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GEOLOGY OF URANIUM AND ASSOCIATED ELEMENTS IN NEW BRUNSWICK

H.H. HASSAN, W.E. HALE AND M. CHRZANOWSKI

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by

H.H. HASSAN, W.E. HALE AND M. CHRZANOWSKI

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ABSTRACT

Eighty-two uranium occurrences have been identified in New Brunswick. Most of the data describing these occurrences is contained within assessment reports by claim holders to the provincial Department of Natural Resources and Energy. Additional information is contained within publications of the Geological Survey of Canada and in university theses.

Seven metallogenic uraniferous domains are identified in New Brunswick: the Gaspe Synclinorium, Aroostook-Matapedia Anticlinorium, Chaleur Bay Synclinorium, Miramichi Anticlinorium, Fredericton Trough, Avalonian Platform and the Carboniferous Basin. Of these seven domains, the Miramichi Anticlinorium, Fredericton Trough and the Carboniferous Basin appear to be the most promising.

The uranium occurrences in New Brunswick are preferentially associated with the Devono-Carboniferous rocks and appear to be related to deformational, magmatic and hydrothermal processes associated with the Acadian Orogeny.

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SECTION ONE
INTRODUCTION

1.1.0 Objectives of the Investigation

The objectives of this investigation are:

1) to complement present assessment of Canadian resources of uranium and associated elements
2) to provide information concerning the status of exploration in New Brunswick for uranium and the elements with which it is commonly associated and guidance for further exploration
3) to delineate environments within New Brunswick favourable for the occurrence of uranium deposits and associated elements
4) to prepare a basis for future detailed lithostratigraphical, structural, mineralogical and geochemical analysis of uranium and associated elements in New Brunswick
5) to develop conceptual genetic models for various types of deposits that contain uranium and associated elements.

1.2.0 Methods of Investigation

As a result of active uranium exploration in New Brunswick, particularly in the seventies, a large amount of data (published and unpublished) was compiled by the New Brunswick Department of Natural Resources and Energy, the Geological Survey of Canada and other organizations.

This published and unpublished data was reviewed, reorganized systematically, and analysed in the context of uranium metallogenesis in the Province. The goal of this metallogenetic study was to provide an improved assessment of the uranium resource potential and genetic interpretations of uranium occurrences in New Brunswick.

The approach followed in this study is to some degree, according to the guidelines outlined by Ruzicka (1982). These guidelines include: a) the general description of geological features associated with the uranium occurrences, b) establishment of conceptual models for various types of uranium deposits and, c) the interpretation of favourable geological, geochemical and geophysical features for uranium concentration in order to outline new areas of potential exploration interest.

A total of eighty-two uranium occurrences were reviewed in this investigation. With these occurrences, the inferred types of mineralization, metal and mineral associations, host rock geology and structure, alteration and exploration techniques used in their evaluation were also reviewed and summarized (Appendix I) in this report.

The uranium occurrences in New Brunswick were plotted on a 1:500,000 structural map of New Brunswick (modified after Fyffe et al., 1982). Later, the uranium occurrences (Fig. 1) were divided into seven distinctive metallogenic uraniferous domains (the Gaspe Synclinorium, Aroostook-Matapedia Anticlinorium, Chaleur-Bay Synclinorium, Miramichi Anticlinorium, Fredericton Trough, Avalonian Platform and the Carboniferous Basin) according to the lithotectonic zones of New Brunswick described previously by Rodgers (1971), Ruitenberg et al. (1977) and Fyffe et al. (1981).

A generalized metallogenic chart for the New Brunswick uranium occurrences was also prepared to illustrate the relation of these occurrences with the lithotectonic settings, geologic age of their host rocks, metamorphism, volcanism and intrusive activities (Fig. 2).

The occurrences were indexed by M. Chrzanowski on a special format 'CANMINDEX' provided by the Geological Survey of Canada for this purpose and submitted separately from this report to the Geological Survey of Canada.

1.3.0 Previous Investigations

Radioactive minerals were first discovered in New Brunswick in 1953 (Gross, 1957) at Shippegan Island, Hampton, Shediac River and Harvey Station (Fig. 1). These discoveries led federal and provincial agencies and several exploration companies to explore for uranium in the province. An extensive search for uranium started in 1975, following the signing of the Federal-Provincial Uranium Reconnaissance Program (URP). The initial phase of this program involved airborne gamma-ray spectrometric traverses in 1976, over New

Brunswick (except for the area underlain by the Carboniferous Basin) at five kilometres line-spacing. Results of this survey were released by the Geological Survey of Canada in the spring of 1977. Later, extensive follow-up including: ground gamma-ray spectrometric surveys (e.g., Chandra, 1981; Ford, 1982 and Hassan, 1984), lake and stream sediment surveys and water sampling for geochemical analysis of uranium (e.g., Austria, 1976-1979) were carried out.

Several other reconnaissance and detailed investigations, including geophysics and geochemistry have been carried out by the personnel of the New Brunswick Department of Natural Resources and Energy, the Geological Survey of Canada, the University of New Brunswick and numerous exploration companies.

In these investigations, several favourable areas for uranium mineralization were delineated. These included: the Devonian/Mississippian granitic rocks of the Miramichi Anticlinorium, the Devonian/Mississippian granitic rocks of Eastern Charlotte Pluton and the Mississippian felsic volcanic and volcanogenic sedimentary rocks of the Harvey Station and Mount Pleasant areas and the sedimentary rocks of the Carboniferous Basin (Fig. 1).

In an attempt to locate uranium deposits similar to those discovered in the Colorado Plateau, USA ('roll-front' sandstone-type), A.Y. Smith (1968) of the Geological Survey of Canada analysed stream sediment samples for their uranium contents in the Carboniferous rocks of the Moncton Subbasin (Fig. 1). These rocks have striking similarities with rocks of the Colorado Plateau uranium districts which suggested that some uranium potential may exist in New Brunswick Carboniferous Basin as well. Results of this survey indicated the presence of anomalous uranium in stream sediments, particularly over areas underlain by rocks of the Windsor Group. The Windsor Group comprises marine limestone and evaporites and is overlain by conglomerate and red sandstone. A thin rhyolitic ash bed lies at the base of the Windsor Group and is probably similar in age to those rhyolites of Harvey Station which contain significant uranium (Smith, 1968). Dyck et al. (1976) conducted reconnaissance well water analyses for U, Rn, He, F, CH_4, Zn, Cu, Pb, Mn, Fe, pH, conductivity and alkalinity over large areas. According to these authors, chemical reaction cells (or roll-fronts) similar to those observed in the uranium mining districts of Colorado and Wyoming were identified. Most of the uranium anomalies detected in this latter survey were located at the edge of the Moncton Subbasin around previously known occurrences such as Jordan Mountain, Dee Brook, Havelock, Lutes Mountain and Shediac. A new anomalous uranium occurrence was also located in the Cape Tormentine area by this well survey.

Uranium mineralization was discovered at the Lake George antimony mine (Fig. 1) by V. Ruzicka and H.E. Dunsmore of the Geological Survey of Canada (Ruzicka and Littlejohn, 1981). There, uranium occurs as fracture filling associated with the quartz-stibnite veins in Silurian shale, greywacke and quartzite that are intruded by Devonian granitic rocks of the Pokiok Batholith. The uranium minerals recognized were uranoan hydrocarbon (a thorium-free mixture of hydrocarbon, pitchblende, coffinite and iron oxides), coffinite, pitchblende and thucholite (Ruzicka and Littlejohn, 1981).

Field investigations of the airborne gamma-ray spectrometric maps and profiles by K.L. Ford of the Geological Survey of Canada during parts of the 1977 and 1980, field sessions indicate that major regional radioelement anomalies in New Brunswick are related to felsic igneous rocks (Ford, 1982). The maximum concentration of uranium is associated with the younger (Devonian/Mississippian) and highly differentiated (two-mica) phases of the granites. The same conclusion was reached by Chandra (1981) where he identified uranium favourability indices from the aeroradiometric data using the formulas of Saunder (1978).

Uranium distribution in southwestern New Brunswick was investigated in detail by Hassan (1984), using in-situ gamma-ray spectrometry. This investigation revealed that post-Acadian rocks have, in general, higher uranium content than pre-Acadian rocks and that uranium concentrations in the Devonian to Carboniferous granite of the Charlotte Pluton and Mississippian rhyolitic rocks at Harvey Station are of potential economic interest. Vein-type uranium mineralization was discovered during this study in the granitic rocks of Eastern Charlotte Pluton near Welsford (Fig. 1). It was suggested by Hassan (1984) that supergene and hydrothermal processes were active in the eastern end of the Eastern Charlotte Pluton and these were responsible for redistributing uranium after it had been initially concentrated by magmatic differentiation. The uraniferous Eastern Charlotte Pluton is chemically, geologically and geophysically similar to other uraniferous granites in the U.S.A. and Europe (Hassan 1984).

In 1985, D.V. Venugopal compiled and up-graded data on 52 uranium occurrences in New Brunswick (Venugopal, 1985). His compilation served as a background for this study.

1.4.0 Nature and Limitation of Results

Results of the present study reveal in general that New Brunswick is favourable for uranium concentration associated, in some deposits, with varying amounts of Cu, Pb, Zn, Mo, Sn, W, Ag, Sb and Au. The most promising areas for economic uranium concentration appear to be within the Miramichi Anticlinorium, Fredericton Trough and the Carboniferous Basin.

Only limited field work was done in support of results compiled and reported here. The report is largely based on assessment data in the files of the New Brunswick Department of Natural Resources and Energy. This data varies considerably in age, quality and quantity among the occurrences. This report must therefore be considered a current compilation.

The 1:500,000 scale 'Uraniferous Domains' map of New Brunswick, and the 'Uranium Metallogenic' chart, prepared for the present report summarize present knowledge on uranium and associated elements in the province.

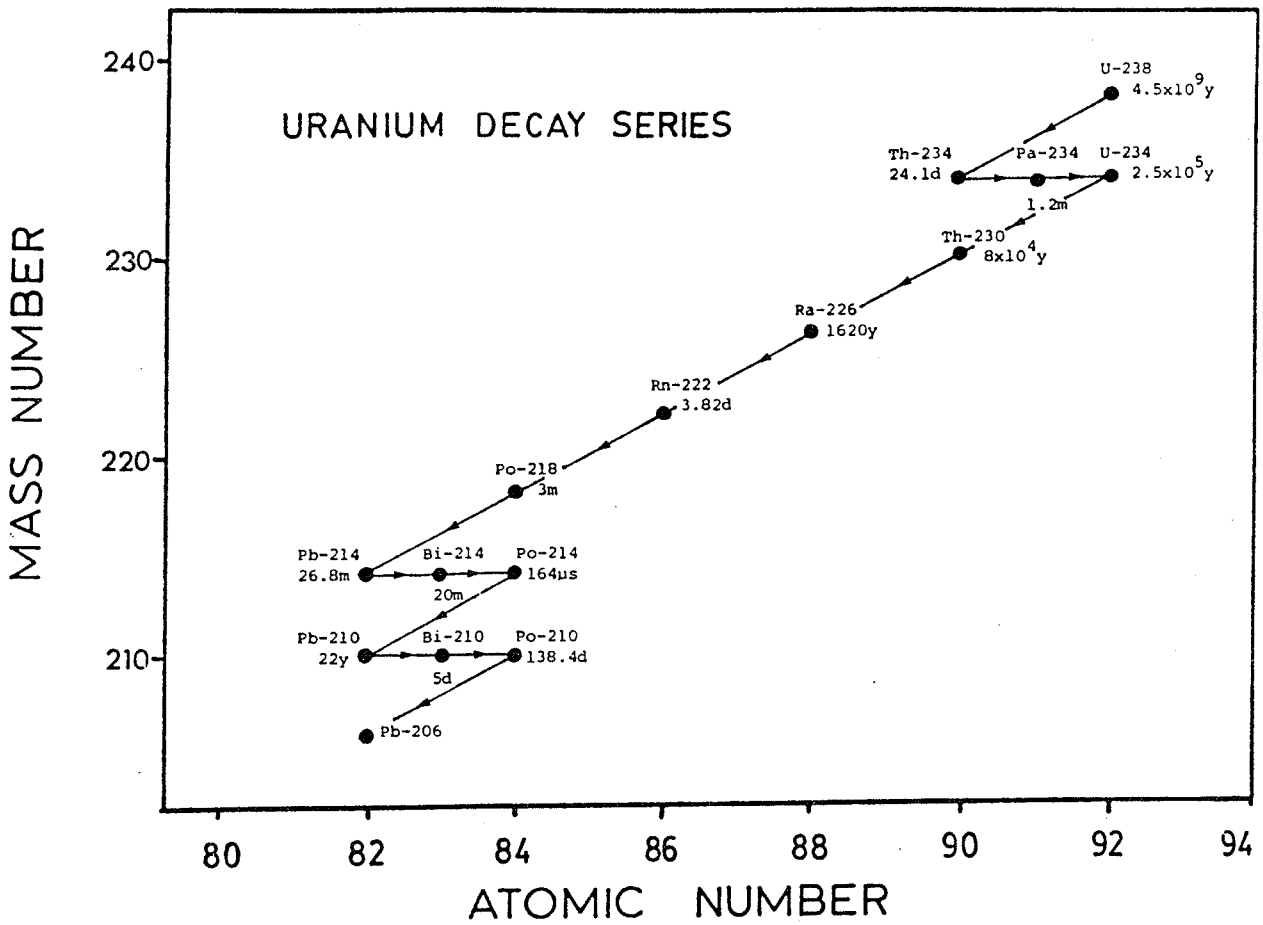


Fig. 3. The ^{238}U decay series (modified after Rieppo,1978)

SECTION TWO

RADIOACTIVITY, RADIOACTIVE DISEQUILIBRIUM AND GEOCHEMISTRY OF URANIUM

2.1.0 Radioactivity and Radioactive Disequilibrium

Radioactivity was observed as early as 1867, when Niepce de Saint-Victor noticed fogging of photographic silver chloride emulsions by uranium salts. He reported that blackening of the emulsions occurred even when they were separated from the uranium salts by thin sheets of paper. He did not recognize the true cause of the blackening; but, this was later identified as radioactivity by Marie Curie in 1898. Radioactivity is used to detect uranium distribution in nature. The radioactivity measured by the gamma ray spectrometer is actually that emitted by bismuth (^{214}Bi) a daughter product of the uranium decay series (Fig. 3). Bismuth has a distinctive gamma ray emission which is easier to detect than emissions from other members of the series. Uranium contents determined in this manner are reported as uranium 'equivalent' (eU) to bismuth, assuming the series to be in equilibrium, i.e., that all members of the series are present in amounts dependent only on disintegration without any gains or losses of members by other means such as solution, gas escape etc. from the original mineral host.

