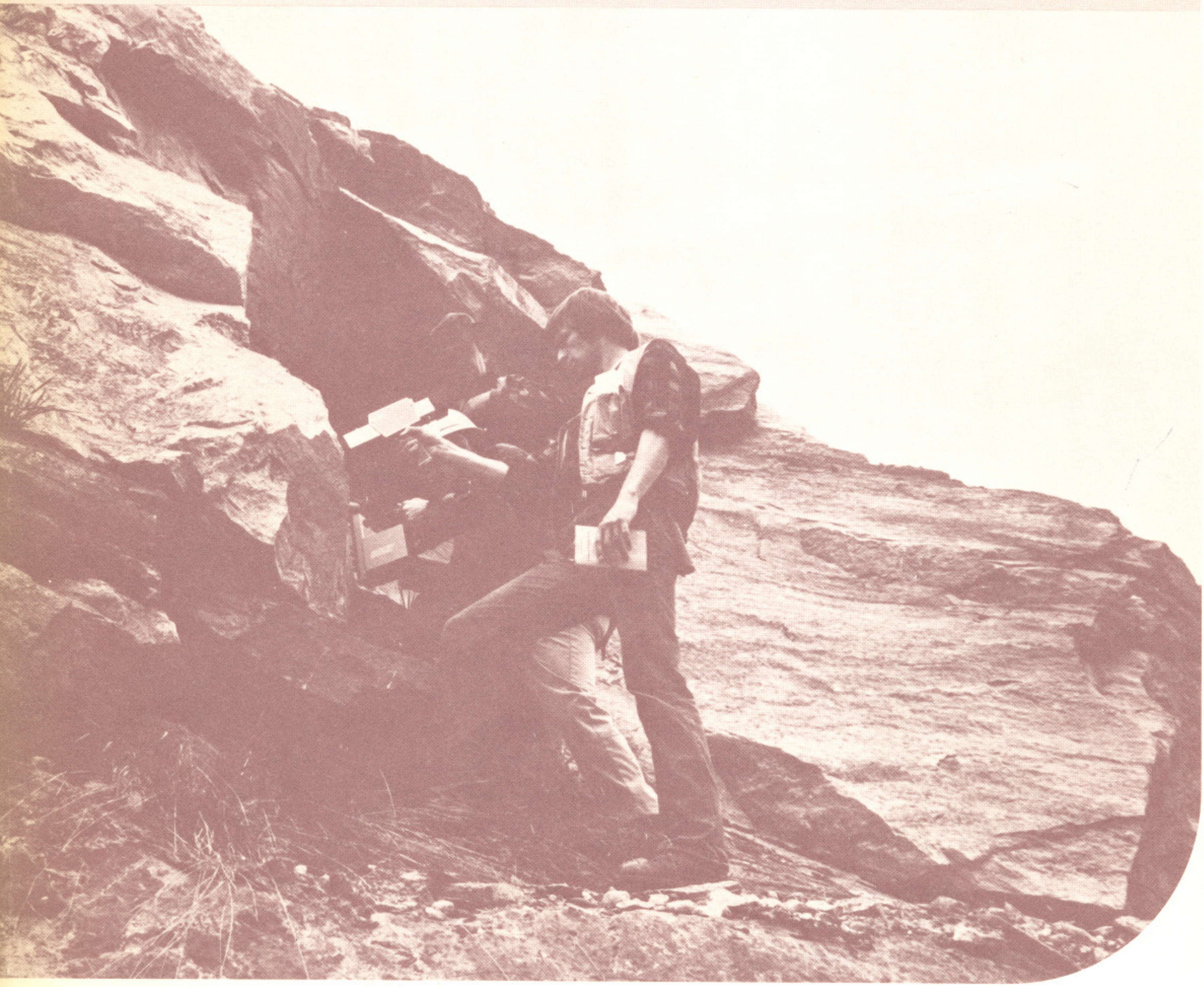
A Brief Submitted to the Royal Commission of Inquiry

Health and Environmental Protection Uranium Mining

September, 1979



PAPER 1979–6

Province of British Columbia

Ministry of Energy, Mines and Petroleum Resources

BY THE GEOLOGICAL DIVISION
MINERAL RESOURCES BRANCH

SUBMISSION OF MINISTRY OF ENERGY MINES AND PETROLEUM RESOURCES TO ROYAL COMMISSION ON HEALTH AND ENVIRONMENTAL PROTECTION – URANIUM MINING

PHASE I – OVERVIEW

September 1979
Geological Division
Mineral Resources Branch

TABLE OF CONTENTS

TABLE OF CONTENTS—*Continued*

APPENDICES

TABLES

TABLE OF CONTENTS—*Continued*

Page

TABLES—*Continued*

FIGURES

SUMMARY AND CONCLUSIONS

● The need of our society for metals, non-metallic minerals, and coal are fulfilled only by continuous exploration and discovery.

● The Geological Division's basic objectives are to provide accurate and current information on the quality and distribution of mineral and coal resources of the Province for government and industry, to provide maps and other data, ideas, and interpretations useful in the search for deposits, and to assist in the orderly exploration, development, and use of these resources.

● Early stages of exploration are not normally designed for the search of a single mineral commodity nor are they readily monitored. A system has been developed by the Geological Division whereby a small number of geologists can monitor exploration on claims and provide systematic reports on exploration effort.

● Cordilleran British Columbia consists of five sub-parallel belts of similar geology which from west to east are called the Insular, Coast Crystalline, Intermontane, Omineca, and Eastern Marginal Belts.

● The distribution of metals in background amounts in rocks and in mineral deposits shows a zoning across these belts. Uranium background increases toward the Eastern Marginal Belt.

● The level of uranium in rocks is rarely high enough to form ore unless a second-stage geological process of concentration has occurred.

● The first uranium exploration in British Columbia recorded was in 1932. Since then exploration has been sporadic, with minor peaks during the late 1940's, mid 1950's, and late 1960's. During this period only one deposit was found of sufficient size and grade to be a potential mine, and British Columbia was considered by most geologists to be a mediocre terrain for uranium exploration.

● In the last 10 years exploration for uranium slowly increased as a result of the following:

(a) realization that basal type deposits existed in the East Okanagan area;
(b) greatly increased world demand and resultant higher prices for uranium;
(c) regional geochemical surveys.

● Many classes of uranium deposits are known in the world and representatives of most of these occur in British Columbia. However, to date only the basal type and volcanogenic type have been shown to be potentially of such a size and grade to be mined.

● Basal type deposits are ones formed in young sands and gravels of former stream channels which normally contain carbonaceous trash and are capped by plateau basalt flows that preserve them. The uranium has been leached from local high background granites or alkaline volcanic rocks, transported by surface and groundwaters, and deposited where reducing conditions were encountered. Basal type deposits of significance include the Blizzard, Fuki and Donen, Haynes Lake (PB), and Hydraulic Lake deposits, all in the East Okanagan Highlands.

● Volcanogenic deposits are formed during some volcanic eruptions and are bedded with the resulting volcanic flows or pyroclastic rocks. Only very alkaline volcanic rocks would have the potential to form uranium deposits in this manner. The only volcanogenic deposit of significance is the Rexspar deposit near Birch Island.

● To carry out its mandate to provide data to aid exploration, the Geological Division has engaged in multi-element regional geochemical reconnaissance surveys since 1975. About 20 per cent of Cordilleran British Columbia will have been surveyed at the end of 1979 by these stream silt and water surveys. They have been successful in:

(a) stimulating exploration;
(b) adding rigour to resource analysis;
(c) providing environmental baseline data on the distribution of 14 heavy metals.

● Some natural waters discovered during the regional geochemical surveys to be anomalous in their uranium content and which are used for domestic purposes are being monitored on a monthly basis to study their variations and total effects.

Conclusions

A. Early stages of exploration are seldom directed at a single commodity. These stages are neither environmentally damaging nor are they readily monitored because an element of secrecy is necessary in a competitive system.

B. 1. The average uranium content of upper continental crust is exceeded in wide areas of the Province, especially in granitic terrains. In general, granites of eastern British Columbia are more radiogenic in uranium, thorium, and potassium than those of the west.
   2. Uranium deposits of basal type are moderately common in the East Okanagan area and some are of such a size and grade they could be mined. Similar deposits have not been proven to exist elsewhere, but it is likely that they do.
   3. Volcanogenic uranium deposits are a relatively rare type world wide, but the occurrence of one that is potentially mineable and the fairly widespread distribution of alkaline volcanic rocks in the Province indicate others may be found.
   4. A potential exists for other types of mineable uranium deposits in the Province.

I. INTRODUCTION

1.1 Role and Responsibility of the Geological Division

Metals, non-metallic minerals, and coal are non-renewable judged by the scale of man's lifetime. The supply of these commodities for our own use and export is fulfilled only by continuous exploration and discovery.

Modern mineral exploration is dependent on the quality and extent of the geoscientific data base. This term is generally taken to mean the available information from basic surveys, systematic information on mineral deposits, land status data, assessment reports, drill core libraries, and miscellaneous sources. Exploration in terrains that do not have an adequate data base is restricted in many ways. It may be confined to undirected prospecting or require initial expenditure on regional surveys which in many instances inefficiently duplicate preparation of the necessary background information. The need for a superior data base increases proportionately as the frequency of discovery of deposits that outcrop decreases. The primary role of compiling the data base falls upon government by new work and by collection and compilation of the work of others.

In British Columbia the work of assembling and augmenting the data base is largely the responsibility of the Geological Division, one of the four Divisions of the Mineral Resources Branch of the Ministry of Energy, Mines and Petroleum Resources.

The Ministry, which in addition to the Mineral Resources Branch has a Petroleum Resources Branch and an Energy Resources Branch, is authorized by the *Ministry of Mines and Petroleum Resources Act* to carry on its work. Authority for the work of the Geological Division is found principally in sections 6 (a), 6 (b) and 9 to 13 inclusive of that Act.

The Geological Division's basic objectives are to provide accurate and current information on the quantity and distribution of mineral and coal resources of the Province for government and industry, to provide maps and other data, ideas, and interpretations useful in the search for deposits, and to assist in the orderly exploration, development, and use of these resources. In addition, the Division is responsible for direct aid to the exploration industry through prospector training and mineral exploration incentive grants.

1.2 Organization

To carry out its objectives the Division is organized into four sections: Project Geology, Applied Geology, Resource Data and Analysis, and Analytical Laboratory (*see* Table 1.1, Organization Chart). The Division has a permanent staff of 55: 29 geoscientists, 6 chemists, 12 technicians,

TABLE 1.1. ORGANIZATION CHART
GEOLOGICAL DIVISION – MINERAL RESOURCES BRANCH

CHIEF GEOLOGIST

A. Sutherland Brown

Secretary

N. H. Chin C.S. 4

RESOURCE DATA AND ANALYSIS

[vacant]	G. 5

Special Projects

K. E. Northcote	G. 4
Z. D. Hora	G. 4

Mineral Inventory

[vacant]	G. 3
G. L. James	S.A. 4
J. E. Forester	R.O. 2
A. Matheson	R.O. 4
* C. Kenyon	

Clerks

C. Ritchie	C. 3
E. Tait	O.A. 1
[vacant]	O.A. 1

APPLIED GEOLOGY

E. W. Grove	G. 5

Prospectors Assistance

A. F. Shepherd	G. 4
G. Dickson	O.A. 2
J. Novak	Lbr. 1
* J. Bristow	

District Geologists

Kamloops	
G.P.E. White	G. 3
Smithers	
T. G. Schroeter	G. 3
Nelson	
G. G. Addie	G. 3
Prince George	
G. H. Klein	G. 3
Charlie Lake	
R. Karst	G. 2
G. V. White	Eng. Asst.
M. Parlee	O.A. 2
Fernie	
D. A. Grieve	G. 2

ANALYTICAL LABORATORY

W. M. Johnson	L.S. 5
L. Parker (Secretary)	C.S. 3
P. F. Ralph (Deputy Chief)	L.S. 4
R. J. Hibberson	L.S. 3
V. Vilkos	L.S. 3-
B. Bhagwanani	L.S. 3
J. Kwong	L.S. 2
M. A. Chaudhry	LT. 3
F. F. Karpick	L.T. 4
L. E. Sheppard	L.T. 1

PROJECT GEOLOGY

N. C. Carter	G. 5
D. Bulinckx (Receptionist)	O.A. 2

Geologists

P. A. Christopher	G. 3
B. N. Church	G. 4
G.E.P. Eastwood	G. 4
T. Hoy	G. 3
W. J. McMillan	G. 4
D. G. MacIntyre	G. 2
A. Panteleyev	G. 4
D. E. Pearson	G. 4
V. A. Preto	G. 4
R. D. Gilchrist	G. 2
* T. Kalnins	

Draughting

J. Armitage	T.A. 4
R. Hoenson	T.A. 3
P. Chicorelli	T.A. 3
J. St. Gelais	T.A. 3

Lapidary and Technical

R. E. Player	Eng. Asst.
C. R. Cadwallader	Eng. Aide 2

* Temporary or Contract Employees.

and 8 clerks. This staff is augmented in summer by about 20 geological assistants. Of the professional staff 16 have Ph.D.'s and 6 have Master's; in addition, 23 are professional engineers.

Project Geology is concerned principally with detailed geological mapping and related research in terrains with mineral or coal potential. The projects are designed to solve problems related to resources and normally involve mapping at 1:50 000 or more detailed scales. The section is also responsible for the Regional Geochemical Surveys (*see* Section VI).

Applied Geology has duties that include aid in the field to exploration personnel and prospectors, monitoring of exploration and geological developments at producing mines, coal core storage and study, prospector training, and control of incentive grants to prospectors and to exploration companies. District Geologists located in Kamloops, Nelson, Prince George, Smithers, Charlie Lake, and Fernie carry out all these technical duties and in addition are involved in integrated resource management committees which provide information to the public.

Resource Data and Analysis is responsible for the collection, compilation, interpretation, and distribution of exploration and development data gathered from various sources (*see* 1.3). Most of the information is readily available after requisite confidential periods, normally one to three years. The major sources of information are: MINFILE, a shallow computer file of over 8 000 mineral occurrences; assessment report file consisting of over 7 000 microfilmed reports available at reader/printers in Vancouver or Victoria; 'property' files of historic maps and data of producers and prospects recovered from many sources and filed by NTS system; and industrial minerals reference files. In addition, a computerized coal data file is being constructed under contract jointly with the Geological Survey of Canada, and a computer file of statistics on producing mines and major prospects is underway. The annual volume, *Exploration in British Columbia*, is produced by the section coincident with its update of MINFILE.

In addition, the section administers the Portable Assessment Credit account, produces map compilations, mineral potential evaluation studies related to land-use conflicts, and advises on regulations. Field-oriented studies related to industrial minerals and structural materials are also handled by this section.

The **Analytical Laboratory** is responsible for a complete range of analytical services for the Division geologists and grantee prospectors as well as some services to other government agencies. The facilities include X-ray fluorescence, atomic absorption and emission spectrography, X-ray diffraction, gamma ray spectrometry, and mineral separation. Capability in traditional wet analytical chemistry still exists. Instrument output is fully computerized. The laboratory also runs control samples and handles the chemical data for the British Columbia geochemical surveys.

TABLE 1.2. SAMPLE MINFILE PRINTOUT

093N 005

NAME(S)= RONDAH	N.T.S.= 093N14W	UTMZ= 10U
DUCK	LAT= 55.55 (DEG.MIN)	UTMN= CS6199700
DOREL	LONG= 125.16	UTME= CS0357600
		LOCATION ACCURACY= 1

CAPSULE GEOLOGICAL COMMENT=
Pyrite, chalcopyrite and minor bornite occur disseminated and in fractures within feldspathized Omineca monzonite intrusives.

COMMODITIES PRESENT= CU MO AU

PUBLISHED RESERVES DATA
ZONE= DUCK LAKE RHONDA - TOTAL D
DATE 04NOV71

CLASSIFICATION= MEASURED GEOLOGICAL QUANTITY= 9072000 TONNES
CU 0.7 PC

BIBLIOGRAPHY
BCDM MMAR 1949-98, 1951-118
BCDM GEM 1970-185, 1971-213, 1972-455
BCDM ASS RPT 532, 73, 378, 384, 430, 513, 3861
BCDM PREL MAP 9 #2
GSC MEM 252
GSC MAP 907A
GCNL NOV 4,1971 RES

1.3 Methods of Collecting, Assembling, and Disseminating Exploration Data

Resource Data and Analysis Section has primary responsibility for these functions but in co-operation with Applied and Project Geology, and Inspection and Engineering and Titles Divisions. General appraisal of exploration activity is done by District Geologists who assemble data from Forms 10–11 (*see* below), and from discussions with company personnel and prospectors and from extensive property visits. Monthly reports on activity are submitted to Victoria and these are used as a check against Forms 10–11 and as a source of deeper information for the yearly publication, *Exploration in British Columbia*. Project geologists, during the course of field mapping, also examine and report on exploration properties in their project areas. Commonly these reports are very detailed but coverage in any one year may be limited by exigencies of project distribution. In some instances a project is in effect a commodity study, in which case a systematic review of the geology in the field of occurrences of the commodity may be made over a period of one or more years.

The most systematic data on current exploration is assembled by the Resource Data and Analysis Section in the following manner. The *Mines Regulation Act* requires an explorer to submit in advance a Form 10–11, *Notice of Work on a Mineral Property*. This is received by District Inspectors of Mines and distributed to other government ministries and to RDA. After the calendar year these forms are used to build up, in a preliminary way, the data on exploration for the year. Partially completed data sheets are sent to the owner/operator to finish and return. They are reviewed when submitted, checked against other sources such as District Geologists' monthly reports, reports in the trade literature, and assessment reports. All this data is compiled, analysed, and issued yearly as *Exploration in British Columbia*, which usually is published near the middle of the year following that in which the work is done.

The RDA maintains a data base on all known mineral occurrences in the Province. This computerized file consists of over 8 000 deposits. The data are updated yearly as a result of input to the volume *Exploration in British Columbia*. The format of the individual entries is as shown on Table 1.2. Printouts by area, by commodity or groups of commodities, by property, or by claim names and also for properties with production or reserves are available at cost. In conjunction with this inventory is a series of 90 inventory maps covering the Province, mostly at 1:250 000 scale and showing the location of mineral occurrences.

Reports, frequently in great detail, submitted under the *Mineral Act* in lieu of assessment work are another major source of information. These reports document geological, geophysical, and geochemical surveys, and drilling or prospecting, carried out by companies or individuals to maintain mineral claims in good standing. Approximately 7 200 of these reports are on file and available for reading or duplication from microfiche. About 500 are received each year. They are confidential for one year from the date of submission.

Various indexes are available to access all this information.

II. SUMMARY OF GEOLOGY AND METALLOGENY OF BRITISH COLUMBIA

Many extended accounts of the geology and metallogeny of British Columbia exist (*see* References, Section II). The following grossly simplified account is given so that the natural distribution of uranium can be better understood.

2.1 Geological Framework

British Columbia, west of the Great Plains, is largely a mountainous terrain that forms part of the North American Cordillera. In British Columbia this terrain consists of two parallel orogens, that is, linear belts that have been subject to mountain building. These are the Columbia orogen on the eastern or continental side and the Pacific orogen on the west or oceanic side. The orogens contain two culminating zones of deformation, metamorphism, and intrusion in their cores called the Omineca Belt on the east and the Coast Crystalline Belt on the west. These core zones are separated by a central terrain characterized by plateaus and called the Intermontane Belt. Two other parallel belts complete the Cordillera: the Eastern Marginal Belt and the Insular Belt on the west. Hence there are, in effect, five sub-parallel belts in Cordilleran British Columbia from west to east: the Insular, Coast Crystalline, Intermontane, Omineca, and Eastern Marginal (Fig. 2.1). The boundaries between these belts are fundamental zones of faults and sutures – the continental margin, borders of core zones, and the edge of the disturbed belt with the Great Plains.

These belts have to a considerable extent had different histories, so that each belt is built up of rocks that are similar in age of formation and subsequent treatment but differing to some or to a considerable degree from its neighbours. In general, the rocks of the two eastern belts were formed as a great deltaic terrace wedge of sands, muds, and limy sediments on the western edge of what was then the Continental Shield. These sediments were deposited over a great period of time from 2 billion to 350 million years ago. Subsequently the rocks of the Omineca Belt have been highly deformed and subjected to high temperatures, pressures and partially melting at great depths while those of the Eastern Marginal Belt have only been subjected to folding and translation eastward over the rocks of the Great Plains. In contrast, the Pacific orogen (three western belts) consists dominantly of volcanic and related sedimentary rocks and intrusions formed chiefly from 350 million years to about 5 million years ago. These belts have been accreted to the continent by a number of processes related to plate tectonics. The core zone was once probably a volcanic island arc formed during the consumption of oceanic crust under the continental margin. The volcanic rocks were later engulfed by rising intrusive granitic rocks from the same source. The Intermontane zone is a complex one probably with remnants of volcanic oceanic crust as well as younger volcanic and intrusive and sedimentary rocks. The Insular Belt is dominated by 200-million-year-old oceanic basalts that may have formed some distance oceanward but later became welded to the continent during plate motion.

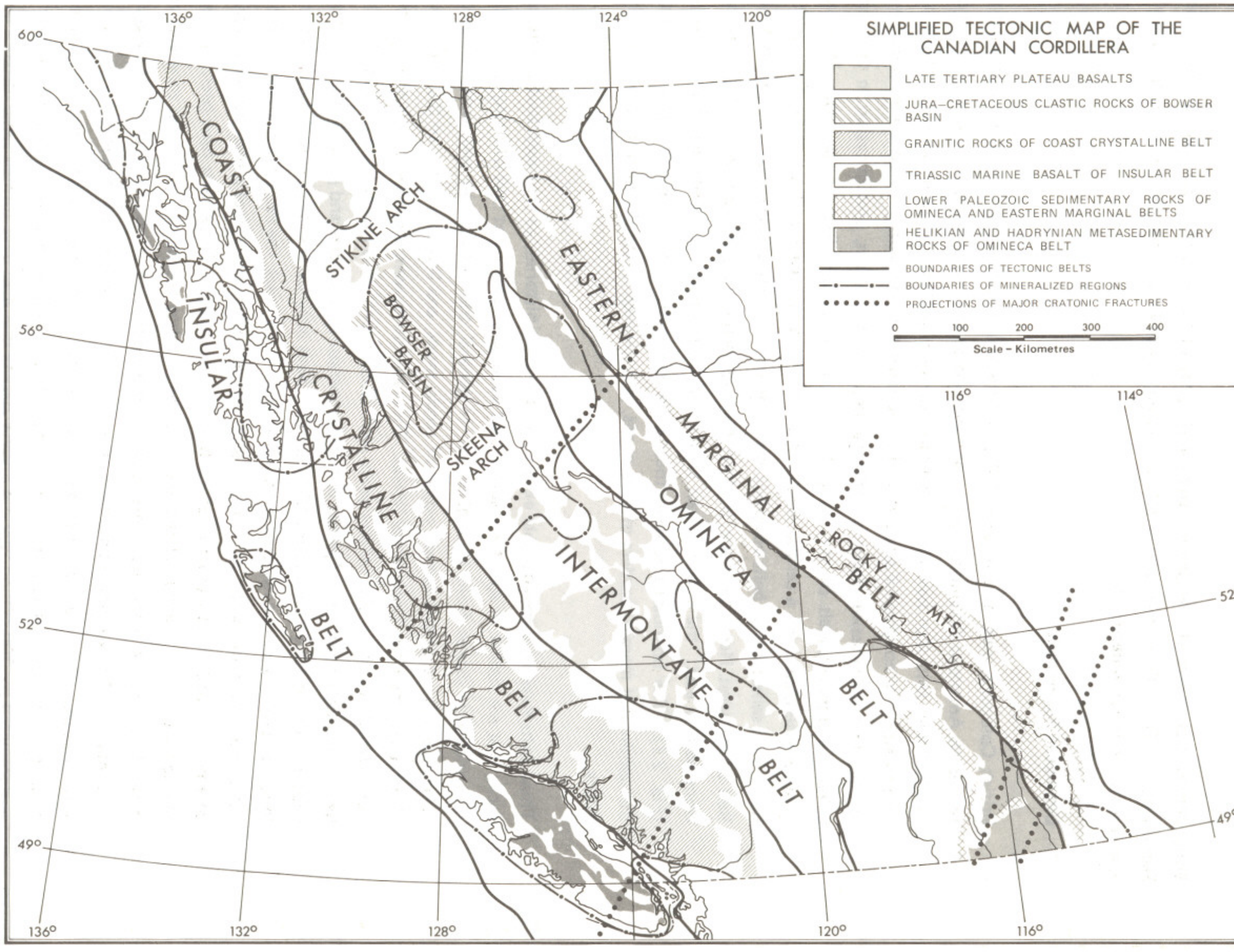


FIGURE 2.1. SIMPLIFIED TECTONIC MAP OF THE CANADIAN CORDILLERA.

2.2 Metallogeny

Metallogeny is the study that deals with the genesis of mineral deposits particularly their relationship in time and space to regional geology. An aspect of importance in metallogeny is the spatial distribution of metals.

British Columbia shows a pronounced zoning of metals both in regard to the natural background abundances in rocks and in distribution of mineral deposits (Sutherland Brown, 1969; Sutherland Brown, *et al.*, 1971). The zoning is clearly related to the geological belts and is compatible with the concept of an accretionary origin of the Cordilleran crust.

Background Abundances: Insufficient data on abundances in rocks of major ore metals (copper, zinc, molybdenum, lead) are available to provide a view of regional trends. However, the voluminous silt and soil geochemical data have revealed patterns in backgrounds of these metals so similar to each other that they may be taken to reflect fairly accurately the regional background trends in rocks. A generally eastwardly decreasing gradient exists for background copper, one of lesser eastward slope for zinc, and a westwardly decreasing one for lead. Molybdenum rises to a central peak in the Intermontane Belt. This distribution has been related to a theoretical model dependent on time and degree of mantle and crustal processes in general, and to crustal accretion in particular (Sutherland Brown, 1974), in which high metal abundances and concentrations might be expected in the following order, from west to east: nickel, iron, zinc, copper, molybdenum, tungsten, tin, silver, mercury, lead, uranium, thorium. A similar distribution of mineral deposits has been reported in other mountain belts such as the Chilean Andes. Theoretically we would expect, and in fact we find, that the regional concentrations of radioactive elements, uranium, thorium, and potassium, would increase eastward through the Intermontane Belt to the Omineca Belt.

This overall eastward-increasing gradient is an averaged effect, and individual rock types do not necessarily reflect it. In fact the major primary concentration of radioactive elements is within granitic intrusions and in some related acid or alkaline volcanic flows. The processes that produce acid igneous rocks preferentially concentrate radioactive elements. Other rocks, such as basic igneous rocks and sedimentary rocks and particularly limestone, generally have much lower backgrounds. The eastward gradient mentioned is most evident in the acid igneous rocks. The Eastern Marginal Belt (Rocky Mountains) has few igneous rocks of any kind hence it is lower in general radioactivity although the few known intrusive rocks are highly radioactive.

Rarely concentrations within granitic or acid volcanic rocks can be high enough to form ore. In most cases these are related to internal processes within these rock masses that increase concentration such as differentiation, remelting, etc. Some small pegmatite bodies have such an origin as does the Rexspar deposit in all probability.

In most instances a further concentration is commonly necessary to form a uranium mineral deposit. One of the commonest second-stage concentration processes in British Columbia is related to surface chemical weathering in areas of high background granites, particularly where these are readily leachable and surface or groundwaters are alkaline and oxygenated. Under these natural conditions surface waters may transport considerable uranium in solution which may then be deposited where chemical or physical conditions are changed. Such has been the case in the formation of the basal type deposits of the eastern Okanagan. These have formed in stream courses in unconsolidated sands and gravels, that commonly have been protected or had their hydraulic conditions formed by a capping of young (5 million year) plateau basalt lava.

Another process of erosion, one related to physical weathering, can also produce concentrations of radioactive minerals of ore grade. Areas of high background granites with resistant minerals can have these concentrated on erosion in a manner analogous to gold placers. The Bugaboo pyrochlore deposit is such a placer.

III. HISTORY OF URANIUM EXPLORATION IN BRITISH COLUMBIA TO 1969

The history of uranium exploration in British Columbia prior to 1969 can be assembled from review of the Annual Reports of the Minister of Mines and Petroleum Resources.

The earliest record of investigation of radioactive minerals in British Columbia was in 1932 when an electroscopic survey was carried out by the University of British Columbia on the Radium property on Quadra Island. Carnotite was identified in seams in volcanic rocks and samples submitted to the Mines Branch, Ottawa, assayed 27.7 per cent U_3O_8 and 28.9 per cent U_3O_8. While a company was formed, Radium Explorers, Inc., apparently very little development work was done.

Available records suggest that little, if any, further exploratory work for radioactive minerals was done until after World War II. From that time until 1969, three periods of noteworthy activity are apparent. These include the late 1940's, the early to mid 1950's, and the late 1960's.

The Rexspar deposit at Birch Island, originally known as the Smuggler, was first investigated in 1920 when the fluorite zone was tested. However, the exploration and development work in the 1920's and 30's was directed to lead-silver mineralization and some ore was shipped to the Trail smelter. The fluorite zone was further explored in 1942 but it was not until 1949 that the Rexspar Uranium and Metals Mining Company investigated uranium mineralization and defined the three zones known today: the A, B, and BD. Diamond drilling and 300 metres of underground work were performed in 1950.

Many deposits explored during this period were previously discovered as precious metal vein deposits. The Victoria gold-silver-cobalt-molybdenum property south of Hazelton was found to have uraninite erratically distributed in narrow veins in granitic rocks of the Rocher Deboule stock. The Little Gem gold-silver vein in the Bridge River area is of a similar geological setting with the vein, containing some uraninite, developed in the Bendor pluton. Both of these properties were tested by drilling and underground work.

Other properties investigated during this period included the Verity, Paradise, near Lempriere on the North Thompson River, where uranium-bearing pyrochlore was found in a carbonatite contained in a gneiss-pegmatite sequence of the Shuswap terrane.

Two copper properties, the AM on the Skagit River and the Copperado near Merritt, were investigated for uranium by the British Columbia Department of Mines' geologists using Geiger counters.

Recognition of radioactive mineralization at the Husselbee property on the west side of Atlin Lake in 1953 caused the staking of 1 000 claims in that area. Uranium and thorium values were found to occur in amphibolite and metasediments marginal to granitic rocks. Conwest Exploration Company Limited carried out limited trenching and drilling in 1954 but the option was dropped. Other work in the area went on north of Surprise Lake, east of Atlin, where metazeunerite was found in shears in granitic rocks on Cracker and Ruby Creeks in 1955.

In 1955 and 1956 radioactive secondary hydrous aluminium phosphate minerals were investigated in rhyolite dykes cutting Topley granitic rocks on Nithi Mountain south of Fraser Lake. Limited drilling and trenching disclosed that this was a surface feature only. Uranium and thorium mineralization was tested on the Sta-tite property on Upper Arrow Lake, and the Little Gem property was further explored by tunnelling and drilling.

Four uranium-niobium-thorium deposits associated with nepheline syenites and carbonatites were explored in the mid 1950's. Further trenching went on at the Verity, Paradise showing on the North Thompson and the Ice River alkaline complex was investigated but, being in a National Park, no physical work was done. The Lonnie property near Manson Creek was discovered in 1953 when an unusual 'limestone' was submitted to the Ministry for examination. Pyrochlore, columbite, and other minerals were found to be associated with syenite and carbonatite when the claims were explored in 1954–55 by trenching. Near Spillimacheen, on Vowell and Malloy Creeks, placer deposits containing pyrochlore, uraninite, and other related minerals were tested extensively in 1954–55 and 1956. The minerals concentrated in this placer originated from monzonite and syenite phases of the Bugaboo batholith. Thirty-three churn-drill holes indicated 1 million cubic metres of pyrochlore-bearing gravel in these deposits. A concentrator was constructed in 1956 to test these deposits and from 8 187 tonnes of gravel 11 312 kilograms of concentrates was produced, having an average grade of 2.496 per cent Nb, 0.923 per cent U_3O_8, and 1.294 per cent ThO_2.

Radioactive occurrences were investigated 11 kilometres north of Lytton and development work at the Rexspar property in 1957, consisting of 4 600 metres of diamond drilling, defined the three uranium zones as containing 1.45 million tonnes of 0.08 per cent U_3O_8, in addition to close to 1 million tonnes in the fluorite zone.

In the late 1960's, uraninite in Shuswap pegmatites at China Creek was explored by 460 metres of diamond drilling. Uraniferous Tertiary sandstones, conglomerates, and arkoses were investigated in Vidler Creek near Lumby in 1960, and geological and geophysical studies were conducted at Rexspar.

In August of 1968 geologists of the Power Reactor & Nuclear Fuel Development Corporation of Japan, while conducting a car-borne scintillometer survey between Beaverdell and Christian Valley, discovered autunite in poorly consolidated sediments of Late Tertiary age beneath a basalt cap on Dear Creek. This exposure, known as the Fuki showing, was the first recognition of Tertiary basal type uranium deposits in British Columbia and provided the catalyst for the present era of uranium exploration in the Province.

The experience of these years was that, at the grades and tonnage necessary for a viable deposit then, British Columbia was not an excellent terrain to explore for uranium.

IV. RECENT URANIUM EXPLORATION, 1969–1978

Modern exploration is a staged process. An office analysis leads normally to the mounting of a grassroots exploration program consisting of a series of one or more reconnaissance surveys. While some grassroots exploration is directed toward a single commodity, it is far more common to be looking for a suite of minerals of geological affinity, or similar geochemical or geophysical responses such as uranium, molybdenum, and tungsten. Any anomalous areas found during reconnaissance would be followed up by more detailed ground search and study possibly leading to the location of claims. Up to this stage various levels of secrecy are an integral and necessary part of the exploration effort. Thereafter exploration normally would be directed to a more restricted group of minerals by a sequence of geological mapping, soil geochemical surveys, and suitable geophysical surveys. If the target is still potentially interesting it would be trenched and/or drilled at wide intervals. Success at this stage would lead to closer drilling and possibly later to underground exploration. All stages of exploration on claims are readily monitored by the Geological Division as interest requires.

The history of uranium exploration since 1969 is recorded in individual reports in the yearly volume, *Geology, Exploration and Mining in British Columbia*, published since that year.

In the period 1969 to 1975, limited exploration for uranium was concentrated principally in the southeast Okanagan, where Power Reactor & Nuclear Fuel Development Corporation began investigations of their basal type uranium occurrences on the Fuki, Donen, and PB claim groups. This work consisted of geology, trenching, and drilling (*see* table, Appendix 4.1* for details of exploration work). Development drilling continued at the Rexspar deposit near Clearwater, and limited work was done on the adjacent Bullion claims.

