburden are, however, probably unfounded.

Geiger counters are the most common types of radioactivity detectors. The cheaper and lighter models that are equipped with earphones, but not with meters, are satisfactory for ordinary prospecting and preliminary radioactivity surveys. Instruments equipped with meters are desirable for making detailed radioactivity surveys. A detector called a scintillometer, which makes use of a crystal instead of a Geiger tube, has recently been marketed. Scintillometers have been used extensively during the last year, with good results, but as they have been in use for a relatively short time, complete comparisons between them and Geiger counters cannot be made. They seem to have both advantages and disadvantages. They do not appear to get out of order as frequently as Geiger counters; they are sensitive and efficient; and very accurate readings can be made with them. On the other hand, they are more expensive, and heavier, than meter-equipped Geiger counters. The choice is, therefore, a matter for individual preference.

Radioactivity detectors do not normally distinguish between uranium and thorium. Attempts have been made to design field instruments to distinguish between these elements, but the results have not yet been entirely satisfactory.

Experiments are also being made with special types of shielded Geiger counters, chiefly for underground use.

Extensive experiments have been made with airborne radioactivity detectors, but this type of prospecting is still in the experimental stage.

Radioactivity Surveys. Radioactivity surveys are a type of geophysical surveys, made by recording readings of a meter-equipped detector at evenly spaced intervals called 'stations'. Surveys of this kind are commonly made for the systematic prospecting of claims or concessions. Preliminary traversing of the entire holding may be done at the outset, or work may be begun at some locality that seems favourable. Common spacings for preliminary traverse lines are 400 or 200 feet for large holdings and 100 feet for smaller areas. These lines should be extended across the average strike of the formations, or across the most probable strike of the mineral occurrence, if this is known. Spacing of stations is generally the same distance as the distance between the lines. Lines are sometimes surveyed or picketed in advance, or they may be run by pace and compass at the time the readings are taken. The operator usually keeps his instrument turned on while walking between stations, and records any anomalies so obtained, and geological observations may be noted as well. At stations, the reading may be taken without setting the instrument down, or it may be placed on the ground. Some persons set it on sticks or keep the bottom of the case covered with waxed paper, to prevent moisture and radioactive dirt from entering the case. Care should be taken not to carry radioactive samples, or watches or compasses with luminous dials, near the instrument. Places where high readings are obtained may be marked by blazes, stakes, or paint on rock.

More detailed surveys are generally made later to test strongly radioactive areas, or by engineers or geologists when examining showings. The intervals for such surveys depend on local conditions; a common procedure for detailed work is to take readings at 5-foot intervals along lines 15 feet apart, and for very detailed work the interval may be the width of the instrument. Detailed surveys may be based on instrumental surveys, or a common method for small areas is to lay one tape along a base line and to hold another tape perpendicular to the base line, at the appropriate intervals. Plans of radioactivity surveys should always carry a legend stating the instrument used, the average background count, and the method of recording. Plans commonly show lines analogous to contour lines drawn through points of equal radioactivity, one of the most favoured methods being to space such lines at even multiples of the background count.

If possible, radioactivity surveys should be made before any blasting is done in the vicinity, because radioactive particles may be scattered widely by blasting.

EXPLORATION OF DEPOSITS

When a prospector makes a discovery he will probably do some preliminary exploratory work himself, to determine whether it seems promising, and, if so, to prepare it for the first examination by an engineer or geologist. This work will consist of stripping or trenching through overburden to expose the width of the deposit, to permit an estimate of the length of the deposit, and to determine whether the mineralization is evenly or erratically distributed. The prospector may also blast a few rock trenches, and take samples according to one of the methods described later. If he is prospecting for a syndicate or company, a supervisor will probably visit the discovery as a matter of routine, but if the prospector is independent, he will have to convince an engineer or geologist that the showing is worth visiting; this can best be done by giving a careful description, with sketches, and sampling results.

If an engineer or geologist representing capital is impressed with a showing, he will recommend further work. This will take the form of additional stripping or trenching, or preliminary diamond drilling; bulldozers and fire pumps have been used successfully for stripping at some properties. When this work has been done, a second examination will be made, and abandonment or continuation of work will be recommended. In this way, the exploration of a favourable showing proceeds by stages. The type of work done will depend on the characteristics of the deposit and the preference of the engineer. Some uranium deposits on which much exploratory work has been done, and on which trenching has shown encouraging results, have later been thoroughly diamond drilled; others have been diamond drilled without any previous trenching; and still others have been explored by prospect adits or shafts before any drilling was done, because the management thought that the type of deposit was unsuited for drilling. In general, the Eldorado company does not do extensive stripping or trenching, and favours preliminary drilling of favourable showings at a fairly early stage of exploration.

Most showings cannot be expected to improve at depth, but if a showing is near a favourable structure it may be worth diamond drilling even if the surface indications are not particularly impressive. The satisfactory results obtained at the Ace property at Goldfields may be cited as an example. The Ace surface showings are not large, but they contain pitchblende. The proximity of the showings to a prominent fault, along which pitchblende had been found at other places, led to preliminary diamond drilling. This gave encouraging results, and further drilling was done. This suggested the advisability of underground exploration and, as a result, a large tonnage of pitchblende ore has been indicated. Diamond drilling along other parts of this fault, where no mineralization outcrops, may lead to other important discoveries by revealing radioactivity or favourable rocks or intense red alteration, and, therefore, suggesting that additional drilling should be done nearby.

Diamond Drilling. Diamond drilling has been shown to be a useful method of exploration at many uranium deposits, but it may not be satisfactory in special cases. Good results are not usually obtained with standard, light, 'X-ray' drills, but fair results for short holes have been obtained with such drills when modified to use 'E' rods. At some properties fair core-recovery has been obtained by conventional drilling with 'E' rods, but at others the recovery has been poor, partly because of friable rock and partly because pitchblende itself is friable. The Eldorado company, which has done a great amount of drilling on several properties, favours "A" core ($1\frac{1}{8}$-inch diameter) for preliminary drilling, and changing to "E" core ($\frac{27}{32}$-inch diameter) later if recovery has been satisfactory. Preliminary drilling is commonly done at 400- or 500-foot intervals (Buffam and Gillanders, 1951, p. 5).

In addition to conventional logging, drill core should be tested carefully with a portable radioactivity detector or with a special drill-core counter. The latter consists of a partly shielded Geiger tube under which a box of core is pushed slowly. If a significant count is obtained, the row of core responsible is determined, and the section of radioactive core is sampled.

A special instrument called a 'drill-hole counter' has been developed successfully. It consists of a water-proofed Geiger probe on one end of a long cable on a reel, the other end being attached to a reliable, battery-operated, meter-equipped counter. Readings are usually taken at 5-foot intervals, and more closely where significant radioactivity has been detected. Comparison of readings with sampling results has provided enough statistical data to permit semi-quantitative interpretation of the readings. The advantages of the instrument are that it provides an estimate of the radioactivity of the rock for about a foot around the hole, whereas the core might miss the radioactive mineralization, and it may show radioactivity in places where core was lost.

Sampling. At certain deposits that are well mineralized and near favourable structures little or no surface sampling may be required before exploration by preliminary diamond drilling, but at least some samples are usually taken from surface showings. Sampling of radioactive drill core and underground workings is usually done, the amount of sampling depending on the character of the deposit.

Use of portable radioactivity detectors does not avoid sampling, because there are too many variable factors to permit a close estimation of the uranium content with Geiger counters or other instruments. Use of detectors may, however, indicate that the radioactivity is so weak that sampling is not worth while. Also, if a detailed radioactivity survey of a deposit is made, a smaller number of samples may be required than would be taken at a non-radioactive deposit. Sampling of surface showings may be done in one or more of the following ways.

Selected samples are specimens of the best mineralized material, generally taken for mineralogical study, because as much of the mineral as possible is desirable for that purpose. Radioactivity tests or analyses made on such samples give a misleading idea of the average content of the deposit.

Grab samples are pieces taken at random, but considered to be more or less representative of the deposit. Selected samples are sometimes wrongly called 'grab samples', and may have mistakenly been referred to as such in some of the data supplied for the property descriptions in this report.

Chip samples consist of chips taken at uniformly distributed points, usually across an exposure, care being taken to make the sample as representative as possible. A pound or more of chips should be taken for each foot of width of the deposit.

Channel samples consist of the material cut with a moil from a channel across the width of the deposit. Some authorities recommend channels as large as 4 inches wide and 2 inches deep, but they are usually smaller and may not be perfectly shaped grooves. In both chip and channel sampling, if the deposit is wide and uniform, the samples from each 3 feet or so across the deposit should be kept separate. On the other hand, if the deposit contains bands that are mineralized differently or to different degrees, samples of each band should be kept separate unless the bands are very narrow. In order to mine a rich vein less than about 2 feet wide, some of the barren rock at one or both sides of the vein would have to be removed as well; minimum widths of mine openings are generally considered to be 2½ or 3 feet. Therefore, if a sample is taken across a vein say, 6 inches wide, additional separate samples of the rock for 12 or 15 inches on each side of the vein might also be taken and the assay results of these averaged with that obtained from the vein sample; or the content of the vein sample may be reduced by calculation, so that it represents 2½ or 3 feet instead of the actual width of the vein.

Bulk samples consist of a large amount of representative material taken from trenches or underground workings. They may be taken from one place or from several places along a deposit, and the entire sample may be shipped, or a large sample may be crushed and 'quartered' so that a smaller shipment is representative of the whole sample. The amount shipped should be not less than 300 pounds. Bulk samples are useful both for determining the average grade of a deposit and for test work to determine the best method of treatment and the recovery or extraction that may be expected. As a rule, the expense of bulk sampling is not warranted unless a deposit shows likelihood of being of economic size. Tests on bulk samples are done at some commercial laboratories and by the Mines Branch. If it is desired to have work of this kind done by the Mines Branch, a letter asking for details should be sent to the Radioactivity Division, Mines Branch, 552 Booth street, Ottawa. Samples for concentration and extraction tests should contain as little weathered material as possible.

The outcrops of uranium deposits are usually altered, and it is frequently asked whether samples taken from the immediate surface, or from trenches blasted into a deposit, give any reliable estimate of the grade of the unaltered mineralization. There is not yet sufficient statistical information to permit a full answer to this question, but those who have had most experience believe that visual estimation of a deposit, as exposed at the surface, readings with a radioactivity detector, or samples from the immediate surface will give a sufficiently accurate estimate to permit deciding whether or not to do further work, but that the grade of the altered material would not be closely similar to that of the unaltered deposit. Buffam and Gillanders (1951, p. 4) state: "Rock trenching to provide fresh surfaces for sampling has only rarely been done, as it is thought that oxidation and migration of uranium salts makes it difficult to obtain an accurate surface sample".

Radiometric Tests. Ordinary radiometric tests give an accurate estimate of the total content of radioactive material in the samples, but they do not indicate whether all or any of the radioactivity is caused by uranium. Radioactivity tests are made on instruments calibrated by known amounts of U_3O_8, and the results of radioactivity tests are, therefore, quoted as 'U_3O_8 equivalent'. These tests can be made fairly quickly, so it is usually desirable to have samples tested first in this way; if the total radioactivity is low, it is unnecessary to do more elaborate work to estimate how much of the radioactivity is caused by thorium.

More elaborate tests that measure the amounts of beta and gamma radiations separately indicate the relative amounts of uranium and thorium to an accuracy dependent on the degree of radioactive equilibrium. Radioactive samples may be 'out of equilibrium' because they contain unusual amounts of radon or radium, in which case special tests or chemical analyses are required to determine the exact amount of uranium.

Radioactivity tests on samples from new discoveries and from prospects in very early stages of exploration are made free of charge by the Geological Survey, if the locations from which the samples were taken are given.

Chemical Analyses. Chemical analyses, if properly made, give accurate determinations of the amount of uranium in samples, but they are costly. The usual procedure is to have samples tested radiometrically, and if these tests show that work on the deposit may be desirable to have a proportion of the samples checked chemically or fluorimetrically. The same procedure is usually adopted for samples taken during exploratory work.

The names of laboratories that make radioactivity tests and chemical analyses can be obtained from the Mines Branch or the Geological Survey, and information on the equipment and techniques for doing this work can be obtained from the Mines Branch.

PART III

DESCRIPTIONS OF AREAS AND PROPERTIES

YUKON TERRITORY

MAYO DISTRICT

Small quantities of allanite occur as an accessory mineral in granitic stocks near Dublin Gulch, and in placers in that gulch and in other streams draining into McQuesten River (H. S. Bostock, personal communication). In the same region, monazite was detected in samples from placers on Boulder and Clear Creeks (A. Aho, unpublished manuscript).

BRITISH COLUMBIA

Radioactive minerals have been found at about thirty localities in British Columbia during the last 3 years, mainly at properties that had previously received attention because of the presence of gold, cobalt, molybdenum, or other metals. Most of the other radioactive occurrences in the province are pegmatite or placer deposits. All known significant radioactive occurrences are in the part of the province that lies west of the Rocky Mountain Trench. The only mining camps that contain three or more radioactive discoveries are the Hazelton and Bridge River camps; the remaining occurrences are scattered, and are described under "Other Occurrences".

The only indications of radioactivity in the part of the province east of the Rocky Mountain Trench are in the Fernie and Glenogle formations. The writer examined briefly several occurrences of phosphate rocks in the Fernie formation in the Crowsnest region, but the most radioactive sample collected showed only 0·005 R[1]. A radioactive spring about a mile west of Glenogle, near Golden, is reported (Allan, p. 201) to have formed a yellowish, calcareous deposit. The writer was told by Dr. C. S. Evans that, about 1925, he had tried to find this occurrence and had found yellow material in the Glenogle shale at about the location reported by Allan, and that this material had produced an autoradiograph. The writer tried to find the occurrence in 1949 but found only some limonitic material, which was not radioactive. Nevertheless, the report may repay further investigation.

HAZELTON CAMP

Hazelton is on a branch of the Canadian National Railways, 177 miles northeast of Prince Rupert. Properties in the area are reached by road or pack-trail.

Several mines on Rocher Déboulé Mountain, immediately south of Hazelton, have been intermittent producers of gold, cobalt, molybdenum, tungsten, and other metals. In 1948, interest was taken in testing cobalt occurrences for radioactivity and, as a result, uranium was found in samples from the Victoria group. Later, uranium was found at several other properties on the mountain. Recent work has been directed chiefly toward developing by-product production of uranium at the Victoria property.

The uranium deposits at the Victoria have been described in detail (Stevenson, 1949), and the general geology and mineral deposits other than uranium have been described by O'Neill, Kindle, and Armstrong (*See* References).

[1] For an explanation of this method of reporting results of radiometric tests and chemical analyses, *See* page 8.

The mountain is underlain partly by the Rocher Déboulé stock, a large body of granodiorite and quartz diorite, which intrudes sedimentary and volcanic rocks of Jurassic to Upper Cretaceous age. The deposits consist of complex mineral assemblages filling fractures, shear zones, and faults, some in the stock and some in the intruded rocks. They are believed to belong to the high-temperature hydrothermal type of uraninite-bearing deposits, but some of the deposits consist partly of pegmatitic material; mineralization may have occurred in stages, a pegmatitic stage being followed by a hydrothermal stage. The mineralization is believed to be related genetically to the stock, and to be of late Upper Cretaceous or Tertiary age.

Delta and Highland Boy Group. This property consists of eight claims, north of and adjoining the Rocher Déboulé claims. It is now owned by Messrs. A. M. Whiteside and M. S. Logan, of 615 West Pender Street, Vancouver, B.C. Seventy-five tons of copper-gold-silver ore are reported to have been shipped from the property in 1917, work being discontinued because of a decline in the price of copper. Kindle (1940, p. 48) reported that the group contains two principal zones in granodiorite, mineralized with chalcopyrite, pyrite, and magnetite, and small amounts of gold and silver, in a gangue of hornblende, actinolite, chlorite, quartz, and carbonate.

A sample from the property was sent by Mr. Logan to the B.C. Department of Mines, who reported that it showed 0·08 R, and that spectrochemical analysis indicated that the radioactivity was caused by uranium.

Golden Wonder Claim. Mr. G. L. Oates, 4350 Capilano Road, North Vancouver, B.C., sent a sample from this claim to the B.C. Department of Mines. It contained chalcopyrite, hornblende, and microscopic grains of probable uraninite; it showed 0·08 R, and spectrochemical analysis showed a little uranium and tungsten. No further information regarding the occurrence of uranium has been obtained.

Kindle describes the Golden Wonder group as follows: "Two parallel zones lying 115 feet apart have been traced by open-cuts for 200 feet...... .... The fissured zones range from 1 to 3 feet in width and contain narrow sulphide lenses consisting largely of pyrrhotite with small amounts of pyrite, arsenopyrite, and chalcopyrite. At the surface the sulphide lenses are narrow and short. They do not exceed 6 inches in width and for the most part are less than 3 inches. A 100-foot shaft is sunk on the more northerly of the two zones. At the collar of the shaft the sheared zone carries very little sulphide, but during sinking operations some massive sulphide lenses were encountered containing considerable chalcopyrite. Some of the ore from the shaft is piled in two nearby heaps of about 20 tons. A representative sample from the smaller of the two piles assayed: gold, 0·20 ounce a ton; silver, 7·25 ounces a ton; copper, 6·50 per cent; nickel, none. The westerly continuation of this zone is exposed several hundred feet farther west on the side of the road. It has been trenched for 50 feet and is prospected by a shaft 30 feet deep. The shaft is sunk on two fissures from 2 to 3 feet apart. One fissure ranging from 3 to 6 inches in width consists largely of sheared rock sparsely mineralized. The other fissure carries a 3-inch sulphide vein at the surface, which increases in width to form a pyrrhotite lens 2 feet in width 10 feet down the shaft at the water-level. A representative sample taken from a small heap of pyrrhotite lying at the collar of the shaft assayed: gold, 0·04 ounce a ton; silver, 0·16 ounce a ton; copper, 0·30 per cent; nickel, none".

Homestake Group. Mr. G. Royles, Box 556, Prince Rupert, B.C., sent two samples from this group, which showed 0·088 and 0·14 R. They contained allanite, arsenopyrite, cobaltite, cobalt bloom, molybdenite, and gold. Mr. Royles reported that he had sold the claims to Western Uranium Cobalt Mines Limited.

Red Rose Mine. Five samples taken by Stevenson at the Red Rose mine showed 0·07, 0·07, 0·10, 0·21, and 0·41 R. No further information on the occurrence of uranium at this property is available. The deposits are shear zones in diorite, all the underground workings being on one main zone, which is mineralized with hornblende, quartz, biotite, pyrite, chalcopyrite, pyrrhotite, arsenopyrite, scheelite, wolframite, and ferberite. A small mill was built during the last war, and 1,200,000 pounds of tungsten concentrate were produced in 1942 and 1943, after which the mine was closed because no additional shipments were required (Davis; Kindle). The property has recently been acquired by Western Uranium Cobalt Mines Limited, and production of tungsten has been resumed.

Rocher Déboulé Mine. As described by Kindle (1940), this property is at the west contact of the Rocher Déboulé stock, which is traversed by an unspecified number of fault zones from several hundred to several thousand feet long. These are mineralized, for widths of 4 inches to 8 feet, with chalcopyrite and variable amounts of magnetite, pyrrhotite, arsenopyrite, pyrite, tetrahedrite, safflorite, and molybdenite, with a gangue of hornblende, actinolite, quartz, and subordinate amounts of calcite and siderite. These deposits were developed from five adits, with more than 2 miles of underground workings. Substantial tonnages of copper-gold-silver ore were mined and shipped in 1915-17 and 1929.

In 1948, low radioactivity was detected in specimens from this property in the possession of E. D. Kindle. In 1949, J. S. Stevenson reported that a sample from the property showed 0·25 R.

The property was acquired by Western Uranium Cobalt Mines Limited in 1950, and further development was begun with a view to producing copper, gold, and cobalt from the Rocher Déboulé, and of extending the main haulageway on this property so that it could be used also for development of the adjoining Victoria group.

Victoria Group. The Victoria group, sometimes called the "Hazelton View", is owned by Western Uranium Cobalt Mines Limited. Sixty-three tons of gold-silver-molybdenum-cobalt ore were shipped from this property between 1918 and 1941. The following account has been condensed chiefly from the reports by Stevenson and Kindle.

The claims are at elevations of 4,000 to 6,000 feet, and include four veins, chiefly in granodiorite. At least some of the veins occupy faults, one of which has been traced for more than 1,500 feet. They range in width from a few inches to a sheeted zone 4 feet wide. The vein filling consists of cobalt-nickel sulpharsenides, arsenopyrite, molybdenite, uraninite, and a little allanite, in a pegmatitic gangue composed chiefly of feldspar and quartz. The cobalt-nickel minerals occur as clusters and streaks in shoots up to several inches wide and several tens of feet long. Octahedral crystals of uraninite up to $\frac{1}{8}$ inch in diameter are either widely disseminated or in streaks up to 1 inch long. They are usually associated with films or nodules of molybdenite, near pegmatitic lenses in the faults.

Stevenson took thirty-six samples at frequent intervals along the Number 1 vein. His object was to determine the amount of uranium in different types of vein matter; accordingly, the samples were taken where a particular type was found rather than at predetermined intervals along the vein. All samples were taken across the full width of the particular type of vein matter. By careful testing with a Geiger counter it would be possible to select individual specimens that would assay considerably higher in U_3O_8 than the complete section sampled. Although very fine grained, the uraninite is erratically distributed in the ore, and a few small grains of uraninite produce a very marked difference in assay value. The samples showed radioactivity ranging from 0·003 to 0·75 R, and their unweighted average is 0·096 R. Almost all of them were taken across widths ranging from 4 to 24 inches. He took one sample from the cross vein, across 14 inches; this showed 0·12 R. He took two selected samples from the Number 2 vein, which showed 0·49 and 0·93 R; and two samples across the vein, which showed radioactivity below 0·05 R. He did not examine the Number 3 vein, but reported that it was said to contain small amounts of radioactive material. He concluded that "uranium could be a valuable by-product in ore of the type found and mined".

The company reported in 1950 that recent work had traced the Number 1 vein an additional 250 feet, over the crest of a ridge and down toward the Rocher Déboulé property. A sample from this part of the vein was reported to have been taken across 33 inches, and to have shown 1·38 ounces in gold a ton, 0·90 per cent cobalt, and 0·19 R. The Number 2 vein was reported to have been mapped for a horizontal length of 2,400 feet, and a sample taken from a veinlet 15 feet from the main vein was said to have shown 4·18 ounces in gold a ton, 2·05 per cent cobalt, and 0·69 R. Late in 1950, the company announced that it intended to install a 150-ton mill in 1951, for joint operation of this property and the Rocher Déboulé.

BRIDGE RIVER CAMP

Uranium was found at the Gem property in this camp in 1948 by a prospector who was testing known cobalt occurrences with a Geiger counter. This caused a prospecting rush, but, although many claims were staked in the district, radioactivity was found only on a few claims near the Gem. The general geology and properties of the region were described by Cairnes (1943) before the discovery of uranium.

The Bridge River camp is reached by road from the Pacific Great Eastern railway. The properties described are reached by a trail from a branch road.

Gem Group. This property, sometimes called the "Little Gem", is owned by Mr. J. M. Taylor, 1949 Beach Avenue, Vancouver, B.C. It lies about 25 miles northwest of the main gold mines of the Bridge River camp, and was explored by surface work and two adits several years ago because of the occurrence of gold and cobalt.

The claims are near the eastern contact of the Coast Range batholith, and are underlain by granodiorite or quartz diorite. A fracture zone in these rocks contains pegmatite lenses carrying masses and disseminations of cobaltiferous lollingite or danaite, allanite, molybdenite, and crystals of uraninite. Stevenson (1948) states that the pegmatite lenses range from a few inches to 7 feet wide and from 1 foot to 16 feet long, and that the uraninite is distributed erratically. He estimated that the dumps contain 96 tons averaging 0·26 R, and that the workings contain 232 tons averaging 0·71 R, 658 tons averaging 0·026 R, and 609 tons averaging 0·004 R. Published reports list several assays that indicate substantial contents of gold and cobalt.

In 1949, the old workings were cleaned out and surface prospecting was done. Mr. Taylor reported as follows: "Re-sampling has shown two high-grade sections in the foot-wall of the lower adit, the first with a width of 80 inches assaying 0·87 R and 2·21 ounces in gold a ton, and the second with a width of a further 72 inches adjoining the first, assaying 0·015 R and 2·14 ounces in gold a ton. Both sections also contain 6 per cent cobalt. At the face of the drift on the upper level, beneath 250 feet of backs, is a 4-foot width averaging 1·40 ounces in gold a ton and 1 per cent cobalt, with negligible uranium oxide". A shipment of 600 pounds was sent to the University of British Columbia for test work; Mr. Taylor reported that the test showed high recoveries for gold and cobalt, and that tests for the recovery of uranium were not made. Seven open-cuts were made on the extension of the main zone, about 1,000 feet north of the upper adit. Mr. Taylor reported that most of these showed only slight radioactivity, but that one section of stronger radioactivity was found about 250 feet from the upper adit; a 12-inch sample across this section showed 2·69 R.

Pacific Gold and Uranium Mines Limited. This company acquired twenty-three claims surrounding the Gem property. A mineralized shear zone is reported to have been found and to have been traced for 1,500 feet by eight open-cuts. A sample received from the property showed 0·19 R. A sample sent to the B.C. Department of Mines from the Cobalt No. 2 claim showed 0·19 R, and a press report stated that a radioactive vein on this claim is 20 inches wide. The company reported that other samples tested by private assayers had shown 1 C to 2·25 C, and also gold and cobalt.

Taseko-Mohawk Group. Mr. L. J. Russell of Lillooet, B.C., reported that he had obtained a high count with a Geiger counter at this property, which is in the Taseko River region northwest of Bridge River. The property is described by Dolmage (1929, p. 90), under the name "Mother Lode-Mohawk", as containing two wide fracture zones in quartz diorite. The zones contain networks of quartz veins carrying chalcopyrite and small amounts of other sulphide minerals; occasional samples contained up to half an ounce in gold a ton. Mr. Russell reported that a sample sent to the B.C. Department of Mines showed 0·016 R.

OTHER PROPERTIES

Armstrong Occurrence. The writer was shown a specimen of pegmatitic material said to be from the claim of Mr. L. J. Bird, of Armstrong, B.C. It contained a few grains of a radioactive mineral resembling uraninite, but the specimen could not be obtained for laboratory tests. Mr. Bird reported that the claim is between Meggait and Nash Creeks, 5 miles east of Armstrong.

Black Diamond Group. A sample from the Black Diamond No. 2 claim was sent by Mr. R. Johnston of Chu Chua, B.C., to G. S. Eldridge and Company. It was reported to contain pyrite, sericite, and fluorite, and to have shown 0·05 per cent U_3O_8. It was not stated whether this was determined radiometrically or chemically.

Bugaboo Creek Occurrence. A sample of black sand from the head of Bugaboo Creek, west of Brisco, B.C., was sent to the B.C. Department of Mines. It was reported to have shown 0·21 C. The property is owned by Mr. G. O. Reid, Box 327, High River, Alta. Three samples sent to the Geological Survey by Mr. Reid showed less than 0·05 R.

Clinton Occurrence. A sample sent to the Geological Survey in 1915 was said to be from a pegmatite deposit near Clinton. It contained what appeared to be an intimate mixture of ilmenite and one of the rare-earth minerals. A chemical analysis showed this material to contain less than half of 1 per cent U_3O_8, a small amount of cerium earths, no thorium, and considerable titanium (Ellsworth, 1932).

Dall Lake Occurrence. Mr. R. Anson-Cartwright, 30 Wineva Avenue, Toronto, found a small piece of radioactive float in a creek near Dall Lake, which is about latitude 58° 40′, longitude 127° 30′. He sent the sample to the Ontario Department of Mines, where it was shown to contain 0·06 R.

Giant and Coxey Mines. An engineer in the employ of Messrs. Young, Young, and Gross, Toronto, Ont., took sixteen grab samples of molybdenitic mineralization at the Giant and the adjoining Coxey claim at Rossland. The samples showed 0·02 to 0·24 C. The Giant and Coxey are old copper-gold mines, which contained considerable molybdenite. They have been described by Drysdale (1915) and Eardley-Wilmot (1925). The Giant claim is owned by The Consolidated Mining and Smelting Company of Canada, Limited, and the Coxey is under lease to Mr. A. J. Arland, 3692 Osler Street, Vancouver, B.C.

Gold Thorium Claim. Two samples of black sand sent to the Geological Survey by Mr. E. P. Short, Sinclair Mills, B.C., were reported to be from the Gold Thorium placer claim at the foot of Grand Canyon on Fraser River, near Sinclair Mills. They showed 0·10 and 0·37 R (gamma), and discrepancies between gamma and beta radioactivity indicated that much of the radioactivity was probably attributable to thorium.

Hope Occurrence. Mr. E. Howard, Minto Mines post office, B.C., sent a sample of black sand concentrate from the vicinity of Hope, which showed 0·2 R.

Index Property. Uraninite is reported to occur at the Index molybdenite property on Texas Creek near Lillooet (Stevenson, 1950). A report by W. R. Bacon (1949) indicates, however, that although radioactive material is definitely present, the amount is very small, the highest assay obtained from samples taken by him being 0·0085 R.

Kelowna Occurrence. Mr. O. Hill, 819 Clement Avenue, Kelowna, B.C., sent a sample from a pegmatitic occurrence 15 miles east of Kelowna. It showed 0·09 R and contained fergusonite.

Lemon Creek Occurrence. A sample from Lemon Creek in the Slocan region was sent by Mr. D. Bain, 2238 Second Avenue, Trail, B.C. It was said to come from a locality 2¼ miles above the Lemon Creek bridge. The sample contained allanite and showed 2·11 R, the discrepancy between gamma and beta radioactivity indicating a large percentage of thorium. Four samples from this property, showing 0·20 R to 2·0 R were subsequently received.

Lytton Occurrence. A sample of black sand taken from Lytton Bar on Fraser River by S. S. Holland of the B.C. Department of Mines showed 0·16 R.

Molly Mine. The Molly (sometimes spelled Moly) mine is a molybdenite property on Lost Creek south of Salmo. Ten claims owned by The Consolidated Mining and Smelting Company of Canada, Limited, are under option to Pacific Gold and Uranium Mines Limited.

As described by Eardley-Wilmot (1925, pp. 36-38), the deposit is at the west end of a granite mass. Molybdenite occurs close to the contact, chiefly in a sheeted zone up to 10 feet wide. Associated minerals are pyrrhotite, chalcopyrite, scheelite, and pyrite. Between 1914 and 1917, 200 tons of ore were shipped, the estimated recovery being 3½ per cent molybdenite. Specimens contained up to 2½ ounces in silver a ton, with traces of gold and copper. The deposit has also been described by Stevenson (1940, pp. 54-57). Considerable diamond drilling was done by The Consolidated Mining and Smelting Company of Canada, Limited, prior to 1934. Radioactivity was detected at the property in 1948. A sample taken by the B.C. Department of Mines showed 0·13 R. Four picked samples given to the writer by Mr. E. B. Johnson showed 0·047, 0·088, 0·089, and 0·13 R, and very fine-grained uraninite was identified in some of them.

Nicola Occurrence. Allanite is reported to have been found in a pegmatite deposit near Nicola (Stevenson, 1950).

Quadra Island Occurrence. Carnotite was reported to occur at a vanadium deposit at Gowland Harbour, Quadra Island, but subsequent examinations have failed to reveal additional carnotite or other uranium minerals (Ellsworth, 1932, p. 139).

Quesnel River Occurrence. Johnston (1915) states that "monazite occurs sparingly in the black sand of Quesnel River about 8 miles above its junction with the Fraser River".

NORTHWEST TERRITORIES

The Northwest Territories include the northern third of the Precambrian Canadian Shield, the western boundary of which extends southeasterly through Great Bear Lake, Great Slave Lake, and Fort Smith. To the west of this line lie younger strata, in which no uranium deposits have been found. Many uranium deposits, chiefly of pitchblende-bearing types, have been found in the Precambrian rocks of the Northwest Territories. The deposits are in two main belts. One extends along the west edge of the Shield, from near the northeast corner of Great Bear Lake almost to the North Arm of Great Slave Lake. The rocks of this terrain are believed to be of Proterozoic age. The other main region is a belt of Proterozoic rocks along the East Arm of Great Slave Lake. A few occurrences are known in another area of Proterozoic rocks in the Nonacho region, between Great Slave Lake and the south boundary of the Northwest Territories. A few other deposits are widely scattered and are described under the heading "Other Occurrences".

The deposits in the northern belt are grouped in three parts of it, described in this report as the Great Bear Lake, Hottah Lake, and Marian River regions.

GREAT BEAR LAKE REGION

Most of Great Bear Lake is underlain by rocks of Palæozoic and Mesozoic ages, but the east shore and the islands along it are composed of rocks of the Canadian Shield, which extends eastward for hundreds of miles. The Precambrian rocks near Great Bear Lake are divisible into three main ages. The oldest group is a complex of much altered sedimentary and volcanic rocks. Next in age are bodies of diorite, granodiorite, and granite, which intrude the sedimentary and volcanic rocks. A third, younger, group, called the Hornby Bay group, consists of little-disturbed beds of sandstone and conglomerate. Rocks of all three groups are cut by basic sills and dykes, some of which have diabasic texture.

Kidd (1936, p. 5) considered the old complex to be of Archæan age, the plutonic rocks to be Archæan or Proterozoic, and the Hornby Bay group to be early Palæozoic or late Proterozoic. The Snare group north of Great Slave Lake, which is lithologically similar to the old complex at Great Bear Lake, and which is almost certainly Proterozoic, has been traced by recent mapping almost into the old complex; therefore, the present tendency is to regard the old complex as Proterozoic (Henderson, 1948, pp. 48-51).

Kidd separated the old complex into two subdivisions called the Echo Bay and Cameron Bay groups, which he mapped separately only near Port Radium. The Echo Bay group includes interbedded tuffs, lavas, argillite, and quartzite. The Cameron Bay group contains sandstone, arkose, quartzite, and conglomerate. It overlies the Echo Bay rocks, but as the contacts are faulted the relationships of the two groups have not been proved definitely (Kidd, 1933, pp. 4-10; Thurber, 1946, pp. 1-7; Henderson, 1948, p. 49).

The region is characterized by deposits of pitchblende or native silver, or both. Some of these deposits also contain an unusually large number of other metallic minerals. The most common gangue minerals are quartz and carbonate minerals. Some occurrences are small pitchblende-bearing stringers or lenses; some are large complex orebodies in fault zones; some are quartz veins containing a little pitchblende; and some are 'giant quartz veins' carrying a little pitchblende. The principal deposits are in rocks of the old complex, but some have been found in granitic rocks. It has not been definitely established whether the deposits are related genetically to any of the plutonic rocks now exposed, or whether they represent a much later period of mineralization. Kidd (1933, p. 15) gives evidence suggesting two ages of quartz mineralization, one older and one younger than the Hornby Bay group, but the relationship of the age or ages of metallic mineralization to the Hornby Bay group is unknown. Kidd also reports pebbles of vein quartz in conglomerate of the Cameron Bay group. The more complex deposits show evidence of at least three stages of mineralization, which may have been related to different ages of igneous activity (Kidd, 1935, p. 938).

The only settlement in the region other than small camps is the private establishment of Eldorado Mining and Refining (1944) Limited, at Labine Point, about midway along the east shore of Great Bear Lake. The official name of this establishment is Port Radium. The settlement of Cameron Bay, 4 miles away, has been abandoned.

Aircraft are the only practical means of passenger travel to the region. Port Radium is 270 air miles north of Yellowknife, and about 850 miles north of Edmonton. Aircraft equipped with floats or skis, based at Yellowknife, fly to Port Radium on charter, and also make occasional scheduled trips. Larger, wheel-equipped aircraft fly from Edmonton to a landing field at the south shore of Great Bear Lake, whence the trip to Port Radium is continued by boat. Most heavy freight is shipped from Edmonton to the railhead at Waterways, thence by barges of the Northern Transportation Company on the Mackenzie River system. The route from Waterways to Port Radium is 1,380 miles long, and freight must be trucked on long portages at Fort Smith and on Great Bear River. The average season for water transportation at Great Bear Lake is from July 15 to October 15.

Achook Island Occurrence. Feniak (1949) described five radioactive occurrences on Achook Island, which is at the east side of Great Bear Lake, about 20 miles north of Port Radium. They are not known to be staked. They are narrow quartz veins in dacite, near a northeasterly trending fault. All contain chalcopyrite, uranium stain, and carbonate, and some contain hematite, bornite, pyrite, or barite.

Balachey Lake Occurrence. The former Walter group of Eldorado Mining and Refining Limited, at the outlet of Balachey Lake, near the southeast corner of Great Bear Lake, has been re-staked by Mr. E. Boffa of Yellowknife, and is now optioned to Fairmont Exploration Company. Two quartz-carbonate veins containing pyrite, chalcopyrite, and hematite fill fractures in rock classed as brecciated granite by Parsons (1948, p. 12). A trench was blasted in the wider vein a few years ago, and there one sample taken by the writer across 6 inches showed 0·68 R, and one taken across 5 feet showed 0·38 R. No visible pitchblende was found.

Bell Group. Port Radium Mines Limited owns fifty-three mineral claims, known as the Bell group, situated between Contact Lake and Bay 66 on Great Bear Lake, some 10 miles southeast of the Eldorado mine.

Diamond drilling on the company's property amounts to 1,304 feet, of which approximately half is confined to the principal showing on Bell No. 9 claim. This zone outcrops for some 600 feet, striking northerly and dipping west at 75 degrees. An adit was driven into the side of a hill beneath the outcrop where the vein was cut at 40 feet, and 55 feet of drifting was done along the zone. A representative chip sample taken from the drift back is reported to have averaged 0·50 C. Grab samples taken from the outcrop are reported to have shown up to 25 C.

The remainder of the diamond drilling and rock trenching was done on four zones outcropping a short distance north of Long Lake on mineral claims Bell 36, 37, and 44. Samples of the drill core are reported to have shown low uranium content.

The general geology, structure, and mineralization of veins, fractures, and shear zones are reported to be similar to those under development at the Contact Lake mine.

Contact Lake Mine. The Contact Lake mine, 9 miles southeast of the Eldorado mine, was formerly a small producer of native silver and minor amounts of pitchblende. The claims were staked in 1931, and from 1936 to 1939 a 25-ton mill was operated intermittently by Bear Exploration and Radium, Limited. Lord (1941, p. 50) reported that the total production up to the end of 1939 was 6,933 pounds of U_3O_8 and 348,250 ounces of silver, from 10,079 tons of ore milled, plus some crude silver ore shipped in 1934. In 1942, the claims were bought by International Uranium Mining Company, Limited, who did additional exploratory work between 1944 and 1949, including radioactivity and geological surveys, 15,300 feet of diamond drilling, and a little underground work. Late in 1949, the company was reorganized as Acadia Uranium Mines Limited, who recently began diamond drilling to explore, below the present bottom level, the ore shoot from which previous production was obtained.

It was estimated in 1944 that 9,940 tons of mill tailings contained 27,000 ounces of silver and 4,000 pounds of U_3O_8. A recent estimate of ore in place above the second level states that 3,000 tons containing 100 ounces in silver a ton and 1 per cent U_3O_8 are available, and that a similar tonnage lies above the stoped area on the third level.

Three principal quartz-carbonate veins occur in fractured and sheared zones in granodiorite. Granite is in contact with the granodiorite about 1,000 feet southwest of the main or No. 1 zone (*See* Figure 2). The granite appears to intrude the granodiorite, and the veins are believed to have been formed after the intrusion of the granite. As described by Lord (1941, pp. 53-55) and Parsons (1948, pp. 11-12) the No. 1 zone is up to 5 feet wide. It has been exposed on surface at the principal outcrop for a length of 350 feet and has been followed underground for 1,100 feet east of the shaft to its juncture with the No. 3 zone; the No. 1 zone is open to the west. In places, this zone contains veins of quartz and carbonate minerals, and these veins contain, or contained, shoots carrying native silver, some hematite, pyrite, chalcopyrite, magnetite, bornite, and pitchblende, and a little arsenopyrite, chalcocite, tetrahedrite, algodonite chalcostibite, famatinite, cobaltite, safflorite-lollingite, glaucodot, niccolite, gersdorffite, rammelsbergite, breithauptite, sphalerite, galena, native bismuth, bismuthinite, pearcite, stromeyerite, argentite, hessite, malachite, azurite, erythrite, and secondary uranium minerals. Pitchblende was one of the earliest metallic minerals formed, and native silver was the latest. In places the wall-rock is altered to chloritic material, and in other places shows typical red alteration.

Underground work was done on all three zones. The No. 1 was explored and mined from an adit and a shaft, two levels from the shaft being 90 and 190 feet below the adit. About 2,400 feet of drifting was done on No. 1 zone. The No. 2 zone consists of quartz-carbonate stringers in a sheared zone 2½ feet wide; it has been traced for 1,340 feet on surface, and was explored by drifting for 711 feet on the second level. Metallic minerals include hematite, chalcopyrite, and native silver; no pitchblende is known to occur, but radioactivity is reported to have been detected. The No. 3 zone consists of similar stringers in a sheared zone 4 feet wide, traced for 2,000 feet on surface. A total of 932 feet of drifting was done on No. 3 zone, on two levels. It contains hematite, chalcopyrite, and pyrite. Several other zones were explored by diamond drilling, and silver was found in some of them.

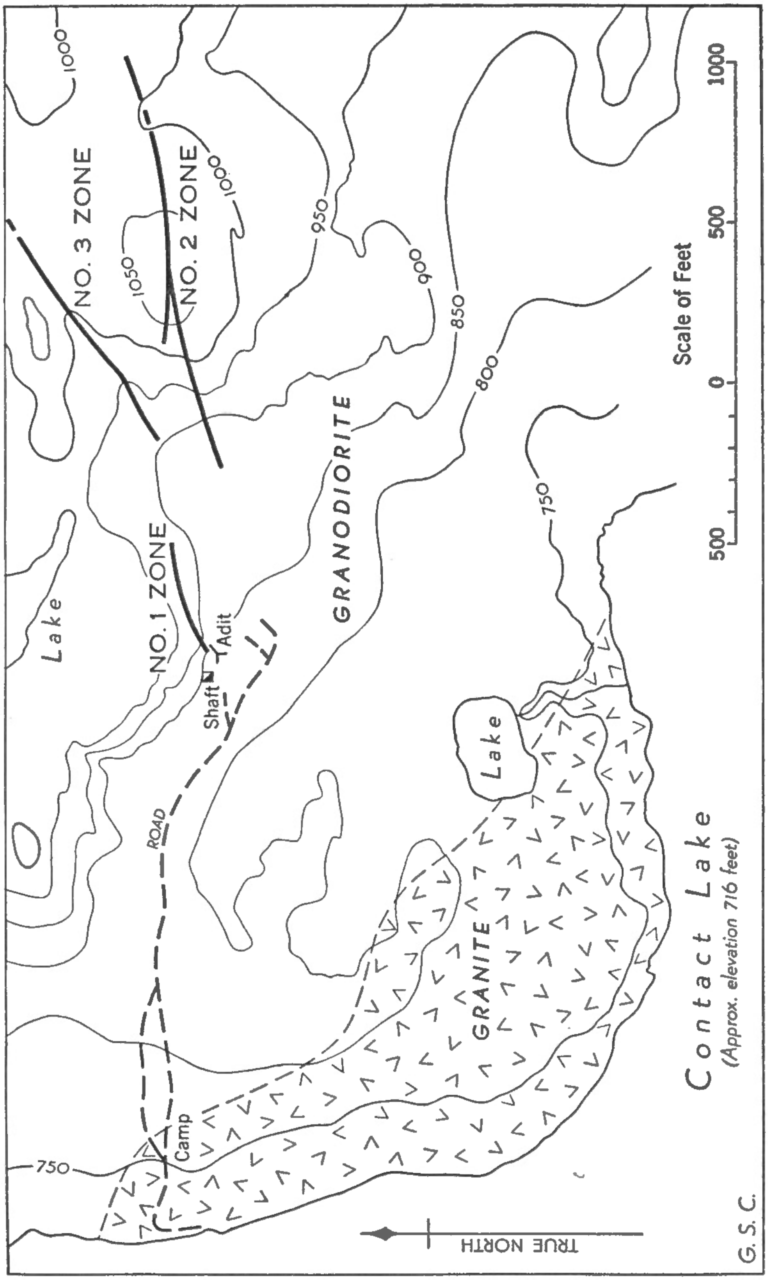


Figure 2. Contact Lake mine, Northwest Territories. From plan by Bear Exploration and Radium, Limited.

Echo Bay Group. The Echo Bay group, of The Consolidated Mining and Smelting Company of Canada, Limited, adjoins to the northeast the main holdings of Eldorado Mining and Refining (1944) Limited. The claims are underlain by representatives of almost all the units of the Echo Bay group of strata. Work was done intermittently by the owners between 1930 and 1948, and by the Eldorado company, under option, in 1944 and 1945.

Numerous small pitchblende deposits, ranging from narrow stringers to concentrations in a small 'giant quartz vein', have been found. These are mainly at two widely separated parts of the property. One part, near Cross Fault Lake, is on the strike of the strata and structure that contain the No. 1 zone of the Eldorado mine. The other, near Glacier Bay, is far to the southeast of the strike of the Eldorado deposits. The showings have been explored by about eighty test pits, several thousand fet of underground work in two adits, and 1,900 feet of diamond drilling. A little cobbed silver ore is reported to have been recovered from the underground work.

The earlier work has been described in detail by Kidd (1932, pp. 66-67; 1933, pp. 21-24; 1936, p. 37). The following summary of descriptions by Kidd was made by Lord (1941, pp. 47-48):

"The rocks are tuff, dacite, feldspar porphyry, and fine-grained, banded sediments, and all belong to the Echo Bay group. All are altered and contain pyrite, chlorite, magnetite, biotite, actinolite, and tourmaline. Six steeply dipping shear and fracture zones, five of which trend northeast, occur in an area 2,000 feet long and 600 feet wide that extends northeasterly across the crest of a prominent hill. The exposed length of the zones ranges from 50 to 800 feet, but their widths are not known. The zones are belts of intense fracturing that in places near the middle contain up to 1 foot of gouge-like material. The fracturing dies out away from the central zone of shearing. In most places the fractures are coated with supergene manganese minerals, and in many places the rock adjacent to them contains disseminated chalcopyrite or galena. Metallic minerals in the zones are in part disseminated throughout the fractured rock and in part occur in veins or stock-works of manganiferous carbonate or quartz. Those seen are pyrite, magnetite, arsenopyrite, pitchblende, chalcopyrite, sphalerite, marcasite, galena, bornite, rammelsbergite, unidentified minerals containing cobalt or nickel or both metals, niccolite, stromeyerite, argentite(?), native silver, covellite, and surface alteration products of manganese, copper, iron, and cobalt minerals. Neither the proportion of vein filling to rock in the zones nor the proportion of metallic to non-metallic minerals in the vein filling is known. One quartz vein is 2 feet wide in one place. Silver-bearing minerals occur in places in most of the zones and a little pitchblende occurs in one zone."

In 1948, the company sampled four pits near Cross Fault Lake. The results, with widths in feet quoted in parentheses, were as follows: 19·9 C (0·05); 7·7 C (0·8); 2·5 C (0·5); 6·3 C (muck). Five diamond-drill interinsections on a vein near Glacier Bay gave the following results, with widths in feet quoted in parentheses: 33·0 C (0·20); 21·2 C (0·2); 3·6 C (0·2); 1·6 C (0·4); 0·5 C (0·2). No work has been done since 1948.

El Bonanza Group. This silver property is at the east shore of Great Bear Lake, 6 miles southwest of Port Radium. It was owned by a subsidiary of the original Eldorado company, called El Bonanza Mining Corporation Limited, share control of which was transferred to the Crown company, who sold it in 1950 to private parties. A narrow belt of sheared sedimentary rocks lying between bodies of granite and granodiorite contains narrow carbonate veins carrying quartz and fluorite and small amounts of silver, chalcopyrite, bornite, and galena. The property was explored by two shafts and by diamond drilling; and, about 1935, a shoot of silver ore was found and mined. High-grade ore was cobbed and the rejects were milled at the Eldorado mine. Pitchblende is said to have been found during this work, and Feniak (1947) reports finding pitchblende on the dump.

Eldorado Mine. This mine (*See* Plate II), which is the most northerly producing lode mine in Canada, is now operated by the government-owned company Eldorado Mining and Refining (1944) Limited. The history of the mine and its ownership are outlined in the historical section of this report.

The geology and mineralogy of the Eldorado mine have been described by Kidd (1932, 1933, 1935, 1936), Haycock (1935), Lord (1941), Murphy (1946), Jolliffe and Bateman (1944), and others. Although recent work has added greatly to detailed knowledge, it has not changed the fundamental descriptions already published. The following short description is almost entirely a summary of the above-mentioned reports, for those readers who wish only a brief, up-to-date account.

The rocks exposed at and near the mine are members of the Echo Bay group, and intrusive rocks. Joliffe and Bateman subdivided these rocks as follows, in descending order of age:

(9) Late quartz diabase
(8) Early diabase, locally amygdaloidal
(7) Granite
(6) Granodiorite

Echo Bay Group (1-5)

(5) Massive and stratified tuff, in part porphyritic; separates each of the andesitic flows (4)
(4a) Porphyritic breccia, andesite; some tuff; assemblage representing upper parts of the andesitic flows
(4b) Amygdaloidal andesite, in part porphyritic; some tuff and breccia
(4c) Porphyritic andesite, representing lower parts of the andesitic flows
(3) Feldspar porphyry, hornblende-feldspar porphyry; locally fragmental, but probably largely intrusive
(2) Stratified rocks: thinly banded cherty sediments; bedded tuff and coarser fragmental rocks; banded limestone (on Cobalt and Limestone Islands only)
(1) Massive crystalline tuff; age relationships to 2 indefinite

Many of the rocks of the Echo Bay group are much altered, so that it is difficult or impossible to determine their exact original character. This fact, with the added complication that some contacts are gradational and some are faulted, makes the relationships of some of the units uncertain. This is particularly true in the case of units 1 and 2, as listed above. The most abundant rocks at and near the mine are units of 1, 2, and 3. The porphyry forms bands and masses within the stratified rocks, and may represent either sills or flows; the limited evidence available suggests that the porphyry is, at least in places, intrusive, because crosscutting relationships have been noted, but there are also some evidences of volcanic origin, such as pillows and fragmental bands. The total thickness of the stratified rocks is more than 2,000 feet, unless beds have been repeated as a result of structural conditions that are not apparent. The oldest plutonic rock has been classed as diorite by some workers and as granodiorite by others; the main body of this rock is about 2 miles northeast of the mine. Nearer to the mine, granite is exposed at several places along the shore of the lake and on nearby islands, leading to the conclusion that it underlies much of the lake in the vicinity of the mine, and that it may underlie more of the mainland at depth. Apophyses of granite have been found in the westerly mine workings. Aplite dykes intrude the granite, and they also cut some of the older rocks within 1,000 feet of the granite contacts. The youngest rocks near the mine are diabases, divided into two groups. Early diabase dykes are cut by structures containing pitchblende. The late diabase forms flat-lying bodies that may once have been continuous; apophyses of this rock cut some of the pitchblende-bearing veins.