The problem facing uranium explorationists when assaying uranium in nature by using radiometric methods, is that erroneous estimates of uranium will be obtained when nonradiogenic gains or losses of some members has occurred. The series is then said to be in disequilibrium.

In any rock that has remained a closed chemical system for a sufficient amount of time (about 5×10^5 years for the ^{238}U series) the radioactive equilibrium condition is attained.

Equilibrium is established in a radioactive series when all the daughter products decay at the same rate as that at which they are produced. If, for some reason all or part of one or more of the daughters or parents is lost from the system, the series will be in a state of disequilibrium, and the radioactivity of ^{214}Bi will not correspond to the amount of uranium present in the rocks.

Disequilibrium in the ^{238}U decay series (Fig. 3) often occurs because decay products in the series have different chemical and physical properties from the parent ^{238}U and each other. This leads to the fractionation of the daughters from the parent. The main causes of ^{238}U decay series disequilibrium are the following:

1) Leaching of ^{234}U relative to ^{238}U in nature (Cherdynstev, 1971)
2) Severe disequilibrium in the uranium decay series is caused by ^{222}Rn migration
3) Preferential leaching of uranium relative to the immobile daughter product ^{234}Th
4) Separation of ^{226}Ra from the ^{238}U decay series by groundwater leaching and transportation.

2.2.0 Radioactive Disequilibrium in the Rocks of New Brunswick

Uranium values presented in this report are mainly determined by using radiometric techniques on samples in which disequilibrium is encountered, and unreliable estimates of uranium are likely in many cases. Unfortunately, the problem of radioactive disequilibrium is not considered, or even estimated in most other investigations. However, it is of interest to give a general background on the status of uranium equilibrium in the rocks of New Brunswick.

Chandra (1981) has analysed 90 rock samples (from various rock types) in New Brunswick for uranium by using both in-situ gamma-ray spectrometry and neutron activation analysis and obtained a correlation coefficient of 0.72 between the uranium values measured by the two techniques. Chandra relates this discrepancy in uranium measurement, in part to radioactive disequilibrium in the uranium decay series.

Laboratory analyses by gamma-ray spectrometry and delayed neutron counting were carried out by Ford (1982) on rock samples collected in New Brunswick, in an attempt to test for the possibility of disequilibrium between elemental

uranium and equivalent uranium. For 54 rock analyses, Ford noticed a good correlation between elemental uranium and equivalent uranium on an average basis which was attributed to radioactive equilibrium in uranium on a regional basis. However, considerable disequilibrium was detected on the local scale (outcrop scale).

Radioactive equilibrium is considered to be attained within the fresh rocks of southwestern New Brunswick (Hassan, 1984). However, Hassan has suggested that disequilibrium is widespread in rock samples exhibiting weathering, alteration and vein mineralization.

In summary, it appears that secular radioactive equilibrium in the uranium series has, in general, prevailed for rocks of New Brunswick on a regional scale and in fresh rock samples. However, a deviation from this equilibrium exists locally particularly in weathered, altered and veined samples. Therefore, to avoid the disequilibrium problem in rocks of New Brunswick it is necessary to 1) collect fresh samples, 2) increase the sampling density and 3) collect samples from all portions of the outcrop to avoid clustering samples.

2.3.0 Geochemistry of Uranium

2.3.1 General Statement

Uranium has three naturally occurring radioactive isotopes; ^{238}U, ^{235}U and ^{234}U with relative natural abundances of 99.274, 0.720 and 0.006 respectively (Dongarra, 1984). Of the five valence states of uranium, U(II), U(III), U(IV), U(V) and U(VI), only the tetravalent and hexavalent states are of geologic importance.

Uranium is a lithophile element. Because of its large ionic size and high charge it is incompatible within the lattices of most abundant rock- forming minerals of the earth's mantle and hence is strongly partitioned into any residual liquid phases during crystallization of magma.

2.3.2 Uranium in Soils

The uranium content of soils is highly variable. It ranges from less than 1ppm to 8ppm for normal soils with an average of about 1ppm (Boyle, 1982). In uraniferous areas values as high as 50ppm were detected (Boyle, 1982). In normal soils the uranium content in the C horizon is, in general, higher than in the A horizon. In residual soils, the uranium content is dependent essentially on the type of parent rock. For instance, residual soils developed on felsic igneous rocks contain higher uranium than those developed on mafic igneous rocks.

Humic constituents of soils are the most effective trapping agents for uranium in natural waters (Nash et al., 1981).

2.3.3 Uranium in Aqueous Solutions

The uranium content of natural terrestrial waters is small (0.2ppb) and in waters leaching uraniferous zones it ranges from 1 to 10ppb (Boyle, 1982). For streams and ground waters in contact with uranium deposits a value of 50ppb or more is reported (Boyle, 1982), especially in those waters rich in sulphate, chloride, nitrate, carbonate, phosphate, or humic matter. Uranium content of groundwater is generally greater than that of surface waters in the same terrane.

Uranium moves in solution usually as the uranyl ion. In pure water, uranium exists in the form of uranyl and uranous ions and their hydrates (Lisiten, 1962; Dongarra, 1984). In solutions, uranium persists as uranyl ion and forms complexes with fluoride, chloride, phosphate, sulphates, carbonates and silicates (Naumov, 1961; Dyck, 1975; Langmuir, 1978a, 1978b).

In hydrothermal solutions, uranium is mainly transported in the form of a carbonate (Naumov, 1959; Romberger, 1984). This is indicated by the presence of CO_2 in most uranium-bearing hydrothermal solutions and in the high solubility of U(VI) in carbonated, aqueous solutions. Oxidation (i.e., hematitization) of host rocks and the absence of thorium minerals from hydrothermal uranium deposits suggest that uranium is transported in solution in the hexavalent form and reduced only at the time of deposition.

Under acidic conditions, the most abundant complexes are: uranium hydroxides and oxides (Carpenter et al. 1979); uranium sulphates (Dyck, 1978) and uranium fluorides (Langmuir, 1978b). Phosphate, and humic complexes are important under near neutral conditions (Langmuir, 1978b). Silicate complexes, are predominant in neutral solutions (Dyck, 1975; Carpenter et al., 1979; Soyer, 1984).

Under reducing conditions, uranium is precipitated as primary uranium minerals. The uranous minerals formed tend to be black or brown in colour and are variably metamict (Hutchinson and Blackwell, 1984). The most important uranous minerals are uraninite, pitchblende and coffinite.

Under oxidizing conditions, uranium is precipitated as secondary uranium minerals. The uranyl minerals formed tend to be bright yellow, red,

orange or green. The most common uranyl minerals include autunite, torbernite and uranophane.

The precipitation of uranium from aqueous solutions requires a process of reduction or adsorption. Important reducing mechanisms that may cause the precipitation of uranium from solutions include: a) addition of H_2S or HS- from sulphide minerals to the solution, b) degradation of organic matter or natural gas, c) the oxidation of ferrous to ferric iron in sulphide minerals in adjoining rocks and d) methane or carbon dioxide reduction by the action of decaying organic matter or oxidation of graphite. Uranium precipitation can also be carried out by bacterial fixation, rapid pressure loss accompanied by CO_2 boiling, and by rapid temperature or pressure decreases that result in saturation of the solution.

Adsorption has a significant role in the accumulation of uranium from solutions. Among the minerals which have a strong adsorptive capacity for uranium are illites, goethite, hematite, rutile, ilmenite, leucoxene and zeolites, as well as organic compounds.

2.3.4 Uranium in Igneous Rocks

2.3.4A. Plutonic Rocks

The association of uranium with granitic rocks is well known. It is mainly due to the increase in the content of uranium with increasing silica content reflected in an increase in the differentiation index.

A positive correlation between SiO_2 content and uranium abundance was found by Tilling and Gottfried (1969) for rocks of the calc-alkaline Boulder Batholith, Montana. A closer correlation was observed when uranium is plotted against the 'Peacock index' (the weight percentage of SiO_2 at which the weight percentages of CaO and (Na_2O + K_2O) are equal). It appears from the data cited in the literature that the abundance of uranium is higher for rocks of lower 'Peacock index'. For instance, uranium content is higher in the Boulder Batholith (calc-alkaline) than in the Southern California Batholith (calcic).

Volatile components of a magma (particularly F and Cl) play an important role in uranium concentration. Magmas that have retained their volatiles tend to retain uranium (Nishimori et al., 1977). Therefore, high uranium concentrations in late differentiated rocks usually correlate positively with the content of volatiles. Sorenson (1977) has reported that peralkaline magmas, particularly silica-undersaturated magmas of agpaitic type (rocks that have a ratio of (Na + K)/Al greater than unity) strongly retain such volatiles as F during crystallization. Therefore such rocks as the nepheline syenite of the Ilimaussaq Complex of South Greenland, contain high ^{214}Bi) uranium (as much as 0.1 wt. % uranium).

Confining pressure at the time of magmatic crystallization may affect the concentration of uranium in igneous rocks. Carpenter et al. (1979) have pointed out that at pressures below 1.5 kilobars uranium is usually released during devolatilization and concentrated in hydrothermal solutions. At pressures of 5.0 to 10.0 kilobars, however, alkali and silica remain in very hydrous residual solutions to form pegmatites which may be uraniferous if the original magma was enriched with uranium.

Recently, attempts have been made to distinguish between the characteristics of uraniferous and nonuraniferous granites. Darnley (1982) has used the term 'uraniferous granite' for those granites that contain at least twice as much uranium as the average granite (more than 8.0ppm U). The term 'uraniferous' does not necessarily indicate the presence of separate uranium minerals in such granites.

It was suggested by Moreau (1976), on the basis of his investigations of the plutonic rocks of the Massif Central, France, that uraniferous granites have S-type characteristics (generated by anatexis of aluminous sediments): peraluminous, high silica; high initial $^{87}Sr/^{86}Sr$ ratio and low ferric iron. Plant et al. (1980), on the other hand, indicated that in the British Isles the distinctions between uraniferous and nonuraniferous granites on the basis of being S- or I-type (the latter generated from melts of pre-existing igneous rocks) are not clear cut. Moreover, many uraniferous granites have some S-type characteristics as a result of near-surface water-magma interaction and are probably modified I-type granites.

Studies of uraniferous and non-uraniferous granites of France (e.g, Moreau, 1976), and Britain (e.g. Simpson et al., 1979; Plant et al., 1980; Hennessy, 1981; Halliday, 1981), Ireland (O'Connor, 1981); east Greenland (Steenfelt, 1982), eastern U.S.A. (Rogers et al. 1978) and Colorado, U.S.A. (Howarth et al., 1981) have resulted in the identification of significant structural, mineralogical, petrological, geochemical and geophysical criteria that distinguish uraniferous granites from non-uraniferous granites. A compilation of these criteria from these several studies follows:

A - Structural criteria:

1 - Post-orogenic

2 - Epizonal

B - Mineralogical and petrological criteria:

1 - Highly differentiated silica- and alkali-rich phases

2 - Calc-alkaline or alkali-calcic characteristics of magma

3 - Crystallized under conditions of low partial pressure of water

4 - Abundance of such accessory minerals as uraninite, uranothorite, thorite, fluorite, topaz, beryl, cassiterite, xenotime, monazite and apatite

5 - Characterized by the presence of biotite and muscovite (two-mica granites), i.e., peraluminous

6 - Alterations are common; sericitization and/or kaolinization of feldspars, hematization and chloritization of ferromagnesian minerals, greisenization and tourmalinization.

C - Geochemical criteria:

1 - High mean contents of Th, Rb, K, Sn, Nb, Y, Cs, Ta, Li, Be and F

2 - Low mean contents of Ca, Mg, Ti, Fe, Ba, Sr and Zr

3 - High U/Th, Rb/Sr, Cs/K and K/Ba ratios

4 - Low K/Rb and Sr/Y ratios

5 - Enriched in light rare-earth elements with a marked negative Eu anomaly.

D - Geophysical criteria:

1 - Strong negative Bouguer gravity anomalies of the order of -40.0 milligals relative to the surrounding rocks (Darnley, 1982)

2 - Strong, large-amplitude, long-wavelength, ring-shaped magnetic anomalies

3 - High heat-generating capacity which may be up to four times greater than that of average granite (Darnley, 1982). (Average granite has a heat-generating capacity of about 19.0 cal/m^3/year).

2.3.4B. Volcanic Rocks

As in plutonic rocks, uranium tends to be enriched in the more differentiated phases of a cogenetic volcanic suite. But uranium is slightly more abundant in volcanic rocks than in their plutonic equivalents (Adams, 1954). This is probably the result of the rapid cooling of lavas allowing the greater part of the uranium to be retained while the slower cooling of intrusive magmas permits accumulation of uranium in a separate fluid phase (Klepper and Wyant, 1965, as cited in Kovalev and Mulayasova, 1971). For the same reason Kovalev and Mulayasova (1971) have suggested that the uranium content of extrusive rocks provides a more accurate clue to the initial uranium content of the magma. Volcanic rocks are of special interest because they may represent important primary sources of uranium which, on mobilization, may form uranium ore deposits in sedimentary basins.

Volcanic rocks usually accommodate uranium in the matrix, such as in volcanic glass, rather than in the phenocrysts. Furthermore, there is a close correlation between the amount of fluorine and chlorine, two other elements markedly incompatible with most rock-forming minerals, in the glass and the whole-rock uranium contents (Shatkov et al., 1970; Rosholt et al., 1971). Uranium in felsic volcanic rocks such as rhyolite can also be concentrated in such accessory minerals such as zircon, sphene and apatite (Zielinski, 1978).

2.3.5 Uranium in Sedimentary Rocks

Significant concentrations of uranium are found in some sedimentary rocks of marine origin, particularly those rich in organic material, such as black shales and phosphatic rocks.