In the same time period, uranium in pegmatites was investigated north of Grand Forks while exploration was carried out on the Horsethief Creek granitic stock in southeast British Columbia which contains some uranium with copper-molybdenum mineralization. Two properties east of Vernon, near Lumby, were also investigated. The Husselbee prospect near Atlin was re-staked and the Lonnie carbonatite prospect near Manson Creek underwent some trenching. Elsewhere in northern British Columbia, uranium associated with coal seams in the Bowron River area was explored by drilling.

Uranium exploration experienced a dramatic upswing beginning in 1976 in response to increased world demand. Most of the activity was centred on the southeast Okanagan where the Blizzard and Hydraulic Lake deposits were discovered (*see* Figs. 4.1 and 4.2 for locations). These discoveries resulted in virtually the entire Okanagan area, extending from west of Penticton to east of Vernon being staked. Exploration in the general region reached a peak in 1977 when a number of properties were drilled, generally with negative results (*see* table, Appendix 4.1). The increase in claims staking in 1977 was also related to the release of the 1976 Uranium Reconnaissance Program survey which covered NTS map-areas 82 E, L, and M.

*In this table and elsewhere in this brief, the National Topographic System (NTS) nomenclature for map-areas is used. Figure 4.1 shows the major units of this system.

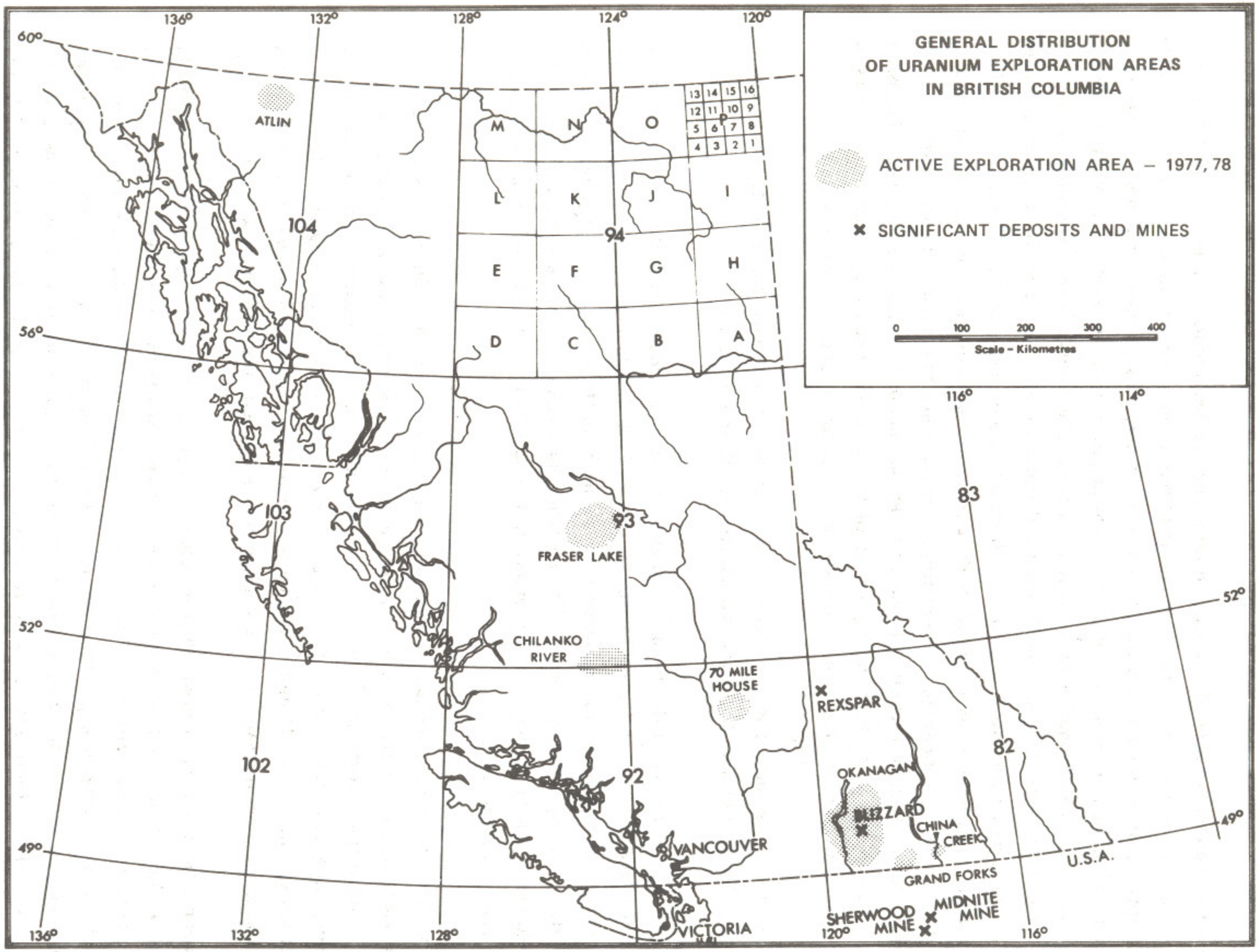


FIGURE 4.1. EXPLORATION AREAS AND MAJOR PROPERTIES.

Elsewhere in southern British Columbia, uranium claims were explored north of Grand Forks, west of Midway, south of Castlegar, and in the Forster Creek area west of Radium Hot Springs.

The recognition of basal type uranium occurrences such as Blizzard and Fuki–Donen, and the knowledge that similar geological environments existed throughout the southern and central British Columbia Interior, led to staking of numerous mineral claims in the southern Chilcotin and south and west of Vanderhoof. These areas are depicted on Figure 4.1 (in text) and Figure 4.2 (in pocket). Many of these claims, particularly in the Vanderhoof area, were explored by diamond drilling (*see* table, Appendix 4.1) but no significant deposits were detected.

In northwest British Columbia, the Surprise Lake batholith east of Atlin was investigated by major programs in 1977 and 1978, again partly reflecting the release of Uranium Reconnaissance Program data.

Listed in the tables in Appendix 4.1 are details of significant exploration work done in the past 10 years on mineral claims only, based on data provided to the Division by way of yearly exploration forms and assessment reports. Locations of claims (1978) and known radioactive mineral occurrences are shown on Figure 4.2.

Details of regional exploration programs are not readily known. An important point is that most exploration programs are undertaken for a variety of mineral commodities, including uranium. However, airborne radiometric surveys have been carried out over many areas by many companies although there is a general feeling they are not particularly effective in British Columbia. This was one of the reasons the Uranium Reconnaissance Program was a geochemical program in this Province. The Geological Survey of Canada also carried out experimental regional airborne gamma-ray spectrometric surveys in the Prince George area (Mount Averil and Giscome) in 1977 which were released on open file in June 1978.

TABLE 5.1. CLASSIFICATION OF IMPORTANT URANIUM DEPOSITS (AFTER McMILLAN)

Genetic type of deposit		Structural or Petrographic Association	Characteristic Elements	Characteristic Minerals	Examples
IGNEOUS		Carbonatite, * Alkaline syenite	Nb, U, Th, Cu, P, Ti, Zr, REE	uranothorianite, pyrochlore, betafite, perovskite, niocalite, ilmenite apatite, zircon	Prairie Lake, Ont.; Nova Beaucage, Ont.; Poços de Caldas, Brazil. *Verity, Ice River, B.C.* *
METAMORPHIC		Pegmatite (alaskite), Skarn	U, Th, Mo, REE, Nb, Ti	uraninite, uranothorite, molybdenite, betafite, fluorite, zircon	Bancroft, Ont.; Rössing, S.W. Africa *China Creek, B.C.*
DETRITAL		Pyritic Quartz Pebble Conglomerate	U, Th, Ti, REE, Au, Zr, C	uraninite, brannerite, pyrite, monazite, native Au	Elliot Lake, Ont.; Witwatersrand, S. Africa
		Uraniferous Black Sand Placers	*U, Th, Ti, Nb, REE*	*uraninite, pyrochlore, magnetite, uranothorite, euxenite*	*Bugaboo, B.C.*
HYDROGENIC	Volcanogenic (hydrothermal)	Trachytic or Felsic Tuffs	U, Th, REE, Mo, Cu, F, Sr	uraninite, uranothorite, fluorite, celestite, pyrite, biotite	Rexspar, B.C.; *
	Syngenetic	Shale, Phosphorite, Evaporitic Limestone	U, P, V, Cu, Co Ni, As, Ag, C	pitchblende, carbon, apatite, gypsum	*Fernie, B.C.* Ranstad, Sweden; Kitts, Labrador; Todilto Limestone, New Mex.
	Epigenetic	Sandstone (Tabular, Roll, etc.)	U, C, Cu, V, Se, Mo	pitchblende, pyrite, coffinite, carnotite	Colorado Plateau; Wyoming, Texas Basins
		Channel Conglomerate	U, C	pitchblende, marcasite, coffinite, autunite	Kelowna-Beaverdell District B.C.; Ninge Toge, Japan
		Lignite	U, C, Mo, V		Cypress Hills, Sask.; Dakotas
	Syngenetic and (or) Epigenetic	Veins: Classical	U, Cu, Ag, Co, V, Ni, As, Au, Mo, Bi, Se	pitchblende, pyrite, chalcopyrite, Ni-Co arsenides, native Ag, Au	Beaverlodge, Sask.; Port Radium, N.W.T.; Schwartzwalder, Colo. *Hazelton View, B.C.*
		Veins: Unconformity	U, C, Cu, Ag Co, Ni, As, V, Se, Au, Mo	pitchblende, pyrite, Ni-Co arsenides, chalcopyrite, native Au, Ag	Wollaston, Key and Cluff Districts, Sask.; Midnite, Washington
	Supergene	Cappings Duricrusts (Calcrete etc.)	U, Si, Ca, Cu, Ag, Ni, As	'gummite', uranophane, carnotite, coffinite	Bolger, Eldorado, Sask.; Poços de Caldas, Brazil; Yeelirrie, W. Australia

*Additions to McMillan's classification include items in italicized print. Boxed structural/petrographic associations are those common in British Columbia. Underlined examples are the common 'economic' types present and used in the original classification.

V. GEOLOGY OF BRITISH COLUMBIA URANIUM DEPOSITS

5.1 Classification

Exhaustive study of uranium deposits in recent years related to the intensive and successful search for new reserves has lead to many classifications (Ruzicka, 1976; McMillan, 1978; Gabelman, 1977; Christopher and Ballantyne, 1976). Similar elements are evident in most classifications but some are very elaborate and consider all the genetic and morphological alternatives while others are simpler, pragmatic, and related to the types with large reserves. Table 5.1 is McMillan's classification which is fairly elaborate. It has been slightly modified to indicate classes that are important in British Columbia. McMillan's classification calls the *basal type* deposits of British Columbia and Japan, *channel conglomerates*. His classification has been expanded to indicate under the *detrital genetic* class the uraniferous black sand and gravel placer deposits that occur in the Bugaboo area of the East Kootenays. It has also had examples added to each type common in British Columbia. The original table had two examples: the *volcanogenic* (Rexspar) and the *basal type* (channel conglomerate) (Kelowna-Beaverdell district). These are in fact the principal types of uraniferous deposits that are common in the Province at grades and economic conditions of today.

The discussion that follows treats them in order of our present knowledge of their importance: basal, volcanogenic, pegmatite, carbonatite, placer, and vein.

The distribution of classified deposits is shown on Figure 5.1. Noteworthy on this map are the following distributions:

(1) broad distribution of vein deposits;
(2) clustering of pegmatitic deposits on the fringe of the Shuswap terrane;
(3) known basal deposits confined to the Okanagan;
(4) common distribution of carbonatite and placer deposits either side of the Rocky Mountain trench;
(5) relative poverty of deposits in the west and their virtual restriction to vein, shear, and breccia deposits.

5.2 Basal Type Uranium Deposits

Recent uranium exploration in British Columbia has been oriented dominantly toward the discovery of basal type uranium deposits that occur in poorly consolidated fluvial or lacustrine carbonaceous sediments. Host Tertiary sedimentary rocks are capped by an impermeable horizon, either Pliocene or Miocene plateau basalt (4.7 Ma* and 5.0 Ma K/Ar† ages) or by sediments of low permeability. Organic-rich sediments that occupy paleostream channels or basins

*Ma = million years.
†K/Ar = potassium/argon.

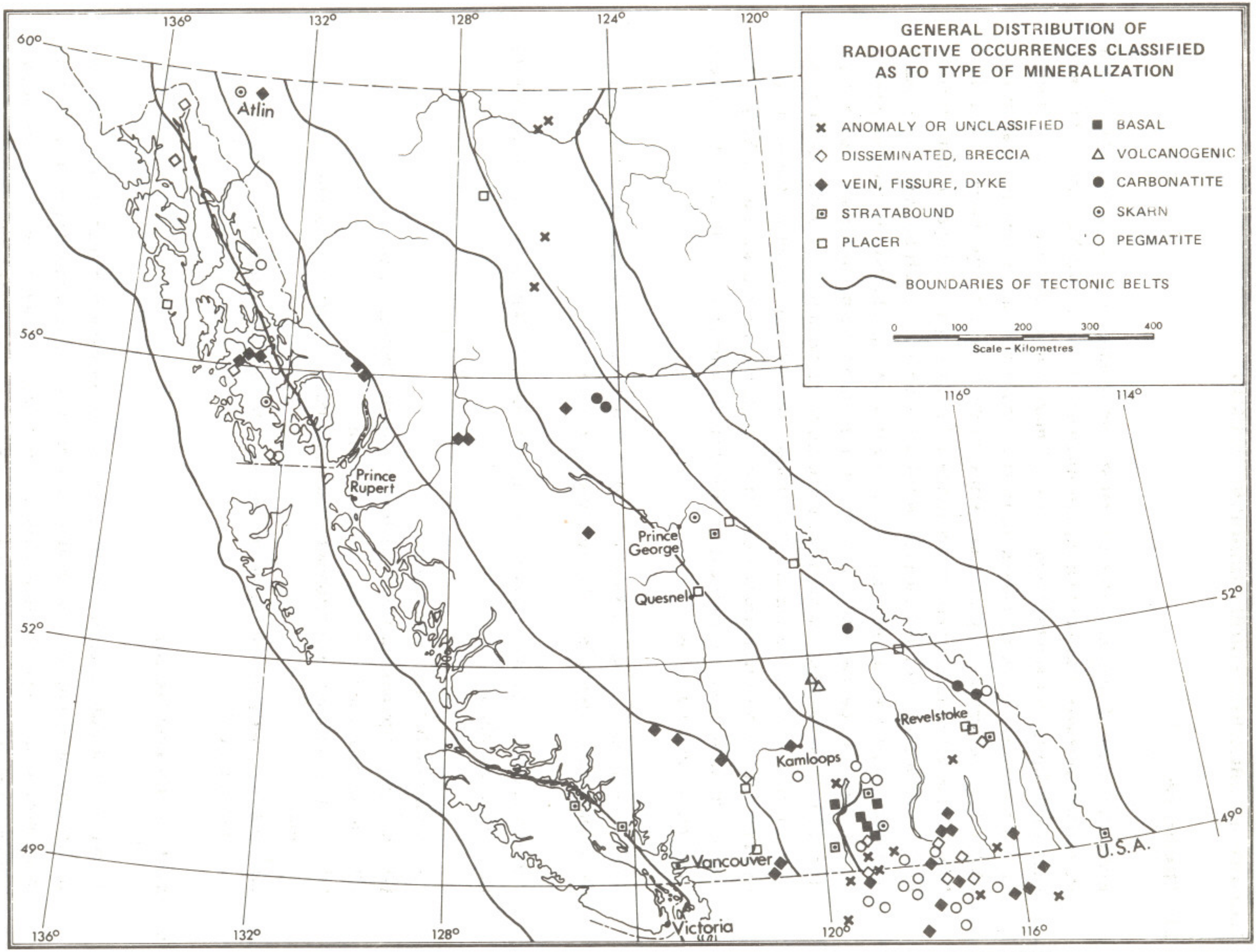


FIGURE 5.1. GENERAL DISTRIBUTION OF RADIOACTIVE OCCURRENCES CLASSIFIED AS TO TYPE OF MINERALIZATION.

have maintained a reducing environment that caused deposition of secondary uranium minerals in areas of groundwater entrapment. The term 'basal type' uranium deposit is applied to these deposits because they often occur in a basal sequence of gravel and sands overlying a major unconformity. Unifying genetic and physical characteristics also allow classification of the deposits as channel, stratabound, sedimentary, or groundwater type uranium deposits. Favourable parameters for the formation of basal type uranium deposits are:

(1) the presence of leachable uranium in a high background granitic or volcanic terrane, for example, Coryell syenite, Valhalla quartz monzonite, Kettle River volcanics, or Kamloops Group volcanics in the East Okanagan uranium area;

(2) weathering or faulting provides ground preparation for oxidizing groundwater or other leaching solution;

(3) the presence in an aquifer of carbonaceous (reducing) stream and lake sediments that allow trapping of groundwater solutions and formation of a reducing environment in a normally oxidizing groundwater system;

(4) an impermeable cap (for example, plateau basalt) that protects the deposits from erosion and from oxidizing surface waters.

The East Okanagan uranium area (Christopher, 1978 and Fig. 4.2, in pocket) of south central British Columbia contains several basal type uranium deposits and occurrences (Fig. 5.2). The Blizzard, Fuki, Donen (Cup Lake), Hydraulic Lake, and Haynes Lake deposits are the main deposits. Table 5.5 outlines occurrence grades and reserves of deposits as of June 1, 1979. Total reserves of the East Okanagan uranium area amounts to about 7 000 tonnes of U_3O_8 in the proven and reasonably assured categories. The geology and features of individual deposits are discussed below and outlined in Table 5.2.

5.2.a Blizzard Uranium Deposit

The Blizzard uranium deposit is about 49 air kilometres southeast of Kelowna and 24 air kilometres northeast of Beaverdell in the Okanagan Plateau area of south central British Columbia. The deposit is in NTS 82E/10W and is centred at longitude 118 degrees 55 minutes west and latitude 49 degrees 37 minutes north. Access from Kelowna is via Highway 33 and the Trapping Creek and Lassie Lake logging roads and from Beaverdell via the Beaver Creek, Cup Lake, and Lassie Lake forestry roads. The property is situated at the divide between the Kettle and West Kettle River drainages with local runoff entering Beaverdell Creek, Trapping Creek, and Copperkettle Creek.

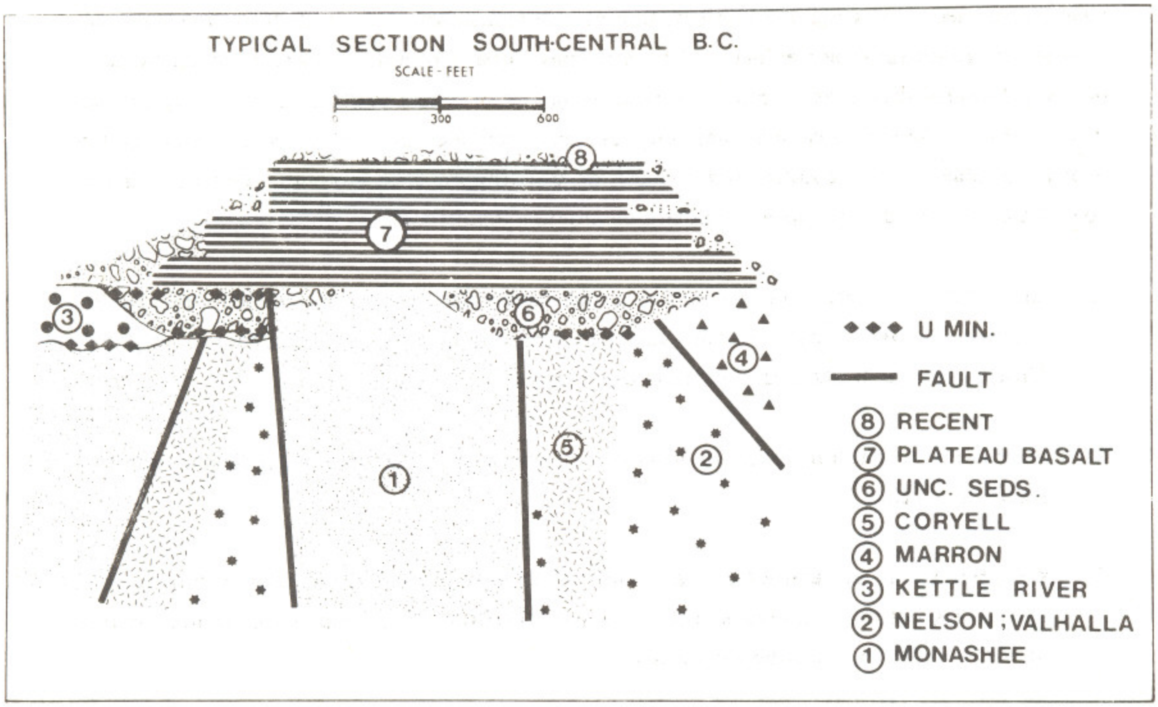


FIGURE 5.2. DIAGRAMMATIC SECTION OF TYPICAL BASAL DEPOSIT.

TABLE 5.2. COMPARISON OF THE BLIZZARD, DONEN, FUKI, HAYNES LAKE, AND HYDRAULIC LAKE BASAL TYPE URANIUM DEPOSITS

NAME	NTS	EXPLORATION STAGE	BASEMENT ROCKS	URANIUM MINERALS	IRON SULPHIDE	CARBONACEOUS MATERIAL
BLIZZARD	82E/10W	deposit outlined	Nelson, Valhalla, and Coryell	saleeite, autunite, pitchblende?	minor marcasite	common to abundant
DONEN	82E/10W	*	Nelson, Valhalla, and Coryell	autunite	common	common to abundant
FUKI	82E/10W	*	Valhalla, Coryell, and Kamloops Group	autunite	common	common
HAYNES LAKE	82E/11E 82E/14E	mainly wide-spaced drilling	Monashee, Valhalla, and Coryell	not determined	common	common to abundant
HYDRAULIC LAKE						
Tyee Lake Resources Ltd.	82E/14E	deposit outlined	Kettle River, Monashee, and Valhalla	ningyoite, gummite	abundant marcasite	common to abundant
PNC Exploration (Canada) Co. Ltd.	82E/14E	wide-spaced drilling				

* A 5 000 to 7 000-metre drilling program presently in progress should define the reserve picture on the Fuki–Donen property.

General Geology: The general geology of the Blizzard property is shown on Figure 5.3. Rocks considered to be 'basement' to the Blizzard deposit consist mainly of Nelson and Valhalla intrusions (Little, 1957, 1960, and 1961) and dykes of a felsic, alkaline nature (Coryell) and olivine basalt (feeders of plateau basalts). Dykes account for about 5 per cent of the basement rocks and occur in swarms with north 20 degree west and north 15 to 25 degree east strikes. Structurally controlled linears and the structurally controlled channel containing the Blizzard deposit have similar orientations. The paleo-stream channel that contains the carbonaceous sediments that host the Blizzard deposit is considered to have formed during Miocene (26 Ma to 7 Ma) or earliest Pliocene (7 Ma to 2 Ma) before the extrusion of the plateau basalt cap at about 5 Ma (K/Ar whole rock age determination). The olivine plateau basalt cap protected the channel sediments from erosion by Pleistocene glaciers and also sealed and protected the groundwater system from highly oxidizing surface conditions. Pleistocene glacial and glaciofluvial deposits represent the last major unit deposited in the area and overlying all other units.

Mineralization: Mineralization in the Blizzard deposit consists mainly of autunite (a hydrated phosphate of calcium and uranium) and saleeite (a hydrated phosphate of magnesium and uranium) with unidentified black sooty, uraniferous coating that is probably pitchblende or gummite. Unlike other basal deposits, the iron sulphides marcasite and pyrite are not common within the mineralized zones. A preliminary study of mineralized and unmineralized samples did not show strong correlation between clays and mineralization or the presence of zeolites, but all mineralized specimens examined had abundant carbonaceous trash, and reducing conditions maintained by the decay of organic material is considered to have promoted precipitation of uranium.

Reserves for the Blizzard deposit have been reported by Norcen Energy Resources Limited as 2 100 000 tonnes grading 0.226 per cent or about 4 760 tonnes of U_3O_8. Potential for additional discoveries appears to exist in the Sandrift Meadow area southeast of the Blizzard deposit and north of the Donen deposit on the Blizzard property.

5.2.b Fuki and Donen Uranium Deposits

The Fuki-Donen property adjoins the Blizzard property to the south and the properties have similar settings and access. The Donen (Cup Lake) deposit is situated east of Lassie Lake and northwest of Cup Lake about 54 air kilometres southeast of Kelowna and 23 air kilometres northeast of Beaverdell. The deposit is centred at longitude 118 degrees 54 minutes west and latitude 49 degrees 36 minutes north. The Fuki deposit is situated near Dear Creek about 60 air kilometres southeast of Kelowna and 18 air kilometres northeast of Beaverdell and centred at longitude 118 degrees 53 minutes west and latitude 49 degrees 32 minutes north. The initial discovery of basal type uranium mineralization in

British Columbia at the Fuki showing was made in August of 1968 by geologists engaged in a car-borne scintillometer survey for PNC Exploration Ltd. (Japan). The Fuki showing near Dear Creek is the only significant exposure of uranium mineralization on the Fuki–Donen property and is exposed in a roadcut at Mile 14.3 (22.8 kilometres) on the Beaver Creek forestry road. Gravel from this showing has been used for road metal on a short section of the Beaver Creek road.

The Fuki–Donen property is drained by Beaverdell Creek, Dear Creek, and Copperkettle Creek with runoff eventually entering the Kettle River system. Geochemical surveys have shown only weak uranium anomalies, and it is doubtful that the deposits would have been discovered without the aid of the exposure created during road building.

General Geology: The general geology of the Fuki–Donen property is shown on Figure 5.4. Basement rocks to the Donen deposit are granitic rocks of the Nelson, Valhalla, and Coryell intrusions. A sharp contact striking about north 60 degrees east exists between Nelson and Valhalla rocks and the apparent pinch out of the Valhalla in the area of the Donen deposit is based on regional trends and company diamond-drill reports. The geology of the Fuki deposit differs from that of the Blizzard and Donen deposits in that basement rocks to the fluvial sediments that contain the uranium mineralization are mainly volcanic rocks of the Kamloops Group. At the Fuki showing the basement rocks are biotite andesites and south of the showing trachytes occur along Dear Creek. The north 20 degree east and north 20 degree west structures that control channel locations and intrusive distribution on the Blizzard property are present at both the Fuki and Donen deposits, and like the Blizzard deposit both the Fuki and Donen uranium deposits occur in fluvial sediments that have been protected from erosion by plateau basalt caps.

Mineralization: Secondary uranium minerals occur as films on pebbles and in the matrix of loosely consolidated conglomerates and carbonaceous sediments that were deposited in paleostream channels. Autunite is the only uranium mineral that has been identified. Extensive areas of Coryell and Valhalla intrusive rocks of high uranium background occur topographically above and to the north of the Fuki deposit and directly below the Donen deposit. These rock units are considered the main sources of uranium mineralization.

Preliminary reserve estimates of $>$500 tonnes U_3O_8 for the Donen deposit and $>$150 tonnes U_3O_8 for the Fuki deposit are based on drill results obtained prior to 1976. A 6 000 to 7 000-metre diamond-drilling program during 1979 on the Fuki and Donen property by PNC Exploration (Canada) Co. Ltd. should establish the uranium reserves of these properties.

5.2.c Haynes Lake Uranium Deposit (PB 81–140 Claims)

The Haynes Lake deposit is near the McCulloch road and Highway 33 junction about 30 air kilometres southeast of Kelowna. The deposit is in NTS 82E/11E and 82E/14E and is centred at longitude 119 degrees 05 minutes west and latitude 49 degrees 45 minutes north. Mineral claims, PB 81 to PB 140 covering the Haynes Lake deposit area, were located by Nissho-Iwai (Canada) Ltd. in December of 1972. A total of 31 diamond-drill holes totalling about 2 000 metres were drilled on the property by Nissho-Iwai (Canada) Ltd. before the property was acquired by PNC Exploration (Canada) Co. Ltd.

General Geology: The general geology of the Haynes Lake property is shown on Figure 5.5. The basement rocks to the plateau basalts and fluvial sediments are layered gneiss of the Monashee Group, Valhalla and Coryell intrusive rocks. The Monashee Group is part of the Shuswap Metamorphic Complex which has widespread distribution in south-central British Columbia and contains many small uraniferous pegmatite occurrences, but generally has a low uranium background relative to the intrusive rocks. The Valhalla and Coryell rocks in the area are considered to be source rocks for uranium and more favourable basement rocks. A north 45 degrees west fault zone appears to extend from the area of the Haynes Lake deposit through the area of the Hydraulic Lake deposit.

Mineralization: The uranium minerals in the Haynes Lake deposit have not been identified, but because of its similarity to other deposits in the area, autunite is believed to be the main uranium mineral.

Uranium reserves of greater than 400 tonnes U_3O_8 have been estimated for this property but diamond-drill hole BCP-10 with 3 metres of 0.4 per cent U_3O_8 was only considered as greater than 0.02 per cent. If a high-grade section of the channel can be located, this deposit will have significant additional reserves.

5.2.d Hydraulic Lake Uranium Deposit

The Hydraulic Lake deposit straddles the McCulloch road northwest of Hydraulic Lake about 23 air kilometres southeast of Kelowna. The deposit is in NTS 82E/14E and is centred at longitude 119 degrees 12 minutes west and latitude 49 degrees 48 minutes north. Much of the deposit north of the McCulloch road is presently controlled by PNC Exploration (Canada) Co. Ltd., while that part of the deposit south of the McCulloch road is controlled by Tyee Lake Resources Ltd. Hydraulic Creek, a tributary of Mission Creek, flows through glacial deposits at the southern end of the deposit.

LEGEND

MIOCENE AND PLIOCENE

10 BASALT; OLIVINE BASALT (PLATEAU BASALT); 10A UNCONSOLIDATED SEDIMENTS

EOCENE

9 DACITE (MARAMA FORMATION ?); 9A – FEEDER

8 CORYELL, MAINLY SYENITE AND MONZONITE

7 KAMLOOPS GROUP TUFFS AND FLOWS AND RELATED VOLCANICLASTIC SEDIMENTARY ROCKS

6 KETTLE RIVER FORMATION

5 VALHALLA PLUTONIC ROCKS

4 NELSON PLUTONIC ROCKS; 4A – ALTERED NELSON

3 CACHE CREEK GROUP; GREENSTONE

2 ANARCHIST GROUP OR WALLACE FORMATION (METASEDIMENTARY ROCKS)

1 MONASHEE GROUP LAYERED GNEISS; 1A – ALTERED MONASHEE

SYMBOLS

DRILL HOLE; GRID OR CLOSELY SPACED DRILLING ....

K/Ar AGE DATE SAMPLE (BASALT WHOLE ROCK) ....

DYKE ....

OUTCROP AREA ....

EDGE OF MAPPING ....

CONTACT: KNOWN, ASSUMED ....

FAULT OR STRONG LINEAR FROM AIR PHOTO ....

SYNCLINE AXIS ....

MINE ....

HIGHWAY (LOOSE SURFACE) ....

GRAVEL ROAD; LOGGING ROAD ....

TRAIL ....

SCALE

Metres 1000 0 1000 2000 3000 4000 Metres

CONTOUR INTERVAL – 500 FEET

LEGEND FOR FIGURES 5.3, 5.4, 5.5, 5.6

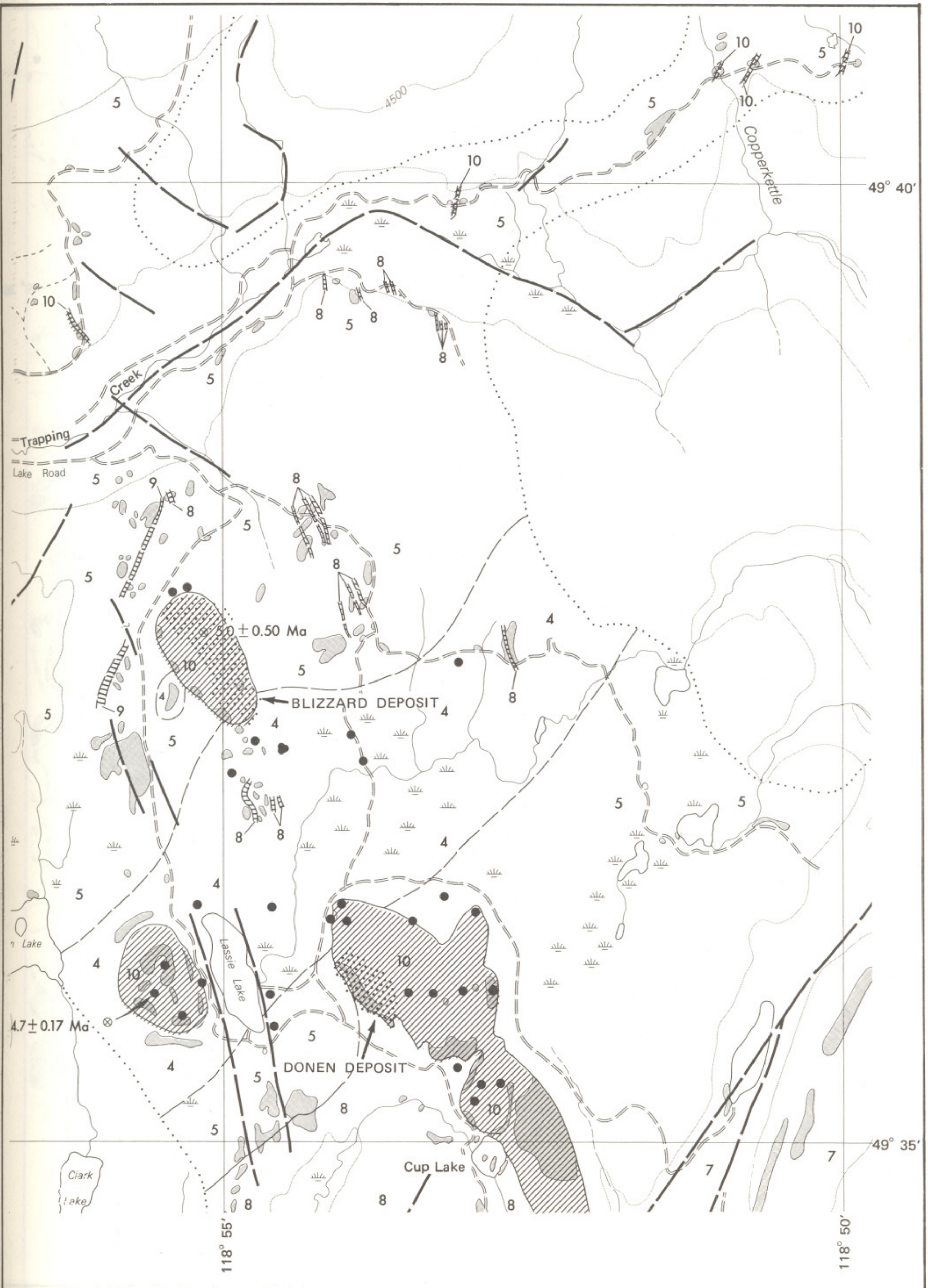


FIGURE 5.3. GEOLOGICAL SETTING OF BLIZZARD URANIUM DEPOSIT.