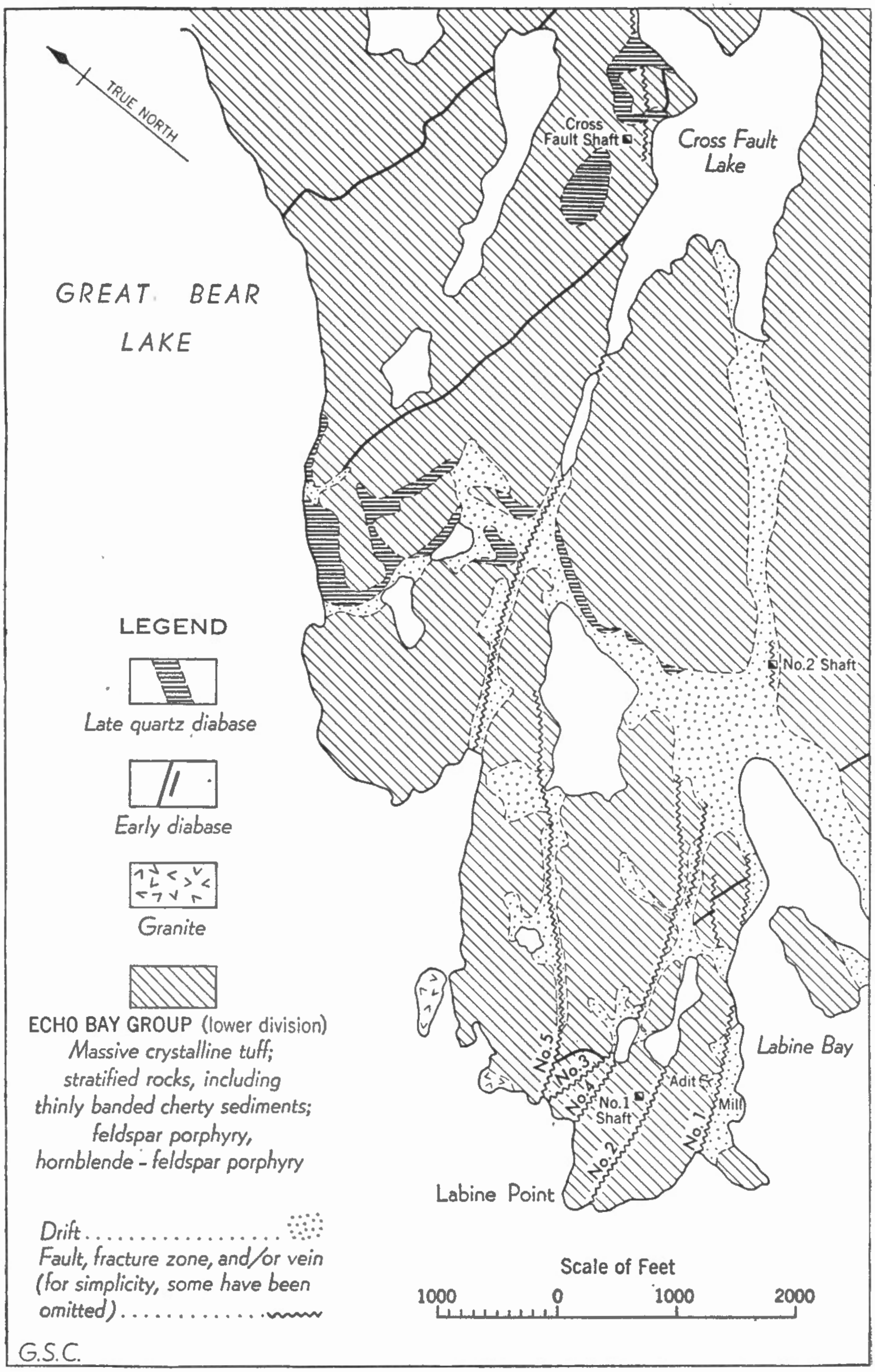


Figure 3. Eldorado mine and vicinity, Great Bear Lake, Northwest Territories. The orebodies are in the Nos. 1, 2, 3, and 5 zones. After map by Jolliffe and Bateman, 1944.

Murphy states that the rocks of the Echo Bay group have been "folded on axes striking north-northeast, with folds plunging slightly to the north ...... A cross-section through the mine would show, on the west, a syncline with porphyry enclosing sediments to a depth of a thousand feet, and, on the east, an open anticline with the gently-rolling porphyry sheet outcropping over a wide zone". Numerous faults, some of which have displacements of several miles, have strikes ranging from slightly east of north to northeast, and all appear to be later than the folding. Rocks of all ages have been faulted, but only slight displacement of the late diabase has been found. Many faults are branching. The stronger faults form wide zones of shearing and brecciation, a few being several hundred feet wide. The main faults are shown on Figure 3.

The orebodies range from narrow, high-grade veins that are stoped by resuing, to stock-works up to 40 feet wide that are only partly of ore grade. Individual veins range in width from less than an inch to about 10 feet. The orebodies are distributed at irregular intervals within four, more or less parallel fault zones, some of which eventually coalesce in the northeastern part of the mine. The average strike is north 65 degrees east, and dips range from 60 degrees north to vertical. Murphy states that "shoots of minimum stoping width range in length from 50 feet to 700 feet, and have been followed vertically for more than 600 feet. The orebodies locally widen to as much as 15 feet because of the occurrence of multiple stringer zones and masses of pitchblende". The orebodies are almost entirely confined to the stratified rocks or to places where the fault zones follow contacts between these rocks and early diabase; they extend only a short distance into parts of the zones that cross porphyry, and longitudinal sections show that the orebodies rake in conformity with the distribution of porphyry bodies. Recent work by Mr. D. Campbell, geologist at the mine, has shown that there appears to be a marked distribution of ore shoots around 'noses' of porphyry. The influence of the porphyry may have been partly due to the fact that it did not fracture as readily as the other rocks, and partly because it was not as favourable chemically for the precipitation of ore minerals from their solutions. Few changes in the character of mineralization with depth have been found, the main differences being that silver was only found in important amounts for a few hundred feet below surface, and botryoidal pitchblende decreases with depth.

In the lowest level, a strong shear zone cuts an apophysis that could be classed as either aplite or granite, thus suggesting that the ore-bearing structures could extend into the main granite mass.

The deposits consist chiefly of altered rock, quartz, carbonate minerals, and hematite, with smaller amounts of pitchblende, chalcopyrite, sulpharsenides of cobalt and nickel, native silver and bismuth, pyrite, argentite, galena, and chlorite. By microscopic study, Haycock identified pitchblende, magnetite, hematite, "limonite", arsenopyrite, pyrite, smaltite-chloanthite, safflorite-rammelsbergite, skutterudite, nickel-skutterudite, cobaltite, gersdorffite, glaucodot, nickeliferous lollingite, niccolite, polydymite, molybdenite, native bismuth, bornite, chalcopyrite, chalmersite, tetrahedrite, freibergite, chalcocite, covellite, sphalerite, galena, stromeyerite, jalpaite, argentite, hessite, native silver, pyrolusite, psilomelane, polianite(?), and five other minerals that could not be determined, bringing the total number of metallic minerals recognized by him to forty.

Haycock found that the pitchblende occurs in several forms, which he called botryoidal, colloform, cellular, dendritic, spherulitic, brecciated, and vein forms, the last being minute seams. Some of these types are intimately associated with quartz, forming what is called 'siliceous pitchblende ore'. Haycock also found that the pitchblende is of two distinct compositions, with different ratios of UO_2 to UO_3.

Mineral deposition occurred in four main stages, resulting, in places, in banded orebodies; all stages are not represented in some orebodies. Pitchblende is believed to have been the earliest metallic mineral formed, and native silver the last. Pitchblende, pyrite, magnetite, chalcopyrite, and cobalt minerals are found in orebodies throughout the mine; but native silver and nickel minerals were only found to any extent in the upper workings. In spite of its distribution, most of the native silver is believed to be primary. Secondary uranium minerals were common in surface workings, and were found in minor amounts in the uppermost level. Gruner and Gardiner (1950) list becquerelite, curite, and liebigite as secondary uranium minerals found at Great Bear Lake.

The ore-bearing zones, from south to north, are called the No. 1, No. 2, No. 3, and No. 5 or Dumpy. In order of importance, they are the No. 1, No. 3, No. 2, and No. 5. The Nos. 1, 2, and 5 are shear zones containing some gouge, the ore occurring in areas where tension fractures lie along the shear zone, especially in the vicinity of masses of porphyry. A fifth zone, called the No. 4, has not been productive. The No. 1 zone is much banded and shows evidence of three main stages of deposition, the first represented by massive quartz with a little chlorite and pyrite; the second, mainly by quartz and hematite followed by pitchblende, silver, and cobalt-nickel minerals; and the last stage, by small veins of quartz, carbonate, and chalcopyrite cutting the late diabase. The No. 2 zone consists partly of banded carbonate with seams of pitchblende, together with silver, chalcopyrite, hematite, and cobalt-nickel minerals; and partly of pitchblende veins along narrow chloritic shear zones. The No. 5 zone resembles the No. 1, but on a smaller scale. The No. 3 is a zone of discontinuous fractures, which form a breccia cemented by relatively little vein matter; pitchblende and chalcopyrite are more disseminated than in the other zones, and sulphide and arsenide minerals are more abundant than in the other zones.

Kidd and Haycock (1935, p. 885) considered that the conditions under which the deposits were formed were "mesothermal almost to epithermal". Haycock made further studies of this problem in 1950, including studies of the decrepitation temperatures of quartz, higher temperatures being found in samples from the orebodies than elsewhere. The relationships are not yet completely established, and this preliminary statement has been made available through the courtesy of E. B. Gillanders and M. H. Haycock.

Evidence of reddish, hematitic alteration is widespread, and the process has affected rocks of all ages except the late diabase. Where most intense, as in and near parts of the mineralized zones, the alteration resulted in a hard 'jasperoid' containing quartz, hematite, magnetite, sericite, chlorite, and carbonate. Murphy (1946, p. 432) states that the alteration is undoubtedly related to the quartz-hematite stage of mineralization. The alteration is a guide in exploration, but intense alteration is not everywhere indicative of important mineralization.

The mine is operated from a shaft placed between the No. 2 and No. 3 zones. The first level is connected with an adit to form a haulageway. The other levels are below the level of the lake, the deepest being 1,300 feet below the shaft-collar. The mine contains about 14 miles of underground workings, and long exploratory drifts are now being driven to the northeast on the No. 1 and No. 2 zones.

A prospect shaft was sunk on showings about ¾ mile northeast of the mine, and another explored showings about 1½ miles northeast of the mine. These are on the general strike of zones at the mine. In addition, structures parallel to those that contain the orebodies of the mine remain to be explored completely.

Glacier Lake Occurrence. Fortier (1948, p. 8) states that an "occurrence (of radioactive mineral), some thousand feet west of Glacier Lake, in granodiorite may justify some exploration in the draw in which it occurs, and along which are probable large faults that are possible controlling structures for mineral deposition". The occurrence is about 3 miles northeast of Port Radium.

Glen Lake Occurrence. Feniak (1948, p. 26) states that "a small sample of pitchblende was found in a fracture near a large, northeast-trending fault about 400 feet west of the southwest end of Glen Lake", about 1½ miles east of the El Bonanza property.

Gossan Island Occurrence. A map showing uranium occurrences reported to the Eldorado company shows a locality at the south end of Gossan Island in Echo Bay of Great Bear Lake. No details are known.

Hunter Bay Occurrence. At Hunter Bay, 30 miles northeast of Port Radium, a 'giant quartz vein' in granite contains a stringer that carries pitchblende.

J. B. Group. This group, 20 miles southwest of Port Radium, is owned by Fairmont Exploration Limited. Assays of 0·11, 0·39, 0·49, 1·37, and 13·4 R were reported by Mr. Mintern. Fairmont Exploration Limited reported that they did trenching in 1950, which revealed small amounts of radioactive material, and that they did 202 feet of diamond drilling.

Lode-Sonny Boy Group. This group is at the northeast end of Dowdell Peninsula, 4 miles southeast of Port Radium. It is owned by Dr. Comfort, of Buffalo, N.Y., and represented by Mr. J. R. Stirrett, 350 Bay Street, Toronto, Ont. Mr. Stirrett reported that a specimen of pitchblende said to be from the claims was given to Dr. Comfort by the vendor. A map showing uranium occurrences in the district indicates three showings on or near the property. The writer failed to find radioactivity on the property, but as it is large, he could not make an exhaustive search.

Mystery Island Occurrence. The Canadian Mines Handbook for 1935 reported that the Radium Corporation of Canada, now non-existent, held six claims on Mystery Island of Great Bear Lake. Eighteen narrow veins were said to have been found on the south part of the island, and several pits were said to contain silver and pitchblende.

Rad Group. This group consists of six surveyed mineral claims at Glacier Bay, adjoining the Eldorado holdings to the east. The claims are owned by Athona Mines (1937) Limited, and were prospected for pitchblende and silver in 1931-32 and 1933. Prospecting methods did not permit of radioactive determinations at that time, but a promising silver vein was reported to have been found, upon which a shaft was sunk to 125 feet. Strong radioactivity was detected at one place by a Geological Survey party in 1944.

Sloan River Occurrence. Feniak (1940, p. 12) states that a little pitchblende occurs in a quartz vein less than 1 foot wide, near a 'giant quartz vein', near the mouth of Sloan River, 30 miles northeast of Port Radium. This may be the same occurrence as the one described under "Hunter Bay".

Stevens Island Occurrences. A map showing uranium occurrences in the district includes two on Stevens Island, 12 miles northeast of Port Radium. One is in granitic rocks at the south end of the island, and the other is in the intruded rocks at the north end of the island. No details are known.

Thompson Occurrence. An occurrence between Bow and Contact Lakes has been described under the name "Thompson group" (Kidd, 1933, p. 26; Lord, 1941, p. 55). It was re-staked as the "Pitch 1 to 4 group" in 1948, and was acquired recently by Indore Gold Mines Limited. Kidd described the showing as a fracture zone up to 1 foot wide, traced for 50 feet, in a basic dyke in granite. The zone contains quartz stringers carrying pyrite, chalcopyrite, bornite, cobalt bloom, and uranium stain. The deposit is interesting because it suggests pitchblende mineralization considerably later than the granite. Indore Gold Mines Limited reported that a grab sample showed 1·10 C, and that surface prospecting, and three diamond drill-holes totalling 205 feet, failed to find anything of importance.

U. O. Group. This group, at the north shore of Belleau Lake about 50 miles northeast of Port Radium, was staked by Mr. E. Boffa of Yellowknife, and optioned to Ridley Mines Holding Company. Two samples were taken by Mr. W. L. MacDonald, consultant to the company. One, from a band of breccia 20 inches wide, showed 2·72 per cent U_3O_8 and 0·34 per cent ThO_2 by radiometric test. The other, from a 6-foot width of fractured breccia, showed 1·67 per cent U_3O_8 and 1·33 per cent ThO_2, by radiometric test. The radioactive mineral or minerals have not yet been identified. Mr. Ridley reported that the zone is largely covered by overburden, but that present indications were that it might be as much as 10 to 15 feet wide and 1,500 feet long.

Uranium Group. This group of three claims, owned by Ventures Limited, is surrounded by the main holdings of Eldorado Mining and Refining Limited. The southern part of the group includes the northeastern continuation of some of the structures that contain orebodies at the Eldorado mine. The claims were prospected by surface pits several years ago, and some pitchblende showings were found. No work was done from 1944 to late 1950, when the Eldorado company made an agreement with the owners, whereby Eldorado will do further exploratory work and will pay a royalty on any ore mined. Diamond drilling was begun in the autumn of 1950, and was reported recently to have intersected pitchblende in what is now called the No. 7 vein, lying between the No. 5 and Cross Fault zones of the Eldorado property. A drift has shown that the No. 7 vein consists of tension fractures resembling those of the No. 3 zone.

Vance Peninsula Occurrences. An unpublished map showing uranium occurrences indicates five localities along the north shore of Vance Peninsula, about 12 miles northeast of Port Radium. No details are known.

White Eagle Mine. This silver property, from which uranium has been reported, is at the north shore of Camsell River, between Rainy Lake and White Eagle Falls. The following description is by W. H. Parsons (1948, pp. 9-10):

"This property was developed originally by White Eagle Silver Mines, Limited, but has not been operated by that company for some years. It was re-staked by A. V. Giauque in 1945 and 1946, and a new company, known as Camsell River Silver Mines, Limited, was formed.

"The mine was visited in August 1947, and was found deserted; however, there was evidence that a diamond-drilling program had recently been completed.

"The main showing, that of the old White Eagle Silver mine, has been described in some detail by Kidd (1936, pp. 30-32).

"So far as known, the work done since White Eagle Silver Mines, Limited, ceased exploration comprises surface stripping, diamond drilling, and geological mapping.

"The underground workings, left by White Eagle Silver Mines, Limited, include an adit, which leads to No. 1 drift on the same level; a crosscut from No. 1 drift to a two-compartment winze that has been sunk to a depth of 125 feet; and the No. 2 drift at this lower level, which parallels No. 1 drift for 180 feet west of the winze.

"No. 2 drift, the winze, the crosscut, and No. 1 drift west of the crosscut, were flooded when visited. A 60-foot shaft has been sunk on the AVG 1 group, 1 mile east of the adit, and some diamond drilling and stripping have been done on the AGX veins south of Camsell River.

"The mineralized rock at the Camsell River Silver Mines property is a massive, fine-grained, grey-green rock, described by Kidd as diabase. In thin section this rock is seen to have a rough trachytic structure, with subhedral phenocrysts of andesine (An_{40}) embedded in a groundmass of minute plagioclase laths. A few patches of radiating, fibrous amphibole, chlorite, magnetite, and carbonate may represent completely altered pyroxenes. It is not clear whether this rock is an old, altered diabase or an andesitic volcanic rock.

"In some places the mineralized rock is in contact with porphyritic andesite. The contact is poorly defined, and in most places is obscured by drift.

"The porphyritic andesite is a very fine-grained, dark greenish to black rock, with shiny black amphibole laths as much as ¼ inch long. Under the microscope the amphibole was identified as actinolite, and the feldspars of the groundmass were seen to be andesine (An_{30}).

"Both the mineralized rock and the porphyritic andesite are cut by dykes of feldspar porphyry along the northern boundary of the property.

"Greenstone tuffs outcrop along the river bank a mile east of the adit.

"No. 1 'vein' outcrops 30 feet north of the adit portal; its strike varies between north 60 to 80 degrees west, and the dip is about 70 degrees to the northeast. The 'vein' is composed of a network of quartz-carbonate stringers from ½ inch to 6 inches wide; it pinches and swells from several inches to 2 feet in width. In places it is heavily mineralized with pyrite, chalcopyrite, galena, and silver minerals.

"Two smaller 'veins' parallel the strike of No. 1 'vein', and outcrop 200 and 250 feet northeast of the adit portal. They range up to 12 inches in width, dip steeply to the southwest, and are of the same type as No. 1 'vein'.

"A fourth vein intersects the above two veins on a strike of north 55 degrees east. It varies in width from 6 inches to 2 feet and carries some pyrite.

"A smaller quartz vein outcrops at the edge of a drift valley 400 feet northeast of the adit mouth. This vein strikes north 85 degrees east and dips 60 degrees south; it is composed of quartz stringers ½ inch to 6 inches wide across a width of 2½ feet. The vein has been stripped and in some places is heavily mineralized with chalcopyrite, pyrite, and silver minerals.

"A sample taken at the intersection of the adit and No. 1 drift contained 7·38 ounces of silver and 0·226 per cent U_3O_8 to the ton.

"The diamond-drilling program, completed in 1947, includes twenty-six diamond drill-holes, aggregating about 1,750 feet."

Workman Island Occurrence. A little pitchblende was found in a 'giant quartz vein' in granite on Workman Island, about 12 miles northeast of Port Radium (Kidd, 1936, p. 40; Feniak, 1949, p. 12).

HOTTAH LAKE REGION

The Hottah Lake region lies along the western edge of the Canadian Shield immediately south of the Great Bear Lake region and, in some ways, is a continuation of it. However, the rocks of the Hottah Lake region are not on the strike of the formations or structures at Great Bear Lake.

The region was mapped geologically in reconnaissance fashion by Kidd (1936), and parts of it have been mapped in more detail by Henderson (1949) and Parsons (1948). The region is underlain mainly by granite and related rocks, which intrude bodies of altered sedimentary and volcanic rocks that Henderson correlated with the Snare group, of Proterozoic age.

Several pitchblende occurrences were found in the region soon after the discoveries at Great Bear Lake, and some have been found more recently. Several have received preliminary exploratory work. They are associated with quartz and hematite, without the native silver and other minerals characteristic of many deposits at Great Bear Lake. Some occurrences are in quartzite at or near the contacts with porphyries; some are in or at the contacts of sills and dykes of gabbro cutting granitic rocks; others are in 'giant quartz veins'.

The region is reached by air from Yellowknife or by a canoe route extending from Rae on Great Slave Lake to Great Bear Lake. Transport by barges would require the construction of several portage roads.

Bingo Group. This group, described in some reports as the WLO and WK claims, is at the southeast corner of Hottah Lake. The property is owned by Gold-Uranium Exploration Limited, who did 4,700 feet of diamond drilling in the winter of 1947-48. No work has been done since then.

The claims are underlain principally by granitic rocks, which intrude bodies of feldspar-quartz porphyry, dacite, quartzite, conglomerate, argillite, and bodies of gabbro that are older than the granitic rocks but younger than the volcanic and sedimentary rocks. Younger sills and dykes of gabbro are later than the granitic rocks. A long zone that has been described as a 'giant quartz vein' crosses the property in a northeasterly direction and extends across adjoining properties. This is not a typical giant quartz vein; instead, it was shown by Henderson (1949) to consist of a band of quartzite into which irregular masses and stock-works of vein quartz have been introduced in places. Pitchblende, associated with hematite and quartz, occurs sparingly in pods, lenses, and veinlets. Some of these are at the contacts of quartzite with other rocks, and others are in the older gabbro. Anomalies, without visible pitchblende, were also found associated with the younger gabbro.

Several pits were blasted at surface showings soon after 1930. A bulk sample probably of sorted material, which contained 13·70 C, is believed to have come from one of these pits (Kidd, 1936, p. 29). The present owners placed diamond drill-holes under several of these showings. Only one intersection gave evidence of significant radioactivity, and this was apparently unrelated to any surface showing; it was 2 feet long and was sampled in two, 12-inch sections, which showed 0·177 and 0·11 R. The writer took six chip samples across what appeared to be the best surface showings, with the following results: 0·005 R (90 inches); 0·022 R (30 inches); 0·006 R (45 inches); 0·027 R (114 inches); 0·015 R (84 inches); and 0·514 R (12 inches).

Blende Group. This group, which is believed to be unstaked at present, is at the south shore of Zebulon Lake, east of Hottah Lake. The writer was told that the claims included a pitchblende occurrence, but there is no further information.

Cormac Group. This property, at the north shore of the East Arm of Beaverlodge Lake, is described in some reports under the name "Tatee and Bee claims" (Kidd, 1936, pp. 26-29). The showings are also described by Henderson (1949, pp. 11-12).

The claims are crossed, on its southwestern continuation, by the quartzite zone described under the Bingo property. The main showings are on the top of a rocky ridge, near a contact of quartzite and feldspar-quartz porphyry. The quartzite contains veinlets and large irregular masses of vein quartz, and also a lens of conglomerate and talc-sericite schist about 40 feet wide and 150 feet long. "For a length of about 80 feet in the conglomerate, scattered quartz veinlets carry seams of pitchblende a fraction of an inch across" (A. W. Jolliffe, unpublished report). Two deep pits and a shaft, which is said to be about 50 feet deep, have been sunk on the showings, and most of the pitchblende appears to have been removed. About 1½ tons of cobbed material, which averaged 34 C, is reported to have been shipped to the Mines Branch in 1934. About a mile to the southwest discontinuous lenses about a foot wide and up to 8 feet long, in quartzite, contain some pitchblende.

J. J. Claim. This claim, which is understood to have been allowed to lapse, was staked to include a uranium discovery found at Hottah Lake several years ago. No details are available.

L. L. Group. These claims, near Zebulon Lake, are owned by Mr. Ira Bennett, Yellowknife, N.W.T. A sample said to be from a showing on these claims showed 14·17 C.

Pitch-Ind Group. This group, consisting of the Pitch Nos. 1 to 6 and the Ind Nos. 1 to 3 claims, is at the south end of Hottah Lake, adjoining the Cormac property. It is owned by Indore Gold Mines Limited. The claims are crossed by part of the quartzite zone described under the Bingo property. Pitchblende has been found at three places, associated with hematite and quartz, in quartzite, and at the contact of quartzite with other rocks. These showings are described under the headings "8", "9", and "10" by Henderson (1949, p. 13), No. 10 being, apparently, the largest. Henderson states: "In summary, the best part of this (No. 10) showing is exposed in the two southwesterly trenches, where a zone of quartz stringers 4 to 14 inches wide carrying pitchblende is exposed over a length of 35 feet. This zone dies out to the southwest, where it passes into slaty argillite, and apparently also to the northeast, where it has not been picked up in the most northeasterly trench".

A bulk sample of 1,680 pounds of material from this property was sent to the Mines Branch in 1950. It averaged 2·58 C, and a concentrate containing 8·86 C, representing a recovery of 75·5 per cent, was obtained. The sample contained hematite, pitchblende, and torbernite. Three diamond drill-holes, totalling 136 feet, were put down without encountering radioactive material.

Pitch 8 to 10 Group. This group, owned by Indore Gold Mines Limited, is at the shore of Hottah Lake, 7 miles north of the south end of the lake. The claims are numbered Pitch 8 to 10 and 29 to 31. One of the claims is understood to include a radioactive occurrence found by Mr. S. Campbell in 1934. The claims are underlain mainly by granitic rocks, cut by basic dykes. One of these dykes, about 25 feet wide, has been traced for about 600 feet. Hematite and pitchblende occur in places along both contacts, for widths up to 10 inches. This mineralization is exposed in several rock trenches, from which grab samples taken by the company have shown up to 10·92 C. The showings are exposed intermittently for a total length of about 600 feet.

Eight diamond drill-holes were put down along the zone in 1950, without recovering radioactive core. Original plans to do thorough diamond drilling were abandoned because of the possibility of poor core recovery, and, instead, it was decided to explore the zone from an adit (Figure 4), although this would not be more than about 50 feet below surface. This was begun in October 1950, and the company reported, in January 1951, that a total of 198 feet of underground work had been done. This consisted of 130 feet of crosscutting, and 68 feet of drifting along the dyke contact. The company reported as follows on the results of the drifting: "Lenses of pitchblende up to 3 inches in width were observed in places. A sample taken across 3 feet returned 2·30 C and a high-grade sample taken over 8 inches assayed 20·0 C. Further sampling of dyke material 3 feet from the contact zone assayed 0·70 C and an analysis of this material showed disseminated pitchblende. In the drift from 48 feet to 61 feet a seam of pitchblende was observed which averaged 2 inches in width".

Pitch 27 and 28 Group. This group, at the northeast corner of Hottah Lake, is owned by Indore Gold Mines Limited. The company reported that a system of quartz veins in quartz-feldspar porphyry had been traced for about 700 feet. Most of the veins are narrow, but one is said to be 4 feet wide. Sulphide minerals and cobalt bloom occur in places. Although no radioactive minerals have been reported, grab samples have shown 10·32 C, 4·95 C, and 4·88 C.

U. R. Group. This group, at Hidden Bay of Hardisty Lake, is owned by Gold-Uranium Exploration Limited[1]. A giant quartz vein in feldspar porphyry

[1] Ownership is understood to have passed recently to U. R. Mines Limited.

and granodiorite has been traced for about 2,000 feet. It consists of a stockwork of quartz veins containing hematite and seams of pitchblende. The showings are exposed in several pits and three deep trenches. One sample is reported to have shown 8·63 C. The present owners acquired the claims in 1947, and put down several short diamond drill-holes, but the only information received is a plan showing the locations of the holes. Mr. G. E. Midgely reported that a radioactivity survey made by him in 1948 located nine additional showings.

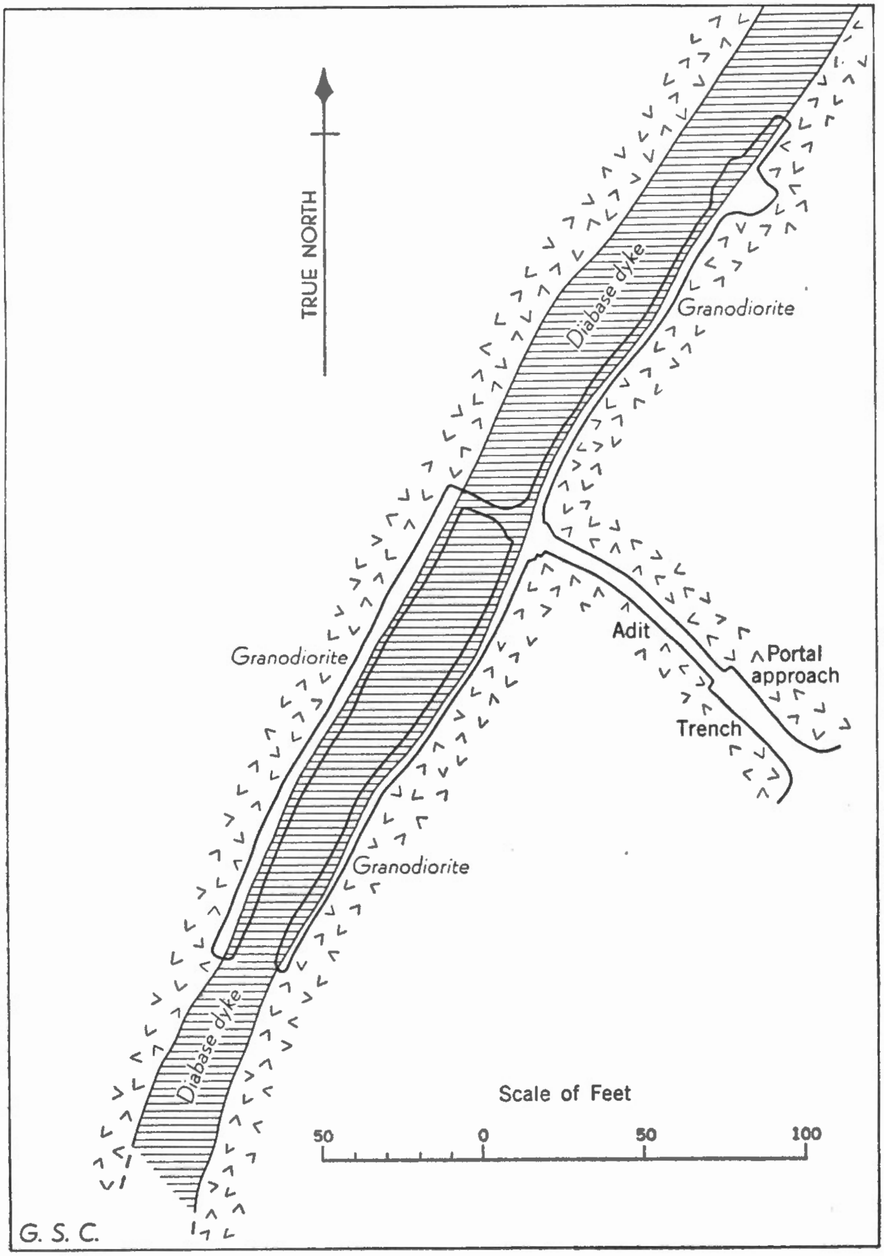


Figure 4. Plan of adit on the Pitch No. 8 claim, Hottah Lake, Northwest Territories. From plan by Indore Gold Mines Limited.

MARIAN RIVER REGION

This region is at the west edge of the Canadian Shield, 100 miles northwest of Yellowknife and 40 miles north of the North Arm of Great Slave Lake. The area is reached by air from Yellowknife or by a canoe route from Rae. The water route is suitable for small boats to within about 20 miles of the properties described below.

The geology of the region has been described by Lord (1942). The area is underlain by strata of the Snare group, believed to be of Proterozoic age, and by granitic rocks, part or all of which are younger than the Snare group. The stratified rocks are mainly argillaceous beds, tuff, greywacke, quartzite, schist, gneiss, andesite, and dacite, with some dolomite limestone. The region is crossed by several northeasterly trending faults, some of which contain giant quartz veins in places. One fault contains these 'veins' at intervals over a length of 25 miles. Some of the giant quartz veins contain, in places, seams and pods of specular hematite and pitchblende. At some other places, lenses and stringers of hematite and pitchblende occur in country rock.

Uranium stain was found in the area by a Geological Survey party in 1934, and the showing was again investigated in 1944. Further prospecting and staking began in 1948 and has resulted in several discoveries. Some of these have been trenched, and a little diamond drilling has been done.

K. R. Group. The Mining Recorder at Yellowknife reported that this group, at the east end of Treasure Lake, was said to contain radioactive minerals and was staked by Mr. Bert Raymond, of Yellowknife. No further information has been received.

Marian Group. This group, staked by Mr. W. Rossing of Yellowknife, consists of three claims along the fault that contains the Hush showings, about a mile southwest of the Cookie group at the main bend of Marian River. Small stringers containing hematite and pitchblende, in granitized or silicified rock, are reported to have been found, and three samples showed 2·32 R, 0·82 R, and 0·60 R. Mr. Rossing reported that he had sold the claims to Duback Yellowknife Mines Limited.

M. M. Group. This group, owned by Mr. M. Martin of Yellowknife, adjoins the Hush group, near the south end of Maryleer Lake. It is understood to include part of the same giant quartz vein that occurs on the Hush group. A showing is reported to have been found a short distance west of the giant quartz vein. Twelve samples gave results ranging from 0·43 R to 5·96 R, and pitchblende was identified in one of them. Another sample was reported by the Quebec Bureau of Mines to have shown 9·0 R. The claims were formerly known as the Rob group, and were re-staked in 1950 as the M. M. group, which is reported also to include a claim formerly called the Hush No. 1.

Ted Group. This group of twelve claims, 4 miles north of the Hush group, is owned by Yellowknife Volcanic Gold Mines Limited. The claims are underlain partly by granodiorite and partly by rocks of the Snare group. These rocks are displaced by a fault parallel with, and about 4 miles northwest of, the one described above as crossing the Hush and other properties. The fault on the Ted group contains a giant quartz vein about 150 feet wide.

The discovery mentioned earlier in this report as having been made in 1934 is described from a location that coincides with what is now part of the Ted group. This occurrence was visited by A. W. Jolliffe in 1944, but only low radioactivity was noted at that time.

In 1949, pitchblende and a mineral resembling thucholite were reported to have been found along the sheared contact between the giant quartz vein and granodiorite. This was explored by surface trenches, and some diamond drilling

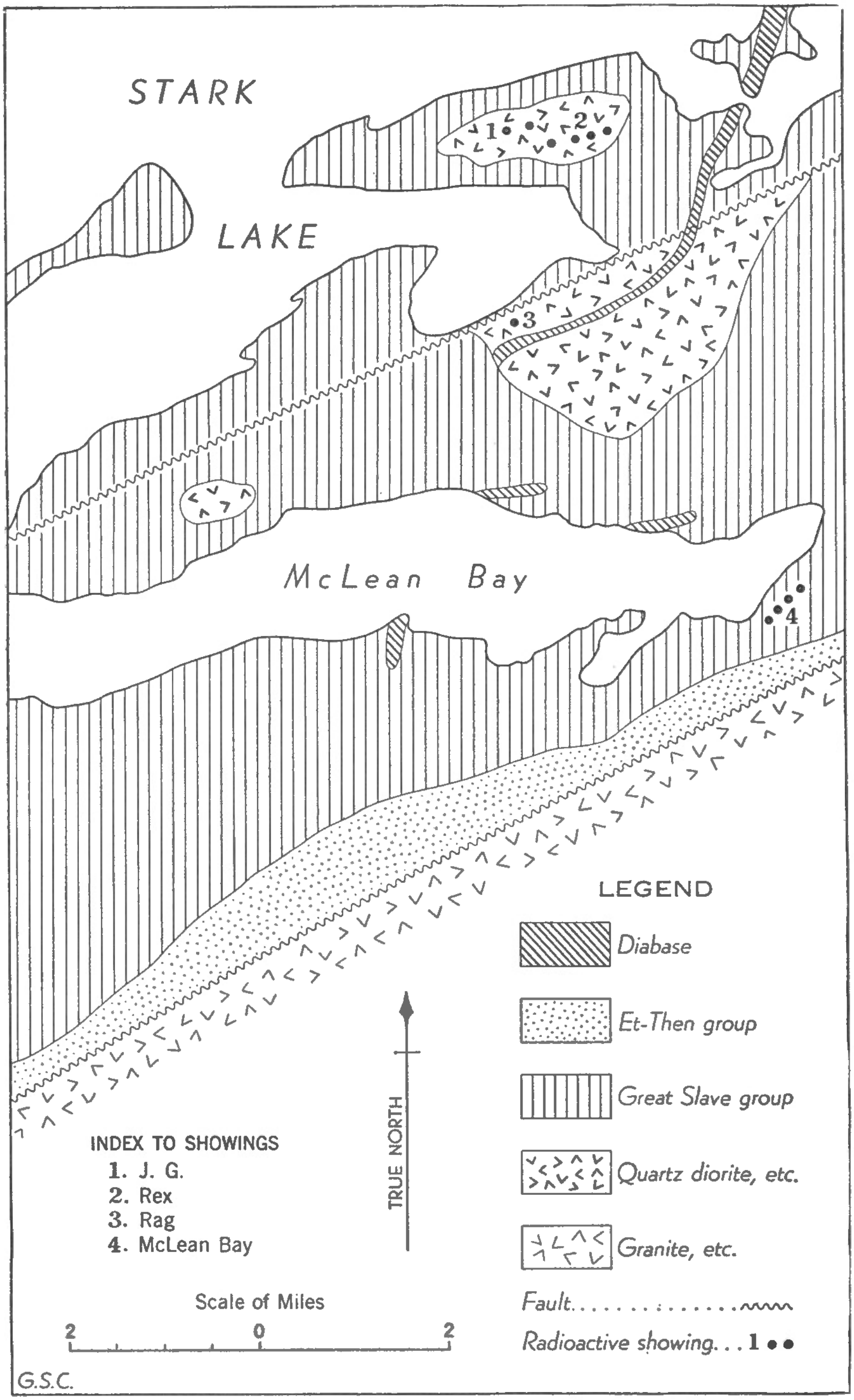


Figure 5. Sketch-map, showing generalized geology and radioactive occurrences, Stark Lake region, Northwest Territories. Geology after I. C. Brown, 1949, and F. Q. Barnes, 1951.

was done, but the results of the latter have not been received. The mineralized zone is reported to contain pitchblende in places, to range in width from 2 to 10 feet, to have been exposed at intervals for a length of 260 feet, and to have a possible extension indicated by Geiger counter readings. Eighteen samples from the property showed radioactivity ranging from 0·011 R to 4·56 R, and five samples analysed chemically showed 0·55 C, 0·72 C, 21·5 C, 2·42 C, and 4·08 C.

U_3O_8 and Fred Group. This group, owned by Yellowknife Volcanic Gold Mines Limited, adjoins the Hush group to the north and east. No radioactivity was noted on the extension of the 'giant quartz vein', but at one locality east of it a body of altered granodiorite containing much hornblende showed an average anomaly of about eight times background, with readings up to thirty times background in places. The body is about 30 feet long and 12 to 16 inches wide. No radioactive minerals were identified. Four diamond drill-holes, totalling about 150 feet, were put down without results.

EAST ARM OF GREAT SLAVE LAKE

The east arm of Great Slave Lake contains many islands, channels, and bays. Nearby are several smaller lakes that are almost part of the main lake, but separated from it by short channels or streams with currents or rapids. Transportation is by air, boat, canoe, or barge. The region contains an outpost of the Hudson's Bay Company at Snowdrift, and the Royal Canadian Corps of Signals and the Royal Canadian Mounted Police maintain stations at Fort Reliance, at the east end of the arm.

The region was mapped geologically in a preliminary way by Stockwell (1933), and part of this work was revised by Brown (1950). The Snowdrift area was mapped in more detail by Barnes in 1950, and this work was continued in the Stark Lake area in 1951.

The north shore of the arm and the country to the north is underlain by early Precambrian volcanic and sedimentary rocks and by granitic rocks, most or all of which are believed to be Archæan. The islands and the south shore are underlain chiefly by a succession of folded sedimentary strata, with some volcanic rocks of Proterozoic age, called the Great Slave group. This is divided into a lower and an upper part, probably separated by an unconformity. The Great Slave group is overlain in places by the younger, unconformable, Et-Then group, believed to be of late Proterozoic age. Both the Great Slave group and the Et-Then group are cut by numerous large diabasic dykes and sills, which form spectacular cliffs along much of the shoreline. The Proterozoic rocks are displaced by several more or less parallel faults that follow the general northeasterly trend of the east arm. Some of these have been traced for many miles, and some form prominent scarps and are among the longest and most spectacular faults mapped anywhere in the Canadian Shield. The most southerly of these faults marks the boundary between the Proterozoic strata and the mainly granitic rocks that lie to the south.

Deposits of copper minerals and cobalt bloom were found along the east arm many years ago, but, to date, none has been proved to be commercially important. Prospectors for the Eldorado company found a low-grade deposit of thorium and uranium at McLean Bay in 1945. This attracted prospectors to the region in 1949, and led to several uranium discoveries of pegmatitic and vein types, greatest interest being taken in recent discoveries at Stark Lake, where deposits classed tentatively as diorite pegmatites containing uraninite, and pitchblende occurrences, have been found. Occurrences found north of the east arm, in what is generally called the Barnston River area, contain pegmatitic minerals in biotite schist.

Stockwell and Brown mapped several bodies of granodiorite, quartz diorite, and related rocks, and they considered that these rocks intruded the Great Slave group but were overlain unconformably by the Et-Then group. Barnes has shown that at least most of these intrusives are older than the Great Slave group. The uraninite deposits on the Rex property are in one of these bodies of quartz diorite, and because they appear to be related to the quartz diorite genetically, these deposits are believed to be older than the Great Slave group. The pitchblende deposit on the Rag property, on the other hand, is stated by Barnes (personal communication) to be partly in quartz diorite and partly in the ancient weathered phase of that intrusive; the pitchblende mineralization appears, therefore, to be much younger than the intrusive, and to be related to the nearby regional fault shown in Figure 5.

In the past, there has been considerable speculation regarding the origin of the thorium and uranium occurring in dolomite at the McLean Bay property. Barnes' work suggests that this deposit is sedimentary, and that the thorium and uranium were derived from the weathering of deposits such as those of the Rex property.

A. G. Group. These claims are near Murky Channel, and owned by Mr. C. E. Ridley of Maida, North Dakota. Five samples taken by Mr. Ridley showed 0·15 R, 1·08 R, 0·15 C, 0·47 C, and 1·08 C. No information regarding the type of deposit has been received.

Bell Group. This claim, near Murky Channel, is owned by Mr. C. E. Ridley, who reported that a sample showed 0·77 C. The type of deposit is unknown.

Copmor-M. M. Group. This group was staked on one of the Simpson Islands, between Copmor Channel and Harnie Bay, by Mr. J. A. Harquail of Malartic, Que., and associates. A sample sent to the Mines Branch, which consisted mainly of feldspar and which was probably pegmatitic, showed 0·57 R. Chemical analysis, however, showed less than 0·1 C, indicating that most of the radioactivity was caused by thorium. The deposit may be related to a body of diorite or allied rock mapped as occurring near the location of the discovery.

DeStaffany Property. This property, on the north shore of Great Slave Lake about 60 miles southeast of Yellowknife, is owned by DeStaffany Tantalum Beryllium Mines Limited. Two pegmatite bodies called the Moose and Best Bet dykes have been explored because of their content of beryl and tantalite. A sample of concentrate from the Best Bet dyke showed 0·094 R. Two picked samples taken by C. S. Lord from the most radioactive parts of each dyke in 1950 showed 0·059 R (Moose), and 0·088 R (Best Bet).

G. E. E. Group. This group, staked by Mr. J. McAvoy of Yellowknife, is east of the mouth of Burpee River, north of the east arm of Great Slave Lake. A sample of pegmatitic material that contained a little uraninite showed 1·45 R.

G. M. Group. This group was staked by Messrs. G. Labelle and G. Michalow, of Yellowknife, about a mile northeast of the entrance to Murky Channel. A discovery is reported to have been made in a stock of diorite or related rock. Six samples showed 0·065 R, 1·27 R, 1·75 R, 6·10 R, 8·17 R, and 12·00 R.

J. G. Group. These claims lie immediately west and north of the Rex group at Stark Lake. They were staked by Mr. J. M. Richards, and others, of Yellowknife. The property includes part of the granodiorite stock that contains the discoveries on the Rex group. Mr. Richards told the writer that three radioactive occurrences had been found on the claims, two of them resembling the deposits on the Rex group, and the other lying in or near a fault at the south boundary of the stock. A sample, said to be from the latter occurrence, contained magnetite and copper stain, and showed 0·37 R.

J. U. F. Group. This group, 3 miles west of Herriman Lake, was staked by Mr. J. Woolgar of Yellowknife. Radioactive anomalies were found at several places in masses of biotite schist in granitic rocks. The schist contains a little pyrite and graphite. Two samples showed 0·033 R and 0·15 R.

McLean Bay Property. A deposit near the south shore of McLean Bay of Stark Lake, 16 miles east of Snowdrift, has been staked and explored by the Eldorado company. It occurs in dolomite mapped as part of the Kahochella formation, which is one of the formations of the lower part of the Great Slave group. The dolomite is interbedded with quartzite, and the beds dip 45 degrees southeast. Most mineralization was found in a bed that has an average width of 43 feet and that contains concentric structures believed to be algal. Within this bed, two zones 10 and 6 feet wide contain more radioactive minerals than the rest of the bed. These zones are brownish red at many places, because of the presence of hematite. Radioactive minerals cannot be seen in the field, but laboratory work by S. Kaiman of the Mines Branch showed fine-grained monazite and uraninite (or pitchblende).

After surface trenching was done, the deposit was explored for a length of 1,400 feet and to a vertical depth of 200 feet by 2,535 feet of diamond drilling. Many surface and core samples were tested. Only one out of 246 samples showed more than 0·05 R, 81 samples showed 0·01 to 0·05 R, and 164 showed less than 0·01 R. The average was estimated at 0·033 R, but tests showed about five times as much thorium as uranium. The average content of U_3O_8 was estimated to be about 0·005 per cent.

Other radioactive occurrences associated with sedimentary rocks were found by Eldorado prospectors near Stark Lake, and on Preble Island.

Rag Group. This group, owned by Ridley Mines Holding Company, is on the south shore of Stark Lake, 14 miles east of Snowdrift. The showings lie a short distance south of a prominent northeasterly striking fault, and occur in a shear zone that strikes about north 40 degrees east, at an angle to the main fault. The shear zone is in a body of quartz diorite and related rocks. It has been exposed in four trenches about 150, 150, and 60 feet apart. The zone, which is 2 to 3 feet wide, contains a little pitchblende, chalcopyrite, molybdenite, and cobalt bloom, and one low gold assay has been reported. Most pitchblende was seen in the northernmost trench, where a shear or fracture zone appears to intersect the main zone. More work will be required to expose this adequately, and to prepare the showings for systematic sampling. Grab samples have shown up to 16·47 C.

Rex Group. The Rex group of twenty-four claims is on a peninsula at the south shore of Stark Lake, 130 miles east of Yellowknife and 14 miles east of Snowdrift. Messrs. A. Krys and H. R. Wilson found a radioactive occurrence here in 1949 and staked the group, which was acquired by Ridley Mines Holding Company.

The claims are underlain partly by sedimentary rocks of the lower part of the Great Slave group, and partly by quartz diorite, which outcrops on the northwest half of the property. Six main radioactive deposits, called the A, B, C, D, E, and Stevens, have been found within an area of about 700 feet by 5,000 feet in the southeastern part of the diorite stock. The combined length of the deposits is about 1,900 feet, and the average width about 3 feet. The deposits occupy steeply dipping fractures, some striking northwest, and some north; two subsidiary mineralized fractures strike northeast. The fractures are filled with pegmatitic material of an unusual type, apparently related to the quartz diorite. The dominant mineral is actinolite. Minerals occurring in smaller amounts are apatite, magnetite, calcite, uraninite, and fluorite.

Eleven surface pits show mineralized widths ranging from 1 foot to 6 feet. Because the rocks are well exposed, the zones can be traced fairly well on the surface. In places, instead of continuous fractures, a series of *en échelon* cracks is mineralized. The longest zone traced is the "C", which has been found intermittently for a length of about 650 feet. The writer took one chip sample across 6 feet in a pit on the B zone; this showed 0·095 R. Another, chipped across 3 feet in a pit on the C zone, showed 0·99 R. The Stevens zone, which was exposed after the writer's visit, is reported to be 10 feet wide for a length of 100 feet, with possibility of further extension beneath overburden. Chip samples are reported to have shown 2·02 C for a width of 5 feet.

Fifteen diamond drill-holes, totalling 3,300 feet, are reported to have been drilled along the C zone, with intersections of 3 to 45 inches and assays ranging from 0·01 to 2·99 C. The unweighted average of the assays is 0·63 C. The deepest intersection was reported to be 170 feet below surface.

A little X-ray diamond drilling was done on the Stevens vein, with inconclusive results.

X. A. M. Group. This group was staked by Mr. J. McAvoy, of Yellowknife. It is in the Barnston River region north of the east arm. The showings consist of concentrations of biotite, exhibiting a little uranium stain, in granitic rocks. Three samples taken by the writer showed 0·005 R, 0·007 R, and 0·13 R. Two specimens submitted by Mr. McAvoy for these claims, or nearby ones staked by him, showed 0·26 R and 1·49 R.

NONACHO REGION

A belt of folded sedimentary strata in the vicinity of Nonacho Lake, between Great Slave and Athabasca Lakes, has been correlated by Henderson (1939, 1948) with the lower part of the Great Slave group. Granitic rocks both older and younger than these strata have been recognized. A few occurrences of radioactive minerals have been found in the Nonacho region proper, and others that lie beyond it are included in this section for convenience.

Key Group. This group, at latitude 60°54′ and longitude 109°42′, was staked in 1949 by the Eldorado company. A shear zone in biotite schist contains visible pitchblende and has been traced for a length of 60 feet. Four samples taken over widths of 2 feet averaged 0·58 R.