In non-marine sedimentary rocks, uranium can be removed from weathering solutions by a number of reducing agents (particularly organic matter, Fe^{2+} and sulphides) and precipitate as uraniumoxides or hydrates (Dongarra, 1984).

Uranium has a great affinity for carbonaceous material (peat, lignite and sub-bituminous coal) in sediments, provided that the carbon has not gone too far in its fixation to chemically inert forms approaching graphite (Gruner, 1956). Uranium is reported to be associated with coals as in the coalfield sandstones of the Colorado Plateau, U.S.A. (Breger, 1974).

Most of the uranium deposited in sedimentary rocks occurs in detrital, continental sandstones of fluviatile, littoral or lacustrine origin (Gasparini and Mantovani, 1980). The most favourable host for uranium, according to Bowie (1979), is impure, medium- to coarse-grained, quartz sandstone that contains clay minerals, volcanic ash and plant remains. The uranium content of clastic sedimentary rocks is thought to vary with grain size

and colour (oxidation-reduction states). For example, Simon and Rose (1980) have noticed a negative correlation between uranium abundance and grain size, probably because the finer grains contain a higher proportion of organic material. In addition, they found that, if grain size is constant, uranium abundance increases from red (oxidized) to green (reduced) sandstones and shales.

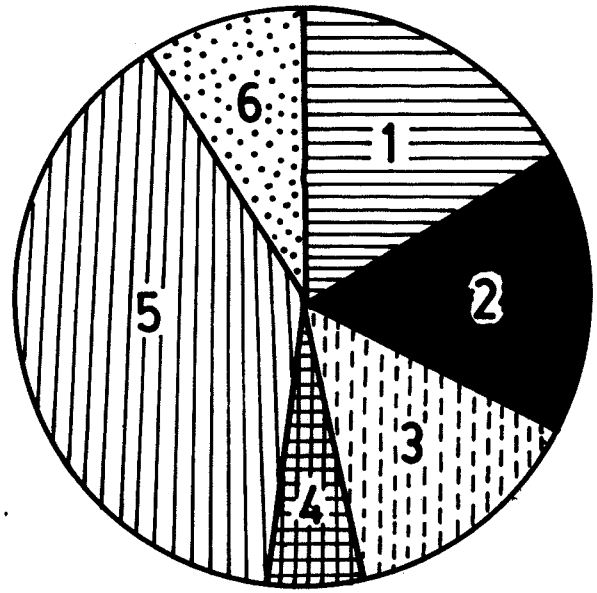
Sorption has a significant role in the accumulation of uranium in sedimentary rocks. Langmuir (1978a; 1978b) calculated the 'enrichment factor', which is the weight of sorbed uranium per weight of sorbent plus uranium, for common sorptive material and ranked the following materials according to their sorption potential: kaolinite (low), montmorillonite, phosphorites, fine- grained natural geothite, peat, amorphous Fe^{+3}, oxyhydroxides, and amorphous $Ti(OH)_4$ (high).

2.3.6 Uranium in Metamorphic Rocks

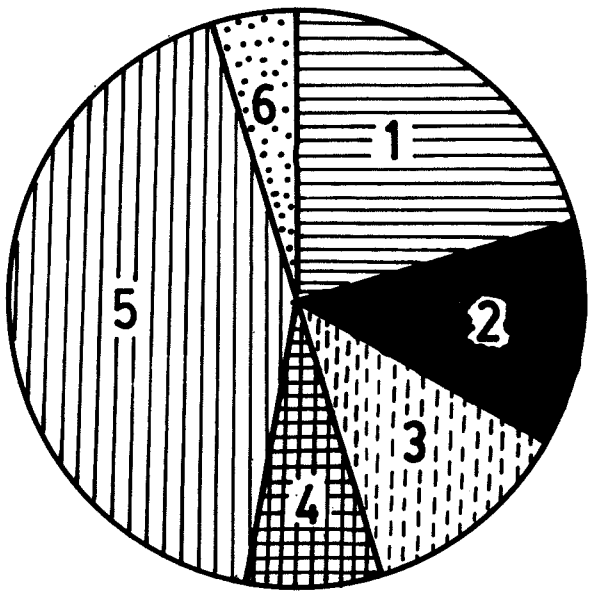
Uranium content of metamorphic rocks is variable and tends to reflect in part the uranium concentration of the original pre-metamorphic rocks (Rich et al., 1977).

In general, uranium is mobilized from rocks at low grades of regional metamorphism (Yermolayev, 1971, 1973) and solutions formed by rock dehydration and decarbonization provide a medium of uranium transport. Yermolayev (1971) points out that in aluminosilicate rocks, uranium concentration is reduced by 20 to 40 percent as progressive metamorphism proceeds, whereas for carbon-bearing rocks the concentration may be reduced by up to 50 percent. He indicates that uranium is probably released as carbonate or hydro metasilicate complexes. At the end stage of metamorphism (rheomorphism) a melt of high uranium concentration is produced from these aluminosilicate rocks (Yermolayev, 1971).

Dostal and Capedri (1978) have indicated that uranium is mobilized during progressive metamorphism up to amphibolite grade, but uranium is lost, through migrating fluid phases, during granulite metamorphism. In addition, they found a difference in the nature of the occurrence of uranium in rocks of these two facies. In rocks of the amphibolite facies, the bulk of uranium is located along fractures and cleavage planes of ferromagnesian minerals and accessory minerals, whereas in granulites most of the uranium is in accessory minerals. Furthermore, they suggest that most of uranium released is from fractures into migrating fluid phases, perhaps related to dehydration. Carpenter et al. (1979) have suggested that in addition to the generation of fluid phases by dehydration and decarbonation, CH_4 and H_2 from carbonate-rich sediments are also responsible for uranium mobilization in metamorphic rocks.



Reasonably Assured Resources
(< $ 130/kg U)



Estimated Additional Resources
(< $130/kg U)

1. Quartz-pebble conglomerate (Placer) deposits
2. Proterozoic unconformity-related deposits
3. Magmatic deposits
4. Vein deposits
5. Sandstone deposits
6. Other types of deposits

Fig. 4

SECTION THREE

GENERAL GEOLOGY OF URANIUM

3.1.0 World Distribution and Production of Uranium

According to the OECD/IAEA 'Joint Steering Group on Uranium Resources', meeting in Paris in 1978, the world's major uranium resources can be assigned on the basis of their geological setting to the following six ore types:

a) Quartz-pebble conglomerate (placer) deposits

b) Proterozoic unconformity-related deposits

c) Magmatic deposits

d) Vein deposits

e) Sandstone deposits

f) Other types of deposits (e.g., calcrete, limestone and limestone karst).

The world's uranium resources that are known to exist in deposits of these types, recoverable at costs of $130/kg U or less, are summarized in Figure 4. A brief summary of these major ore types follows:

a) Quartz-pebble conglomerate (placer) deposits

Quartz-pebble conglomerate deposits are located at Elliot Lake, Ontario and in the Witwatersrand, South Africa. These deposits occur in basal Lower Proterozoic beds unconformably situated above the Archaean granitic and metamorphic basement. The conglomerates are highly pyritic, compact and firmly cemented by chlorite and sericite and slightly metamorphosed. The uranium occurs as uraninite and brannerite in the matrix. None of these deposits is known to be younger than 2,200 m.y. Younger conglomerates are considered unfavourable for detrital uranium as they were deposited in an oxidizing atmosphere reflected in the presence of hematite common in younger conglomerate rather than pyrite. These deposits are generally of high tonnage and low grade and account for about 60 percent of total world reserves (Roscoe, 1969).

b) Proterozoic unconformity-related deposits

The best examples of this type are the Cluff Lake, Key Lake and Rabbit Lake deposits of northern Saskatchewan and those in the Alligator River area of northern Australia. These are spatially associated with major unconformities developed during a world-wide orogenic period about 1800-1600 m.y. ago. Uranium ores occur in clay, sericite, and chlorite masses at the unconformity and along intersecting faults, in clay-altered basement rocks and kaolinized cover rocks (Tremblay 1982). These deposits are of high tonnage and grade and represent about 50 percent of current uranium reserves in Canada and about 15 percent of world's current uranium reserves.

c) Magmatic deposits

Magmatic deposits include those associated with granites, migmatites, syenites, pegmatites, and carbonatites. A well known example of this type is the Rossing deposits of Namibia which is associated with pegmatitic granite and alaskite. The Rossing deposit is a large tonnage body (with a grade of 800ppm U) consisting essentially of uraninite widely disseminated through a great volume of closely spaced aplitic, pegmatitic and medium-grained alaskite dikes, and irregular masses that are emplaced in intensely folded schists, gneisses, and marbles of Proterozoic age (Berning et al., 1976). The mineralized alaskite dikes are more sheared and crushed and contain smoky quartz, darkened feldspars, and more biotite than the barren rocks.

Uranium associated with pegmatitic dykes in the Bancroft area, Ontario is another example of this type of deposit. The uraniferous pegmatitic dykes, there, are characterized by strong red colouration of quartz and feldspar due to the presence of hematite. The host rocks are of Precambrian age and consist mainly of amphibolite, metagabbro, granite, syenite and gneiss. The highest concentration of uranium is found where the mafic content of the country rock is highest.

d) Vein deposits

Vein deposits mostly occur in Hercynian granites of Europe. The deposits are associated with two-mica leucogranites. The major uranium minerals are pitchblende and coffinite and are usually associated with minor amounts of marcasite, pyrite, iron oxide, galena and chalcopyrite. Quartz or chalcedony are the most abundant gangue minerals.

Vein deposits are also known in western U.S.A. such as the Schwartzwalder mine in Colorado, where

uranium occurs in fractures in fine-grained biotitic Precambrian schists that were derived from pelitic sediments.

These deposits are of moderate to high grade but with relatively low tonnage.

e) Sandstone deposits

The uranium deposits of this type are usually contained in sandstones that were deposited under fluvial or marginal marine conditions (OECD, 1978). The sandstones are usually medium to coarse grained, poorly sorted and contain pyrite and organic matter of plant origin. Unoxidized deposits of this type consist of pitchblende and coffinite in arkosic and quartzitic sandstones. Secondary minerals such as carnotite and uranophane are formed from the weathering of these deposits.

The sandstone deposits are usually associated with felsic volcanic and plutonic rocks which are the main source of uranium in these deposits. Hence, the presence of carbonaceous pyritic sandstones with nearby (above average uranium content) felsic volcanic and plutonic igneous rocks is considered the most favourable site for these types of deposits.

f) Other types of deposits

Uranium deposits which cannot be classified into one of the above types fall into a separate category for the present. These uranium deposits are associated with calcrete, limestone, phosphorite, black shale, lignite and recent volcanic rocks. These deposits are generally of variable grade and tonnage.

3.2.0 Canadian Distribution and Production of Uranium

At the World Energy Conference held in Munich in September, 1980, it was estimated that the 'Reasonably Assured Resources' of the world's uranium is about 1.7 million tonnes. In addition, it is estimated that the world's uranium resources which can be exploited economically is about 3.1 million tonnes (DeVivo and Ippolito, 1984). Canada possesses approximately 9 percent of total world reserves (excluding China, USSR and Eastern Europe). Almost 50 percent of Canada's Reasonably Assured Resources (RAR) are contained in quartz-pebble conglomerate deposits. The remaining RAR is attributable to unconformity-related type deposits.

The Speculative Uranium Resources (those deposits which exist in areas where no reserves are yet known) in Canada are estimated to be about one million tonnes (EMR, 1985).

Uranium exploration by the Geological Survey of Canada in Canada started in 1942, and private prospecting has continued since 1949. Levels of Canadian uranium exploration activity decreased sharply after 1981 in response to the decline in price of uranium.

3.3.0 Uranium Provinces and Epochs

A uranium province is an area of the Earth's crust which is anomalously enriched in uranium relative to the average crustal abundance (Finch, 1982; IAEA, 1977).

Intervals of geological time (within metallogenic provinces) favourable for the deposition of a definite mineral are designated as metallogenic epochs (Bilibin, 1968; Noble, 1970; Guild, 1978). Most uranium deposits fall into one of several distinct age groups or metallogenic epochs (Robertson et al., 1978; Nash et al., 1981). Five major uranium metallogenic epochs were identified by Toens and Andrews-Speed (1984). A summary description of these epochs is given in Table 1 and their distribution in time and space is illustrated in Figure 5.

3.4.0 Relationship between Felsic Igneous Rocks and Metallogenic Provinces

Uranium ore deposits are formed at various times ranging from Precambrian to Tertiary, but it appears that the uranium cycles were established with the development of uranium provinces in early geological times (e.g., Precambrian). The later stages of mineralization are believed to be the result of rejuvenation and concentration of the original Precambrian uranium mineralization (Ruzicka, 1971).

The relationship between felsic igneous rocks (particularly those with above-normal uranium content) and the formation of uranium provinces is well known. A close genetic relationship between uraniferous granites and subsequent uranium mineralization is well demonstrated in the uranium provinces of Europe (Moreau, 1976; Simpson et al., 1980; Wilson and Akerblom, 1982).

According to Simpson et al. (1982), uranium provinces are related to igneous intrusion as a result of transfer of uranium via felsic magmatism (particularly with late-tectonic granites) from the subcontinental lithosphere into the upper crust during cratonisation. Rapid uplift, faulting, hot spring activity and circulating ground water would further redistribute uranium from felsic magmas into different types of hydrothermal ore deposits. Uraniferous granites also provide uranium for roll-front or other sedimentary uranium deposits.