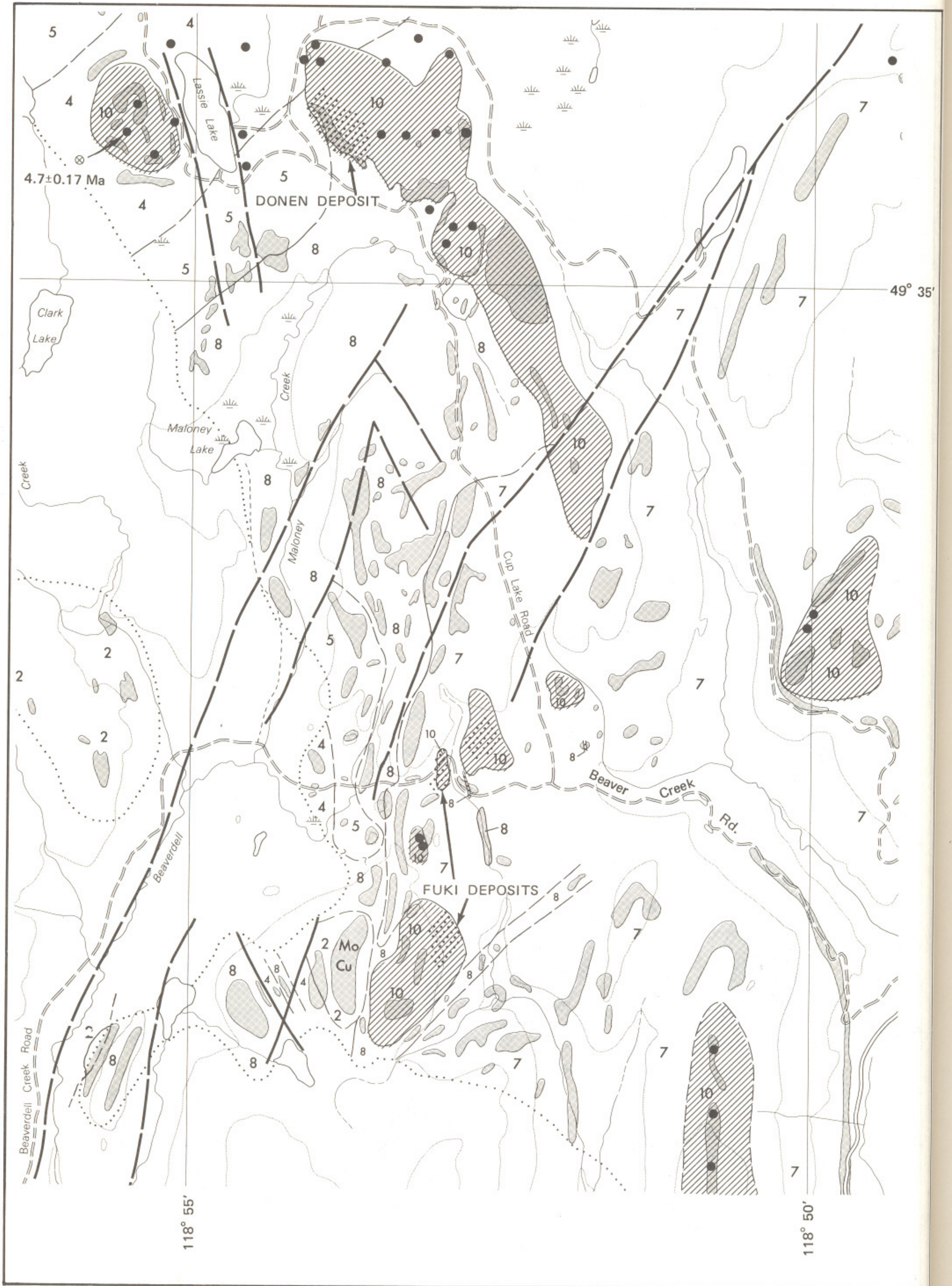


FIGURE 5.4. GEOLOGICAL SETTING OF FUKI–DONEN URANIUM DEPOSITS.

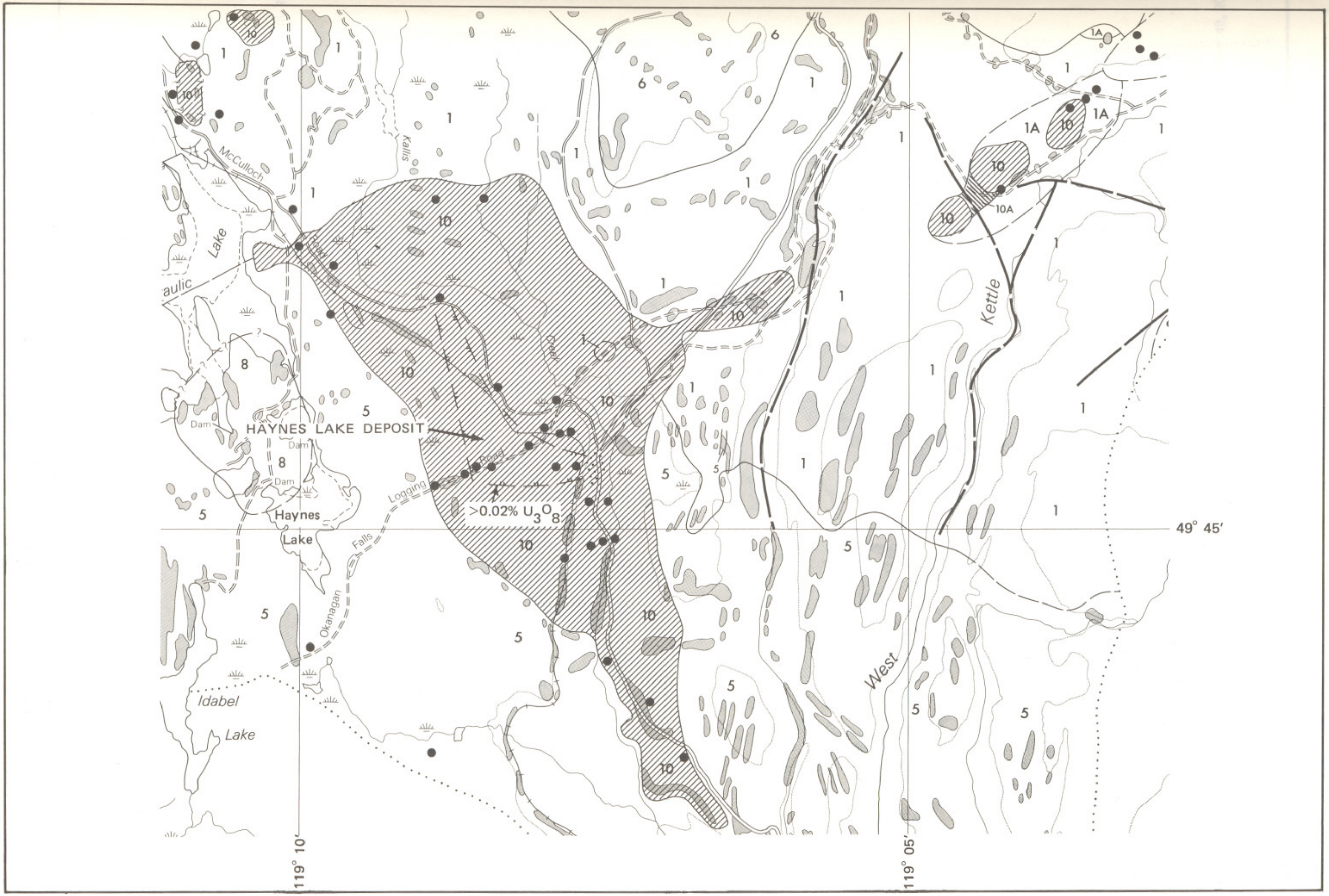


FIGURE 5.5. GEOLOGICAL SETTING OF HAYNES LAKE AREA URANIUM DEPOSIT.

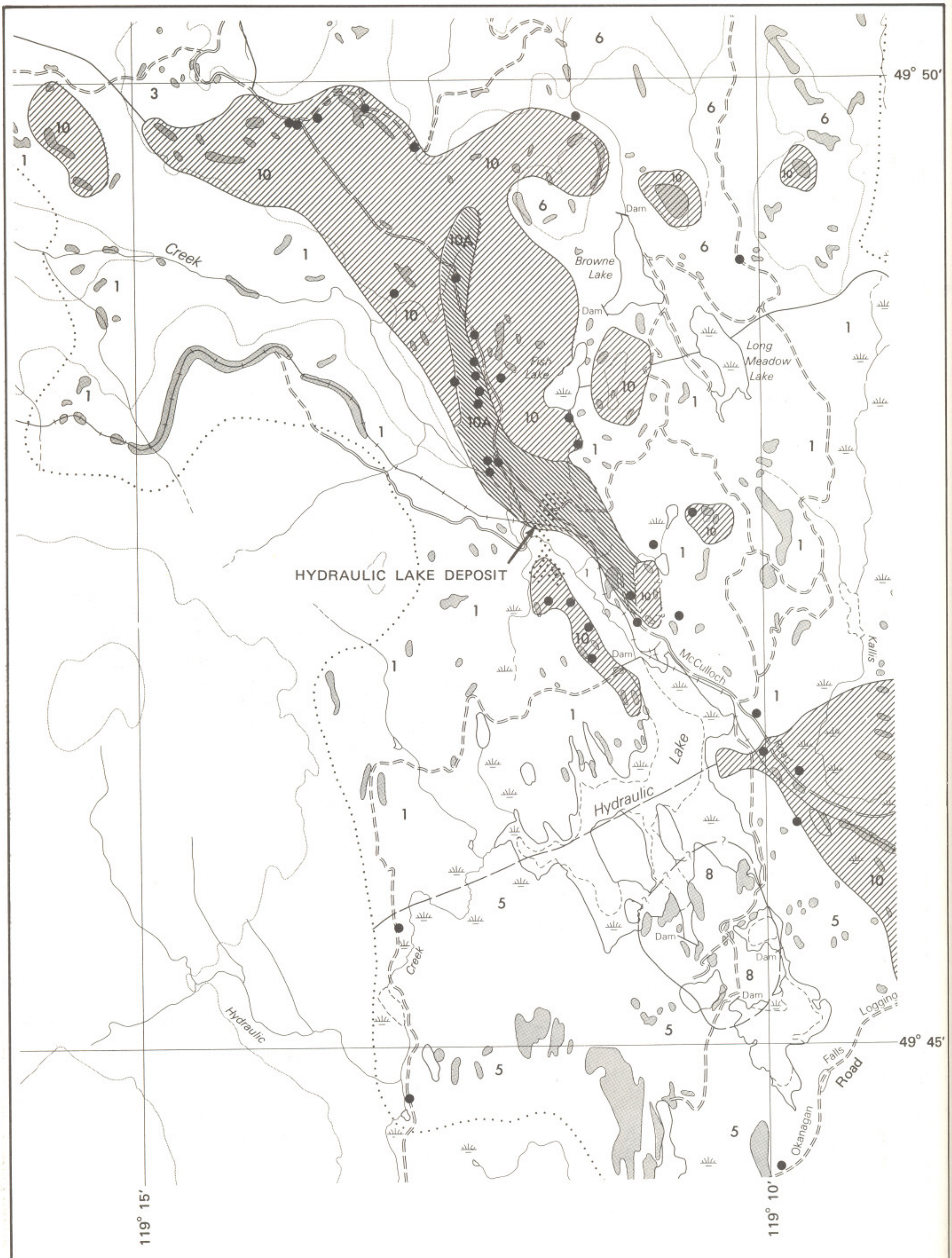


FIGURE 5.6. GEOLOGICAL SETTING OF HYDRAULIC LAKE URANIUM DEPOSIT.

General Geology: The general geology of the Hydraulic Lake property is shown on Figure 5.6. Layered gneissic rocks of the Monashee Group, Valhalla and Coryell intrusive rocks and volcanic-sedimentary rocks of the Eocene Kettle River Formation are basement rocks to the plateau basalt. The Hydraulic Lake deposit differs from other basal-type deposits in the East Okanagan uranium area in that the highest grade mineralization is associated with a layer of nearly massive iron sulphide and the basalt cap that seals and protects other mineral deposits has been eroded from above much of the deposit. The impermeable cap appears to be clay-rich layers within the sedimentary sequence, and overlying the mineral deposit is several metres of poorly sorted glacial material. A strong north 45 degree west structural zone occurs in basement rocks below the Hydraulic Lake deposit and probably provided ground preparation for leach solutions.

Mineralization: Uranium minerals identified at the Hydraulic Lake deposit include ningyoite (Boyle, 1979) and gummite with associated strong concentrations of the iron sulphide, marcasite. The mineralogy of this deposit suggests that strong reducing conditions existed when the deposit formed.

The reserves of the Tyee Lake Resources' property are defined by grid drilling at about 693 tonnes U_3O_8 but the 200 tonnes assigned to the PNC property area is based on wide-spaced drilling only.

5.3 Volcanogenic Deposits

Volcanogenic deposits of uranium appear to be relatively rare in the world. They are shown as a minor type by Ruzicka (1976). However, similar polymetallic deposits of copper, zinc, and lead are common. Such deposits originated during the formation of the original volcanic flows and breccias by a number of processes but they are normally bedded parallel to the volcanic rocks that contain them. These rocks also commonly show an alteration zone below the deposits if they have formed near a vent area. The deposit at Rexspar is probably the best example of a volcanogenic uranium deposit.

The Rexspar Deposit

Location and History: The Rexspar deposit is located on Red Ridge, 100 kilometres north of Kamloops and 5 kilometres south of the village of Birch Island, on the south slope of the North Thompson Valley, between Lute and Foghorn Creeks.

The Rexspar showings have received intermittent attention since 1918. Initially interest was for silver-lead and fluorite and, in the late 1920's, for manganese. Further work on the fluorite occurrences was done in the 1940's, and the presence of uranium mineralization was discovered

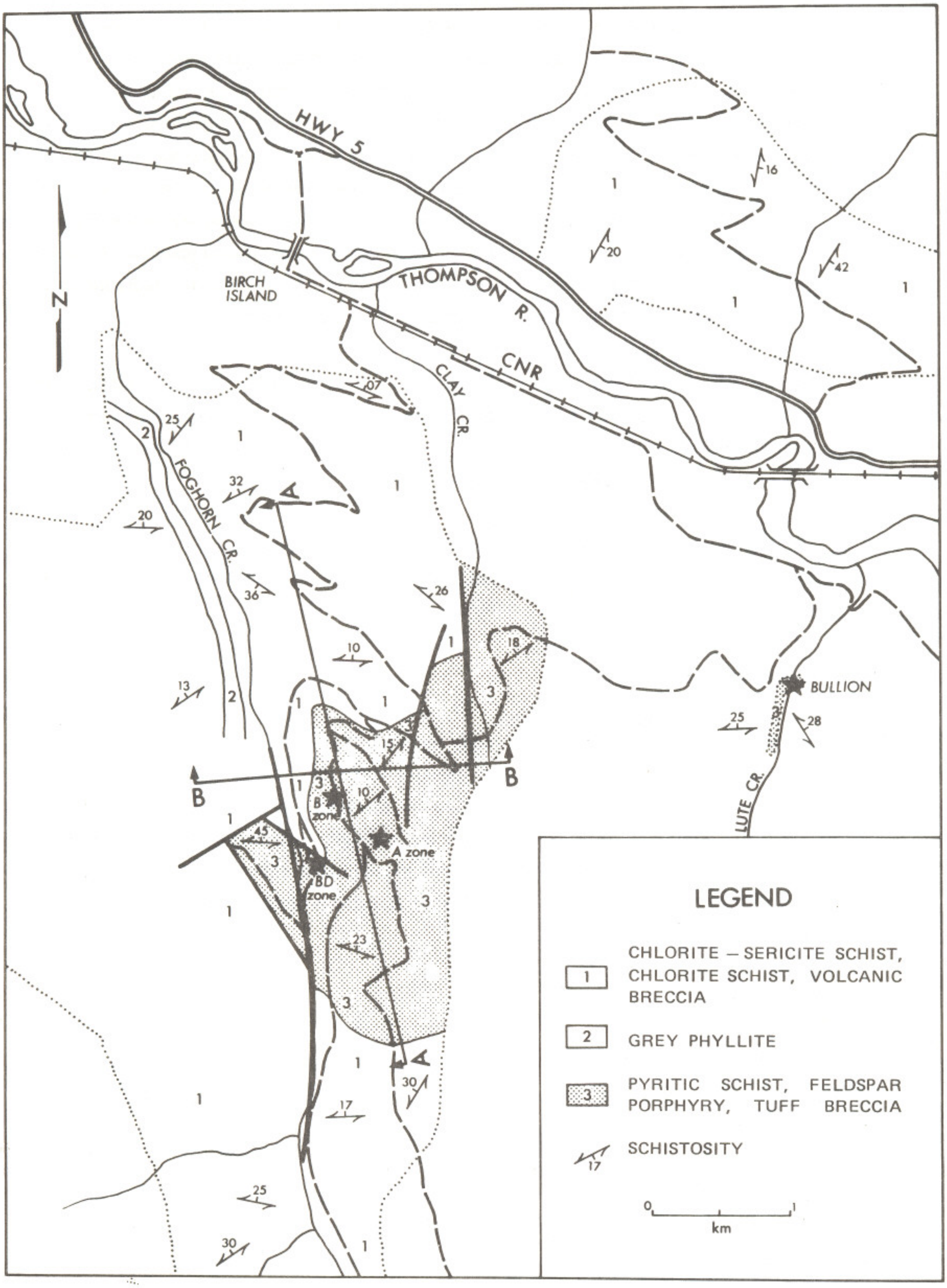


FIGURE 5.7. GEOLOGICAL SETTING OF REXSPAR PROPERTY.

in 1949. Extensive surface and underground work in the early and mid 1950's outlined three zones of commercial-grade uranium mineralization and one contiguous zone of fluorite mineralization. Geological studies and diamond drilling were resumed in 1969 and continued until 1976. The three zones of uranium mineralization, known as the A, B, and BD, have combined reserves of 1 114 158 tonnes of ore grading 0.773 kilogram of U_3O_8 per tonne. Engineering studies done on behalf of Consolidated Rexspar Minerals & Chemicals Limited by Kilborn Engineering Ltd. indicate that these reserves are sufficient to support, for a period of four and one-half years, a 1 270-tonne-per-day, five days a week mining operation and a 910-tonne-per-day beneficiation plant that is to operate continuously. Fluorite mineralization, located adjacent to the uranium orebodies, if proven to be economic, could extend the life of the operation by an additional four years.

Geology: All foliated rocks within the area mapped (Fig. 5.7) are part of the Eagle Bay Formation of pre-Late Triassic and probable Mississippian age. To the southwest, near Foghorn Mountain, these rocks are in contact with massive to weakly foliated basalt and pillow basalt of the Fennell Formation of Mississippian or later age. To the south, on Granite Mountain, schists of the Eagle Bay Formation are intruded by massive quartz monzonite and granodiorite of the Cretaceous Baldy batholith.

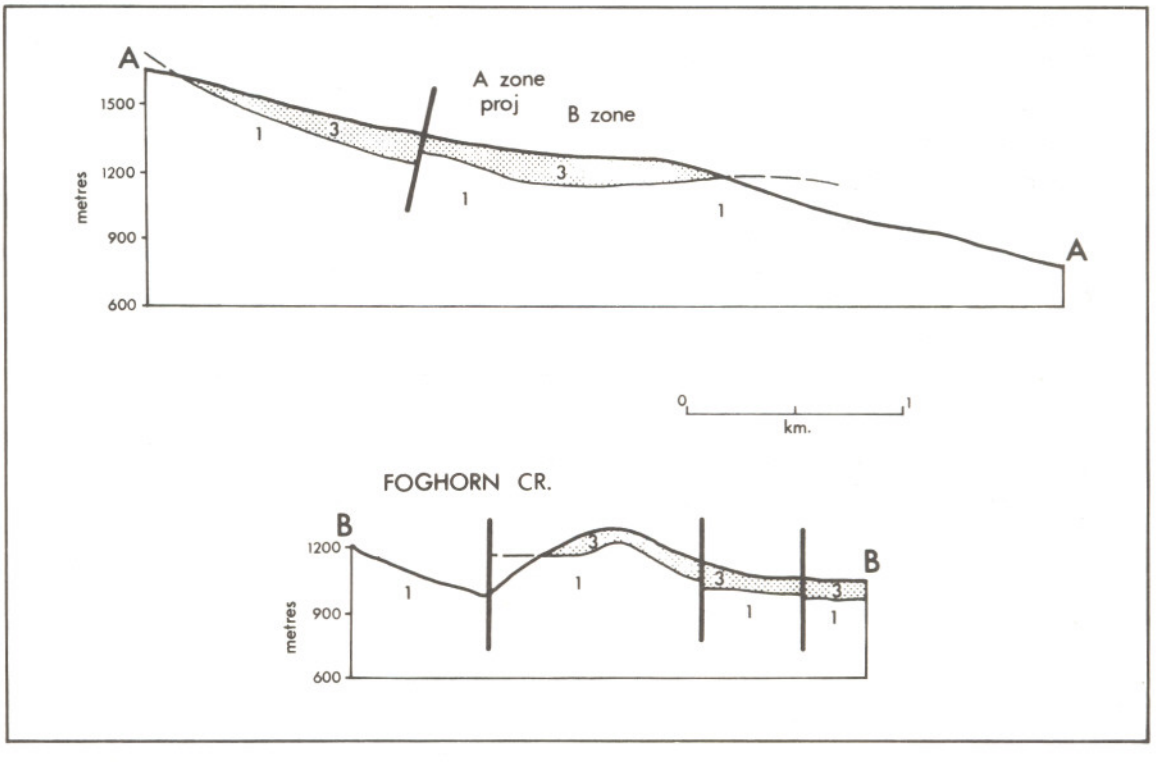


FIGURE 5.8. CROSS–SECTION OF REXSPAR PROPERTY.

South of the Thompson River, and especially in the vicinity of the Rexspar deposits, the foliated rocks are flat lying (*see* Fig. 5.8) and mostly of volcanic origin. Green chlorite and chlorite-sericite schist and silver-grey sericite-quartz schist of map unit 1 are the most common rock type and contain several exposures of clearly recognizable dacitic and andesitic volcanic breccia which attest to the volcanic origin of a good part of these rocks. Interlayered sedimentary members of grey phyllite and slate (unit 2), quartzite, and ribbon chert are distinctly less abundant than schists of volcanic origin. Uranium mineralization is found exclusively in map unit 3, locally known as the trachyte unit. On Red Ridge, and particularly in the vicinity of the orebodies, this rock consists of a rusty weathering, light grey, pyritic alkali feldspar porphyry which may be massive, brecciated, or strongly schistose and lineated. Another common variety of unit 3, and particularly near the A zone and south of the BD zone, is a breccia which contains a predominance of feldspar porphyry fragments as well as fragments of other fine-grained, darker coloured rocks. Fragment size in these breccias ranges from less than 1 centimetre to rarely more than 20 centimetres. The breccias, because of their setting, distribution, and appearance, can best be interpreted as intrusive and volcanic breccias, which indicate that the area of the mineral deposits, and particularly that between the B and BD zones, probably is a volcanic centre or vent from which part or all of map unit 3 was derived.

Mineralization: Uranium-thorium mineralization is found exclusively in map unit 3 and, as far as can be determined by surface mapping and from old drill records, occurs mainly in the upper part of the unit. Dark-coloured zones of the 'trachyte unit' which are extensively replaced by silver-grey fluorphlogopite and pyrite are by far the best host to mineralization. Drilling indicates that ore-grade material occurs in a series of discontinuous lenses generally less than 20 metres thick and conformable with the schistosity in the trachyte. Fluorphlogopite-pyrite replacements, commonly with lesser amounts of fluorite and minor calcite, range from a few centimetres to several metres in size, and generally occur as coarse-grained segregations which show both conformable and crosscutting relationships.

Previous work by officers of the Geological Survey of Canada and British Columbia Ministry of Energy, Mines and Petroleum Resources, as well as further optical, chemical, X-ray, and electron microprobe work during the present investigation, has yielded the following results:

(1) The principal uranium-thorium minerals at Rexspar are uraninite, thorian uraninite, torbernite, and metatorbernite, thorianite, and thorite. In addition, some uranium and thorium occur in monazite, and niobian ilmenorutile.

(2) Rare earths are found in bastnaesite and monazite.

(3) Other minerals include pyrite, fluorphlogopite, apatite, fluorite, celestite, galena, sphalerite, chalcopyrite, molybdenite, scheelite, siderite, dolomite, calcite, barite, quartz, albitic plagioclase, and alkali feldspar.

(4) Uranium-thorium minerals occur as tiny, discrete grains inside fluorphlogopite flakes and surrounded by single or double pleochroic haloes or as discrete grains scattered in the pyrite-fluorphlogopite matrix.

(5) Radiation damage has caused pleochroic haloes in fluorphlogopite and the purple coloration in fluorite.

(6) Analyses indicate that thorium-uranium ratios range from nearly 1:1 to much greater than 1:1 (Table 5.3). Rare earths, and particularly cerium and lanthanum, are present in very substantial amounts (Table 5.4).

(7) Oxidation of the ore has been negligible.

(8) Fluorite is commonly found in the zones of uranium-thorium mineralization, but the fluorite zone which could be commercial grade is separate from ore-grade uranium-thorium mineralization.

(9) All phases of the 'trachyte unit,' including zones of fluorphlogopite-pyrite replacement and uranium-fluorite mineralization, display evidence of deformation and range from brecciated to markedly schistose and lineated. They appear to have been subjected to most or all of the deformation that affected the rest of the foliated rocks in the area, though their response was not uniform.

It appears therefore that the mineralized zones at Rexspar not only are located close to a part of the 'trachyte unit' which might represent a vent area, but also that, assuming the strata are upright, they are concentrated in the upper part of the unit. The close association with the pyrite-mica replacement and the occurrence of radioactive minerals within mica grains suggest that all these minerals formed at about the same time. The setting and aspect of the pyrite-mica zones suggest that these were formed by late magmatic, volatile-rich fluids during a late stage in the formation of the 'trachyte unit.' It follows, therefore, that the zones of uranium-thorium mineralization, and of fluorite, probably are syngenetic with the formation of the 'trachyte unit' and thus be of volcanic origin.

Age: A K/Ar age of 236±8 Ma has been obtained by S. S. Gandhi of the Geological Survey of Canada (personal communication, March 9, 1978) for fluorphlogopite from one of the min-

TABLE 5.3. U AND Th CONTENT OF SELECTED HAND SPECIMENS FROM REXSPAR

(All values in ppm)

Sample		Total		Sinks +3.29 S.G.				Floats −3.29 S.G.	
				+40 mesh		−40+60 mesh		+40 mesh	
No.	Zone	U	Th	U	Th	U	Th	U	Th
1	BD	687	3270	1017	2401	825	1949	963	2230
2	A	412	504	374	493	230	264	496	416
3	A	265	204	331	197	312	114	230	172
4	A	1468	2418	2646	4093	1472	2452	1165	1343
7	A	231	411	377	696	227	312	251	386
8	BD	53	47	21	65	27	10	41	47

Analyses done by gamma-ray spectrometric determinations at the
Analytical Laboratory of the Ministry of Energy, Mines and Petroleum Resources

TABLE 5.4. SEMI–QUANTITATIVE EMISSION SPECTROGRAPHIC ANALYSES OF SELECTED HAND SPECIMENS FROM REXSPAR

(Values in weight per cent)

Element	Sample No. and Zone					
	1 – BD Zone	2 – A Zone	3 – A Zone	4 – A Zone	7 – A Zone	8 – BD Zone
Si	>10.0	>10.0	>10.0	>10.0	>10.0	>10.0
Al	8.5	7.5	>10.0	>10.0	9.0	>10.0
Mg	2.0	2.0	0.7	2.0	1.0	2.0
Ca	3.5	2.5	1.35	2.5	>20.0	1.5
Fe	16.0	>20.0	12.5	17.5	11.5	9.0
Pb	0.015	Tr.	0.015	0.03	Tr.	0.015
Cu	0.07	0.05	0.03	0.05	0.01	0.02
Zn	0.01	0.01	Tr.	Tr.	N.A.	Tr.
Mn	0.12	0.15	0.13	0.1	0.1	0.14
Ag	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
V	0.05	0.05	0.05	0.05	0.05	0.03
Ti	0.3	0.35	0.3	0.35	0.35	0.15
Ni	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
Co	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
Na	0.15	0.08	>2.0	0.15	0.15	2.0
K	>2.0	>2.0	>3.0	>3.0	>2.0	>5.0
Mo	0.01	Tr.	0.01	Tr.	0.015	Tr.
Zr	0.05	0.02	0.03	0.05	0.025	0.025
Sr	>2.0	0.1	0.04	0.15	0.1	>1.0
Ba	0.13	0.06	0.2	0.13	0.07	0.18
U	0.1	N.R.	N.R.	0.15	N.R.	N.R.
Th	0.23	0.04	0.02	0.23	0.04	N.R.
Li	0.015	0.03	0.01	0.04	Tr.	0.02
Nb	0.025	0.025	0.015	0.03	Tr.	Tr.
Y	0.01	0.015	0.01	0.02	0.05	Tr.
La	0.07	0.09	0.25	0.1	0.25	0.02
Ce	0.08	0.1	0.2	0.16	0.15	0.04
Nd	0.12	0.14	0.12	0.14	0.12	0.025
P	1.2	1.2	1.0	1.2	0.5	N.A.
Sn	N.R.	Tr.	Tr.	Tr.	Tr.	Tr.
Ge	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
Cr	Tr.	Tr.	0.01	Tr.	Tr.	0.01
Be	Tr.	Tr.	Tr.	Tr.	Tr.	N.A.
Yb	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.

Analyses done at the Analytical Laboratory
of the Ministry of Energy, Mines and Petroleum Resources

eralized zones. This must be considered a minimum age and used cautiously because of some analytical problems.

This Permo/Triassic age for the fluorphlogopite and, by inference, for the mineralization, though somewhat young for the presumed Mississippian age of the Eagle Bay rocks, tends to confirm the interpretation that the mineralization at Rexspar is old, probably syngenetic with the host rocks, and not related to the Cretaceous Baldy batholith.

5.4 Other Classes

5.4.a Pegmatite

Pegmatitic uranium deposits are a fairly common world-wide phenomena. McMillan (1978) includes them, if at all, under *igneous* and Ruzicka (1977) under *orthomagmatic* and *anatectic* deposits. These include some major deposits such as Rossing in Namibia. In British Columbia uranium-bearing pegmatites occur mainly in the southern Omineca Belt around the fringes of the Shuswap Metamorphic Complex. The largest concentration of reported pegmatite occurrences is in the Grand Forks–Nelson area but no mineable reserves have been established by exploration programs to date.

5.4.b Carbonatite

The association of uranium with carbonatites and related alkaline syenites is well known. Probably the best example, Palabora in South Africa, was initially explored for uranium although now also produces copper and other minerals as well. In British Columbia much of the early uranium exploration was associated with the small carbonatites (*see* Section III) and the relatively important Bugaboo placer deposits are reconcentration of minerals from such sources. In British Columbia the carbonatite and related alkaline intrusives are concentrated in the eastern Omineca Belt and adjacent Rocky Mountains. No economic reserves have been developed in such deposits.

5.4.c Placer Deposits

Placer deposits of uranium are among the most important type for world reserves. Most are related to 2.6 to 2.0 billion year old Proterozoic basins deposits on eroded Archean basement. The Rand (South Africa) and Blind River–Elliot Lake (Ontario) are such areas.

Younger placer deposits are relatively rare, however the Bugaboo placer deposits are an example. In these deposits pyrochlore, uraninite, magnetite, uranothorite, and euxenite occur in layers of an outwash sand and gravel below the existing Bugaboo glaciers. The resistant uranium, thorium, and niobium-bearing minerals were eroded from the syenitic and monzonitic phase of the Bugaboo batholith.

The only uranium or thorium known to be exported from British Columbia was from placers on Vowell and Malloy Creeks in 1956. Concentrates from tests made at a temporary plant near Spillimacheen were shipped by Falconbridge Nickel Mines Limited to Quebec Metallurgical Industries. At that time and later by Dillingham Corporation of Canada Limited, a potential 18 million cubic metres have been identified containing about 0.07 kilogram per metre of Nb_2O_5 and 0.013 kilogram per metre of U_3O_8.

5.4.d Vein Deposits

Vein deposits are one of the commonest types of uranium deposit known. In many countries they are found on either side of major unconformities. The northern Saskatchewan deposits are mostly examples of this structural occurrence. In British Columbia such an association has not been identified, but many independent vein deposits are known. A typical example is the Victoria–Hazelton View veins at Rocher Deboule where uraninite is associated with gold, silver, nickel-cobalt sulpharsenides, and molybdenite. Another example is the Little Gem in the Bridge River where uraninite is associated with gold and silver.

Many other classes are known in British Columbia including shear zones, bedded dark shales and phosphorites, and skarn deposits. However, no substantial resource has yet been established in any one of these classes.

5.5 Potential British Columbia Uranium Resources

On the basis of present knowledge, basal type uranium deposits appear to have the best potential for expanding British Columbia's uranium reserves. In addition to the Blizzard deposit in the southeast Okanagan, mineable reserves may be defined by further exploratory and development work at the PB (Haynes Lake), Fuki–Donen, and Kettle (Hydraulic Lake) properties.