Lady Grey Lake Occurrence. Mr. T. Payne of Yellowknife reported that he had found a small occurrence of allanite at this lake.

Nonacho Lake Occurrence. Prospectors for the Eldorado company detected radioactivity in arkose and quartzite near this lake. Two samples showed 0·17 R and 0·31 R.

Tee Lake Occurrence. The Eldorado company investigated an occurrence at Tee Lake, 56 miles north of Fort Smith. An area 30 by 60 feet in size is radioactive, and two samples showed 0·018 C and 0·092 C. Although pegmatite occurs nearby, the samples were granitic.

Thekulthili Lake Occurrences. Messrs. L. Kaip and A. Ritz, of Likely, B.C., reported a discovery at the southwest shore of this lake. A sample submitted by them contained allanite, and showed 0·15 R.

Mr. H. C. Norman reported that he had staked six claims near Thekulthili Lake, for the Eldorado company. These included several showings from which samples gave results up to 6 R. If the company decided to abandon the claims, they would revert to Mr. Norman and his partner.

OTHER OCCURRENCES

The following radioactive occurrences have been reported from widely scattered parts of the Northwest Territories.

Edgell Island Occurrences. Mr. C. C. Chappell, of Sydney, N.S., reported radioactive discoveries on Edgell Island, in the Resolution group off the south-east coast of Baffin Island. He and two associates prospected with a Geiger counter, incidentally to a sealing cruise in 1950. Several pegmatite dykes and stock-works were found on Edgell Island in schist and gneiss. The most radio-active one, 4 feet wide and exposed for a length of 60 feet, contained a little molybdenite. Four samples showed 0·30 R, 0·30 R, 0·40 R, and 0·70 R. One of these samples, which was tested for both beta and gamma radioactivity, contained more thorium than uranium.

Nicholson Lake Occurrence. Mr. A. Stinson, of Stony Rapids, Sask., made a discovery at the northwest end of Nicholson Lake, which is southwest of Dubawnt Lake. Three samples sent by him showed 0·12 R, 0·23 R, and 0·27 R. Five other samples sent by him showed radioactivity ranging from 0·14 R to 1·31 R, but, as the locality was not stated, it is not certain that they came from the Nicholson Lake occurrence.

Yamba Lake Occurrence. A Geological Survey party under R. E. Folinsbee found a low-grade thorium occurrence on the southwest shore of Yamba Lake, 200 miles northeast of Yellowknife. Tests showed less than 0·05 R, but the deposit is mentioned because it is an interesting type. A large esker evidently contains small amounts of radioactive mineral. Where the esker follows the shore of the lake, wave action has concentrated the material to make a small beach placer, estimated to contain about 70 tons of sand. A sample was separated into a magnetic fraction, which showed 0·001 R, whereas the non-magnetic fraction showed 0·037 R. All radioactivity was attributed to thorium, but the mineral was not identified definitely. It is probably monazite, derived from the weathering of gneisses injected by granite or pegmatite containing monazite.

SASKATCHEWAN

Rocks of the Canadian Shield underlie a little less than one-third of Saskatchewan, in the northern part of the province. One hundred uranium properties have been reported from northern Saskatchewan; most of these contain pitchblende deposits. Many properties contain more than one occurrence, and a few properties each contain more than one hundred occurrences, so the total number of individual uranium discoveries is very large.

Most of the occurrences are near the north shore of Lake Athabasca, near the northwestern corner of the province. Most of the discoveries within that region are concentrated in a smaller area within a radius of about 12 miles from Goldfields. Exploratory work on some of the more attractive occurrences in this area has been more successful than any other work done for uranium in Canada in recent years, and one property, the Ace, already shows promise of eventually equalling or exceeding the production from Great Bear Lake. Several discoveries have also been made in the Stony Rapids and Porcupine River areas, within about 60 miles of the east end of Lake Athabasca, and these may be considered as part of the general Lake Athabasca region. For convenience of description in this report, the Lake Athabasca district is treated under three headings, namely: Goldfields, Fond-du-Lac, and Stony Rapids-Porcupine River regions. Another part of Saskatchewan in which uranium has been discovered is the Lac la Ronge region, 250 miles south of Black Lake.

GOLDFIELDS REGION

Location and Transportation. Goldfields (*See* Plate IV A), about midway along the north shore of Lake Athabasca, is reached by air from Fort Smith in the Northwest Territories, or from Lac la Ronge, Saskatchewan, or Fort McMurray, Alberta. From the railhead at Waterways, Alberta, freight is taken by barge for a distance of about 340 miles to Goldfields or other points nearby. Freight for the Beaverlodge camp of Eldorado Mining and Refining (1944) Limited (*See* Plate III A) is trucked across a short portage to Beaverlodge Lake, across which it is barged a distance of 9 miles, but a new road completed late in 1951, between Black Bay of Lake Athabasca and Beaverlodge Lake, will avoid the necessity of barges on Beaverlodge Lake. An airstrip was also built near Beaverlodge Lake in 1951.

In this report the name 'Goldfields region' is applied in rather a broad sense, to an area extending from Camsell Portage, about 30 miles west of Goldfields, to a point about 20 miles east of Goldfields, and northward to Tazin River, a distance of about 25 miles. Most of this region is covered by claims or concessions, the latter being rectangles up to 25 square miles in area, granted by the Saskatchewan Government in 1949 for ground that was not already staked; some of these concessions have been relinquished, and staking on that ground has again been permitted.

The name 'Beaverlodge region' is used in a more restricted sense to describe the part of the Goldfields region in the vicinity of Beaverlodge Lake.

Previous Work. A geological reconnaissance that included the northwestern part of Goldfields region was done by Camsell in 1914 (1916). Alcock mapped a large region north of Lake Athabasca, and did more detailed work near Goldfields in 1935 (1936). A small area at Goldfields was studied in detail by Cooke (1937). A small area near the Nicholson property was studied in detail by Jolliffe in 1945 (1946). Two map-areas including Beaverlodge Lake were mapped on the scale of 1 inch to ½ mile by Christie in 1947 and 1948 (1949), and this work was continued to the east by Blake in 1950. Much unpublished work has also been done by geologists of the Eldorado company and private companies.

A study of the mineralogy of the uranium deposits of the Goldfields district was begun by Robinson in 1949, and an interim report (1950) has been published. A description of the mineralogy has also been given by Kerr and Everhart (1950). A separate study of wall-rock alteration in the district was made by K. R. Dawson for the Geological Survey in 1950.

General Geology. As in many other parts of the Canadian Shield, the rocks of the Goldfields region are divisible into three main groups, consisting of an ancient complex of altered sedimentary and volcanic strata, a group of granitic and related intrusions, and a younger group of Proterozoic sedimentary rocks; later diabasic dykes intrude rocks of all three groups, but are of minor areal extent.

Camsell gave the name "Tazin group" to the rocks of the older complex in the territory traversed by him, and he considered them to be Archæan in age, although all that could be said definitely was that they were Precambrian. Alcock extended the use of the term Tazin group for the older rocks throughout the Athabasca region, and like Camsell, he regarded them as Archæan. He classed the upper part of the old complex, however, as the Beaverlodge series, which he described as resting unconformably on the Tazin group. He divided the plutonic intrusive rocks into two groups, one older than the Beaverlodge series, and one younger. Alcock applied the name "Athabaska series" to a group of sedimentary and volcanic strata, which in places overlie unconformably the old complex and the granitic rocks; he classed the age of the "Athabaska series" as Proterozoic. The name "Athabaska" was first applied to somewhat

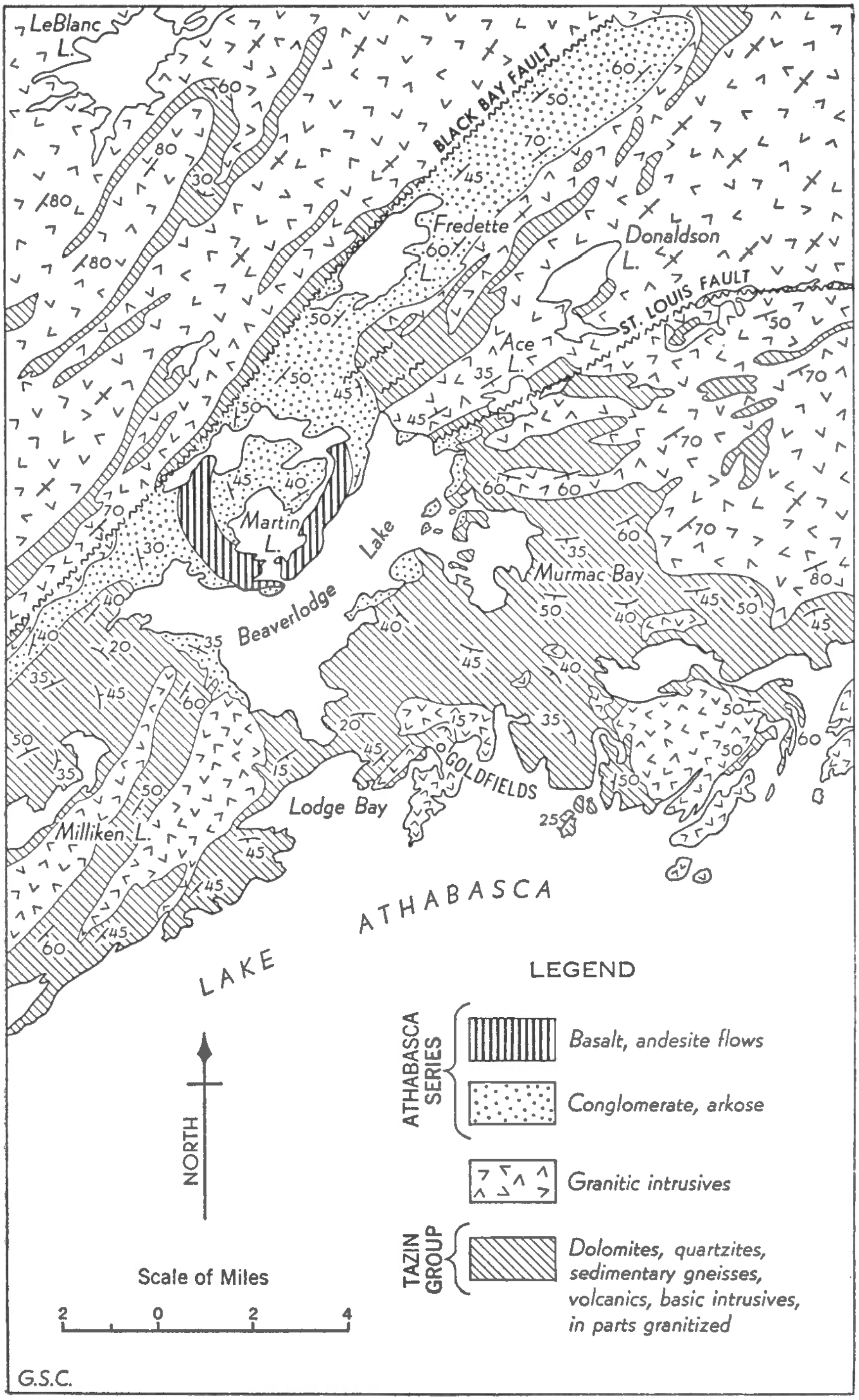


Figure 6. Generalized geological map of part of the Goldfields region, Saskatchewan. After map by A. M. Christie.

similar rocks along the south shore of Lake Athabasca by McConnell in 1888. McConnell regarded their age as Cambrian, but later geologists have included them in the Proterozoic; some workers believe, however, that the strata south of Lake Athabasca may be younger than those now called the Athabasca series in the Goldfields region.

Christie did not recognize the Beaverlodge series as a separate unit in the areas mapped by him, and he mapped all of the old complex under the name "Tazin group"; he recognized granitic rocks of two ages, but stated that "whether they represent different phases of the same period of intrusion or separate geological periods is uncertain".

As listed by Christie, the table of formations is as follows:

Era	——	Formations and Lithology
Proterozoic		Diabase dykes
	Athabasca series......	Basalt and andesite flows (a few believed to be sills) Arkose Conglomerate
		Unconformity
		Lamprophyre dykes Granite and granite-gneiss
		Intrusive contact
Archæan or Proterozoic	Tazin group..........	Mafic rocks { amphibolite; biotite schist or gneiss; garnetiferous gneiss; chlorite-bearing rocks; epidote-bearing rocks; chlorite-epidote rocks grading to more siliceous types } Quartzite Conglomerate Dolomite and dolomitic quartzite

Structural Geology. The structure of the rocks of the Tazin group is, in places, difficult to decipher because many of these rocks are 'hybrids' representing different degrees of granitization, but the broad pattern of faults and folds has been mapped. The axes of folds have a general northeasterly trend. The Athabasca series has been folded more gently, also along northeasterly trending axes. The remnants of this series are found in two main belts that owe their position partly to folding and partly to faulting.

The region is traversed by many faults, most of which strike northeast, and most of which have pronounced surface expression in the form of gullies. Some of the larger faults have formed zones of sheared or brecciated rock. The area contains many other lineaments that may represent additional faults or fracture zones. The two most prominent faults recognized in the area, called the "Black Bay" and "St. Louis" faults (*See* Plate I), have been traced for several miles. The St. Louis fault is estimated to have an apparent horizontal displacement of about 1,100 feet, but that of the Black Bay fault remains to be determined. These faults are post-Athabasca, but some movement may have taken place before the deposition of the Athabasca series. Christie believes that this series has been deposited in local terrestrial basins bordered by faults.

The area contains numerous minor faults, breccia zones, and fractures, many of which contain pitchblende. Some of the fracture systems are very intricate. Allen, who made a special study of the fractures in the Beaverlodge area for the Eldorado company, summarized his findings as follows (1950): "Radioactive fractures show shearing and strike between N 65° E and N 85° E, with dips between 70° and 90°. Cross-fractures of the N 35° E strike are found; though seldom of sufficient prominence to be easily recognized on the ground, they show clearly in aerial photographs, and are found in most instances passing through or close to areas of marked radioactivity wherever a sufficient east-striking fracture zone occurs. Elsewhere there are evidences of echeloning along these fractures in the manner described as occurring at Martin Lake".

Uranium Deposits. The region contains deposits of uranium, gold, copper, lead, zinc, and iron, but only the uranium deposits are of interest at present.

The uranium deposits are of two main types: (1) pitchblende deposits in veins, lenses, pods, stringer-systems, and, to a minor extent, in disseminations; and (2) pegmatite deposits containing uraninite. Pitchblende deposits are the more important type. Numerous occurrences of this kind have been found, but only the larger veins and the multiple deposits that consist of several closely spaced stringers and lenses are likely to be important.

Mineralogically, the pitchblende occurrences are divisible into complex and simpler types. The complex type, represented by the principal deposits at the Nicholson property and by one at the Fish Hook Bay property, contains, in addition to pitchblende, considerable amounts of cobalt-nickel minerals and other metallic minerals. The common gangue consists of carbonate minerals, but quartz or chlorite is found as well at some deposits. The deposits of this class have been found only within a small part of the Goldfields region, in or near strata of dolomite and ferruginous quartzite; this suggests that zoning, or the type of host rock, may have been responsible for the restricted distribution of deposits of this kind. It may also be significant that the main deposits of this kind strike northwest, whereas most deposits of the simpler type strike northeast. The simpler type consists mainly of hematite, with different proportions of pitchblende; other metallic minerals are generally lacking or found in minor amounts. Carbonate is the most common non-metallic constituent, but quartz and chlorite are plentiful in many deposits.

Many deposits occur in fractures and brecciated zones close to a fault. Several of the most important occurrences found to date are close to the St. Louis fault. Faults are, therefore, believed to have been the main loci of mineralization; but, in contrast with the principal deposits at Great Bear Lake, which lie within fault zones, very few occurrences have thus far been found within the main fault zones in the Goldfields region. Instead, most of those that are believed to be related to faults are in fracture and crush zones in the walls of the faults.

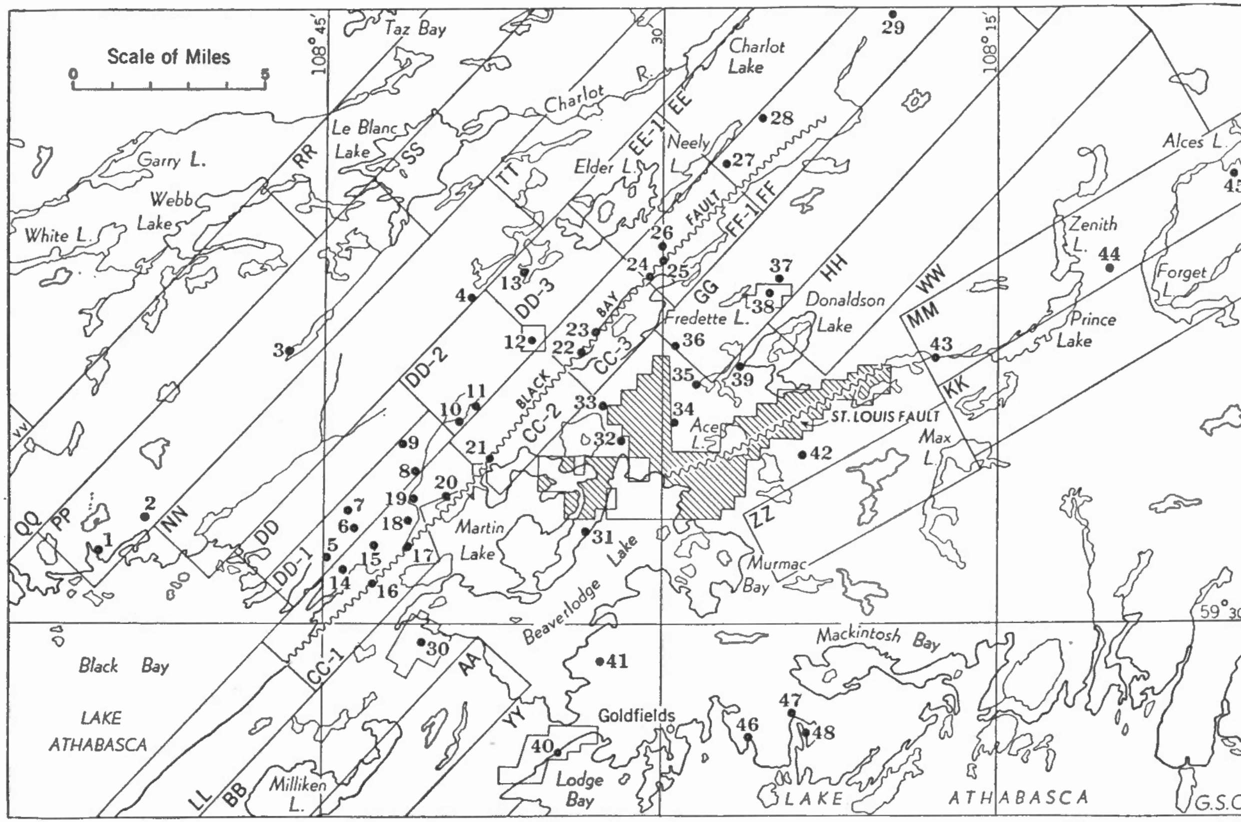


Figure 7. Map showing mining concessions in the Goldfields region, Saskatchewan, and locations of showing that have been explored underground or diamond drilled, including some that were explored initially in 1951, and exclusive of some of the main showings of Eldorado Mining and Refining (1944) Limited. The latter lie within the shaded area and are shown in Figure 8. Boundaries of claim groups and concessions are approximate.

PP Concession
1. Zones 5, 5A
2. Zone 3
3. Zone 6A

NN Concession
4. Showings 70 and 75

DD-1 Concession
5. Showing 55
6. Showing 59
7. Showing 111
8. Leonard series adit
9. Showing 27 (Smith)

DD-2 Concession
10. Showing 31
11. Showings 17, 32, 33

Don Group
12.

DD-3 Concession
13. Hacker Lake showings

CC-1 Concession
14. Showings 1, 4, 80
15. Showings 6, 97
16. Drilling along Black Bay fault
17. Drilling along Black Bay fault
18. Showings 9, 128, 148
19. Showings 11, 61, B 11
20. Showing 46

CC-2 Concession
21. Drilling along Black Bay fault

CC-3 Concession
22. Drilling along Black Bay and Crackingstone faults
23. Drilling along Black Bay and Pinky faults

FF-1 Concession
24. Black Bay fault showings
25. Drilling along Black Bay fault
26. Emar fault showings

FF Concession
27. Showing 1A
28. Showing 2D
29. Showings 6, 10

Pitche group
30. Zones 1, 7

Pitch-Ore group
31.

ABC group
32. Nesbitt showing

H W group
33. Showings 7, 9

Jam and Maj group
34. Eagle-Ace shaft

Paul group
35. Zone 40

GG Concession
36. Showing 27
37. Showing 1A

Hab group
38.

Tom group
39. Tom fault zone

Gil group
40.

Ike group
41.

NW-GC-Lee group
42. Showing C-1

MM Concession
43. Griff showing
44. Monty showing
45. Alces Lake showing

Nicholson group
46. No.2 and No.4 shafts

Fish Hook Bay group
47. Zones B, C
48. Zone A

List of showings indicated on Figure 7.

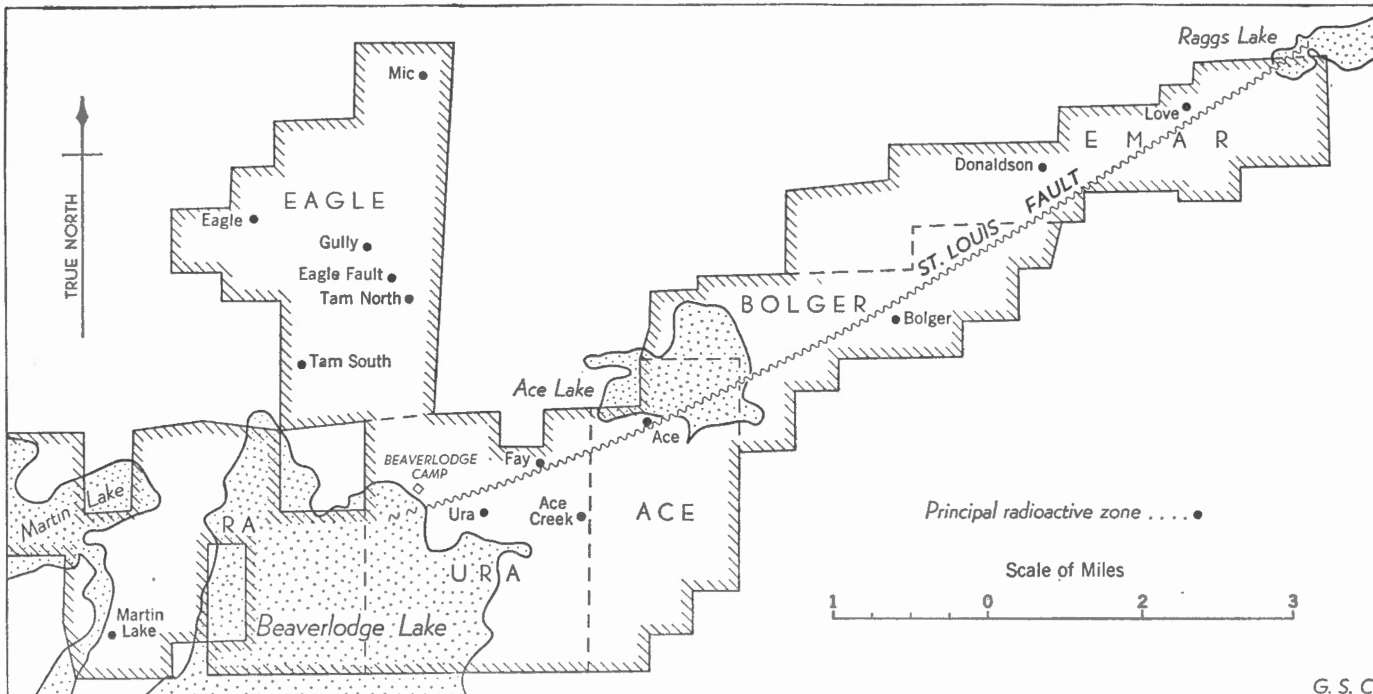


Figure 8. Sketch of main holdings of Eldorado Mining and Refining (1944) Limited in the Goldfields region, Saskatchewan. Boundaries of claim groups are approximate.

The pitchblende deposits are believed to be of late Proterozoic age, and to have been derived from granitic rocks that are not exposed in the area.

The Goldfields region contains seventy-one properties from which uranium oxide in amounts of 0·05 per cent or more have been reported. Several properties contain many individual occurrences, the total number found to date in the region being estimated at 2,400.

Eldorado Mining and Refining (1944) Limited holds ten groups of claims in the region. These groups are classed as separate properties for the purpose of this report. Six of these groups form a single large, irregularly shaped block of claims, extending from Martin Lake to Christie Lake, and including more than 6 miles along the St. Louis fault. From west to east, these groups are the RA, Eagle, Ura, Ace, Bolger, and Emar. The other four groups of the Eldorado company are the Don, Hab, Gil, and Fish Hook Bay, which are scattered in several parts of the region.

Concessions and claims totalling about 300 square miles are, or have been, held by six associated companies, namely: Amax Athabaska Uranium Mines Limited, Aurora Yellowknife Mines Limited, Clix Athabaska Uranium Mines Limited, Goldfields Uranium Mines Limited, Rix Athabaska Uranium Mines Limited, and American Canadian Uranium Mines Limited. The individual holdings of these companies are in several parts of the region, and the names of the groups and concessions can be obtained by reference to these companies in the index at the end of this report. Several other companies hold claims or concessions.

Figure 7 shows, entirely or in part, all the concessions that were granted in the Goldfields region. Some of these have already lapsed. It is understood that all the concessions will expire by March 31, 1952, and that the owners will be permitted to stake a percentage of the ground as claims, the percentage depending on the amount of work done, and that the remainder of the ground will be open for general staking.

A.A. Concession. This concession, owned by Clix Athabaska Uranium Mines Limited, covers part of a large peninsula east of Black Bay of Lake Athabaska. It is underlain mainly by quartzite and granitic rocks, but includes several bands of mafic rocks, chiefly in the northern half of the concession. Preliminary traversing with scintillometers was completed in 1950. This resulted in the discovery of sixty-five occurrences or anomalies, most being in or near shear or fault zones in mafic rocks or at the contacts of mafic and other rocks. Most of the showings are in the northern half of the concession. Ten were considered to be worth stripping and trenching, and that was done on several of the showings. Seven of these are reported to be in a mafic band near Griff Lake, and, of these, two are thought to be more important than the others. One is reported to consist of several occurrences within a length of 650 feet, in a shear or fault zone 1 foot to 2 feet wide; a grab sample of massive pitchblende from one of these showings is said to have been 6 by 8 inches in size. The other zone is reported to have been traced at intervals for 1,200 feet, and to vary in width from a 'spot count' to 10 feet.

A.B.C. Group. This group of nine claims is owned by Nesbitt-LaBine Uranium Mines Limited. It is at the northwest corner of Beaverlodge Lake, west and south of the Eagle block of claims owned by the Eldorado company.

The main occurrence lies near the junction of two faults, one trending northeasterly and the other northwesterly. The former is a faulted contact between granitic and mafic rocks. The latter is a faulted contact between a body of arkose of the Athabasca series and mafic rocks of the Tazin group. The original showing was found with a Geiger counter, through about 3 feet of overburden. It was trenched and stripped for about 100 feet, revealing a zone up to 3½ feet wide and 80 feet long, which appears to end to the northeast and extends into heavy overburden to the southeast along the arkose contact. It consists of streaks and masses of hematite and pitchblende in a gangue of chlorite, quartz, carbonate, and altered rocks. Stripping revealed two radioactive fractures angling eastward from the main zone. Zippeite was identified as one of the secondary uranium minerals at the outcrop of the zone.

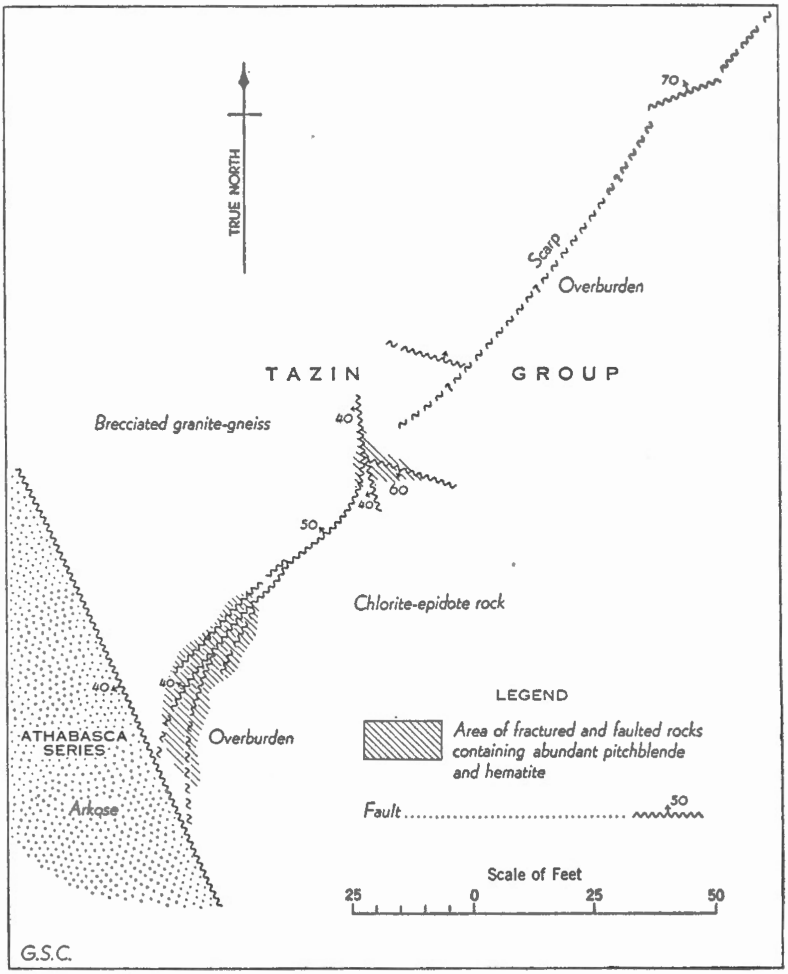


Figure 9. Sketch of Nesbitt showings, A.B.C. group, Goldfields region, Saskatchewan. From plan by S. M. Roscoe.

In 1950, the main zone and another nearby were explored by twenty diamond drill-holes that totalled 5,000 feet. Eight short holes drilled along the north-easterly fault did not prove ore continuity in this direction. Nine holes drilled along the arkose contact confirmed the presence of a fault or shear zone. Two holes revealed small carbonate veins containing disseminated pitchblende, and five other holes showed radioactivity within or near the fault zone. The company's engineer considered that the core recovery was insufficient to permit a final assessment of the possibilities of this part of the property.

Detailed prospecting resulted in a discovery of several other showings on the claims. Two of these are shear zones in the northeast corner of the property, which are reported to be about 3 feet wide and to be strongly radioactive, although visible pitchblende has not yet been found. Another, about 400 feet southwest of the main showing, is described as a narrow fracture containing small lenses of pitchblende at intervals; this fracture was traced by stripping and trenching for a length of 114 feet. Another showing is about 350 feet east of the main one. It is reported to consist of a shear or fracture zone up to 1½ feet wide, traced for a length of about 80 feet by stripping and trenching, and to be strongly radioactive and to contain pods of pitchblende up to 2 inches wide in places. Three diamond drill-holes were placed under a muskeg 250 feet east of the main showing, between it and the last-mentioned one; these holes are reported to have encountered small carbonate veins carrying disseminated pitchblende.

The company proposes to explore the main occurrence with an inclined shaft and lateral work.

Ace Group. The Ace group of Eldorado Mining and Refining Limited is a rectangular block of claims extending 5,000 feet from west to east and about 10,000 feet from north to south. It extends from Ace Lake southward almost to Beaverlodge Lake, and is bounded on the west by the Ura Group and on the east by the Bolger and NW-GC-Lee groups. The northern claims are crossed by the St. Louis fault for a distance of 5,500 feet, the eastern half of this part of the fault being under Ace Lake, an irregular body of water about a mile in diameter. The fault strikes north 65 degrees east and dips almost 50 degrees to the southeast, the hanging-wall being the down-thrown side. On the foot-wall side, the rocks exposed at the surface are mainly mafic rocks of the chlorite-epidote type. On the hanging-wall side the rocks are mainly granite-gneiss, capped at one place near Ace Lake by a remnant of Athabasca conglomerate, with minor sandstone interbeds. Where penetrated underground, the fault is marked by a gouge-seam 1 foot wide.

The main surface showings are several short, narrow fractures in the foot-wall rocks, close to the south shore of Ace Lake and within 100 feet of the fault. Another fracture is exposed about 300 feet northwest of the fault. The showings strike subparallel to the fault and appear to be tension fractures. They contain carbonate and considerable visible pitchblende, and in places the wall-rocks show marked red alteration. Most of the veins dip steeply toward the fault, but one of the larger ones is flatter, dipping 38 degrees southeast. Several scattered radioactive anomalies were found in the Athabasca conglomerate southeast of the fault.

The main surface showings were explored first by trenching. They are small and not particularly impressive, but the fact that they occur close to a prominent regional fault and that the rocks in the vicinity are largely covered by overburden led to a decision to test the fault and its adjacent rocks thoroughly by diamond drilling. The belt was explored to a depth of 300 feet by 12,097 feet of diamond drilling, mainly in closely spaced holes near the main surface showings. This drilling suggested the presence of two fairly large bodies of moderate grade, lying in the foot-wall block close to the fault, one being close to Ace Lake and the other about 700 feet farther southwest. Because of the dip of the fault, the mineralized bodies dip under the capping of Athabasca conglomerate.

The encouraging results obtained by drilling made underground exploration desirable. Sinking of a shaft (*See* Plate III B), inclined 50 degrees to the southeast, was begun late in 1949. The shaft is in the foot-wall block, about 200 feet northwest of the fault, and is between the two bodies that were outlined by drilling. A road 2 miles long was built from the Beaverlodge camp to the shaft site. Lateral work was done on the 150- and 275-foot levels, consisting of short crosscuts from the shaft and long line drives to the northeast and southwest. Short horizontal diamond drill-holes were placed at 50-foot intervals, and several stub crosscuts were driven. By the end of 1950, large amounts of lateral work and underground diamond drilling had been done.

Isolated stringers and pods containing visible pitchblende have been found in places in the underground workings, but the main mineralization found to date is in the two bodies that were first indicated by diamond drilling from the surface. These bodies are not yet fully explored, and their outlines and structural relationships are, therefore, not yet completely known. They consist chiefly of rocks that show much red alteration and others that are silicified. The original compositions are obscure. At least some of the rock is believed to be quartzitic argillite that has been granitized in places and which was made favourable for alteration and pitchblende mineraliztion by intense fracturing, brecciation, and crushing. These rocks are at or near the foot-wall of the St. Louis fault, and their shattering is evidently related to the faulting. The west orebody rakes toward the west, apparently because of the angle at which favourable beds intersect the St. Louis fault. Small stringers and masses of visible pitchblende are found, generally associated with chlorite, but most of the pitchblende appears to be in veinlets or disseminations of microscopic size. Pyrite, chalcopyrite, and a little galena and clausthalite have been reported by Robinson. In the west orebody some small, high-grade veins contain considerable chalcedony. Detailed microscopic studies of the mineralization are being made but the results are not yet available.

The company announced in March 1951 that the results of underground work had reached a point where it is possible to forecast an operation with a minimum of 500 tons a day, with good prospects of a larger tonnage. The shaft is being deepened to permit exploration on two additional levels, and plans for sinking an operating shaft and building a treatment plant are being made.

A.L. Group. This group of three claims, held by Norancon Exploration Limited, is at the west shore of Felix Bay of Lake Athabasca, 11 miles east of Goldfields. As described by Blake (1951), the claims are underlain by granitized and silicified sedimentary rocks intruded by granite and pegmatite. The showing on the property is related to a fault that is marked by a gouge-seam ½ inch wide. Two closely spaced pits astride this fault reveal a series of lenses and veinlets up to ½ inch wide, containing pitchblende. The longest pitchblende-bearing fracture exposed has a length of 4 feet. The pitchblende is associated with hematite and graphite, and the wall-rock contains considerable pyrite. Two grab samples taken by Blake showed 0·36 R and 4·92 R. Testing with a Geiger counter in the vicinity of the showing failed to reveal additional radioactivity.

Ath Group. This group of nine claims lies immediately south of Raggs Lake and is owned by Athona Mines (1937) Limited. The St. Louis fault is believed to pass through this lake. Prospecting in the summers of 1949 and 1950 resulted in the detection of six radioactive anomalies, two of which were explored by rock trenches. No pitchblende was noted.

Axe Group. This group, between Martin and Cinch Lakes, is held by Continental Exploration Limited. Several radioactive occurrences have been found in basalt of the Athabasca series. Four samples, some of which contained pitchblende, showed 0·06 R, 0·13 R, 0·42 R, and 3·36 R. The sample that showed most radioactivity was reported to have been taken across a width of 3 inches, from a shoot 10 feet long.

Beaver Group. This group, on Beaver Island of Beaverlodge Lake, was formerly held by the Eldorado company, but has been relinquished. According to the agreement with prospectors formerly in the employ of the company, Einer Laurum, the prospector who discovered uranium on the island, had the

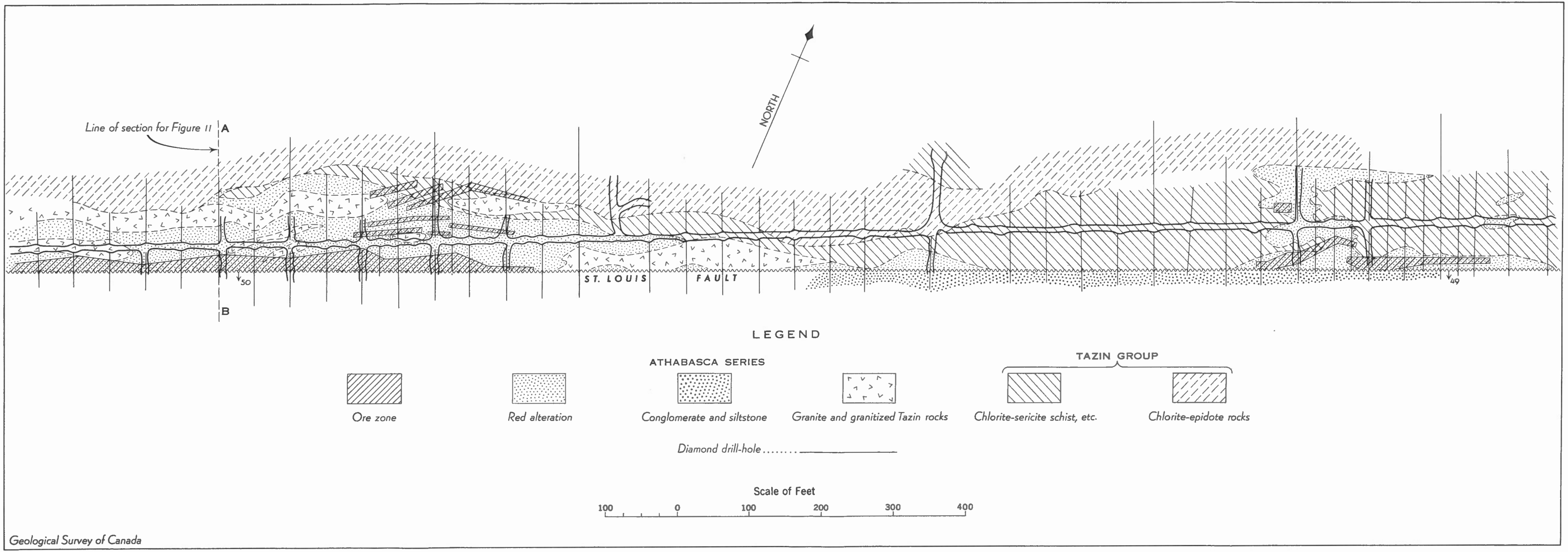


Figure 10. Generalized geological plan, 175-foot level, Ace mine, Saskatchewan. From plan by R. B. Allen, Eldorado Mining and Refining (1944) Limited.

first right to re-stake the claims. About eighty easterly trending fractures, up to 100 feet long, were found in conglomerate of the Athabasca series. Some of these contain a little visible pitchblende, with hematite and sulphides, in a gangue of carbonate and quartz.

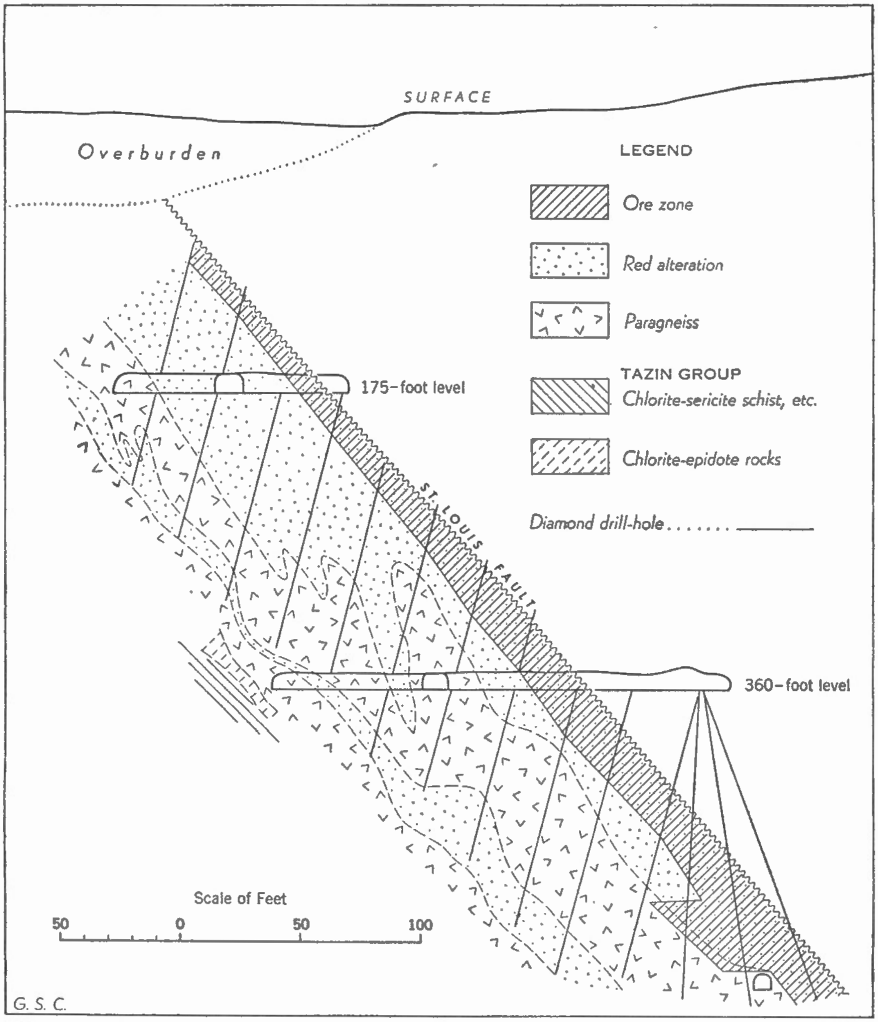


Figure 11. Vertical section of Ace mine, Saskatchewan, through line A-B (*See* Figure 10). From drawing by R. B. Allen, Eldorado Mining and Refining (1944) Limited.

Bolger Group. This group, held by Eldorado Mining and Refining (1944) Limited, lies north and east of Ace Lake. It is bounded to the north by the Strike group and by the Eldorado Emar group, and to the south by the NW-GC-Lee group and the Eldorado Ace group. The claims are underlain partly by granitic and gneissic rocks, and partly by amphibolite and epidote-chlorite rocks. The St. Louis fault crosses the claims diagonally for a distance of 2 miles.

The main showing on the Bolger group is 1,000 feet east of Verna Lake and 800 feet south of the St. Louis fault. Seven trenches have explored a zone of fractures striking north 70 degrees east, almost parallel with the St. Louis fault.

The fracture zone is in much-weathered amphibolite and related rocks. The fractures are filled mainly with carbonate and chlorite, and the wall-rocks and rock fragments in the zone show much red hematitic alteration. Pitchblende occurs irregularly, and small amounts of galena, chalcopyrite, niccolite, native silver, and native gold have been reported (Christie and Kesten, 1949, p. 25; Robinson, 1950, p. 29). Small stringers of pyrite and quartz cross the deposit. The largest individual pitchblende-bearing vein is up to 4 inches wide and is exposed for a length of 5 feet. Sampling of the trenches indicated a zone with an average width of 11·8 feet and 76 feet long, averaging 0·38 C.

An unusual feature of the Bolger showing is that, for an area of 6,500 square feet, the overburden near the showing contains enough secondary uranium in the form of gummite, and probably other minerals, to be readily visible because of its yellow colour. This deposit is at the foot of a slope, and surface water is believed to have dissolved uranium from the pitchblende and deposited it in the gravel, the average content of which is estimated at 1·42 C.

Another occurrence on the Bolger group is the Mack showing, on the north shore of Ace Lake. It consists of a slightly sheared fracture that strikes north 75 degrees west and was traced for 100 feet. Small pods of pitchblende were blasted out during the emplacement of the single trench on the showing.

Box. This inactive gold property is owned by The Consolidated Mining and Smelting Company of Canada Limited. Many low anomalies were found in the outcrop of the orebody. Christie (1949, p. 22) reported that a small veinlet of pitchblende was seen, and that fragments of pitchblende were found in overburden. The presence of thucholite has also been reported.

Cab, Paul, Mike, Tom, and Jim Groups. These groups, lying between Eagle and Donaldson Lakes, are held by American Canadian Uranium Mines Limited. Some of these claims cover the former Ridge or Hump group of the Eldorado company, who made some discoveries but later allowed the claims to lapse because they had many other showings to investigate. The new owners did further work on some of these showings in 1950, and also made several additional discoveries.

The Tom group contains fourteen showings, the most important being on the portage between Mickey and Donaldson Lakes. This showing was examined by the writer. The surface work indicated a radioactive fault zone from 2 to 10 feet wide continuous for a length of at least 500 feet. Assays as high as 1·60 R over 0·9 foot and 0·96 C over 1·4 feet were obtained, although some samples gave low or nil values, particularly where the fault zone could not be completely exposed.

During November 1950 this deposit was tested by seven short drill-holes. Six of the holes were reported to have shown significant radioactivity and some encouraging assays are reported to have been obtained. Further diamond drilling on this occurrence is planned by the company.

Eight showings were reported to have been found on the Mike group, three being thought worth further work.

The company reported as follows on the Paul group: "At one place on the Paul group, pitchblende has been found in fractures that appear to be related to a plunging syncline. Pitchblende seems to be confined to places where fractures cross particular bands of mafic rocks. A number of channel samples gave encouraging returns. The assays varied from 0·13 C over 2·5 feet to 1·3 C over 5 feet. Nine short drill holes have been used to test this zone to date. Geiger probe readings indicated radioactive fractures in a number of the holes although no assays of consequence were obtained. Further surface work and diamond drilling is planned.

"At another locality on the Paul group, radioactivity was found on the surface for a length of about 400 feet. The radioactive minerals occur in a complex system of fractures that appear to be related to a strong fault zone. During November of 1950, the showing was tested over a length of 375 feet by six short diamond drill holes. The drilling results were encouraging and the company intends to carry on development of this showing."

CC-1 Concession. This concession, northeast of Black Bay of Lake Athabasca, is held by Amax Athabaska Uranium Mines Limited. It covers part of the Black Bay fault, and it contains other lineaments that may be parallel faults or shear zones. Preliminary prospecting of the concession was finished in 1950, and is reported to have resulted in the finding of two hundred and seven occurrences or anomalies. About twenty-five were reported to be worth further work. Most of the showings are in fractures in granite-gneiss and amphibolite, and the fractures appear to be related to the faulting.

The company reported that seven diamond drill-holes, totalling 325 feet, explored one showing for a length of 100 feet. Five of these holes showed radioactivity when tested with a drill-hole counter.

Another showing consists of nine parallel fractures exposed for lengths of 10 to 350 feet. Nine samples taken across one of these fractures, which is 325 feet long, are reported to have shown an average of about 1·0 C.

Another showing is reported to consist of a shear zone 18 inches wide, mineralized across widths of 10 to 12 inches. Four diamond drill-holes totalling 228 feet explored this zone for a length of 70 feet. One hole is reported to have intersected 1·7 feet that averaged 0·29 R; another intersected 3·2 feet that averaged 0·23 R; another yielded 2 feet averaging 0·28 R; another hole showed two sections of 1·8 and 2 feet that averaged 0·12 and 0·8 R respectively.

Surface work was done on several other showings, some of which are reported to contain pitchblende.

CC-2 and CC-3 Concessions. These form the northeast half of concession CC, between Martin and Fredette Lakes. The ground is held by Aurora Yellowknife Mines Limited. The Black Bay fault passes through the property, dividing granite-gneiss and altered rocks of the Tazin group from sedimentary rocks of the Athabasca series.

Preliminary traversing of the ground was completed in 1950, and resulted in the discovery of seventy-eight occurrences or anomalies. Eighteen of these were considered worth surface work. Reports of preliminary work on four showings indicated that two are radioactive fractures near the Black Bay fault; another is a zone containing pitchblende, chlorite, and graphite, near the Black Bay fault; and another is a showing containing pitchblende, hematite, chalcopyrite, and pyrite.

Chum Group. This group, 5 miles northwest of Martin Lake, is owned by Mr. A. McIver of Goldfields, and is within the DD concession. The claims cover part of a fault zone or shear zone called locally the 'Heron shear'. Radioactivity has been found at intervals along this zone for a length of about 1,200 feet. Seven trenches have exposed this zone at intervals of 50 feet, for a total length of 300 feet. They show a zone up to 8 feet wide, composed of sheared granite, with a little pyrite and pitchblende. Results of forty-five samples reported by the company give an unweighted average of 0·108 C.

D.D. Concession. The following refers to the quarter of concession DD that is held by Goldfields Uranium Mines Limited. It is north of Black Bay of Lake Athabasca, and is underlain mainly by gneisses. Preliminary traversing, finished in 1950, resulted in thirty-six radioactive discoveries, of which three were considered worth further work. Details of two of these were reported.

One is described as a shear zone 1 foot wide, traced for 100 feet. The outcrop contains rust and uranium stain. A sample chipped across 10 inches is reported to have shown 5·07 R.

Another showing, of variable but unstated width, is reported to have been traced for a length of 27 feet and to have shown visible pitchblende in places. A grab sample is reported to have indicated 17·43 R.