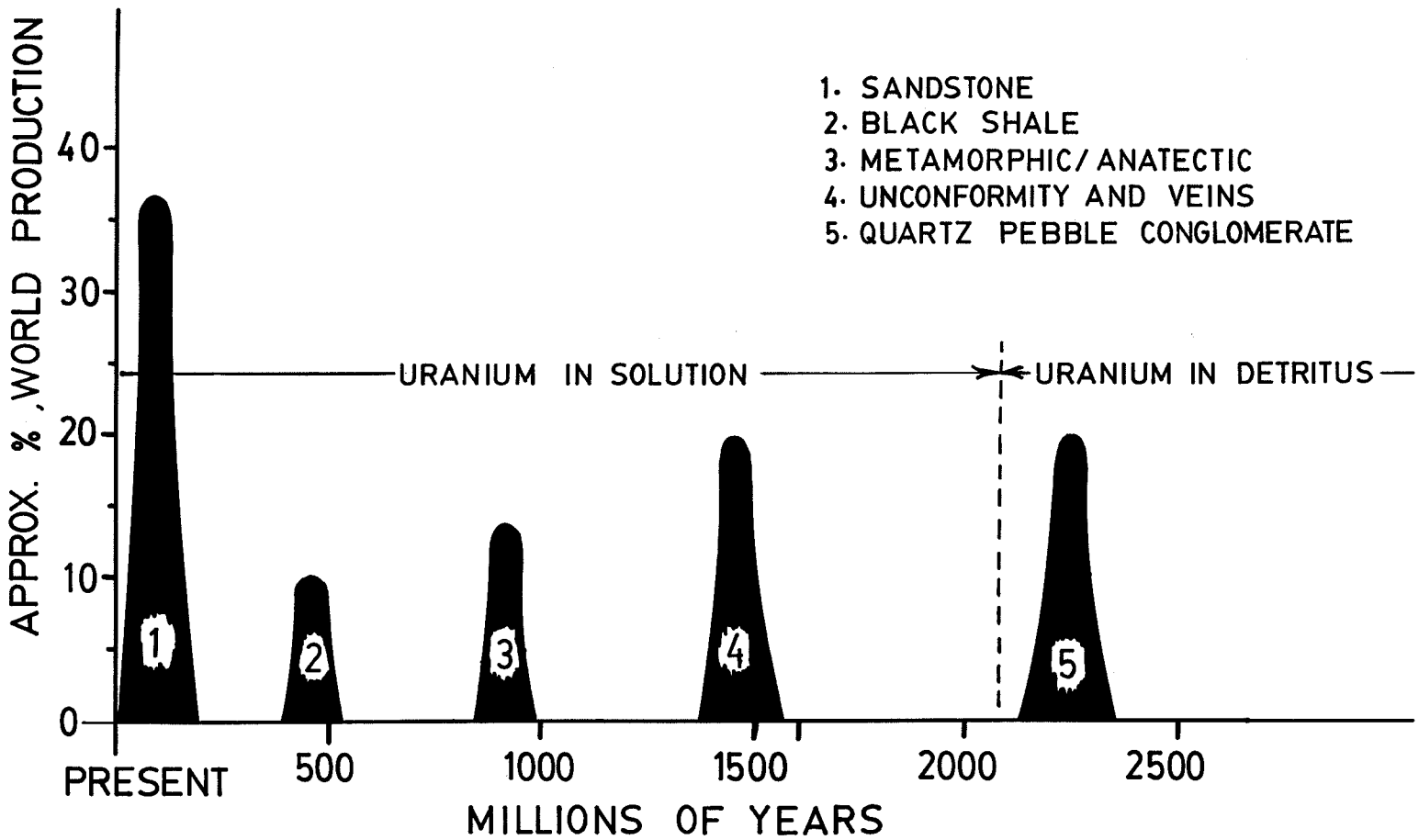

APPROX. % WORLD PRODUCTION
40
30
20
10
0
1. SANDSTONE
2. BLACK SHALE
3. METAMORPHIC/ANATECTIC
4. UNCONFORMITY AND VEINS
5. QUARTZ PEBBLE CONGLOMERATE
URANIUM IN SOLUTION
URANIUM IN DETRITUS
1
2
3
4
5
PRESENT
500
1000
1500
2000
2500
MILLIONS OF YEARS

Figure 5

SECTION FOUR

GENERAL GEOLOGY OF NEW BRUNSWICK

4.1.0 General Statement

The Province of New Brunswick lies at the northern end of the Appalachian folded belt. This fold belt (Appalachian orogen or geosyncline), has had a long and complex depositional, structural and intrusion history extending from Precambrian to recent times.

The Appalachian orogen has a distinct northeasterly trending linear outline which is reflected in both the topography and litho-structural features. The major periods of sedimentary deposition, intrusion and tectonism occurred in the Paleozoic era (Cambrian to Carboniferous).

Four major tectonic stages; Avalonian, Taconian, Acadian and Alleghanian-Variscan are recognized in the lithotectonic framework of New Brunswick (Rast, 1983). The Avalonian stage is restricted to the southern coastal area of New Brunswick and it was active in late Precambrian time. The Taconian stage, which was operative in mid-Ordovician time, predominates in the Miramichi Anticlinorium of north-central New Brunswick. The Acadian tectonic stage which occurred during mid-Ordovician to mid-Devonian time has affected the Silurian and Devonian strata of the Fredericton Trough and Chaleur Bay Synclinorium. During mid-Devonian to Middle Permian time the Alleghanian- Variscan stage of deformation took place and mainly affected the rocks of the Carboniferous Basin.

4.2.0 Lithotectonic Zones of New Brunswick

The Appalachian orogen in New Brunswick is divided into several lithotectonic zones based on stratigraphic and structural contrasts as reported in: Rodgers, 1970; Ruitenberg et al., 1977 and Fyffe et al., 1981. In these studies different terminologies and zone definitions have been used. In an attempt to avoid ambiguities in nomenclature, the following zone names are applied here:

1. Gaspe Synclinorium
2. Aroostook-Matapedia Anticlinorium
3. Chaleur Bay Synclinorium
4. Miramichi Anticlinorium
5. Fredericton Trough
6. Avalonian Platform
7. Carboniferous Basin (includes Moncton Subbasin, Central Carboniferous Subbasin and Plaster Rock Subbasin).

A map showing the locations of these lithotectonic zones is given in Figure 6. A generalized stratigraphic column for these zones is exhibited in Figure 7. A brief summary of the geological characteristics of these zones follows:

4.2.1 Gaspe Synclinorium

The Gaspe Synclinorium contains Upper Ordovician to Lower Devonian sedimentary rocks and Upper Silurian to Lower Devonian volcanic rocks. The oldest rocks exposed in this zone are those of the Grog Brook Group which consists of clastic turbidites with abundant volcanic detritus derived from erosion of the Tetagouche Group (Fig. 7). The Grog Brook Group is overlain by Upper Ordovician to Lower Silurian limestone and calcareous slate of the Matapedia Group (St. Peter, 1978). The Matapedia Group (Fig. 7) is followed conformably by turbidites of the Siegas Formation which itself is succeeded by a sequence of slate, calcareous and quartzose sandstone, and argillaceous limestone of the Perham Formation. The stratigraphic sequence ends with the Temiscouata Formation which rests disconformably on the top of the Perham Formation. The Perham Formation contains a flysch sequence of micaceous slate and greywacke.

4.2.2 Aroostook-Matapedia Anticlinorium

The rocks exposed in the Aroostook-Matapedia Anticlinorium zone are those of the Grog Brook Group and the Matapedia Group (Fig. 7). According to Bradley (1983) the Aroostook-Matapedia Anticlinorium was an oceanic basin which lacked sufficient width to generate a volcanic arc when it closed. The rocks of the Anticlinorium exhibit a single phase of deformation and subgreenschist facies of metamorphism as a result of the Acadian Orogeny (Fyffe et al., 1981).

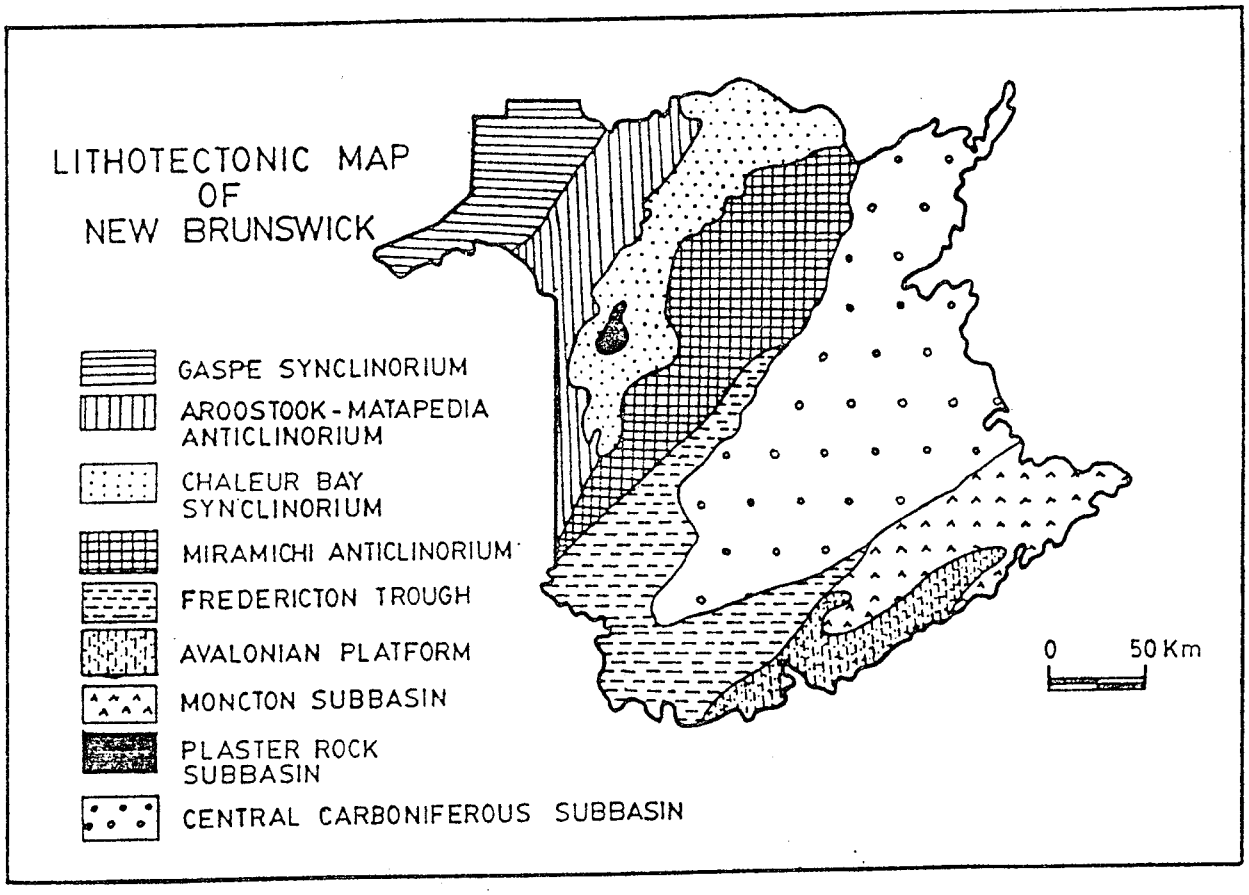


Fig. 6. Lithotectonic map of New Brunswick (modified after Ruitenberg et al.,1977)

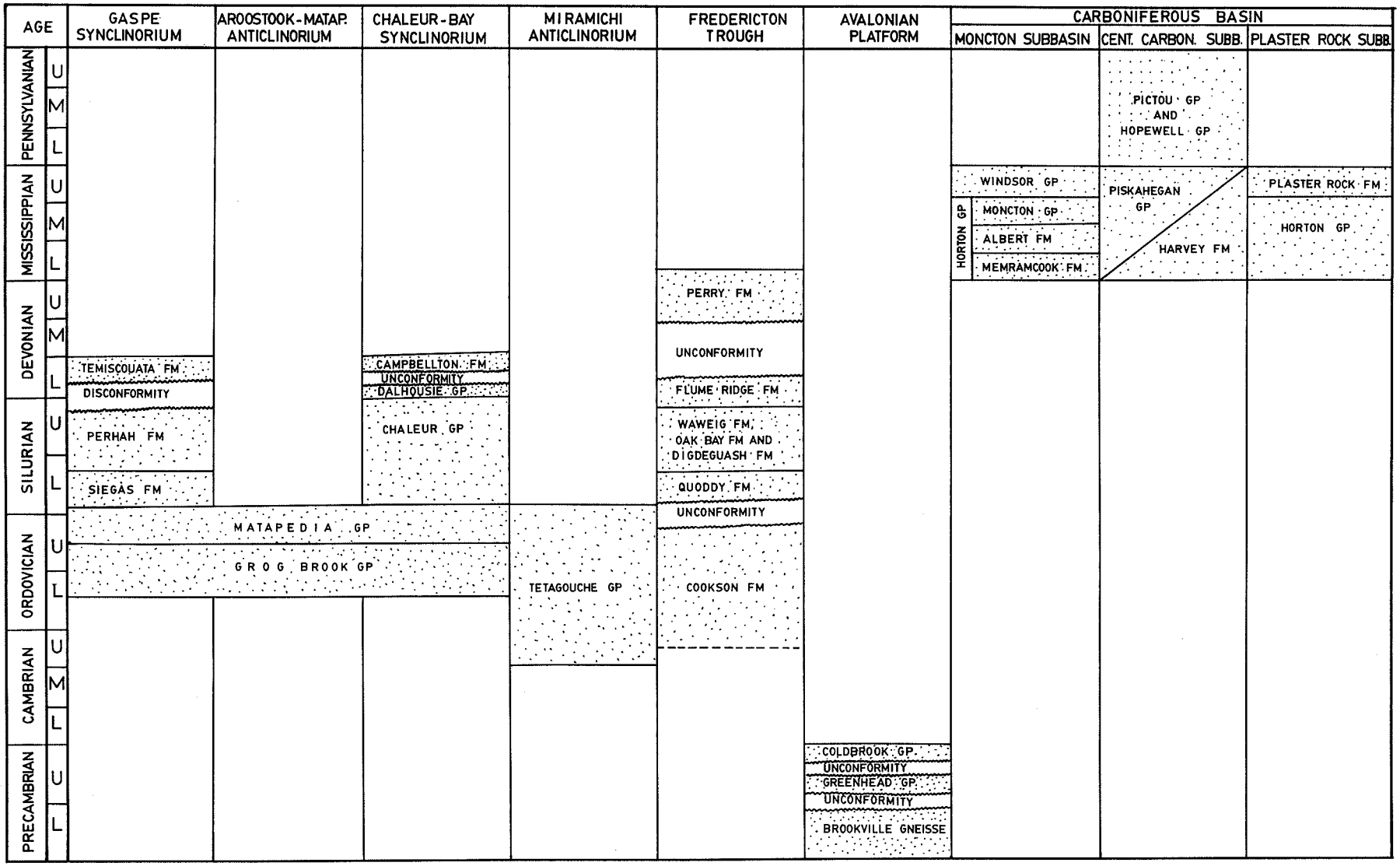

AGE
GASPE SYNCLINORIUM
AROOSTOOK-MATAP. ANTICLINORIUM
CHALEUR-BAY SYNCLINORIUM
MIRAMICHI ANTICLINORIUM
FREDERICTON TROUGH
AVALONIAN PLATFORM
CARBONIFEROUS BASIN
MONCTON SUBBASIN
CENT. CARBON. SUBB.
PLASTER ROCK SUBB.
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PRECAMBRIAN
U
M
L
PICTOU GP AND HOPEWELL GP
WINDSOR GP
PISKAHEGAN GP
PLASTER ROCK FM
HORTON GP
MONCTON GP
ALBERT FM
MEMRAMCOOK FM
HARVEY FM
HORTON GP
PERRY FM
UNCONFORMITY
TEMISCOUATA FM
CAMPBELLTON FM
UNCONFORMITY
DALHOUSIE GP
DISCONFORMITY
FLUME RIDGE FM
PERHAH FM
CHALEUR GP
WAWEIG FM, OAK BAY FM AND DIGDEGUASH FM
SIEGAS FM
QUODDY FM
UNCONFORMITY
MATAPEDIA GP
GROG BROOK GP
TETAGOUCHE GP
COOKSON FM
COLDBROOK GP
UNCONFORMITY
GREENHEAD GP
UNCONFORMITY
BROOKVILLE GNEISSE

Figure 7

TABLE 1. Major uranium deposits and their distribution in time.