Elsewhere in the Province, the exploration potential for basal type uranium deposits has been tested in only isolated sections of the Interior. Favourable conditions for the formation of these deposits have been outlined in Section 5.2 and these include the presence of potential source rocks (high background granites or volcanic rocks), stream and lake sediments containing carbonaceous material, and impermeable cap rocks (plateau basalts). These parameters are illustrated schematically on Figure 5.2, and Figure 5.9 shows the distribution of potentially favourable granitic source rocks and Late Tertiary plateau basalt cap rocks, which in many places are underlain by poorly consolidated sediments. Vast areas of the central Interior would appear to be potentially favourable for the discovery of basal type uranium deposits. To date,

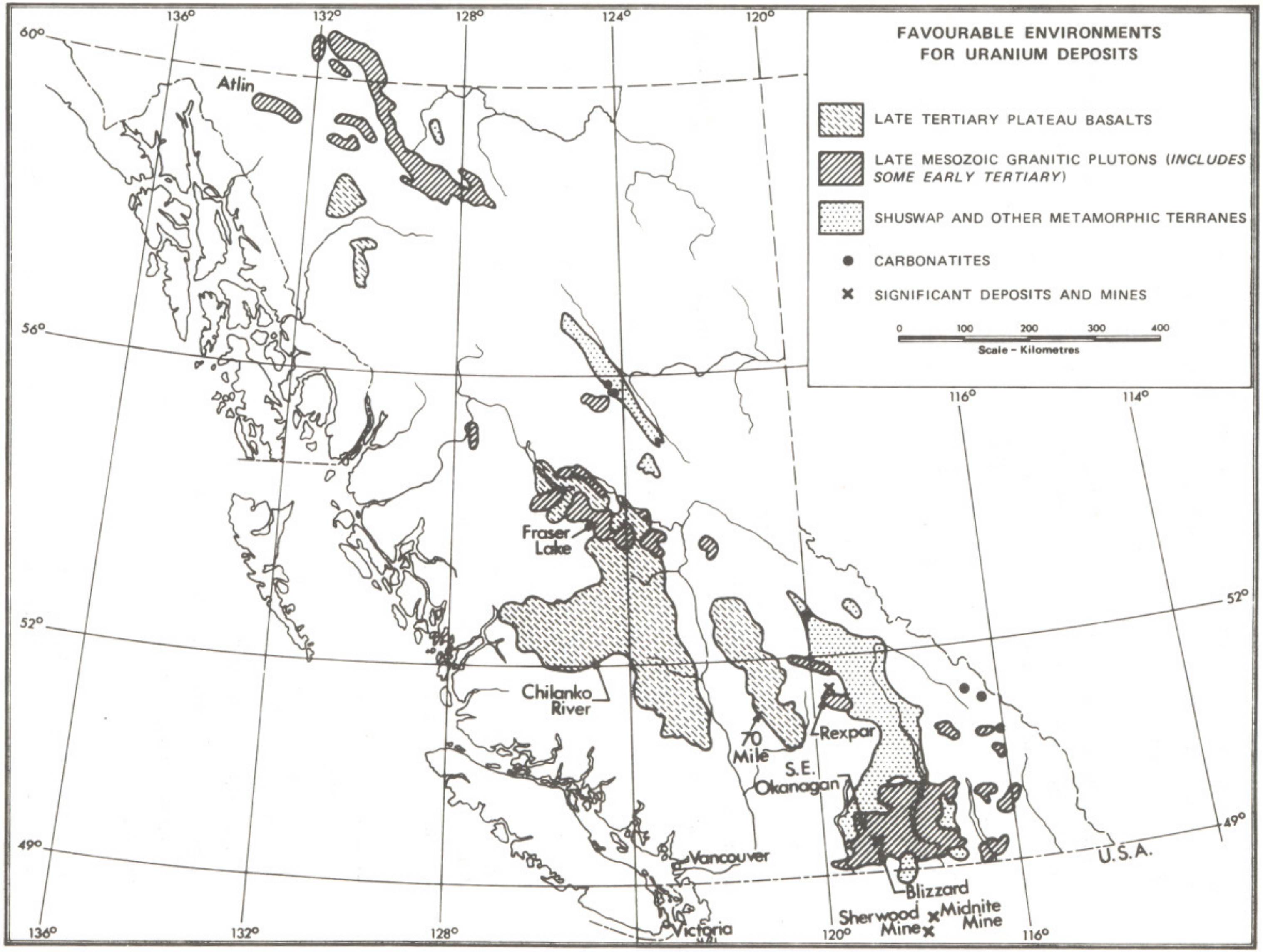


FIGURE 5.9. FAVOURABLE ENVIRONMENTS FOR URANIUM DEPOSITS.

only the 70 Mile House, Chilanko River, and Fraser Lake areas (Fig. 5.9) have been seriously explored. However, it should be emphasized that basal type uranium deposits represent very small targets which may not have a significant geochemical expression. Continued refinement of exploration techniques may result in the discovery of additional basal type deposits in central British Columbia.

Further discoveries of other types of uranium deposits, referred to earlier in this section, may provide additional reserves. Rexspar is the only volcanogenic uranium deposit recognized to date. Volcanogenic massive sulphide deposits of copper-zinc such as Western Mines and Kutcho Creek occur in rocks of similar Permo/Triassic age but do not contain uranium mineralizaton, possibly because their host rocks are of a more acidic nature. Tertiary alkaline volcanic rocks such as those of the Eocene Marron Formation west of Penticton are characterized by high radioactive background and have received considerable attention over the past several years. No significant deposits have been identified.

Uranium deposits in plutonic igneous rocks include those associated with pegmatites and carbonatites. While no commercial deposits have as yet been recognized, their distribution patterns suggest good potential for the discovery of additional prospects. Uraniferous pegmatites are best developed in metamorphic terrains, principally fringing the Shuswap (Fig. 5.9), but the Wolverine and Horseranch in central and northwest British Columbia may represent favourable areas for future exploration. Similarly, such environments may also host pyrochlore-bearing carbonatites.

Contact or skarn type deposits such as Midnite mine in Washington (Fig. 5.9) may exist in calcareous sedimentary rocks marginal to high background granitic bodies such as the Valhalla and Coryell granitic intrusions in south central British Columbia or the Surprise Lake batholith near Atlin. The latter intrusive body, noted for its multi-element geochemical signature, is known to host secondary uranium minerals in fracture and fluorite stockwork zones.

Black shales, phosphate, and sandstone uranium deposits, which constitute a significant portion of the world-wide reserves, have not as yet been recognized in British Columbia, although favourable geology exists. Jurassic phosphate formations are widespread in the East Kootenays, while high gamma-ray background Paleozoic and Mesozoic black shale sequences are known in northeastern British Columbia. The Tertiary Sustut and Sifton basins in north central British Columbia have been a target for previous uranium exploration, but it appears that the sandstones and conglomerates in these basins have been derived principally from low background volcanic terrains.

In summary, basal type deposits offer the best potential for expanding present Provincial uranium resources. Exploration for other types of deposits, particularly those types not yet recognized in the Province (black shale, phosphate, sandstone), is warranted.

5.6 Comparison of Identified Resources in British Columbia, Canada, and the World

Current estimates of British Columbia uranium reserves are listed in Table 5.5. Basal type deposits such as Blizzard in the East Okanagan account for most of the estimated reserve figure of about 7 500 tonnes U_3O_8. The Rexspar deposit has defined reserves of 861 tonnes U_3O_8. As suggested in Section 5.5, basal type deposits have the best potential for increasing present known uranium reserves.

British Columbia reserves are about the same order of magnitude as those in Washington State (Table 5.6). Two Washington deposits, Midnite and Sherwood, are producing mines.

Table 5.7 shows the 1978 assessment of Canadian uranium reserves and resources. Note that there are two categories of reserves: those based on present world price of $125.00 (Canadian) per kilogram of elemental uranium (1 tonne U = 1.179 tonnes U_3O_8), and reserve projections based on a potential future price of $175.00 (Canadian) per kilogram.

A comparison of British Columbia estimated uranium reserves (Table 5.5) with Canadian reasonably assured reserves at present day prices indicates that British Columbia reserves constitute less than 3 per cent of the Canadian total. In contrast, Canadian reserves in either category represent a significant part of the world uranium resource.

TABLE 5.5. URANIUM RESOURCES AND RESERVES IN BRITISH COLUMBIA

COMPANY DEPOSIT	TONNES	GRADE *per cent*	TONNES U_3O_8	REFERENCE
BASAL TYPE URANIUM DEPOSITS IN THE EAST OKANAGAN AREA				
Norcen Energy Resources Ltd.				
BLIZZARD	2 100 000	0.226	4 760	Northern Miner, July 19, 1979, Vol. 65, No. 19, p. B-4
Tyee Lake Resources Ltd.				
HYDRAULIC LAKE	2 055 697	0.0366	693	L. Trenholme, October 1977, company report
PNC Exploration (Canada) Co. Ltd.				
DONEN (Cup Lake)	>1 000 000	0.05	>500	Estimates by P. A. Christopher based on Assessment Reports 2013, 2484, 4629, 3775, 3135, 5570, 5090, 5972, 4630, 5982, 5115
FUKI	>500 000	0.03	>150	
HAYNES LAKE (PB 81–140)	>2 000 000	>0.02	>400	
HYDRAULIC LAKE (PB 180–214)	>1 000 000	>0.02	>200	
OTHER DEPOSITS WITH RESERVES				
Cons. Rexspar Minerals & Chemicals Ltd.				
REXSPAR	1 114 158	0.0773	861	Canadian Mines Handbook, 1978/79, p. 83

TABLE 5.6. WASHINGTON STATE AND ALASKA URANIUM RESERVES AND PRODUCTION

DEPOSIT	LOCATION	PRODUCTION U_3O_8	RESERVES U_3O_8	REFERENCES
ROSS ADAMS	Bokan Mountain, Alaska	58 600 t @ 1.0%, 1.0% Th	under evaluation	Eakins, G. R. and Forbes, R. B. (1976)
SHERWOOD MINE	Stevens County, Washington	1958–1963, 85 333 t @ 0.17% (138 665 kg); re-started production May 1978 @ 2 000 t/day	8 000 000 t @ 0.089% (6 400 kg)	Robbins, D. A. (1978); Nash, J. T. and Lehrman, N. J. (1975)
MIDNITE MINE	Stevens County, Washington	3 000 000 t @ 0.2% (presently milling 470 t at Ford, Washington)	2 200 000 t @ 0.145%	Milne, P. C. (1979)
DAYBREAK MINE	Spokane County, Washington	27 216 kg; mining ended 1966		Milne, P. C. (1978)
SPOKANE MOUNTAIN URANIUM DEPOSIT	Stevens County, Washington	1975 discovery	160 000 t @ 0.25%	Robbins, D. A. (1979)

TABLE 5.7. 1978 URANIUM RESOURCE ASSESSMENT OF ELEMENTAL URANIUM IN MINEABLE ORE

Resource	Mineable at Uranium Prices up to: $125 (Canadian)/kg elemental U Canada	$175 (Canadian)/kg elemental U Canada
Measured (Canadian terminology)	76 000*	80 000†
Indicated (Canadian terminology)	139 000	155 000
Reasonably Assured (NEA/IAEA terminology) (Measured plus Indicated)	215 000 (12% of world resource estimate in this category)	235 000 (9% of world resource estimate in this category)
Inferred	223 000	302 000
Prognosticated	147 000	426 000
Estimated Additional (Inferred plus Prognosticated)	370 000 (25% of world resource estimate in this category)	728 000 (30% of world resource estimate in this category)

*All estimates in metric tons elemental U contained in mineable ore.
†Includes $125 (Canadian) ore.

SOURCE: 1978 Assessment of Canada's Uranium Supply and Demand, *Energy, Mines and Resources Canada,* Report EP 79–3, June 1979.

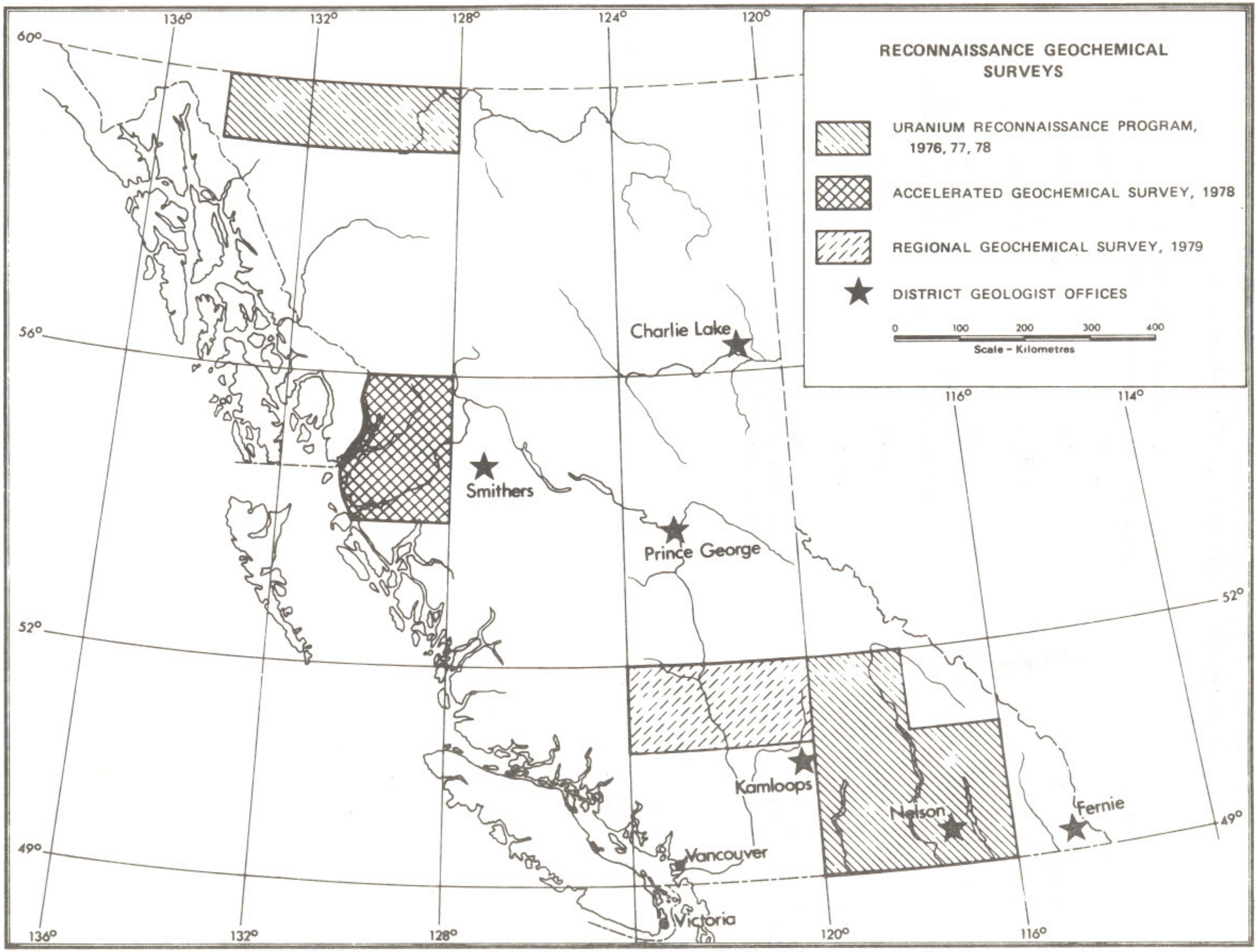


FIGURE 6.1. DISTRIBUTION OF GEOCHEMICAL RECONNAISSANCE SURVEYS.

VI. RECONNAISSANCE GEOCHEMICAL SURVEYS

6.1 History

The Geological Division has been involved in reconnaissance geochemical surveys since 1975, initially in a cooperative program, the Uranium Reconnaissance Program, with the Geological Survey of Canada and, since 1978, by itself. URP was an outgrowth of a recommendation of a Provincial Mines Ministers' Conference in 1973. The Division was involved in initial planning in 1974 (*see* Appendix 6.1) but the Ministry did not sign an agreement until 1976 (*see* Appendix 6.3). In some provinces URP was an airborne radiometric program but British Columbia opted for a multi-element geochemical survey because of their greater utility (*see* Appendices 6.1 and 6.2). Surveys started in the Okanagan to Clearwater areas (NTS areas 82 E, L, and M) in 1976, continued in the East Kootenays (82 F and K) and Atlin (104N) in 1977, and terminated with Jennings River (104O) and Cassiar (104P) in 1978. The same year British Columbia started its own survey, the Accelerated Geochemical Survey (AGS), in the Terrace and Nass River areas to stimulate prospecting in what was at that time a somewhat depressed area. This survey conformed to national standards and was conducted with considerable help from the Geological Survey of Canada, particularly in data handling. British Columbia continued in 1979 with Regional Geochemical Surveys (RGS) in Taseko Lakes (92O) and Bonaparte (92P) areas. Figure 6.1 shows the areas surveyed. The large number of published maps and data are only listed summarily in the References for Section VI.

6.2 Objectives

The surveys had many objectives that are evident in Appendices 6.1 to 6.3. These can be summarized as follows:

(1) to provide industry with high quality reconnaissance exploration data to aid in the search for uranium and 13 other metals, particularly copper, lead, zinc, molybdenum, tungsten, and tin;

(2) to provide a consistent national data base for these metals to serve as a basis for resource appraisal;

(3) to provide base-line data on the distribution of heavy metals for use for environmental purposes. Mercury was added to the list of analysed elements initially at the request of the Federal Department of the Environment. In British Columbia surveys, arsenic is analysed as well as mercury.

6.3 Method

Geochemical reconnaissance to the national standard involved sample collected on secondary or tertiary stream drainage with a density of one sample per 5 square miles (12.95 square kilometres). Two pounds (1 kilogram) of active silt (stream sediment) and 0.25 litre of water are collected at each site. Sample collection, sample preparation, and water and silt analysis are all carried out by separate contractors. Supervision, management, and quality control have been done jointly by the Geological Survey of Canada and the Geological Division of the Ministry of Energy, Mines and Petroleum Resources or in British Columbia surveys, by the latter. Data handling has been done by the Geological Survey of Canada for all surveys.

Silts are analysed for zinc, copper, lead, nickel, cobalt, silver, manganese, iron, arsenic, molybdenum, tungsten, mercury, and uranium. Waters are analysed for uranium, fluorine, and pH.

The various programs to the end of this year will have surveyed 164 250 square kilometres (63,400 square miles) or about 20 per cent of Cordilleran British Columbia. Some 15 300 sites will have been sampled.

The results are released in May or June of the year following the survey. A considerable effort is made to ensure the data is secure until released. The data packet includes sample location maps, detailed data listings, and statistical summaries, and in most instances maps for individual elements showing range symbols or values. The data is issued at its cost of reproduction. It is also available on computer tapes.

6.4 Costs

The costs of the URP surveys were shared equally between the Geological Survey of Canada and the Geological Division, except for in-house costs which would be greater for the Geological Survey of Canada because of data handling. Costs for AGS and RGS are entirely borne by the Geological Division, except for the data handling costs by the Geological Survey of Canada.

	CONTRACTS	SUPERVISION	LABORATORY AND IN HOUSE
British Columbia Ministry of Energy, Mines and Petroleum Resources			
URP, 1976–78	$ 335 000	$ 30 000	$ 9 000*
AGS, 1978	350 000	------	5 000*
RGS, 1979	243 000	------	5 000*
TOTALS	$ 928 000	$ 30 000	$ 19 000
Geological Survey of Canada			
Costs to GSC can only be estimated by the Geological Division except for contract costs.			
	$ 325 000	$ 75 000*	$125 000*
TOTALS	$1 263 000	$105 000	$144 000

GRAND TOTAL = $1 512 000

COST per site = $98.80
per square kilometre = $9.20

*approximate

6.5 Results

Release of the data greatly stimulates exploration for the whole array of metals. This can be shown by the pattern of claim staking in successive years following release. In 1977 when prospecting was still somewhat depressed, release of the data triggered an immediate 170-per-cent increase in claim locations over the month previous. After the close of the year, locations were up 38 per cent over the year before. In 1978 releases for the north and south were at different times. The following list shows the response to the release.

Map Area	104 N	82F	82K
Release Date	June 15, 1978	June 8, 1978	June 8, 1978
Claim locations in units per month			
May	34	76	234
June	238	453	656
July	896	354	450
August	148	186	219

In 1979 some 20 helicopters were standing by for the releases of URP and AGS data at both Lower Post and Terrace respectively.

A great many new mineral prospects have been located, old ones have been re-evaluated, and a number of areas, heretofore regarded as having little mineral potential, are being investigated.

In regard to the second objective, the data are used to give more rigour to the Ministry's Land-Use evaluations and Mineral Deposit/Land Use map series.

Preliminary results from the third objective are:

(1) The only substantial evidence of regional natural distribution of uranium in waters and terrains is these surveys.

(2) The monitoring program sites were selected as a result of these surveys.

6.6 Discussion of Uranium Distribution in Silts and Waters on Geochemical Reconnaissance Maps

Estimates of the natural abundance of uranium in the upper third of the earth's continental crust are based on estimates of the proportions of the various rock types in the same zone because uranium content is very closely related to rock chemistry. This is shown for broad groups of igneous rocks on Figure 6.2 (Peterman *in* Wederpohl, 1974, Vol. II, p. 92-E-4).

At the same time the composition of this zone of the crust is normally considered to be substantially the same as that of the magmatic igneous rocks because the contribution of sedimentary cover and metamorphic rocks is judged not to distort the relative proportions significantly. The many estimates of the proportions of magmatic rocks in the upper crust are all in substantial agreement that the granitic suite forms about 87 per cent and the gabbro-diorite suite about 13 per cent (Wederpohl, Vol. I, pp. 241-244). Therefore from Figure 6.2 one can judge the upper continental crust would have an average natural background of about 3.5 ppm.* The background for the whole crust is judged to be about 2.6 ppm (Dyck, 1969).

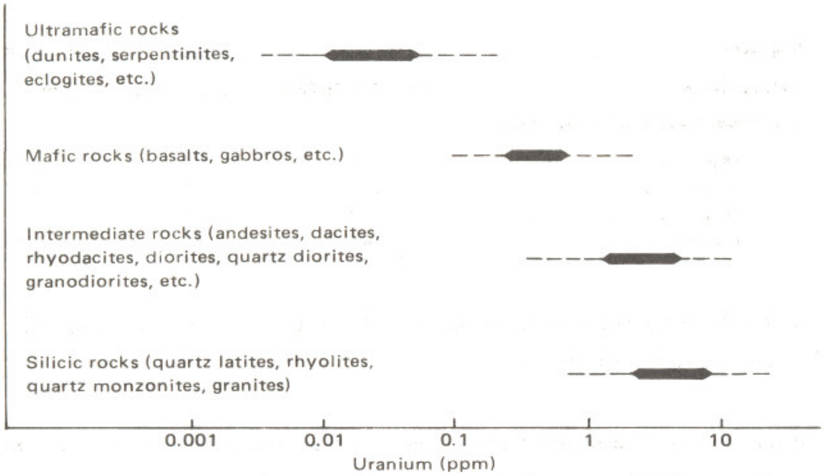


FIGURE 6.2. GENERALIZED DISTRIBUTION OF URANIUM IN VARIOUS BROAD GROUPS OF IGNEOUS ROCKS.
[From Peterman, Z. E.: unpublished communication (1963)]

Uranium in silts and waters generally reflects the uranium content of nearby rocks that are subject to erosion and weathering. Resistant uranium minerals are present in silts in addition to hydromorphic material. Uranium content of waters is more complex because they are also very dependent on their chemistry, particularly the carbonate and oxygen content (Langmuir, 1978, pp. 20, 21).

To illustrate the distribution of uranium, the regional reconnaissance survey maps of uranium in silts and in waters have been contoured by hand and redrafted at 1:500 000 (Figs. 6.3a to 6.4c). An attempt has been made to show areas above crustal background by this method with four contours.

For silts the range of values selected are as follows: 5 to 10 ppm, 10 to 20, 20 to 50, and >50 ppm. These values have been selected for convenience related to the symbol plot maps of URP. As discussed previously, natural background for the whole upper continental crust would be about 3.5 ppm. The mean value of 1 546 samples in the East Okanagan area (NTS 82E), an area of known deposits and some high background areas, is 6.8 ppm. Therefore the selection of 5 ppm as the lowest contour value seems appropriate.

*ppm = parts per million.

Selection of values for waters is more difficult. Average values for sea are said to range from 1 to 4 ppb*. Normal continental surface waters are much lower. Fix (1956) states the average for the United States to be 0.1 ppb. The mean value for 1 546 samples from 82E is 0.29 ppb. The contoured values selected for convenience are as follows: 0.2 to 0.5, 0.5 to 1, 1 to 2, >2 ppb.

Silt maps generally confirm the discussion under 2.2, Metallogeny. The increasing gradient from west to east is evident. Within this framework the granite areas in particular show as highs, and in a general way these increase from west to east. The highest averaged regional values and the highest granitic areas are found in southeastern British Columbia, especially in granites of Cretaceous age (140 to 70 Ma). In the same region the recrystallized metamorphic terrain is generally above crustal background. At the other side of the Province, the Coast Crystalline Belt is generally below crustal average except for young granites of the east flank of the Coast Crystalline Complex. Even these are low compared to those of the southeast. In the north, the Surprise Lake batholith of the Intermontane Belt is anomalously high but the remainder of the belt is generally low and below crustal background. The Cassiar batholith further east is characterized by generally higher values than the Coast crystalline batholiths.

The data for uranium in waters is not complete because that for the Jennings River and Cassiar areas has been delayed because of analytical problems. It will not be released until after September 1979.

The water maps in general are subdued reflections of the silt maps with the exception of the Okanagan area where alkaline surficial and groundwaters carry very much increased quantities of uranium in solution.

*ppb = parts per billion.

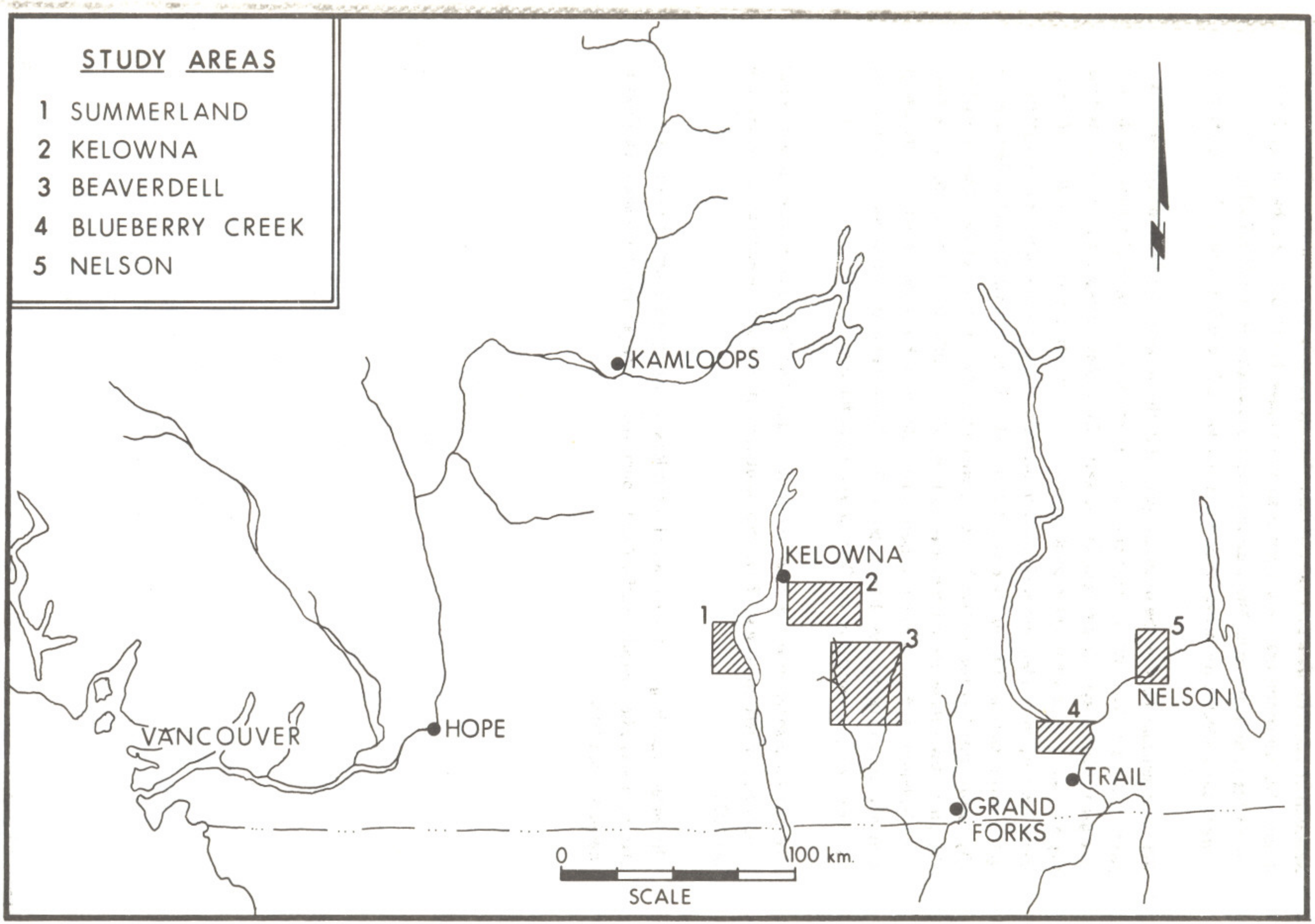


FIGURE 7.1. INDEX MAP OF WATER MONITORING STUDY AREAS.

VII. MONITORING STUDIES

The Ministry of Energy, Mines and Petroleum Resources has provided a $13 000 grant to finance a 12-month water-monitoring project in cooperation with the Ministry of Health.

The project is designed to monitor the quality of water at selected sites from the standpoint of natural uranium and gross alpha particle and gross beta particle concentrations in these waters. The sites were selected on the basis of those waters used for domestic purposes which showed higher than average uranium values in the recently completed 3-year Uranium Reconnaissance Program regional geochemical surveys (*see* Section VI).

The objective of this water quality monitoring program is to obtain values for the natural levels of uranium, gross alpha, and gross beta in these waters on a year-round basis. This will enable health authorities and others to determine the average annual exposure to this natural source of radioactivity of the people using these waters for domestic purposes.

The study is being run over a 12-month period so that variations such as those associated with spring runoff, differences in drainage areas between winter and summer flows, and other factors can be evaluated. In addition, this type of monitoring has not been carried out previously in British Columbia. As a result, sampling problems, analytical techniques, and interpretation of the data all have to be perfected before any definitive statements can be made about the meaning of the information accumulated. Appendix 7 has a brief description of the analytical techniques used.

Because the program is not complete, no interpretation of the data is possible. The test results have been forwarded for the information of the local Public Health officials who are cooperating in this study by collecting the samples. When the study is completed, the information and the interpretation will be published.

Table 7.1 summarizes water quality data for the first 5 months (February to June) of a planned 12-month monitoring program. The values for uranium concentration, conductivity, and pH represent averages of five separate monthly samples (with some exceptions). Gross alpha (α) and beta (β) particle activities are indicated as the total range measured to date. Tables 7.2 to 7.7 give the results for individual months from February to July, inclusive. The variable results for some sample sites show the need for sampling over an extended period of time prior to making any interpretations.

The five areas of investigation are shown as shaded areas on the map (Fig. 7.1) In each area several samples are collected including composite samples taken in private residences. These locations are included on the accompanying maps (Figs. 7.2 to 7.4). Because of limited funding, 11 of the 31 samples will be analysed in government laboratories beginning with the samples collected in June. In addition, $2 300 in supplemental funding will be spent by this Ministry to maintain the current program at its present level.

In summary, the Ministry of Health and the Ministry of Energy, Mines and Petroleum Resources are cooperating in investigating five watersheds to determine temporal variations in the natural uranium concentration and the natural radioactivity. A quarterly resume of accumulated results will be given to the Commission and upon completion of this study the final report will be available to all interested parties.

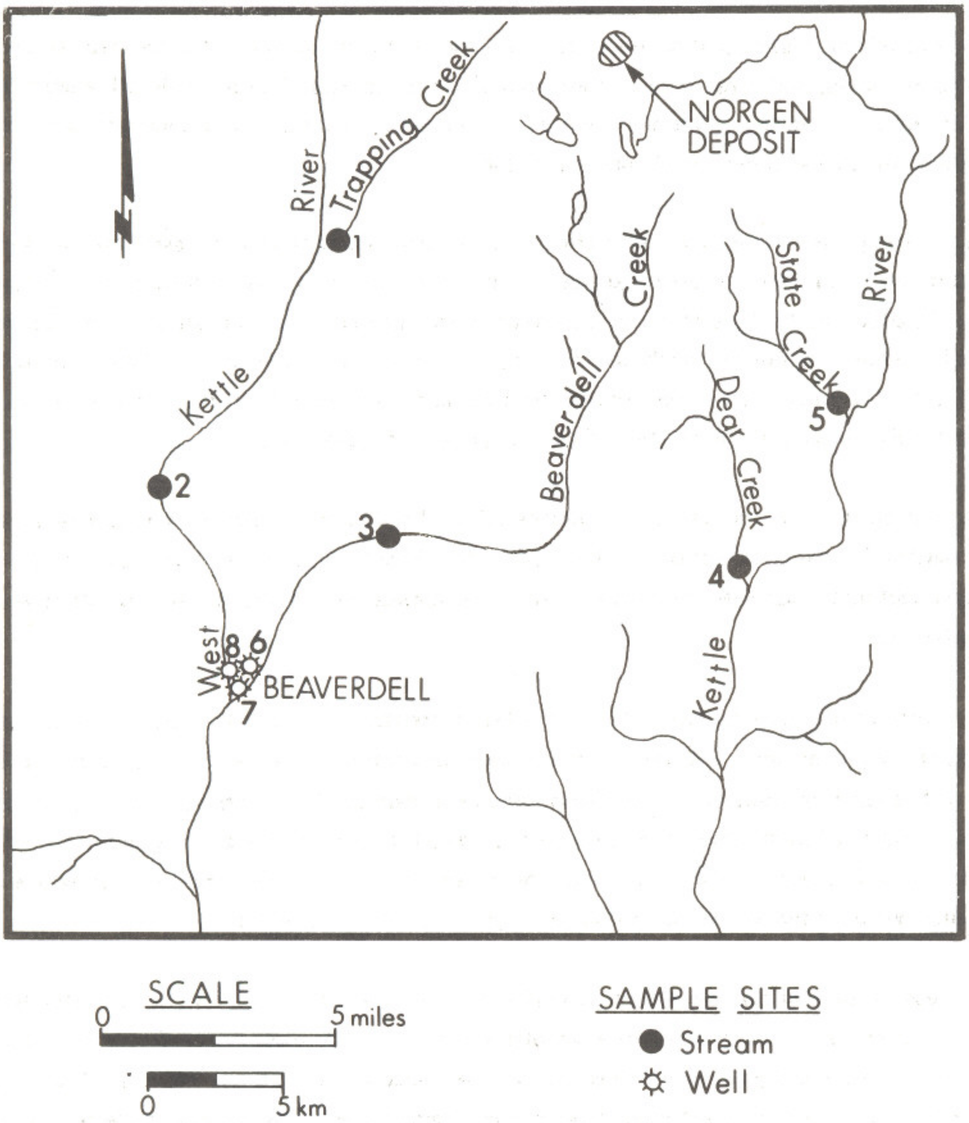


FIGURE 7.2. BEAVERDELL AREA.