DD-1 Concession. This quarter of concession DD is held by Rix Athabaska Uranium Mines Limited. The area is underlain chiefly by granite and gneiss, with some mafic rocks. Traversing is reported to have resulted in the discovery of more than one hundred and fifty radioactive occurrences. Several of these were considered to justify surface work. This was begun in 1950, and preliminary diamond drilling was done late in the year. Some of the following information was obtained from the company, and some from examinations by the writer and by K. R. Dawson of the Geological Survey.

Showing No. 55 is a shear zone 2 to 3 feet wide, in gneiss. It has been trenched for 50 feet and appears to continue. It contains uranium stain, but no pitchblende was seen. Diamond drilling was commenced in October 1950, and three holes totalling 153 feet were drilled.

Showing No. 56 is a zone of narrow fractures up to 30 feet long, containing visible pitchblende in places.

Showings 57 and 58 are in a large mass of pink granite that is fairly radioactive. It is not yet known whether this is caused by original constituents of the granite, or by introduced minerals. Two grab samples are reported to have shown 0·09 and 0·14 R. Three short diamond drill-holes were drilled on showing 58, and five on showing 59.

Showing 94 is a zone 6 to 48 inches wide, in granite-gneiss, traced for about 300 feet. Visible pitchblende was found in places. Four samples are reported to have yielded the following results: 0·86 R (1·0 foot); 0·95 R (0·8 foot); 0·18 R (1·5 feet); 0·26 R (4·0 feet).

Showing No. 111 consists of one main fracture and several branch ones, in mafic rocks. The main one has been stripped for a length of 360 feet and may continue farther. Uranium stain occurs in places, for widths up to 10 inches. Eight diamond drill-holes totalling 528 feet were drilled on this showing.

The diamond drilling at the four showings mentioned above is reported to have shown radioactivity, but assay results were not reported up to the time of writing.

Early in 1951 an adit was driven to explore part of the Leonard series of showings, which are near the boundary between concessions CC-1 and DD-1, and about a mile southwest of the northeast boundary of concession DD-1. The Leonard series consists of nine radioactive zones along faults that strike westerly across interbanded granitic and mafic rocks. It was reported that topographic evidence suggests that the faults are from 800 to 900 feet long, and that the longest continuous section exposed to date is 370 feet, on the No. 1 zone. The results of sampling of the surface exposures of the No. 1 zone were stated to indicate that a length of 150 feet averaged 7·6 pounds of U_3O_8 a ton for a width of 5·4 feet, that a 70-foot length was too weathered for surface sampling, and that a length of 130 feet averaged 10·2 pounds of U_3O_8 a ton for a width of 2·2 feet. The adit was driven along the No. 1 zone.

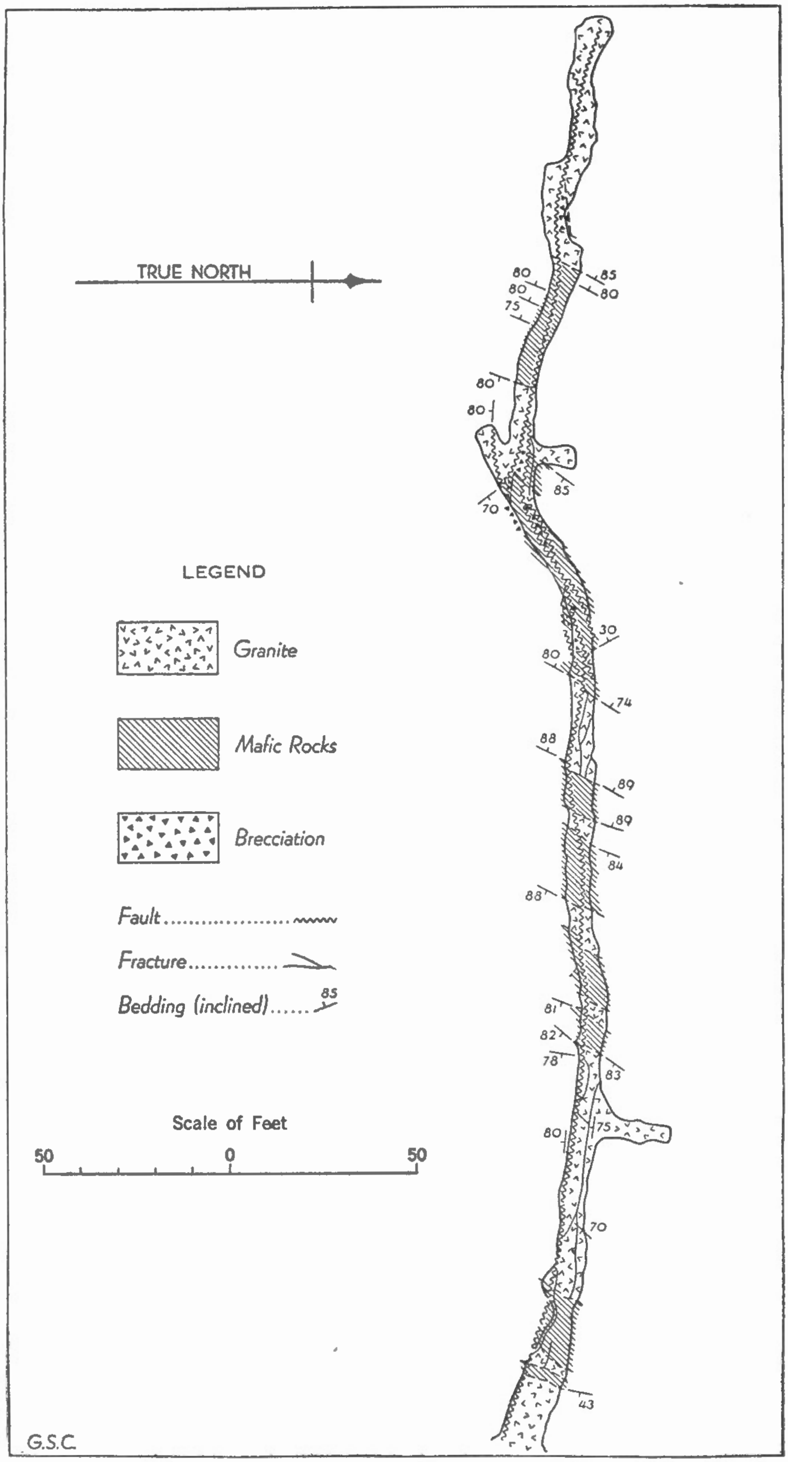


Figure 12. Plan of adit on No. 1 zone, Leonard series, concession DD-1, Goldfields region, Saskatchewan. From plan by Rix Athabaska Uranium Mines Limited.

DD-2 Concession. This quarter of concession DD is held by Mr. W. N. Millar, 370 Silverthorne Avenue, Toronto. The area is underlain chiefly by gneiss, with several bands of mafic rocks. Traversing with a scintillometer resulted in the discovery of one hundred and forty-eight radioactive localities, and a few additional ones were found with an airborne instrument. About twelve of these were considered worth immediate stripping and trenching, and this work is reported to have shown two main zones, which the geologist in charge has recommended for diamond drilling.

One of the main groups of showings is at a shear or fault zone in mafic rocks at the east side of Jean Lake. Pitchblende is reported to have been found in the shear zone, which has been trenched for a length of 37 feet along the strike. Six channel samples across widths of 3 feet are reported to have shown 0·33 R, 0·34 R, 1·72 R, nil, 0·10 R, and 0·20 R. Seven cross-fractures, four of which contain visible pitchblende, are reported to have been found in the hanging-wall of the zone; these have an aggregate length of 200 feet. Sixteen channel samples taken for widths of 1 foot across these fractures gave results ranging from nil to 2·26 R.

The other principal discovery is about a mile northeast of Jean Lake. It is near a shear or fault zone that is one of a system of such structures extending northeastward from Jean Lake to the Don showings of the Eldorado company. The radioactive zone is reported to have been traced for a length of 150 feet, and to appear to extend farther under overburden. The following sampling results were reported:

Representative hanging-wall rock	Nil
Hanging-wall fracture filling	0·44 R
Representative intervening rock	0·06 R
Foot-wall fracture filling	Nil
Representative foot-wall rock	0·13 R
Chip channel sample over true width of 7 feet	Nil

DD-3 Concession. This quarter of concession DD is also held by Mr. W. N. Millar. Flights with an airborne scintillometer located fourteen anomalies. Ground prospecting with a scintillometer is reported to have found about forty radioactive localities, chiefly in granite-gneiss, which underlies most of the holding. Some of the radioactive occurrences found on the ground appear to be the same as ones located from the air. No visible pitchblende, and only one occurrence of uranium stain has been reported, but details on all showings have not yet been received.

Dello Group. This group of nine claims, staked by Neiman Lake Uranium Prospecting Syndicate, is at the head of Reed Bay of Lake Athabasca, about 14 miles east of Goldfields. As described by Blake (1951), pitchblende was found in a shear zone 5 feet wide in amphibolite that is silicified in places. The pitchblende occurs in veinlets up to ½ inch wide and 8 feet long, which also contain calcite and specularite. Six grab samples taken by the discoverers gave results ranging from 0·07 R to 12·75 R; one sample showed 0·03 ounce in gold a ton. A grab sample taken by Blake showed 0·17 R.

Don Group. The Don group consists of four claims staked by Eldorado Mining and Refining (1944) Limited 4 miles northwest of the Beaverlodge camp. The claims are underlain by amphibolite, quartzite, and granite-gneiss. They cover part of a lineament extending northeasterly through Jean Lake. This lineament appears to mark a zone of faulting, along which pitchblende has been found not only on the Don group but also at several places to the southwest, in concessions CC-1 and DD-2.

Radioactivity was found at thirty-five places on the Don group. The most important showings are in a zone that extends for a length of about 700 feet, in a direction across the trend of the lineament already mentioned. This zone contains several small shear zones containing quartz, carbonate, hematite, pitchblende, and a little pyrite. The zone has been explored by a little diamond drilling, which did not reveal important mineralization. One occurrence of this group is at the contact of a diabase dyke.

Eagle Group. This large group of claims, held by Eldorado Mining and Refining (1944) Limited, lies north of Beaverlodge Lake and extends eastward from Melville Lake to Eagle Lake. The group is underlain by a complex assemblage of rocks consisting mainly of chlorite-epidote rocks, quartzite, and reddish granite-gneiss. The rocks are crossed by several fracture zones, most of which strike northeast. Mineralization has been found at several separate groups of showings. The most westerly group, called the Eagle Shaft showings, is about 7,000 feet north of the northwest corner of Beaverlodge Lake. The Mic showings are 7,000 feet northeast of the Eagle Shaft showings and roughly on their strike. The Gully zone lies about 5,000 feet east of the Eagle Shaft showings, and, farther to the southeast, are the Eagle Fault and Tam North showings. In the southern part of the group, near Tam Lake, are the Tam South showings. Radioactivity has also been detected at several other, widely scattered localities.

The Eagle Shaft showings are associated with four northeasterly striking zones that converge to the southwest. From northwest to southeast, these are the Edie, Spur, Conglomerate, and Lost Mine zones. Christie and Keston (1949, p. 27) state that the zones are inferred to be faults from topographic breaks, structural breccia, abrupt truncation of beds, and, in some places, by exposed shearing and slickensides. Drilling and underground work have not, however, indicated the presence of strong faults. In places, the rocks near the faults contain pitchblende, which is most abundant in mafic rocks near contacts with granite-gneiss. The Spur and Lost Mine zones are being explored from the Eagle shaft, which is about 4 miles by road from the Beaverlodge camp. The Spur zone strikes north 70 degrees east, dips steeply southeast, and is up to 18 inches wide, consisting of a series of small fractures containing carbonate, quartz, chlorite, stringers of pitchblende, and minor amounts of sulphide minerals. There is considerable hematitic alteration. Some fractures contain mineralization of high grade, but they have slight continuity, either laterally or vertically. This lack of continuity is caused partly by the intercalation of unfavourable quartzite beds and granite sills. The Lost Mine vein is about 1,000 feet southeast of the Spur zone. It has an average strike of about north 80 degrees east, and dips vertically to steeply southeast. It consists of a zone up to 8 feet wide, containing fractures mineralized in much the same way as described for the Spur zone. The Spur zone was traced intermittently on surface for about 700 feet, and the main part of the Lost Mine zone was exposed by a trench 200 feet long, with intermittent exposures extending for several hundred feet to the west and east. The zones were explored by 22,000 feet of diamond drilling from the surface, which confirmed the presence of two series of narrow veins. The results were sufficiently encouraging to suggest the advisability of underground exploration. A vertical shaft, placed between the two zones, was begun in January 1950, and sunk to a depth of 300 feet. Crosscuts were driven on the 150- and 275-foot levels northwesterly toward the Spur zone and southerly toward the Lost Mine zone. From the latter crosscut, line drives were run to the west and east to permit diamond drilling at 100-foot intervals, to explore the main Lost Mine zone and a parallel zone lying about 200 feet farther south. At the time of the writer's visit in the autumn of 1950, about 3,800 feet of lateral work and 8,000 feet of diamond drilling had been done, mainly on the 150-foot level. The mineralized zones were not exposed by underground workings at that time.

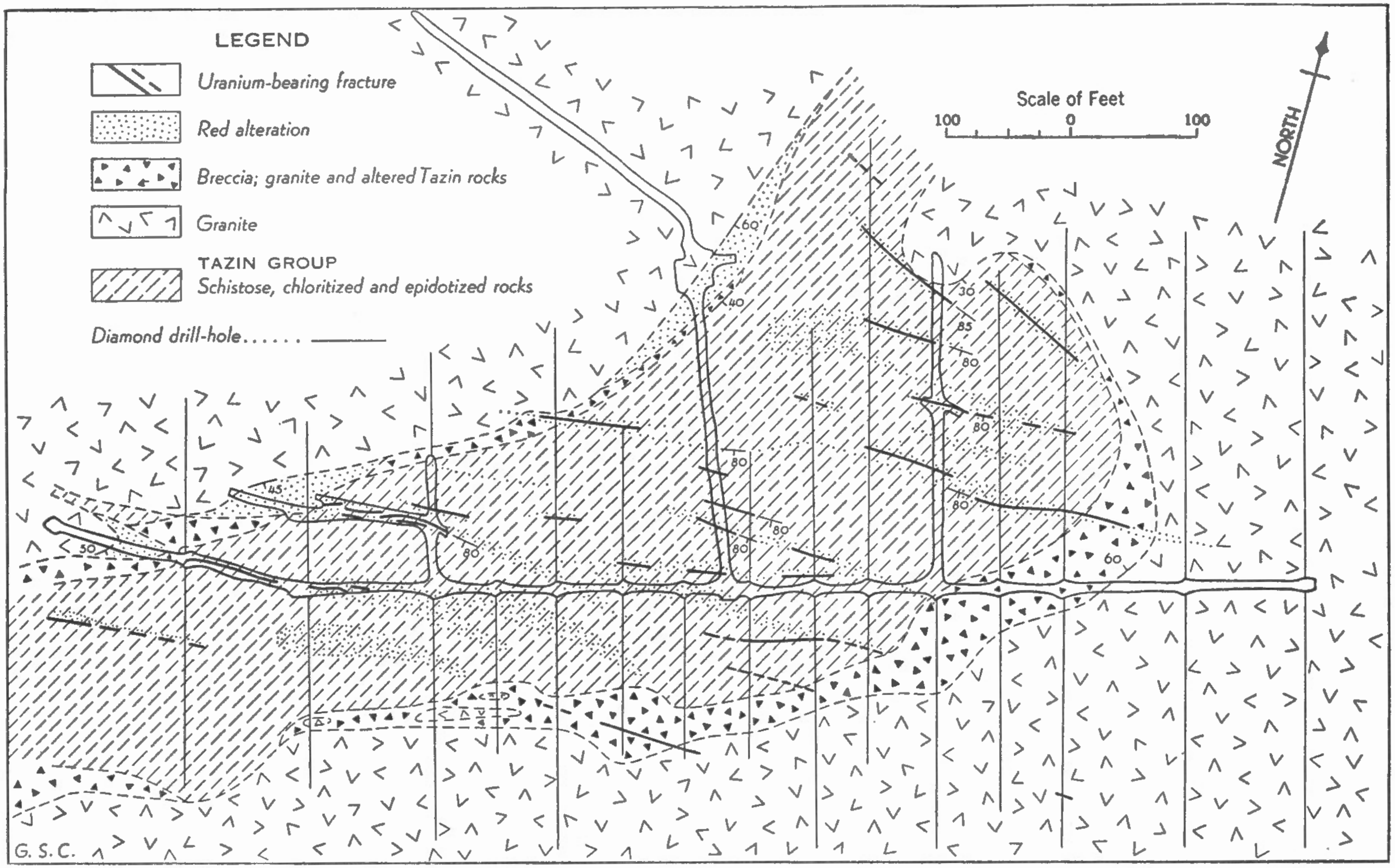


Figure 13. Geological plan, 275-foot level, Eagle mine, Saskatchewan. From plan by Eldorado Mining and Refining (1944) Limited.

The Mic showings are about 800 feet northwest of Mic Lake and 7,000 feet northeast of the Eagle Shaft showings. Pitchblende has been found in a series of irregular, narrow fractures mainly within 25 feet of a shear zone that is probably related to one or other of the zones near the Eagle shaft. The fractures lie normal to the shear zone, and are near a contact between mafic rocks and granite-gneiss, most of the mineralized fractures being in gneiss. The fractures contain chlorite, quartz, and minor amounts of carbonate, together with hematite, pitchblende, and a little pyrite and galena. Radioactivity was detected at sixteen places, which to date have been explored only by stripping. Zippeite was identified as one of the secondary uranium minerals in the surface exposures.

The Gully or Beth Lake zone is immediately west of Eagle Lake and about 5,000 feet east of the Eagle shaft. A deep depression probably marks a fault or shear zone striking north 35 degrees east, crossing chlorite-epidote rock, gneiss, and quartzite. Narrow, radioactive fractures occur at both sides of the depression, and contain quartz and minor amounts of carbonate and chlorite, together with hematite, pitchblende, and traces of pyrite, chalcopyrite, and galena. The zone was explored for a length of 2,400 feet by seven diamond drill-holes that resulted in thirteen intersections ranging from 0·62 C for a length of 11 feet to 10·40 C for a length of 1 foot.

A showing called the Intermediate zone was found between the Lost Mine and Gully zones. Trenching exposed a narrow vein for a length of about 50 feet. One diamond drill-hole showed two, 1-foot intersections assaying 0·10 C and 0·15 C, but a second hole failed to show extension of the mineralization.

The Eagle Fault zone extends southwestward from the southwest corner of Eagle Lake, crossing mafic rocks mainly of the chlorite-epidote type. It was explored for a length of 4,000 feet by diamond drilling. Two holes yielded intersections of 0·46 C for a length of 2·5 feet and 1·29 C for a length of 1·2 feet, but seven other holes failed to reveal significant mineralization.

The Tam North zone is roughly parallel with the Eagle Fault zone, and 500 to 800 feet southeast of it. The rocks in the vicinity are mainly of the chlorite-epidote type. Five diamond drill-holes showed encouraging intersections, up to 1·40 C for a length of 1 foot. A zone that may be the continuation of this zone was found north of Tam Lake, about 3,000 feet farther southwest. This was described by Christie and Kesten (1949, pp. 26-27) as follows:

"The area is underlain by well-banded mafic rocks (chlorite-epidote type), probably sediments or tuffs, which apparently overlie quartzites, the latter being exposed at the core of an anticlinal structure that plunges gently east-northeast. These formations have been intruded by granites now represented by banded gneisses. A wide sheared zone extends northeasterly from the northwest tip of Tam Lake. Carbonate-pitchblende veins occur near this zone at various places, some striking parallel with the zone but more commonly normal to it. Dips are steep to vertical. The strongest veins so far noted are in the mafic rocks just north of the quartzite contact 800 feet north of Tam Lake. If significant mineralization is here restricted to the mafic rocks, the depth to the quartzite contact beneath may be an important factor in further exploratory or development work."

The zone has been explored by five diamond drill-holes, each of which showed significant intersections, the better ones being 2·13 C for a length of 1 foot, and 1·34 C for a length of 3 feet.

Ed and Tom Group. This group of fourteen claims, at the southwest end of Martin Lake, is owned by Basalt Uranium and Exploration Company Limited. The claims are underlain by basalt and arkose of the Athabasca series, at the south end of a plunging syncline. The strata are crossed by at least three faults. A sample sent to the Mines Branch showed 6·45 C, and was reported to be "a general sample taken in a long narrow draw where the vein enters into the muskeg on Claims Ed 7 and Tom 2".

EE-1 Concession. The south part of concession EE, about 5 miles north of Beaverlodge Lake, is held by Goldfields Uranium Mines Limited. The area is underlain chiefly by gneiss, with bands of mafic rocks. At Neely Lake, a prospect shaft was sunk several years ago on claims then held by Borealis Syndicate. Alcock (1936, p. 32) describes quartz veins containing pyrite at this locality.

Prospecting in 1950 is reported to have found thirty-one radioactive occurrences in gneiss. No visible pitchblende was found, but one sample showed 0·20 R.

Emar Group. This large block of claims, staked by Eldorado Mining and Refining (1944) Limited, extends easterly for about 3½ miles, from the southeast end of Mickey Lake to the west end of Raggs Lake. The claims are underlain mainly by reddish granite-gneiss, with inclusions of amphibolite and chlorite schist. The St. Louis fault crosses the group diagonally for a distance of 2 miles. North of this fault are two mineralized zones, the more westerly being called the "Donaldson" and the other the "Love"; the Donaldson is considered the more important, and although only partly explored, the results of this work have been promising.

The Donaldson fracture zone is up to 400 feet wide and has been traced for about 10,000 feet. It lies subparallel to the St. Louis fault and about 1,000 feet north of it. Christie and Keston (1949, pp. 25-26) describe the zone as follows:

"The rock of the fractured zone contains brick-red, hematite-stained feldspar, with shreds of green chlorite, the interstices between the feldspar grains being filled by white carbonate. Quartz is typically missing, or is present in only minor amounts.

"Pitchblende, accompanied by hematite, occurs most commonly with carbonate gangue as stringers and lenses along shears, minor faults, and tension fractures, which are in general subparallel with the St. Louis fault. Quartz stringers and veins occur in this area, but are not abundant. They strike about north 80 degrees west, dip vertically, and contain euhedral crystals of quartz. Three of these quartz veins are known to be radioactive. Many calcite-filled fractures cut across the pitchblende-mineralized fractures and are not themselves radioactive. It is considered that much calcite was introduced after the formation of the pitchblende-bearing veins."

Mineralization has been found at intervals for a length of about 3,500 feet along the fractured zone, which has been explored by more than 3,000 feet of diamond drilling. The best results to date have been within a length of 250 feet.

The main showing on the Love zone is about 300 feet north of the St. Louis fault, near the northwest end of Christie Lake. It is called the Christie Lake showing in some reports. A shear zone parallel with the St. Louis fault crosses reddish granite-gneiss and contains carbonate and small amounts of pitchblende. The zone was explored by 2,862 feet of diamond drilling, but results were not encouraging.

FF-1 Concession. The south part of FF concession is owned by Goldfields Uranium Mines Limited. It lies immediately northeast of Fredette Lake, and about 5 miles north of Beaverlodge Lake. The Black Bay fault extends through the centre of the holding, separating gneissic rocks from strata of the Athabasca series. The area that is underlain mainly by gneissic rocks also contains quartzite, mafic rocks, porphyry, and diabase dykes. This area is crossed, in an easterly direction, by a fault called the Emir fault, which appears to be a branch of the Black Bay fault.

About fifty radioactive occurrences were found in the part of the property lying west of the Black Bay fault. Eleven of these were considered by the company to be worth exploring, and several of the showings were trenched. To date, this has resulted in two main showings, called the No. 3 and No. 4.

The No. 3 showing is reported to be a pitchblende-bearing fracture zone associated with the Emir fault and traced for a length of about 250 feet. Three grab samples are reported to have shown: nil, 6·90 R, and 8·24 R. Several other showings, containing pitchblende associated with chalcopyrite and graphite, are reported to have been found along the Emir fault.

The No. 4 showing is described by K. R. Dawson (unpublished report) as a zone of subparallel fractures in quartzite in the hanging-wall of the Black Bay fault. The fractures are reported to occur over a width of about 25 feet, within 30 feet of the Black Bay fault. The zone is reported to have been traced for a total length of 500 feet, with visible pitchblende in pods up to ½ inch wide occurring at intervals for a length of about 150 feet. The pitchblende is accompanied by calcite and a little chalcopyrite, pyrite, and specularite. Thirteen samples reported by the company ranged from nil to 6·68 R.

Goldfields Uranium Mines Limited consider this to be their most important concession, at least on the basis of present showings. Plans for exploring the principal discoveries by diamond drilling, in 1951, have been reported.

F. F. F. Concession. Great West Uranium Mines Limited acquired a group of claims, called the Tuck group, north of Camsell Portage. In 1950, this company applied for, and received, a concession to include these claims and adjoining territory. A discovery was apparently made on the Tuck group in 1949, as analyses indicating 0·02 C, 0·05 C, 0·26 C, 4·06 C, and 23·07 C were reported during that year, but no notification or description of the deposit was received. The company is believed to have done additional work in 1950, because reports of radiometric tests indicated 0·34 R, nil, and 0·14 R.

Fish Hook Bay Group. This group, consisting of forty-seven claims staked by Eldorado Mining and Refining (1944) Limited, is at Fish Hook Bay of Lake Athabasca. The claims are about 3 miles east of Goldfields. They adjoin the Nicholson property to its north and east, and were the first claims explored by the Eldorado company in the Lake Athabasca region.

The claims are underlain by a succession of beds of ordinary quartzite, ferruginous quartzite, dolomitic quartzite, dolomite, siliceous iron formation, and dolomitic iron formation. Many of these rock-types grade one to another. The beds generally strike northwest and dip 30 to 50 degrees southwest.

Surface prospecting resulted in discovery of two hundred and seventy-eight separate radioactive anomalies, visible pitchblende being found at about 15 per cent of these localities. Pitchblende forms lenses and pods in fractures, mainly in dolomitic rocks. The main zones, called the "A", "B", and "C", extend along the main valley of Fish Hook Bay in a direction slightly west of north, about parallel with the strike of the strata. Another zone, called the "Hacker", is at the east side of the bay. Discoveries known as the "Joe" showings lie between the Nicholson property and the entrance to Fish Hook Bay. The several showings on the Fish Hook Bay group have been explored by about forty trenches and 20,825 feet of diamond drilling.

The "A" zone, the most southerly of the main showings, lies along the west shore of the "hook" of the bay, and consists of a vertical shear zone that crosses the dip of beds of siliceous and dolomitic iron formation. The zone has been traced for about 400 feet, and another showing roughly on strike lies about 1,200 feet to the northwest. The "A" zone contains carbonate and a minor amount of chlorite. The chief metallic mineral is hematite, with minor pitchblende and chalcopyrite, and traces of pyrite and galena. An iron-vanadium mineral has also been found.

The "B" and "C" zones underlie a depression that extends from the north end of Fish Hook Bay to the east side of a small lake called Fish Hook Lake. This depression is underlain by a zone of brecciated quartzite and dolomitic quartzite, cemented by hematite and carbonate, which has been traced by trenching and diamond drilling for a total length of about 2,500 feet. In the more southerly, "B", zone pitchblende has been found mainly along the hanging-wall of the brecciated zone, whereas the mineralization of the "C" zone is mainly along the foot-wall. Pitchblende is accompanied by major amounts of niccolite and cobalt-nickel arsenides, with minor arsenopyrite, in a small parallel zone along a contact between quartzite and dolomite about 700 feet west of the south end of the "B" zone.

The Hacker zone occurs in quartzite, and has been traced for a length of about 300 feet. The radioactive mineral here has been identified provisionally as uraninite, as opposed to pitchblende, by Robinson (1950, p. 8) who described the mineralization as follows: "In the Hacker vein the mineral [uraninite] occurs as a swarm of minute grains, some of which show cubic outlines, in ragged bands of biotite, which are found in a rock composed mainly of quartz but also containing similarly ragged bands of chlorite that are devoid of uraninite. The rock may well be a product of hydrothermal alteration. In the same deposit, chalcopyrite and arsenopyrite are found in chlorite, with which traces of carbonate are also associated; however, no association of these minerals with uraninite was observed".

The main 'Joe' showing is a carbonate zone containing hematite and pitchblende, with traces of chalcopyrite, pyrite, and native gold.

The principal zones on the Fish Hook Bay group contain significant amounts of uranium, the following intersections being quoted as examples: 0·31 C (3·0 feet); 0·72 C (3·0 feet); 0·46 C (5·0 feet); 0·247 C (25·0 feet); and 0·433 C (7·0 feet). Unfavourable features are the amount of carbonate, the degree of alteration, and the distance from the main operations of the Eldorado company near the north end of Beaverlodge Lake. Exploratory work was suspended to allow the company to concentrate its activities on other deposits, but the deposits at Fish Hook Bay may demand further attention.

Gil Group. The Gil group of Eldorado Mining and Refining (1944) Limited consists of thirteen claims along the shore of Lodge Bay of Lake Athabasca, and extending across the narrow ridge that separates that lake from Beaverlodge Lake. The claims are underlain by a succession of beds of quartzite, belonging to the Tazin group, and basic sills now altered to amphibolite.

The following description of the occurrences is by Christie and Kesten (1944, pp. 21-22); no subsequent exploratory work has been done on the claims.

"Several veins containing pitchblende occur in the amphibolite. All occupy minor fractures or weak shear zones a few inches wide striking approximately north 70 degrees east. Although these fractures are very minor features, some of them can be traced for remarkable distances along strike, one being 1,200 feet long.

"The veins show rough banding, and in places contain vugs. Brecciation is common, with carbonate and a minor amount of euhedral quartz filling the spaces between the wall-rock fragments. Carbonate is everywhere present in these veins. Wherever pitchblende occurs, the carbonate is stained deep red-brown, a colour probably due to hematite, which everywhere accompanies the radioactive minerals. The pitchblende may occur as small veinlets cutting the carbonate, in small (up to 5 mm.) rounded or angular masses within the carbonates, or as nodular masses adjoining the carbonate veinlets. It is invariably accompanied by hematite, and generally by minor amounts of disseminated chalcopyrite and bornite. (Copper selenide minerals and native copper in small amounts were later identified by Robinson (1950, p. 29).)

"All the pitchblende found in the area occurs within the amphibolite masses. None has been found in the quartzite. In the case of the long mineralized fracture south of Henry Lake, which crosses from amphibolite to quartzite and to amphibolite again, hematite and pitchblende occur where amphibolite is the wall-rock but not where the wall-rock is quartzite. This is true also in a small vein west of Seaberg Lake, where the quartzite inclusion is relatively small.

"As the evidence seems to show that the radioactive minerals occur only in the amphibolite in this area, the thickness of the sills in which the veins occur is important. Unfortunately, diamond drilling has shown that the sills in the vicinity of the showings are less than 50 feet thick and are separated from other thin sills by great thicknesses of quartzite."

G. G. Concession. This concession is held by American Canadian Uranium Mines Limited. Its south end is 3 miles north of Beaverlodge Lake. It is underlain partly by granite-gneiss and mafic rocks of the Tazin group, and partly by conglomerate and arkose of the Athabasca series. Systematic prospecting was begun in 1949, when seventy-nine radioactive occurrences were reported to have been found. This work was continued in 1950, when several additional discoveries were made. Most of the occurrences are believed to be unimportant, but at least one was considered worth further work. It is an occurrence of visible pitchblende in a fault zone in granite. It is reported to have been exposed for a length of 15 feet, and to have possibilities of extending farther in each direction. Six samples are reported to have shown 0·18 C to 1·17 C.

Hab Group. This group of six claims was staked by Eldorado Mining and Refining (1944) Limited about a mile north of Donaldson Lake. The claims are underlain by quartzite, chlorite-epidote rocks, and granite-gneiss.

Radioactivity was found at thirty-three places, the main showings being a group of shear zones containing quartz, chlorite, and a little carbonate, and also pitchblende, thucholite, hematite, and a little pyrite. Pitchblende is most abundant where the shear zones cross bands of chlorite-epidote rock. The main shear zones form a zone that has been traced for 700 feet in a northeasterly direction parallel with the regional structural trend.

The group has received preliminary diamond drilling for assessment purposes, totalling 1,202 feet. Although low-grade mineralization was encountered in several of the holes, it is not considered sufficiently important to interfere with other work of the company and, consequently, no further exploration is planned for the immediate future.

H. W. Group. This group of nine claims is owned by Mr. H. Walberg of Goldfields, and is optioned to Baska Uranium Mines Limited. The claims are immediately west of the Eagle group held by the Eldorado company. The H. W. group is underlain partly by granite and granite-gneiss, with inclusions of chloritic mafic rocks, and partly by conglomerate and arkose of the Athabasca series. Twenty-eight radioactive occurrences are reported to have been found in the parts of the property underlain by granite-gneiss and mafic rocks. Some of these are near a fault, called the Edie fault, which extends into the property from the Eldorado claims. The following descriptions of the seven principal showings are summarized from a report by Mr. G. C. McCartney.

The No. 1 and No. 1A showings comprise several radioactive fractures in an area about 200 feet long and 50 feet wide, underlain by granite-gneiss, with chloritic inclusions. Pitchblende in seams up to ¼ inch wide was found at two places.

The No. 7 showing consists of several fractures in granite-gneiss, exposed in two pits 25 feet apart. The fractures form a zone 4 feet wide. Samples showed 0·05 C (3½ feet); 0·06 C (1½ feet); and 0·04 C (2½ feet).

The No. 9 showing is a fracture zone up to 20 feet wide, exposed for a length of 180 feet. It occurs in granite-gneiss. The results of six chip samples ranged from nil to 1·35 C (4 feet). Grab samples from six trenches showed 1·68 C, 0·02 C, 0·075 C, 0·015 C, 3·30 C, and 0·255 C.

The No. 11 showing consists of a mineralized fault that separates granite-gneiss from chloritic mafic rock. It is exposed in two pits 25 feet apart, and consists of gouge with fragments of calcite and patches of uranium stain. Samples of the gouge showed 0·12 C (6 inches) and 0·90 C (6 inches). Cross-fractures near the fault also contain uranium stain.

The No. 12 showing consists of a series of radioactive anomalies over a length of 200 feet. They are about 200 feet south of the No. 11 showing and may represent fractures related to it.

The No. 21 and No. 22 showings are radioactive anomalies along the probable extension of the Edie fault.

Jam Group. Cinch Lake Uranium Mines Limited hold this group of eight claims, west of Martin Lake. The company reported that three showings had been found on the Jam No. 1 claim. One of these was reported to have been exposed for a length of 28 feet, with five samples showing 2·0 R to 12·5 R. Two samples from another occurrence showed 8·2 R and 12·3 R. A sample from the third occurrence indicated 0·08 R. A picked composite sample from the three showings indicated 19·0 C. The radioactive mineral is probably pitchblende.

Jam and Maj Group. This group, which lies between Eagle and Ace Lakes, was formerly owned by Eagle-Ace Uranium Mines Limited. Late in 1950, a new company called Nesbitt-LaBine Uranium Mines Limited was formed to take over this group and the A B C group. The claims are underlain mainly by granite-gneiss and mafic rocks of the Tazin group, these rocks being cut by at least three faults.

Prospecting in 1949 resulted in thirty-eight discoveries, and forty-five additional ones were reported in 1950. Most of these contain pitchblende, in fractures near one or other of the faults mentioned above. The main showings are in two parts of the property, one near the southeast corner of Eagle Lake, and the other about 5,000 feet to the east.

The showings near Eagle Lake are related to two northeasterly trending faults about 550 feet apart. The more westerly one cuts mafic sediments, and the other is near the contact between these rocks and granitic rocks that lie to the east. Twenty-six radioactive fractures have been found between these two faults, within an area extending northeasterly for 1,800 feet. Most of these fractures are about perpendicular to the faults; therefore, they form a 'ladder-work', with some of the fractures extending from one fault to the other and others discontinuous. In addition, about ten radioactive fractures have been found on the west side of the more westerly fault. The widths of the fractures range from ½ inch to 2 feet, and visible pitchblende occurs in places for widths up to 4 inches. This group of fractures forms a fairly compact series of veins, which the company proposes to explore from a prospect shaft. Results of grab samples reported by the company are up to 25·65 C.

The main showings on the eastern part of the property consist of two parallel fractures, about 30 feet apart, in chlorite schist and granitic rocks. This zone was stripped for about 400 feet, and it has been traced at intervals by radioactivity for about 800 feet farther. The fractures vary in width from narrow cracks to a few inches. Visible pitchblende was reported to have been obtained from a few places while the showings were being stripped; none was seen by the writer, but readings with a Geiger counter indicated that it is probably present.

K.K. Concession. This concession is held by American Canadian Uranium Mines Limited. It lies in the eastern part of the Goldfields region, south of Prince and Alces Lakes, and is underlain mainly by granite-gneiss, quartzite, and mafic rocks. Prospecting in 1950 is reported to have resulted in the discovery of three radioactive showings. One of these is reported to be pegmatitic, and the other two to be radioactive fractures in granite-gneiss. One of the latter was traced for a length of 80 feet, showing visible pitchblende in places; a sample from this occurrence was reported to have indicated 0·18 C.

L.L. Concession. This concession, held by Northern Uranium Limited, is at the east side of Black Bay of Lake Athabasca. Six radioactive occurrences are reported to have been found on this holding; the most important one, called the Gulch showing, is described as comprising three pitchblende stringers in altered volcanic rocks, within an area 300 by 500 feet. A 25-pound sample sent to the Mines Branch showed 3·76 C, 0·26 ounce in silver a ton, and a trace of gold. Twelve samples sent to the Mines Branch showed radioactivity ranging from 0·14 R to 14·06 R; five of these were analysed chemically and showed 0·13 C to 15·0 C. Pitchblende, thucholite, chalcopyrite, and pyrite were identified in one of the samples.

M.M. Concession. This concession, held by Goldfields Uranium Mines Limited, extends from the west end of Prince Lake to the middle of Alces Lake. It is underlain by granite, gneiss, and altered quartzite and mafic rocks. Much of the granite is pegmatitic. The concession is astride a fault that is believed to be the eastern continuation of the St. Louis fault. The concession was prospected systematically in 1950, and thirty-nine radioactive occurrences were reported to have been found. Most of these were pegmatite deposits that were not considered important, but five occurrences of probable hydrothermal origin were classed by the company as worth further work. Three of these are reported to be in a probable shear zone, near and parallel with the St. Louis fault; these occurrences form a zone traced at intervals for 1,900 feet. Thirteen grab samples from them gave results ranging from nil to 2·58 C. Visible pitchblende was not found in this zone, but it was found in one other occurrence.

Murphy Group. This group, between Cinch and Martin Lakes, was formerly held by the Eldorado company, who abandoned the claims in favour of Einer Larum. Carbonate and pitchblende were found at four places in fractures in basalt of the Athabasca series, the largest being 40 feet long and a few inches wide.

Neiman Lake Occurrence. The Neiman Lake Uranium Prospecting Syndicate reported a discovery from the vicinity of Neiman Lake, about 25 miles northeast of Goldfields. The occurrence was described as being along the contact of a basic dyke with granite, and a selected sample sent to the Geological Survey showed 0·67 R.

Nicholson Group. The property of Nicholson Mines Limited is at the north shore of Lake Athabasca, 2 miles east of Goldfields. The showings on the property contain complex mineralization, and were explored first for their copper content in 1930 (Alcock, 1936, pp. 36-37). Further work was done in 1935 because of the gold content of the deposits. Alcock examined the property at that time, and reported that pitchblende was found at two places. A company called J. D. Nicholson Mines Limited was formed in 1936. About that year, the main showing was explored by two adits, with underground work totalling about 350 feet, interest then being chiefly in gold. No work was done for several years thereafter, but the claims were retained by the company. In 1947 the company was reorganized as Nicholson Mines Limited, a subsidiary of Transcontinental Resources Limited. Trenching and diamond drilling were done in 1948, two shafts were sunk in 1949, and underground exploration was done on the main vein throughout 1950.

The claims are underlain by dolomite, dolomitic quartzite, and ferruginous quartzite breccia, of the Tazin group. These strata have been intruded by a basic sill that is altered to amphibolite. The rocks are folded steeply. A pronounced depression that strikes northwest, in the northwestern part of the property, may mark a fault or shear zone, but overburden prevents study of this feature.

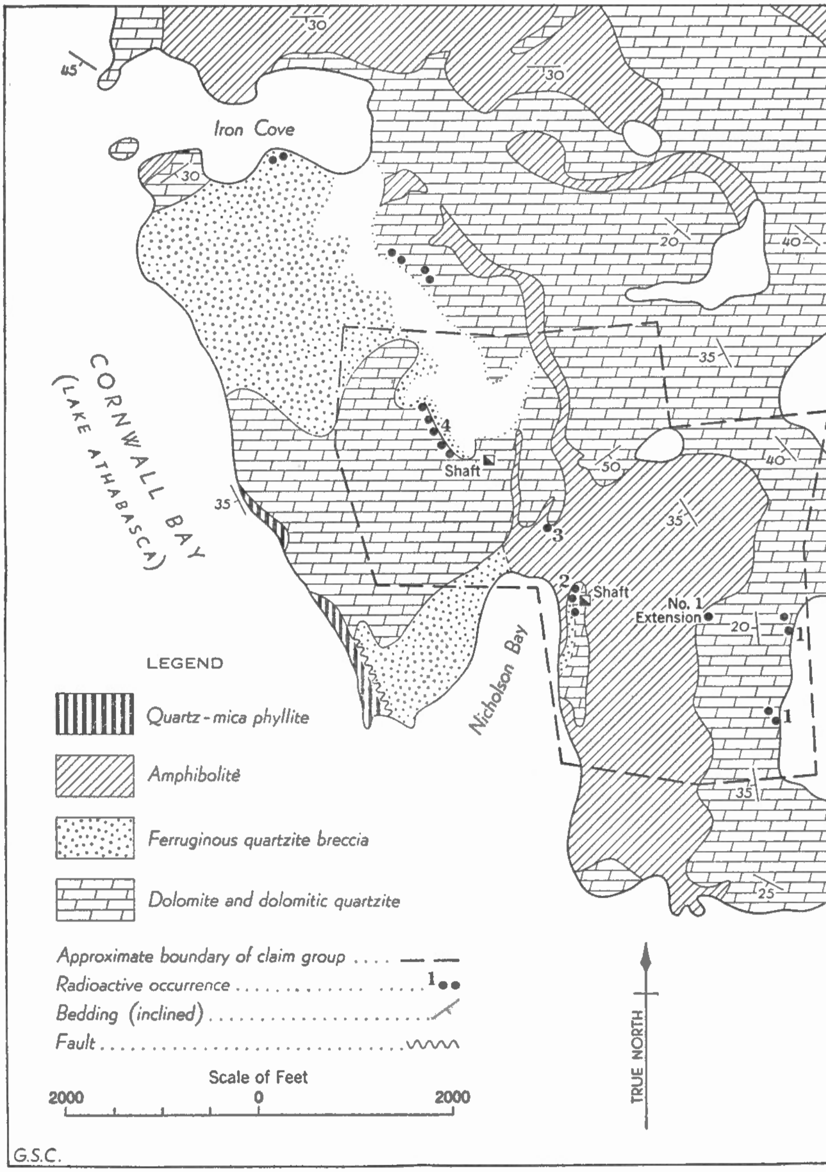


Figure 14. Sketch-map showing geology and locations of radioactive zones on property of Nicholson Mines Limited, Saskatchewan. Geology after A. W. Jolliffe. Boundary of claim group shown approximately.

Four separate deposits were found during early work on the property; these are numbered 1 to 4. An additional radioactive deposit, called the No. 1 extension, was found in 1949. The No. 4 appears to be the most important, and has received most attention.

The No. 1 zone is on the Jim claim, at the east side of the property. It is a vein up to 10 inches wide, in quartzite; it strikes north 64 degrees west and dips 45 degrees northeast. It is a carbonate vein containing pitchblende, sulphide minerals, and cobalt bloom. The length of the vein is not apparent from the surface showing. Another showing that is grouped with the No. 1 lies about 800 feet north of it, but it is not on strike. The two showings were explored by seven short diamond drill-holes, but results were inconclusive.

The showing called the No. 1 extension was detected through overburden, about 1,500 feet northwest of the No. 1 and the same distance east of the No. 2. Stripping revealed a radioactive zone at a contact between quartzite and ferruginous quartzite. It is exposed for a length of about 25 feet and may extend farther. The width of the most radioactive part seems to be about 8 feet, but this is uncertain because cracks may contain secondary uranium minerals over a greater width than that of the primary deposit. Surface sampling showed significant amounts of uranium across widths of up to 6 feet, the highest assay being 1·84 C for a width of 1½ inches. This sampling also showed up to 0·20 ounce in gold, and 14·34 ounces in silver, a ton. No primary minerals have been identified.

The No. 2 zone is at a contact between quartzite and ferruginous quartzite breccia, about 200 feet east of the head of a small bay called Nicholson Bay. The zone strikes north, dips vertically, and was traced on surface for 180 feet. It is to 1½ feet wide, and consists of several *en échelon* shears and fractures. It contains carbonate, pitchblende, specular hematite, and small amounts of sulphide and arsenide minerals; sampling indicated the presence of gold and platinum. Tiemannite (HgSe) and dyscrasite (Ag_3Sb) were identified by Kaiman in samples from this zone. A shaft was sunk to explore this zone in 1949, and 565 feet of lateral work was done on the 100-foot level. Short sections were well mineralized with pitchblende, but in general the results were disappointing and work at this shaft was suspended.

The No. 3 zone is a copper showing, 600 feet north of the head of Nicholson Bay, at a contact between amphibolite and dolomitic quartzite. Uranium stain was seen in places, and pitchblende has been reported, but no work has been done recently on this part of the property.

The No. 4 vein begins about 1,400 feet northwest of the head of Nicholson Bay and strikes north 30 degrees west, dipping almost vertically. It lies at a contact between dolomitic quartzite and ferruginous quartzite breccia, and is exposed along a steep hillside, which forms the southwest side of the depression mentioned above as possibly marking a fault. Early work consisted of trenching and two short adits 30 and 60 feet respectively below the outcrop; both adits encountered the vein, and the lower one also penetrated a cavern in dolomitic rock.

In 1948, old trenches on the No. 4 vein were cleaned and new ones were dug, with the result that the zone is exposed at intervals for a length of about 1,100 feet. The 'break' is straight, and appears to be continuous, although the mineralization occurs in lenses up to 3 feet wide. A test shipment of sorted material from the trenches and the upper adit was sent to the Eldorado refinery, and payment was made for high contents of uranium, gold, and silver. The vein was also explored by diamond drilling in 1948, but core recovery was poor.

In 1949, a shaft (*See* Plate IV B) was sunk to a depth of 232 feet near the No. 4 vein; lateral work was done on the 100 and 200 levels, and this was continued in 1950. During the early stages of lateral work, great difficulty was experienced because of strong flows of water from vugs and caverns, but this water was finally drained. By the end of 1950, underground work on the 100 level consisted of the following: crosscutting, 613 feet; drifting, 913 feet; raising, 66 feet; slashing, 346 tons. On the 200 level it consisted of: crosscutting, 712 feet; drifting, 628 feet; raising, 130 feet; and slashing, 714 tons. The upper level encountered a shoot that is reported to have an average width of 3·8 feet, and an average grade of 0·38 C and 0·23 ounce in gold a ton. Under this shoot, on the 200 level, is a body with an average width of 6 feet, reported to average 0·47 C; drifting along a branch fracture nearby encountered a short mineralized body 5 feet wide, which is reported to average 3·75 C.

The No. 4 vein consists chiefly of carbonate, with quartz as a second gangue mineral. Hematite, pitchblende, rammelsbergite, and other cobalt-nickel arsenides are the principal metallic minerals; minerals occurring in smaller amounts are thucholite, chalcopyrite, arsenopyrite, galena, pyrite, and sphalerite (Robinson, 1950, p. 29). At the surface and on the upper level, the vein is banded, and has the appearance of having been deposited in open, brecciated zones. On the lower level, however, the vein is massive, showing evidence of having been formed at least partly by replacement.

The shoots encountered on the 100 and 200 levels are of good width and grade, and they are fairly long, but where evidence of mineralization is lacking, there is little evidence of an unmineralized 'break'. The discovery of a second shoot in an unexpected place on the lower level suggests that other branching or *en échelon* bodies may exist. Work to date has shown a substantial amount of material of good grade, but the tonnage suggested above the 200 level is insufficient to justify the building of a treatment plant. The company has announced plans for deepening the No. 4 shaft and exploring on two additional levels, with the hope of establishing enough ore for that purpose.

N.N. Concession. This concession, which is north of Black Bay of Lake Athabasca, is held by Goldfields Uranium Mines Limited. It is underlain mainly by granite and gneiss, with bands of mafic rocks. Systematic prospecting is reported to have resulted in the discovery of seventy-one radioactive occurrences, chiefly pegmatitic. Six showings were considered by the company to be worth further work; several of these contain pitchblende, molybdenite, arsenopyrite, and pyrite. One showing is reported to have been traced for about 350 feet, and two representative samples from it are said to have shown 1·36 R and 1·49 R. The other principal showings are near Fold Lake, in the northeastern part of the concession; there pitchblende is reported to have been found in an area on the south limb of the main fold, extending from the Heron fault to Long Lake. Trenching and diamond drilling were begun in 1950.

Nubar Group. A group of claims north of Cornwall Bay of Lake Athabasca was held formerly by Roybar Uranium and Gold Mines Limited. This company was recently reorganized as Nubar Mines Limited. Systematic prospecting in 1949 resulted in discovery of six radioactive anomalies. Two of these were at the intersections of depressions that may mark faults or shear zones. The following descriptions of the main showings have been condensed from a report by Mr. G. C. McCartney.

The No. 1 zone is a band of chlorite-biotite schist 1 foot wide and exposed for a length of 100 feet. Four samples representative of the full 1-foot width showed 0·03 C to 0·20 C, and a grab sample showed 0·44 C.

The No. 2 zone is exposed at the face of a cliff that is believed to mark one side of a fault. Here a bed of altered sedimentary rock, 3 to 12 inches thick, shows radioactivity for a length of about 250 feet, and contains uranium stain in places. A sample containing uranium stain showed 0·07 C.

NW-GC-Lee Group. This group of twenty-four claims, southeast of Ace Lake, is held jointly by Athona Mines Limited, Goldcrest Mines Limited, and Greenlee Mines Limited. The north boundary of the group is about half a mile south of the St. Louis fault, and the claims are underlain mainly by granite, gneiss, quartzite, and mafic rocks. Prospecting in 1949 revealed numerous radioactive occurrences, with visible pitchblende at ten of them. Considerable stripping and trenching were done on several of the more important showings.