AGE (m.y.)	DEPOSIT-TYPE	MINERALIZATION PROCESSES
>2800	No deposits	Uranium introduced into the upper crust by magmatic and metamorphic processes.
2800-2200	Quartz-pebble conglomerate	Low level of O_2 in the atmosphere (reducing environment) plus rapid burial in the sedimentary basin during diagenesis served to preserve the uraninite.
2200-1200	Unconformity-related	Increased level of O_2 in the atmosphere led to the release of uranium (as uranyl ions) in solution from Archaean granites and later precipitated near the basal unconformity, where there were reducing sedimentary environments.
1200-400	Metamorphic/Anatectic	With the start of modern plate tectonics at ~1200 m.y., greater potential for thermally activated remobilization of uranium due to widespread continental splitting and orogenesis resulted in the metamorphism or anatexis of previous sedimentary rocks. Metamorphic/anatectic deposits formed.
700-400	Black shale	The Pan-African and Brazilian orogenies were led to the generation of uraniferous syn- and post-tectonic granites that provided the uranium concentrated in marginal marine sediments.
400-0	Sandstone type	The incorporation of organic material into continental clastic sediments allowed uranyl ions to be precipitated before they reached the sea, to form the important sandstone-type of deposits.

4.2.3 Chaleur Bay Synclinorium

The rocks of the Chaleur Bay Synclinorium include the Silurian Chaleur Group, the Devonian Dalhousie Group and the Devonian Campbellton Formation (Fig. 7). Calcalkaline volcanic rocks have been observed in all the units with the exception of the Campbellton Formation (Ruitenberg et al., 1977). The Chaleur Group consists of a sequence of dark-grey, laminated argillaceous and calcareous siltstone and sandstone that grade downward into limestone of the Matapedia Group. The Chaleur Group is overlain by calcareous sandstone, siltstone and limestone with intercalated volcaniclastic rocks (Dalhousie Group). The rocks of these groups are unconformably overlain by continental, greenish grey conglomerate and sandstone of the Campbellton Formation.

4.2.4 Miramichi Anticlinorium

The Miramichi Anticlinorium is underlain by an intensely deformed belt of Cambro-Ordovician volcanic and sedimentary rocks and minor Silurian sedimentary rocks (Helmstaedt, 1971).

The oldest rocks exposed in the Miramichi Anticlinorium are those of the Tetagouche Group (Fig. 7). The lower part of the Tetagouche Group contains a thick sequence of quartz wacke, quartzite and slate. Rhyolite, quartz-feldspar crystal tuff and pillow basalt interbedded with red and black slate and chert, iron formation, and minor limestone comprise the upper part of the Tetagouche Group (Fyffe, 1985). The broadly circular pattern of Ordovician felsic volcanic rocks in the Bathurst area, at the northern end of the Miramichi Anticlinorium, suggests the presence of a large caldera complex (Davies, 1966).

A large number of granitic plutons were emplaced in the anticlinorium prior to and after the Acadian Orogeny. The abundance of these granitic plutons, along with the felsic volcanic rocks of both Ordovician and Devonian age, suggests that the Miramichi Anticlinorium is a rifted fragment of continental crust (Fyffe et al., 1981).

4.2.5 Fredericton Trough

The Fredericton Trough contains intensely deformed Ordovician to Devonian sedimentary rocks with abundant volcanic rocks along its southern margin. McKerrow and Ziegler (1971) believe that the Fredericton Trough represents the Proto Atlantic floor. The predominant rock unit in the trough is a thick sequence of tightly folded Silurian turbidites particularly, along its northern margin.

The major rock units included in the Fredericton Trough (Fig. 7) are pelitic and arenaceous rocks of the Ordovician Cookson Formation, turbidites and conglomerates of the Silurian Waweig, Digdeguash and Oak Bay Formations, and calcareous clastic sedimentary rocks of the Upper Silurian/Lower Devonian, Flume Ridge Formation (Ruitenberg et al., 1977). Mafic and felsic volcanic rocks were deposited contemporaneously with these sedimentary rocks. The rocks of the Devonian Perry Formation rest unconformably on the sequence in the southern margin of Fredericton Trough.

The Fredericton Trough represents a mature rift that had developed into a turbiditic basin by middle Silurian time and was closed during the Acadian Orogeny (Fyffe et al., 1981). The Acadian Orogeny resulted in the polyphase deformation of the rocks and subgreenschist to greenschist facies of metamorphism.

4.2.6 Avalonian Platform

The Precambrian rocks of southeastern New Brunswick are referred to as the 'Avalonian Platform', containing two main stratigraphic units: the Greenhead Group and the Coldbrook Group (Fig. 7). The Greenhead Group consists of a sequence of carbonates, quartzites, and argillites (Wardle, 1978). The Coldbrook Group which overlies unconformably the Greenhead Group, contains principally mafic and felsic tuffaceous rocks and pillowed mafic flows, and minor purple siltstone, sandstone and conglomerate (Fyffe, 1985).

The Greenhead Group unconformably overlies the Aphebian or Paleohelikian Brookville Gneiss which consists of quartzofeldspathic gneiss (Currie et al., 1981).

The Avalonian Platform is separated from the Fredericton Trough by the Beaver Harbour-Belleisle Fault.

4.2.7 Carboniferous Basin

The Carboniferous Basin of New Brunswick contains predominantly marine and nonmarine sedimentary rocks, ranging in age from Mississippian to Pennsylvanian and these unconformably overlie the Pre-Carboniferous rocks in the area (Fig. 7).

The Carboniferous Basin in New Brunswick includes three major subbasins; the Moncton Subbasin, the Central Carboniferous Subbasin and the Plaster Rock Subbasin. The Central Carboniferous Subbasin which is separated from the Moncton Subbasin by the Kingston Uplift, is occupied mainly by Pennsylvanian, coal-bearing,

clastic sedimentary rocks. The Moncton Subbasin is covered by both Mississippian and Pennsylvanian sedimentary rocks that locally contain oil, gas, salt and potash deposits. The Plaster Rock Subbasin is located in the Chaleur Bay Synclinorium and contains Mississippian rocks that rest unconformably on Siluro-Devonian, metamorphosed, volcanic and sedimentary rocks.

The Carboniferous strata are believed to represent an erosional remnant of a large basin that once extended from the Gulf of St. Lawrence to Newfoundland (van de Poll, 1973). The basin developed following the Acadian Orogeny and became fully established by Late Devonian times. In southeastern New Brunswick the basin consists of a major northeasterly trending rift valley, called the 'Fundy Basin' by Belt (1968), within which a complex series of northeasterly trending horst and graben structures developed. During the Late Devonian and Carboniferous time, the entire rift valley was characterized by the deposition of essentially non-marine sediments. Marine sedimentation took place only during Middle Mississippian (Visean) time, when a cyclic sequence of marine carbonate, evaporites and red siltstone was deposited (van de Poll, 1973). The rest of the sequence was deposited within alluvial fan, fluvial, fluvial-deltaic and lacustrine environments (Pickerill and Carter, 1980).

Basal Carboniferous rocks contain a series of coarse, immature, red clastics (Memramcook Formation) interrupted by grey beds of alluvial, fluviatile, deltaic, limnic and evaporatic origin (Albert Formation) which are locally petroliferous (Webb, 1984). These rocks are overlain by a marine sequence of conglomerate, sandstone, shale, limestone, gypsum, halite and potash deposits (Windsor Group). Windsor Group evaporites are overlain by and interbedded with siltstones, sandstones and conglomerates of the Hopewell Group. The Hopewell Group is in turn overlain by conglomerates, sandstones and siltstones of the Pictou Group. The Pictou Group is the most widespread stratigraphic unit in New Brunswick and is thought to represent semi-arid, nonmarine, terrestrial deposits (Webb, 1984). The Pictou strata are mostly flat-lying except for locally tilted beds near faults.

The Mississippian sedimentary rocks in many parts of New Brunswick are associated with bimodal volcanic rocks, which are generally subaerial and may be in part submarine (Rast and Grant, 1973; Strong et al., 1979).

Mississippian rhyolitic rocks of the Harvey Formation were deposited along the northern margin of the Central Carboniferous Basin at Harvey Station, York County (Fig. 1). An extensive sequence of undeformed ignimbrite and minor mafic flows of the Piskahegan Group were formed along the southern margin of the Central Carboniferous Basin, north and east of Mount Pleasant (Fig. 1). Mount Pleasant itself comprises an intensely altered subvolcanic or caldera eruptive complex (Ruitenberg, 1976). The Piskaghegan Group includes several formations among which is the Carrow Formation. The Carrow Formation contains red to brown volcanogenic sandstone, conglomerate and siltstone which are in part intensely bleached or chloritized and contain anomalous amounts of uranium (Ruitenberg et al., 1976).

4.3.0 Igneous Intrusions

Igneous intrusions in New Brunswick range in age from Precambrian to Triassic (Ruitenberg et al., 1977; Fyffe et al., 1981 and Ruitenberg and Fyffe, 1982). These intrusions fall into two distinguishable groups: one which was emplaced during or after the Acadian Orogeny (post-tectonic) and the other group emplaced prior to the Acadian Orogeny (pre-tectonic). The post-tectonic plutons (Upper Devonian to Lower Carboniferous in age) were mainly emplaced in areas affected by intense wrench faulting. They crystallized at shallow depth in the earth's crust, are undeformed, highly fractionated (mainly felsic in composition) and contain high contents of lithophile elements such as Mo, Sn, W and U. In contrast, the pre-tectonic plutons are pervasively deformed, less fractionated (mainly intermediate in composition); they crystallized deeper in the crust and are depleted in lithophile elements (Fyffe et al., 1981; Ruitenberg and McCutcheon, 1982).

The largest volume of igneous intrusions were emplaced during the Early and Middle Devonian (post-Acadian) time. Small gabbroic, granodioritic and granitic plutons were emplaced in the Chaleur Bay Synclinorium (Fig. 1). Larger north- to northwest-trending plutons of ultramafic and gabbroic compositions with minor granodioritic and granitic intrusions were emplaced along the faulted boundary between the Chaleur Bay Synclinorium and the Miramichi Anticlinorium (Fig. 1). Muscovite-biotite granite, biotite granite and granodiorite batholiths are predominant in the Miramichi Anticlinorium. Batholiths of granite and northeast-trending ultramafic, gabbroic and granodioritic stocks intruded the Fredericton Trough. Both felsic and mafic intrusive rocks have been recognized in the Avalonian Platform (Donohoe and Barr, 1981). The majority of the granites intruding the Avalonian Platform are Precambrian in age (Rast, 1983).

4.4.0 Evolution of the New Brunswick Appalachian Orogeny

Several hypotheses are proposed to explain the development of the New Brunswick Appalachian Orogen in terms of plate tectonics (e.g., Bird and Dewey, 1970; McKerrow and Ziegler, 1971; Bradley, 1983 and Rast, 1983). Bird and Dewey (1970) have suggested that the northern Appalachian Orogen was produced as a result of continental collision between North America and Eurafrica continents. This collision was assumed to take place during the Middle Devonian Acadian Orogeny. This event led to the generation of the Proto-Atlantic Iapetus Ocean. This hypothesis was later modified by Rast (1983). According to Rast, the Iapetus Ocean was produced during late Precambrian time and later closed by the Taconian Orogeny. The closure of the ocean resulted in a collision between the Avalonian microcontinent and North America continent. Siluro-Devonian sediments, derived from the erosion of the Taconian mountains were laid unconformably on the Cambro-Ordovician rocks and a series of rifts formed. These rifts were later closed in Middle Devonian time as a result of the Acadian Orogeny.

McKerrow and Ziegler (1971) have proposed a bilateral subduction model for the Acadian Orogeny which is supported by Bradley (1983). On the basis of this hypothesis, two volcanic arcs are assumed to have existed and the sea between these two arcs was closed at the time of the Acadian Orogeny. One of these arcs was built on the basement arc previously accreted to the North America continent during the Taconic Orogeny. The other arc was built on the Precambrian basement of the Avalonian microcontinent. The Fredericton Trough is interpreted as the site of an ocean which closed in Siluro-Devonian time by simultaneous subduction beneath both continental margins.

4.5.0 Economic Potential

New Brunswick is potentially favourable for Sn, W, Mo, Sb, Ag, Au and base metal sulphide deposits in addition to U. Several of these elements are produced economically in the area. For example, base metal sulphide deposits are exploited in the Bathurst area in the northern Miramichi Anticlinorium, Sb from the Lake George mine at the northern margin of the Fredericton Trough and Sn, W and base metal sulphides from the Mount Pleasant mine on the southern margin of the Central Carboniferous Basin. Other nonmetallic minerals such as coal, salts and potash are produced from the Carboniferous Basin. For more details on these deposits refer to Ruitenberg and Fyffe (1982; 1983).