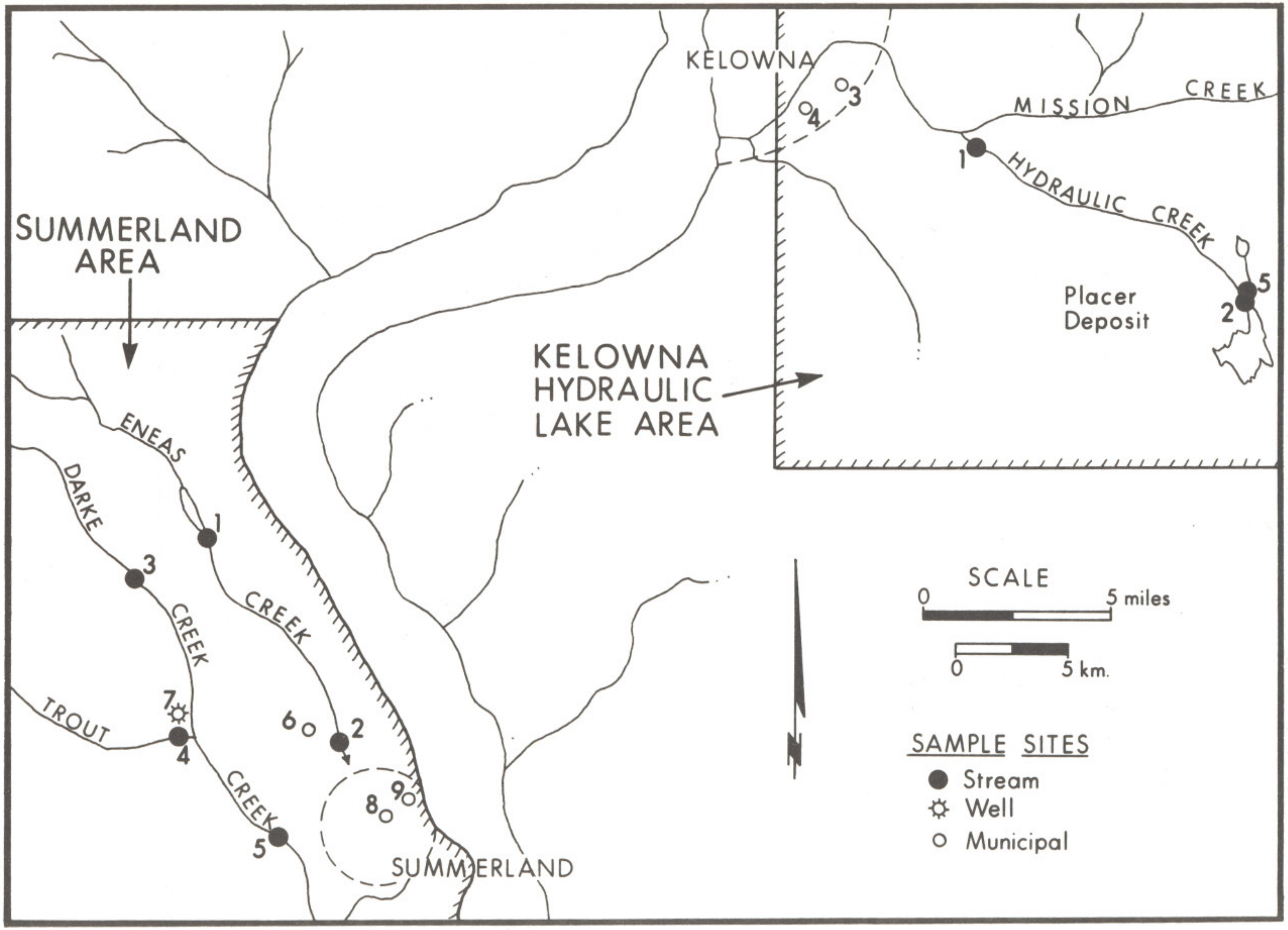


FIGURE 7.4. KELOWNA–HYDRAULIC LAKE AND SUMMERLAND AREAS.

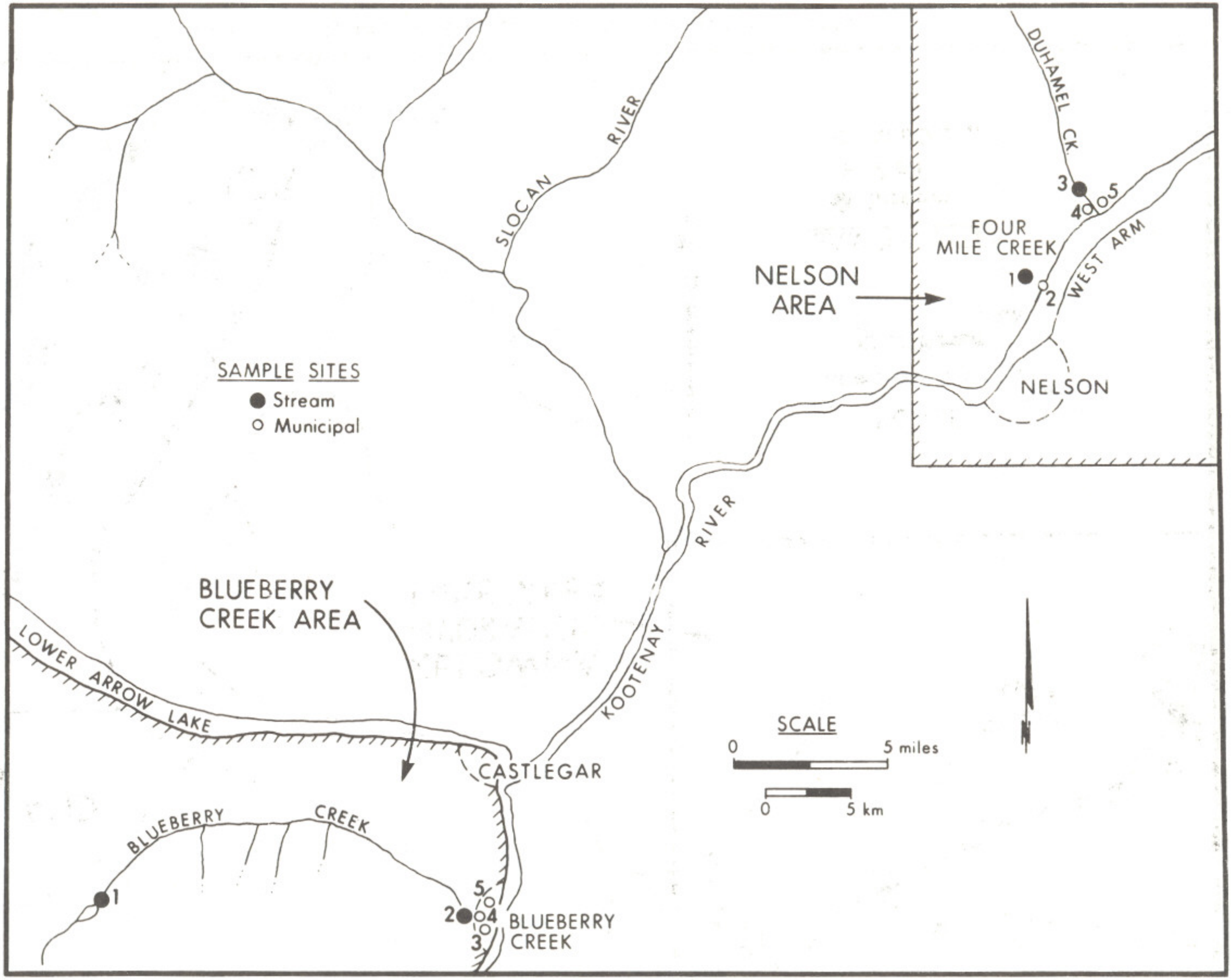


FIGURE 7.3. BLUEBERRY CREEK AND NELSON AREAS.

TABLE 7.1. SUMMARY OF WATER QUALITY DATA (FEBRUARY TO JUNE 1979)

Area	Site No.	Description	Gross α pCi/l	Gross β pCi/l	Uranium ppb	Conductivity @ 25° C μmhos/cm	pH
Beaverdell	1	Trapping Creek	1– 2±1	<3– 6±3	0.7	85	7.0
(BR)	2†	West Kettle River	<1– 1±1	<3– 4±3	1.0	65	7.2
	3	Beaverdell Creek	<1	<3– 3±3	1.3	165	7.6
	4	Dear Creek	<1	<3– 5±3	0.6	140	7.7
	5	State Creek	<1	<3– 3±3	1.0	150	7.7
	6	Beaverdell Ranger Station	1– 4±2	<3– 8±3	5.5	370	7.4
	7†	Tamarack Lodge	<1– 2±2	3– 8±3	8	380	7.3
	8†	Beaverdell Home	3– 4±2	<3– 5±3	7	415	8.0
Blueberry Creek	1†	Blueberry Creek at lake	<1	<3– 3±3	0.1	85	7.2
(BC)	2	Blueberry Creek at intake	<1	<3– 3±3	0.2	90	7.4
	3†	Blueberry Creek Home	<1	<3– 4±3	0.2	90	7.3
	4	Blueberry Creek Home	<1	<3– 4±3	0.2	85	7.3
	5†	Blueberry Creek Home	<1	<3– 4±3	0.3	90	7.3
Kelowna	1	Hydraulic Creek at intake	<1	<3– 7±3	0.5	100	6.8
(KL)	2	Hydraulic Lake Spillway	<1	<3– 5±3	0.4	65	6.4
	3	S.E.K.I.D. Office	<1	<3– 5±3	0.5	115	6.9
	4†	Kelowna Home	<1	<3– 4±3	0.5	130	7.0
	5†	Fish Creek	<1	<3– 4±3	0.3	60	6.7
Nelson	1†	Four Mile Creek	1–20±3	<3–12±3	13.2	75	7.6
(NL)	2	Four Mile Creek Home	<1–19±3	<3–11±3	11.9*	75	7.5
	3†	Duhamel Creek	<1– 2±1	<3– 3±3	1.8	70	7.6
	4	MacDonald Landing School	<1– 2±1	<3	1.5	65	7.5
	5†	MacDonald Landing Home	<1– 1±1	<3– 4±3	1.8	70	7.6
Summerland	1	Garnet Lake Spillway	3– 7±2	5–10±3	10.7	360	7.7
(SU)	2	Eneas Creek	6–12±3	6–15±6	21.0	500	7.9
	3	Darke Creek	3– 7±2	3–10±3	11.3	265	7.7
	4	Trout Creek	<1– 2±1	<3– 5±3	3.0	145	7.5
	5	Trout Creek at intake	<1– 2±1	<3– 5±3	3.2	125	7.4
	6	Well, Eneas Creek	6–12±4	10–15±7	21.1	610	7.2
	7	Well, Darke Creek	5–12±3	6–10±3	19.7	360	7.5
	8	S.O.H.U. Office	<1– 1±1	<3– 8±3	2.9	130	7.2
	9†	Summerland Home	<1– 2±1	<3– 7±3	3.4	165	7.1

* Range of 43 to 1.25.

† Sites no longer analysed by Chemex so no data for June.

TABLE 7.2. WATER QUALITY DATA (FEBRUARY 1979)

Area	Site No.	Description	Gross α pCi/l	Gross β pCi/l	Uranium ppb	Conductivity @ 25° C μmhos/cm	pH
Beaverdell	1	Trapping Creek	1±1	6±3	1.00	185	7.6
(BR)	2	West Kettle River	------	------	------	------	------
	3	Beaverdell Creek	<1	<3	2.3	250	7.5
	4	Dear Creek	<1	<3	1.9	------	------
	5	State Creek	------	------	------	------	------
	6	Beaverdell Ranger Station	1±1	8±3	2.0	240	7.9
	7	Tamarack Lodge	------	------	------	------	------
Blueberry Creek	1	Blueberry Creek at lake	<1	<3	0.20	91	7.5
(BC)	2	Blueberry Creek at intake	<1	<3	0.15	116	7.2
	3	Blueberry Creek Home	<1 (1±1)	<3 (5±3)	0.25 (0.30)	116 (117)	7.1 (7.1)
	4	Blueberry Creek Home	<1	4±3	0.25	110	7.3
	5	Blueberry Creek Home	<1	4±3	0.70	110	7.1
Kelowna	1	Hydraulic Creek at intake	<1	7±3	0.30	------	------
(HL or KL)	2	Hydraulic Lake Spillway	<1	5±3	0.30	------	------
	3	S.E.K.I.D. Office	<1 (<1)	<3 (<3)	0.30 (0.30)	(155)	(7.7)
	4	Kelowna Home	<1 (<1)	<3 (4±3)	0.30 (0.30)	------	------
	5	Fish Creek	<1	<3	0.10	------	------
Nelson	1	Four Mile Creek	20±3	12±3	41.0	107	7.6
(NL)	2	Four Mile Creek Home	19±2 (16±2)	11±3 (17±3)	43.0 (40.0)	105 (112)	7.6 (7.5)
	3	Duhamel Creek	2±1	<3	2.8	77	7.6
	4	MacDonald Landing School	2±1	<3	2.4	79	7.6
	5	MacDonald Landing Home	1±1 (<1)	4±3 (3±3)	2.6 (2.7)	77 (87)	7.5 (7.4)
Summerland	1	Garnet Lake Spillway	4±2	7±3	11.1	360	7.4
(SU)	2	Eneas Creek	6±3	7±4	22.0	480	7.9
	3	Darke Creek	7±2	3±3	13.4	300	7.9
	4	Trout Creek	1	<3	3.9	270	7.8
	5	Trout Creek at intake	1±1	<3	3.9	170	7.6
	6	Well, Eneas Creek	10±4	10±6	23.0	600	7.1
	7	Well, Darke Creek	9±3	6±3	14.5	340	7.5
	8	S.O.H.U. Office	<1 (1±1)	8±3 (5±3)	3.7 (3.3)	170 (163)	7.2 (7.5)
	9	Summerland Home	2±1	7±3	3.6	170	7.1

NOTE: Values in brackets are for composite samples.

TABLE 7.3. WATER QUALITY DATA
(MARCH 1979)

Area	Site No.	Description	Gross α pCi/l	Gross β pCi/l	Uranium ppb	Conductivity @ 25° C μmhos/cm	pH
Beaverdell (BR)	1	Trapping Creek	<1	<3	1.3	85	7.4
	2	West Kettle River	<1	<3	1.7	85	7.1
	3	Beaverdell Creek	<1	<3	1.7	175	7.9
	4	Dear Creek	<1	<3	1.0	180	8.0
	5	State Creek	<1	<3	0.9	150	8.0
	6	Beaverdell Ranger Station	4±2	5±3	9.2	400	7.2
	7	Tamarack Lodge	2±2	3±3	10.0	380	7.2
	8	Beaverdell Home	(4±3)	(5±3)	(10.0)	(410)	(8.0)
Blueberry Creek (BC)	1	Blueberry Creek at lake	<1	<3	0.10	90	6.8
	2	Blueberry Creek at intake	<1	<3	0.20	110	7.4
	3	Blueberry Creek Home	<1	<3	0.20	110	7.4
	4	Blueberry Creek Home	<1	<3	0.15	115	7.2
	5	Blueberry Creek Home	<1	<3	0.15	115	7.1
Kelowna (KL)	1	Hydraulic Creek at intake	<1	3±3	0.35	160	7.2
	2	Hydraulic Lake Spillway	<1	4±3	0.45	60	6.2
	3	S.E.K.I.D. Office	<1	<3	0.80 (0.1)	160 (144)	7.1 (7.6)
	4	Kelowna Home	<1	4±3	0.90 (0.1)	175 (152)	7.5 (8.0)
	5	Fish Creek	<1	4±3	0.65	65	6.8
Nelson (NL)	1	Four Mile Creek	3±1	4±3	7.0	70	7.7
	2	Four Mile Creek Home	5±1	6±3	7.2	70	7.5
	3	Duhamel Creek	<1	3±3	2.6	75	7.6
	4	MacDonald Landing School	<1	<3	2.6	80	7.7
	5	MacDonald Landing Home	<1	3±3	2.6	80	7.9
Summerland (SU)	1	Garnet Lake Spillway	5±2	8±3	14.2	370	7.7
	2	Eneas Creek	8±3	12±4	27.0	470	8.1
	3	Darke Creek	4±1	6±3	15.6	300	8.0
	4	Trout Creek	2±1	<3	5.9	150	7.9
	5	Trout Creek at intake	1±1	3±3	6.7	150	7.7
	6	Well, Eneas Creek	6±4	15±6	25.0	600	7.2
	7	Well, Darke Creek	5±2	9±3	26.0	350	7.6
	8	S.O.H.U. Office	1±1	6±3	5.1	155	7.4
	9	Summerland Home	<1	<3	5.0	160	7.1

NOTE: Values in brackets are for composite samples.

TABLE 7.4. WATER QUALITY DATA
(APRIL 1979)

Area	Site No.	Description	Gross α pCi/l	Gross β pCi/l	Uranium ppb	Conductivity @ 25° C μmhos/cm	pH
Beaverdell (BR)	1	Trapping Creek	2±1	5±3	0.75	80	7.3
	2	West Kettle River	1±1	4±3	0.75	75	7.6
	3	Beaverdell Creek	<1	<3	1.00	115	7.8
	4	Dear Creek	<1	5±3	0.95	115	7.8
	5	State Creek	------	------	------	------	------
	6	Beaverdell Ranger Station	2±1	5±3	6.0	390	7.3
	7	Tamarack Lodge	<1	8±3	5.9	380	7.4
	8	Beaverdell Home	------	------	(8.2)	(410)	(8.0)
Blueberry Creek (BC)	1	Blueberry Creek at lake	<1	3±3	0.15	95	6.9
	2	Blueberry Creek at intake	<1	3±3	0.25	90	7.4
	3	Blueberry Creek Home	<1	4±3	0.20	90	7.2
	4	Blueberry Creek Home	<1	4±3	0.35	95	7.1
	5	Blueberry Creek Home	<1	3±3	0.25	90	7.2
Kelowna (KL)	1	Hydraulic Creek at intake	<1	3±3	0.45	120	6.9
	2	Hydraulic Lake Spillway	<1	<3	0.25	130	6.5
	3	S.E.K.I.D. Office	<1	5±3	0.55 (0.30)	150	6.7
	4	Kelowna Home	<1	<3	0.55 (0.30)	150	6.7
	5	Fish Creek	<1	3±3	0.40	55	6.3
Nelson (NL)	1	Four Mile Creek	2±1	3±3	3.8	65	7.5
	2	Four Mile Creek Home	2±1	3±3	3.8	65	7.3
	3	Duhamel Creek	1±1	3±3	1.5	70	7.5
	4	MacDonald Landing School	1±1	<3	1.6	70	7.5
	5	MacDonald Landing Home	1±1	<3	1.6	70	7.5
Summerland (SU)	1	Garnet Lake Spillway	3±2	8±3	11.1	360	7.3
	2	Eneas Creek	9±3	8±3	22.0	470	7.7
	3	Darke Creek	2±2	6±3	12.7	300	7.5
	4	Trout Creek	1±1	<3	4.3	160	7.2
	5	Trout Creek at intake	2±1	5±3	3.9	160	7.2
	6	Well, Eneas Creek	12±2	17±3	24.0	620	6.9
	7	Well, Darke Creek	5±2	8±3	20.0	380	7.1
	8	S.O.H.U. Office	<1	5±3	4.6	160	7.0
	9	Summerland Home	1±1	<3	4.3	160	7.0

NOTE: Values in brackets are for composite samples.

TABLE 7.5. WATER QUALITY DATA (MAY 1979)

Area	Site No.	Description	Gross α pCi/l	Gross β pCi/l	Uranium ppb	Conductivity @ 25° C µmhos/cm	pH
Beaverdell (BR)	1	Trapping Creek	1±1	<3	0.15	30	6.9
	2	West Kettle River	<1	4±3	0.45	35	7.0
	3	Beaverdell Creek	<1	3±3	0.35	115	7.7
	4	Dear Creek	<1	<3	0.25	130	8.0
	5	State Creek	<1	<3	0.30	115	8.0
	6	Beaverdell Ranger Station	3±2 (<1)	<3 (<3)	3.5 (5.0)	400 (410)	8.1 (8.0)
	7*	Tamarack Lodge	------	------	------	------	------
	8	Beaverdell Home	3±2 (6±2)	<3 (6±4)	2.9 (3.5)	420 (410)	8.0 (8.4)
Blueberry Creek (BC)	1	Blueberry Creek at lake	<1	<3	0.05	65	7.8
	2	Blueberry Creek at intake	<1	<3	0.20	65	7.8
	3	Blueberry Creek Home	<1	<3	0.20	50	7.6
	4	Blueberry Creek Home	<1	<3	0.20	55	7.8
	5	Blueberry Creek Home	<1	3±3	0.20	50	7.7
Kelowna (KL)	1	Hydraulic Creek at intake	<1	<3	0.50	65	6.8
	2	Hydraulic Lake Spillway	<1	<3	0.45	35	6.7
	3	S.E.K.I.D. Office	<1	<3	0.45 (0.50)	65 (65)	6.9 (7.7)
	4	Kelowna Home	<1	3±3	0.20 (0.40)	65 (65)	6.7 (7.7)
	5	Fish Creek	<1	<3	0.15	55	7.0
Nelson (NL)	1	Four Mile Creek	1±1	<3	1.20	65	7.8
	2	Four Mile Creek Home	<1	<3	1.25 (1.35)	65 (50)	7.8 (7.7)
	3	Duhamel Creek	<1	<3	0.45	50	7.6
	4	MacDonald Landing School	<1	<3	0.36	55	7.8
	5	MacDonald Landing Home	<1	<3	0.50	50	7.7
Summerland (SU)	1	Garnet Lake Spillway	6±3	5±3	9.4	360	7.8
	2	Eneas Creek	10±4	6±6	17.3	540	7.8
	3	Darke Creek	3±1	6±3	6.0	200	7.5
	4	Trout Creek	1±1	5±3	0.25	60	7.1
	5	Trout Creek at intake	<1	3±3	0.55	60	7.0
	6	Well, Eneas Creek	6±4	<3	14.4	640	7.5
	7	Well, Darke Creek	6±2	10±3	20.5	370	7.6
	8	S.O.H.U. Office	<1	<3	0.55 (1.20)	70 (75)	6.9 (7.8)
	9	Summerland Home	1±1	<3	0.70	70	7.0

* Site BR–7 dropped beginning in May 1979.

NOTE: Values in brackets are for composite samples.

TABLE 7.6. WATER QUALITY
(JUNE 1979)

Area	Site No.	Description	Gross α pCi/l	Gross β pCi/l	Uranium ppb	Conductivity @ 25° C μmhos/cm	pH
Beaverdell	1	Trapping Creek	<1	<3	0.40	40	5.9
(BR)	2*	West Kettle River	-----	-----	-----	-----	-----
	3	Beaverdell Creek	<1	3±3	1.30	180	7.1
	4	Dear Creek	<1	<3	0.40	160	7.0
	5	State Creek	<1	3±3	0.60	165	7.0
	6	Beaverdell Ranger Station	3±2	3±3	6.8	410	6.4
	7*	Tamarack Lodge	-----	-----	-----	-----	-----
	8*	Beaverdell Home	-----	-----	-----	-----	-----
Blueberry Creek	1*	Blueberry Creek at lake	-----	-----	-----	-----	-----
(BC)	2	Blueberry Creek at intake	<1	<3	0.20	60	7.3
	3*	Blueberry Creek Home	-----	-----	-----	-----	-----
	4	Blueberry Creek Home	<1	<3	0.15	60	7.2
	5*	Blueberry Creek Home	-----	-----	-----	-----	-----
Kelowna	1	Hydraulic Creek at intake	<1	<3	0.70	50	6.4
(KL)	2	Hydraulic Lake Spillway	<1	4±3	0.65	35	6.1
	3	S.E.K.I.D. Office	<1	5±3	0.60	50	6.3
	4*	Kelowna Home	-----	-----	-----	-----	-----
	5*	Fish Creek	-----	-----	-----	-----	-----
Nelson	1*	Four Mile Creek	-----	-----	-----	-----	-----
(NL)	2	Four Mile Creek Home	2±1	4±3	4.1	80	7.1
	3*	Duhamel Creek	-----	-----	-----	-----	-----
	4	MacDonald Landing School	<1	<3	0.60	50	6.7
	5*	MacDonald Landing Home	-----	-----	-----	-----	-----
Summerland	1	Garnet Lake Spillway	7±2	10±3	7.8	355	8.1
(SU)	2	Eneas Creek	12±4	15±6	16.9	550	7.9
	3	Darke Creek	5±2	10±3	8.7	220	7.8
	4	Trout Creek	<1	<3	0.55	90	7.7
	5	Trout Creek at intake	<1	3±3	0.70	90	7.7
	6	Well, Eneas Creek	12±4	12±7	19.2	590	7.4
	7	Well, Darke Creek	12±3	9±3	17.3	370	7.6
	8	S.O.H.U. Office	<1	3±3	0.55	85	7.3
	9*	Summerland Home	-----	-----	-----	-----	-----

* Sites no longer analysed by Chemex.

TABLE 7.7. WATER QUALITY
(JULY 1979)

Area	Site No.	Description	Gross α pCi/l	Gross β pCi/l	Uranium ppb	Conductivity @ 25° C μmhos/cm	pH
Beaverdell (BR)	1	Trapping Creek	<1	<3	0.40	50	7.5
	2*	West Kettle River	-----	-----	-----	-----	-----
	3	Beaverdell Creek	<1	3±3	1.3	230	8.1
	4	State Creek	<1	<3	0.60	175	8.0
	5	Dear Creek	<1	3±3	0.70	195	8.1
	6	Beaverdell Ranger Station	4±2	3±3	5.1	420	7.2
	7*	Tamarack Lodge	-----	-----	-----	-----	-----
	8*	Beaverdell Home	-----	-----	-----	-----	-----
Blueberry Creek (BC)	1*	Blueberry Creek at lake	-----	-----	-----	-----	-----
	2†	Blueberry Creek at intake	-----	-----	-----	-----	-----
	3*	Blueberry Creek Home	-----	-----	-----	-----	-----
	4	Blueberry Creek Home	2±1	6±3	0.30	85	7.5
	5*†	Blueberry Creek Home	-----	-----	-----	-----	-----
Kelowna (KL)	1	Hydraulic Creek at intake	<1	<3	0.60	45	6.6
	2	Hydraulic Lake Spillway	<1	<3	0.45	35	6.1
	3	S.E.K.I.D. Office	<1	<3	0.55	45	6.2
	4*	Kelowna Home	-----	-----	-----	-----	-----
	5*	Fish Creek	-----	-----	-----	-----	-----
Nelson (NL)	1*	Four Mile Creek	-----	-----	-----	-----	-----
	2	Four Mile Creek Home	5±1	5±3	6.2	95	7.3
	3*	Duhamel Creek	-----	-----	-----	-----	-----
	4	MacDonald Landing School	<1	<3	1.0	70	7.2
	5*	MacDonald Landing Home	-----	-----	-----	-----	-----
Summerland (SU)	1	Garnet Lake Spillway	4±2	4±3	7.1	350	8.1
	2	Eneas Creek	11±4	6±6	16.2	580	8.1
	3	Darke Creek	1±1	8±3	2.2	170	7.8
	4	Trout Creek	1±1	<3	0.90	110	8.0
	5	Trout Creek at intake	<1	3±3	0.85	110	7.9
	6	Well, Eneas Creek	11±4	11±6	16.2	590	7.6
	7	Well, Darke Creek	13±3	12±3	14.4	370	7.8
	8	S.O.H.U. Office	<1	<3	0.85	115	7.6
	9*	Summerland Home	-----	-----	-----	-----	-----

* Dropped sites.

† Samples not received from these sites for July.

NOTE: Values in brackets are for composite samples.

REFERENCES

GENERAL

Kimberley, M. M. (Ed.) (1978): Uranium Deposits, Their Mineralogy and Origin, *Min. Assoc. Canada,* Short Course Handbook No. 3.

Wederpohl, K. H. (Ed.) (1969): Handbook of Geochemistry, *Springer-Verlag,* Berlin.

SECTION I

Annual Reports, *Minister of Mines & Pet. Res.,* B.C.

James, G. L. (1979): B.C. Mineral Exploration Information: Resource Branch has a Wealth of Data, *Western Miner,* Vol. 52, No. 7, pp. 15-22.

SECTION II

Douglas, R.J.W. (Ed.) (1970): Geology and Economic Minerals of Canada, *Geol. Surv., Canada,* Economic Geology Report No. 1.

Monger, J.W.H., Souther, J. G., and Gabrielse, H. (1972): Evolution of the Canadian Cordillera: A Plate Tectonic Model, *Amer. Jour. Sc.,* Vol. 272, pp. 577-602.

Sinclair, A. J., Wynne-Edwards, H. R., and Sutherland Brown, A. (1978): An Analysis of Distribution of Mineral Occurrences in British Columbia, *B.C. Ministry of Mines & Pet. Res.,* Bull. 68.

Sutherland Brown, A. (1969): Mineralization in British Columbia and Copper and Molybdenum Deposits, *CIM,* Trans., Vol. 72, pp. 1-15.

.... (1974): Aspects of Metal Abundances and Mineral Deposits in the Canadian Cordillera, *CIM,* Trans., Vol. 77, pp. 14-21.

Sutherland Brown, A., Cathro, R. J., Panteleyev, A., and Ney C. S. (1971): Metallogeny of the Canadian Cordillera, *CIM,* Trans., Vol. 74, pp. 121-145.

Wheeler, J. O. and Gabrielse, H. (1972): The Cordilleran Structural Province, *in* Variations in Tectonic Styles in Canada, *Geol. Assoc. Canada,* Special Paper No. 11, pp. 1-81.

SECTION III

Annual Reports, *Minister of Mines & Pet. Res., B.C.,* to 1968.

SECTION IV

Geology, Exploration, and Mining in British Columbia, *B.C. Ministry of Mines & Pet. Res.,* 1969 to 1978.

SECTION V

Boyle, D. R. (1979): The Dispersion of Uranium in the Vicinity of Miocene 'Basal Type' Uranium Occurrences in Lassie Lake Area, *Geol. Surv., Canada,* Current Research, Paper 79–1A, pp. 349-356.

Christopher, P. A. (1976): Radioactive Occurrences in British Columbia, *B.C. Ministry of Energy, Mines & Pet. Res.,* Preliminary Map No. 22.

.... (1978): Geology of the East Okanagan Uranium Area, *B.C. Ministry of Energy, Mines & Pet. Res.,* Preliminary Map No. 29.

Christopher, P. A. and Ballantyne, S. B. (1976): Recent Developments in Uranium Exploration in British Columbia, *CIM,* Bull., Vol. 69, No. 773, p. 70 (abstract).

Christopher, P. A. and Kalnins, T. (1977): Exploration for Basal Type Uranium Deposits in British Columbia, *Western Miner,* Vol. 98, pp. 75-79.

Church, B. N. (1979): Tertiary Stratigraphy and Resource Potential in South-Central British Columbia, *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork 1978, pp. 7-15.

Church, B. N. and Johnson, W. M. (1978): Uranium and Thorium in Tertiary Alkaline Volcanic Rocks in South-Central British Columbia, *Western Miner*, May 1978, pp. 33, 34.

Eakins, G. R. and Forbes, R. B. (1976): Investigation of Alaska's Uranium Potential, *Alaska Dept. of Nat. Res.,* Rept. 12, p. 311.

Energy, Mines and Resources Canada (1979): 1978 Assessment of Uranium Supply and Demand, Report EP 79–3, June 1979.

Gabelman, J. W. (1977): Migration of Uranium and Thorium – Exploration Significance, *Amer. Assoc. Petrol. Geol.,* Studies in Geology No. 3.

Little, H. W. (1957): Geology of Kettle River (East Half), *Geol. Surv., Canada,*

.... (1960): Nelson Map-Area (West Half), British Columbia, *Geol. Surv., Canada,* Memoir 308.

.... (1961): Geology of Kettle River (West Half), *Geol. Surv., Canada,* Map 15–1961.

McMillan, R. H. (1978): Genetic Aspects and Classification of Important Canadian Uranium Deposits, *CIM,* Bull., Vol. 71, No. 800, pp. 61-67.

Milne, P. C. (1979): Uranium in Washington State, *CIM,* Bull., Vol. 72, No. 804, pp. 95-101.

Nash, J. T. and Lehrman, N. J. (1975): Geology of the Midnite Mine, Stevens County, Washington: A Preliminary Report, *USGS,* Open File Report 75–402, 36 pp.

Ninineer, R. D. (Symposium Chairman) (1974): Formation of Uranium Ore Deposits, *Inter-Atomic Energy Agency,* Vienna.

Nuclear Energy Agency/International Atomic Energy Agency (1979): Uranium Resources, Production and Demand, *OECD,* Paris.

Preto, V. A. (1978): Setting and Genesis of Uranium Mineralization at Rexspar, *CIM,* Bull., Vol. 71, No. 800, pp. 82-88.

Robbins, David A. (1976): The Sherwood Uranium Deposit, *AIME,* unpublished report presented at meeting, May 1976, Spokane, Washington, 17 pp.

.... (1978): Applied Geology in the Discovery of the Spokane Mountain Uranium Deposit, Washington, *Economic Geology,* Vol. 73, pp. 1523-1538.

Ruzicka, V. (1976): Potential for Uranium Discoveries in the World, *Atomforum,* Geneva.

.... (1977): Conceptual Models for Uranium Deposits and Areas Favourable for Uranium Mineralization in Canada, *Geol. Surv., Canada,* Paper 77–1A, pp. 17-25.

See also *General References.*

SECTION VI

Accelerated Geochemical Surveys (1978): Sample location maps, data listings, and statistical summaries, *B.C. Ministry of Energy, Mines & Pet. Res.,* NTS areas 93 I, J, O, and P.

Ballantyne, S. B. (1976): Geochemical Orientation Surveys for Uranium in Southern British Columbia, *Geol. Surv., Canada,* Open File 341.

Boyle, D. R. (1979): The Dispersion of Uranium in the Vicinity of Miocene 'Basal Type' Uranium Occurrences in Lassie Lake Area, *Geol. Surv., Canada,* Current Research, Paper 79–1A, pp. 349-356.

Dyck, W. (1978): The Mobility and Concentration of Uranium and its Decay Products in Temperate Surficial Environments, *Min. Assoc. Canada,* Short Course Handbook No. 3, pp. 37-100.

Fix, P. F. (1956): Hydrogeochemical Exploration for Uranium, *USGS,* Professional Paper 30, 667.

Langmuir (1978): Uranium Solution Mineral Equilibria at Low Temperatures with Applications to Sedimentary Ore Deposits, *Min. Assoc. Canada,* Short Course Handbook No. 3, pp. 17-36.

Uranium Reconnaissance Program (1977–1979): Sample location maps, element value or range maps, data listings, and statistical summaries, *Geol. Surv., Canada* and *B.C. Ministry of Energy, Mines & Pet. Res.,* NTS areas 82 E, F, K, L, and M and 104 N, O, and P.

Wederpohl, K. H. (Ed.) (1969): Uranium *in* Handbook of Geochemistry, Vol. II, pp. 92A to O, *Springer-Verlag,* Berlin.