The B-4 showing consists of a zone of irregular fractures in chloritic rock. The fractures contain quartz and uranium stain, but no visible pitchblende was noted. Sampling by the owners indicated 0·12 C across a width of 14·2 feet, and a sample chipped by the writer across the same width showed 0·15 R. It is difficult to estimate the possible length of the zone because it is exposed at the side of a cliff. The B-5 showing, 185 feet to the west, could be an extension of the B-4; visible pitchblende was noted at B-5, and grab samples are reported to have shown up to 1·90 C across narrow widths. The B-12 showing is exposed for 85 feet in a narrow fracture, from which channel sampling indicated 0·41 C across 3 feet.

The C-1 showing is a zone of fractures immediately north of a fault that has been traced for 350 feet. The zone contains three radioactive fractures, one of which is reported to carry visible pitchblende. The management reported that sampling of the main trench on this zone showed an average of 1·138 C across a width of 19·1 feet; and that sampling of a second trench 30 feet away showed an average of 0·615 C across a width of 4·4 feet. A bulk sample from the C-1 showing was reported to contain an average of 0·91 C. Tests made on this sample at the Mines Branch showed that it contained much secondary material, but that the unaltered material appeared to be well suited to concentration.

The C-3 showing lies in a shear zone explored by two trenches 40 feet apart. Three channel samples, taken across 1·7 feet at a part of No. 1 trench where pitchblende was noted, were reported to have averaged 0·82 C.

Pal Group. This group, west of Mackintosh Bay of Lake Athabasca, is held by Mr. J. G. Paulsen, whose address is Alberta Hotel, Edmonton, Alta. A sample sent by Mr. Paulsen showed 0·098 R, and was described as being from a vein 8 feet wide.

Pitch, Blende, and Hope Group. This group, about a mile north of St. Joseph's Point of Lake Athabasca, was staked by Athona Mines Limited, American Yellowknife Gold Mines Limited, and Goldcrest Mines Limited. Prospectors for these companies found about twelve radioactive occurrences. The main one is a shear zone 4 feet wide, trenched for a length of 45 feet. At one place it contains a pitchblende-bearing fracture 2 inches wide and 2½ feet long. Eight chip-panel samples taken by the geologist in charge yielded results ranging from nil to 0·096 R. After further prospecting in 1950, the claims were relinquished.

Pitche Group. This group of ten claims is at the southwest corner of Beaverlodge Lake, within the former B. B. concession, which has been cancelled. The claims were staked in 1950 by Messrs. R. Tamblyn and P. Bloomstrand, of Goldfields. The claims are underlain chiefly by quartzite, but the showings are in sericite schist, graphite schist, and a rock that appears to be intrusive basalt. The showings are near the intersection of two lineaments that probably represent faults or shear zones.

The two main showings consist of two subparallel shear or fracture zones about 100 feet apart, which strike northwest and are nearly vertical. They have been trenched at intervals for total lengths of 100 and 250 feet. They were not sufficiently exposed at the time of the writer's visit to permit proper estimate of widths, but the widths appeared to be 1 foot to 2 feet. The zones contain quartz, considerable pyrite, and some uranium stain, but no visible pitchblende was noted. Samples examined by S. Kaiman, of the Mines Branch, were reported by him to contain carnotite and two unidentified vanadium-bearing minerals. A sample chipped by the writer across 4 feet showed 0·30 R, and another, from a width of 1 foot, showed 0·16 R. Results of six samples analysed by The Consolidated Mining and Smelting Company ranged from 0·05 C to 0·8 C, and from 1·0 to 4·2 per cent V_2O_5.

Pitch-Ore Group. Pitch-Ore Uranium Mines Limited holds this group of twelve claims at the west side of Beaverlodge Lake, immediately south of the R. A. group of the Eldorado company. The R. A. group includes the Martin Lake operation of the Eldorado company. The Pitch-Ore claims are underlain by interbedded arkose and basalt of the Athabasca series. These strata are displaced by at least five faults. One main pitchblende-bearing zone, and two radioactive occurrences that have not yet been exposed to any extent, are associated with three of these faults.

The main, or No. 1, zone lies in a fault that, on its continuation, passes near the portal of the Martin Lake adit. Mineralization has not yet been found in the part of the fault within the Eldorado holdings. On the Pitch-Ore ground, twelve trenches have been opened along the fault, within a total length of 1,100 feet, and additional trenching has been done on several branch faults. Radioactivity was noted along the entire length, but some of this may result from fragments scattered by blasting. The main fault and several of the branches are mineralized in places with quartz, carbonate, hematite, pitchblende, and a little galena. Pitchblende appears to be confined to the sections where the wall-rock is basalt, and exploration has not yet been sufficiently detailed to indicate the exact lengths of the pitchblende-bearing shoots. Individual mineralized lenses exposed are only a few inches wide, but in places several such lenses or veinlets occur across total widths of 5 feet, and at one place, near the north end of the zone, several veinlets occur across a total width of about 25 feet. Numerous grab and selected samples taken by the management have given results ranging from 0·035 C to 45·79 C. The zone was explored by four short diamond drill-holes. Recovery was poor, but testing of the holes with a Geiger probe is reported to have shown strong radioactivity for widths of 5 feet in two holes.

The No. 2 showing is a radioactive anomaly at a fault about 2,000 feet west of the No. 1 zone. The No. 3 showing is at another fault, where a grab sample is reported to have shown 0·47 C.

P.P. Concession. This concession extends northeasterly from Black Bay of Lake Athabasca to LeBlanc Lake. It is held by Orbit Uranium Developments Limited. The concession is underlain mainly by granite, with which considerable pegmatite is reported to be associated, and by granite-gneiss. Bands of mafic rocks are said to occur in places. Several northeasterly trending lineaments may mark faults or shear zones. Systematic prospecting was begun in 1949, when eight pitchblende showings and forty-seven occurrences of radioactive pegmatite are reported to have been found. In 1950, a few additional showings were found, and exploratory work was done on several of the principal discoveries of that and the former year. The following descriptions of the main showings have been condensed from a report made by Mr. C. S. Johnston for the company.

The No. 2 zone is a pegmatite deposit near the shore of Black Bay. It is reported to be strongly radioactive for a width of 75 feet and a length of 200 feet. Results of sampling ranged from 0·25 C to 0·20 C.

The No. 3 zone, also near the shore of Black Bay, is considered the best one found to date on the concession. It is reported to contain four separate shear zones 1 inch to 8 inches wide, near, and approximately perpendicular to, a pronounced lineament that is believed to represent a fault. All four contain pitchblende, with hematite and carbonate, and one shear zone contains visible pitchblende at intervals for a length of 25 feet. Grab samples contained 2·42 to 26·24 C. Three additional showings of visible pitchblende were found in zone No. 3 late in the season of 1950. The zone was explored by seven short X-ray diamond drill-holes, and radioactivity was detected in some of the core.

Zone No. 4 is a belt of pegmatitic deposits about 8 miles northeast of Black Bay. Radioactive lenses are reported to be from 2 to 6 feet wide and from 50 to 200 feet long, occurring at intervals in a zone 125 feet wide and 3 miles long. Results of samples taken close to the surface were all below 0·10 C.

Zone No. 5 consists of three parallel shear zones, 6 to 24 inches wide, in mafic rocks. A selected sample showed 0·77 C. Zone No. 5A is a shear zone about 6 feet wide in mafic rocks, about ½ mile west of the No. 5. The shear zone contains, at one place, two stringers of material resembling thucholite, and four similar stringers occur at another place 400 feet to the west. Two X-ray diamond drill-holes were put down on the No. 5 zone, and two on the No. 5A.

Zone No. 6 is about 6 miles northeast of Black Bay. It is reported to be strongly radioactive for a length of 15 feet, and to appear to continue beneath a swamp; although no pitchblende was seen, it is believed to be a pitchblende deposit with the pitchblende weathered away at the surface.

Q.Q. Concession. This concession is held by Beta Gamma Mines Limited, who reported that several radioactive occurrences were found in 1950, chiefly in the northern part of the holding. No sampling was done in 1950, but the company reported that further work was planned for 1951.

R.A. Group. The R.A. group of Eldorado Mining and Refining (1944) Limited covers a strip of land about ½ mile wide and 2 miles long that separates the north ends of Martin and Beaverlodge Lakes, and the group also contains water claims extending eastward for about a mile to the boundary of the Ura group. Two small groups of claims called the Bar and Cab within this area are, however, held by other owners. The R.A. group contains the Martin Lake showings of the Eldorado company.

The ridge between Martin and Beaverlodge Lakes rises to about 300 feet above the level of the lakes, and is formed by rocks of the Athabasca series consisting of a succession of flows or sills of amygdaloidal basalt alternating with beds of arkose and sandstone. These strata dip 45 to 80 degrees to the west and are on the east limb of a broad syncline. The rocks are displaced slightly by several steeply dipping faults and shear zones. The most prominent ones strike north 60 to 70 degrees east, less-prominent ones strike north 30 degrees west, and minor faults, shear zones, and fractures strike in several other directions, as described below.

The Martin Lake showings are approximately on the theoretical southwestward continuation of the St. Louis fault, and the faulting with which these showings are associated is almost certainly related to the St. Louis fault, but the exact relationships are obscured by Beaverlodge Lake. The northeasterly trending faults at Martin Lake may represent a fingering of the St. Louis fault at its western limit, or the main fault may swing slightly northward and be marked by a depression that extends eastward from Martin Lake 4,000 feet north of the showings.

Many of the faults and shear zones contain carbonate, and both the wall-rocks and the carbonate are much stained by hematite. The carbonate vein-filling contains stringers and disseminations of pitchblende. Small amounts of copper selenides, native copper, bornite, chalcocite, covellite, chalcopyrite, clausthalite, and gold have been reported by Robinson (1950, p. 29) and Kerr (1950, p. 36).

Evidence of significant mineralization has been found only in basalt, which, near the showings, forms sills or flows from about 50 to 300 feet thick. Pitchblende-bearing stringers have been found only rarely in the intervening arkose or sandstone, which seems to have been physically less favourable for fracturing, as well as chemically less favourable as a host rock.

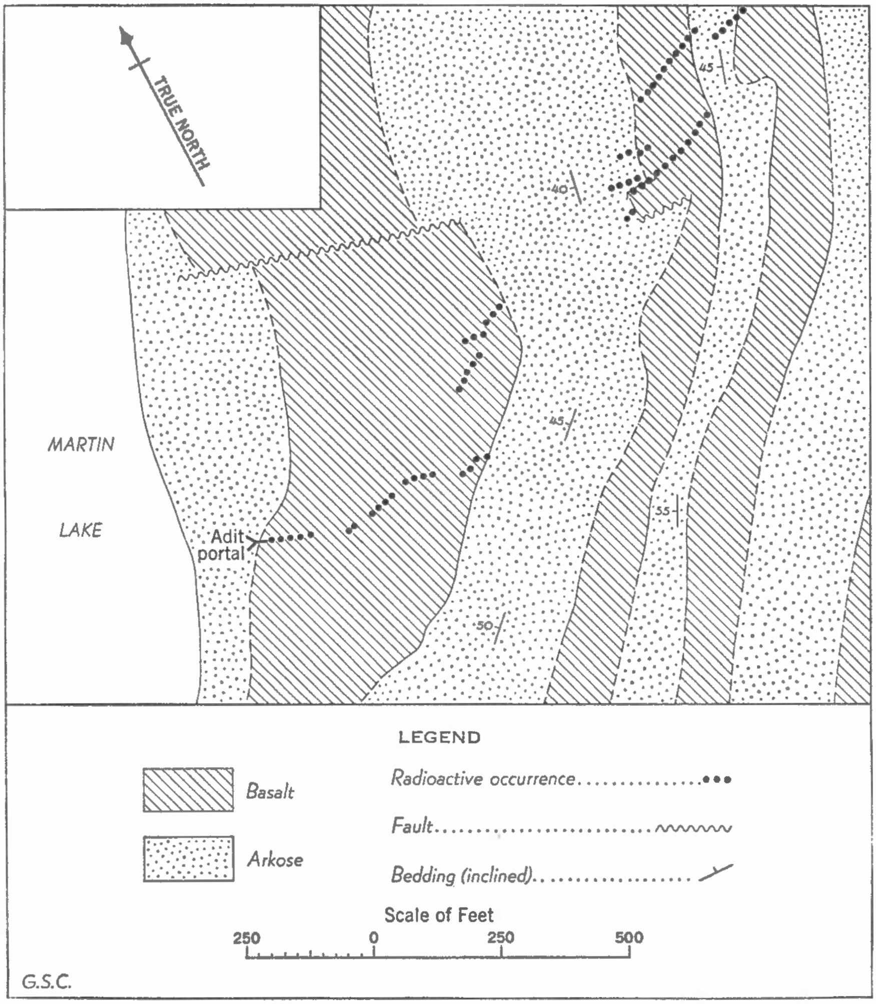


Figure 15. Geological plan of part of R.A. group, Lake Athabaska, showing position of Martin Lake showings and adit. From plan by Eldorado Mining and Refining (1944) Limited.

The deposits were studied in detail by R. B. Allen (1950, p. 436) who found that the main mineralized faults and shear zones have an average strike of north 68 degrees east and that shorter ones strike about north 85 degrees east. He states that the latter commonly occur as branching spurs along non-radioactive shear zones striking north 30 to 40 degrees east, thus forming *en échelon* zones.

After stripping and trenching had revealed evidence of possibly significant mineralization, an adit was begun in 1948 from a point near the shore of Martin Lake. About 3,000 feet of crosscutting and drifting and 200 feet of raising were done, as well as about 12,000 feet of diamond drilling from underground stations. One main mineralized block and several minor ones were partly outlined, but it

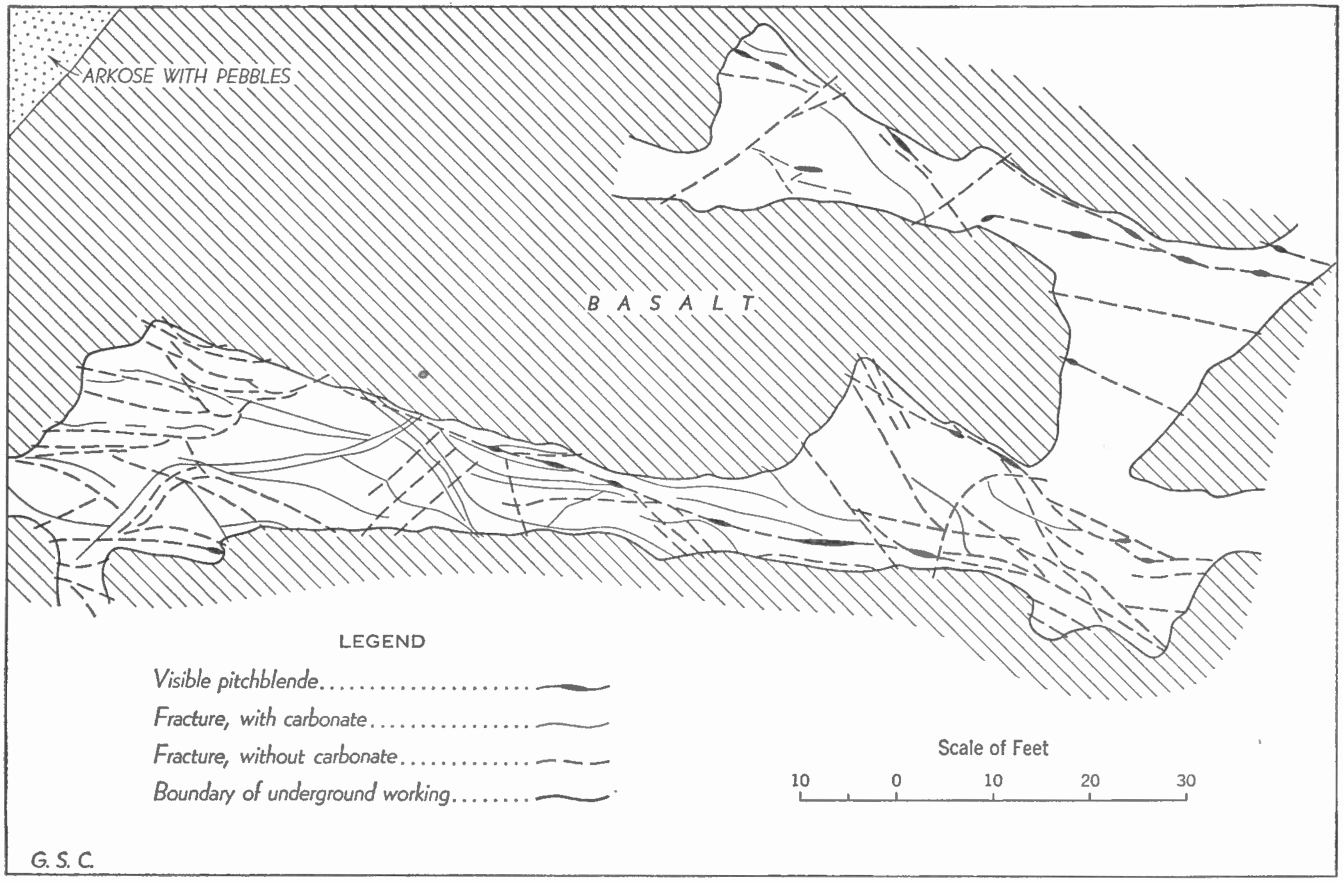


Figure 16. Plan of part of underground workings, Martin Lake showings. Many fractures are omitted, and occurrences of visible pitchblende are generalized. From plan by R. B. Allen, Eldorado Mining and Refining (1944) Limited.

is difficult to estimate sizes and average grades because of the irregularity of the stringers and the differences in grade that would be effected by mining selectively or by taking larger amounts of lower grade material. An unfavourable feature of the mineralization is the large amount of carbonate gangue. If the deposits are mined extensively, the adit may be continued through to the east side of the ridge, thus permitting entry at a point considerably nearer the Beaverlodge camp.

Rex, Cat, and Joe Group. This group, held by American Canadian Uranium Mines Limited, is near Bearcat and Melma Lakes, about 6 miles northeast of Goldfields. The claims are underlain by quartzite and mafic rocks, intruded by granite and pegmatitic granite. Prospecting is reported to have resulted in the discovery of one radioactive showing, 4 to 8 inches wide, in a narrow band of mafic rocks in quartzite. A grab sample is reported to have shown 0·44 C.

R.R. Concession. This concession, near the east end of Tazin Lake, is held by Athlodge Uranium Mines Limited. The concession is underlain mainly by granite and granite-gneiss, with several belts of amphibolite and chlorite-epidote rocks. The latter are reported to have been found only in a folded area south and east of Clarry Lake. Many narrow diabase dykes have been found. Several northeasterly and easterly trending faults have been mapped by the company. The most prominent one, called the Clarry Lake fault, is reported to have been traced for 2 miles eastward from Clarry Lake, and to be marked by fractured, hematitic carbonate rock.

The company reported that twenty-four radioactive showings had been found, and that at least seven appeared to warrant further trenching and sampling. The following descriptions of these seven showings are summarized from a report submitted by the company.

No. 3 showing consists of hematitic carbonate rock exposed for a few feet along the scarp of the Clarry Lake fault. A sample showed 0·05 R.

No. 7 consists of two parallel radioactive fractures in granite. They are 5 feet apart and have been stripped for lengths of 40 and 100 feet, and appear to extend farther in each direction. Weathered samples that contained considerable uranium stain in vugs showed 0·57 C and 0·63 C.

No. 9 consists of several showings in mafic rocks within an area 400 feet by 1,700 feet. The main showing contains three radioactive zones within a width of 30 inches; two grab samples each showed 0·06 R.

Showings 17 and 18 are about 300 feet apart, in a fault zone in amphibolite. They are strongly radioactive but have not yet been sampled. Showing 15 is a shear zone 900 feet west of No. 17, and 50 feet north of the above-mentioned fault. It strikes parallel with the fault, is 3 feet wide, and has been stripped for about 55 feet, with probable extensions at each end. It contains pyrite and a little chalcopyrite, sphalerite, and galena, with a gangue of quartz and feldspar. Grab samples of oxidized material showed 0·48 R and 0·55 R. Chip samples across widths of up to 3 feet gave results ranging from nil to 0·05 C.

No. 20 is a shear zone that probably represents a fault that joins the above-mentioned fault zone. It contains sheared granitic material, with bands of chlorite schist. A chip sample taken across 2 feet of weathered material showed 0·16 R.

S.S. Concession. The S.S. concession, which extends northeasterly from LeBlanc Lake, is held by Goldfields Uranium Mines Limited. It is underlain chiefly by granite-gneiss, with smaller amounts of mafic rocks and quartzite. Systematic prospecting in 1950 revealed one hundred and thirty-five radioactive anomalies. Most of these were in pegmatite, and only three were considered worth further work. One of these is described as a narrow seam of biotite at a contact between granite and quartzite; a length of 8 feet is exposed, showing quartz, pyrite, and a little molybdenite, but no visible pitchblende. Channel samples along a 50-foot length of the biotite-bearing seam, and widths of a few inches, gave results as follows: nil, 0·07, 1·6, nil, 0·08, 0·05, 0·18, 0·19, and 0·13 R. The two other showings are said not to exhibit visible pitchblende, but to be worth further work because of structural conditions. A sample of about 100 pounds of material from one of the last mentioned showings was sent to the Mines Branch. It was reported to consist of pegmatitic material containing much chlorite and a little molybdenite and chalcopyrite. Chemical analysis indicated an average content of 0·071 C.

Strike Group. This group consists of four claims located ½ mile northeast of Ace Lake. The claims are owned by Messrs. Alexander, Findlay, and Lonetti of Goldfields. The property is underlain by granite-gneiss, quartzite, and mafic rocks, and one basic dyke is exposed.

Eight radioactive occurrences were found on the property early in 1950. Seven of these are arranged at intervals in the pattern of an ellipse 700 feet wide and ½ mile long.

The No. 1 zone consists of three showings within a total length of 1,200 feet. Stringers and lenses of pitchblende occur at intervals and range in width from ½ inch to 3 inches. Channel samples across widths of 6 inches are reported to have given results ranging from 1·04 R to 16·85 R.

The No. 2 showing is a fracture up to 1 foot wide, containing hematite and some uranium stain, but no visible pitchblende. It is exposed for a length of 45 feet, with a possible extension to 150 feet. A grab sample is reported to have shown 0·45 R.

At the No. 3 showing, radioactivity is detectable along a cliff for a length of 90 feet. Visible pitchblende is exposed at one place, and a grab sample from here is reported to have indicated 1·44 R.

The No. 4 showing contains weathered radioactive material that has not been exposed in such a way as to permit an estimate of the size or character of the deposit. Three grab samples are reported to have indicated 0·05 R, 0·10 R, and 0·10 R.

The No. 5 showing is a radioactive fracture traced at intervals for a length of about 600 feet. Three channel samples are reported to have been taken across widths of 7, 5, and 12 inches, and to have indicated 0·50 R, 4·42 R, and 0·73 R respectively.

The No. 6 showing is a radioactive fracture traced at intervals for a length of about 300 feet. One part of this showing contains pitchblende at intervals for a length of 30 feet; two samples from this part, taken across widths of 5 and 6 inches, are reported to have shown 3·95 and 13·29 R.

The No. 7 zone consists of four parallel fractures, the main one being traced for about 50 feet. Visible pitchblende is said to have been found during trenching, but none was seen by the writer. Channel samples taken across 4, 8, and 3 inches are reported to have shown 4·74 R, 16·10 R, and 12·63 R respectively.

The East showing, in the southeastern corner of the property, was not visited by the writer. A radioactive zone containing a little uranium stain is reported to have been traced for about 250 feet.

Tazin Group. Tazin Mines Limited holds a group of claims comprising the former Murmac property, which adjoined the Box claims and which received exploration as a gold prospect several years ago. The ground was prospected for uranium in 1949, and one occurrence was found about a mile north of the head of Cornwall Bay. This showing was reported to have been traced for a length of about 150 feet. Six samples from claim J U 4 are reported to have shown results ranging from 0·03 C to 0·415 C. No further details regarding the deposit are known to the writer.

In 1950, it was reported that part of concession H.H., comprising an area of about 5 square miles, had been added to the Tazin holdings, and that further prospecting was done.

Tena Group. The Tena group of six claims is owned by Mr. A. McIver of Goldfields. This property is underlain mainly by granite and granite-gneiss. Four radioactive deposits were found on the Tena claims. The No. 1, which is regarded as the most important, consists of a series of pitchblende veinlets within a total length of 180 feet. Sampling of this zone is reported to have shown results up to 2·7 C for an average width of 1·1 feet. The No. 2 and No. 3 showings are reported to contain lenses of pitchblende at intervals for total lengths of 70 and 20 feet respectively.

T.T. Concession. This concession lies between Charlot and Nesbitt Lakes, and is held by Goldfields Uranium Mines Limited. It is underlain chiefly by granite and granite-gneiss, with smaller amounts of quartzite and mafic rocks. Fifty-six radioactive occurrences are reported to have been found by detailed prospecting, the principal ones being the Nesbitt Lake and No. 10 showings.

The Nesbitt Lake occurrence is described by Robinson and Dawson (personal communication) as a large zone of pegmatitic lenses, containing uraninite, pyrite, and molybdenite. Eighteen samples taken by the management in 1949 are reported to have shown contents ranging from 0·03 C to 1·10 C; the unweighted average of the samples is 0·361 C. In 1950 two zones were blasted and sampled for lengths of approximately 200 and 50 feet. Ninety-seven samples indicated an approximate grade of 0·07 R for a width of about 3 feet and a length of about 120 feet.

Showing No. 10 is reported to lie about 11,000 feet northeast of the north end of Nesbitt Lake, and to be a sheared contact zone containing rust and uranium stain. No visible pitchblende was found, but deep overburden prevented adequate exposure of the showing. The company considers it worth diamond drilling.

Ura Group. The Ura group of Eldorado Mining and Refining (1944) Limited forms a block 1½ miles square at the north end of Beaverlodge Lake. It includes the main camp of the company, and is bounded to the west by the R.A. group, and to the east by the Ace group. The claims are underlain partly by quartzite, amphibolite, and chloritic rocks of the Tazin group and by granite-gneiss. These rocks are, in places, overlain by arkose and conglomerate of the Athabasca series. The St. Louis fault crosses the claims for a distance of at least a mile, and also probably extends under the part of the property that is covered by Beaverlodge Lake. The first discoveries on the group were called the Ura showings. Later, other discoveries called the Fay zone and the Ace Creek showing were found.

The Ura showings consist of a zone of fractures in Athabasca conglomerate, about 1,000 feet south of the St. Louis fault. The zone strikes parallel with the fault, is from 50 to 200 feet wide, and has been traced for about 2,000 feet. It contains carbonate-pitchblende veins up to 8 inches wide and 300 feet long that conform with the strike of the zone and dip 65 degrees southeast, and, also, networks of small radioactive quartz stringers. The zone was explored by trenching and by six diamond drill-holes totalling 1,447 feet. The latter encountered encouraging intersections, the best being 0·15 C for a length of 30 feet, but these results are inconclusive, and it is suspected that the mineralization may not extend into the rocks below the Athabasca series.

The Fay zone is in rocks of the Tazin group close to the foot-wall of the St. Louis fault, and it strikes parallel with the fault. It does not outcrop, because of overburden, and was found during systematic diamond drilling of the rocks near the fault, in the hope of encountering mineralization analogous to that found on the Ace group. The zone has been explored for a length of 1,200 feet, and forty-eight intersections of good-grade material have been obtained, together with much material of lower grade. The mineralization is very similar to that of the Ace orebodies. Drilling has not been sufficiently closely spaced to prove continuity, but the results are considered sufficiently important to cause the company to decide to commence a new, large shaft in 1951, near the east end of the zone. This shaft is planned to serve as the main production opening for both the Ace and the Fay zones.

The Ace Creek showing is at the south side of the creek about ¾ mile above its mouth. It is in mafic rocks of the Tazin group, which are granitized in places, and which lie about 2,000 feet southeast of the St. Louis fault. A shear zone strikes north 73 degrees west and dips steeply northeast, shows hematitic alteration for a width of 4 to 5 feet, and also contains carbonate. Pods of pitchblende up to an inch wide have been found in places across a width of 2 feet and for a length of 25 feet.

White Dog Group. This group, owned by Mr. C. E. Cody of Goldfields, is at the north shore of Lake Athabasca about 5 miles east of Goldfields. A zone that contains an unusual type of pitchblende shows strong radioactivity for a length of about 600 feet (S. C. Robinson, personal communication). A sample from this property is reported to have shown 0·28 R.

Wolf Group. This group is 2 miles north of Lake Athabasca and about 7 miles east of Goldfields. It is owned jointly by Athona Mines (1937) Limited, Goldcrest Mines Limited, and Greenlee Mines Limited. The claims are underlain by quartzite and granite-gneiss, intruded by gabbro and diabase. A radioactive zone was found along a contact between quartzite and gabbro, for a length of about 200 feet. A plan submitted for the owners shows that seven trenches were placed along the zone, and that assays ranging from 0·04 to 0·63 C were obtained from samples taken from widths of 3 to 12 inches. Visible pitchblende was reported to occur in one trench.

W.W. Concession. This concession, held by Baska Uranium Mines Limited, is an irregularly shaped area lying north and south of the Emar group of the Eldorado company, and between the H.H. and M.M. concessions. The W.W. concession is underlain by granite, granite-gneiss, quartzite, and mafic rocks. Eleven radioactive occurrences have been found in the southwestern part of the concession, most of them being near two parallel faults about 4,000 feet south of the St. Louis fault. The following descriptions of the main showings have been condensed from a report made by G. C. McCartney for the company.

The No. 1 showing is exposed in eight trenches at 20-foot intervals in feldspathized quartzite. The showing consists of several fractures that contain minute particles of pitchblende. Two samples taken across widths of 2 feet showed 0·04 C and 0·05 C, and one sample taken across 6 inches showed 0·84 C.

The No. 2 showing consists of three fractures in feldspathized quartzite. The fractures contain pitchblende stringers up to ⅛ inch wide. A grab sample showed 4·40 C; a sample taken across a width of 0·8 foot showed 1·75 C; and a sample chipped across 6 feet showed 0·07 C.

At the No. 3 showing, uranium stain occurs in places in quartzite and mafic rocks across a width of 10 feet. A sample taken across 1 foot of this zone showed 0·10 C. The showing is only 250 feet from the No. 2, and it is thought that further work may reveal that the two showings are part of a single zone.

The No. 4 showing consists of two radioactive fractures in feldspathized quartzite. The fractures are at one side of a lineament that may mark a fault. The No. 7 showing is a fracture occurring along the same lineament and in the same type of quartzite as the No. 4. The No. 7 fracture has been traced for a length of 80 feet. Minute particles of pitchblende were found at one place, and a sample taken across 6 inches showed 1·15 C.

The No. 11 showing is a carbonate vein 6 inches wide, in quartzite and mafic schist. It has been trenched at intervals for a length of 150 feet. A sample taken across 6 inches showed 0·10 C.

Y.Y. Concession. This concession is west of Lodge Bay of Lake Athabasca and south of Beaverlodge Lake. Part of it is bounded by the Gil group of the Eldorado company. The concession is held jointly by American Yellowknife Gold Mines Limited, Athona Mines (1937) Limited, Goldcrest Mines Limited, and Greenlee Mines Limited.

The concession is underlain chiefly by quartzite, amphibolite, and granite. The holding was prospected in 1949 and 1950; many radioactive occurrences were found, mostly in the northeastern part of the property. Pitchblende was found in several of the showings, but only one was considered worth extensive trenching. This zone contains four veins, up to 2 feet wide, in granite, quartzite, and amphibolite. They contain carbonate, hematite, and pitchblende, the last forming pods up to about 2 inches wide in places. A sample sent to the Mines Branch was found to contain an iron mineral identified tentatively as hydro-goethite. The veins in this zone are called "B", "H", "J", and "K". The B vein has been exposed for a length of 35 feet, and pitchblende has been found at intervals for the entire length. Mr. N. W. Byrne reported for the owners that extensive sampling had showed an average grade of 1·32 C for an average width of 2·1 feet. The H vein has been exposed for 44 feet; it is, strictly speaking, a zone of up to seven parallel pitchblende-bearing fractures. Mr. Byrne reported that sampling of this zone showed an average of 2·13 C for an average width of 2·3 feet. The J zone contains two parallel fractures about 7 feet apart, bearing visible pitchblende in lenses up to 3 inches wide. The fractures have been exposed for lengths of 20 and 44 feet. Mr. Byrne reported that sampling of one fracture showed an average of 1·46 C for a width of 1·6 feet, and that systematic sampling of the other fracture had not yet been done. The K vein was not seen by the writer, but is reported to be a fracture in amphibolite, close to a contact with quartzite, and to contain a carbonate stringer an inch wide carrying pitchblende in a streak ⅛ inch wide. A channel sample across 3 inches is reported to have shown 1·43 C.

A bulk sample sent to the Mines Branch, believed to have been a composite sample from showings B, H, and J, had an average content of 1·7 C.

Z.Z. Concession. This concession, held by American Canadian Uranium Mines Limited, extends northeasterly from Murmac Bay of Beaverlodge Lake. It is underlain chiefly by granite-gneiss, quartzite, and mafic rocks. A lineament that may represent a fault extends northeasterly through the concession. Systematic prospecting resulted in discovery of four radioactive occurrences, two of which are reported to be pegmatitic. No visible pitchblende was found.

FOND-DU-LAC REGION

The Fond-du-Lac region, at the east end of Lake Athabasca, has been described by Alcock (1936) and Mawdsley (1949). The region is underlain mainly by gneisses of the Tazin group, intruded by granite and norite. Deposits of gold, copper, and nickel were explored unsuccessfully several years ago, and data on these occurrences can be found in the reports cited above. Mawdsley (1949, p. 33) states that a Geiger counter was carried during his mapping, but that no indication of radioactive minerals was noted. Four concessions were granted in this region recently, but radioactive discoveries have been reported from only one, which is described below.

Sucker Bay Concession. This concession, about 20 miles east of Fond-du-Lac, is held by Goldfields Uranium Mines Limited. Systematic prospecting in 1950 is reported to have resulted in the detection of radioactivity at fourteen places. Two of the occurrences are described as pegmatitic, and the others as fracture fillings. Two of the latter were considered worth exploring, and this was done on one, called the S B No. 1 showing. It is reported to have been traced for more than 300 feet by trenching, and investigated by eight diamond drill-holes averaging 80 feet in length. Two are reported to have provided good assay results, and the others revealed only weak radioactivity when tested with a drill-hole counter. Samples from the surface are reported to have shown 0·48 R, 0·80 R, and 0·13 R.

STONY RAPIDS-PORCUPINE RIVER REGION

This region lies almost immediately east of the east end of Lake Athabasca. Barges from that lake travel up Fond-du-Lac River to the small settlement and Hudson's Bay post at Stony Rapids, and a road has recently been built from there to Black Lake to aid the exploration of the Nisto property. Travel elsewhere in the region is by canoe or aircraft. Most travellers now reach the area by air from Prince Albert or Goldfields.

The region was mapped geologically by G. M. Furnival in 1939 (Geological Survey Maps 658A and 659A). The geology of the part of the region near Black Lake was studied by M. E. Hriskevich (1949), and another section near Charlebois Lake was studied by J. B. Mawdsley (1950). The region is underlain mainly by gneisses and schists of the Tazin group, and by granitic rocks, which at many places form 'hybrid' rocks by injection into the sedimentary complex. Conglomerate and sandstone of the Athabasca series outcrop in the southern part of the region. Perhaps the most prominent geological feature of the region is the Black Lake fault, which extends northeasterly along the shore of that lake, and beyond. A lineament that appears to mark the continuation of this fault extends northeastward for many miles in Saskatchewan and the Northwest Territories, part of its course being marked by a long stretch of Dubawnt River. At least part of the movement along the Black Lake fault occurred after the deposition of the Athabasca sediments, for diamond drilling at the Nisto property has shown the fault there dips about 60 degrees northwest, and that Athabasca sediments form the foot-wall. The northwest side seems definitely to have moved upward with respect to the southwest side, in the manner of a thrust fault; Hriskevich states (1949, p. 14) that drag-folds suggest that there may also have been a horizontal component, with the northwest side moving to the southwest. Several less prominent faults have been found in the region, and, in addition, there are lineaments that may mark faults.

Pitchblende was found at what is now the Nisto property, in 1948. As a result, several concessions were granted by the Saskatchewan Department of Natural Resources. Many claims have also been staked, and much prospecting has been done. Although a few other pitchblende occurrences have been found, they appear to be small. Pitchblende mineralization on the scale found at the Nisto property does not seem to have been duplicated in the region, but much of the territory near the Black Lake fault and elsewhere is covered by overburden, which may conceal pitchblende deposits. Many deposits of radioactive pegmatite have been found, chiefly in the vicinity of Charlebois Lake. Some of these, which are not typical granite pegmatites, contain important amounts of fine-grained uraninite. Some of these deposits are fine-grained granite pegmatite or coarse granite, containing concentrations of biotite, and others are injection gneisses or migmatites, consisting of bands of pegmatite and biotite schist. The size and uranium content of the more promising of these may warrant further investigation, probably in the form of diamond drilling, bulk sampling and concentration and extraction tests.

A Concession. This block, comprising 6¼ square miles immediately northeast of the Nisto concession, is held by Black Lake Uranium Mines Limited. Prospecting in 1950 was reported to have resulted in discovery of nine occurrences, all near the Black Lake fault. Four were reported to be of the Nisto type, but finding of pitchblende was not mentioned. Three samples were reported to have shown 0·035 C, 0·305 C, and 0·47 C.

Alpha Group. This group, in the Charlebois Lake region, is held by Mr. E. F. Partridge of Prince Albert, Sask. Eight samples, said to be representative of large bodies of pegmatitic material, showed 0·067 R, 0·092 R, 0·087 R, 0·026 R, 0·094 R, 0·081 R, 0·13 R, and 0·10 R.

Art Group. This group of seven claims is owned by The Consolidated Mining and Smelting Company of Canada Limited. The claims are at the east side of the south bay of Charlebois Lake. The showings consist of biotite schist and pegmatite; one is massive pegmatite, but the three main zones are 'migmatites'. The most radioactive material appears to be biotite schist. The radioactive mineral is probably uraninite, because it occurs at nearby properties, but this could not be confirmed because the specimens taken by the writer from the Art group were lost. Two of the zones were trenched extensively in 1950.

The No. 1 zone has been exposed for a length of 110 feet. Channel sampling by the company is reported to have shown an average of 0·12 C for an average width of 4·6 feet. This included samples from one trench on a parallel zone 20 feet to the west of the main one. The No. 2 zone is exposed by one trench, from which a channel sample across a width of 16·5 feet is reported to have shown 0·12 C. The No. 3 zone has been trenched at intervals for a length of 75 feet; two additional trenches to the southwest failed to reveal a continuation of the zone. Channel samples representing a length of 75 feet showed an average of 0·18 C across a width of 6·2 feet. A grab sample from the No. 4 showing is reported to have shown 0·10 C.

Bell Group. This group of eleven claims, held by Mr. E. F. Patridge of Prince Albert[1], is about 600 feet south of the south end of Charlebois Lake and about 1 mile south of the showings on the Art group. A zone of pegmatite and biotite schist, found at intervals for a length of about 2,500 feet, follows the approximate boundary between granitic and schistose rocks mentioned earlier in this report. Much stripping and trenching have been done, but it is not yet possible to determine the dimensions of the individual, more radioactive, sections within the general zone, which in places is up to 11 feet wide. The most radioactive parts appear to be parallel zones ranging in width from 1 inch to 2½ feet. Uraninite has been identified in samples, and it seems to be most abundant near concentrations of biotite. Seventeen samples submitted by Mr. Partridge gave results ranging from 0·077 R to 0·58 R, and two others showed 0·26 C and 0·64 C. Two samples taken by J. B. Mawdsley showed 0·44 R and 0·59 R. A sample taken by the writer from the main zone in the 'A' trench showed 0·24 R. Mr. Partridge reported that another showing consists of a shear zone 4 feet wide, in sedimentary schist; and that a grab sample containing material resembling thucholite showed 1·61 R.

Butch Group. This group was staked by Mr. F. MacAskill near the mouth of Carp River, 4 miles east of Stony Rapids. Hriskevich (1949, p. 23) states that a veinlet of pitchblende a few feet long was found near the contact of a basic dyke with metamorphosed sedimentary rocks of the Tazin group. Samples from these claims, sent to the Ontario Department of Mines, showed 0·001 R, 0·01 R, and 0·31 R.

Corrigan-Stinson Group. This group is near the junction of Porcupine and East Porcupine Rivers, about 30 miles northeast of Black Lake. Hriskevich (1949, p. 25) reports that a belt of biotitic quartzite about 5 miles long and a

[1] This property is now held by Charlebois Lake Uranium Mines Limited.

mile wide is surrounded by granite and is, locally, intimately injected by granite and pegmatite. Two zones in this 'migmatite' are of variable width and have been traced for about 150 and 400 feet.

D. Concession. This concession, owned by Black Lake Uranium Mines Limited, covers the probable northern extension of the Black Lake fault and begins about 20 miles north of Black Lake. According to geological maps, the holding is underlain by gneissic rocks of the Tazin group. Traversing at 300-foot intervals in 1949 is reported to have resulted in two radioactive discoveries. One is described as an occurrence of biotite-gneiss, from which a grab sample showed 0·045 C. The other is described as a radioactive zone detected for a length of 2,600 feet. Stripping and trenching along 650 feet of this zone is reported to have revealed three lenses of sulphide-bearing quartz with an aggregate length of 215 feet and widths of about a foot. Three samples are reported to have shown 0·03 C, 0·05 C, and 0·06 C.

Erickson Occurrence. A sample submitted by Mr. F. Erickson of Stony Rapids, Sask., from a locality near Fond-du-Lac River about half a mile west of Stony Rapids, showed 1·06 R. Mr. Erickson also reported that a sample sent to the United States was found to contain monazite.

Fisher-Haydukevich Group. This group, also called the Discovery group, is at the west side of Pluto Bay of Black Lake. It is held by Fisher Uranium Company Limited. Hriskevich (1949, p. 23) reported that the property contains sedimentary gneisses intimately injected by dykes and sill-like masses of granite and pegmatite, and the radioactive occurrences consist of three irregular pegmatitic lenses having widths of up to about 15 feet and lengths up to 120 feet.

A similar occurrence is reported to have been staked by Messrs. Fisher and Haydukevich at the east side of Pluto Bay half a mile south of Pluto Point.

G. Concession. This concession, at the northwest corner of Black Lake, is held by Mr. E. F. Partridge of Prince Albert, Sask. It lies along the east side of the supposed extension of the Black Lake fault, and two faults parallel with it have been mapped by Hriskevich, who states (1949, p. 25) that irregular masses of pegmatite occur in granitized sediments and sheared gabbro. A shear zone about a foot wide, in radioactive pegmatite, is reported to be strongly radioactive, to contain much biotite, and to have been traced for about 20 feet. Samples submitted by Mr. Partridge from this property showed 0·03 R, 0·04 R, and 0·48 R; and from nil to 0·08 C. A sample taken by J. B. Mawdsley showed 0·32 R.

M. Concession. This concession, which is west of the Nisto concession and north of Fond-du-Lac River, was held by Athona Mines Limited, American Yellowknife Gold Mines Limited, Discovery Yellowknife Mines Limited, Goldcrest Mines Limited, Greenlee Mines Limited, and Northland Mines Limited. It is underlain chiefly by biotite-hornblende gneiss. Prospecting in 1949 is reported to have shown that a fault may extend westerly across the concession from the vicinity of the Nisto showings. Six anomalies were found near this supposed structure, and the two most promising ones were trenched. This work revealed that the radioactivity is probably associated with biotite in the gneiss; samples gave results ranging from a trace to 0·46 C. The concession was abandoned by the above-mentioned companies in 1950.

MacArthur-Anderson Groups. Two groups of claims were staked by Messrs. L. MacArthur and R. Anderson, one near the entrance to Pluto Bay and the other at the east end of the bay. Both groups are stated to contain exposures of abnormally radioactive granite, and the eastern group contains several lenses of radioactive pegmatite containing molybdenite (Hriskevich, 1949, p. 25).

M.L.U. Group. This group of eight claims, 2½ miles west of Higginson Lake and about 6 miles north of Black Lake, is owned by Dee Explorations Limited. The claims are surrounded by a concession, called Dee concession, which is held by the same company. Radioactivity surveys were made for the company on both the group and the concession in 1950. According to plans submitted by the company, the property is underlain chiefly by granite and granite-gneiss, but two large areas of injection gneiss, hornblende gneiss, and carbonate rocks lie at the east side of the property. The plans show three zones of radioactive pegmatite and related rocks; two of these, called the A and B zones, are on the M.L.U. No. 1 claim, near the contact between granitic rocks and one of the masses of injection and hornblende gneisses; the other, called the G zone, is near a similar contact near the east side of the concession. Samples from three parts of the A zone are reported to have shown 0·04 R, 0·07 R, and 0·24 R. Two diamond drill-holes, 38 and 74 feet long, were drilled on this zone; one hole showed radioactivity, but results from samples were not reported. Seven samples from the B zone gave results ranging from 0·02 R to 0·15 R, and twelve samples from the G zone gave results ranging from 0·01 R to 0·75 R.

Nisto Group. The Nisto property is at the west side of Black Lake, opposite Fir Island. Pitchblende was found here in 1948 by Messrs. Tobey and Albrecht, who were granted a concession extending 12 miles along the west shore of the lake. This concession was bought by Transcontinental Resources Limited in 1949, and a subsidiary company called Nisto Mines Limited was formed to explore the property. Stripping, trenching, and diamond drilling were done in 1949, and underground exploration by two adits was begun in 1950.

The showings are pitchblende-bearing fractures and shear zones in gneisses and other sedimentary rocks of the Tazin group, and in sills and dykes of gabbro that cut these rocks. The showings begin about 100 feet west of the Black Lake fault, which follows the lake-shore, and are on a hill about 100 feet above the level of the lake. As mentioned by Hriskevich, diamond drilling showed that the strike of the fault changes by about 10 degrees, and the showings occur close to this bend in the fault.

The showings are in an area 500 feet wide and 2,500 feet long, extending northeast along the west side of the Black Lake fault; the main ones are in a smaller area about 250 feet wide and 1,200 feet long, within the larger area. Individual shear zones and fractures strike in one of three directions: some tension fractures strike northwest and dip about vertically; some fractures and shear zones are about parallel with the fault, and dip steeply; others are diagonal to the fault, and dip steeply. Most have widths of a fraction of an inch to 6 inches, and a few shear zones are up to 2 feet wide. Some of the fractures and shear zones are short, but several are more than 100 feet long, and one has been traced for about 600 feet. Eight principal zones have been found, most of which contain several mineralized fractures or shear zones, some parallel and others branching.

Mineralization consists chiefly of quartz, hematite, and pitchblende, with a little chalcopyrite, pyrite, and galena. Cobaltite and stibnite have been identified doubtfully. Pitchblende occurs as disseminations and in fairly pure masses that have been reported to be up to 3 inches wide; those seen by the writer were up to 1½ inches wide, but wider examples were doubtless removed as specimens. The larger masses are lenticular, but some fractures are radioactive for long distances. Red alteration of wall-rocks is not conspicuous. In some of the zones pitchblende tends to be more abundant where the wall-rocks are gabbro, but this is not always the case (Hriskevich, 1949, p. 21).

Detailed sampling of the surface showings was done by the management, who reported that, by adding together the results from fifteen separate zones, a total length of 1,730 feet was estimated to have an average width of 2½ feet

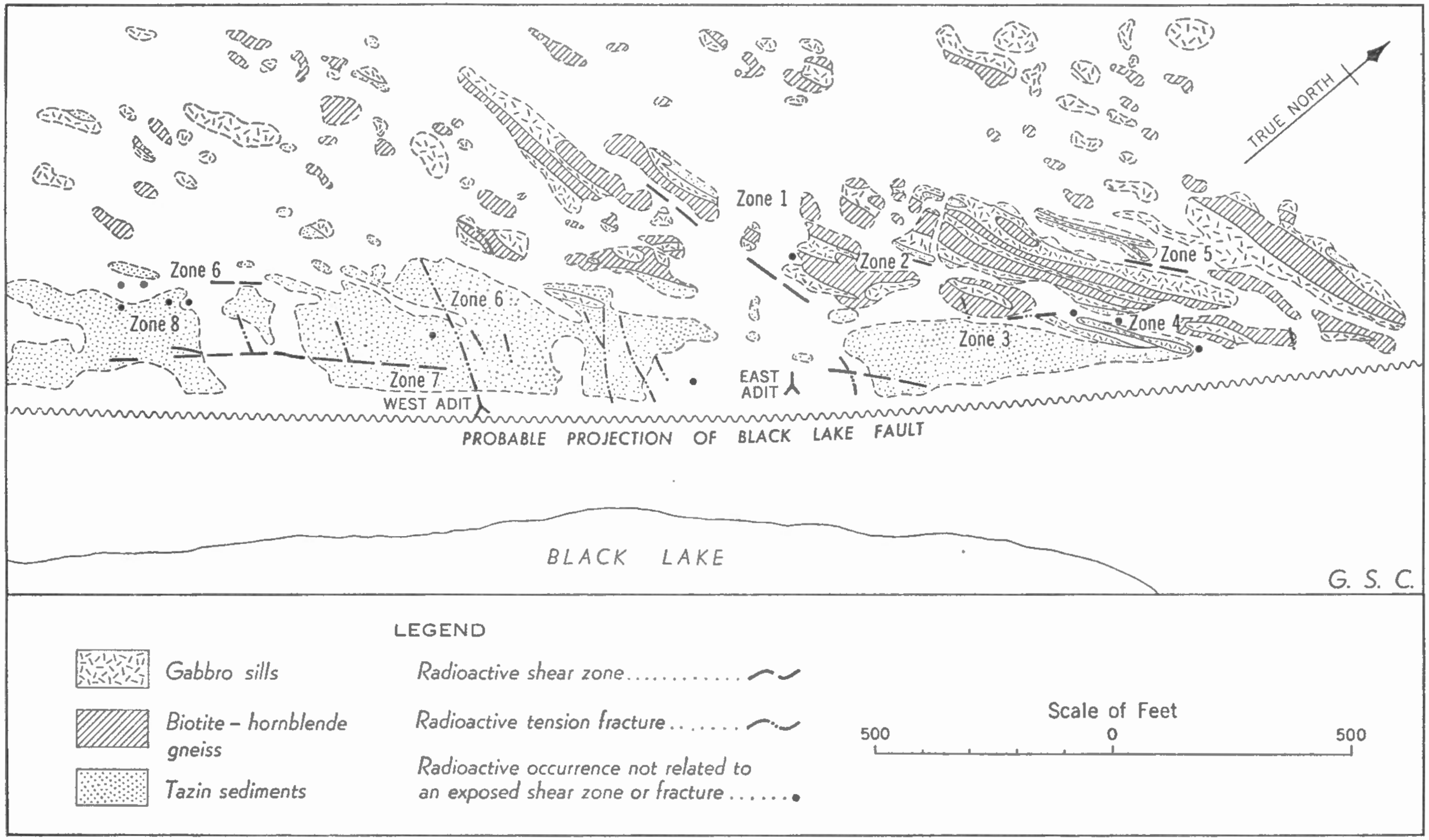


Figure 17. Geological plan showing surface occurrences and adits, Nisto property, Black Lake, Saskatchewan. After plans by Nisto Mines Limited and M. E. Hriskevich.

and an average grade of 0·256 C, after allowing for 10 per cent dilution. Concentration tests were not conclusive because the material tested was from the surface and contained much secondary mineralization.