SECTION FIVE

URANIUM METALLOGENESIS, NEW BRUNSWICK

5.1.0 General Statement

A total of 82 uranium showings in the Province of New Brunswick were reviewed during the literature survey conducted in this study. Although none of these occurrences have proven to be encouraging enough to warrant exploitation at present, they deserve attention and evaluation for future consideration.

Uranium occurrences in New Brunswick are of different deposit types. These differences may be attributed to broad variations in the depositional environments, lithologies, styles of deformation, ages of their enclosing rocks, tectonism, intrusion, volcanism and metamorphism.

Mineralogically, two kinds of uranium occurrences were identified; monometallic (simple) where only uranium is recognized as a significant element and polymetallic (complex), where in addition to uranium, other economically interesting metals were concentrated.

5.2.0 New Brunswick Uranium Deposit Types

Uranium deposits have been classified by several researchers (e.g., Ruzicka, 1971; McMillan, 1978; Dahlkamp, 1978; Nash et al., 1981). The scheme adopted in this study is mainly descriptive in nature where the occurrences are classified according to their host rock lithology. These classes are:

1. Sedimentary Rocks
   a. Shale
   b. Siltstone
   c. Sandstone
   d. Conglomerate
2. Volcaniclastic Sedimentary Rocks
3. Felsic Volcanic Rocks
4. Magmatic Rocks
5. Metamorphic Rocks
6. Veins
7. Soils and/or Stream Sediments

Several uranium occurrences were only identified in soil and stream sediment samples. These occurrences are treated as a separate class. A brief description of the uranium types designated for the New Brunswick uranium occurrences is given below:

5.2.1. Sedimentary Rock Type

The Sedimentary Rock Type includes uranium in sandstone, siltstone, shale and conglomerate. These occurrences are mainly in the Carboniferous sedimentary rocks (Fig. 1) and are essentially formed by supergene processes. The source of uranium in these deposits is not fully known but is most likely to be the Devonian-Carboniferous felsic intrusions and Mississippian felsic volcanics emplaced adjacent to and beneath the Carboniferous Basin (Fig. 1). The Lower Mississippian evaporitic sequence deposited in the Moncton Subbasin may also have provided part of the uranium in these deposits.

Both monometallic and polymetallic deposits have been recognized. In polymetallic deposits, uranium occurs in association with Cu, Pb, Zn, Mo, V, Mn and Y. The enclosing rocks are in general gently dipping and exhibit, if any, a low grade of metamorphism. Uranium in the Mississippian sedimentary rocks is commonly associated with carbonaceous materials, hydrocarbons (albertite) and phosphatic materials. These deposits where found particularly in permeable sites where uranium-bearing solutions could move freely along unconformity surfaces, shear zones and bedding planes.

Uranium is also found in association with coal, pyrite and plant debris in the fluviatile sandstone of Pennsylvanian age. Here, uranium occurrences are found to occur at the base of fining-upward cycles of sedimentation (Dunsmore, 1977).

5.2.2. Volcaniclastic Sedimentary Rock Type

Volcaniclastic sedimentary uranium deposits are found in sedimentary rocks composed entirely or in part of volcanic fragments produced either by direct volcanic activity (pyroclastic deposits) or by erosion

of pre-existing rocks (epiclastic deposits). The enclosing rocks are Mississippian in age and contain a large proportion of rhyolitic clasts. Uranium is usually associated with fluorine in these deposits, and spatially associated with hydrothermally altered and fractured rocks. Silicification and chloritization are common in these occurrences.

5.2.3. Felsic Volcanic Rock Type

Felsic volcanic uranium deposits are to some extent identical in nature of mineralization to those found in volcaniclastic sedimentary rocks. Both types are related spatially and perhaps in time of their formation. However, it is worth mentioning here that the Mississippian felsic volcanic rocks which host this type of deposit are favourable for uranium mineralization and contain above-average uranium abundances relative to the global average in similar rock types. This may suggest that the source of uranium, in these rocks and in volcaniclastic sedimentary rocks is likely the Mississippian felsic volcanic rocks themselves.

Uranium occurs in polymetallic association with Cu, Pb, Zn, Mo, Sn, W, Ag, Bi and As in these rocks. One of the most distinctive features of uranium in these deposits, as in the volcaniclastic sedimentary types, is a close association with fluorite. This association may suggest that uranium was transported to the site of mineralization as fluoride complexes within highly reactive magmatic fluids (Bohse et al., 1974).

5.2.4. Magmatic Rock Type

In magmatic rock types, uranium occurs mainly in granitic rocks. These occurrences are, in general, associated with the post-Acadian, highly differentiated, non-cataclastic, Devonian to Carboniferous, two-mica granites. The favourable granites that host these deposits are peraluminous. These granites usually exhibit rapakivi texture and contain miarolitic cavities. Fluorite is usually enriched in these granites. Several metals are known to be associated with uranium in this type of deposit but Sn, Mo and W are the most common.

5.2.5. Metamorphic Rock Type

Only one metamorphic type uranium occurrence has been recognized (Ridge Brook). This occurrence is in Silurian argillite. The argillite is grey, laminated, and exhibits iron-staining. The deposit occurs immediately below an unconformity surface separating Silurian metasedimentary rocks from Carboniferous sedimentary rocks. This may suggest that the source of uranium is elsewhere and the uranium has been transported along the unconformity surface to the argillite.

5.2.6. Vein Type

Vein type uranium deposits usually occur as fracture fillings in felsic igneous rocks and in sedimentary and metamorphic rocks adjacent to them. These deposits are commonly polymetallic in nature. Uranium is usually associated with Cu, Pb, Zn, Sb, Mo, W, Sn, Ag and in some of them, with Au. In this type of deposit uranium is associated with hydrothermal alteration particularly silicification, hematitization, kaolinitization, chloritization, sericitization, pyritization and fluoritization. Uraninite, autunite, torbernite, pitchblende, coffinite, soddyite and uranophane are the common uranium minerals identified in these rocks.

These deposits are generally associated with granites which contain above-normal uranium content relative to global averages. These veins are associated with the same granitic rocks that hosted the magmatic-type uranium mineralization in the area.

5.2.7. Soil and/or Stream Sediments

Uranium has been deposited in soil and stream sediments in the area. These deposits occur particularly in areas favourable for other types of uranium mineralization. The uranium is either associated with organic-rich debris or with clay-enriched soils and stream sediments. Swampy areas are the most favourable sites for uranium of this type.

5.3.0 Uraniferous Domains of New Brunswick

The uranium occurrences with their elemental associations and their interpreted types of concentration are plotted on the 1:500,000 scale Structural map of New Brunswick (Fig. 1).

The attempt to divide the uranium occurrences in New Brunswick into metallogenic domains (subprovinces), it was found that such domains are best outlined by the lithotectonic zones of New Brunswick (Fig. 6). Hence, seven uraniferous metallogenic domains were proposed for the Province of New Brunswick (Fig. 1):

1. Gaspe Synclinorium (Domain I)
2. Aroostook-Matapedia Anticlinorium (Domain II)

3. Chaleur Bay Synclinorium (Domain III)
4. Miramichi Anticlinorium (Domain IV)
5. Fredericton Trough (Domain V)
6. Avalonian Platform (Domain VI)
7. Carboniferous Basin (Domain VII)
   A. Plaster Rock Subbasin (Domain VIIA)
   B. Moncton Subbasin (Domain VIIB)
   C. Central Carboniferous Subbasin (VIIC)

Most of the uranium occurrences are clustered within or spatially associated with three of these domains, namely the Miramichi Anticlinorium Domain, the Fredericton Trough Domain and the Carboniferous Basin Domain (Fig. 1). In some cases, the term 'domain' is used for an area with no known uranium occurrences such as the Gaspe Synclinorium and the Avalonian Platform. The term 'domain' is proposed because there are indications that these areas have received less attention from uranium exploration companies relative to other areas (with known uranium occurrences). It is believed, on the basis of favourable geological conditions, that uranium may be found in these 'barren' areas.

The uraniferous domains proposed herein were outlined on the regional airborne gamma ray spectrometry maps of New Brunswick (Fig. 8) in order to test them against these data. It appears that these airborne data successfully outline rocks favourable for uranium concentration, such as granitic rocks, but they do not locate individual prospects. Hence, the airborne data can only outline potential sources for uranium in an area. Highly anomalous uranium values as indicated in Figure 8, appear to relate mainly to the more differentiated phases of the Devonian-Carboniferous granitic rocks in the Miramichi Anticlinorium and in the Fredericton Trough domains.

The uranium occurrences, listed according to their domains, along with their geographical locations, deposit types, mineralogical and elemental association and their host rock lithology and structural setting and methods used for their investigation are given in Appendix I.

A brief description of the proposed uraniferous metallogenic domains (only those domains that contain uranium occurrences) is given below:

5.3.1 Aroostook-Matapedia Anticlinorium Domain

Only a single and relatively small uranium occurrence is located in the Aroostook-Matapedia Anticlinorium domain (Fig. 1). This occurrence (Popelogan) is associated with Devonian rhyolitic rocks. Otherwise, the rest of the domain appears to be barren of significant uranium mineralization probably due to the absence of igneous intrusive masses and the deformed and metamorphosed characteristics of the older rocks in this domain.

5.3.2 Chaleur Bay Synclinorium Domain

Both felsic volcanic and related vein-type uranium deposits occur in the Chaleur Bay Synclinorium domain. Most of these occurrences located at the borderline between this domain and the Miramichi Anticlinorium Domain (Fig. 1). These occurrences are found in the north of the domain and are spatially associated with Devonian felsic volcanic rocks (Gross, 1957) (eg. at Atholville and at Coxs Brook). These volcanic rocks cut dark grey to black slate and slate-argillite of Upper Ordovician age. Radioactive materials are finely disseminated in the felsic volcanic rocks within 2.5cm of the contact with the slate, at Atholville. At Coxs Brook (Fig. 1), uraninite, or pitchblende have been found in specks and veinlets along narrow fractures in the felsic volcanic rocks. The rocks along the fractures that contain uranium are altered (kaolinized?). Uranium and lead are also reported to occur in these volcanic rocks at Durham Centre (Fig. 1).

Small, but potentially significant polymetallic, vein-type uranium deposits were found in the Devonian felsic and mafic volcanic, and sedimentary rocks of the domain (Left, Stew and Evy, Fig. 1). At these deposits uranium (+ Cu, Pb, Zn, Mo, Ag, Au) is concentrated mainly in hydrothermally altered rocks intersected by shear zones.

5.3.3 Miramichi Anticlinorium Domain

The Miramichi Anticlinorium Domain (Fig. 1) is probably the most favourable area for uranium mineralization in New Brunswick. The diversity of geological environments and the wide variety of mineral prospects throughout the domain make it an exceptional target for mineral exploration, in general. The potential for uranium discovery in the domain is considered great, because of the large volume of metal-bearing (including uranium) granitic rocks of post-Acadian age emplaced in the domain. These granitic rocks probably provided a source for uranium and some other metals in the domain.

In general, the uranium occurrences in this domain are of two types: magmatic and vein. These occurrences are spatially and perhaps genetically related to post-tectonic Devonian to Carboniferous granitic rocks particularly with those containing

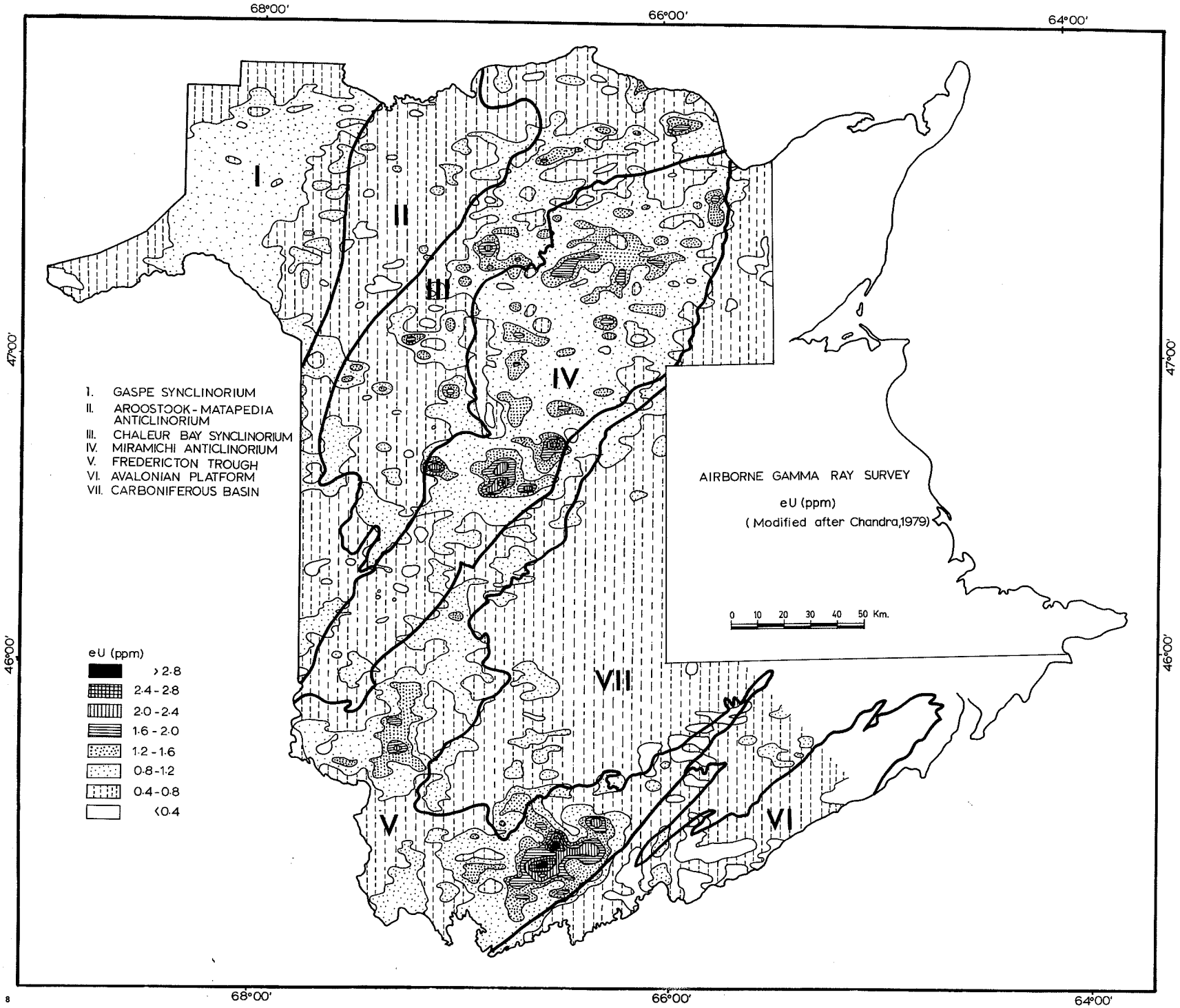

68°00'
66°00'
64°00'
47°00'
46°00'
I
II
III
IV
V
VI
VII
I. GASPE SYNCLINORIUM
II. AROOSTOOK-MATAPEDIA ANTICLINORIUM
III. CHALEUR BAY SYNCLINORIUM
IV. MIRAMICHI ANTICLINORIUM
V. FREDERICTON TROUGH
VI. AVALONIAN PLATFORM
VII. CARBONIFEROUS BASIN
eU (ppm)
> 2.8
2.4 - 2.8
2.0 - 2.4
1.6 - 2.0
1.2 - 1.6
0.8 - 1.2
0.4 - 0.8
< 0.4
AIRBORNE GAMMA RAY SURVEY
eU (ppm)
(Modified after Chandra, 1979)
0 10 20 30 40 50 Km.