APPENDICES

APPENDIX 4–1. URANIUM EXPLORATION ON MINERAL CLAIMS, 1969 – 1978

NTS 82E

PROPERTY NAME	LOCATION (NTS)	COMPANY	NUMBER OF CLAIMS (UNITS)	TYPE	GEOLOGY	GEOCHEMISTRY	GEOPHYSICS	TRENCHING	DRILLING
JO	82E/1W	Chinook Construction & Engineering Ltd.	20 (1977) 20 (1978)	pegmatite		soil	scintillometer		
SD	82E/1W	Boundary Exploration Ltd. (1970)	36 (1970)	pegmatite	X	rock; soil	radiometric, 2 500 km; scintillometer	X	percussion, 630 m
		Chinook Construction & Engineering Ltd. (1975)	28 (1975)						
		Cassiar Asbestos (1977, 1978)	22 (1976) 207 (1977)						
MIDWAY	82E/2W	E&B Explorations Ltd.	40 (1977)	volcanic	X	stream sediment; soil	radiometric		
ROB	82E/2W	J. S. Hilton	8 (1977)	volcanic	X		scintillometer		
JADO	82E/2W	Wespas Resources Ltd.	29 (1977)	volcanic	X	soil	scintillometer		
XUL	82E/2W	Mascot Mines & Petroleums	15 (1977)	volcanic			gamma ray spectrometer		
GREEN	82E/2W	E&B Explorations Ltd.	20 (1977) 185 (1978)	volcanic	X	soil; stream sediment	scintillometer		
WEST	82E/2W	E&B Explorations Ltd.	20 (1977)	volcanic	X	soil; stream sediment	radiometric		
DOLO	82E/2W	New Dolomite White Mining Ltd. (1970)		Mg, W, Th in dolomite				X	
BM, BD	82E/3E	BP Minerals Ltd.	22 (1977)	volcanic	X	soil; silt	scintillometer		
R	82E/4E	British Newfoundland Exploration Ltd.	11 (1977)				gamma ray spectrometer		
POLVO	82E/4E	British Newfoundland Exploration Ltd.	123 (1977) and 8 Crown grants (1978)		X	soil	scintillometer		
ASTRO	82E/4, 5	Pacific Petroleums Ltd.	744 (1977) 900 (1978)	volcanic	X	water; stream sediment; rock	magnetometer; scintillometer; induced polarization		diamond, 1 571 m
TWIN	82E/5	Union Oil Co. of Canada Ltd.	75 (1977) 31 (1978)	sandstone	X	soil; silt	scintillometer; induced polarization		

KER	82E/5W	Union Oil Co. of Canada Ltd.	38 (1977)	sandstone	X	soil; silt; rock	scintillometer		
OLALLA	82E/5W	British Newfoundland Exploration Ltd.		volcanic			radiometric		
CLARK	82E/5W	Canadian Occidental Petroleum Ltd.	143 (1978)	sandstone ?	X	rock; water; silt; soil	scintillometer		
PLEX	82E/6W	E&B Explorations Ltd.	40 (1978)		X	soil; silt	radiometric		
HEIDI	82E/6E	Union Carbide Exploration Corp.	53 (1977)	sandstone	X	rock; silt			
SCINT	82E/6E	Lion Mines Ltd.	11	basal	X		radiometric		
JP	82E/7E, 1W, 2E, 8W	Getty Mining Pacific Ltd.	202	basal	X	soil; rock	scintillometer, 37 km		
HC	82E/8W	Long Lac Mineral Explorations Ltd.	80 (1978)			soil; silt; rock	scintillometer; electromagnetic		
DELL	82E/10W	Peregrine Petroleums Ltd.	282 (1977)	basal	X	silt; water	induced polarization; airborne spectrometer; electromagnetic		diamond, 54.8 m
AT	82E/10W	Wespas Resources Ltd.	20 (1977)	basal	X	soil	scintillometer		
FUKI, DONEN	82E/10W	PNC Exploration (Canada) Co. Ltd. (1969, 1970, 1971, 1972, 1973, 1976, 1977)	320 (1969) 175 (1973)	basal	X		scintillometer	X	diamond, 5 337 m
BLIZZARD	82E/10W	Lacana Mining Corp. (1976)	63 (1976)	basal	X	radon gas; soil	scintillometer		percussion, 750 m
		Norcen Energy Resources Ltd. (1977, 1978)							diamond and rotary, 19 561 m
BEAVER	82E/10W	Darva Resources & Development Ltd.	38 (1977)	basal	X		scintillometer		overburden, 59.8 m
DEAN	82E/10W	Seatu Explorations Ltd.	28 (1978)	basal		soil			
CUP 2	82E/10W	E&B Explorations Ltd.	20 (1978)	basal	X	soil; silt; water	scintillometer		
BOX	82E/10W	Seatu Explorations Ltd.	70 (1978)			soil	gamma ray spectrometer; magnetometer		
SHORE, LAKE	82E/10W	Norcen Energy Resources Ltd.	35 (1978)	basal	X	soil; silt	gamma ray spectrometer		
HONEST	82E/10W, 11E	Du Pont of Canada Exploration Ltd.	13 (1977) 13 (1978)	basal	X				percussion, 238 m
TRAP	82E/10W, 11E	Lacana Mining Corp.	118 (1977) 118 (1978)	basal	X	water; silt	magnetometer		percussion, 1 050 m

JUNE	82E/10W, 11E	Du Pont of Canada Exploration Ltd.	22 (1977)		X				percussion, 608 m; diamond, 323 m
CAP, TAR	82E/10W, 11E	Norcen Energy Resources Ltd.	24 (1978)		X				
TAR	82E/10W, 11E	Norcen Energy Resources Ltd.	250 (1978)	basal	X				
FAULDER	82E/12	British Newfoundland Exploration Ltd.	169 (1977)	volcanic		soil; water; silt			
AGUR, ASH	82E/12W	British Newfoundland Exploration Ltd.	145 (1978)	volcanic	X	soil; silt; water	gamma ray spectrometer		7 diamond-drill holes
CM	82E/13E	Tyee Lake Resources (1976)	270 (1976)	basal					diamond, 530 m
ACTIVE	82E/13E	Mountain Minerals Ltd.	131 (1978)		X	soil; water	scintillometer		
PLUTO	82E/14W	Consolidated Silver Butte Mines Ltd.	20 (1977)				airborne radiometric; magnetometer		
KLO	82E/14W	Klondex Mines Ltd.	189 (1977)				airborne scintillometer; magnetometer		
KNIGHT	82E/14W	Kerr Addison Mines Ltd.	39 (1977)	basal			induced polarization		diamond, 712.3 m
WHO	82E/14W	Manny Consultants Ltd.	12 (1978)				scintillometer		
SCOTT	82E/14W	Lacana Mining Corp.	83 (1978)	basal					percussion, 300 m
ARK	82E/14E	Lacana Mining Corp.	53 (1978)	basal	X	soil	radiometric		
BAG	82E/14E	E&B Explorations Ltd.	18 (1978)	basal	X	soil	gamma ray spectrometer		2 diamond-drill holes
KETTLE	82E/14E	Tyee Lake Resources	165 (1977)	basal			induced polarization; resistivity		rotary, 4 522 m; diamond, 4 402 m
		Noranda Exploration Co. Ltd. (1977)							
		Placer Development Ltd. (1978)							
BASALT	82E/14E	Lacana Mining Corp.	456 (1977)	basal			scintillometer	X	percussion, 165 m
GOAT	82E/14E	Peregrine Petroleums Ltd.	138 (1976)	basal		stream sediment	airborne magnetometer; radiometric		diamond, 751.5 m
		(Noranda option, 1976, 1977)	119 (1978)				electromagnetic		
PB	82E/14E, 11E	PNC Exploration (Canada) Co. Ltd. (1973, 1974, 1976)	98 (1973) 165 (1974) 132 (1976)	basal	X		radiometric, 20 km; scintillometer		diamond, 2 203 m

DM	82E/15W	Union Carbide of Canada Ltd.	166 (1977)	basal	X	track etch; geobotanical			percussion, 908.3 m
BASIN	82E/15W	Canex Placer Ltd.	20 (1977)	basal					diamond, 971 m
GRAND DADDY	82E/15W	Lacana Mining Corp.	24 (1978)						percussion, 502.9 m

NTS 82F

TOP	82F/4	San Antonio Explorations Ltd.	16 (1978)		X	soil			
MOTA	82F/4E	China Creek Consortium (Manny Consultants Ltd.)	78 (1977)	pegmatite	X	radon survey	scintillometer	2 test pits	percussion, 52 holes totalling 1 150 m; diamond, 135 m
U_3O_8	82F/4E	P. Leontowicz	4 (1975, 1976, 1977)	pegmatite	X				30 m
ENERGY	82F/4E	Burlington Gold Mines Ltd.	40 (1978)	pegmatite	X	soil			percussion, 90 m
CC	82F/4E, 5E	Hans Buhr, Roy Carlson	40 (1978)	pegmatite	X			X	
LINDA	82F/4W	Sharp Exploration Syndicate	26 (1977)	pegmatite	X	silt; water; rock; soil	scintillometer		
		Lacana Mining Corp.	50 (1978)						
AC	82F/4W	Cherokee Development Ltd.	20 (1977)	?		soil	scintillometer		
DC	82F/4W	Kendal Mining & Exploration Co. Ltd.	20 (1977)	pegmatite			scintillometer	X	
SYNDICATE	82F/4W	F. Hastings	12 (1978)	pegmatite		soil	scintillometer		
ROMA	82F/5E	Roy Carlson	24 (1978)	pegmatite	X				
JACKASS	82F/5E	S. Paszty, A. Teretoff	75 (1978)	pegmatite			scintillometer		

NTS 82G

COMMERCE	82G/1W	Kintla Exploration Ltd.	88 (1976) 54 (1977) 54 (1978)	Precambrian sediments with Au, Ag, Cu		rock	scintillometer; radiometric		

VAN	82G/12E	E. J. Frost	1 (1977)	vein				X	

NTS 82K

ANNETTE, SLIDE	82K/9W	Canadian Johns-Manville (1970, 1971, 1972, 1973, 1976)	150 (1970) 119 (1972) 77 (1973) 6 (1976)	stockwork Mo, W	X	soil	scintillometer; induced polarization	X	16 m
SERENA	82K/9W	Chevron Standard Ltd.	12 (1977)	stockwork		soil; silt; rock	scintillometer		
TOBY (J)	82K/9W	Esso Minerals Canada Ltd.	16 (1978)			soil; silt; rock	airborne radiometric		
STAR	82K/9W, 10E	Chevron Standard Ltd.	18 (1977)	stockwork		soil; silt; rock	scintillometer		
ANNETTE 55	82K/10E	Cominco Ltd.	77 (1977) 77 (1978)	stockwork	X	silt; water; rock			

NTS 82L

GATE	82L/2E	Shell Canada Resources Ltd.	80 (1978)	basal	X	water; silt			rotary, 157.3 m
COAL	82L/2E	Union Oil Co. of Canada Ltd.	40 (1977) 44 (1978)	basal	X	water; rock	airborne magnetometer; airborne scintillometer		
SPAR	82L/2W	Able Explorations Ltd.	34 (1971)	pegmatite U, W			radiometric with ultra-violet lamp	X	
VAL	82L/2W	Chatham Resources Ltd. (1976)	40 (1976)	basal	X	soil; water	radiometric		diamond, 574.8 m; rotary, 181 m
		Kerr Addison Mines Ltd. (1977)	57 (1977)						
SUE	82L/2W	Union Carbide Canada Ltd.	154 (1977)	basal					percussion, 1 170.4 m
TAI	82L/2W	E&B Explorations Ltd.	108 (1977)	volcanic	X	soil	scintillometer		diamond, 291.1 m
CLIER	82L/2W	E&B Explorations Ltd.	94 (1977)		X	soil; silt; water; rock	scintillometer		
KING	82L/3	Kerr Addison Mines Ltd.	64 (1977)	basal	X				114.9 m

LEAL	82L/3	Union Carbide Canada Ltd.	112 (1977)	basal	X	track etch			percussion, 472.4 m
ROD	82L/3E	Kerr Addison Mines Ltd.	74 (1977)	basal	X	X	radiometric		
FISSION	82L/3E	Mattagami Lake Mines Ltd.	158 (1977)	basal	X	water; soil	magnetometer; induced polarization		diamond, 548 m
CRESCENT	82L/3E	Kerr Addison Mines Ltd.	59 (1977)	basal					diamond, 893 m
CHANNEL	82L/3E	Kerr Addison Mines Ltd. (1977) Banqwest Resources Ltd. (1978)	58 (1977)	basal		water; silt; soil			diamond, 709 m; rotary, 106 m
BURCHAN	82L/3E	Union Oil Co. of Canada Ltd.	18 (1978)	basal	X	soil; water	scintillometer		
OYAMA	82L/3E, 4E	Du Pont of Canada Exploration Ltd.	94 (1977)	basal	X				percussion, 137 m
REEF	82L/3W	Union Oil Co. of Canada Ltd.	100 (1977)	basal	X	rock; water; silt	scintillometer; airborne radiometric; airborne magnetometer		
ECHO	82L/3W	E&B Explorations Ltd.	67 (1978)	basal	X	silt; water; soil	scintillometer		
ESP	82L/4	Shell Canada Resources Ltd.	92 (1978)	basal	X	water; silt			rotary, 41.5 m
NAHUN	82L/4E	British Newfoundland Exploration Ltd.	40 (1978)	basal	X	silt; water; rock			
DUO	82L/4E	E&B Explorations Ltd.	100 (1978)	basal	X	silt	scintillometer		
SH, AS	82L/7W	Stanholm Silver Mines Ltd.	35 (1972) 15 (1973)	pegmatite				345 m	
JEN JEN	82L/11W	Union Oil Co. of Canada Ltd.	117 (1978)	basal	X	soil; water; rock	gamma ray spectrometer		
SYPHON	82L/11W, 14W	Banqwest Resources Ltd.	69 (1978)	vein		water; soil	radiometric		
CRAN	82L/16E	Cajac Explorations Ltd. (Noranda option)	84 (1978)	pegmatite	X		scintillometer; airborne gamma ray spectrometry	X	

NTS 82M

REXSPAR	82M/12W	Consolidated Rexspar Minerals and Chemicals Ltd. (1969, 1970, 1972, 1973, 1975, 1976)	40 Crown grants and 337 located claims (1969); 265 located (1972); 225 located (1973)	volcanogenic	X	radon; soils	induced polarization; scintillometer	X	4 520 m
BULLION	82M/12W	Granby Mining Co. Ltd. (1969)	16 (1969)		X		scintillometer		240 m
		J. Arden (1975)	15 (1975)						
		Copper Lake Exploration Ltd. (1977)	10 (1977)						

NTS 92H

BEE	92H/5W	Jet-Star Resources Ltd.	8 (1978)	pegmatite	X	soil	radiometric	X	diamond, 86 m
McNULTY	92H/8E	Lacana Mining Corp.	30 (1977) 30 (1978)	basal	X	water	scintillometer		percussion, 430 m
FIN	92H/9E	Canadian Occidental Petroleum Ltd.	40 (1978)		X	silt; water			
LINK	92H/9E	Canadian Occidental Petroleum Ltd.	42 (1978)		X	silt; water			
GLAD	92H/9W	Canadian Occidental Petroleum Ltd.	4 modified grid system		X	silt; water			
UP	92H/9W, 10E	Cominco Ltd.	100 (1977)	sandstone					diamond, 304.8 m

NTS 92I

WAS	92I/1	Canadian Occidental Petroleum Ltd.	36 (1978)		X	silt; water			

FOX	92I/2E	Canadian Occidental Petroleum Ltd.	12 (1978)		X	silt; water		
RAD	92I/5E	Highland Lode Mines	75 (1976)				radiometric	diamond, 68.4 m

NTS 92N

EMM	92N/16	Kelvin Energy Ltd.	66 (1978)			track etch; soil	scintillometer; VLF; airborne magnetometer; electromagnetic	

NTS 92O

JAY	92O/14E	Kelvin Energy Ltd.	208 (1978)			track etch; soil	scintillometer; VLF; airborne magnetometer; electromagnetic	

NTS 92P

BAF	92P/5E, 6W	Pacific Petroleums Ltd.	620 (1978)	basal	X	water	induced polarization; magnetometer; scintillometer	diamond, 249 m; percussion, 1 289 m

NTS 93B

ALEXANDRIA	93B/10E	Texasgulf Inc.	30 (1978)	basal?		water		
BUCK RIDGE	93B/16W	Texasgulf Inc.	40 (1978)	basal?		water		

NTS 93C

BEE, EFF, GEE	93C/1, 2E	Kelvin Energy Ltd.	1 400 (1978)	basal?		track etch; soil	scintillometer; airborne magnetometer; airborne scintillometer	overburden

NTS 93F

RON	93F/9E	Denison Mines Ltd.	4 modified grid system (1978)	basal?	X	soil; rock; water	scintillometer	
SWAN	93F/9E	E&B Explorations Ltd.	20 (1978)	basal?				225 m
GY	93F/9E	E&B Explorations Ltd.	820 (1978)	basal?	X			615.2 m
CABIN	93F/9W	Shell Canada Resources Ltd.	260 (1978)	basal?	X	silt; water; rock		diamond, 187.4 m
RUP	93F/9W	Denison Mines Ltd.	11 modified grid system (1978)	basal?	X	soil; rock; water	scintillometer	rotary, 265 m
JIM	93F/10W	Denison Mines Ltd.	20 (1978)	basal?	X	soil; rock; water	scintillometer	
BIN	93F/13E	Dome Exploration (Canada) Ltd.	116 (1978)		X	soil; silt	airborne scintillometer	
SWAB	93F/15W	Dome Exploration (Canada) Ltd.	80 (1978)		X	soil; silt	airborne scintillometer; magnetometer	diamond, 230 m
NIT	93F/15W	Dome Exploration (Canada) Ltd.	20 (1978)		X	soil; silt	airborne scintillometer	
LILY	93F/15E	Canex Placer Ltd. (1977, 1978)	11 modified grid system	basal?				diamond, 500 m; percussion, 45 m
TAIGA	93F/15E	Denison Mines Ltd.	14 modified grid system (1978)	basal?	X	soil; rock; water		rotary, 381 m
GREER, KLUSKUS	93F/16W	Shell Canada Resources Ltd.	10 modified grid system (1978)	basal?		silt; water		diamond, 822 m
GRABEN	93F/16W	Denison Mines Ltd.	40 (1978)	basal?	X	soil; water; rock	scintillometer; VLF	rotary, 91 m

GAP	93F/16W	Denison Mines Ltd.	6 modified grid system (1978)	basal?	X	soil; rock; water	scintillometer		rotary, 354 m
WELCH, STONY	93F/16W	Shell Canada Resources Ltd.	416 (1978)	basal?	X				diamond, 598 m
EN	93F/16W, 15E	E&B Explorations Ltd.	380 (1978)	basal?	X	X			diamond, 620.1 m
ER	93F/16E	E&B Explorations Ltd.	600 (1978)	basal?	X	X			diamond, 463.8 m

NTS 93H

UG, LAD	93H/13W	Zulu Exploration Ltd.	148 (1974)	sandstone —coal					diamond, 975 m

NTS 93K

LOY, LIZ, JAN	93K/1	Denison Mines Ltd.	6 modified grid system (1978)	basal?	X	soil; rock; water	scintillometer		diamond, 163.5 m
STELLA	93K/2E	Himac Resources Ltd.	120 (1978)						percussion, 640 m
ENDEX	93K/2W	Placer Development Ltd.	48 (1978)			soil; silt	scintillometer		
SAVORY RIDGE	93K/3	Placer Development Ltd.	177 (1978)	stockwork Mo		rock; water; silt	scintillometer		
LOON	93K/3E	Placer Development Ltd.	64 (1978)	stockwork Mo					diamond, 567.2 m

NTS 93N

LONNIE	93N/9W	Manson Lake Mines Ltd. C. Powney (1977)	8 (1970) 2 (1977)	carbonatite				X	

SMOKE	93N/11W	Anglo-Bomarc Mines Ltd.	36 (1974) 4 (1977)	stockwork Cu, Mo		soil	magnetometer	X	

NTS 104N

CX, FOX	104N/10	Placer Development Ltd. (1977, 1978)	12 modified grid system (1977)		X	silt; water; soil; track etch	airborne magnetic; radiometric; seismic		overburden, 112.6 m
SNOWBIRD	104N/10W	Union Oil Co. of Canada Ltd.	260 (1977) 100 (1978)	stockwork, vein	X	soil; silt; rock	VLF; magnetometer; scintillometer		450 m
EVA	104N/10W	Union Oil Co. of Canada Ltd.	16 (1978)	stockwork, vein	X	soil	radiometric		
SAL	104N/10W, 11E	Mattagami Lake Mines Ltd.	18 (1978)	stockwork, vein		silt; rock			
CY	104N/10W, 11E	Mattagami Lake Mines Ltd.	16 modified grid system (1977)	stockwork, vein		water; silt; rock; soil	radon; scintillometer; VLF–EM; induced polarization		
MONT	104N/11E	Union Oil Co. of Canada Ltd.	36 (1977) 36 (1978)	stockwork, vein	X	soil; water; rock	scintillometer		
SLA	104N/11E	Union Oil Co. of Canada Ltd.	12 (1978)	stockwork, vein	X	soil; water; silt	scintillometer		
RU, ZAPU	104N/11W	Union Oil Co. of Canada Ltd.	38 (1978)	stockwork, vein and basal	X	soil; silt; water; rock	scintillometer		
PURPLE ROSE	104N/11W	Union Oil Co. of Canada Ltd.	36 (1977) 36 (1978)	stockwork, vein	X	soil; rock; water	scintillometer		
RUST	104N/11W	United Rayore Gas Ltd.	38 (1977) 38 (1978)	stockwork, vein	X	soil; silt	gamma ray spectrometer		
HUSSELBEE	104N/12W	Jason Explorers Ltd.	25 (1969)	skarn				X	
IRA	104N/14	Union Oil Co. of Canada Ltd. (1977) R. H. Seraphim (1978)	67 (1977) 67 (1978)	stockwork, vein	X	soil; silt; water	gamma ray spectrometer		
TUPA	104N/14E	Union Oil Co. of Canada Ltd.	20 (1977) 20 (1978)	stockwork, vein	X	soil; silt	scintillometer		

APPENDIX 4.2. ANNOTATED LIST OF RADIOACTIVE OCCURRENCES IN BRITISH COLUMBIA

More than 60 radioactive occurrences have been recorded in British Columbia. These include several types of deposits and contain various radioactive minerals.

The abbreviations below have been used in all references:

(1)	AS	– Assessment Report, on file with the B.C. Department of Mines and Petroleum Resources
(2)	BCAR	– Annual Report, *Minister of Mines and Petroleum Resources, B.C.*
(3)	Bull.	– Bulletin, *B.C. Department of Mines and Petroleum Resources*
(4)	EG 16, 1952	– Economic Geology Series No. 16, 1952, *Geological Survey of Canada*
(5)	EG 16, 1962	– Economic Geology Series No. 16, 1962, *Geological Survey of Canada*
(6)	EG 18	– Economic Geology Series No. 18, *Geological Survey of Canada*
(7)	EG 27	– Economic Geology Series No. 27, *Geological Survey of Canada*
(8)	GEM	– Geology, Exploration and Mining in British Columbia, *B.C. Department of Mines and Petroleum Resources*
(9)	Mem. 223(R)	– Memoir 223, revised edition, *Geological Survey of Canada*
(10)	P M 1949	– Property map, 1949, on file with the B.C. Department of Mines and Petroleum Resources
(11)	Sum. Rpt.	– Summary Report, 1932, Part A, *Geological Survey of Canada*

Occurrences are listed according to NTS map designations. Numbers in brackets after properties refer to locations shown on the accompanying map, Figure 4.2.

82E/1W **SD** (1) (49° 07.4' - 118° 23.4') – On the ridge between Toronto and Snowball Creeks, 4 kilometres east of Granby River and 10.5 kilometres north-northeast of Grand Forks. Scattered uraninite and some uranophane occur in pegmatite in gneiss. GEM 1970, p. 432; AS 3172.

82E/2W **DOLO** (2) (49° 01.3' - 118° 57.9') – At 1 065 metres elevation, south of Myers Creek, 5.6 kilometres south of Rock Creek. Magnesium, tungsten, and thorium reported in dolomite. GEM 1970, p. 411.

82E/5W **RENO** (3) (49° 20' - 119° 48') – On Marsel Creek, 14 kilometres north of Keremeos and 2.4 kilometres above Keremeos Creek. Possible columbite in black chert associated with serpentinized olivine pyroxenite. GEM 1974, p. 55; AS 5005.

82E/10W **SAND, CUP, LASSIE** (4) (49° 36.3' - 118° 47.4') – On Sandrift and Copperkettle Creeks between 870 and 1 310 metres elevation, 6.4 to 13 kilometres north of Christian Valley. Some radioactive mineralization found in volcanic rocks and in crosscutting intrusive dykes. GEM 1970, p. 410; AS 2482.

82E/10W **FUKI – DONEN** (5) (49° 32.4' - 118° 52.9') – On Dear Creek, 17.6 kilometres northeast of Beaverdell. Secondary radioactive mineralization is found in Tertiary sedimentary rocks in a stream valley buried under Tertiary lava. GEM 1969, p. 302; AS 2013, 2484, 3135, 3775, 4630.

82E/11E, 6E **CARMI MOLYBDENUM** (6) (49° 29.0' - 119° 08.8') – Between 1 800 and 2 700 metres elevation on Wilkinson Creek near Carmi, 13 kilometres northwest of Beaverdell. Uraninite, associated with purple fluorite, as disseminated grains in gneissic granodiorite breccia. AS 5208.

82E/11E, 14E **PB 81-179** (7) (49° 45.5' - 119° 07.7' – At 1 190 metres elevation, 27 kilometres southeast of Kelowna, astride the Canadian Pacific Railway line. Radioactivity anomaly in thin basal sandstones and conglomerates, and locally in overlying vesicular basalt. GEM 1973, p. 52; AS 4629.

82F/1W **LUCKY** (8) (49° 07.5' - 116° 26.5') – At the junction of Arrow Creek and Goat River. Thorite has been reported. EG 16, 1962, p. 234.

82F/3E **MOLLY** (9) (49° 05' - 117° 12') – On Lost Creek south of Salmo. Uraninite was detected with molybdenum-tungsten mineralization in skarn. EG 16, 1952, p. 45; Bull. 41, p. 132.

82F/4E **MOTA** (10) (49° 13.8' - 117° 42') – On China Creek, 1.3 kilometres west of the Trail-Castlegar Highway. Uraninite is found in pegmatite. BCAR 1968, p. 239.

82F/4W **GIANT – COXEY** (11) (49° 05.3' - 117° 49.7') – On the west slope of Red Mountain, 2.4 kilometres northwest of Rossland. Some radioactivity is reported with molybdenite mineralization. EG 16, 1952, p. 44; BCAR 1966, p. 200.

82F/5E **GIBSON CREEK GOLD MINE** (12) (49° 22' - 117° 38.5') – At about 915 metres elevation, 5 kilometres north of Castlegar. Uraninite occurs in granitic rocks. Assays up to 0.11 per cent U_3O_8 across 0.6 metre are reported. BCAR 1955, p. 50.

82F/5E **LUCKY BOY** (13) (49° 27.7' - 117° 37') – About 2.4 kilometres northwest of Krestova. Scattered grains of samarskite are found in pegmatite pods in syenite gneiss. BCAR 1956, p. 77.

82F/6W **LUCKY, BILL, TAG** (14) (49° 29.5' - 117° 23.5') – On Kootenay River near the Canadian Pacific Railway bridge at Sproule Creek. Uraninite occurs in pegmatite. EG 16, 1962, p. 234.

82F/8E **CARIBOO** (15) (49° 22' - 116° 10') – At the head of the north fork of Moyie Creek. Radioactivity was detected in galena-sphalerite-scheelite mineralization. BCAR 1969, p. 347.

82F/11W **TRY AGAIN (LEMON CREEK)** (16) (49° 42' - 117° 26') – On Lemon Creek about 3.2 kilometres from the highway and 8 kilometres south of Slocan. Allanite and fergusonite (?) are found in pegmatite. BCAR 1955, p. 65.

82K/4E **STA – TITE (ARROW LAKE)** (17) (50° 14' - 117° 58') – On a tributary of Arrow Park Creek, 14.4 kilometres north of Arrow Park. Uranium and thorium were detected in samples from a narrow seam in granite. BCAR 1954, p. 142.

82K/6W **LUCKY JACK – BULLOCK** (18) (50° 24.5' - 117° 07.5') – About 0.8 kilometre south of Poplar Creek settlement. Uranium indicated in some samples. BCAR 1952, p. 191.

82K/9W **ICE 9 (ANNETTE, SLIDE)** (19) (50° 38.5' - 116° 30.0' – On Forster Creek, at elevations 1 460 to 2 746 metres, 37 kilometres west of Radium Hotsprings. Geochemical anomalies of molybdenum, uranium, and possibly niobium in granite and meta-sedimentary rocks. GEM 1971, p. 426; AS 3222.

82K/9W **FORSTER CREEK** (20a) (50° 39' - 116° 21'-27') – Gravels contain uraninite, pyrochlore, and other radioactive minerals derived from a granite pluton at the head of the creek. EG 18, 1958, p. 28.

82K/15W **VOWELL CREEK** (20b) (50° 50' - 116° 45'-50') – As for Forster Creek.

82K/15W **MALLOY CREEK** (20c) (50° 50' - 116° 52') – As for Forster Creek.

82K/15E **BUGABOO CREEK** (20d) (50° 44'-50' - 116° 42') – As for Forster Creek.

82L/2W **VAL** (21) (50° 04' - 118° 55' approximately) – On Vidler Creek near Lumby. Uranium has been reported in Tertiary sandstones, conglomerates, and tuffaceous arkoses. BCAR 1968, p. 222.

82L/2W **SPAR** (22) (50° 14.8' - 118° 48.5') – On the hill north and east of Blue Springs Creek, 11.2 kilometres east of Lumby. Monazite occurs in irregular patches in pegmatite in Shuswap rocks. One sample showed U_3O_8 = 0.044 and ThO_2 = 0.069. GEM 1971, p. 431; AS 3434.

82L/6E **BRETT – BIRD** (23) (50° 28.5' - 119° 06.5') – On Sneezby Creek, 1.6 kilometres east of Highway 97A, 7 kilometres north of Armstrong. Uraninite (?) reported in pegmatite. EG 16, 1952, p. 44; BCAR 1950, p. 226; AS 49.

82L/7W **SH, AS** (24) (50° 18' - 118° 49') – Twelve kilometres northeast of Lumby, extending north-northwest from Shuswap Falls. Uraninite mineralization associated with pegmatite. GEM 1973, p. 101.

82M/12W	**REXSPAR** (25) (51° 33' - 119° 55') – At about 915 metres elevation on the east side of Foghorn Creek, 5 kilometres south of Birch Island. Several radioactive minerals occur with fluorite and celestite in trachyte (?). BCAR 1954, p. 108; Canadian Mining Journal, July 1956, p. 59; EG 16, 1962, p. 205; AS 2337, 2340.
82M/12W	**BULLION** (26) (51° 34.3' - 119° 51.5') – At the mouth of Lute Creek. Similar to Rexspar. BCAR 1968, p. 164.
82M/12W	**RAY** (27) (51° 32' - 119° 55') – At head of Foghorn Creek. Uranium and fluorite reported. BCAR 1968, p. 165.
82M/12W	**MY, RAY** (28) (51° 37' – 119° 55') – At Birch Island, on the north side of the North Thompson River, between Raft River and Crossing Creek. Two small radioactivity anomalies (uranium and thorium) reported by airborne gamma ray survey. BCAR 1968, p. 165; AS 1737.
82M/16E	**TRIDENT CREEK** (29) (51° 56.9' - 118° 03.9') – At mouth of Trident Creek where it enters Kinbasket Lake (Columbia River). Radioactive minerals reported in delta believed to originate from nepheline syenite near head of creek. BCAR 1959, p. 104.
82N/1W	**DEMON, COLTI** (30) (51° 11.5' - 116° 20.6') – Near the head of Moose Creek, about 43 kilometres southeast of Golden. Radioactive mineralization, largely thorium bearing, occurs in an igneous complex. BCAR 1954, p. 150.
82N/1W	**WATERLOO** (31) (51° 10.0' - 116° 22.9') – At approximately 2 130 metres elevation at head of Moose Creek, 48 kilometres southeast of Golden. Some uranium minerals present in limestone and calcareous shale. GEM 1970, p. 467; GEM 1972, p. 94.
82N/7W	**KING DAVID** (32) (51° 18.1' - 116° 52.9') – Along Kicking Horse River, approximately 7 kilometres upstream from Golden. Weak radioactivity anomaly with occasional values in germanium, zirconium, and uranium. AS 184.
83D/6E	**VERITY – PARADISE** (33) (52° 24' - 119° 09.7') – East of the Canadian National Railway tracks at Mile 109, 37 kilometres north of Blue River. Uranian pyrochlore and columbite occur in a 'carbonatite' layer in gneiss. BCAR 1950, p. 229; BCAR 1952, p. 115; BCAR 1954, p. 111; EG 18, 1958, p. 31; AS 1630.
92F/16W	**LANG BAY (GE)** (34) (49° 48' - 124° 19') – On Lang Creek, above Lang Bay, 22 kilometres southeast of Powell River. Germanium occurs in thin sparse streaks of lignite coal and in carbonaceous shale. BCAR 1949, p. 218; BCAR 1959, p. 127.
92H/3E	**INTERNATIONAL** (35) (49° 00.4' - 121° 08.5') – At the head of Galene Creek near the International Boundary. Carnotite (?) has been reported in lead mineralization. BCAR 1938, p. F22; EG 16, 1961, p. 233.

92H/3E **AM** (36) (49° 09.8' - 121° 01.3') – Five kilometres south of Highway 3 near the west boundary of Manning Park. Uraninite and monazite have been identified with copper mineralization. BCAR 1949, p. 210; BCAR 1954, p. 152; AS 4074, 4075.

92H/6W **HOPE** (37) (49° 23' - 121° 26') – Black sand from the Hope area is said to have contained radioactive material. EG 16, 1952, p. 45.

92I/2E **COPPERADO** (38) (50° 12' - 120° 36') – About 8 kilometres north of the outlet of Nicola Lake. Allanite occurs in pegmatite. BCAR 1949, p. 120.

92I/4W **ROSYD (BOTANIE OCCURRENCE)** (39) (50° 15' - 121° 34') – On the east bank of Thompson River 1.6 kilometres north of Lytton. A sample from a shear in limestone contained U_3O_8 = 0.062 and ThO_2 = 0.001. BCAR 1955, p. 34.

92I/4W **LYTTON BAR** (39) (50° 15' - 121° 36') – Placer concentrate from Lytton Bar, on the west side of Fraser River 1.6 kilometres upstream from Lytton, contained 0.16 per cent U_3O_8 equivalent. BCAR 1948, p. 180.

92I/5E **ORLEAN (PAQUET OCCURRENCE)** (39) (50° 19.5' - 121° 39') – In a road cut 11.7 kilometres north of Lytton on the highway to Lillooet. Metazeunerite was identified in copper-stained material from a shear zone in slate. BCAR 1955, p. 33.