In 1949, 8,738 feet of diamond drilling was done, chiefly from stations near the lake-shore. Many holes obtained radioactive intersections, but drilling was not entirely satisfactory because of core losses and because it was difficult to drill zones that contained veins and stringers striking at angles to one another. It was decided, therefore, to explore the zones from adits, and two of these were begun in September 1950. The west adit is planned to explore the Nos. 6, 7, and 8 zones, but these had not been reached by the end of the year, when about 480 feet of drifting and crosscutting had been done. Much of this work explored a vein called the B cross-fracture, which was encountered near the portal; a 25-foot length of this vein is reported to have shown an average of 0·18 C for a width of 2·4 feet. The east adit is planned to explore the Nos. 1, 2, and 3 zones. About 380 feet of underground work was done in this adit by the end of 1950, when it was reported that the No. 1 and No. 2 zones had been intersected and that some drifting had been done on them. A 30-foot length of the No. 1 zone was reported to have shown an average of 0·30 C for a width of 2½ feet, and a 14-foot length of the No. 2 zone was reported to have shown an average of 0·80 C for a width of 2·4 feet.

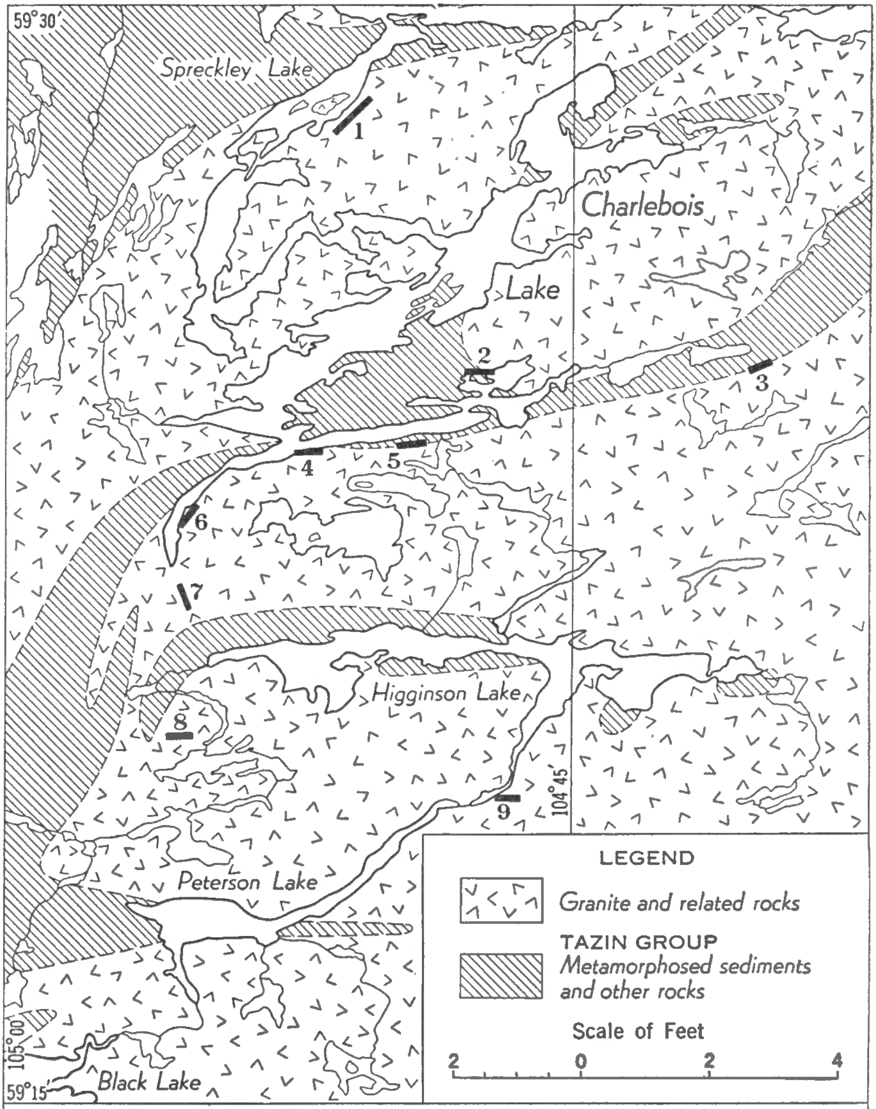
Rapids Group. This group, owned by The Consolidated Mining and Smelting Company of Canada, is immediately southeast of the rapids between Peterson and Higginson Lakes, 8 miles northeast of Black Lake. Results of fourteen samples reported in 1949 ranged from 0·05 C to 0·3 C, and five others were below 0·05 C. A plan submitted by the company shows that a zone extending southeast from Higginson River has been trenched at intervals for 330 feet. The zone is understood to be pegmatitic. A 50-foot length of this zone was reported to have shown an average of 0·10 C for a width of 4·2 feet, by channel sampling. A 140-foot length in another part of the zone was reported to have shown an average of 0·35 C for a width of 4·7 feet.

Rio Group. This group, staked by Dee Explorations Limited, is at Pinkham Lake, about 30 miles northeast of Black Lake. A radioactive pegmatite dyke was reported to have been found near the shore of the lake, and eleven samples were reported to have shown 0·03 R to 0·45 R. Samples taken in 1950 were reported to have indicated 0·030 C and 0·066 R.

Row Group. This group of nineteen claims at the south shore of Charlebois Lake is held by Arctic Yellowknife Mines Limited.[1] A zone of sheared pegmatitic rock containing much biotite is reported to have been traced along a contact between granitic and sedimentary rocks for a length of 1,700 feet. Trenching in places was reported to have shown that the zone has a width of 7 to 8 feet. Samples totalling 134 pounds, sent to the Mines Branch, showed an average of 0·098 R, and four additional lots, of 75 pounds each, showed 0·04 C, 0·04 C, 0·16 C, and 0·20 C. Work done at the Mines Branch on the four 75-pound samples showed that the material contained much biotite and some molybdenite, uraninite, and thorianite; and that the uraninite was associated with the biotite. Gravity-concentration tests gave poor results.

Arctic Yellowknife also hold a group called the Mike group, 6 miles east of the Row group. Here a radioactive zone is reported to have shown high anomalies for a length of 1,200 feet, along the continuation of the contact occurring on the Row group. It is understood that none of the samples mentioned above came from this group.

[1] This property is now held by Charlebois Lake Uranium Mines Limited.



INDEX TO DEPOSITS

1. Spreckley Lake group, Dee Explorations Limited; **2. M.C. group, 3. Mike group, 4. Row group,** and **5. Sun group,** Charlebois Lake Uranium Mines Limited; **6. Art group,** The Consolidated Mining and Smelting Company of Canada Limited; **7. Bell group,** Charlebois Lake Uranium Mines Limited; **8. Corrigan group,** Dee Explorations Limited; **9. Rapids group,** The Consolidated Mining and Smelting Company of Canada Limited.

G.S.C.

Figure 18. Sketch-map showing generalized geology, Charlebois Lake region, Saskatchewan, after G. M. Furnival, 1939. Also shows locations of deposits diamond drilled in 1951.

S.K. Group. This group, held by Mr. S. K. Hansen of Yellowknife, and Mr. J. Campbell, is ½ mile north of Peterson Lake and about 5 miles northeast of Black Lake. It is reported to contain a pegmatitic zone 20 feet wide and traced for about 1,000 feet. Two samples showed 0·20 C and 0·46 C.

Souter River Group. This group, in the Charlebois Lake region, is held by Mr. E. F. Partridge of Prince Albert, Sask., who reported that a zone averaging 9·3 feet wide has been stripped at 25-foot intervals for a total length of 1,050 feet. Six samples, described as representing large bodies of pegmatitic material along a sheared contact in metamorphosed sediments, gave results ranging from 0·026 R to 0·71 R. Five samples taken by J. B. Mawdsley gave results ranging from 0·023 to 0·170 R.

Spreckley Lake Group. Dee Explorations Limited hold a group of twenty-eight claims at the south bay of this lake, which is in the Charlebois Lake region. The company reported that radioactivity had been detected in rocks that have some of the characteristics of granite, pegmatite, and migmatite, which occur near the contacts of bodies of granite that intrude sedimentary gneisses. The pegmatites and related rocks are reported to have been traced at intervals for about 4 miles. They are said to contain much biotite, in small bunches and larger streaks, individual flakes being up to 1½ inches in diameter. Molybdenite and zircon are common, and chalcopyrite, pyrite, and pyrrhotite are found sparingly. The company reported that the radioactive material occurs in fine grains in close association with biotite, and is thought to be uraninite.

The company reported that a scintillometer survey of the northern 8,000 feet of the zone indicated that radioactivity was almost continuous for this distance, but that some places showed only low radioactivity. The rest of the zone could not be surveyed before the end of the season. Forty-one chip-channel samples of fresh material were reported to have been taken from the northern 5,500 feet of the zone, two samples being taken across a width of 2 feet and the remainder across 1 foot; these represent only parts of the total width of the zone. The results of radiometric tests range from 0·029 R to 0·540 R, and the results of beta and gamma tests agree fairly closely, suggesting that most of the radioactivity is caused by uranium.

LAC LA RONGE REGION

The Lac la Ronge region is in the southern part of the Canadian Shield. The settlement of La Ronge, on the west shore of a fairly large lake of the same name, is the northern terminus of a highway that extends northward for 180 miles from Prince Albert. Some parts of the region are readily accessible from La Ronge by canoe or small boat, and other parts require portaging or travel by aircraft. Saskatchewan Government Airways has a base at La Ronge.

The region is underlain mainly by ancient Precambrian schists and gneisses, with some altered volcanic rocks, quartzite, and crystalline limestone, and by granitic rocks with which much pegmatite is associated. Considerable prospecting for gold and base metals has been done in the region. Radioactive pegmatite was discovered at the north side of Lac la Ronge by Mr. L. N. McArthur late in 1947. In 1948, he formed a partnership with Mr. W. A. Richardson; other pegmatite occurrences were found, and these two men were granted a concession of 25 square miles, which has since been acquired by La Ronge Uranium Mines Limited. These discoveries caused other prospectors to enter the region, with the result that several other occurrences of radioactive pegmatite have been found and staked. The greatest amount of work has been done on the La Ronge concession, where several large bodies with low average uranium content have been explored.

Black Bear Island Lake Occurrence. Mr. E. F. Partridge sent thirteen samples from a pegmatite occurrence at Black Bear Island Lake, which is about 40 miles northwest of La Ronge. One sample showed 0·087 R, and the rest showed radioactivity below 0·05 R.

Claus and Ford Claims. A group of claims was reported to have been staked by Messrs. Claus and Ford at Nunn Lake, which is near Hunter Bay of Lac la Ronge. A shear zone on these claims was described as containing uraninite or pitchblende, and three samples showed 0·10 R, 0·26 R, and 2·4 R. Other claims are reported to have been staked in the vicinity, and uraninite crystals up to 1 inch square were reported in the press to have been found by a party working for the Saskatchewan Department of Natural Resources, but the exact location from which these crystals were obtained was not stated.

Hub Group. This group, owned by Northern Uranium Limited, is at the north end of Hunter Bay of Lac la Ronge. Two samples sent to the Mines Branch from these claims consisted of coarse-grained granitic rock containing secondary uranium minerals. Small rectangular areas in biotite appeared to mark the former position of a primary uranium mineral. One of these samples showed 0·04 R, and the other showed 0·047 C. A sample sent to the Geological Survey indicated 0·087 R, and two sent to the University of Saskatchewan showed 0·11 and 0·21 R.

La Ronge Concession. La Ronge Uranium Mines Limited hold a concession of 25 square miles, extending northeasterly between Lac la Ronge and Churchill River, and lying immediately west of Montreal River. This includes the McArthur showings discovered in 1948.

The concession is underlain by altered sedimentary rocks intruded by granite and pegmatite. The writer visited the property in 1948, when five main radioactive discoveries had been made at widely separated parts of the concession. All were pegmatitic, and some of the bodies exposed were fairly large, the most radioactive parts consisting of concentrations of biotite along fractures. A sample chipped across 40 inches at one of these zones showed 0·037 R, and another across 30 inches, showed 0·014 R. Selected samples from different showings gave results up to 0·18 R.

The company reported that twenty-four radioactive showings are now known, and that exploratory work was done on four showings within a length of 3,450 feet, in the northern part of the property, near the southwest corner of Nistowiack Lake. These showings are reported to be in a fairly flat-lying pegmatite sill. The areas of the showings, and the results of radioactivity surveys, are summarized as follows (background taken at 25 radiations per second):

No. 3 — 20,510 square feet; 2 to 9 times background
No. 4 —423,905 square feet; 2 to 28 times background
No. 5 —123,950 square feet; 2 to 20 times background
No. 6 — 32,575 square feet; 2 to 15 times background
No. 6X— 70,825 square feet; 2 to 11 times background

These figures indicate large tonnages of low-grade material, the average content being as yet unknown.

The company reported that $45,000 have been spent in systematic prospecting, grid surveys, and blasting five trenches varying from 7 to 17 feet deep and having lengths of 20, 23·0, 12, 15, and 38·5 feet respectively. Scintillometer readings at each trench were reported to have shown a marked increase in radiations per second as depth was increased, and secondary uranium minerals were reported to be more abundant in the trenches than in the leached surface exposures. Chemical analyses of fifteen blasted samples have given the following results: 3 samples: 0·03 C to 0·05 C; 4 samples: 0·05 C to 0·10 C; 3 samples: 0·10 C to 0·15 C; 2 samples: 0·162 C and 0·170 C; 1 sample: 0·215 C; 1 sample: 0·334 C; and 1 sample: 0·372 C. A bulk sample was blasted last winter from the most accessible location for shipment by tractor train. At this point sampling by the company indicated 0·054 C, and the 4,200-pound shipment was reported by the Mines Branch to contain 0·061 C.

R.A.C.U. Group. A discovery was reported to have been made on a group of claims of this name, staked along a contact between granite and volcanic rocks about 11 miles west of Stanley Mission. No other details have been received.

Stanley Occurrence. Samples that showed 0·16 R and 0·26 R were reported to have been obtained from a showing 1 mile north of Stanley Mission.

Struder Occurrences. Struder Gold Mines Limited was reported to hold twenty-five claims about 25 miles north of La Ronge, and to have detected low radioactivity at a gold prospect.

T.O.W. Group. This group was staked by Messrs. R. Anderson and L. McArthur of La Ronge. The claims are near Drinking Lake, which is an expansion of Churchill River about 12 miles east of Stanley Mission. One sample showed 0·32 R, and another, 0·016 R.

Triveet Lake Occurrence. Samples were obtained from Dee Explorations Limited from an occurrence at the west shore of Triveet Lake, 1½ miles from its north end. This lake is about 30 miles northwest of La Ronge. The notification of discovery did not state whether the occurrence was staked by Dee Explorations Limited or by others. Two samples sent to the Geological Survey showed 0·26 R and 0·28 R, and tests indicated that a large part of the radioactivity was probably caused by thorium. Three samples sent to the University of Saskatchewan showed 0·047 R, 0·18 R, and 0·25 R.

MANITOBA

Several occurrences of radioactive pegmatite have been found in parts of Manitoba underlain by rocks of the Canadian Shield. These occurrences are almost entirely in southeastern Manitoba, and the properties are, therefore, not listed according to separate regions. Uraninite was found in a pegmatite deposit on the Huron claim near Winnipeg River several years ago. During the last 2 years much prospecting was done for uranium in southeastern Manitoba, chiefly in the parts near the Trans-Canada Highway. Radioactivity was detected at several places, but only a few properties have been reported to contain uranium or thorium in amounts of 0·05 per cent or more.

East Found Group. This property is 1 mile west of Star Lake, and about 10 miles east of Rennie station on the Canadian Pacific railway. It is owned by Whiteshell Uranium Syndicate. Radioactivity was detected in a zone composed of alternating bands of pegmatite and biotite schist and gneiss. This zone, which extends westward across the Triangle and West Found groups, is described in more detail in the description of that property. Work on the property is reported to consist of one test pit, about 100 yards north of the Trans-Canada Highway. Samples from the "Found group" were found to contain cyrtolite, thorite, uraninite, and doubtful allanite and uranothorite, but it is possible that some of these samples included material from the West Found group. Nine selected samples from the East Found group showed contents up to 0·70 C, and a bulk sample sent to the Mines Branch had an average content of 0·051 C.

Huron Claim. The Huron claim, in the Winnipeg River region, contains a pegmatite deposit that was explored several years ago because of its beryl content. It has been described in detail by Wright (1938, p. 103) and Springer (1950, p. 11), who report that it contains minor amounts of uraninite and monazite. Springer also states (1950, p. 14) that other dykes in the region contain radioactive minerals.

Remniak. Mr. M. Remniak, of Herb Lake, sent a sample of pegmatite from an undisclosed locality, in 1949. This sample showed 0·056 R. In 1950 he sent two samples, reported to be from a dyke 4 to 6 feet wide and 4,000 feet long, 16 miles from a railway. These samples, which were pegmatitic, showed 0·001 and 0·014 R.

Schaller. Mr. R. J. R. Schaller, of 283 Wildwood Park, Fort Garry, Man., sent a sample from an occurrence in the Bird River region, which showed 0·14 R. He reported that the sample was from a radioactive band about 3 feet wide, at the centre of a belt of re-fractured iron formation about 75 feet wide.

Triangle and West Found Groups. These two groups of claims, which are near one another, are held by Whiteshell Uranium Syndicate. The Triangle group of nine claims is at the north side of the Trans-Canada Highway at mileage 101. The West Found group consists of six claims, and the showings are a few hundred feet south of the highway, about a mile west of Manahan's tourist camp. The following information was obtained from an unpublished report by W. E. Hale, of the Geological Survey, who examined the properties in 1950.

A zone composed of alternating bands of pegmatite and biotite schist and gneiss, with a total width of at least 600 feet, has been traced for about 10 miles, partly on the two groups under discussion. The zone occurs along the contact of a body of gneissic granite. Radioactivity in amounts up to 8 times background was detected over small areas scattered irregularly in the pegmatitic zone. These areas of anomalous radioactivity are chiefly at places underlain by pegmatite, but some are underlain by biotite schist or gneiss near pegmatite contacts. Samples of the radioactive material contained uraninite, pyrrhotite, pyrite, and molybdenite.

Several of the radioactive areas have been stripped and sampled, and one test pit has been sunk on each group of claims. The results of many samples ranged from 0·003 R to 0·17 R, and from 0·008 C to 0·086 C. A bulk sample weighing about 400 pounds was sent to the Mines Branch, where it was found to contain an average of 0·028 R.

ONTARIO

KENORA-PORT ARTHUR REGION

About thirty radioactive properties have been staked in the southern part of the Canadian Shield in what may be called the Kenora-Port Arthur region, lying between the Manitoba boundary and Heron Bay of Lake Superior. An occurrence of uranium-bearing anthraxolite near Port Arthur has been known for several years. Most of the other occurrences in the region are pegmatitic deposits that have been found during the last 2 years as a result of increased interest in prospecting for uranium. Several of these discoveries were described by E. O. Chisholm, of the Ontario Department of Mines (1950). Many of these deposits consist of parallel bands of pegmatite and gneiss or schist. Several radioactive properties in the Kenora-Port Arthur region were examined in 1950 by W. E. Hale of the Geological Survey; some of the following descriptions have, accordingly, been prepared with the collaboration of Mr. Hale. A property near Red Lake is, for convenience, described in this part of the report.

Byberg Property. This property, which is along the Trans-Canada Highway 30 miles east of Kenora, is controlled by Mr. M. Jensen of Kenora. An area about 400 feet wide and ½ mile long contains numerous dykes and irregular masses of pegmatite intruding Keewatin lavas. The pegmatite contains much magnetite, some of which is concentrated near contacts with the lavas.

Chisholm (1950, p. 3) reports lemon-yellow stain in the magnetite. Uraninite and thorite are distributed erratically in the pegmatite and in shear zones along contacts between pegmatite and lava. Molybdenite was also noted by Chisholm (1950, p. 3). A radioactivity survey showed counts up to eighteen times background. A bulk sample sent to the Mines Branch had an average content of 0·054 C. The average of the results of two channel samples and twenty-one grab samples taken by W. E. Hale is 0·016 R.

Cameron Property. The Cameron property is 2 miles east of the south end of Vermilion Lake, about 15 miles north of Kenora. The claims are held by Mr. M. Y. Cameron, of Kenora, and Mr. C. Alcock. The main showing is a pegmatite dyke exposed for a width of 9 feet and a length of 30 feet; to the west, it appears to extend farther under a swamp. Mr. Hale reported that counts up to eight times background were obtainable in a pit on this dyke; that the radioactivity appeared to be associated with concentrations of biotite in the pegmatite; and that a selected sample taken by him showed 0·10 R. Chisholm (1950, p. 2) reports that some molybdenite is present. Tests showed that at least part of the radioactivity was caused by monazite and uraninite. Mr. Hale reported that many other dykes and irregular masses of pegmatite had been found on the property, but that the highest count obtained over them was three times background. Samples submitted by the owners, probably from the main showing, indicated 0·05 R, 0·19 R, 0·29 R, and 0·14 C.

Christianson Property. This property is at the west shore of Greenwich Lake, 12 miles north of Loon Lake Station on the Canadian Pacific Railway. It is owned by Mr. T. Christianson, 27 Orchard View Blvd., Toronto. The showing is a shear zone in granitic rock, exposed for a length of 36 feet. The zone consists of 2 to 3 feet of breccia, and 1 foot of massive pyrite along the hanging-wall. Mr. Hale reported that counts of three times background, or slightly more, were obtained throughout the zone, and that very high readings were obtained over some parts of the pyritic zone. The radioactive minerals are uraninite, probably in the form of pitchblende, and thucholite. The zone has not yet been trenched, and sampling has been done only on weathered material. Five channel samples taken across the mineralized zone by W. E. Hale gave results that average 0·042 R, and six selected samples taken by him showed contents ranging up to 1·5 R. Samples taken by the owners have indicated 0·21 R, 0·32 R, 0·64 R, 1·91 R, and 2·68 C.

Cramette Occurrence. A discovery made by Mr. C. Cramette, of 241 South John St., Fort William, at a place about 7 miles north of Angler, Ont., yielded two samples that showed 0·06 R and 0·07 R.

Davidson Property. Claims held by Mr. E. A. Davidson, 320 Argyle St., Port Arthur, are along the Trans-Canada Highway near Mountain Bay, between Nipigon and Schreiber. Dykes and masses of radioactive pegmatite, up to 4 feet wide and 100 feet long, are exposed in rock cuts along the highway. Mr. Hale reported that he obtained counts of twice background at several places, and five times background in the single test pit on the property. Five selected samples taken by Hale averaged 0·005 R. Samples submitted by Mr. Davidson gave results up to 0·73 R.

Hemlo Occurrence. Radioactivity was reported to have been detected at a gold prospect owned by Lake Superior Mining Corporation, near Hemlo. The Northern Miner stated in its issue of June 9, 1949, that five parallel radioactive zones had been found along a contact between biotite granite and greenstone, and that anomalies up to ten times background had been obtained. Two samples sent to the Geological Survey showed 0·06 R and 0·09 R.

Johnson Property. Mr. D. E. Johnson, of Port Coldwell, Ont., staked a group of claims at Port Monroe. Mr. Hale described the occurrence as a mass of red syenite along the shore of Lake Superior, and he was unable to obtain counts of more than twice background over it. Of nine samples sent by Mr. Johnson, two showed 0·07 R, and the rest were below 0·05 R.

Langton Township. Lot 9, con. IV, Langton tp., has been staked by Mr. M. Jensen, Box 363, Kenora. The property is along the Trans-Canada Highway about 56 miles east of Kenora. Radioactivity is associated with two lenses of gneissic, pegmatitic granite 3 and 5 feet wide and about 50 feet long. W. E. Hale reported that the most radioactive parts are deeply weathered, contain pyrite, and have been explored by rock work and by one 30-foot diamond drill-hole. He detected radioactivity up to nine times background in places, but found that the average radioactivity was much lower. A sample from the property was reported in 1949 to have shown 0·71 C, but it is not certain whether this was determined chemically or radiometrically. Twenty-eight picked samples taken by Mr. Hale gave results that average 0·015 R. Two sections of the drill core, each 1·2 feet long, showed 0·088 R and 0·050 R.

Longlac Occurrence. An occurrence near Longlac is described here for convenience, although it is some distance north of the other properties in the region under review. It is in a quarry at the south side of the highway 1 mile east of Longlac, and was reported by Mr. A. Brisebois, Box 133, Geraldton, Ont. A radioactive zone 2 feet wide and 40 feet long is poorly exposed because of weathering and oxidation, and may represent a dyke. Samples submitted from the property showed 1·87 R to 5·31 R, and one sample contained 0·15 C. Tests showed that most of the radioactivity was attributable to thorium, but the radioactive mineral could not be identified by X-ray diffraction tests. Mr. Hale found that the zone was strongly radioactive, and two selected samples taken by him showed 0·03 R and 0·1 R.

Marathon Occurrences. Pic Bamoos Prospecting Syndicate hold a property 2 miles west of Marathon. The claims include two occurrences of fractured and sheared pegmatite, 900 feet apart, exposed in rock cuts on an abandoned highway grade. Two samples submitted in 1949, which were stated to be representative of a width of about 40 feet of pegmatite, showed 0·01 R and 0·045 R. Chemical analysis of a selected specimen sent to the Mines Branch indicated 22·65 per cent ThO_2 and 0·85 C. Thorite was identified in a specimen sent to the Geological Survey. Mr. Hale reported that he obtained readings up to three times background with a Geiger counter. Four grab samples taken by him showed 0·002 R, 0·007 R, 0·01 R, and 0·01 R.

Medicine-stone Lake Occurrence. This occurrence, near the south end of Medicine-stone Lake, in the Red Lake region, is included in this section of the report for convenience. It is held by Mr. I. O. Persson, care of Mr. R. McIntosh, Madsen Red Lake Gold Mines, Madsen, Ont. Mr. Hale reported that radioactivity is associated with a mass of sheared, hornblende granite that contains many inclusions of greenstone. He found that the greatest radioactivity, up to eight times background, occurs in areas about 2 by 8 feet in size, underlain by shear zones in greenstone inclusions. Samples sent from the property showed 0·055 R, 0·069 R, 0·079 R, and 0·47 R. Tests on the last-mentioned sample suggested that a large part of the radioactivity was caused by thorium.

Meehan Property. The claims of Mr. J. P. Meehan of Quibell, Ont., are about a mile west of Quibell, a station on the Canadian National railway. Lenses and dykes of granite and pegmatite cut greenstone, which in places has been rendered gneissic or schistose. Mr. Hale states that pyrite is abundant along certain planes of gneissosity, and that there is also a little graphite and molybdenite. He found that one showing was radioactive to the extent of three times background, and obtained readings of about one and a half times background at the others. One sample sent by Mr. Meehan showed radioactivity between 0·05 R and 0·1 R, and thirteen others gave results of 0·01 R or less. Three grab samples taken by W. E. Hale showed less than 0·01 R.

McLean Occurrence. Mr. G. A. McLean of 506 First St. South, Kenora, Ont., sent a sample that showed 0·066 R from an island in Lake of the Woods, about 10 miles south of Kenora. Chisholm (1950, p. 2) reports higher than normal counts along a narrow quartz carbonate vein in pillow lava, which appears to be associated with the intrusion of a diabase dyke. The vein is too small to be of commercial value. A sample selected by Chisholm assayed 0·10 R and a trace of gold.

Eric Nelson Occurrence. Mr. Eric Nelson, 282 Bay St., Port Arthur, Ont., found a radioactive occurrence in a rock cut on the Trans-Canada Highway 45 miles west of Port Arthur. He sent a sample, which indicated 0·10 R, and which contained uraninite, molybdenite, pyrrhotite, and chalcopyrite. Mr. Hale found that the occurrence was a dykelet 1 inch wide, consisting of biotite, feldspar, and quartz, which showed radioactivity of about twice background; the enclosing rock, which is granitic, did not give counts above background.

E. W. Nelson Occurrence. Mr. E. W. Nelson, 414 John St., Port Arthur, Ont., staked a fracture system in Animikie conglomerate, which contains quartz, fluorite, and sulphide minerals. Samples sent by Mr. Nelson showed radioactivity up to 0·1 R, and one contained 0·09 C. Mr. Hale was unable to find exposures showing radioactivity greater than twice background, and the results of sixteen grab samples taken by him average about 0·003 R.

Parth Property. Twenty-seven claims have been staked by Mr. L. Parth, Box 136, Kenora, Ont., and his associates, along the north side of the Trans-Canada Highway 45 miles east of Kenora. Pegmatite lenses occur at intervals, in granitic rocks, for a distance of about 2 miles. Mr. Hale describes the main showing as a lens averaging 8 feet in width. He obtained counts up to five times background over an area of about 6 square feet, but elsewhere radioactivity over the lens was from two to three times background. A sample sent by Mr. Parth showed 0·13 R.

Port Arthur Occurrences. Deposits of uranium-bearing anthraxolite in and near the city of Port Arthur have been known for some time (Tanton, 1931; Ellsworth, 1934) and are commonly referred to as the Port Arthur occurrences. Narrow veins, most not more than 6 inches wide, fill fractures in Animikie sediments and diabase. They contain material classed as anthraxolite, and a sample of this material obtained 0·0034 C; it is probably related to the thucholite group of compounds. In different veins, one or more of the following minerals also occur: native silver, argentite, galena, chalcopyrite, sphalerite, pyrite, quartz, calcite, fluorite, and barite.

Potvine Property. This property, held by Port Monroe Uranium Prospecting Syndicate, is near Angler Siding about 5 miles west of Marathon. Radioactive fractures have been found in red syenite dykes cutting amgydaloidal lavas. The fracture systems average about 3 inches in width and about 200 feet in length. Widths up to 8 inches have been noted, and the longest showing is about 500 feet. The radioactive mineral has not been identified, but samples taken by the owners have shown up to 0·19 C. According to W. E. Hale, one fracture was radioactive to the extent of eight times background, and the others gave counts of about three times background; the results of seven selected samples taken by him range from a trace to 0·07 R.

Ratuski Occurrence. Mr. P. Ratuski, care of Mr. M. Y. Cameron, 218 Second St. South, Kenora, Ont., found an occurrence near Vermilion Lake, from which a sample showed approximately 0·05 R.

Smith Occurrence. Mr. D. E. Smith, Box 268, Marathon, Ont., sent a sample from an occurrence at Heron Bay. The sample showed 0·33 R, and tests indicated that the radioactivity was almost entirely attributable to thorium. W. E. Hale describes the occurrence as a shear zone in a body of syenitic pegmatite. He found that localized areas of 2 to 3 square feet, within the outcrop of the shear zone, gave counts up to eleven times background.

Vermilion Lake Property. This property, 1·5 miles east of Vermilion Lake, north of Kenora, has been staked by Mr. S. Stevenson, care of Mr. M. Y. Cameron, 218 Second St. S., Kenora, Ont. A sample sent by Mr. Stevenson showed 0·29 R, and it contained monazite and uraninite. According to W. E. Hale, the property contains two showings. One is a lens of pegmatite, with an area of about 9 square feet, containing much biotite, and intruding greenstone. Counts up to eleven times background were obtained over the pegmatite by Mr. Hale, and a picked sample taken by him showed 0·066 R.

Mr. Hale describes the other showing as a pegmatite dyke 10 feet wide and 350 feet long. Radioactivity in amounts up to four times background appears to be associated with cross fractures in the dyke. The results of three picked samples taken by Mr. Hale were 0·002 R, 0·006 R, and 0·042 R.

SAULT STE. MARIE REGION

For convenience in this report, the Sault Ste. Marie region is regarded as including the territory between Michipicoten Harbour and a point half-way between Sault Ste. Marie and Sudbury. This does not conform with any official usage, but it is a convenient unit for description of uranium deposits. The geology of this large area in the southern part of the Timiskaming subprovince of the Canadian Shield is diversified, and in places fairly complex; parts of it have been mapped and described in several geological maps and reports issued by the Ontario Department of Mines and the Geological Survey of Canada. In the following paragraph only a brief outline of the geology is given, together with references to a few of the maps and reports that are most likely to be useful to those interested in uranium deposits. This is followed by a short general discussion of the uranium occurrences of the region.

The geology of the entire region is shown on the Lake Huron Sheet (Geological Survey Map 155A). The dominant rocks are pre-Huronian granitic intrusions, and smaller amounts of younger, Killarnean granite occur as well. Remnants of ancient volcanic and sedimentary strata, older than the pre-Huronian intrusive rocks, underlie large areas in some parts of the region. Several places in the southern and eastern parts of the region are underlain by sedimentary rocks of Huronian age, belonging to the Bruce and Cobalt series. Sedimentary and volcanic rocks of Keweenawan age outcrop in places at and near the shore of Lake Superior. Part of the region was folded in Keweenawan time to form what has been called the Penokean range (Cooke, 1933; Gill, 1948). The region is characterized by numerous diabase dykes, some of which are believed to be Lower Keweenawan in age, and others late Keweenawan or even younger. The dykes tend to weather more readily than their host rocks, particularly where the latter are granitic rocks. For this reason many dykes form depressions and even small canyons, especially along the shore of Lake Superior. This condition is not universal, however, as some dykes form ridges.

Areas that contain many of the known uranium deposits of the region have been mapped by McConnell (1927) and Moore (1927), but their reports were issued before interest was taken in uranium occurrences. A more recent report that deals with the uranium occurrences of part of the region has been prepared by Nuffield (1950), and another report by the same author is expected shortly.

The radioactive deposits that have attracted most attention in the region are pitchblende occurrences, most of which have been found in the vicinity of Montreal River, about 60 miles north of Sault Ste. Marie. In addition, there are numerous occurrences of radioactive granite and pegmatite, and one occurrence that appears to be a replacement deposit in conglomerate. The events that led to the re-discovery of uranium in this region have been mentioned briefly in the section of this report on history, but as the subject is of considerable interest it is discussed more fully in the following paragraph. Further details are included in a paper by the writer (Lang, 1949).

What appears to have been the first Canadian discovery of uranium was recorded by LeConte (1847), a well-known American geologist of that time. He stated that he had found a mineral resembling pitchblende in a collection made by a Mr. Stanard on the north shore of Lake Superior, but that he thought the mineral differed sufficiently from pitchblende to warrant classing it as a new mineral, which he called "coracite". This account was referred to in several later publications, including four reports of the Geological Survey, and several attempts to find the occurrence were made by prospectors, and by a member of the Geological Survey, in the period before Geiger counters were available. These attempts were unsuccessful because the original locality was described vaguely. In 1948, Mr. R. Campbell made a systematic search along the shore of Lake Superior, with the aid of a Geiger counter, and found strong radioactivity at what became the Camray property. Whitney (1849) and Genth (1857) had already questioned the validity of the mineral "coracite", stating that they believed the specimen to be pitchblende, and this view has been confirmed by later investigators. Campbell's discovery, or re-discovery, caused much prospecting and staking in the region, with the result that many other pitchblende occurrences, as well as other types of radioactive deposits, have been found. The Camray occurrence agrees fairly well with the description of Stanard's original discovery, and it was thought in 1948 that it was likely the same occurrence. Other occurrences that agree as well with the original discovery have since been found, but there is no doubt that Campbell re-discovered the general locality.

The pitchblende deposits are associated with diabase dykes, which generally dip steeply or vertically. These dykes are very common, many being more than 100 feet wide and traceable for several miles. Some dykes strike northeast, the greatest number strike west or northwest, and a few strike nearly due north; in at least some localities, the relative ages of the dykes are, from oldest to youngest, in this order. Most of the known pitchblende deposits are associated with northwesterly trending dykes, and present indications are that these dykes are early Keweenawan.

The deposits consist of stringers and lenses, generally containing calcite, hematite, and pitchblende, and occurring in shear zones and fractures. At a few properties, notably the Camray, the stringers are in granite immediately adjacent to a dyke contact, but at most properties they are in diabase, commonly near one wall of a dyke and lying in a shear zone parallel with the wall or in cross-fractures; some stringers have been found in fractures in the interiors of dykes. As a rule, the stringers and lenses are small and are unfavourable for mining individually. Exploratory work has been directed mainly toward the possibility of outlining bodies of rock containing, in aggregate, enough stringers and lenses to constitute orebodies. Three properties have been explored underground, namely, the Camray, Ranwick, and LaBine-McCarthy. Work at the Camray was discouraging and was stopped about a year ago. Systematic bulk sampling at the Ranwick has shown that, although the tonnage is fairly large, the average grade is about 0·03 C. Exploration of the LaBine-McCarthy showings is in an earlier stage.

Algoma Ore Properties. A sample that showed 0·11 R was sent to the Ontario Department of Mines by Mr. G. W. McLeod for Algoma Ore Properties Limited, Sault Ste. Marie, Ont. It was stated to be from a rock cut on the Algoma Central railway, near the canyon in tp. 27, rge. XVI, on a property owned by the Algoma Central Railway.

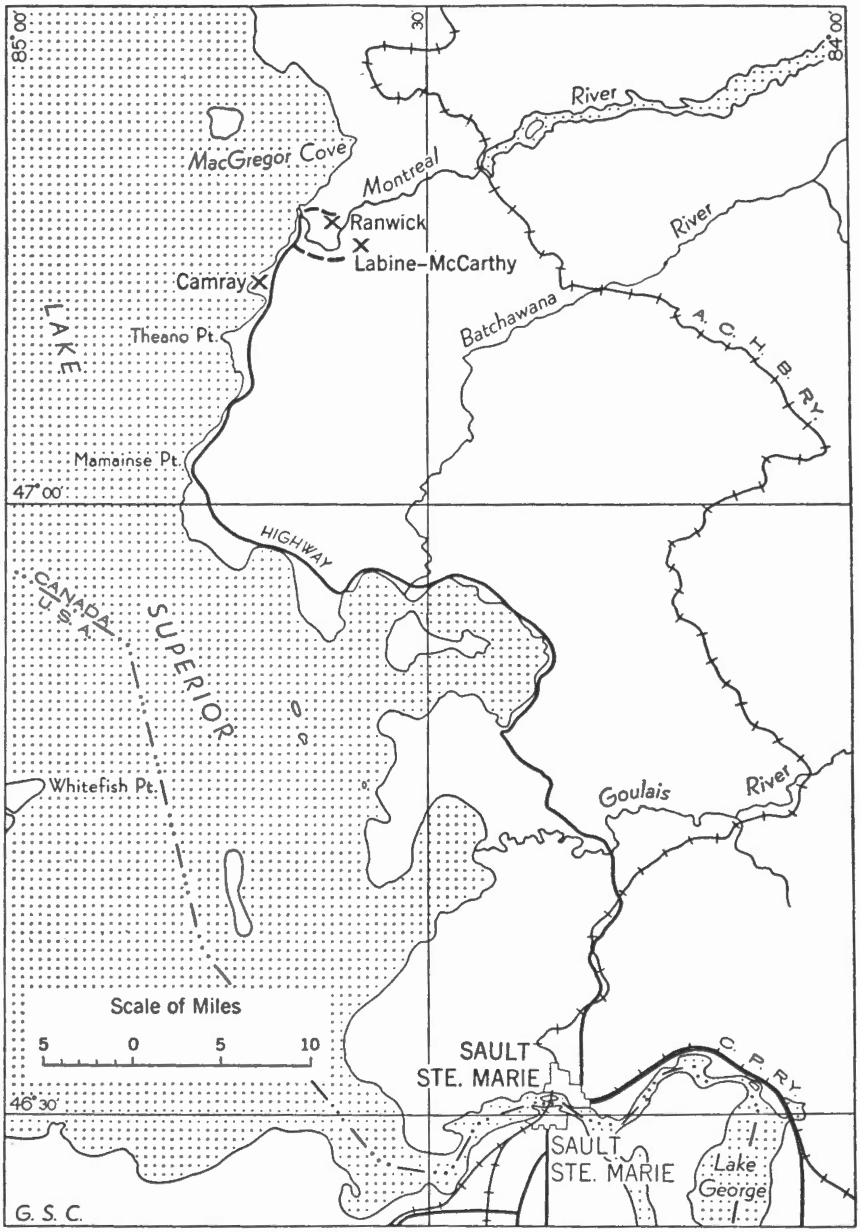


Figure 19. Map of part of Sault Ste. Marie region, Ontario, showing location of properties that have been explored underground.

Aubinadong Group. This group is at the east end of Ranger (Aubakagama) Lake, which is reached by road from Sault Ste. Marie, a distance of 60 miles. The property, which is in township 4G, is reached by boat from the end of the road. The claims were staked by Mr. H. Evans, 1101 Bishop St., Gros Point, Michigan. They are underlain chiefly by granite that appears to be Killarnean, and which is intruded by several diabase dykes. The showing is in one of these dykes, about 60 feet wide, which has an aplite dyke 8 inches wide extending diagonally across it for a length of at least 30 feet. The central part of the aplite dyke is a zone of carbonate and quartz, 2 to 3 inches wide; this zone is radioactive and the writer found anomalies up to five times background along it. A selected sample taken by the writer at the most radioactive part of the dyke showed 0·30 R. Samples taken by others have indicated up to 0·20 R. One sample sent in from this property contained galena and a mineral classed tentatively as uraninite, but it is not clear from the accompanying description whether it came from the showing described above or from some later discovery.

Baldhead River Occurrence. Mr. J. G. McCombe reported a discovery of what appeared to be pitchblende, along the contact of a diabase dyke in granite, at the shore of Lake Superior just south of the mouth of Baldhead River. Samples sent by him showed 1·62 R and up to 0·56 C. Samples sent by Mr. W. Jenks from the same locality showed up to 8·57 R.

Barnes-Prior Property. This property is in tp. 28, rge. XVI. Mr. F. Joubin reported that pitchblende was found in a fracture 1 inch to 6 inches wide and exposed for a length of 20 feet, in silicified biotite schist. Reports on samples indicated 0·83 R, 0·85 R, 0·97 R, and 4·64 R.

Batchawana Property. The claims of Batchawana Uranium Mines Limited are in tp. 29, rge. XIV. The company reported that work in 1950 resulted in the discovery of two pitchblende occurrences. One was described as a zone of cross-fractures up to 3 feet wide crossing a diabase dyke whose width was not stated. The zone was said to contain much visible pitchblende in places. The other occurrence was described as consisting of pitchblende in a series of narrow fractures in a diabase dyke, extending parallel with the walls. The dimensions of this zone were not known because the discovery was made late in the season; therefore, little work had been done to expose it.

Bobcam Property. Bobcam Mines Limited hold a group of claims in tp. 29, rge. XIV, adjoining the Camray group. Detailed prospecting was reported to have resulted in the discovery of a few pitchblende-carbonate stringers in diabase dykes, and in fractured granite near the contacts of diabase dykes.

Breton Property. Mr. A. Breton, 458 Queen St. East, Sault Ste. Marie, Ont., holds seven claims in lot 3, con. II, Long tp. The property is about 2 miles north of the Canadian Pacific railway west of Webbwood. It contains a deposit described by Kesten (1950, p. 49) as a lens of pyritized quartzite conglomerate up to 30 feet wide and exposed for a length of 550 feet, in arkosic quartzite. The lens shows radioactivity up to several times background, and a grab sample taken by Kesten indicated 0·07 R. Mr. F. Joubin reported that the lens lies between two diabase dykes; that granite is exposed in the vicinity; and that he had submitted a specimen of the radioactive material to E. W. Nuffield, of the University of Toronto, who found what he believed to be finely disseminated pitchblende. Samples from the occurrence are also reported to have indicated a low gold content. From these reports it appears that the deposit is probably a replacement in the conglomerate. The results of a dozen samples reported by the owner and by examining engineers range from 0·05 to 0·09 R, and two samples showed 0·18 to 0·22 R. Analyses have indicated up to 0·095 C.

Byrne Group. Claims known locally as the Byrne group, held jointly by Northland Mines Limited and American Yellowknife Gold Mines Limited, are in Whitman township, on the south side of Paquette Lake. The showings are at the side of the Ranger Lake road at a distance of about 36 miles from

Sault Ste. Marie. The claims are underlain mainly by granite. The radioactive zone is a band of carbonate rock that may be an altered dyke; it is up to 4 feet wide and has been traced at intervals for a length of 350 feet. It is crossed by a diabase dyke that appears to occupy a fault that displaces the carbonate zone about 1½ feet. Trenches reveal two, soft, rusty bands 2 and 6 inches wide in the carbonate zone; these bands show radioactivity up to four times background. The results of samples reported by the owners range up to 0·05 C. A sample taken by the writer across the full 47-inch width of the carbonate zone showed 0·007 R, and samples taken from the 2-inch and 6-inch rusty bands showed 0·005 R and 0·046 R respectively.

Camray Property. The events that led to the discovery of the Camray showings have been outlined in other parts of this report. The extensive work done on the property in 1949 by Camray Mines Limited resulted in additional discoveries, but did not reveal enough material of ore grade to warrant a treatment plant. Work was stopped in December 1949.

The main showings are two zones of stringers in the granite foot-wall of a diabase dyke that has been traced for about 4,000 feet. Near the showings, the dyke is about 40 feet wide, striking north 80 degrees west and dipping 70 degrees north. Because olivine was not found in the diabase, it is classed tentatively as belonging to the earlier Keweenawan group of dykes. Erosion of the dyke has formed a deep gorge near and at the shore of Lake Superior, and the stringers are exposed in two zones about 100 and 275 feet long in the granite that forms the south wall of the gorge; these zones are separated by a barren section 200 feet long. The stringers range from a fraction of an inch to 2 inches in width, and one lens was 6 inches wide; most of them extend for only a few feet along the wall of the gorge, and, where explored, they were found to extend 3 to 4 feet into the granite. They consist chiefly of pitchblende, calcite, and hematite; a little clausthalite was found by Nuffield. The company did 3,088 feet of diamond drilling from the surface, mainly on the showings under discussion. As this did not give conclusive results, an inclined prospect shaft (*See* Plate V B) was sunk in the foot-wall, at the east end of the western zone of stringers. The shaft was sunk sufficiently to permit driving in each direction along the contact, at a depth of 100 feet vertically below the bottom of the gorge. A total of 400 feet of drifting revealed three mineralized sections, the longest being 30 feet, but the average grade of the stringers and the granite that would have to be mined as well was below what was considered ore grade. Diamond drilling from underground stations failed to add to the possibilities.

Detailed prospecting of other parts of the property resulted in the discovery of fifteen radioactive localities, and visible pitchblende was found at four of them; these were also along dyke contacts, several dykes being discovered on the claims. The most promising of these showings was explored by an adit, from which 160 feet of drifting was done; this exposed one short section of pitchblende-bearing material.

Canagau Property. The property of Canagau Mines Limited is about a mile east of the mouth of Montreal River, immediately west of the Ranwick claims. The property is underlain chiefly by granitic rocks, and it is crossed by two main diabase dykes that are also exposed on nearby properties. The more northerly, called the Ranwick or Ranson dyke, is about 50 feet wide; it occurs for only a few hundred feet in the northeast corner of the property. The more southerly, called the Canagau dyke, is about 300 feet wide, and it extends for more than half a mile in the central part of the property. The dykes strike slightly north of west and dip steeply northward. Another dyke, called the Austin, has also been found in the southwestern corner of the property. The dykes have been sheared and fractured, chiefly near their

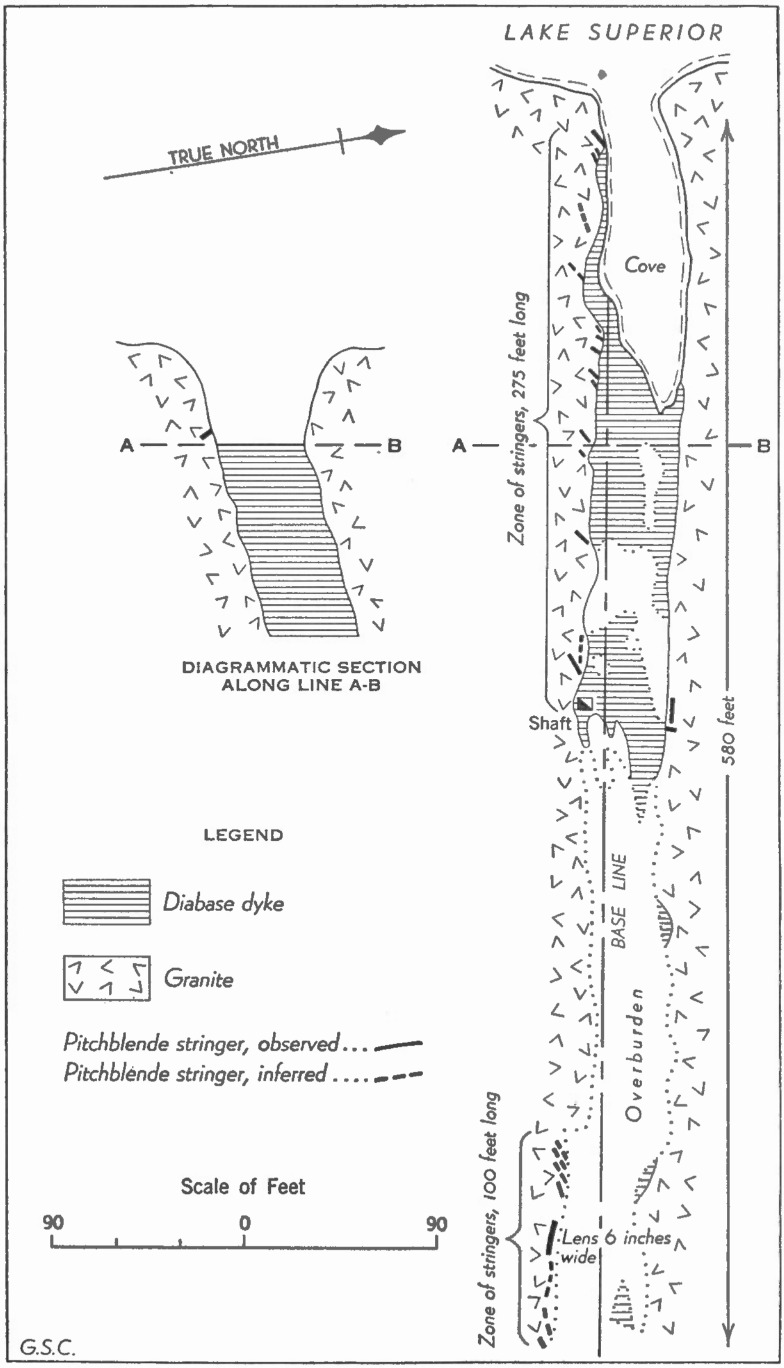


Figure 20. Plan and section of principal showings on property of Camray Mines Limited, Sault Ste. Marie region, Ontario.

walls, where the direction of shearing and fracturing is commonly parallel with the walls; several sets of cross-fractures have also been found in more central parts of the dykes.