Figure 8

both biotite and muscovite. In addition to uranium, these rocks show higher than average levels of other metals particularly Sn, Mo and W. The geological setting of the domain has some characteristics similar to those of vein-type uranium deposits in the Hercynian granitoids of eastern Europe (Ruzicka, 1971), western Europe (Simpson et al., 1982), and to those of Nova Scotia (Chatterjee et al., 1982).

The most favourable area thus far identified within the domain is close to Long Lake (Fig. 1). Two uranium claim groups are located in this area: the Shawn claims west of Long Lake and the Long Lake claims east of it. At this location autunite-bearing, Pb-Zn-Cu-sulphide-bearing and Mo-bearing float was discovered on the Shawn claims (Lipowicz, 1980) and autunite-torbenite-bearing float was discovered on the Long Lake claims (Hauseux, 1981). The mineralization in the Long Lake area occurs in hydrothermally altered (silicification, sericitization, chloritization, limonitization and pyritization), and in places brecciated, granites of the Devonian North Pole Granite. Other elements such as Mn, Sn, Ag and Au were also identified in these rocks, in association with the uranium. Most of the uranium concentrations are located near the shore of Long Lake, close to two inferred, northwesterly-trending faults, one of which is believed to be under Long Lake itself.

The mineralization occurs mainly in altered, brecciated and veined rocks of both the Devonian granite and the quartz-feldspar porphyry observed in the area. The exception is a sample of unaltered, medium-grained muscovite granite containing 3,300ppm uranium in the form of disseminated, microscopic torbernite. This sample, located near the shore of Long Lake, close to the two inferred faults (mentioned above), is believed to be locally derived (Hauseux, 1980). This sample, along with nearby float of fresh muscovitic granite, offer encouragement that a uranium-rich granite of economic interest may lie in the area.

The geological environment which hosts the Long Lake uranium deposit is believed to be similar to that in the recently discovered Swanson uranium deposit in Pittsylvania County, Virginia, USA (Ruzicka and LeCheminant, 1986).

Three interesting vein-type uranium deposits (Add, Serpy and Bear) were formed along shear zones in the Ordovician cataclastic granite at its contact with the North Pole Granite (Fig. 1). These polymetallic deposits contain, in addition to uranium, Cu, Pb, Zn, Mo, Sn, W, Ag, and Au. The source of the uranium in these deposits is most likely the same, or similar to that of the Shawn and Long Lake deposits because they also occur close to the North Pole Granite. The North Pole Granite is emplaced in a seismotectonically active area as evidenced by a series of earthquake tremors with a maximum magnitude of 5.7 (January 1982, Miramichi Earthquake). The earthquake's epicenter is believed to be located within the North Pole Granite (Burke and Chandra, 1983). Granite samples from the earthquake site show a distinctive assemblage of overprinted ductile to brittle microfractures (Mawer and Williams, 1985) which are interpreted to have been developed as a result of a fluid pulse triggered possibly by paleoseismic activity. Sibson et al. (1975) have argued that conditions favourable for hydrothermal vein deposits may be developed in zones of dilation, due to outpourings of warm groundwater following moderate (magnitude 5 to 7) earthquakes.

5.3.4 Fredericton Trough Domain

The geological environment in the Fredericton Trough Domain (Fig. 1) is to some extent similar to that of the Miramichi Anticlinorium Domain. Both have similar types and styles of uranium mineralization. Generally, the uranium deposits occur within, or adjacent to, post-tectonic, felsic, intrusive masses such as the Pokiok Batholith, north of the domain, and the St. George Batholith, south of the domain. These granitic batholiths are known to contain above-normal uranium abundances in comparison to the global average concentrations of uranium granites.

A vein-type uranium prospect (Welsford) was discovered on the top of the Eagle Rock Cliff, near Welsford (Fig. 1), along fractures in a poorly exposed outcrop of coarse-grained granite of the Charlotte Pluton (Hassan, 1984). Uranium content as high as 112ppm was recorded by the gamma-ray spectrometer. The mineralized rocks have a deep red colour and are highly fractured and silicified. Uraninite is the radioactive mineral. Both hydrothermal and supergene processes are thought to be involved in the formation of this vein mineralization.

Among other interesting uranium deposits in the Fredericton Trough is the one associated with antimony at the Lake George mine (Fig. 1), about 42km west of Fredericton (Ruzicka and Littlejohn, 1981). The uranium mineralization there is associated with quartz-veins in Silurian shale, greywacke, and quartzite that are intruded by Devonian granodiorite of the Pokiok Batholith. In addition to stibnite, these veins contain small amounts of pyrite, arsenopyrite, and tetrahedrite, and low uranium, gold and silver (Abbott and Watson, 1975). The principal uranium minerals are coffinite, uraninite and thucholite. Small amounts of soddyite and uranophane were also found (Morrissy

and Ruitenberg, 1980). Phase relations of the uraniferous mineral assemblage (Scott, 1979) suggest depositional temperatures of 200-250°C or less. Although the source of the uranium in the mine is not known with certainty, three possibilities exist: a) the Devonian granitic rocks of Pokiok Batholith, b) the Silurian pelitic sedimentary rocks and c) the lamprophyre dykes intruded into the Silurian sedimentary rocks. These possible sources all contain above normal uranium content relative to the global average of uranium in rocks of similar lithology.

5.3.5 Carboniferous Basin Domain

The Carboniferous Basin Domain (Fig. 1) has been recognized as a favourable site for uranium deposits in the province (Gross, 1957; Roscoe, 1966; Smith, 1968; Ruzicka, 1971; Dunsmore, 1977). The depositional environment of these Carboniferous sandstones is strikingly similar to that of the uranium- rich district of the Colorado Plateau, U.S.A. (Smith, 1968). These similarities may suggest that some uranium deposits of the 'roll-front' types may be discovered in the Carboniferous Basin. Red, oxidized, clastic, terrestrial sedimentary rocks, together with grey, reduced, clastic sedimentary rocks rich in plant debris, are characteristic of both areas. Copper sulphide deposits associated with coalified plant remains are also widespread in both areas (Smith, 1968).

The Devonian to Carboniferous granites emplaced in the Miramichi Anticlinorium Domain and the Fredericton Trough Domain and the Mississippian felsic volcanic rocks, formed at the periphery of the Carboniferous Basin probably provided the uranium to the Carboniferous Basin Domain. However, the Lower Carboniferous evaporitic sequence, deposited within the domain itself is also considered a potential source for uranium (Dunsmore, 1977).

Uranium was discovered in the Carboniferous Basin Domain in 1953 at Shippegan Island and at Hampton (Gross, 1957). Uranium is found in association with plant debris in Pennsylvanian sandstone of the Pictou Group at Shippegan Island (Fig. 1). Along with uranium, copper was precipitated apparently from the same aqueous solution (Dunsmore, 1977). Numerous other uranium deposits of similar type were discovered in the Carboniferous Basin Domain (see Appendix I and Fig. 1).

Uranium in association with hydrocarbon (albertite) was discovered in veins (Fig. 1) along fault zones at Hampton (Gross, 1957). The hydrocarbon is believed to have migrated from oil shale in the Albert Formation. The source of the uranium is not known; but, it may have been leached by groundwater from nearby sedimentary and felsic volcanic rocks, and have been precipitated by the carbonaceous material in the vein.

The Mississippian felsic volcanic rocks in the domain are also favourable for uranium mineralization. At Harvey Station uranium (Fig. 1) is associated with shear zones in the rhyolites and rhyolite tuffs (Harvey Station, Manners Sutton and York Mills). These vein-type deposits are located near the regional Fredericton fault. Fluorite accompanies uranium mineralization in this area. Uranospinite and saleeite were the major uranium minerals identified in these occurrences by the Geological Survey of Canada (Gross, 1957).

Uranium contents up to 749ppm was recorded by gamma-ray spectrometry from an area of about three square meters in the rhyolite lava-flow located at Manners Sutton (Fig. 1). The uranium mineralization occurs as black, powdery pitchblende along fractures cross-cutting the iron-oxide stained lava-flow (Hassan, 1984). A specimen of banded, fine-grained crystalline rhyolite, transected by a reticulate network of thin purple fluorite veinlets was investigated by Gabelman (1981). Sericite and montmorillonite are the main alteration products of feldspar in this specimen. Gabelman found that the feldspar and its alteration products were barren of uranium. The white fluorite was also found to be barren. Uranium was recognized only in the purple fluorite. Furthermore, Gableman has found that the amount of uranium is directly proportional to the intensity of the purple colour in the fluorite.

At York Mills (Fig. 1), uranium compounds were deposited along a fault plane intersecting the rhyolite ash-fall tuff. The intense chloritization in the vicinity of uranium mineralization may have served as a mechanism to release part of the uranium from the ash-fall tuff (Hassan, 1984) based on the fact that the uranium content of the fresh parts of the ash-fall tuff is greater than that of the altered part. Thus part, if not all, of the uranium may have been leached from the ash-fall tuff rhyolite itself.

The Mississippian volcanic and volcaniclastic rocks of the Mt. Pleasant area (Fig. 1) also contain a number of small uranium prospects. The rhyolitic rocks are enriched in uranium and commonly contain fluorite. Comagmatic high- level porphyries on the flank of the Mt. Pleasant caldera contain Mo, W, Bi, Sn and fluorite deposits (Parrish and Tully, 1978), and uraninite is found in this mineral assemblage (Parrish, 1977). Uranium occurs in both the ash-flow tuffs in the caldera and in the volcaniclastic sedimentary rocks adjacent to it.

Fluorite, chlorite, kaolin, and pyrite commonly are associated with the uranium (Curtis, 1981).

Uranium mineralization is reported in intensely altered volcaniclastic sedimentary rocks of the Carrow Formation at Pete Brook (Fig. 1). The alteration there is mostly chloritic. Uranium is also associated with sections rich in hematite and fluorite within the chloritic zone. According to Ruitenberg et al. (1976) uranium was transported by sulphur- and fluorine-rich water moving through highly permeable beds. The concentration took place in the permeable, coarse-grained, volcaniclastic sedimentary rocks. The source of the sulphur- and fluorine-rich water is believed to be from a nearby volcanic centre.

5.4.0 Uranium Occurrences in New Brunswick and their Temporal and Spatial Distribution

A generalized uranium metallogenic chart was constructed by plotting uranium occurrences and their metal associations, against their host rock ages and major geological events characterizing each uraniferous domain (Fig. 2). These geological events include: structural deformation, volcanism, plutonism and metamorphism, along with regional tectonism. As illustrated in Figure 2, uranium in New Brunswick shows a marked association with post-Acadian rocks (Devonian to Carboniferous in age). This may suggest that the uraniferous domains originated during the Acadian Orogeny. The Acadian Orogeny was accompanied by the emplacement of a large volume of highly differentiated intrusive rocks, particularly in the Miramichi Anticlinorium and Fredericton Trough domains. These intrusive rocks generally contain higher abundances of uranium and other lithophile elements relative to the pre-Acadian intrusive rocks in the area (Ruitenberg and Fyffe, 1982). Hence, numerous magmatic-type uranium occurrences are associated with these intrusive rocks. Hydrothermal activity generated with the Acadian Orogeny resulted in the redistribution of uranium into shear zones. Uranium derived from these deposits was later transported by surface and groundwater to the Carboniferous Basin.

It is difficult to determine whether the pre-Acadian rocks were originally low in uranium, or the uranium in these rocks has been depleted progressively with time. Hassan (1984) has argued that the greater abundance of uranium in the post-Acadian rocks, compared to the pre-Acadian rocks is due to depletion of uranium from the older rocks and reconcentration in the younger rocks as a result of weathering, deformation and metamorphism. Hassan also stated that older igneous rocks which are in general less differentiated than the corresponding younger rocks, were derived from magma originally containing relatively little uranium.

Magmatic type uranium deposits in New Brunswick appear to form a time-bounded zone (uraniferous epoch) extending from Lower Devonian to Lower Mississippian. Sedimentary type uranium deposits are restricted to Carboniferous time. Felsic-volcanic and volcaniclastic sedimentary rock types were formed during Mississippian time. Although vein-type uranium deposits were formed during post-Acadian time, they occur in rocks of various ages and lithologies, depending on structural features suitable for their concentration.

5.5.0 Conceptual Models for Uranium Concentration in Selected Areas of New Brunswick

5.5.1 General Statement

The majority of data available on uranium and associated element occurrences in New Brunswick has been collected for assessement reports and economic evaluations. Such reports rarely and only indirectly refer to genetic and related scientific aspects of the occurrences. The genetic models for three types of New Brunswick occurrences, described below must be considered within the limitation noted above. These models are preliminary and need further refinement as more data become available.

In these models the following three factors were taken into consideration: 1) the source of the uranium and associated elements, 2) mechanism of their transportation and 3) favourable sites for their concentration.