92I/10E **COPPER KING** (40) (50° 42.3' - 120° 35.6') – Just north of Highway 1 about 25 kilometres west of Kamloops. Minor amounts of pitchblende occur in patches and veinlets with copper sulphides and magnetite in a shear zone at the entrance to the open cut into the glory hole of the old workings. Memoir 249, p. 109, Geological Survey of Canada; AS 3800, 3823.

92J/9E **INDEX** (41) (50° 31.7' - 122° 00') – On the summit between the north fork of Texas and Cottonwood Creeks. Low-grade radioactive samples were found with molybdenum mineralization in granite. BCAR 1949, p. 113.

92J/15W **GEM (LITTLE GEM)** (42) (50° 53.8' - 122° 57.7') – On Roxy Creek. Uraninite and allanite occur with cobalt-gold mineralization in pegmatite. Assays up to 1.89 per cent U_3O_8 equivalent across 60 inches were obtained. BCAR 1948, p. 112; EG 16, 1952, p. 43.

92J/15W **COBALT (PACIFIC GOLD AND ,URANIUM)** (42) (50° 53.8' - 122° 57.7') – Surrounding the Gem and similar in nature. EG 16, 1952, p. 44.

92K/3E **RADIUM (GEILER) (QUADRA ISLAND OCCURRENCE)** (43) (50° 04' - 125° 13') – North end of Gowland Harbour, Quadra Island, 8 kilometres north of Campbell River. Small seams of carnotite found in crevices in volcanic rocks. BCAR 1932, p. 208; EG 16, 1952, p. 45; Sum. Rpt., p. 54.

92O/3W	**TASEKO – MOHAWK (MOTHERLODE – MOHAWK)** (44) (51° 06' - 123° 23') – At 1 980 metres elevation on spur between Gibson (Granite) Creek and Taseko River. High count with geiger counter. Property underlain by quartz diorite. EG 16, 1952, p. 44; GEM 1970, p. 213 (ref.).
93A/10W	**EAGLET** (45) (52° 34.1' - 120° 58.6') – On the east side of Quesnel Lake at the mouth of Wasko Creek, 3.2 kilometres northeast of the point at the junction of the north arm and main lake. Allanite is found with fluorite and other minerals in pegmatite gneiss. BCAR 1965, p. 263.
93B/16W	**QUESNEL RIVER** (46) (53° 00' - 122° 17') – Monazite was reported in placer sand from workings 13 kilometres above Fraser River. EG 16, 1962, p. 235.
93D/4	**PROMISE WELL** (47) (52° 06.4' - 127° 45') – Pegmatite showed 0.0065 per cent uranium oxide equivalent. BCAR 1953, p. 166.
93F/15W	**ABE (MOLLY)** (48) (53° 59.2' - 124° 51.7') – On the north slope of Nithi Mountain, 9.6 kilometres south of Fraser Lake. Sabugalite and torbernite occur in fractures and cavities in a rhyolite porphyry dyke in granite. BCAR 1955, p. 28; BCAR 1956, p. 28.
93H/8E	**McBRIDE** (49) (53° 18' - 120° 12') – Placer sand from near McBride was reported to be radioactive, probably due to thorium. EG 16, 1962, p. 235.
93H/13E	**GOLD – THORIUM CLAIM** (50) (53° 58' - 121° 39') – As for McBride. EG 16, 1952, p. 45.
93H/13W	**UG, LAD** (51) (53° 49' - 121° 53') – Fifty-six kilometres east-southeast of Prince George along Bowron River at approximately 750 metres elevation. Uranium and germanium in shale beds below coal seams containing uranium, germanium, and resin. GEM 1974, p. 251.
93J/1W	**GISCOME (JHG, SAMSON)** (52) (54° 03.6' - 122° 20.0') – Approximately 2.4 kilometres east of Giscome, just south of Eaglet Lake and the Canadian National Railway line. Uranium-bearing vein reported in gneissic granite. Niobium associated with galena and sphalerite in skarn also reported. P M 1949; GEM 1974, p. 251.
93M/4E	**VICTORIA** (53) (55° 10.4' - 127° 38.9') – On the northwest slope of Rocher Deboule Mountain, 8 kilometres south of Hazelton. Uraninite and allanite occur with sulphides in veins in granodiorite. BCAR 1949, p. 82; Bull. 43, p. 69; EG 16, 1952, p. 42.
93M/4E	**RED ROSE** (53) (55° 08.4' - 127° 36') – Between Armagosa and Red Rose Creeks. Uraninite occurs with other minerals, particularly molybdenite in veins. Bull. 43, p. 54; EG 16, 1952, p. 42.
93M/4E	**HIGHLAND BOY** (53) (55° 10' - 127° 37') – On upper Juniper Creek. Uraninite is found in a complex deposit. Bull. 43, p. 53; EG 16, 1952, p. 41.

93M/4E **ROCHER DEBOULE** (53) (55° 09.5' - 127° 38.6') – At the head of Juniper Creek, 8 kilometres south of Hazelton. Uraninite occurs in veins with other minerals. Bull. 43, p. 59; EG 16, 1952, p. 42.

93M/4E **BLACK PRINCE** (54) (55° 10.2' - 127° 33.8') – At 1 370 metres elevation at the head of Mudflat Creek, 8.8 kilometres south-southwest of New Hazelton. Minor radioactivity associated with scheelite in shear zones in porphyritic granodiorite. Mem. 223(R), p. 30; Bull. 43, p. 48.

93M/4E **BLUE LAKE** (54) (55° 10.2' - 127° 34.2') – Just west of Black Prince at 1 615 metres elevation. Similar to Black Prince. Mem. 223(R), p. 32; Bull. 43, p. 49.

93M/4E **GOLDEN WONDER** (54) (55° 11.1' - 127° 42.0') – At foot of Rocher Deboule, at 400 metres elevation, 0.8 kilometre southeast of Highway 16 and 11 kilometres southwest of New Hazelton. Minor uranium associated with thin sulphide lenses in narrow fissure zones in tuffs. Mem. 223(R), p. 44; EG 16, 1952, p. 41.

93N/9W **LONNIE** (55) (55° 41' - 124° 22.5') – On the southeast side of Granite Creek, 2.4 kilometres from the Manson Creek road. Uraniferous pyrochlore is found in a carbonate complex. BCAR 1954, p. 96; BCAR 1955, p. 29; EG 18, p. 29.

93N/9W **VIRGIL** (56) (55° 44' - 124° 27') – On west flank of Wolverine Range at 1 680 metres elevation, 11 kilometres northwest of Manson Creek. Niobium plus minor uranium values associated with a syenite-carbonate complex. GEM 1974, p. 278; EG 18, p. 29.

93N/11W **SMOKE** (57) (55° 35' - 125° 18') – At 1 220 metres elevation, 24 kilometres west-southwest of Germansen Lake, 6.4 kilometres north of the junction of Kwanika and West Kwanika Creeks. Uraninite locally in quartz stringers in widely spaced fractures in a small alaskite plug (intruding granite). GEM 1974, p. 280; AS 5372.

94E/8E **TOR CLAIMS** (58) (57° 17.7' - 126° 01.5') – Near headwaters of Pelly Creek, 40 kilometres west of Fort Ware. High radiation zones, partly attributable to hafnium in zircon, associated mainly with silicified limestone. No uranium, thorium, or radium found. AS 218.

94F/13 **SPRINGIRON LAKE (GATAGA RIVER)** (59) (57° 58' - 125° 45') – Near headwaters of the south fork of the Gataga River, 2.4 kilometres north of Springiron Lake. Minor uranium and vanadium in gossan associated with grey shale. EG 27, p. 49.

94L/12E **DALL LAKE** (60) (58° 34.8' - 127° 32.2') – Radioactive float was found in a creek. EG 16, 1952, p. 44.

94M/8E **LIARD RIVER HOTSPRINGS** (61) (59° 26' - 126° 06') – At Mile 497 on the Alaska Highway. Radioactivity was detected in the water and tufa at the hotsprings.

94N/12W **WISHING WELL (DEER RIVER SPRINGS)** (62) (59° 31′ - 125° 57′) – Ten kilometres northwest of the Liard River, 22 kilometres north-northwest of Prudence Mountain. Mildly radioactive calcareous tufa from slightly radioactive cool springs.

104N/11W **PURPLE ROSE – FISHER (CRACKER CREEK)** (63) (59° 44′ - 133° 18′) – At 1 525 to 1 830 metres elevation between Cracker, Ruby, and Boulder Creeks. Minor zeunerite and metazeunerite occur with quartz in Cretaceous alaskite. Selected sample contained 0.088 - 0.059 U_3O_8. BCAR 1955, p. 7.

104N/12W **HUSSELBEE (BEAVER)** (64) (59° 42.1′ - 133° 51.8′) – On the west side of Atlin Lake just south of Deep Bay, about 19 kilometres north of Atlin. Uraninite occurs with pyrite, fluorite, and galena in amphibolite. BCAR 1953, p. 79.

104N/10W **MIR** (65) (59° 42′ - 132° 52′) – At 1 860 metres elevation 7 kilometres west of Trout Lake. Kasolite in fractures with base metals in medium to coarse-grained alaskite of the Surprise Lake batholith. BCMEMPR Geological Fieldwork, 1978, p. 106.

104N/11E **CY, ENG** (66) (59° 40′ - 133°) – At 1 700 metres elevation near Mount Weir, 40 kilometres east of Atlin. Zeunerite occurs in fracture zones with various base metals and iron oxides in alaskitic quartz monzonite of the Surprise Lake batholith. BCMEMPR Geological Fieldwork, 1978, p. 106.

82E/10W **BLIZZARD** (67) (49° 37′ - 118° 55′) – Eleven kilometres northwest of Christian Valley adjoining the north ends of Joan Lake and Lassie Lake. Autunite and saleeite occur in carbonaceous sediments of a paleostream channel capped by olivine plateau basalt. Reserves: 2.1 million tonnes of 0.226 per cent U_3O_8. BCMEMPR Preliminary Map 29.

82E/14E **KETTLE (HYDRAULIC LAKE)** (68) (49° 48′ - 119° 12′) – Twenty-one kilometres east-southeast of Kelowna, northwest of Hydraulic Lake. Ningyoite and gummite are associated with marcasite in unconsolidated carbonaceous sediments, partly capped by plateau basalt. BCMEMPR Preliminary Map 29.

APPENDIX 6.1

Mr. J.E. McMynn,

Deputy Minister.

October 3rd 74

~~G-7b~~ F-6.

Re: Federal-Provincial Uranium Reconnaissance Programme

A meeting on September 30th, 1974, took place at the G.S.C. Board Room in Ottawa, in which all Provinces, the G.S.C. and other Federal agencies were present. The attached outline covers most aspects of the discussion other than that on techniques and the responses of the Provincial representatives. You will note that it is proposed that in British Columbia the programme will be entirely geochemical; that it is proposed about half the Province be surveyed; that it is expected this may take ten years and that the Provincial half share of the cost would be $92,500/yearly.

Comments and recommendations:

I recommend we participate in the programme for the following reasons, which are not completely identical with those of the Federal Government.

(1) To appraise the uranium resource for low grade material which is expected to be economic in five to ten years, and to outline favourable districts for detailed prospecting.

(2) To do the same for other metals and particularly lead and zinc which occur in the same general terrain as uranium, but not in similar geological settings. The cost of analysing for twelve to sixteen metals is not significantly different than just uranium and thorium. Our inferred reserves of lead and zinc are much lower than those of copper and molybdenum and need to be augmented.

(3) Regional geochemical data could be used to guide and to add rigor to our evaluation for mineral deposit land-use maps.

(4) The Federal funds are available now. Some of the Provinces wish to speed up their spending and the rate of production so that they might take up the available fund for four to five years if we do not indicate a serious interest now.

-/2

Mr. J.E. McMynn, October 3rd, 1974.
Deputy Minister.

(5) Contractors to do the collection or the analysis are available in British Columbia and highly rated so that the money might be pumped into the Provincial economy.

Because of the lag time involved, the Geological Survey would need to know preferably by 1st December, but certainly by the first of the year, whether British Columbia can fund its share of such a geochemical programme.

ASB

A. SUTHERLAND BROWN,
Deputy Chief Geologist, Geological Div.,
Mineral Resources Branch.

ASB/jr

Encl: Report
Uranium Reconnaissance Programme

cc: Dr. J.T. Fyles

F-6

FROM Dr. A. Sutherland Brown

TO Dr. J. T. Fyles

THE DEPARTMENT OF

PARLIAMENT BUILDINGS, VICTORIA, BRITISH COLUMBIA V8V 1X4

Re: Federal-Provincial Uranium Reconnaissance

DATE March 22,1976

Recent forecasts show that world demand for uranium will outstrip production capacity in the early 1980's.

The purpose of the U.R.P. is to provide for industry high quality reconnaissance exploratory data to indicate areas where there is the greatest probability of finding new uranium deposits, and to provide nationally consistent systematic data to serve as a basis for resource appraisal.

The Geological Division of the B.C. Department of Mines and Petroleum Resources has been consulted on technical aspects of the program since its inception; we set priorities in the areas to be surveyed (see map), we broadened the program to include reconnaissance for other metal, particularly lead and zinc, for which reserves in the province are mostly developed, we were consulted at every step last year on the orientation surveys even though we eventually did not join the program and we have been shown the data. Therefore at the technical level we have had only the best cooperation.

This division is not well prepared to carry out a similar program on its own for several reasons:

1) We do not have a geochemical section even though most of our geologists are well qualified in this field and our laboratory is capable.

2) We did not carry out the orientation survey which is a necessary step to the design of an extensive survey.

3) We have not been involved in designing the control programs that are necessary in such a project in which sample collection and analysis are let by contract to two separate firms.

Benefits accruing to the Province, the B.C. Government and the Department from joining in the program are as follows:

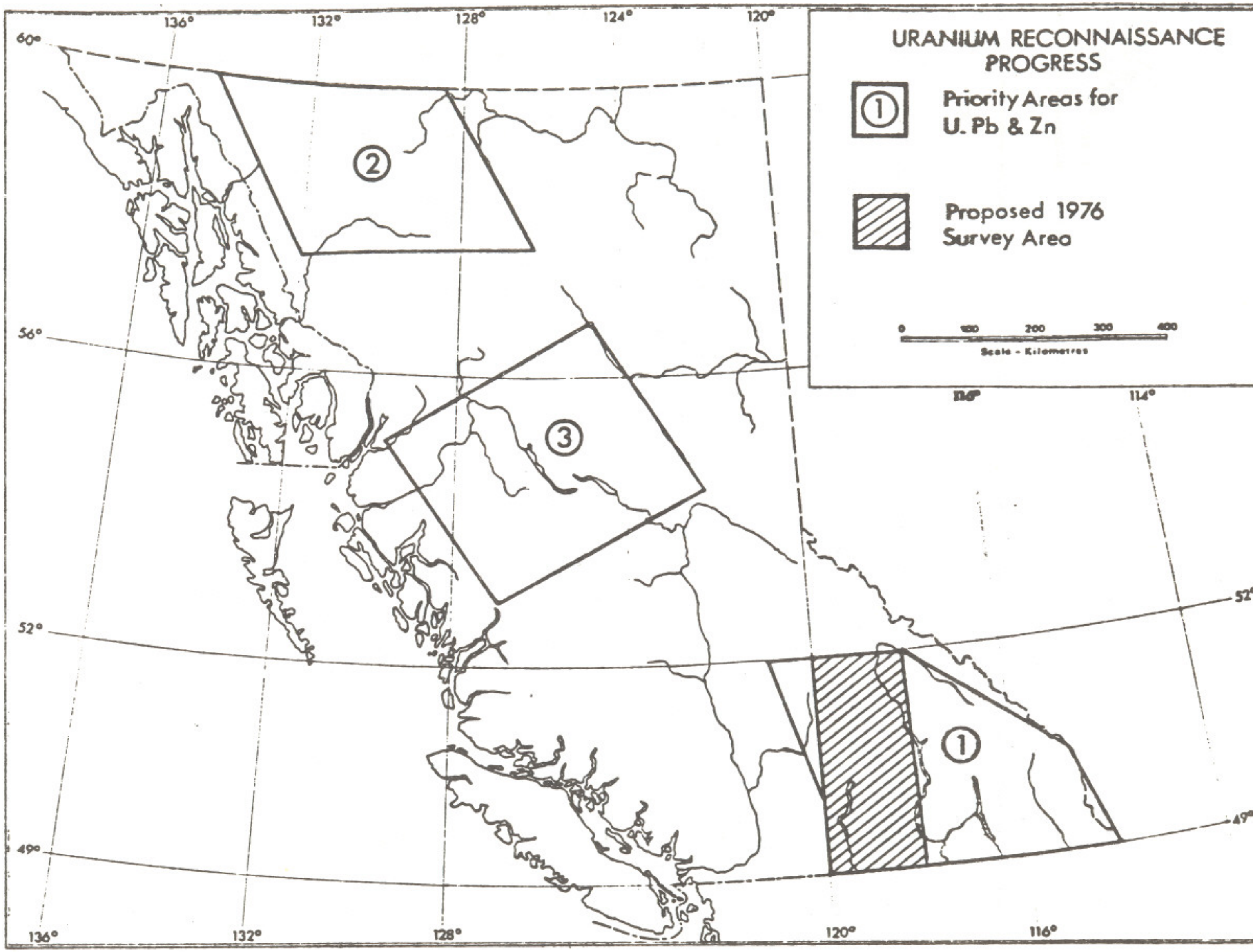
1) The survey will produce reconnaissance data for 12 metals, notably uranium, lead and zinc that will stimulate exploration by indicating areas of high potential for future discovery.

2) The data will be important for resource appraisal for governments.

3) The survey will increase the expertise and capability of the B.C. Department, especially in regard to designing and executing control programs.

4) The contracts for sample collection and for chemical analysis are likely to be B.C. firms because of both logistics and the fact that B.C. geochemical firms are among the most capable.

ASB



URANIUM RECONNAISSANCE PROGRESS
1
Priority Areas for U. Pb & Zn
Proposed 1976 Survey Area
0
100
200
300
400
Scale - Kilometres
1
2
3
60°
56°
52°
49°
52°
49°
136°
132°
128°
124°
120°
116°
114°
136°
132°
128°
120°
116°

APPENDIX 6.3

CANADA - BRITISH COLUMBIA

URANIUM RECONNAISSANCE AGREEMENT, 1976

THIS AGREEMENT made this 27 th day of August 1976

BETWEEN

THE GOVERNMENT OF CANADA,
(hereinafter referred to as "CANADA")
represented by the Minister of
Energy, Mines and Resources

OF THE FIRST PART

AND

THE GOVERNMENT OF THE PROVINCE OF
BRITISH COLUMBIA (hereinafter
referred to as "the Province")
represented by the Minister of Mines
and Petroleum Resources

OF THE SECOND PART

WHEREAS Canada and the Province agreed in principle at the Canadian Ministerial Conference on Mineral Policy on December 6, 1974, with the establishment of a Uranium Reconnaissance Program to facilitate and encourage exploration for uranium in the Province;

AND WHEREAS Canada and the Province desire to share equally in the cost of this work;

AND WHEREAS the Governor in Council by Order in Council P.S. 1976-2/2096 of the 25th day of August, 1976 has authorized the Federal Minister to execute this Agreement on behalf of Canada;

AND WHEREAS the Lieutenant Governor in Council by Order in Council No. 1615 of the 21st day of May, 1976, has authorized the Minister of Mines and Petroleum Resources to execute this Agreement on behalf of the Province;

NOW THEREFORE the parties hereto agree as follows:

1. DEFINITIONS

In this Agreement:

(a) "Federal Minister" means the Minister of Energy, Mines and Resources of Canada and includes any person authorized to act on his behalf;

(b) "Provincial Minister" means the Minister of Mines and Petroleum Resources of British Columbia and includes any person authorized to act on his behalf;

(c) "Fiscal year" means the period commencing on April 1st of any year and terminating on March 31st of the following year;

(d) "Management Committee" means the committee established pursuant to section 4;

(e) "Ministers" means the Federal Minister and the Provincial Minister;

(f) "Program" means the Uranium Reconnaissance Program;

(g) "Project" means a specific scientific or technical activity undertaken in relation to a defined area over a predetermined period of time.

2. PURPOSE OF THIS AGREEMENT

2.1 Canada and the Province agree to establish a three-year program to facilitate and encourage exploration for uranium in the Province. The parties agree that the demand for uranium is growing rapidly, the total cost of satisfying this demand will be very high, and it is necessary to make arrangements to promote the most efficient use of overall uranium exploration expenditures in order to achieve the greatest possible rate of increase in proven uranium reserves for the minimum cost. It is further agreed that in order to expedite discovery of new supplies and simultaneously assist in the appraisal of Canada's uranium resources, it is necessary to ensure that systematic surveys to map the occurrence and distribution of uranium are completed and published as rapidly as possible as a basis for planning and action by government and industry.

2.2 Canada and the Province agree that the most appropriate and up-to-date technology should be employed in order to maximize the probability of finding additional uranium within the shortest possible time-span. It is further agreed that in the interest of efficiency and long-term usefulness it is necessary to ensure that work is performed to meet common national standards with respect to quality, information density, and methods of reporting, for which purpose minimum standards and specifications established by the Geological Survey of Canada shall be used. These standards and specifications shall form part of any surveys undertaken under this Agreement.

2.3 Canada and the Province agree that the principal activity under this Agreement shall be the execution of regional geochemical sampling surveys, primarily directed towards the rapid recognition and delineation of all areas where there is a possibility of discovering additional uranium resources. It is further agreed that if the Management Committee determines that other types of geoscience survey must be employed in particular areas in order to achieve the objective of the program, the Management Committee has authority to require them to be carried out. The Management Committee shall have discretion as to the method or methods to be used in any given area.

2.4 Canada and the Province agree that the requirement of searching for other metallic minerals as a complementary activity to the uranium program will be considered within the framework of the program if so requested by the Provincial Minister, subject to the Province being wholly responsible for any additional costs incurred. Searching for other metallic minerals shall be construed to mean undertaking work within or on material from a given area which is judged by the Management Committee to be additional to that required to facilitate the discovery of uranium in that area.

2.5 Canada and the Province agree that unless a unamimous recommendation to the contrary is made by the Management Committee, the geochemical sampling density will be not more than one sample per 12.5 sq. km, excepting any surveys made over small areas required to verify the effectiveness of the reconnaissance methods being used. If the Province wishes unilaterally to employ a closer geochemical sampling interval, the Provincial Minister may request that such be undertaken, subject to the Province being wholly responsible for the additional costs incurred.

2.6 Canada and the Province agree that the specifications contained in Appendix 1 referring to regional geochemical surveys shall form the basis of specifications for reconnaissance surveys carried out under this Agreement.

2.7 The duration of the program shall not exceed the 3-year period from April 1, 1976 to March 31, 1979 inclusive, it being understood and agreed that the actual duration of any project, within the above time limits, shall be determined by the Management Committee.

3. COSTS

3.1 Subject to terms and conditions of this Agreement, Canada and the Province agree to share equally the costs of the joint program. Canada's share of these costs will be limited to $300,000 and the Province's share will be limited to $300,000.

3.2 Canada and the Province agree to the following schedule of annual expenditures, to be shared equally:

in fiscal year 1976/77	$200,000
in fiscal year 1977/78	$200,000
in fiscal year 1978/79	$200,000

4. ADMINISTRATION AND MANAGEMENT

4.1 The program shall be carried out under the general direction and supervision of, and in accordance with schedules and procedures set by, a Management Committee, comprised of two representatives of the Department of Energy, Mines and Resources of Canada, one of whom shall act as Co-chairman, and two representatives of the Province, one of whom shall act as Co-chairman. One representative in each party shall be a technical authority. In the event of any disagreement in the Management Committee, the matter shall be referred to the Ministers whose decision shall be final.

4.2 The Management Committee shall be responsible for the general co-ordination of this Agreement, and included in its duties shall be the following:

(a) selection and approval of areas and projects under this Agreement;

(b) preparation of an annual plan of operations;

(c) monitoring of the implementation of the projects;

(d) review of the performance of the projects under this Agreement;

(e) transfer of funds from one project to another where appropriate, and consistent with the intent of this Agreement;

(f) establishment of technical subcommittees to advise and assist the Management Committee in monitoring and implementing projects; the subcommittees may include persons who are not members of the Management Committee;

(g) submission of annual progress reports to the Ministers; and

(h) scheduling and authorization of the release of information gathered under this Agreement.

4.3 Each project under this Agreement shall be submitted for the approval of the Management Committee and shall be described in an appropriate project document which shall include the project name, the purpose, the objectives, an outline of how the project is to be carried out, and the cost.

4.4 Either Canada or the Province will arrange for the execution of those projects approved by the Management Committee. In general, it is intended that Canada will arrange for the execution of projects and let contracts where it is economically or technically advantageous to co-ordinate operations in more than one Province or where standardization of data between provinces and territories is essential to achieve maximum value. It is intended that the Province will arrange for the execution of more localized and detailed projects and let any relevant contracts required to monitor the effectiveness of reconnaissance surveys, and ensure the proper interpretation and utilization of results by users. Subject to prior approval by the Management Committee, either party may acquire, either by purchase or rental, whichever is considered more appropriate by the Management Committee, any equipment required to monitor, assess, and evaluate the approved projects.

5. FINANCIAL

5.1 Subject to the terms and conditions of this Agreement and subject to the funds being made available by the Parliament of Canada, the amount provided by Canada in respect of eligible costs of the jointly approved projects shall not exceed $300,000.

5.2 Subject to the terms and conditions of the Agreement and subject to the funds being made available by the Provincial Legislature of British Columbia, the amount provided by the Province in respect of eligible costs of jointly approved projects shall not exceed $300,000.

5.3 For eligible costs incurred under this Agreement, Canada shall contribute fifty percent (50%) and the Province shall contribute fifty percent (50%).

5.4 Eligible costs under this Agreement shall include only costs directly related to approved projects, as determined by the Management Committee. Costs of the Management Committee are not eligible costs.

5.5 Eligible costs for staff of the Province or Canada assigned to projects under this Agreement may cover gross salaries and employers' share of contributions for Canada Pension Plan and Unemployment Insurance benefits as well as reasonable travel expenses incurred in connection with such projects in accordance with applicable travel directives.

5.6 Notwithstanding any other provision in this Agreement, all obligations of Canada incurred by virtue of this Agreement shall be subject to the Financial Administration Act of Canada.

6. CONTRACT PROCEDURES

6.1 All contracts for equipment, work or services shall be awarded either by Canada or by the Province in accordance with recommendations and requirements authorized by the Management Committee. Unless the Management Committee makes a contrary recommendation, contracts shall be awarded to the qualified and responsible tenderer submitting the lowest evaluated bid.

6.2 In awarding contracts, Canada and/or the Province agree to retain the services of Canadian firms or individuals and that preference be given to those firms or individuals based in British Columbia where consistent with economy and efficiency as determined by the Management Committee.

6.3 All contracts for the performance of projects shall be awarded without discrimination by reason of race, sex, age, marital status, colour, religion or political affiliations; it being agreed, however, that the foregoing shall not preclude measures designed to benefit native people or disadvantaged groups in the area concerned.

6.4 The following conditions relevant to employment shall apply in respect of all projects carried out under this Agreement:

(a) labour shall be recruited through Canada Manpower Centres unless the Management Committee considers that this service cannot reasonably be provided;

(b) in the employment of persons on a project there shall be no discrimination by reason of race, sex, age, marital status, colour, religion or political affiliation; and

(c) the provisions of the Labour Standards Arrangement proposed by the Federal Department of Labour in 1970 shall be applicable to this Agreement, it being understood and agreed that to the extent there are higher provincial standards applicable to particular occupations or regions, these higher provincial standards shall apply.

7. PAYMENT PROCEDURES

7.1 Subject to sections 7.2 and 7.3, payments to the contract awarding party shall be made promptly by the other party on the basis of progress claims setting out the project costs actually incurred and paid, submitted in a form satisfactory to the Ministers, bearing an audit certificate, and certified by a responsible financial officer of the contract awarding party.

7.2 In order to assist with the interim financing of the projects under this Agreement, if the contract awarding party so requests, the other party may make interim payments:

(a) for the amount of funds required for the remainder of the quarter of the fiscal year in which a project is approved, based on a forecast prepared by the contract awarding party of the funds required in that quarter, certified by a responsible financial officer of the contract awarding party and submitted in a form satisfactory to the Ministers; and

(b) in subsequent quarters of the fiscal year further interim payments may be made to finance a share of expenditures in connection with approved projects based on a forecast prepared by the contract awarding party of the funds required in that quarter, certified by a responsible financial officer of the contract awarding party and submitted in a form satisfactory to the Ministers.

7.3 The contract awarding party shall account for each quarterly interim payment received under the provisions of section 7.2 by submitting to the other party within the following quarter a detailed statement of the expenditures actually incurred. This statement must be endorsed by a responsible financial officer of the contract awarding party and bear an audit certificate. Any discrepancy between the amounts paid by the other party by way of interim progress payments and the amount actually payable shall be promptly adjusted between Canada and the Province.

7.4 No interim payment shall be made in a subsequent fiscal year until the fourth quarter's interim payment, made in the previous fiscal year, has been liquidated by claims for expenditures actually incurred and paid, certified by a responsible financial officer of the contract awarding party and bearing an audit certificate, and any outstanding balance of the payment has been repaid or accounted for in a form or in a manner satisfactory to the Ministers.

8. EVALUATION

8.1 During this Agreement, Canada and the Province shall undertake an assessment of the effectiveness of the approved projects with regard to stated objectives. Canada and the Province shall provide each other with such information as the other party may reasonably require in order to undertake such assessments.

9. PUBLIC INFORMATION

9.1 Canada and the Province shall jointly share all the technical information obtained as a result of this Agreement and shall develop a system to disseminate this information as quickly and as widely as possible.

9.2 Any public announcement of the measures covered by this Agreement shall be arranged jointly by the Ministers.

10. GENERAL

10.1 Canada and the Province shall indemnify and save each other harmless against and in respect of all liability to any persons or corporations arising out of each other's activity in financing the program, and from, and in respect of all actions, proceedings, claims, damages, costs and expenses whatsoever in relation thereto, but nothing herein requires Canada or the Province to indemnify and save each other harmless from any acts or omissions of its own contractors, or any agent, servant, or workman of such contractors.

10.2 No member of the House of Commons or the Legislative Assembly shall be admitted to any share or part of any contract agreement, or commission made pursuant to this Agreement, or any benefits to arise therefrom.

IN WITNESS WHEREOF this Agreement has been executed on behalf of Canada by the Minister of Energy, Mines and Resources, and on behalf of the Province of British Columbia, by the Minister of Mines and Petroleum Resources.

IN THE PRESENCE OF:

GOVERNMENT OF CANADA

Witness

Minister of Energy, Mines and Resources

GOVERNMENT OF THE PROVINCE OF BRITISH COLUMBIA

Witness

Minister of Mines and Petroleum Resources

APPENDIX 7. RADIONUCLIDE PROCEDURES FOR SOUTHERN BRITISH COLUMBIA WATER–MONITORING PROJECT

Gross Alpha, Beta Activity

Gross alpha and gross beta activity measurements have been performed using a Canberra Model 2200 Low Level α, β Analyser especially designed for environmental counting. This instrument consists of an external proportional counter with an ultrathin detector window; the counter is completely surrounded by 4 inches of virgin lead and requires ultrahigh purity P-10 counting gas (90 per cent argon – 10 per cent methane). The instrument was calibrated for alpha activity by standardizing with an americium-241 source purchased from New England Nuclear Limited. This americium-241 source was previously calibrated against a United States National Bureau of Standards americium-241 alpha disc and had a total uncertainty of ±4.8 per cent in its activity. The instrument was calibrated for beta activity by standardizing with a Cs-137 source purchased from New England Nuclear Limited. This Cs-137 had also been calibrated against a United States National Bureau of Standards gamma source and had a total uncertainty of ±4.2 per cent in its activity.

In order to compensate for self-absorption effects in the counting planchets, alpha and beta standards were prepared with a series of varying solids thickness. For these efficiency curves, the alpha standard used was natural uranium and the beta standard was Cs-137. Experience has shown that the great majority of alpha activity in southern British Columbia surface waters is due to uranium so that the use of uranium as a standard would be expected to provide the most accurate results. The use of Cs-137 as a beta standard is recommended by the reference source because its mean beta energy is a reasonable average of the energies of the various beta emitters formed in the uranium and thorium decay series. The solids mixture used to produce the efficiency curve consisted primarily of a mixture of organic compounds (primarily sugars and acids) spiked with calcium and magnesium. This matrix would be expected to match well a typical surface water from southern British Columbia as experience has shown that organic material constitutes a large part of the dissolved solids content.

Experimental: A 200 ml aliquot of homogenized acid-preserved sample was evaporated to a few millilitres in teflon beakers. The residual material was transferred to a tared counting planchet and the final evaporation was completed under a infrared lamp to ensure uniform deposition. Samples were then dried in an oven at 105° C for 1 hour, cooled in a dessicator, weighed and counted for 100 minutes in the α, β-counter. Two background counts of 50 minutes each were performed every day and all detectors were checked daily using Am-241 and Cs-137 sources. Detection limits of 1 pCi/l for gross alpha activity and 3 pCi/l for gross beta activity were routinely obtained with this method. Where measurable activities are reported, the uncertainty associated with the measurement is reported at the 95 per cent (2 sigma) confidence level.

Reference: APHA Sec. 703, pp. 648-653.

Uranium in Silt Samples

Digestion: 1 gm sample – standard $HClO_4$ – HNO_3

Geochem digestion: 3.0 ml $HClO_4$ – 1.5 ml HNO_3 → 25 ml final volume

Extraction:
(1) Pipette 0.5 ml sample aliquot into 16 x 125 mm screw top tubes.
(2) Add 5 ml tetrapropylammonium hydroxide (TPAN) – $Al(NO_3)_3$ – NH_4OH reagent.
(3) Two ml MIBK.
(4) Cap and shake for 2 minutes on shaker.
(5) Allow phases to separate.

Fusion:
(1) Pipette 0.2 ml MIBK aliquot into platinum dish.
(2) Dry at low heat on hot plate.
(3) Add one 0.5 gm uranium flux pellet.
(4) Fuse at 650° C for 20 minutes.
(5) Remove slowly from furnace and cool in cooling trays for 45 minutes.

Run on Turner Fluorometer – 0–100 per cent (0.5 ppm detection limit).

(1) 0–25 ppm – 30X curve.
(2) 0–100 ppm – 10X curve.
(3) 0–400 ppm – 3X curve.

Standards: 0.5 ml of 0.2, 0.5, 1.0, 2.0, 4.0 μg/ml U standard solution in 10 per cent $HClO_4$ extracted the same as samples, which represent 5 ppm, 12.5 ppm, 25 ppm, 50 ppm, 100 ppm U respectively.