Exploration of the property comprises a detailed radioactivity survey, stripping, and trenching. This resulted in the discovery of pitchblende-bearing stringers in fractures in the diabase chiefly in the foot-wall of the Canagau dyke. The stringers also contain calcite and hematite. Selected samples from various parts of the property were reported to have indicated up to 56·1 R.

Damascus Property. The property of Damascus Mines Limited is about 2½ miles east of the mouth of Montreal River, and immediately east of the Ranwick claims. The property is underlain chiefly by granitic rocks. The eastern extension of the Ranwick dyke has been found on the holding, and also the eastern extension of another dyke called the Roche. Minor, unnamed dykes have also been found. The property was explored by a detailed radioactivity survey, the principal discovery being a shear zone along the hanging-wall of the Roche dyke. Radioactivity is reported to have been traced for about 600 feet; W. E. Hale found that a part of the zone about 4 feet square showed seventeen times background, and that the rest of the zone showed two to four times background. Reports of sampling have indicated up to 17·9 C, but four bulk samples averaged only 0·007 C.

Danaray Property. The claims of Danaray Uranium Mines Limited are at Point aux Mines, 2 miles south of the Camray holdings. The property is reported to be underlain by granite and an older schist complex, both intruded by diabase dykes. Younger than these dykes are small patches of conglomerate and basalt, cut by dykes of olivine diabase. Two main radioactive zones have been found. One is a shear zone 2 to 11 feet wide and traced for 70 feet in a diabase dyke. Four samples are reported to have shown 1·08 to 1·90 C. A 750-pound bulk sample sent to the Mines Branch was divided into three lots, two of which contained 0·009 R, and the other 0·10 C; the material contained hematite and probable pitchblende. The other showing is reported to be a slightly radioactive zone traced for 80 feet along a contact of a diabase dyke; two grab samples are reported to have shown 0·60 R and 0·67 R.

Dickenson Claims. Two groups of claims near the mouth of Montreal River are controlled by Mr. P. J. Roche and associates. One group adjoins the Canagau property to the west, and the other adjoins it to the south. The western group contains the extension of the Canagau dyke, and radioactive fractures were found at several places along its south contact; no visible pitchblende was exposed, but one sample indicated 0·1 R. The southern group contains parts of two dykes called the Austin and Penwood dykes, but discoveries have not been reported from this group.

Dolan Group. The Dolan or Beaver Rock group, at the north side of MacGregor Cove, was held by Mr. J. P. Dolan, 510-100 Adelaide St. West, Toronto. Several diabase dykes have been found on the property, and pitchblende is reported to have been found in one of them. The results of seventeen samples from the property range from 0·003 R to 6·6 R. The claims were abandoned.

Fausten Group. Fausten Exploration Limited owns a group of claims in tps. 28 and 29, rge. XIV, about 2 miles southeast of the mouth of Montreal River. Prospecting was reported to have resulted in the detection of radioactivity at five places. The main showing was described as consisting of three radioactive fractures in granite at the contact of a diabase dyke, within a distance of 15 feet. The results of six samples ranged from 0·026 R to 0·20 R, and four other samples showed 0·068 C to 3·0 C.

Franz Claims. The claims of Mr. J. Franz, Jr., Box 485, Sault Ste. Marie, Ont., are along the shore of Lake Superior immediately north of Agawa Bay. According to W. E. Hale, the hanging-wall contact of a diabase dyke that cuts granitic rocks is exposed along the shore for more than 700 feet. Radioactivity was detected associated with calcite-hematite stringers in a series of diagonal fractures extending for about 40 feet along the dyke, and in a brecciated zone along a fault, also exposed for about 40 feet. Readings with a Geiger counter were up to sixteen times background over the zone of fractures, and up to four times background over the brecciated zone. Results of samples reported to the Geological Survey have indicated up to 6·4 C, and pitchblende was identified in one sample submitted. A channel sample taken by Mr. Hale across a zone of fractures for a width of 3½ feet showed 0·80 R, but another, across a width of 2½ feet, showed only 0·002 R.

Gardiner Occurrence. Mr. M. C. Gardiner of Haileybury, Ont., reported a discovery at the southwest corner of Ranger (Aubakagama) Lake, in tp. 3H. It was reported to consist of radioactive joints in red granite, ¼ mile west of the lake. The results of fifteen samples ranged from 0·01 R to 2·78 R.

Gimby Occurrence. Mr. J. E. Gimby, 493 Queen St. East, Sault Ste. Marie, Ont., sent two samples, which showed 0·063 R and 0·081 R, from the southwest corner of tp. 25, rge. XVI. One sample was pegmatitic and the other consisted of gneiss carrying a little pyrrhotite.

Glowacki Occurrence. Mr. J. Glowacki sent eight samples from a discovery in tp. 10D. Seven samples gave results ranging from nil to 0·09 R and one showed 0·81 R.

Hennessy Groups. Mr. R. R. Hennessy, Box 324, Sault Ste. Marie, Ont., staked two groups of claims, one east of MacGregor Cove and the other near Montreal River about 4 miles east of its mouth. From the former group, three samples reported to be from a diabase dyke showed 0·055 C, 0·065 C, and 0·51 C. A sample from another dyke showed 0·07 R.

The group near Montreal River is controlled by Hennessy Uranium Exploration Incorporated, which financed stripping and trenching in 1950. A sample reported to be from a pegmatite dyke showed 0·32 C. Another sample indicated 2·4 per cent ThO_2 and 0·02 C. Other samples have shown uranium contents up to 0·46 C. All the above mentioned samples are understood to have come from this group, but as descriptions of the showings are not available, some of the samples may have come from the northern group.

Jalore Property. Jalore Mining Company Limited staked a group of claims near mileage 105 on the Algoma Central railway, 2 miles north of Frater station, after a prospector working for the company found radioactivity in a railway cut late in 1948. The discovery consists of a shear zone 5 to 6 feet wide, containing calcite-hematite stringers, crossing a diabase dyke 60 feet wide. The zone extends for about 15 feet into the granite at each side of the dyke. The shear zone is strongly radioactive where it crosses the dyke, but not where it extends into the adjoining granite and granite-gneiss. Representative samples of the zone in the dyke were reported to have indicated 0·15 R and 0·75 R, and results up to 15·71 R were obtained. Samples contained hematite, calcite, a little pyrite and pitchblende, and doubtful thucholite and barite. In 1949, twelve diamond drill-holes were drilled with AX core, and other parts of the property were explored by geological and radioactivity surveys and by nineteen X-ray drill-holes. The drilling is reported to have intersected widths of 10 to 12 feet on the shear zone, the deepest intersection being about 400 feet below surface. Work was discontinued late in 1949.

James Occurrence. Mr. E. B. James, 127 Church St., Sault Ste. Marie, Ont., sent two samples from a discovery in township 4E. They contained microscopic grains of sulphide minerals and showed 0·057 R and 0·15 R.

LaBine-McCarthy Property. The LaBine-McCarthy or Collins group, owned by LaBine McCarthy Uranium Mines Limited, is in tp. 28, rge. XIV. It is on the opposite side of Montreal River from the Ranwick claims, the northwest corner of the property being about ½ mile east of the southeast corner of the Ranwick group. The topography of the claims is rugged, with several high rocky cliffs.

The claims are underlain chiefly by granite rocks. A diabase dyke that appears to be the eastern extension of the Canagau dyke, which here is 150 to 200 feet wide, extends for about ½ mile across the northwestern part of the property. It ends against a cliff striking about north 20 degrees east, which appears to mark a fault, and which is called locally the McCarthy fault. A narrow band of diabase lies along the lower part of the cliff, and appears to be a dyke intruded along the McCarthy fault, but the relationship of this diabase to the "Canagau" dyke is not exposed. A narrow diabase dyke lies 850 feet south of the "Canagau" dyke and parallel with it, and an outcrop at the side of the cliff appears to mark the faulted continuation of this dyke, displaced about 200 feet to the north by the McCarthy fault.

A discovery of pitchblende was made at the south side of the "Canagau" dyke, near the McCarthy fault, late in 1949. The main showing on the property (*See* Plate V A) consists of a brecciated zone 1 foot to 1½ feet wide, extending parallel with the wall of the dyke, and about 5 feet from the wall. It contains fragments of diabase cemented by calcite and hematite, carrying visible pitchblende, which was reported to be botryoidal in places. The writer found that the zone had an average radioactivity of twelve times background; fractures parallel with the zone may also be radioactive, but this could not be determined definitely because of radioactivity from the main zone. The showing is about 50 feet long, and Mr. McCarthy reported that three samples taken across widths of 3 feet at intervals along it averaged about 2·0 C. Radioactivity can be detected in places for an additional 150 feet along the contact of the dyke, indicating that the zone may have a length of 200 feet or more. Radioactivity has also been detected at several isolated places along both contacts of the Canagau dyke. Counts up to ten times background, and a little pitchblende, were obtained by the writer in places along the band of diabase parallel with the McCarthy fault, and counts of ten times background were found over the small dyke 850 feet south of the Canagau dyke. Radioactivity is also reported to have been detected at another dyke 1,100 feet north of the Canagau.

Because it was decided to explore the showings from a prospect adit, little surface exploratory work or sampling was done. Work during the summer of 1950 consisted of the construction of a branch power line, pioneer road, and camp buildings. The driving of the adit was begun in February 1951, at the north side of the Canagau dyke, about 1,200 feet east of a point opposite the main showing. The elevation of the portal is about 100 feet below that of the main showing. The following account of underground work to date was summarized from reports supplied by the company. The adit was driven across the dyke, intersecting the south contact 170 feet from the portal. At 140 feet from the portal, drifting was begun along a shear zone in the dyke, parallel with the contact; an exploratory crosscut was begun 70 feet from the beginning of the drift. The underground work to date has not been under places where radioactivity was detected at the surface, and radioactive material was not encountered in the workings.

Long Township. Six samples, which showed 0·025 C, 0·055 C, 0·065 C, 0·11 C, 0·13 C, and 0·15 C, were sent by Muskoka Construction Company. The locality was described as "Location X, Long Tp."; it is not clear whether this refers to the Breton property or to a separate occurrence.

Mackie Occurrence. Mr. W. M. Mackie, Box 94, North Bay, Ont., sent a sample that indicated 0·10 R. The locality was reported only as the Montreal River area.

Migneron Property. This property, held by Mr. A. Breton, Central Hotel, Sault Ste. Marie, Ont., and Messrs. C. Gunterman and C. Migneron, is near mileage 71 on the Montreal River highway. Pitchblende has been found in places along the hanging-wall of a diabase dyke that intrudes granitic rocks. The pitchblende is associated with hematite-calcite stringers, most of which are less than ½ inch wide. The shear zone is about 1 foot wide, and it has been traced intermittently by six trenches for a length of roughly 500 feet, according to a report by W. E. Hale. He obtained readings up to eleven times background in certain places along the zone, but four channel samples taken by him across widths of 2 to 2½ feet gave results below 0·05 R. Two of five selected specimens taken by him showed more than 0·01 R, and three showed less than that amount.

Mosher-Byles Group. Messrs. A. C. Mosher and G. Byles staked a group of claims in tp. 29, rge. XIV. Pitchblende was reported to have been found near a contact of a diabase dyke with granite, the locality being 100 feet from the Montreal River highway at mileage 70·5. A sample indicated 0·42 C.

Murmac Property. The property of Murmac Lake Athabaska Mines Limited is about 2 miles south of Montreal River. The showings are immediately east of the highway, at mileage 75·8. The claims are underlain mainly by granitic rocks intruded by diabase dykes, in one of which a radioactive zone was traced at intervals for a length of about 700 feet. The zone has an average width of about a foot, and it ranges from a crack to a sheared and fractured zone 5 feet wide. The western part of the zone extends for about 400 feet along the south contact of the dyke; to the east it branches diagonally across the dyke and, finally, extends along the north contact; subsidiary fractures also occur. The zone contains much chlorite and many seams and stringers of hematite and calcite. Pitchblende was not definitely identified because of alteration to gummite, but it doubtless occurs in unaltered parts of the zone. The company did much stripping and trenching, and 2,600 feet of diamond drilling, in 1949. Four samples taken by the writer from surface trenches showed less than 0·05 R. Sampling results reported by analysts range from nil to 7·55 C.

McCombe Property. Mr. J. G. McCombe, of 651 Queen St. East, Sault Ste. Marie, Ont., and associates, hold a group of claims on the shore of Lake Superior south of MacGregor Cove. The property is underlain by granitic rocks intruded by diabase dykes. Five radioactive occurrences are reported to have been found. Three are described as fractures in granitic rocks near diabase dykes; ellsworthite was identified by E. W. Nuffield, which suggests that at least one of these occurrences is pegmatitic. The other two occurrences are described as being pegmatitic. Thirteen samples sent from the property gave results ranging from 0·02 R to 0·09 R, and two of these that were tested chemically showed 0·015 C and 0·038 C; allanite was identified in some of these samples.

MacDougal Occurrence. A specimen of meta-allanite was sent by Mr. M. MacDougal, the locality being given as mileage 92 on the Algoma Central railway.

McTiegue Occurrence. A sample that showed 0·07 C was sent by Mr. J. G. McCombe from what was described as the "McTiegue occurrence", 2½ miles northeast of Frater, on the Algoma Central railway. The property is now held by McCombe Syndicate.

Napray Properties. Napray Mining Company Limited holds two properties in the region under discussion. One is immediately south of Agawa River, near mileage 107 on the Algoma Central railway. The company reported that two discoveries were made in diabase dykes on this group of claims. The results of five samples ranged from 0·02 R to 0·22 R, and two other samples indicated 0·075 C and 0·178 C, but details of the showings were not reported. The other group is about 2 miles northeast of the mouth of Montreal River. Here a shear zone in a diabase dyke was reported to have been found, and four samples yielded 0·18 C, 0·48 C, 0·77 C, and 0·84 C.

Nemegos Property. Nemegos Uranium Corporation holds a group of claims in McNaught and Lackner townships, near Chapleau; this is some distance north of the Sault Ste. Marie region, but the description is included here for convenience. A radioactive discovery made in May 1949 was reported by the company to be associated with sizable bodies containing titaniferous magnetite and apatite. In 1950, the company reported that four samples had shown 0·04 R, 0·04 R, 0·07 R, and 0·09 R, and that attention was being directed toward the establishment of an iron-phosphorus operation. In this connection, 7,500 feet of diamond drilling was reported to have been done in 1950.

Nolan Group. This group, in tp. 29, rge. XV, immediately north of the Ranwick property, was optioned to Van Lake Prospecting Syndicate. The property is crossed by part of a diabase dyke called the "Roche dyke". W. E. Hale reported that a shear zone extends along the hanging-wall of this dyke, and that he detected radioactivity in places along this zone, as well as at the south contact and at several cross-fractures in the centre of the dyke. The highest reading obtained by him was eleven times background, at a cross-fracture that was radioactive for a length of 5 feet. Two samples from the property were reported to have indicated 0·08 C and 0·10 C. The syndicate reported that strong radioactivity was detected with a scintillometer along the hanging-wall contact of the dyke, and that the above mentioned samples were taken from a trench on the most northwesterly anomaly.

Ottawa Associates Property. This property, about a mile northwest of the mouth of Agawa River, is held by a group resident in Michigan, which is represented by Mr. J. G. McCombe of Sault Ste. Marie. W. E. Hale, who examined the property in 1950, reported that a diabase dyke intrudes granitic rocks, and that a shear zone 5 to 18 inches wide occurs intermittently along the hanging-wall. The zone was exposed by stripping at intervals over a total length of about 200 feet. He obtained counts up to twenty times background along a part of the zone that is 6 inches wide and exposed for a length of 10 feet, beyond which it was covered by overburden; other parts of the zone yielded counts up to four times background. Analyses of samples are reported to have shown up to 69·2 C. Three samples taken by Mr. Hale showed 0·015 R, 0·094 R, and 0·19 R. Mr. McCombe stated that the main showing was obscured by a slide at the time of Hale's visit.

Patrick Uranium Mines Limited. This company holds a group of claims immediately north of the Labine-McCarthy property. A diabase dyke up to 40 feet wide has been exposed by stripping and trenching. A shear zone 2½ feet wide is exposed along the hanging-wall of the dyke, and pitchblende-bearing calcite-hematite stringers have been found in places in this zone and also in fractures in the centre of the dyke. Low radioactivity was detected by W. E. Hale for a distance of about ¼ mile along the dyke, and counts up to eleven times background were obtained at the main showings. Samples are reported to have shown up to 1·12 R. A bulk sample weighing 410 pounds was sent to the Mines Branch, where it was found to contain 0·075 C. Another bulk sample consisting of about 300 pounds was sent to Mr. H. Weller, whose results average 0·127 C.

Phillips Occurrence. Mr. R. B. Phillips of 130½ South Main St., Elkhart, Indiana, sent two samples of pegmatitic material, which showed 0·025 R and 0·68 R, from an occurrence in tp. 28, rge. XVII, near mileage 100 on the Algoma Central railway.

Preston East Dome Mines Limited. This company explored an occurrence near Aubrey Falls of Mississagi River, near the boundary between townships 4D and 4E. A large diabase dyke was reported to intrude granitic rocks, and radioactivity was said to have been detected in both the dyke and the granite, but the dimensions of the showings were not reported. Results of radiometric tests on samples are: 0·02 R, 0·03 R, 0·08 R, 0·09 R, 0·54 R, 0·79 R, 0·89 R, 1·59 R, and 1·87 R. Chemical analyses were made on three of the samples, and smaller amounts of uranium were found than were indicated by the radiometric tests, thus suggesting that part of the radioactivity was caused by thorium.

Ranrouyn Group. Ranrouyn Mines Limited holds a group of claims immediately east of the LaBine-McCarthy property, in tp. 28, rge. XIV. In 1949, the claims were mapped geologically and prospected systematically by Geiger counter. One radioactive anomaly was found in a gully where the radioactivity was attributed to seepage from a nearby occurrence of pegmatite.

Ranson Occurrence. Mr. R. R. Ranson is reported to have discovered pitchblende in or near a diabase dyke at the lower dam on Montreal River. This is said to be on Water Power Location KG-7, which is held by the Great Lakes Power Company and reserved from staking; Mr. Ranson is understood to hold the discovery under an agreement with the company.

A group of claims formerly known as the Ranson group, unrelated to the above-mentioned discovery, is now part of the Ranwick property.

Ranwick Property. The Ranwick property is in tps. 28 and 29, rges. XIV and XV, 1½ miles southeast of the mouth of Montreal River. It is owned by Ranwick Uranium Mines Limited, which is controlled by Coniaurum Mines Limited. The property is reached by a road about 2 miles long that extends from the end of Highway 17.

Radioactive discoveries were made in 1949 on two adjoining groups of claims called the Ranson and Kausler-Barwick. These groups were acquired by Coniaurum Mines Limited, and the subsidiary Ranwick company was formed in October 1949. In 1950, an option on a group of claims held by Falconbridge Mines Limited was obtained by the Ranwick company, bringing the total holding to forty-two claims; the Falconbridge claims do not adjoin the main Ranwick group, but the southeast corner of the Falconbridge group is only ¼ mile northwest of the northwest corner of the main Ranwick group.

The main group of claims is underlain chiefly by granite and granite-gneiss, intruded by several diabase dykes. The principal dykes, also found on other properties and mentioned elsewhere in this report, are the Roche dyke in the northern part of the property, the Ranwick or Ranson dyke crossing the central part of the property, and the Canagau dyke in the southern part of the group. The discoveries on the properties have been confined to the Ranwick dyke, but the others have not been completely explored. The Ranwick dyke has an average width of 70 feet and strikes northwest, dipping about 70 degrees northeast. It has a probable length of nearly a mile on the main group of claims, and it extends into the Falconbridge group. Pitchblende has been found on the Falconbridge group, but work on these occurrences was deferred while the main Ranwick showings were being explored.

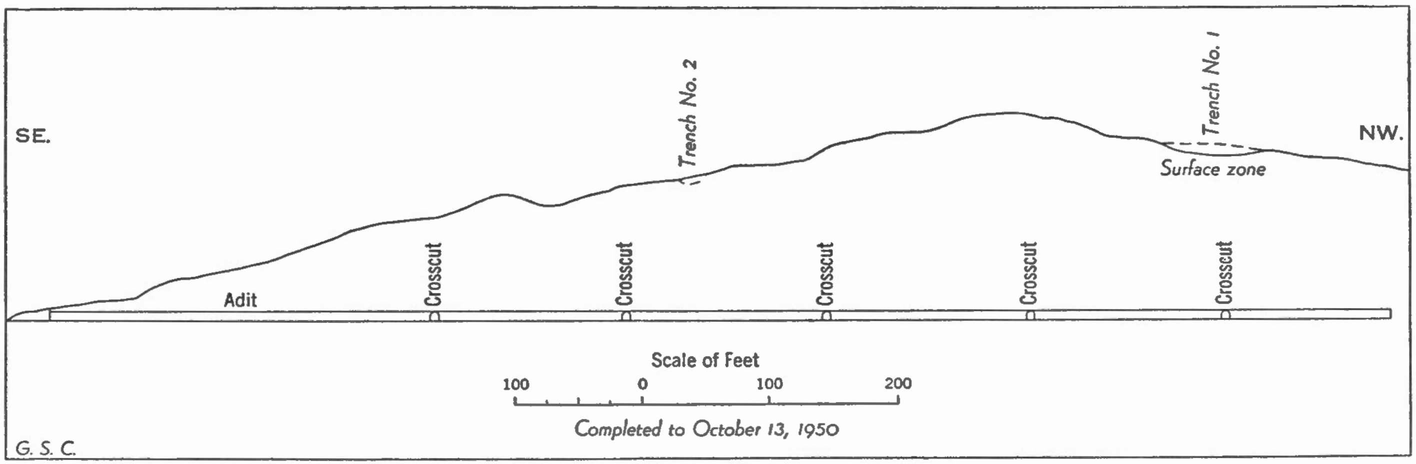


Figure 21. Longitudinal section through adit, Ranwick Uranium Mines Limited, Sault Ste. Marie region, Ontario. From drawing by Ranwick Uranium Mines Limited.

The main showing is near the top of a ridge formed by the Ranwick dyke. Here an area about 70 feet wide and 500 feet long was stripped, exposing several radioactive shear zones and fractures in the dyke, chiefly near the foot-wall and extending parallel with the contact. Lenses of visible pitchblende up to ¾ inch wide were found in places, generally associated with stringers and lenses of calcite and hematite. An open-cut 60 feet long, 10 to 13 feet wide, and 2 to 9 feet deep was excavated on the main part of the showing, and eight bulk samples were obtained from it. Two of these, which were unsorted, showed 0·17 C and 0·45 C; the others were sorted, and they gave the following results: 0·24 C, 2·61 C, 3·67 C, 4·71 C, 5·17 C, and 9·26 C. Another occurrence called the 'South showing', was found in the dyke, about 350 feet southeast of the main showing; a bulk sample from a trench on this occurrence showed 0·25 C. An occurrence containing visible pitchblende, called the 'Creek showing', was found in the dyke, about 900 feet southeast of the main showing. Pitchblende was also reported to have been seen near where the Ranwick dyke crosses the power-line near the north boundary of the property.

In February 1950, an adit was begun at a point near the Creek showing, and drifting was continued along the foot-wall contact of the dyke, with the ultimate objective of exploring beneath the main showing at a depth of about 120 feet. Before reaching it, five mineralized sections 20 to 80 feet long were encountered. These contained pitchblende in calcite stringers averaging ½ to 1 inch in width, pods of pitchblende being up to ¾ inch wide. About three-quarters of the stringers were in the foot-wall section of the dyke and extended parallel with the contact, and the remainder were in fractures and 'slips' extending diagonally and perpendicularly to the contact. The muck from these sections was placed on a separate dump; three lots of samples from it were reported to have averaged 0·16 C, 0·18 C, and 0·38 C. A mineralized section about 20 feet long was encountered approximately under the South showing. Mineralization that appears to be the downward continuation of the main surface zone was encountered at about 870 feet from the portal. Mineralization is then reported to have been found at intervals for 90 feet, followed by a barren section of 17 feet, beyond which mineralization was in evidence at intervals for 70 feet. The backs of the mineralized sections were mined to provide bulk samples, which were crushed in a portable plant at the property. Drifting was continued to a distance of 1,012 feet from the portal, in February 1951.

On February 26, 1951, the company issued the following statement with reference to the results of bulk sampling: "Assays from these samples have now been received and average as follows:

279,375 tons representing a combined length of 358·5 feet returned ·0319% U_3O_8, or ·638 lb. uranium per ton.

By deleting three of the weakest sections and thus confining the samples to 172,125 tons representing a combined length of 256·5 feet the average can be raised to ·0437% U_3O_8, or ·874 lb. uranium per ton.

"The grade of ore thus indicated is lower than that which was estimated by channel samples, but it is without question the closer average and represents what could be expected if an attempt was made to mill the material. Considerable study will have to be given as to the Company's underground policy at this point. In the meantime the work of advancing the adit is being stopped, and, when the snow goes, it is planned to investigate the other diabase contacts where Geiger counter readings have been obtained."

Red Rock River Occurrence. Mr. G. H. Mangun, of 15713 Heyden Ave., Detroit 23, Mich., reported that radioactivity up to eight times background had been found over an area of red granite about 50 by 200 yards in size, near Red Rock River in tp. 31, rge. XX.

Reserve Lake Occurrence. Two samples that showed 0·034 R and 1·36 R were reported by Mr. M. C. Gardiner, of Haileybury, Ont., to have been obtained from a very narrow shear zone in granite, at the west shore of Reserve Lake in Jarvis township.

Rivers-Creighton Group. A sample that showed 0·07 R was reported to be be from a diabase dyke in granite on the Rivers-Creighton group of claims in Gaudette township. These claims are held by Alur Mines Limited.

Roche Group. A group of claims immediately north of the Ranwick property is held by Mr. F. Roche, 802, 85 Richmond St. West, Toronto. The extension of the Ranwick dyke passes through the southwest corner of the property, and pitchblende in calcite-hematite stringers is reported by W. E. Hale to have been found at several places in the dyke; one stringer is reported to have been traced for about 30 feet.

Roche Long Lac Groups. Roche Long Lac Gold Mines Limited holds two groups of claims in the Montreal River region. One group is ¾ mile north of the Ranwick property, and the other extends southward from the southeast corner of the Ranwick group. A diabase dyke called the "Roche dyke" crosses the southwest corner of the northern group of claims. W. E. Hale reported that a shear zone 1 foot to 5 feet wide extends along the hanging-wall of this dyke, and that he obtained counts up to four times background along it; two samples of altered material taken by him across the shear zone showed less than 0·05 R, and unaltered material could not be reached.

Mr. Hale reported that a diabase dyke had been found on the southern property, and that a quartz vein 2½ feet wide was exposed at one place along one of its contacts. Stringers of quartz extend from this vein into the diabase, and one of these stringers was found to be radioactive; two selected samples taken by Mr. Hale showed nil and 0·1 R.

Shields Township. Mr. N. MacLean, Box 231, Sault Ste. Marie, Ont., reported that he had detected strong radioactivity associated with shearing in Shields township. No samples from this occurrence have been received.

Soo-Tomic Group. Soo-Tomic Uranium Mines Limited hold a group of claims 1 mile southeast of MacGregor Cove of Lake Superior. Mr. J. G. McCombe reported that a radioactive zone had been traced for about 600 feet along the foot-wall contact of a diabase dyke. Two samples were reported to have shown 0·05 R and 0·10 R, and another, 0·07 C. Diamond drilling to explore the foot-wall zone was reported to have been begun in June 1951.

Surluga Property. Mr. T. Surluga, of Wawa, Ont., sent a sample that showed 0·10 R, from a pegmatite dyke in tp. 29, rge. XXIII, about 2½ miles southeast of Wawa. He reported that the dyke is parallel with, and about 50 feet from, a gold-bearing quartz vein that has been traced by trenching for a length of 150 feet.

Tooker Occurrence. Two samples that showed 0·024 R and 0·75 R were sent to the Ontario Department of Mines by Mr. E. O. Tooker, R.R. No. 2, Wayland, Mich., from claim SSM 169442, 1 mile east of Lake Superior.

Township 28, Range XVI. Mr. F. Joubin reported that a shear zone 1 foot wide in granitic rock had been found in this township. A sample showed 0·217 C. The occurrence was reported to be on claim SSM 16808.

Township 176. Two samples from an occurrence in this township were sent by Mr. C. E. Kemp, of Sault Ste. Marie, Michigan. The samples showed 0·023 R and 0·055 R. The occurrence is at the north shore of West Twin Lake, about 60 miles east of Sault Ste. Marie. Mr. Kemp reported that radioactivity was found at two places, over areas about a foot long and a few inches wide, and appeared to be caused by secondary minerals in small fissures in arkose.

Van Lake Mines Limited. Mr. J. G. McCombe sent four samples from claim SSM 17852, formerly held by this company. The samples were said to be from a body of red granite, and they showed 0·013 R, 0·015 R, 0·098 R, and 0·52 R. Another sample, sent by Mr. W. Patterson from the same locality, showed 0·04 R.

GRENVILLE GEOLOGICAL SUB-PROVINCE

The name 'Grenville' is commonly applied to a large, natural division of the Canadian Shield, extending northeastward from Georgian Bay to Labrador. It is bounded on the south by the southern boundary of the Shield, and to the north by a line of known and supposed faults; in Ontario the north boundary is placed a few miles south of Sudbury, at a fault that marks the southern limit of Huronian strata. The region is named from the characteristic Grenville series, consisting of crystalline limestone, biotite schist, sillimanite-garnet gneiss, and quartzite, which are the older rocks of the region and which underlie a large part of it. In the past, it has been customary to refer to this region as the 'Grenville sub-province', either considering the entire Shield as a geological province, or considering that the Shield should be divided into provinces, such as those proposed by M. E. Wilson (1941, p. 275), who regards the Grenville as a sub-province of a larger division of the Shield that he calls the 'St. Lawrence province'. Recently, J. E. Gill (1949, p. 65) and J. T. Wilson (1949, pp. 232-233) have suggested that the Grenville region should be classed as a geological province rather than a sub-province because it includes a substantial part of the Shield.

The Grenville region is characterized by abundant pegmatite associated with granitic rocks that intrude the Grenville series and other early Precambrian strata. Most of the pegmatites are ordinary granite pegmatites, but there are also many occurrences of calcite-fluorite pegmatite, notably near Wilberforce. Many deposits of granite pegmatite have been worked for feldspar and mica, and attempts to establish fluorite production from some of the calcite-fluorite deposits have been made. Many deposits, both of granite pegmatite and calcite-fluorite pegmatite, have been known for years to contain radioactive minerals. The Parry Sound and Haliburton-Bancroft areas, in particular, have long been of interest to mineralogists and collectors for this reason, and certain radioactive minerals such as ellsworthite and thucholite were first named and described from these areas. Attempts to mine some of these deposits for radium date from about 1929, and interest in uranium during the last few years caused revival of interest in the known deposits as well as discovery of many additional occurrences of radioactive minerals. The largest amount of exploratory work has been done on uraninite-bearing calcite-fluorite deposits in the hope of establishing fluorite production with production of uranium as a by-product.

Aleck Occurrence. Mr. L. Aleck, of Madawaska, Ont., sent a sample that showed 0·054 R from an occurrence in the south part of lot 17, con. VI, Murchison tp. Later, he sent two samples that showed 0·048 R and 0·12 R; these samples are understood to have come from the same locality.

Alice Township. Mr. R. McCoshen, 359 Agnes street, Sudbury, Ont., sent a sample containing a mineral of the euxenite-polycrase series, from lot. 13, con. XV, Alice tp.

Ambeau Occurrence. Small quantities of a mineral identified as probably belonging to the euxenite series were reported by Ellsworth (1932, p. 173) to have been found at the Ambeau property in Henvey township, where a pegmatite dyke was worked for feldspar several years ago.

Bancroft Feldspar Company. Allanite was reported by D. F. Hewitt, of the Ontario Department of Mines, to have been found at the quarry of this company, in lot 6, con. XII, Monteagle tp.

Bancroft Mica Mine. A sample from the Bancroft mica mine, owned by Bancroft Mica and Stone Products Limited, Selby, Ont., showed 0·10 R. The radioactive mineral was identified tentatively as ellsworthite by the Ontario Department of Mines.

Bathurst Township. Euxenite was reported by H. S. Spence (personal communication) to have been found in the dump of a pegmatite deposit formerly worked for feldspar, in the north half of lot 22, con. IX, Bathurst tp.

Bennett Property. A property that was formerly worked for feldspar and mica, consisting of the north half of lot 2, con. II, Dill tp., is held by Mr. F. Bennett, suite 601, 185 Bay St., Toronto. Four channel samples sent to the Ontario Department of Mines showed 1·63 R, 1·28 R, 1·03 R, and 0·16 R, and three grab samples showed 0·10 R, 0·10 R, and 0·04 R.

Bessner Mine. Thucholite, uraninite, cyrtolite, and allanite were found at the Bessner mine in lot 5, con. B, Henvey tp. This property contains a pegmatite dyke about 70 feet wide that was worked for feldspar on a fairly large scale several years ago, and which is the best known source of pegmatitic thucholite in Canada. Uraninite is intimately associated with the thucholite, and in places thucholite appears to replace uraninite (Ellsworth, 1932, pp. 171-173, 268).

Bromley Township. Samples of pegmatitic material from Bromley township were sent to the Ontario Department of Mines by Mr. J. R. Rae, 802 Federal Bldg., Toronto. One sample showed 0·09 R, and four were below 0·05 R.

Brown Occurrence. Samples from lot 30, con. I, Herschel township, were sent by Mr. D. A. Brown, 113½ Simpson St., Fort William, Ont. One sample showed 0·20 R, and the others showed radioactivity below 0·1 R; ellsworthite was identified tentatively.

Brudenell Township. Allanite is reported to have been found in lot 34, con. IV, Brudenell township, in a pegmatite deposit that was explored because of its corundum content.

Burgess Mine. The Burgess mine in Carlow township was worked for corundum several years ago. The deposits consisted of red syenite pegmatite and associated corundum-bearing rocks. Ellsworth (1932, p. 231) found nodules of radioactive material on the dumps. Sintered grains of uraninite were found in samples of concentrates believed to have come from the site of a concentrator near this property; it is uncertain whether the uraninite came from the Burgess or from the neighbouring Craigmont mine.

Burton Township. Mr. N. A. Taylor, 790 Eastern Ave., Toronto, sent samples that showed 0·05 R and 0·06 R, from lot 37, con. XIV, Burton tp.

Calvin Township. This township contains several pegmatite dykes, some of which were worked for mica and feldspar many years ago. The Molybdenum Corporation of America recently acquired several claims in this township, and did extensive work in the hope of finding workable deposits of rare-earth and radioactive minerals. This work is described elsewhere in this report. Interest in uranium caused prospectors to test other deposits with Geiger counters, with the results described below.

Mr. J. W. MacFarlane, 25 Glenora Ave., Toronto, Ontario, is reported to have found radioactive minerals at eight properties in Calvin township. Pitchblende was reported to have been found, but as the only known deposits in the district are pegmatitic, uraninite was probably meant. Samples sent to the Geological Survey showed 0·18 R, 0·39 R, and 13·86 R; allanite and a mineral of the euxenite group were identified in them.

Mr. W. Stewart sent two samples from a property consisting of lots 11 and 12, con. I, Calvin township. They contained fergusonite, and showed 0·11 R and 0·33 R.

Cameron Property. Dr. D. F. Hewitt, of the Ontario Department of Mines, informed the writer that allanite and euxenite had been found at the Cameron property in lot 22, con. VIII, Murchison tp. These minerals were said to occur rarely in a pegmatite dyke worked for feldspar in 1942 and 1943 by Keystone Contractors Limited of Windsor, Ont., and by Mr. K. Bowser in 1950.

Canada Radium Mine. Canada Radium Mines Limited holds several lots in cons. XII and XIII, Cardiff tp. A pegmatite deposit was developed by a 400-foot shaft, with a total of 1,810 feet of lateral work on three levels (Satterly, 1943, p. 28). A 100-ton concentrator that is still on the property is reported to have recovered feldspar until operations were suspended in 1942. Ellsworthite was identified in specimens reported to be from this property. A sample consisting of about 100 pounds of concentrates reported to have been made in the mill was sent to the Mines Branch in 1950; the sample showed 0·076 C, and uraninite was identified.

Card Property. Cyrtolite was reported to have been found on a property consisting of lots 14 and 16, north of Monck road, Faraday tp., held by Mr. Wm. Card of Bancroft, Ont.

Cardiff Township (Lot 9, Concession XXI). Mr. H. S. Spence (personal communication) reported that a little uraninite was found in a pegmatite deposit on this lot, which is held by Mr. F. K. Montgomery, of Havelock, Ont. The property contains a calcite-fluorite deposit from which test shipments for fluorite have been made.

Cardiff Township (Lots A and 1, Concession XVIII). Wolfe and Hogg (1948, p. 12) reported that radioactivity was detected at a few places in association with calcite-fluorite deposits on this property, which is held by Essential Minerals Prospecting Syndicate.

Cardiff Township (Lots 7 and 8, Concession XX). Mr. G. Pickens, of Wilberforce, Ont., and his associates hold claims covering these lots. According to Wolfe and Hogg (1948, p. 12) uraninite and a mineral identified tentatively as allanite were found in calcite-fluorite pegmatites on this property. Fortier and Elson (1947, p. 8) found two areas, 10 by 32 feet and 17 by 32 feet, that showed off-scale readings with a Geiger counter.

Cardiff Township (Lot 13, Concession XXII). Topspar Fluorite Mines Limited holds the north part of this lot, on which a calcite-fluorite pegmatitic deposit is reported to have been exposed by stripping for a length of 300 feet. Radioactivity was reported to have been detected over an area 400 feet by 600 feet. Ellsworth found that a radioactive mineral from this deposit was closely related to uranothorite, but also contained some boron. A sample from the property is reported to have indicated 7·2 C.

Cardiff Fluorite Mines Limited. This company holds eleven claims, totalling 580 acres, in cons. XVII-XIX, Cardiff tp. The property is being developed with a view to production of uranium, fluorspar, and lime fertilizer. The following description of the property was kindly supplied by Mr. A. G. MacKenzie, Resident Engineer:

"In former literature, the surface exposures which were described as scattered over a distance of 2 miles were divided into five groups or zones. These groups, in order from south to north, which were designated "B", "C", "A", "E", and "F" are now conveniently grouped as follows: "A", "E" and "F" located in the northern section of the property is designated the "North Zone"; "B" and "C" located in the southern area is designated the "South Zone".

"The fluorspar-uranium deposits occur along a contact between crystalline limestone and paragneiss much invaded by pegmatite dikes. The main axis of the contact is approximately N 10° E and dipping eastward at about 45°. The vein material consists of calcite and purple fluorspar. Other crystals found embedded in the calcite-fluorspar are uraninite, apatite, and minor amounts of hornblende, biotite, etc. The dark-purple fluorspar is believed to owe its colour to the radiations from associated radioactive minerals.

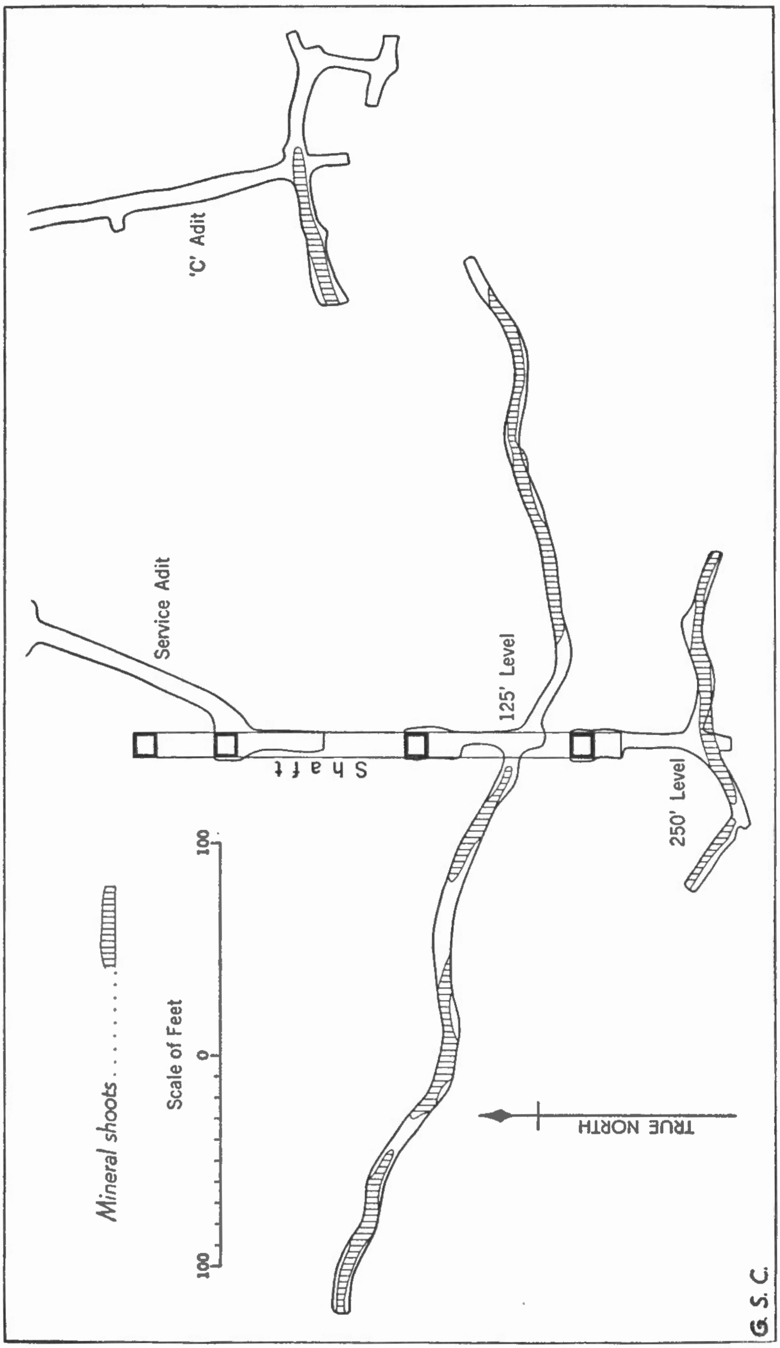


Figure 22. Composite plan of main workings, Cardiff Fluorite Mines Limited, Wilberforce, Ontario. From plan by Cardiff Fluorite Mines Limited.

"North Zone. Exploration work on the North Zone consisted of a considerable amount of surface-trenching, stripping, a limited amount of diamond drilling along the top of a north-south ridge, and an adit has been driven for a total of 705 feet.

"The trenching and stripping has opened up one flat-lying orebody having a length of 290 feet and an average width of 12 feet. Radioactive emanations were obtained with the Geiger Counter on practically all these showings. North of this section and along the strike, a length of 200 feet is indicated in one ore shoot by 5 trenches.

"The adit driven to explore the above-mentioned 200-foot orebody intersected radioactive material 330 feet from the portal, and at a depth of 160 below the surface. A bulk sample sent to the Mines Branch showed an average of 0·135 C, and tests showed that a 10 per cent concentrate could probably be made; the sample contained uraninite associated with pyrrhotite. One hundred feet of drifting has been completed on this occurrence and out of 48 samples assayed none were blanks, 39 were low and 9 averaged 0·20 C. The uraninite occurs erratically in an irregular syenite dike and where values are usually obtained the rock is burned a reddish colour. Uraninite was also noted in three flat drill holes drilled from the adit horizon and further drilling is planned to follow up these intersections.

"South Zone. The main development is now concentrated on the South Zone where the main discovery had been explored in 1947-1948 by diamond drilling and the driving of an adit which intersected the vein approximately 65 feet below the surface outcrop. Further drilling in 1949 extended the orebody for a total length of 1,200 feet, a vertical depth of 400 feet, and a width of from 3 to 30 feet. It has a strike of N 10° E and an easterly dip of about 45°. On surface the vein is exposed continuously for a length of 110 feet and an average width of 5 feet. To the south, it passes under overburden and at the north end it splits into two narrow veins. A character sample of the calcite-fluorite material weighing about 20 pounds and chosen by provincial government geologists, was analysed by the Provincial Assayer and returned 25·96 per cent CaF_2. The Geiger-Mueller counter indicated radioactivity along the full length of the vein.

"In the adit the main vein has been exposed for a length of 80 feet, a width of 3·7 feet and a dip of 40°. The south face is still open while in the north drift, the vein splits into several narrow, irregular branches and shows evidence of dying out in this direction. Samples taken from this drift averaged 22·35 per cent CaF_2 over an average width of 6 feet, and the last sample taken from the south face ran 25·42 per cent CaF_2. Eight bulk samples taken at 10-foot intervals along the back of the drift were sent to the Provincial Assayer where they returned an averagee of 0·052 R across an average width of 5 feet.

"In 1950 another adit was driven for 181 feet as the haulageway for a 50-degree inclined, two-compartment shaft which was then raised to collar on the surface a distance of 52 feet, and sunk to a depth of 275 feet below the adit horizon. A first level 125 feet and a second level 250 feet below the adit was opened up.

"On the 125-foot level 39 feet of crosscutting and 520 feet of drifting has been completed, of which 395 feet are in ore. To the north of the crosscut an ore shoot having a length of 175 feet, an average width of 44 inches and averaging 0·052 R and 13·88 per cent CaF_2 has been opened up. To the south of the crosscut three ore shoots have been developed as follows: the first having a length of 60 feet, an average width of 33 inches is averaged at 0·113 R and 19·57 per cent CaF_2; the second having a length of 75 feet, an average width of 38 inches is averaged at 0·03 R and 24·07 per cent CaF_2; the third shoot, which is still open at the face, having a length of 85 feet, an average width of 40 inches is averaged at 0·20 R and 15·70 per cent CaF_2. A diamond drill hole located 70 feet ahead of the present south face indicates that mineralization continues and is thought to be a continuation of the 85-foot ore shoot.

"On the 250-foot level 51 feet of crosscutting and 177 feet of drifting has been performed. The ore shoot developed at this horizon has a length of 113 feet, an average width of 48 inches and an average value of 0·14 R and 16·17% CaF_2. Both faces are open.

"Early in 1951, bulk samples weighing 4½ tons and 500 pounds from the 125 south and north drifts, respectively, were sent to the Mines Branch, Ottawa, where they were found to contain 0·08 C and 0·12 C, respectively. Tests on the larger sample were reported to indicate that uraninite could be readily concentrated by conventional gravity methods with treatment costs quite low owing to the elimination of fine crushing, no secondary crushing being required; the tests produced a concentrate containing 32·99 C, with a recovery of 81·47 per cent.

"The calcite-fluorite ore shoots have a banded structure and contain a certain amount of green apatite in crystals, biotite in books, and some hornblende. The crystals of uraninite, which are associated with the vein filling, are well defined, vary in size, and several up to an inch across have been noted. Mineralogical examination shows that the ore in the various shoots is similar."

Cavendish Township. Mr. D. J. Smith, Box 145, Beaverton, Ont., sent samples from an occurrence in lot 15, con. IX, Cavendish tp. One sample sent to the Geological Survey showed 0·55 R and was found to contain uranothorite. Samples sent to the Ontario Department of Mines showed 0·11 R, 0·22 R, and 0·41 R.

Chaffy Township. Mr. R. G. Morris, 2431 Oak Grove Place, Toledo 13, Ohio, sent a radioactive sample from Chaffy township, about 6 miles from Huntsville.

Chapman Township. Mr. J. F. Kelly of Huntsville, Ont., sent samples of pegmatitic material from Chapman township. They showed 1·44 R, 0·03 C, and 0·014 C. The radioactive minerals could not be identified definitely, but were reported to be probable allanite and possible uranothorite. Mr. J. A. Bell, of Burks Falls, Ont., sent a sample from this locality and reported that it was from a pegmatite dyke 260 feet wide and traced for 1,500 feet. The sample showed 0·46 R.

Chevrette Occurrences. Mr. E. Chevrette, of Skead, Ont., sent samples from a deposit in granite in the southeast corner of the south half of lot 6, con. III, Maclennan tp. The samples showed 0·096 R, 0·088 R, and 0·08 C. Mr. Chevrette reported that another sample, showing 0·09 C, had been obtained from an occurrence in lot 5, con. II, Maclennan tp.

Conger Township. Radioactive minerals have been found at several places in Conger township, which is a few miles south of Parry Sound. Because the descriptions of these occurrences are short, they are not given separate headings.

Uraninite, calciosamarskite, thucholite, cyrtolite, and allanite were identified by Ellsworth (1932, pp. 174-196, 268) in a pegmatite deposit opened as a muscovite prospect, on the line between lots 9 and 10, con. IX. Uraninite was described as being scattered fairly abundantly in some places.

Calciosamarskite was found in a dyke on lot 10, con. IX.

A few small crystals of uraninite were found in a dyke worked for feldspar on lot 7, con. IX.

Fairly large crystals of allanite were found in a dyke on lot 4, con. IX.

Mr. R. M. Clarke sent three samples from lot 6, con. X. The samples, which consisted of selected material, showed radioactivity between 0·1 R and 1·0 R.

Mr. G. Colautti sent a sample from a feldspar property operated by Opeongo Mining Company on lot 7, con. X. The sample was reported by the Mines Branch to contain euxenite and columbite, and probable monazite.

Mr. J. Dion, of Moon River, Ont., sent samples from lot 42, con. V. They were said to be from a deposit about 2 feet wide and 75 feet long. One sample sent to the Ontario Department of Mines was reported to have shown 0·25 R, and three samples sent to the Geological Survey showed less than 0·05 R.

Mr. W. R. S. Douglas sent samples from an old feldspar pit in lot 3, con. IX. The samples were reported by the Toronto Testing Laboratory to show 0·36 C, 0·64 C, 1·10 C, 2·40 C, 0·28 C, 0·35 C, 0·36 C, 0·54 C, and 1·00 C.

Craigmont Mine. This mine, in Raglan township, was formerly worked on a large scale for corundum, which occurs in red syenite pegmatite and in nepheline rock. A little allanite, and euxenite or a related mineral occur throughout the pegmatite workings (Ellsworth, 1932, p. 231).

Dalton Township. Johnston (1915, p. 9) lists an occurrence of allanite in a pegmatitic deposit on lot 25, con. XII, of this township.