Reagents: TPAN – $A1(NO_3)_3$ – NH_4OH solution.
(1) 1050 gm $Al(NO_3)_3$ into 2 l beaker.
(2) Add H_2O up to 900 ml.
(3) Heat and stir to dissolve solid.
(4) Cool – cautiously add 67.5 ml NH_4OH and stir to dissolve any residue.
(5) Cool to below 50° C.
(6) Add 10 ml of 10 per cent TPAN.
(7) Transfer to 1000 ml volumetric flask and make up to volume.

Uranium in Water Samples

Procedure is similar to Uranium Geochem silts method except that there are two types of H_2O samples, Hydrogeochem and Environmental Modifications, as follows:

Hydrogeochem Uranium (standard $U-H_2O$)

(1) 25 ml sample aliquot taken to dryness in 30 ml beaker after acidification with 0.5 ml $HClO_4$.
(2) Residue taken up in 0.5 ml 10 per cent v/v $HClO_4$.
(3) After the beaker cools add 5 ml TPAN—aluminum nitrate reagent and swirl to mix and decante solution into 16 x 125 mm screw cap test tube.
(4) Add 2 ml MIBK.
(5) Extraction – same as for geochem silts.
(6) Pipette 0.2 ml MIBK extract into platinum dishes, evaporate to dryness, etc., same as silts.
(7) Standards to 0.5 ml of distilled water, add 0.1, 0.2, 0.5, 1.0 μg/ml U standard solution. These represent 2, 5, 10, and 20 ppb U respectively.

Calculation: $$\frac{(0.5 \text{ ml aliquot}) \quad (1.0\ \mu\text{g/ml U})}{25 \text{ ml } (H_2O \text{ volume})} = \frac{20\ \mu\text{g}}{\text{L}} = 20\ \mu\text{g}$$

Thus 0–20 ppb use 30X on new fluorometer. Samples with greater amounts of U are analysed via comparison to higher standards.

Environmental H_2O samples

(1) 50 ml H_2O aliquot take down to dryness with 0.5 ml $HClO_4$ (two 25 ml aliquots with two 0.5 ml $HClO_4$.
(2) Two 0.2 ml aliquots of MIBK extract are added to the platinum dish – 0.4 ml of sample MIBK extract.

NOTE: Standards are prepared as above for Hydrogeochem, that is, 0.5 ml of Blank, 0.2, 0.5, 1.0 μg/ml U but they represent 1.0, 2.5, and 5 ppb U.

(3) Thus 0–5 ppb U use 30X with detection limit of 0.05 ppb.

APPENDIX 8. CURRICULUM VITAE

A. SUTHERLAND BROWN was born in Ottawa in 1923. He received a B.A.Sc. degree from the University of British Columba in 1950 and a Ph.D. degree from Princeton University in 1954. He joined the British Columbia Department of Mines and Petroleum Resources in 1951, became Deputy Chief of the Mineralogical Branch in 1971 and Chief of the Geological Division in 1975. He has been the author of five departmental bulletins, including one on the geology of the Queen Charlotte Islands and co-author of one on the distribution of mineral occurrences in British Columbia. He has been author of many scientific papers including ones on mercury geochemistry, metallogeny, and the application of geochemistry to metallogeny. In 1976 he was both editor and a major contributor to the Canadian Institute of Mining and Metallurgy Special Volume 15, *Porphyry Deposits of the Canadian Cordillera*. He is a registered professional engineer, a Fellow of the Geological Association of Canada and the Geological Society of America, and a member of the Canadian Institute of Mining and Metallurgy and the Society of Economic Geologists. He is currently President of the Geological Association of Canada and Vice-President of the Canadian Geoscience Council, and a member of the Advisory Committee to the Geological Survey of Canada. He has been Co-Chairman of the Management Committee of the Federal/British Columbia Uranium Reconnaissance Program surveys.

NICHOLAS C. CARTER was born in Geraldton, Ontario, in 1937. He received a B.Sc. (geology) from the University of New Brunswick in 1960, and an M.S. from Michigan Technological University in 1962, and a Ph.D. from the University of British Columbia in 1974. From 1962 to 1964 he was employed as a geologist with the International Nickel Company of Canada Limited, at Copper Cliff, Ontario. In 1964 he joined the British Columbia Department of Mines and Petroleum Resources and was involved for a number of years with the study of porphyry deposits in various parts of Central British Columbia. He was appointed Senior Geologist, Resource Geology, in 1972 and Senior Geologist, Project Geology, in 1975. He has been author of many scientific articles on regional geology, geochronology, and mineral resources of Central British Columbia and was a major contributor to the Institute of Mining and Metallurgy Special Volume 15, *Porphyry Deposits of the Canadian Cordillera*. He has been on the Management Committee of the Federal/British Columbia Uranium Reconnaissance Program and has managed British Columbia regional geochemical programs. He is a registered professional engineer, a member of the Canadian Institute of Mining and Metallurgy and councillor (1973–1975) of District 6, and a Fellow of the Geological Association of Canada.

WESLEY M. JOHNSON, born in 1941 in Nelson, British Columbia, was employed for three years as an analytical chemist with Cominco Ltd., during which time he received his Certificate of Efficiency in Assaying in British Columbia. He obtained his B.Sc. degree in chemistry from the University of British Columbia in 1968 and his Ph.D. degree in chemistry from the University of Washington in 1971. Dr. Johnson served one year at McMaster University as a National Research Council Post-Doctoral Fellow prior to joining the British

Columbia Department of Mines and Petroleum Resources as Deputy Chief Analyst in 1972. He became Chief Analyst in 1973 and has held the position since that time. He is a Fellow of the Chemical Society (London), National President of the Spectroscopy Society of Canada (1979–1980), and Vice-Chairman of the Analytical Division of the Chemical Institute of Canada (1979–1980). Dr. Johnson was elected a Fellow of the Chemical Institute of Canada in 1979, is currently involved in co-authoring a second edition of a book entitled *Rock and Mineral Analysis*, and is the author of several scientific publications.

VITTORIO A. PRETO was born in Italy in 1938 and came to Canada in 1957. He received B.A.Sc. and M.A.Sc. degrees from the University of British Columbia in 1962 and 1964, respectively, and his Ph.D. degree from McGill University in 1967. Since then, he has been engaged in geological survey work with the British Columbia Department of Mines and Petroleum Resources in many areas of British Columbia but principally in South Central British Columbia. He is the author of two Ministry bulletins and many scientific articles. His studies have included the Rexspar deposit as well as the area surrounding it. He is a registered professional engineer, a Fellow of the Geological Association of Canada, and a member of the Canadian Institute of Mining and Metallurgy.

PETER A. CHRISTOPHER was born in Albion, New York, in 1944. He received his B.Sc. (1966) from The State University of New York at Fredonia, M.A. (1968) from Dartmouth College, and Ph.D. (1973) from the University of British Columbia. He has worked for several mining companies on prospecting and exploration programs for porphyry mineral deposits in the western United States and Canada. In 1973 and 1974 he served as exploration geologist for Newmont Mining Corporation and in 1974 assumed his current position as project geologist with the British Columbia Department of Mines and Petroleum Resources. His research has included K/Ar age dating of porphyry mineral deposits. Since 1976 he has been principally involved in the study of uranium deposits. He is author of many scientific articles including ones on uranium deposits in British Columbia. He is a registered professional engineer and a member of the Canadian Institute of Mining and Metallurgy and the Geological Association of Canada.

ADDENDUM SHEET

Page 32:

LEGEND

MIOCENE AND PLIOCENE

10	BASALT; OLIVINE BASALT (PLATEAU BASALT);
10A	UNCONSOLIDATED SEDIMENTS

EOCENE

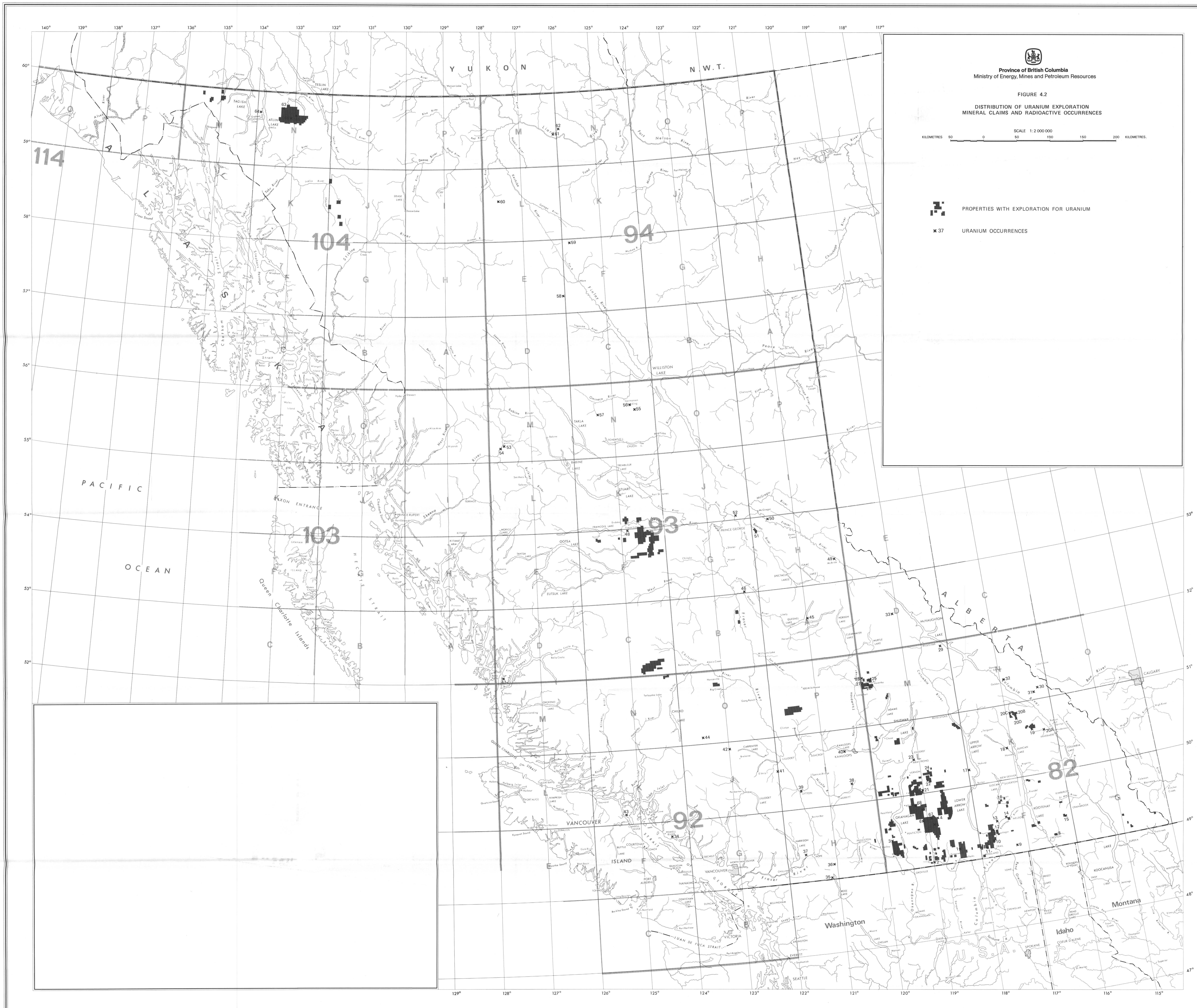
9	DACITE (MARAMA FORMATION ?); 9A – FEEDER
8	CORYELL, MAINLY SYENITE AND MONZONITE
7	KAMLOOPS GROUP TUFFS AND FLOWS AND RELATED VOLCANICLASTIC SEDIMENTARY ROCKS
6	KETTLE RIVER FORMATION

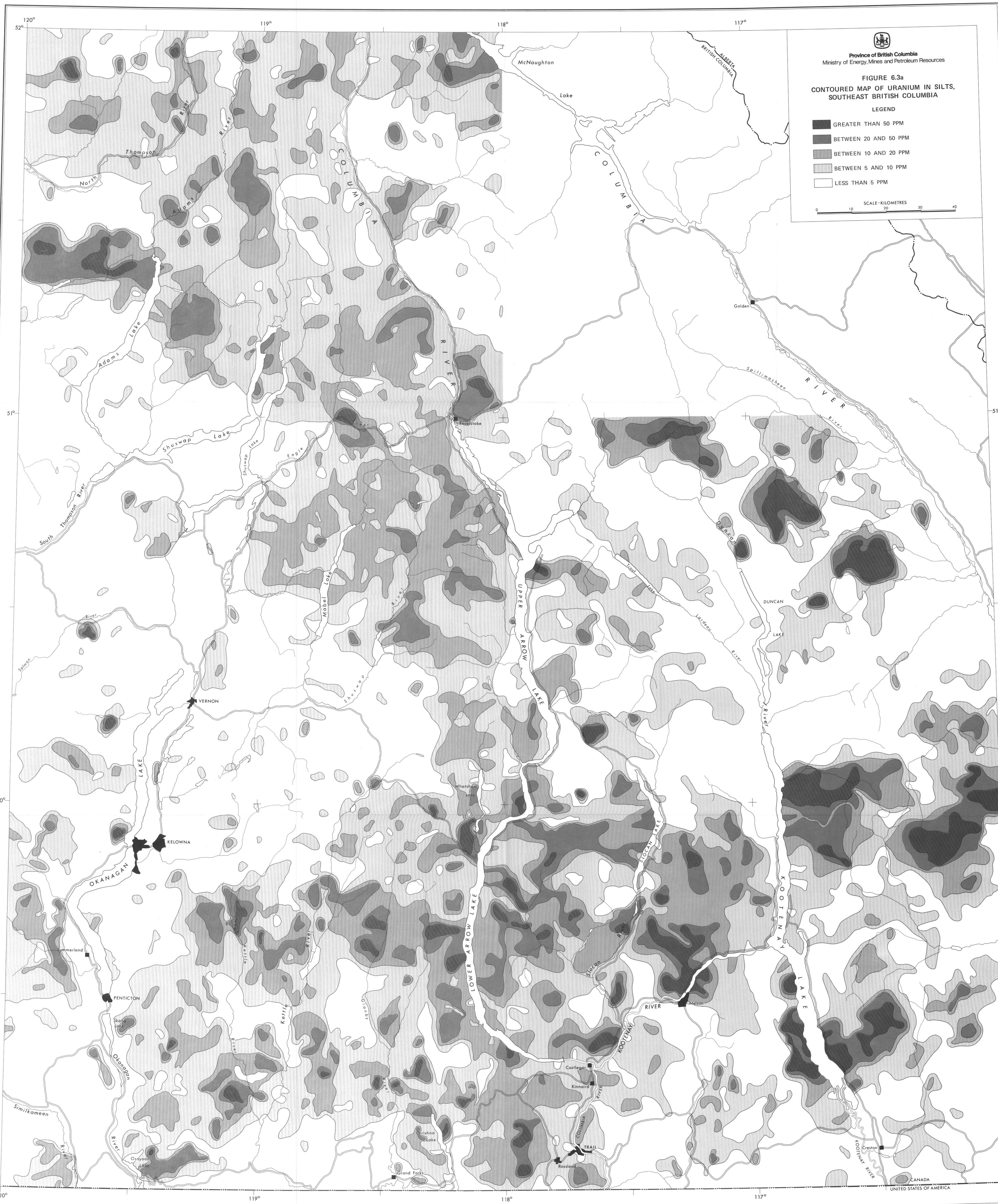
EARLY CENOZOIC (?) AND MESOZOIC

5	VALHALLA PLUTONIC ROCKS
4	NELSON PLUTONIC ROCKS; 4A – ALTERED NELSON

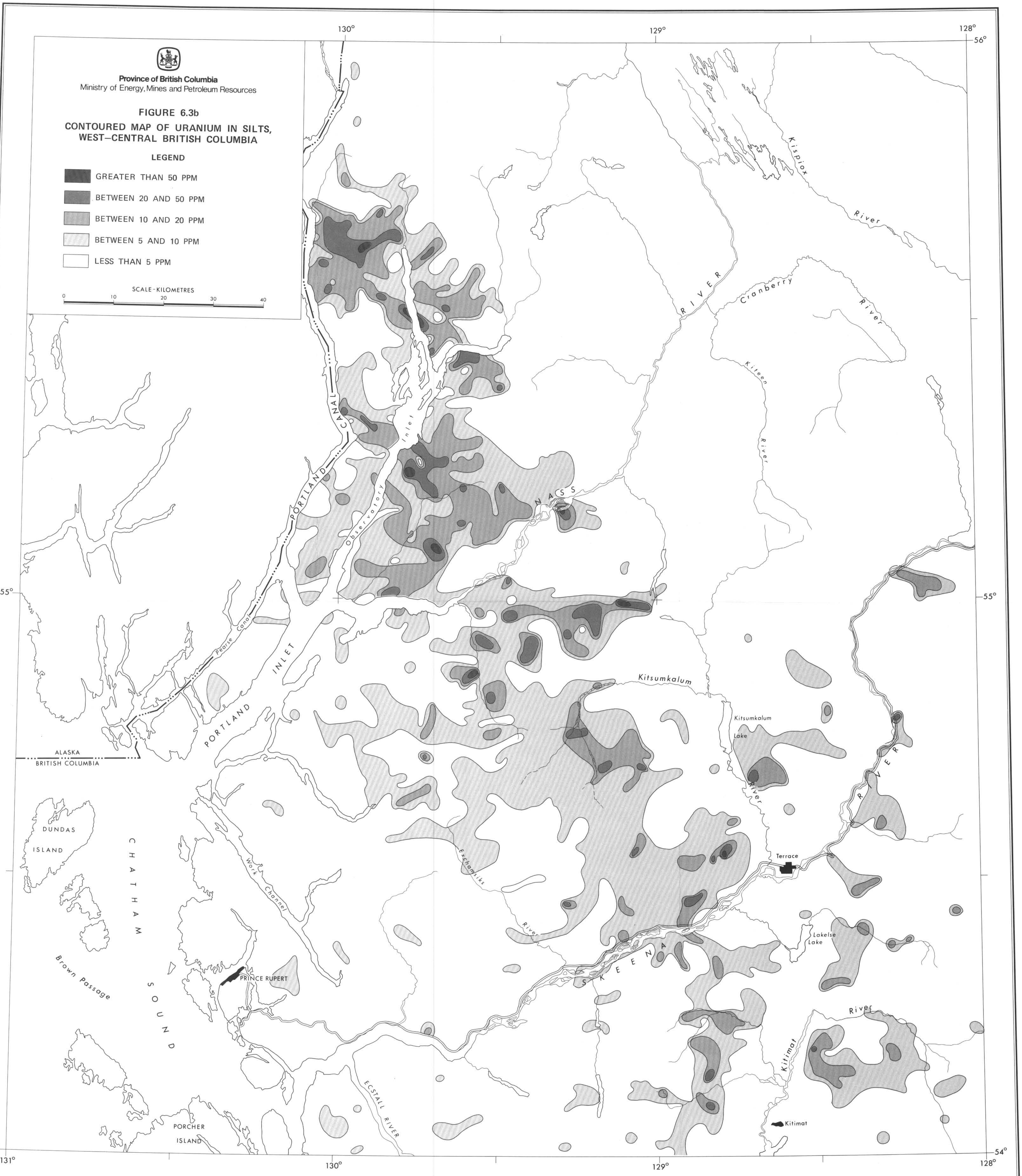
PALEOZOIC

3	CACHE CREEK GROUP; GREENSTONE
2	ANARCHIST GROUP OR WALLACE FORMATION (METASEDIMENTARY ROCKS)
1	MONASHEE GROUP LAYERED GNEISS; 1A – ALTERED MONASHEE


Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources
FIGURE 4.2
DISTRIBUTION OF URANIUM EXPLORATION
MINERAL CLAIMS AND RADIOACTIVE OCCURRENCES
SCALE 1: 2 000 000
KILOMETRES 50 0 50 100 150 200 KILOMETRES.
PROPERTIES WITH EXPLORATION FOR URANIUM
× 37 URANIUM OCCURRENCES
YUKON
N.W.T.
ALASKA
ALBERTA
PACIFIC OCEAN
Washington
Idaho
Montana
U.S.A.
114
104
94
103
93
92
82
VANCOUVER
VICTORIA
PRINCE RUPERT
PRINCE GEORGE
KAMLOOPS
CALGARY
SPOKANE
SEATTLE
WILLISTON LAKE
Queen Charlotte Islands
HECATE STRAIT
DIXON ENTRANCE
VANCOUVER ISLAND

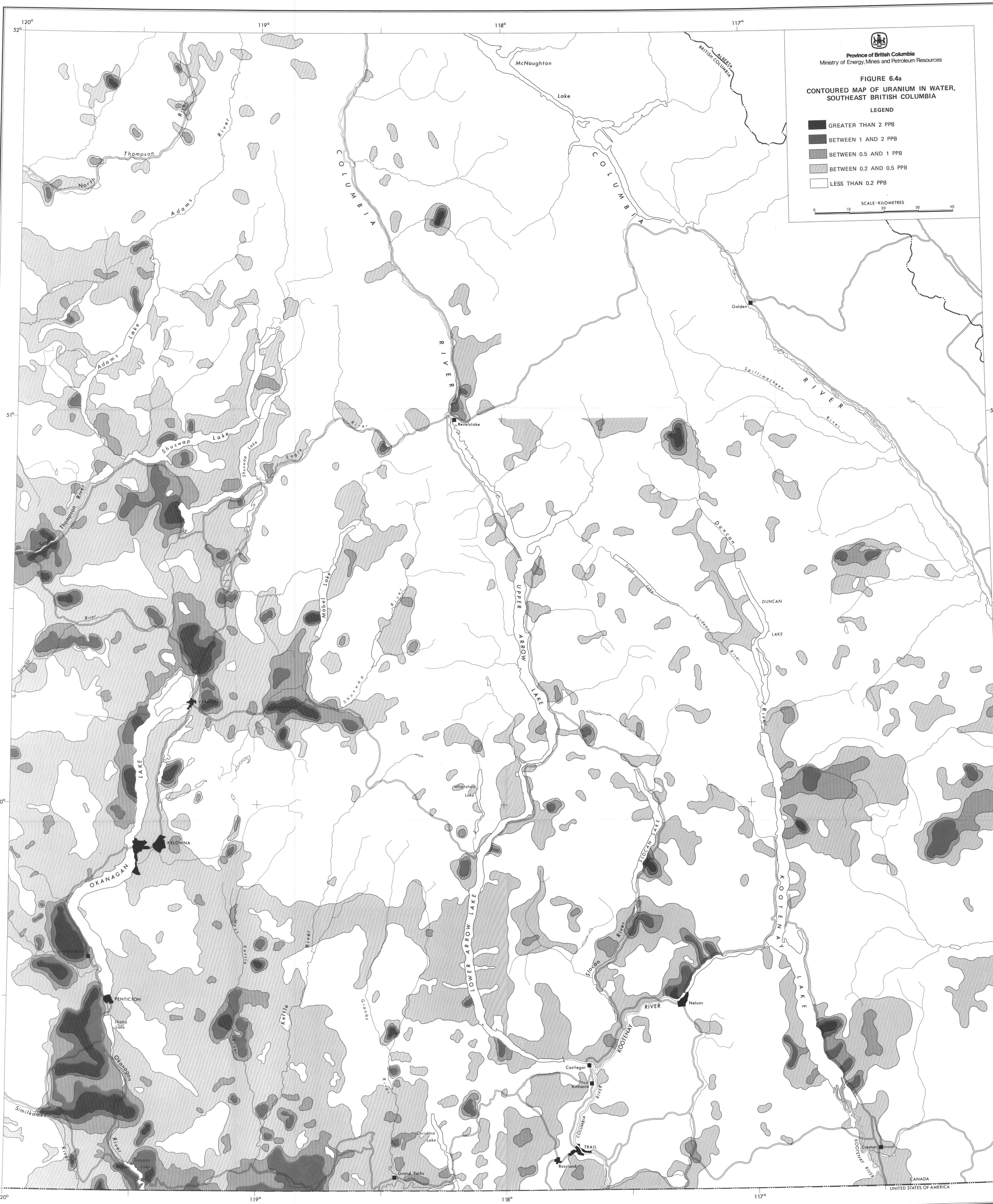


Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources
FIGURE 6.3a
CONTOURED MAP OF URANIUM IN SILTS, SOUTHEAST BRITISH COLUMBIA
LEGEND
GREATER THAN 50 PPM
BETWEEN 20 AND 50 PPM
BETWEEN 10 AND 20 PPM
BETWEEN 5 AND 10 PPM
LESS THAN 5 PPM
SCALE-KILOMETRES
0
10
20
30
40
120°
119°
118°
117°
116°
52°
51°
50°
49°
McNaughton
Lake
ALBERTA
BRITISH COLUMBIA
COLUMBIA
RIVER
Golden
Spillimacheen
Revelstoke
North
Thompson
Adams
Adams Lake
Shuswap Lake
Eagle
South Thompson River
Mabel Lake
Shuswap
UPPER ARROW LAKE
Trout Lake
Lardeau
Duncan
DUNCAN LAKE
VERNON
KELOWNA
OKANAGAN
LAKE
Whatshan Lake
LOWER ARROW LAKE
SLOCAN LAKE
Slocan
KOOTENAY LAKE
KOOTENAY RIVER
Nelson
Castlegar
Kinnaird
TRAIL
Rossland
Kettle River
Granby
Christina Lake
Grand Forks
Summerland
PENTICTON
Skaha Lake
Okanagan River
Similkameen River
Osoyoos Lake
Salmon River
Creston
CANADA
UNITED STATES OF AMERICA


Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources
FIGURE 6.3b
CONTOURED MAP OF URANIUM IN SILTS, WEST–CENTRAL BRITISH COLUMBIA
LEGEND
GREATER THAN 50 PPM
BETWEEN 20 AND 50 PPM
BETWEEN 10 AND 20 PPM
BETWEEN 5 AND 10 PPM
LESS THAN 5 PPM
SCALE-KILOMETRES
0
10
20
30
40
130°
129°
128°
56°
55°
54°
131°
Kispiox
River
RIVER
Cranberry
River
Kiteen
River
NASS
PORTLAND
CANAL
Observatory
Inlet
Pearse Canal
PORTLAND
INLET
ALASKA
BRITISH COLUMBIA
Kitsumkalum
Kitsumkalum
Lake
River
RIVER
Terrace
DUNDAS
ISLAND
CHATHAM
SOUND
Work
Channel
Exchamsiks
River
SKEENA
Lakelse
Lake
Brown Passage
PRINCE RUPERT
Kitimat
River
Kitimat
ECSTALL RIVER
PORCHER
ISLAND

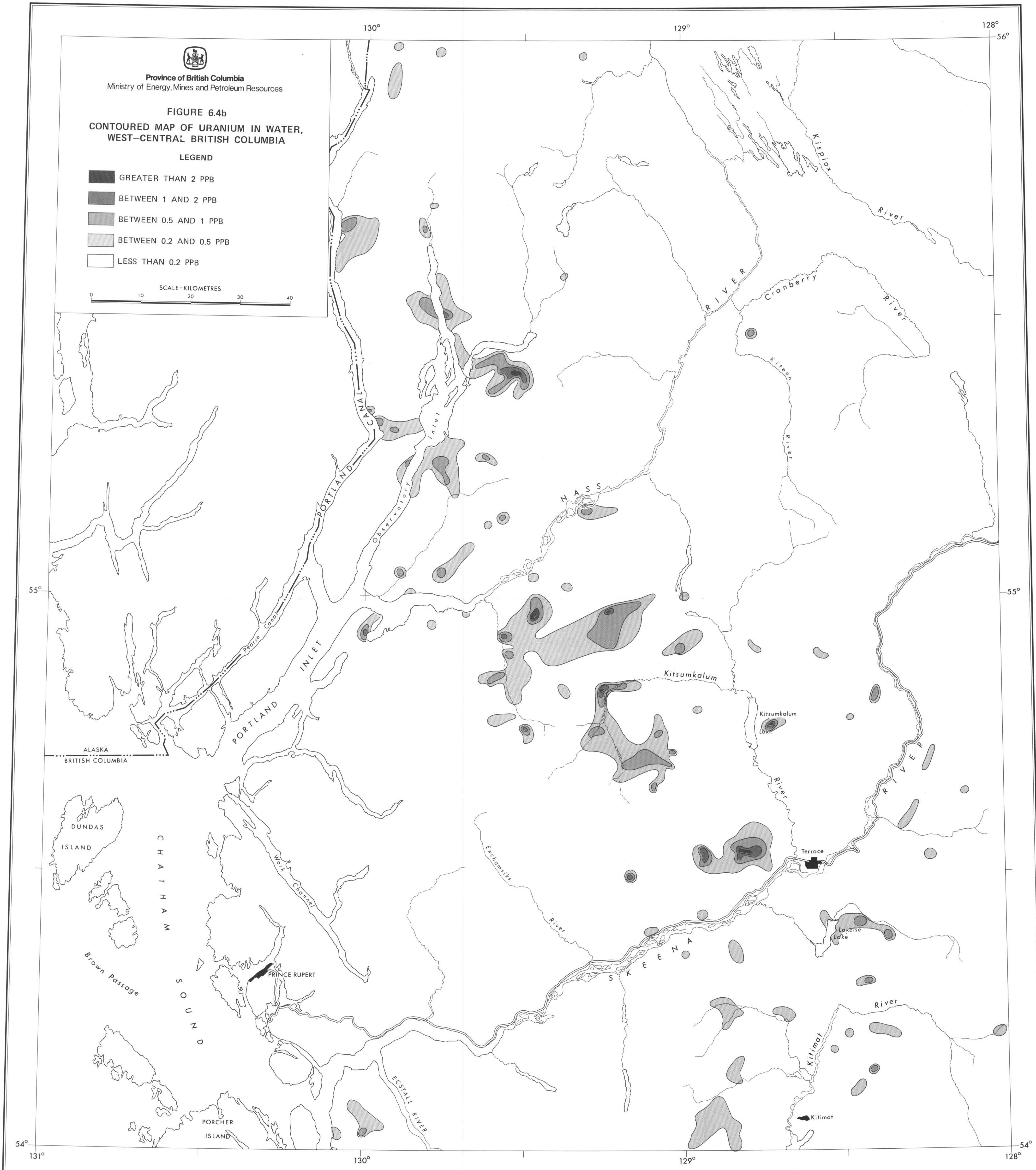
Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources
FIGURE 6.3c
CONTOURED MAP OF URANIUM IN SILTS, NORTH BRITISH COLUMBIA
LEGEND
GREATER THAN 50 PPM
BETWEEN 20 AND 50 PPM
BETWEEN 10 AND 20 PPM
BETWEEN 5 AND 10 PPM
LESS THAN 5 PPM
SCALE - KILOMETRES
0
10
20
30
40
YUKON TERRITORY
PROVINCE OF BRITISH COLUMBIA
60°
134°
133
132°
131°
130°
59°
133°
129°
128°
ATLIN
LAKE
Atlin
Torres Channel
Surprise Lake
Gladys
Gladys Lake
Gladys River
River
TESLIN LAKE
Teslin River
Swift River
ALASKA HIGHWAY
Jennings River
Nome Lake
Jennings Lakes
Little Rancheria River
Blue River
RIVER
DEASE
Deadwood Lake
Tuya Lake
Nakina River

104 N,O,P



Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources
FIGURE 6.4a
CONTOURED MAP OF URANIUM IN WATER, SOUTHEAST BRITISH COLUMBIA
LEGEND
GREATER THAN 2 PPB
BETWEEN 1 AND 2 PPB
BETWEEN 0.5 AND 1 PPB
BETWEEN 0.2 AND 0.5 PPB
LESS THAN 0.2 PPB
SCALE-KILOMETRES
0 10 20 30 40
120°
119°
118°
117°
116°
52°
51°
50°
49°
ALBERTA
BRITISH COLUMBIA
McNaughton
Lake
COLUMBIA
COLUMBIA
RIVER
Golden
Spillimacheen
RIVER
Thompson
North
Adams
River
Adams
Lake
Shuswap
Lake
Eagle
River
Revelstoke
Thompson
River
Mabel
Lake
Shuswap
River
UPPER
ARROW
LAKE
Trout
Lake
Lardeau
River
Duncan
DUNCAN
LAKE
VERNON
OKANAGAN
LAKE
KELOWNA
Whatshan
Lake
SLOCAN LAKE
KOOTENAY
LAKE
LOWER ARROW LAKE
Slocan
River
Nelson
RIVER
KOOTENAY
Castlegar
Kinnaird
COLUMBIA
RIVER
TRAIL
Rossland
PENTICTON
Skaha
Lake
Okanagan
Kettle
Kettle
River
Granby
River
Christina
Lake
Grand Forks
Similkameen
River
River
Osoyoos
Lake
Creston
KOOTENAY RIVER
CANADA
UNITED STATES OF AMERICA

82 E, F, K, L, M, N


Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources
FIGURE 6.4b
CONTOURED MAP OF URANIUM IN WATER, WEST–CENTRAL BRITISH COLUMBIA
LEGEND
GREATER THAN 2 PPB
BETWEEN 1 AND 2 PPB
BETWEEN 0.5 AND 1 PPB
BETWEEN 0.2 AND 0.5 PPB
LESS THAN 0.2 PPB
SCALE-KILOMETRES
0 10 20 30 40
130°
129°
128°
56°
55°
54°
131°
PORTLAND CANAL
Observatory Inlet
NASS RIVER
Kispiox River
Cranberry River
Kiteen River
Kitsumkalum
Kitsumkalum Lake
Kitsumkalum River
Pearse Canal
PORTLAND INLET
ALASKA
BRITISH COLUMBIA
DUNDAS ISLAND
CHATHAM SOUND
Brown Passage
Work Channel
Exchamsiks River
SKEENA RIVER
Terrace
Lakelse Lake
PRINCE RUPERT
ECSTALL RIVER
Kitimat River
Kitimat
PORCHER ISLAND

103 I, J, O, P


Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources
FIGURE 6.4c
CONTOURED MAP OF URANIUM IN WATER, ATLIN AREA
LEGEND
GREATER THAN 2 PPB
BETWEEN 1 AND 2 PPB
BETWEEN 0.5 AND 1 PPB
BETWEEN 0.2 AND 0.5 PPB
LESS THAN 0.2 PPB
SCALE-KILOMETRES
0
10
20
30
40
YUKON TERRITORY
PROVINCE OF BRITISH COLUMBIA
NO DATA
ALASKA HIGHWAY
Swift River
Gladys Lake
Gladys River
Surprise Lake
Pine Creek
Atlin
ATLIN LAKE
Torres Channel
TESLIN LAKE
Teslin River
Jennings River
Jennings Lakes
Nome Lake
Little Rancheria River
Blue River
DEASE RIVER
Deadwood Lake
Tuya Lake
Nakina
River
60°
59°
134°
133°
132°
131°
130°
129°
128°

104 N

Province of British Columbia

Ministry of
Energy, Mines and
Petroleum Resources