Dickens Township, Lot 27, Concession V. Dr. D. F. Hewitt, of the Ontario Department of Mines, reported that ellsworthite and euxenite had been found at this locality. According to Satterly (1945, p. 122) a pegmatite sill was worked for mica and feldspar in 1943, and a little monazite was found as well.

Dickens Township, Lot 9, Concession XIII. Monazite and a mineral resembling euxenite or samarskite were found in a large pegmatite dyke at this locality (Ellsworth, 1932, pp. 192-195, 264).

Dickens Township, Lot 19, Concession I. Mr. G. Colautti reported that a dyke worked by Opeongo Mining Company for feldspar at this locality showed strong radioactivity over a width of 30 feet and a length of 100 feet, and contained a mineral believed to be monazite. Forty-two samples gave results ranging from 0·017 R to 0·33 R, and averaging about 0·084 R.

Dill Township, Lot 4, Concession III. Toddite was identified by Ellsworth (1932, pp. 171, 266) from a pegmatite dyke formerly worked for feldspar at this locality.

Dill Township, Lot 2, Concession II. A specimen of euxenite, that showed 20·2 R, was sent by Mr. C. J. Cunningham-Dunlop from a feldspar quarry in this township, near Wanup. It is not clear whether this is the same property as the one described as lot 4, con. III, of this township.

Dorset Occurrence. Mr. B. Anderson, 417 Prince Edward Drive, Toronto, sent samples from an occurrence 6 miles southeast of Dorset, in Muskoka district. The Ontario Department of Mines reported that the samples were pegmatitic, and that they showed 11·0 R, 25·1 R, and 8·31 C.

Earle Property. A property in Monmouth township, 2½ miles west of Tory Hill, is held by the Charles Earle Uranium Prospecting Syndicate, which reported that a 'vein' up to 25 feet wide had been traced for more than 2,000 feet, and that radioactivity was detected where this 'vein' is crossed by diagonal 'fissure veins'. One sample sent to the Geological Survey showed 0·18 R, and several showed radioactivity below 0·05 R. The samples were pegmatitic, containing uranothorite and a little pyrite and pyrrhotite.

Elliot Claim. Uraninite was found sparingly in a pegmatite dyke 10 feet wide and exposed for a length of 90 feet on a property known as the Elliot claim, consisting of the south half of lot 13, con. VII, Butt tp. Allanite was identified doubtfully. The dyke was once worked for muscovite (Ellsworth, 1932, pp. 187-188, 268).

Faraday Township, Griffith Property. Mr. J. W. Griffith, 321 Lonsdale Road, Toronto, holds a property consisting of 96 acres in lot 31, con. XVI, Faraday tp., and lots 32 and 33, con. I, Herschel tp. He reported that radioactivity had been traced intermittently for 175 feet at a pegmatite deposit, from which a sample showed 3·24 R (gamma) and 1·70 R (beta). Samples reported to be from paragneiss close to a granite contact showed 0·45 R (gamma) and 0·43 R (beta); 0·50 R (gamma) and 0·39 R (beta); and 0·047. Uraninite, uranothorite, and a mineral of the pyrochlore-microlite series were identified in some of the samples. Mr. Griffith reported that a systematic radioactivity survey revealed only spotty occurrences.

Ferrill Occurrence. The Annual Report of the Ontario Department of Mines, vol. XXXIX, pt. VI, p. 45, lists an occurrence of allanite in a pegmatite deposit on the property of Mr. J. F. Ferrill, consisting of lots 27 and 28, con. III, Monteagle tp.

Fission Mines Limited. This company holds a large group of claims in Cardiff and Harcourt townships, the main showings being on lots 4 and 5, con. XXI, Cardiff tp., about 1½ miles east of Wilberforce and a half mile south of the Wilberforce-Bancroft road. Uraninite was found here about 1922 by

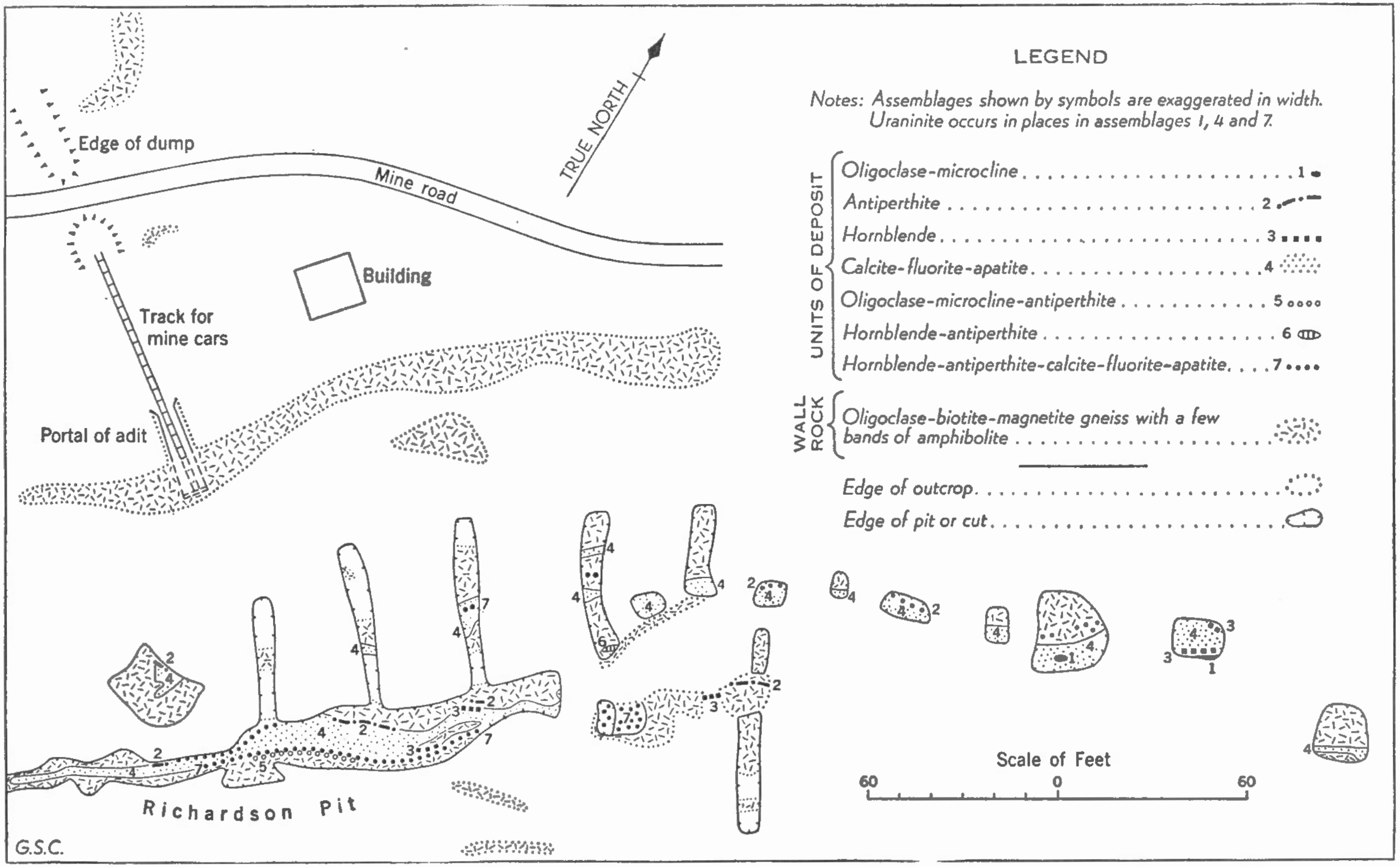


Figure 23. Geological plan of part of Richardson deposit, Fission Mines Limited, Wilberforce, Ontario. From plan by R. B. Rowe, 1950.

the late W. M. Richardson, who later discovered uraninite at several other places scattered within an area 250 feet wide and 3,100 feet long. In 1929, Richardson's property was acquired by Ontario Radium Corporation, a company formed for the purpose, which was succeeded by International Radium and Resources Limited in 1931, and by Wilberforce Minerals Limited in 1937. Surface trenching, and underground exploration that is described below, were done between 1929 and 1931; a concentrator was built but is understood to have made only 'test runs' before being dismantled. Fission Mines Limited, incorporated in 1946, acquired the property and did additional trenching, about 12,000 feet of diamond drilling, and some additional underground exploration before the end of 1948. In 1949, about 3,000 feet of X-ray diamond drilling were reported to have been done to explore the fluorite possibilities of the No. 3 zone.

The deposits and the earlier work have been described by Spence and Carnochan (1930), Ellsworth (1932), and Satterly (1943). In 1947, Fortier and Elson (1947) made a radioactivity survey of the property. The later work on the property was described in detail by Wolfe and Hogg (1948). In 1950, the Geological Survey assigned R. B. Rowe to study the property to learn the applicability of the method of zonal mapping of pegmatites to deposits of this type; this was a doctorate thesis project, the Fission deposits being selected because the underground workings and diamond drilling permitted three-dimensional studies.

The country rocks are granite-gneiss, syenite gneiss, and scapolite gneiss. The deposits are pegmatitic 'vein-dykes' composed mainly of varying proportions of interbanded and contorted calcite, purple fluorite, and feldspars. Other minerals reported are apatite, hornblende, black mica, magnetite, and occasional occurrences of uraninite, allanite, zircon, titanite, molybdenite, pyrite, and pyrrhotite. Some of the uraninite is coarse grained, crystals up to 3 pounds in weight being reported by Ellsworth, and a 5-pound crystal being described recently by Meen (1950). The vein-dykes are reported to pinch and swell from widths of a few inches to 12 feet. The main vein-dyke was traced on surface for a length of 275 feet.

The main, or No. 1 zone was explored by a crosscut adit about 70 feet below the surface exposures. Seven vein-dykes of varying widths and dipping 27 to 35 degrees southeast are reported to have been encountered; two of these were explored by drifting, a total of 850 feet of crosscutting and drifting being reported. Three raises were extended to the surface, on two vein-dykes, and some stoping and slashing was done. The other principal zone, called the No. 3, is about 700 feet southeast of the No. 1 and approximately parallel with it. Several lenticular vein-dykes have been found within a length of 600 feet. Radioactivity readings are reported to be much lower than at the No. 1 zone (Wolfe and Hogg, p. 10).

Recent work on the property has been in the hope of establishing a fluorite operation with a possible uranium by-product. The information available as to tonnage, grade, and recoverability may be summarized as follows: the company announced that Mr. B. D. Weaver estimated that the 450-foot width of Zones 1 and 3, explored by diamond drilling, contained 300,000 tons of fluorite-bearing material from which 80,000 tons of fluorite might be recovered. This would suggest an average recoverable grade of about 26 per cent. Accurate estimates of the average uranium content of either zone have not been made, but Nepheline Products Limited reported that samples sent to them from the No. 1 zone showed the following percentages of U_3O_8: 0·065, 0·114, 0·114, 0·12, 0·07, 0·096, 0·01, 0·01, 0·006, 0·10.

Spence and Carnochan reported on a test shipment of 36 tons of material shipped from the workings in 1929. This was described as the material remaining after 80·5 pounds of uraninite had been hand-picked at the property and shipped separately. The combined U_3O_8 content was estimated to be 2·557 pounds a ton, and good uraninite concentrates were reported to be obtainable by tabling and magnetic separation (Ellsworth, 1932, p. 224). Wolfe and Hogg (1948, pp. 4, 5) expressed the opinion that it might be impractical to recover more than 60 per cent of the uraninite by concentration. Nepheline Products Limited made tests on bulk samples and reported in 1948 that from the ore in Zone 3, 80 per cent of the fluorite could be recovered in a concentrate assaying 96 per cent CaF_2, and that later work indicated that at least 96 per cent might be recovered in an even higher grade concentrate. The presence of apatite was regarded as objectionable, but it was stated that recent work had shown that satisfactory products might be obtainable from material containing as much as 2 per cent apatite. The uraninite in the samples was not recovered satisfactorily by the methods investigated, because of sliming.

Regarding the main or Richardson deposit, Rowe (1951) states: "The veins of the deposit are zoned and exhibit internal structural and textural features remarkably similar to those of granitic pegmatites (Cameron, Jahns, McNair, and Page, 1948), although they are lithologically different. From the walls inward, the zones are as follows: oligoclase-microcline, oligoclase-microcline antiperthite, hornblende, and calcite-fluorite-apatite core. Zones may be missing or telescoped so that the full sequence is present only in a few places.

"Radioactivity at the eastern end of the deposit seems to be associated with the oligoclase-microcline zone, while at the western end, it is associated chiefly with the calcite-fluorite-apatite core.

"Post calcite-fluorite deformation has caused granulation and flowage of the calcite and fluorite of the core."

He summarized his theory for the origin of the deposit as follows: "The feldspathization of the amphibolite and the production of the zoned Richardson deposit were the result of one process that was motivated by the introduction of high-temperature hydrothermal solutions carrying SiO_2, CO_2, F and B. These solutions penetrated slightly deformed amphibolite and were available when larger fractures, the loci of the zoned bodies, developed. The zonation and mineralogy of the deposit can be explained by the rearrangement of pre-existing material plus the addition of material from the solutions". He believes that the uranium may have been introduced hydrothermally, or that it occurred formerly as an accessory constituent of the wall-rocks and was redistributed by hydrothermal solutions.

Foley Township. Mr. R. Anson-Cartwright sent a sample from lot 13, con. II, Foley tp. It contained allanite and showed 0·93 R.

Fraser Township, McCoshen Occurrence. Mr. R. McCoshen, 359 Agnes St., Sudbury, Ont., sent a sample from this township, but did not specify the lot or concession. The sample contained allanite and showed 0·14 R.

Garrett Occurrence. Mr. A. Garrett, 76 Montague St., Smiths Falls, Ont., sent a sample that showed radioactivity between 0·05 R and 1·0 R. The occurrence was reported to be on the south boundary of lot 15, con VI, South Sherbrooke tp.

Genesee No. 2 Property. Dr. D. F. Hewitt, of the Ontario Department of Mines, reported that euxenite had been found at an occurrence known as the Genesee No. 2, on lot 14, con. VII, Monteagle tp. Euxenite was reported to occur near the walls of a pegmatite deposit that was worked by the Genesee Feldspar Corporation about 1920, and reopened by Mr. W. Jessup in 1950.

Gibson Township. Johnston (1915, p. 9) lists an occurrence of allanite at Hollow Lake, in this township.

Gooderham Occurrence. Sherritt Gordon Mines Limited reported a small occurrence of uraninite at mileage 32·75 on the Canadian National railway near Gooderham, Ont. Samples were reported to have indicated 0·03 C, 0·05 C, and 49·6 C.

Hagarty Township. Johnston (1915, p. 9) lists an occurrence of allanite in lot 13, con. A, of this township.

Hardy Township, Tough Property. Mr. G. Tough, Bracebridge, Ont., sent a sample that showed 0·15 R, from the south half of lot 28, con. IX, Hardy tp.

Harvey Township. Mr. R. M. Clark, 120 Angeline St., Lindsay, Ont., sent a sample that showed 0·23 R, from lot 26, con. XVII, Harvey tp.

Henvey Township, Lot 4, Concession A. Mr. H. S. Spence reported (personal communication) that euxenite was found in a pegmatite dyke 25 by 150 feet in size at this location.

Herschel Township, Lots 27 and 28, Concession IV. Mr. A. H. Lewis, c/o Gerry Hardware Electric, Simpson St., Fort William, Ont., sent two samples from this locality. The samples showed 0·012 R and 0·065 R.

LaSalle Yellowknife Gold Mines Limited. The Northern Miner (Oct. 27, 1949) reported that LaSalle Yellowknife Gold Mines Limited had found columbium and uranium on claims staked near the property of the Molybdenum Corporation of America in Calvin township. No reports of these discoveries have been received officially.

Loudon Township. Mr. H. D. Tomlinson, 289 Midland Ave., Scarborough Bluffs, Toronto 13, sent samples that showed 0·17 R and 0·21 R, from a pegmatite deposit in lot D, con. V, Loudon tp. Mr. Tomlinson reported that another sample from this occurrence contained much-altered thorite, and showed 2·86 R.

Loughborough Township. Euxenite and gadolinite were reported by Ellsworth (1932, pp. 232, 262) to occur in a pegmatite deposit formerly worked by M. J. O'Brien Limited in lot 11, con. IX, Loughborough tp.

Lutterworth Township. Johnston (1915, p. 9) lists an occurrence of allanite associated with a deposit of magnetite in this township.

Lyndoch Township. Lyndochite, monazite, and cyrtolite are reported to occur in a pegmatite dyke more than 200 feet long, that produced several tons of beryl about 1926, when it was worked by the late Mr. T. B. Caldwell of Perth, Ont. The deposit is in lot 23, con. XXIII, Lyndoch tp.

Lyndoch Township. Dr. D. F. Hewitt, of the Ontario Department of Mines, reported that allanite had been found on lot 25, con. XV, Lyndoch tp., where Universal Light Metals Company explored a pegmatite deposit because of its content of beryl, columbite, and rare-earth minerals. Lyndochite and monazite are reported to occur.

Maberly Property. The Maberly property, consisting of lot 13, con. V, South Sherbrooke tp., about 3 miles south of Maberly village, was worked intermittently for feldspar by Orser-Kraft Feldspar Limited. The property contains a pegmatite dyke up to 75 feet wide and more than 200 feet long, in which euxenite was found fairly abundantly during mining for feldspar. At the suggestion of H. V. Ellsworth, a bulk sample consisting of 1,593 pounds of euxenite-bearing rock was shipped to the Mines Branch in 1921. The shipment was estimated to contain 0·2 C and 0·08 per cent ThO_2. A concentrate containing 5·7 C and 2·30 ThO_2 was made (Ellsworth, 1932, pp. 233-236, 262).

MacDonald Mine. A property known as the MacDonald mine, consisting of the north halves of lots 18 and 19, con. VII, Monteagle tp., was worked extensively for feldspar and produced a large quantity prior to 1923. The property has been idle for many years, and is understood still to be owned by Mr. P. MacDonald of Hybla, Ont. It contained a pegmatite dyke averaging 40 to 50 feet wide, and worked for a length of about 600 feet by a large open-cut and two adits. Crystallization was on a gigantic scale, making the dyke very suitable for feldspar production. It is the type locality for the mineral 'ellsworthite', and it was estimated that about a ton of this mineral was sold to museums or dealers, or carried away by collectors. Other radioactive minerals found were uranothorite, cyrtolite, and allanite (Ellsworth, 1932, pp. 200-209).

Machar Township. A sample containing allanite and showing 0·09 R was sent from Machar township by Mr. Carl Palangio, 845 McLaren St., North Bay, Ontario.

Madawaska Feldspar Company. This company produced substantial tonnages of feldspar and quartz from a pegmatite dyke 15 to 60 feet wide, which was opened for a length of 900 feet and depths of 15 to 30 feet. The mine, which is in lot 14, con. IV, Murchison tp., was closed in 1944. During mining, crystals of fergusonite were found associated with intergrowths of black mica. Ellsworth estimated that roughly 750 pounds of fergusonite may have been contained in the part of the dyke mined.

Madoc Township. A secondary uranium mineral described as 'uranochre' was reported to occur lining fissures in a magnetite deposit worked for iron ore on lot 11, con. V, Madoc tp. (Logan, 1863, pp. 504, 675).

March Township. Uraninite was found in a body of pegmatite about 30 feet wide and 120 feet or more long, on lot 6, con. II, March tp. The deposit was worked for feldspar by M. J. O'Brien Limited about 1924 (Ellsworth, 1932, pp. 238, 268).

Mattawan Township. Several occurrences of radioactive minerals have been found in pegmatite deposits in this township. Most of them were previously worked or explored for mica or feldspar.

Mr. C. Palangio, 845 McLaren St., North Bay, Ont., sent a sample that contained a mineral of the euxenite-polycrase series, and which showed 7·3 R, from lot 29, con. II, Mattawan tp.

Uraninite was collected by the writer at dykes formerly worked for muscovite by Purdy Mica Mines Limited on lots 6 and 7, con. II, Mattawan tp.

Recent work by Molybdenum Corporation of America on the O'Brien-Fowler property in this township is described under "Molybdenum Corporation of America".

Molybdenum Corporation of America. This company explored two groups of claims in Calvin and Mattawan townships to test the possibility of producing uranium and columbium.

The claims in Calvin township are along Highway 17 near Eau Claire. One group was acquired from Mr. S. B. Bond, and an adjoining group was optioned from Bobjo Mines Limited. These claims contain four main pegmatite dykes that were formerly worked or explored for feldspar. They contain scattered crystals of euxenite and a mineral identified tentatively as samarskite. Allanite had been reported by Spence (1932, p. 51).

The Bond claims contain three dykes averaging 20 feet in width, the longest being traced for about 1,000 feet. One bulk sample was reported to average a trace of U_3O_8 and 0·12 per cent columbium and tantalum oxides, and another to average 0·31 C and 0·15 per cent columbium and tantalum oxides.

The main dyke on the Bobjo claims was reported to average 20 to 25 feet in width, and to have been traced for 800 feet. Three bulk samples from a small shaft were reported to have each shown 0·10 C, and 0·10, 0·12, and 0·15 per cent columbium and tantalum oxides. Nepheline Products Limited reported that work on a test shipment indicated that a concentrate containing 7·16 C and 4·98 per cent columbium oxide could be made.

In 1950 the Molybdenum Corporation of America did bulk sampling on the O'Brien-Fowler property, consisting of lot 29, con. III, Mattawan tp., about 5 miles west of Mattawa. This property contains a pegmatite dyke 18 to 25 feet wide, exposed for a length of 300 feet, which was worked for feldspar in 1925-26 by M. J. O'Brien Limited. Several pounds of specimens of a mineral of the euxenite-polycrase group were collected from this dyke (Ellsworth, 1932, p. 190; Spence, 1932, p. 52). The first six bulk samples sent to the Mines Branch in 1950 showed 0·004 C, 0·007 C, 0·014 C, 0·015 C, 0·034 C, and 0·027 C. A later shipment of nine bulk samples showed 0·07 C, 0·13 C, 0·044 C, 0·041 C, 0·024 C, 0·027 C, less than 0·001 C, less than 0·001 C, and 0·002 C.

Monmouth Lake Uranium Mines Limited. The Canadian Mines Handbook, 1949, states that this company has a uranium prospect in Monmouth and Anstruther townships. No reports of discoveries have been made by this company to the Geological Survey.

Monmouth Township, Claim E. O. 4239. Mr. G. Keller, 1232 Avenue Road, Toronto, sent samples from this claim to the Ontario Department of Mines. Two samples of coarse granitic material showed 0·05 R and 0·25 R.

Monteagle Township, Campbell Claims. Mr. J. R. Campbell, 136 Wheeler Ave., Toronto, sent samples from a property consisting of lots 20, 21, 23, 24, and 29, con. VI, and lots 22, 23, and 24, con. VII, Monteagle tp. The Ontario Department of Mines reported that the samples showed 0·15 R, 0·07 R, 0·007 R, 0·25 R, nil, and 0·015 R. Another sample, from an unspecified locality, showed 0·06 R.

Monteagle Township, Dwyer Property. Dr. D. F. Hewitt, of the Ontario Department of Mines, reported that a mineral identified tentatively as euxenite had been found at a pegmatite deposit in lot 21, con. VII, Monteagle tp. The deposit was worked for feldspar by Mr. P. J. Dwyer.

Monteagle Township, Lots 21, 22, Concession VI. Mr. F. Joubin sent samples of pegmatitic material from this property to the Ontario Department of Mines, who reported that they showed 1·61 R, 1·62 R, 0·18 R, 0·13 R, and 0·008 R.

Monteagle Township, Lot 12, Concession IV. Mr. J. Quirk, R.R. No. 1, Birds Creek, Ont., reported that a body of radioactive material had been traced for a width of 200 feet and a length of 400 feet. A sample of pegmatitic material showed 0·55 R. Samples sent later showed 0·14 R, 3·55 R, and 4·48 R; tests on these indicated that most of the radioactivity was probably caused by thorium, and uranothorite was identified in one sample.

Monteith Township. An occurrence of allanite on lot 21, con. B, Monteith tp., was described by Ellsworth (1932, pp. 191-192).

McRae Uranium Prospecting Syndicate. This syndicate reported exploratory work on pegmatitic deposits on a property consisting of several claims in Butt and Proudfoot townships. The main zone was reported to be a pegmatite dyke with a zone of quartz at the centre, and with masses of radioactive black mica along the edges of the quartz zone. Selected samples were reported to have shown 65·5 R, 2·68 R, 5·05 R, 25·3 R, and 0·06 R. Another sample showed 1·82 C. Samples from lot 3, con. V, Butt tp., believed to be part of this property, showed 0·21 R, 0·34 R, 0·14 R, 0·14 R, 0·12 R, and 0·005 R.

Plexman Property. Mr. J. Plexman, 95 King St. East, Toronto, and associates, are understood to hold a property in Loughrin township, about 20 miles east of Capreol. The Northern Miner (June 16, 1949) reported that radioactivity had been detected with a Geiger counter for a length of 350 feet near an old feldspar pit.

Raglan Township. Mr. J. H. Webster, 20 Caithness St., Toronto, sent a sample from lot 27, con. IX, Raglan tp. The sample showed 0·58 R.

Ranrouyn Mines Limited. This company held a group of claims in lot 12, con. XVIII, Cardiff tp. Wolfe and Hogg (1948, p. 12) reported that an area about 20 feet in diameter in pegmatitic granite showed radioactivity. No sampling results were received, and the claims were abandoned in 1949.

Sabine Township. Euxenite was reported to occur in a pegmatite dyke formerly worked for feldspar in lot 28, con. I, Sabine tp. (Ellsworth, 1932, pp. 195-196).

Sherbrooke Township. Mr. R. M. Clark, 120 Angeline St., Lindsay, Ont., sent a sample that showed 1·63 R to the Ontario Department of Mines. The sample consisted of pegmatitic material and contained a mineral identified tentatively as euxenite.

Servos Township. The Graham Lake Mining Syndicate is understood to hold lot 6, con. VI, Servos tp. A sample sent to the Ontario Department of Mines showed 8·37 C. Samples sent to the Geological Survey showed 0·011 R and 0·74 R; and 0·007 C and 0·12 C. The samples consisted of granitic material and contained a mineral of the euxenite-polycrase series.

Snowdon Township. An occurrence of uraconite associated with magnetite, on lot 20, con. I, Snowdon tp., is mentioned in the Annual Report of the Geological Survey for 1873-74, p. 205.

Summerville Township. Mr. J. H. Webster, 20 Caithness Ave., Toronto, sent samples that showed 0·16 R and 0·58 R to the Ontario Department of Mines. The samples were from lot 9, con. XII, Summerville tp.

Thompson Mine. Dr. D. F. Hewitt, of the Ontario Department of Mines, reported that allanite was fairly common at the Thompson mine, in lot 11, con. VII, Monteagle tp. The mine was worked for feldspar by Feldspar Mines Corporation from 1922 to 1924.

Tiffany Property. Mr. N. B. Tiffany, of Buffalo, N.Y., reported that he and associates hold claims covering 650 acres in Bethune township. He stated that the claims had been staked in 1938 for vanadium, tantalum, titanium, and gold, and that an autoradiograph had shown that samples were radioactive.

Wills Property. Mr. W. L. Wills, 816 Bridge St., Niagara Falls, Ont., reported that he had found pitchblende and graphite on his property, which he described as being 1 mile from Wilberforce. No samples were received. As deposits of pitchblende are not known to occur in the region, it seems likely that this use of the term pitchblende was meant to include uraninite, which is common in the region.

Wilks Mine. A specimen that contained allanite and showed 1·73 R was sent by Mr. J. C. Dunlop, Hoyle Mining Company Limited. The sample was reported to be from the Wilks mine, near Verona, Ont.

Woodcox Mine. The Woodcox mine is in lot 17, con. VII, Monteagle tp., about a mile northeast of the MacDonald mine. A pegmatite dyke 60 feet wide and at least 300 feet long was worked for feldspar before 1923. Hatchettolite, calciosamarskite, and cyrtolite were reported by Ellsworth (1932, pp. 209-213, 258, 260, 262, 270). In 1948, the Atomic Energy Control Board issued a permit to Northern Uranium Mines Limited for exploration of this property. In 1949, three samples were reported to have shown nil, 1·42 C, and 8·12 C. The company has been inactive since 1949.

Zenith Mine. This mine, in lots 27 and 28, con. IV, Bagot tp., is owned by Zenith Molybdenite Corporation. The Quebec Smelting and Refining Corporation sent six samples collected during an examination of this property. One sample showed radioactivity slightly above 0·05 R, and the rest gave results below this amount.

OTHER OCCURRENCES

Bradley-Donaldson Group. Mr. J. T. McMullan, of Haileybury, Ont., reported that radioactivity had been detected in diabase on this property, which is in Auld township about 20 miles east of New Liskeard. No samples were submitted.

Cane Silver Property. Mr. J. T. McMullan, of Haileybury, Ont., reported that radioactivity had been found at five veins on a property formerly held by Cane Silver Mines Limited, in Cane township, about 20 miles northwest of New Liskeard. A sample sent by Mr. McMullan to the Ontario Department of Mines showed 0·20 R. This sample was reported to contain uranium stain and cobalt bloom.

Devils Rapids Occurrence. Prospectors for Moneta Porcupine Mines Limited found a radioactive deposit near Devils Rapids on Mattagami River, in Mowbray township. Two fractures in biotite gneiss were reported to contain quartz, carbonate, pyrite, and pyrrhotite. The veins are up to a foot wide and have been traced for lengths of 27 and 60 feet. A selected sample showed 0·23 per cent ThO_2 and no uranium.

Leach and Johns Property. An occurrence of probable euxenite was reported by Ellsworth (1932, p. 173) from the Leach and Johns property in Carter township. This property, at mileage 98 on the Canadian National railway, contains a pegmatite dyke explored for feldspar several years ago.

Mitchell-Hurst Gold Mines Limited. Mitchell-Hurst Gold Mines Limited reported that counts up to eight times background had been obtained over an area 50 feet wide and ¾ mile long on its property in Hearst township, near Larder Lake. It was also reported that an old diamond drill core on the property showed counts up to six times background.

Otter Rapids Occurrence. Mr. A. C. Mosher discovered a radioactive occurrence near Otter Rapids on Abitibi River, in Pitt township, about 90 miles north of Cochrane. The occurrence was examined by Y. O. Fortier and J. M. Harrison, of the Geological Survey, who reported that veins of carbonate, quartz, and hematite occur in Precambrian gneiss that is intruded by granite and pegmatite. The main vein is about a foot wide, and is exposed at intervals for 234 feet. Seven samples showed 0·004 R, 0·025 R, 0·031 R, 0·053 R, 0·056 R, 0·063 R, and 0·130 R. All the radioactivity was attributed to thorium, but the radioactive mineral was not identified.

Pitt Township. Prospectors for Moneta Porcupine Mines Limited found radioactive pegmatite on three claims in this township. A sample from one occurrence showed 0·139 R and contained monazite.

Smoky Falls Occurrence. Moneta Porcupine Mines Limited reported an occurrence of radioactive pegmatite 3 miles north of Smoky Falls on Mattagami River. A pegmatite dyke about 10 feet wide was traced for about 150 feet. A sample showed 0·091 R.

Spencer Property. Mr. W. A. Spencer holds a property consisting of eleven claims in Hudson, Lundy, and Henwood townships. Dr. R. Thomson, of the Ontario Department of Mines, reported that radioactivity is associated with bands of breccia up to 1 foot wide, consisting of reddish fragments of greywacke in a chloritic matrix. Bands of breccia have been found within a zone about 250 feet long. In places, the breccia contains carbonate and chalcopyrite. A sample taken by Dr. Thomson showed 0·14 R. Seventeen samples sent to the Ontario Department of Mines showed radioactivity ranging from nil to 0·18 R, and the results of twenty-three samples sent to the Geological Survey range from 0·01 R to 0·21 R. The radioactive mineral has not been isolated.

Timagami Lake Occurrences. Mr. J. P. Neil, 410 Leland Ave., Palo Alto, California, reported that he found four small, highly radioactive areas near the east end of Timagami Lake. Quartz veins are said to occur at three of the localities. No samples were taken.

QUEBEC

Thirty-five properties in Quebec have been reported to contain radioactive minerals. Almost all these properties contain pegmatite deposits, and almost all are in the Grenville sub-province of the Canadian Shield. The others include a pegmatitic occurrence in Preissac township and pitchblende occurrences in Gaspe and the Otish Mountains.

GRENVILLE GEOLOGICAL SUB-PROVINCE

The general characteristics of the Grenville sub-province have been described in the part of this report that deals with the Grenville of Ontario. In Quebec, the sub-province forms the southern part of the Canadian Shield, extending from Ottawa River to Labrador. To the south, it is bounded by the St. Lawrence Lowland and, farther east, by the St. Lawrence River and Gulf. Its northern boundary is generally considered to be a zone of faults that extends northeastward from the vicinity of Lake Timiskaming to the Mistassini region; north and west of this zone, the Shield contains Keewatin rocks.

As in the corresponding part of Ontario, the Grenville sub-province in Quebec contains numerous pegmatite deposits, but the part of the Shield that lies to the north is not devoid of pegmatite. Some of the pegmatites in accessible parts of the Grenville region were investigated many years ago, resulting in considerable mining for apatite, mica, and feldspar. Radioactive minerals were found incidentally to this, but the quantities were small and only of academic interest. Allanite was reported to occur near Bay St. Paul and Lake St. John in 1863 (Logan, 1863, p. 505). Samarskite was reported from the Maisonneuve mine in 1883 (Hoffman, 1883, p. 1H), and uraninite was described from the Villeneuve mine (Hoffman, 1887, p. 1OT). Interest in such occurrences was stimulated during the last 2 years by the demand for commercial uranium deposits. Many claims were staked, chiefly in the vicinities of Portneuf and St. Simeon, and many additional discoveries of radioactive minerals in pegmatite were found and investigated. The geology of the Portneuf region was described by Clark (1948), and Ross (1950) described the St. Simeon region.

Arbic Occurrence. Samples of pegmatite material, some of which contained allanite, were submitted by Mr. P. Arbic, of Mont Laurier, from an occurrence near Lièvre River about a mile from Mont Laurier. The results of four samples ranged from 0·05 R to 0·22 R, and others were below 0·05 R.

Bolduc Occurrence. Three samples were submitted by Mr. A. Bolduc, of St. Thuribe, Portneuf county. They were reported to be from an occurrence in St. Joseph concession, St. Thuribe township, 3½ miles from St. Thuribe village. The samples showed 0·10 R, 0·13 R, and 0·21 R.

Callieres Township. St. Simeon Uranium Corporation hold a large block of claims in this township, including a deposit of radioactive pegmatite on lot 11, rge. I. The showing, which is on the shore of the St. Lawrence River, consists of an open pit sunk on a pegmatite dyke 15 inches wide, which intrudes granite-gneiss. The pit exposes the dyke for a length of about 10 feet, and an additional 15 feet has been stripped. Pyrite, molybdenite, fergusonite, and small crystals of uraninite were identified in samples from this dyke. A 600-pound sample sent to the Mines Branch contained 0·15 C.

Clapham Township. Samples sent by Mr. W. Loken, of Campbells Bay, Que., showed 0·07 R, 0·07 C, 0·095 C, and 0·12 C, and were said to be from a 3-foot vein in greenstone that had been stripped for a length of 200 feet.

Gaudry-Caron Property. Messrs. Gaudry and Caron staked several claims in the parishes of Deschambault and Notre-Dame de Portneuf. Several samples were sent to the Geological Survey and the Mines Branch, following which the writer examined the main showing. A description of the property based on this examination was sent to Mr. Gaudry for permission to publish, but as no reply was received, the following account has been summarized from a report issued by the Quebec Department of Mines (Graham, 1949).

The main showing is on lot 331, con. III, parish of Notre-Dame de Portneuf. It is 1·2 miles by road from Portneuf station. It consists of an outcrop of pegmatite about 130 feet long and up to 75 feet wide. In places the outcrop contains radioactive yellow stain identified tentatively as uranophane, and a fluorescent mineral was identified tentatively as autunite. Two primary radioactive minerals were separated, one being thucholite and the other undetermined. A selected sample taken by Mr. Graham showed less than 0·15 C, and one submitted by Mr. Gaudry showed 1·05 C.

Grand Calumet Island Occurrences. Radioactivity has been reported from lots 30 and 31, rge. VII, Grand Calumet Island, owned by Mr. Paul Pare. Samples were sent by Mr. H. Chevrier, who has an agreement covering mineral rights. Three samples gave results ranging from 0·05 R to 0·3 R, and two samples analysed by the Quebec Department of Mines showed 0·06 C and 0·4 C.

Another property is held by Mr. W. Loken, Box 77, Campbells Bay, Que. Mr. Loken reported that a contact between gneiss and sedimentary rocks is strongly radioactive for a width of 10 feet, and that radioactivity had been traced at intervals for a length of 3,000 feet. A sample that contained fluorite and apatite showed 1·32 R, and another sample that was analysed chemically contained 0·06 C.

Lac A Baude Occurrence. A deposit of allanite has been known at this locality for many years; it was described first in the Annual Report of the Geological Survey for 1894, and details have been given in several later reports. The occurrence is in Normand township, 44 miles northwest of Grande Mere. Abundant allanite is said to be exposed in a cliff formed of coarse-grained, reddish granite, crystals of allanite about 3 inches long being common. Mr. J. M. Yates, of 10751 Henri Julien St., Montreal, is understood to have staked the deposit recently. Three samples sent by him showed 0·1 R, 0·125 R, and 0·25 R, and a sample analysed chemically contained 0·05 per cent U_3O_8 and 0·50 per cent ThO_2.

Lac Pied des Monts Occurrence. An occurrence of uraninite and thucholite has been known for many years at this locality, which is about 18 miles north of Murray Bay. It is reported to be a pegmatite dyke 15 to 20 feet wide, traceable for 200 feet. Obalski (1904, p. 245) described uraninite from this locality, and also a coal-like substance now believed to be thucholite. Ellsworth (1932, p. 250) gives details of the deposit.

Lepine Depot Occurrence. Mr. F. B. Watson, Box 34, Dunham, Que., sent samples from an occurrence 6 miles northwest of Lepine Depot, north of Maniwaki. Allanite and monazite were identified in a sample of pegmatitic material, which showed 1·40 R. Mr. Watson reported that the sample was from a deposit containing nickel, cobalt, copper, and small amounts of gold and silver.

Maisonneuve Mine. An occurrence of samarskite at what is called the Maisonneuve mine, 10 miles north of St. Michel des Saints, was explored before 1882, and described by Hoffman (1883, p. 1H). It is also described in the Annual Report of the Quebec Department of Mines for 1905, and by Ellsworth (1932, pp. 248-249, 266). The property is now held by South State Uranium Mines Limited.

The occurrence is described as a pegmatite dyke 100 feet wide and probably several hundred feet long. Crystals of samarskite were reported to be abundant in an area of 10 by 30 feet, and the dyke also contains muscovite, biotite, tourmaline, beryl, fergusonite, and euxenite. Several tons of samarskite-bearing material are reported to have been mined during early operations. A report prepared by P. E. Bourret in 1949, for the Quebec Department of Mines, states that radioactive minerals believed to be chiefly samarskite occur in three pegmatite outcrops within a radius of 500 feet, and that the average samarskite content seemed to be low. A sample of about 1,570 pounds of material was sent by the owners to the Mines Branch in 1950; it contained 0·026 C, and the radioactive mineral gave an X-ray pattern similar to that of euxenite.

Pope Lake Occurrence. Several samples, one of which contained allanite, were sent by Mr. A. Duquette, of Val Limoges, Labelle county, Que., from an occurrence north of Pope Lake in Labelle county. Samples sent to the Quebec Department of Mines indicated 0·07 R, 0·2 R, 0·22 R, and 0·09 R. Samples sent to the Geological Survey showed 0·14 R, 0·16 R, 0·24 R, and 0·37 R.

Portland Township. An occurrence of allanite on lot 13, rge. III, Portland tp., is described by Ellsworth (1932, pp. 244, 258).

Portneuf Molybdenum Company. For several years this company has held a property consisting of many lots in range II of Deschambault and Portneuf Parishes, about 3 miles west of Portneuf Village. Molybdenite occurs at intervals in a zone of pegmatite and biotite gneiss that has been traced intermittently for 1,500 feet. Showings have been explored by several open-pits, and a 40-foot shaft. A sample reported to be from this property showed 6·19 R, and another sample showed 0·16 R. Uraninite and probable uranothorite were identified in the samples. These samples appear to represent isolated occurrences, because the writer visited the property twice and could only detect radioactivity at one place, and a sample of this material showed 0·027 R.

Sagard Township. Quebec Uranium Corporation staked about 1,600 acres in this township, about 12 miles north of St. Simeon. Several pegmatite deposits occur in gneissic rocks. One of these was formerly worked for mica, and a sample reported to be from here, which was sent to the Quebec Department of Mines, contained 58·98 C. The writer was unable to detect radioactivity at this locality, but a sample from a small body of pegmatite about $\frac{1}{4}$ mile away, at the shore of a small lake called Lac de la Mine, showed 0·05 R.

St. Mathieu Township. Mr. A. Perreault, of Shawinigan Falls, sent three samples from lots 38 and 39 of this township, about 3 miles from Shawinigan Falls (the range was not stated). The samples showed 0·14 R, 0·09 R, and less than 0·03 R; most of the radioactivity appeared to be caused by thorium.

Templeton Township. Mr. W. M. Wallingford, of Gatineau Point, Que., sent a sample from the south half of lot 20, rge. XII, Templeton tp. The sample was pegmatitic, and it contained euxenite. A test on a picked sample of the pure mineral showed 15·36 R.

Villeneuve Mine. This property, consisting of lot 31, rge. I, Villeneuve tp., was first worked for mica in 1884, and it produced a large amount of muscovite and feldspar in later years. The deposit was a pegmatite dyke reported to be 150 feet wide. Specimens of uraninite and monazite were found during mining.

Wallingford Mine. The Wallingford mine, in lot 14, rge. II, Derry tp., was worked for feldspar and quartz by M. J. O'Brien Limited. The deposit consists of a pegmatite dyke of varying width, about 75 feet wide at the mine, and traceable for a mile or more. Large masses of sheared allanite were found during mining, and uraninite, thucholite, and cyrtolite were found at one place.

Waltham Occurrence. Mr. C. D. Sauriol, 1027 Dease St., Fort William, Ont., sent a sample that showed 0·071 R. It was reported to be from the Black River area near Waltham.

West Portland Township. A pegmatite dyke about 30 by 75 feet in area was found in lot 2, rge. V, West Portland tp., several years ago. About 10 pounds of euxenite and 20 pounds of monazite were obtained during mining for feldspar (Spence, 1932, p. 76).

OTHER OCCURRENCES

Cross Point Occurrence. An occurrence of uranium has been found on a property owned by Mr. W. B. Busteed, of Cross Point, Que. It is 2 miles east of the village of Cross Point, which is on the south shore of Gaspe Peninsula, the showing being ½ mile north of the highway, and consisting of a small lead-zinc-silver prospect. A vein containing argentiferous galena and sphalerite occurs in porphyritic volcanic rock classed as Lower Devonian in age. Mr. Busteed stated that the deposit was diamond drilled under option in 1928, the core being removed and its present whereabouts being unknown. He also stated that, in 1936, Gulf Development Company shipped 20 tons of picked ore to Belgium, where it was found to average 37 per cent lead and 3 ounces in silver a ton, with some zinc. After that, material was blasted down in such a way as to cover the showing. The writer was, therefore, unable to see the extent of the deposit, but saw one small part of it by removing muck. Mr. Busteed stated that the vein was 14 inches wide and that it had been exposed for a length of 25 feet.

In 1949, a prospector in the employ of Wright-Hargreaves Mines Limited showed a specimen of the ore to the chief geologist for that company, who made a routine test for radioactivity and found that it was radioactive. A sample showed 0·64 R, and pitchblende was identified in it by the Geological Survey. A larger sample was then sent to the Mines Branch, where it was found to contain 0·16 C and to consist of an intimate mixture of galena and pitchblende. A picked sample taken by the writer, from material that seemed to be in place, showed 0·12 R. The deposit was described by F. J. Alcock of the Geological Survey of Canada (1930) and by I. W. Jones for the Quebec Department of Mines (1937, p. 22) before there was any reason to suspect the presence of pitchblende. The discovery of uranium at this property suggests that other lead, or copper, deposits in Gaspe should be checked for radioactivity.

Otish Mountains Occurrence. Mr. G. H. Babcock reported that he had discovered pitchblende in the Otish Mountains, near the headwaters of Mouchalagan River, roughly at latitude 53 degrees, longitude 70 degrees. He stated that pitchblende occurred in a calcite vein at the contact of a diabase dyke with quartzite. A specimen submitted to the Geological Survey was identified as pitchblende. The occurrence is understood to have been staked by Mr. Babcock for Gravimetric Surveys Limited.

Preissac Township. Dr. E. Grondin of Val d'Or, Que., sent samples from two localities in this township. A sample from lots 53 and 54, rge. VII, showed radioactivity between 0·05 R and 0·10 R, and several others from this locality and from lot 60, rge. VII, were below 0·05 R.

NOVA SCOTIA

Gummite and monazite were reported by Johnston (1915, pp. 112, 161) to occur in pegmatite near Lake Ramsay, New Ross, N.S. In 1950, Mr. M. G. Goudge of the Nova Scotia Department of Mines sent the Geological Survey some samples from a greisen vein at the Turner Tin prospect in the New Ross area. The samples showed 0·096 R, 0·22 R, 0·24 R, 0·42 R, and 1·2 R. The radioactive material was identified tentatively as torbernite or metatorbernite. Another sample, which was sent by Mr. A. C. Mosher and which showed 0·16 R, is understood to have come also from the Turner Tin prospect.

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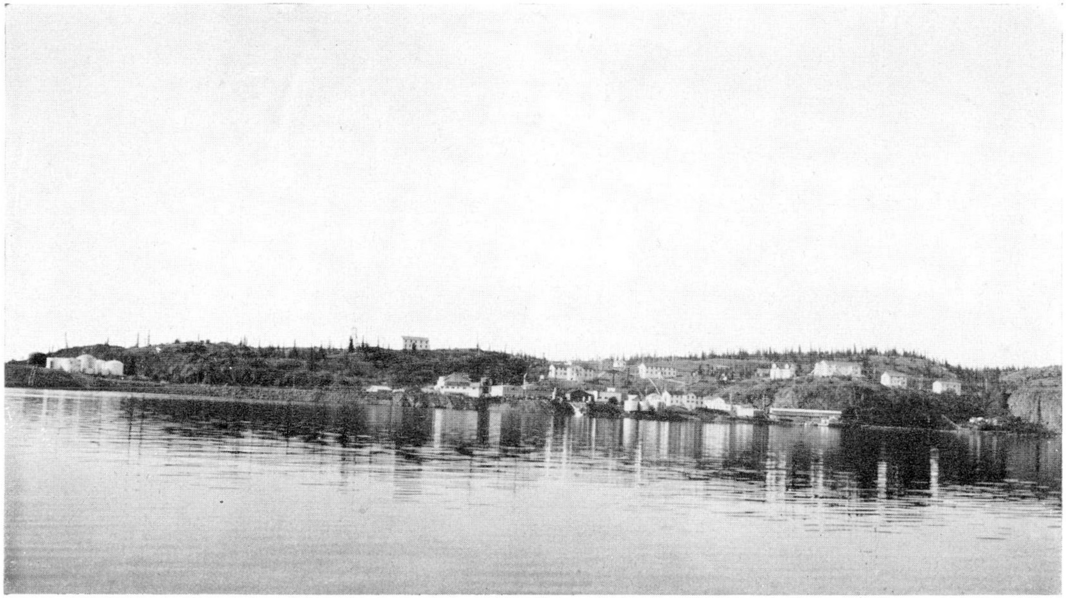
PLATE II



Eldorado mine, Port Radium, Northwest Territories. (5-6, 1948.) (Page 51.)

PLATE III

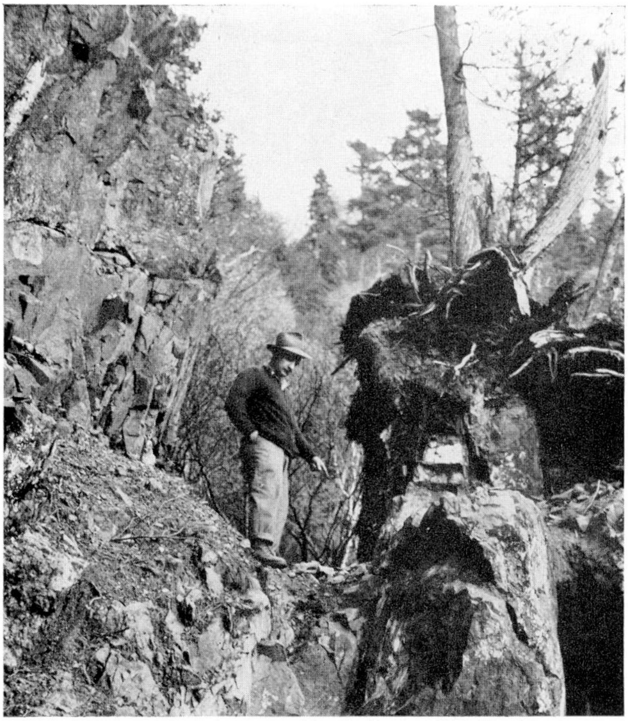
A. Part of staff quarters (under construction), Eldorado Mining and Refining (1944) Limited, Beaverlodge Lake, Saskatchewan. (4-3, 1951.) (Page 68.)

B. Ace shaft, Eldorado Mining and Refining (1944) Limited, Ace Lake, Saskatchewan. (Photo by S. C. Robinson, 1-5, 1950.) (Page 78.)

A. View of Goldfields, Saskatchewan, with buildings of Box mine in foreground. (Photo by S. C. Robinson, 6-3, 1950.) (Page 68.)

B. Number 4 shaft, Nicholson mine, Goldfields, Saskatchewan. (Photo by S. C. Robinson, 5-3, 1950.) (Page 95.)

PLATE V



A. Pitchblende-bearing shear zone at contact of diabase dyke, LaBine-McCarthy property, Sault Ste. Marie region, Ontario. The man is standing on the outcrop of the shear zone, and the dyke is at left. (4-3, 1950.) (Page 129.)

B. Inclined shaft on Camray property, Sault Ste. Marie region, Ontario. This shaft was begun in a depression formed by erosion along a diabase dyke. The shaft timbers were continued upward to form the headframe, which is anchored to the granite foot-wall of the dyke. (5-4, 1949.) (Page 125.)

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[1] Numbers in bold type indicate pages that contain general statements on a particular radioactive mineral; other numbers refer to pages where regions or properties containing a particular radioactive mineral are described. The number of references to properties containing a particular mineral does not in all cases agree with the number of identifications listed in Table I, because permission to publish descriptions of some properties was not received, and because all occurrences of gummite were not mentioned in the descriptions.