5.5.2 Uranium Concentration in the Moncton Subbasin

Uranium deposits in the Carboniferous Moncton Subbasin are mainly found in the Pennsylvanian fluviatile sandstone (Pictou Group) and in the Mississippian sedimentary rock sequence of the Horton Group (Figure 9). The geological setting of this subbasin is suitable for uranium mineralization, because a source of uranium and favourable sites for its deposition are in close proximity. In addition, shear zones (faults, joints and fractures) and paleosurfaces in the subbasin served as channelways to transport uranium- enriched fluids from source areas to sites of concentration.

The Devonian-Carboniferous granite of the Charlotte Pluton, particularly the eastern portion (Fig. 9), is enriched in uranium (average 10.6 ± 4.9ppm, Hassan, 1984). This granite is the most

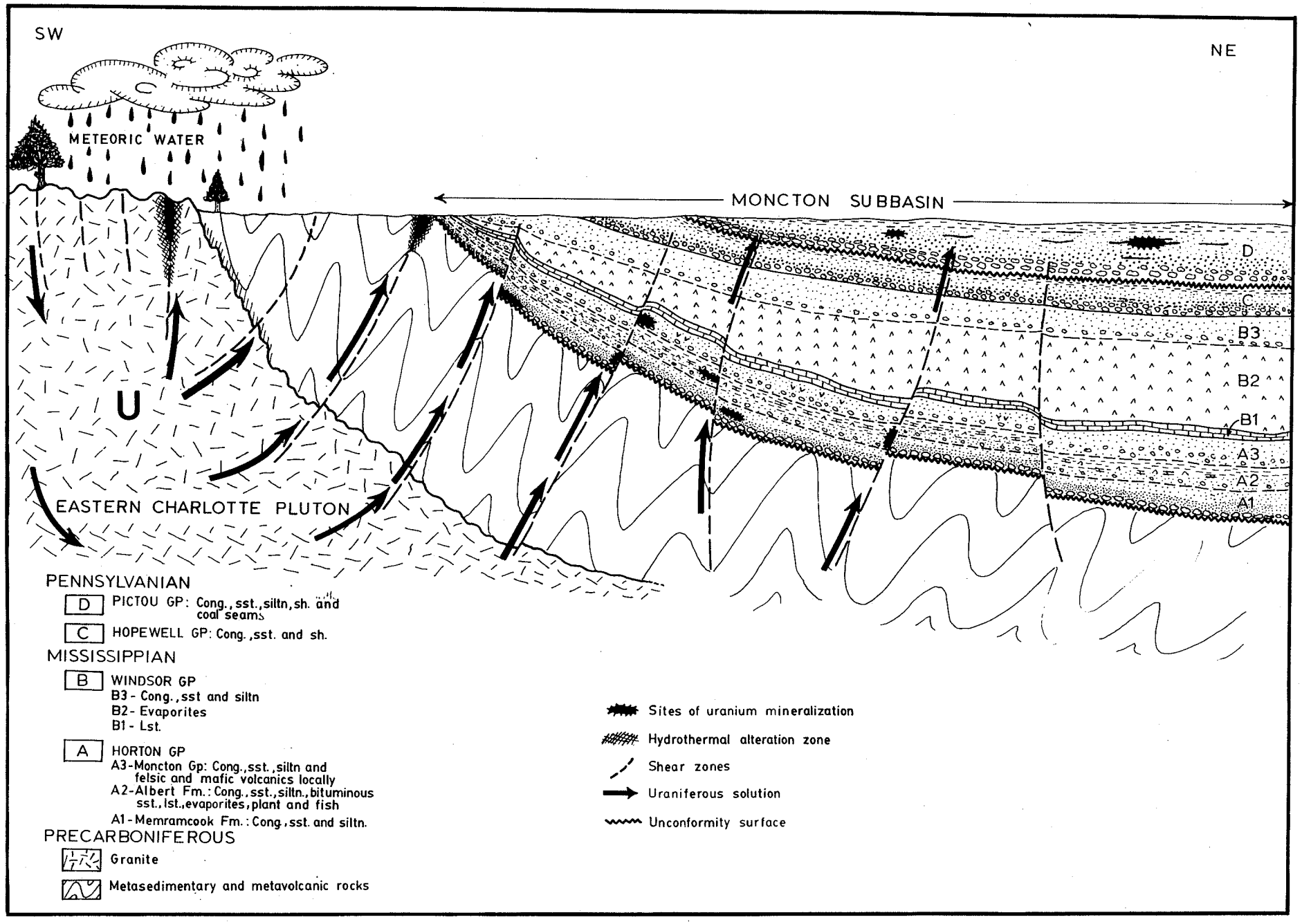

SW
NE
METEORIC WATER
MONCTON SUBBASIN
U
EASTERN CHARLOTTE PLUTON
D
C
B3
B2
B1
A3
A2
A1
PENNSYLVANIAN
D PICTOU GP: Cong., sst., siltn, sh. and coal seams
C HOPEWELL GP: Cong., sst. and sh.
MISSISSIPPIAN
B WINDSOR GP
B3 - Cong., sst and siltn
B2 - Evaporites
B1 - Lst.
A HORTON GP
A3 - Moncton Gp: Cong., sst., siltn and felsic and mafic volcanics locally
A2 - Albert Fm.: Cong., sst., siltn., bituminous sst., lst., evaporites, plant and fish
A1 - Memramcook Fm.: Cong., sst. and siltn.
PRECARBONIFEROUS
Granite
Metasedimentary and metavolcanic rocks
Sites of uranium mineralization
Hydrothermal alteration zone
Shear zones
Uraniferous solution
Unconformity surface

Figure 9

likely source for uranium in the Moncton Subbasin. There is also an indication that considerable uranium may have been leached from the granite, particularly from the upper 30m of partially weathered rock (Hassan, 1984). This is supported by stream and spring sediment data for uranium in the vicinity of the granite (Austria, 1977). Furthermore, multivariate factor analysis and correlations for the elemental relationship with the geochemical variables indicate a moderately significant association between uranium and copper in these rocks (Hassan, 1984). This implies that some copper may also be leached with uranium from these rocks and also deposited in the subbasin. Copper is commonly found with uranium in the uranium prospects in the subbasin.

Other possible sources for uranium are the Mississippian rhyolites and the Silurian pelitic sedimentary rocks. These rocks contain above-normal uranium abundances in comparison to global averages in similar rocks. In addition, sediments derived by erosion of these sources were deposited mostly in the subbasin. These sediments contained trace amounts of uranium which also contributed to the uranium of the subbasin.

There has been some speculation in recent years that some uranium in the Moncton Subbasin might have been derived from the Mississippian evaporite sequences of the Windsor Group at the base (Dunsmore, 1977). According to this hypothesis, uranium and other metals have been concentrated in the evaporites by evaporation of a solution containing above normal uranium.

Uranium and copper were leached from the Charlotte Pluton by meteoric water and hydrothermal solution percolating through fracture systems in the granite. Hydrothermal fluids played a major role in uranium deposition, particularly in areas neighboring the granite such as the Welsford and Ridge Brook occurrences. However for deposits far from the granite, groundwater, surface waters and brines derived from the evaporites may have been responsible for uranium leaching and transportation to new sites of concentration. These uraniferous fluids were transported along shear zones and unconformity surfaces.

A considerable amount of uranium may also have been transported by brine, released from the evaporites within the Windsor Group (Fig. 9). The brine may have scavenged uranium from the evaporites and adjacent sedimentary rocks during its migration. Evaporites that were deposited in sedimentary basins have been considered an important source of both metals and brines (Davidson, 1966; Kostov, 1977; Thiede and Cameron, 1978).

As uraniferous solutions (meteoric, hydrothermal, groundwater and brines) intersected the Mississippian sedimentary rocks, uranium was deposited in favourable sites along shear zones, paleosurfaces and other permeable and porous media in these rocks. Several reducing agents such as organic material, pyrite, H_2O and CH_4 aided in uranium depositions in these sites. Clay minerals, iron oxide and other sorptive agents also aided in uranium concentration.

Part of the uraniferous fluids that are able to reach the Pennsylvanian siliciclastic sandstones deposited their uranium in reducing (coal-bearing) sites; particularly where these reducing sites intersect shear zones, uncomformities and bedding surfaces.

5.5.3 Uranium Concentration in the Mississippian Volcanic Rocks of Harvey Station Area

Uranium in the Harvey Station area (Fig. 10) is mainly associated with rhyolites of the Mississippian Harvey Formation. The uranium occurrences in this area have few common features and it is probable that they were formed by different mechanisms.

Hydrothermal processes were active at Manners Sutton and York Mills and led to the formation of vein-type uranium deposits along shear zones at the latter two localities. It is interesting to note here that these prospects are located near a major fault termed the 'Fredericton Fault'. This fault cuts through the volcanic rocks and extends from the Pokiok Batholith west of these prospects.

Although the uranium in these prospects could be derived from the rhyolitic rocks, themselves as these rocks contain above-normal average uranium abundances, the Devonian granitic rocks, as well as the Silurian metasedimentary rocks may also have contributed part of the uranium. The Fredericton Fault and related shear zones may have served as channelways for uraniferous fluids.

At the Cherry Hill prospect (Fig. 10) uranium mineralization occurs in the rhyolitic tuff of the Mississippian Harvey Formation. The strongest radioactivity is associated with patches of red stain for a distance of 3m along a paleosoil (?) or bedding surface between two rhyolitic tuff units. Some of the uranium concentration also occur along the unconformity separating the Harvey Formation and the York Mills Member, particularly in places where reduction spots are evident. Because the mineralizing solutions consisted of relatively cool uranium-bearing groundwater, alteration is very weakly developed. Iron oxides which occur as a

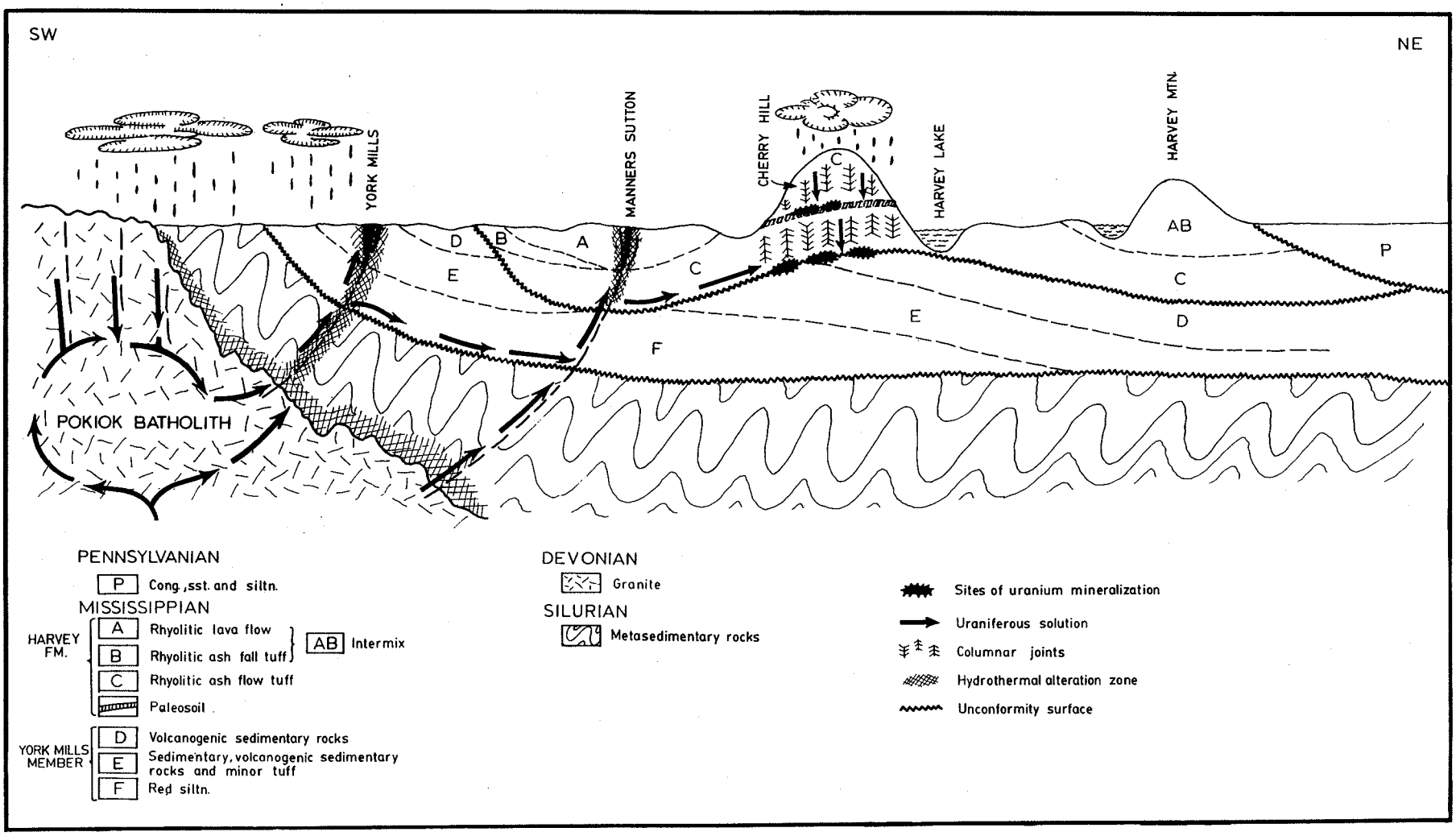

SW
NE
YORK MILLS
MANNERS SUTTON
CHERRY HILL
HARVEY LAKE
HARVEY MTN.
POKIOK BATHOLITH
A
B
C
D
E
F
AB
P
PENNSYLVANIAN
P Cong., sst. and siltn.
MISSISSIPPIAN
HARVEY FM.
A Rhyolitic lava flow
B Rhyolitic ash fall tuff
AB Intermix
C Rhyolitic ash flow tuff
Paleosoil
YORK MILLS MEMBER
D Volcanogenic sedimentary rocks
E Sedimentary, volcanogenic sedimentary rocks and minor tuff
F Red siltn.
DEVONIAN
Granite
SILURIAN
Metasedimentary rocks
Sites of uranium mineralization
Uraniferous solution
Columnar joints
Hydrothermal alteration zone
Unconformity surface

Figure 10

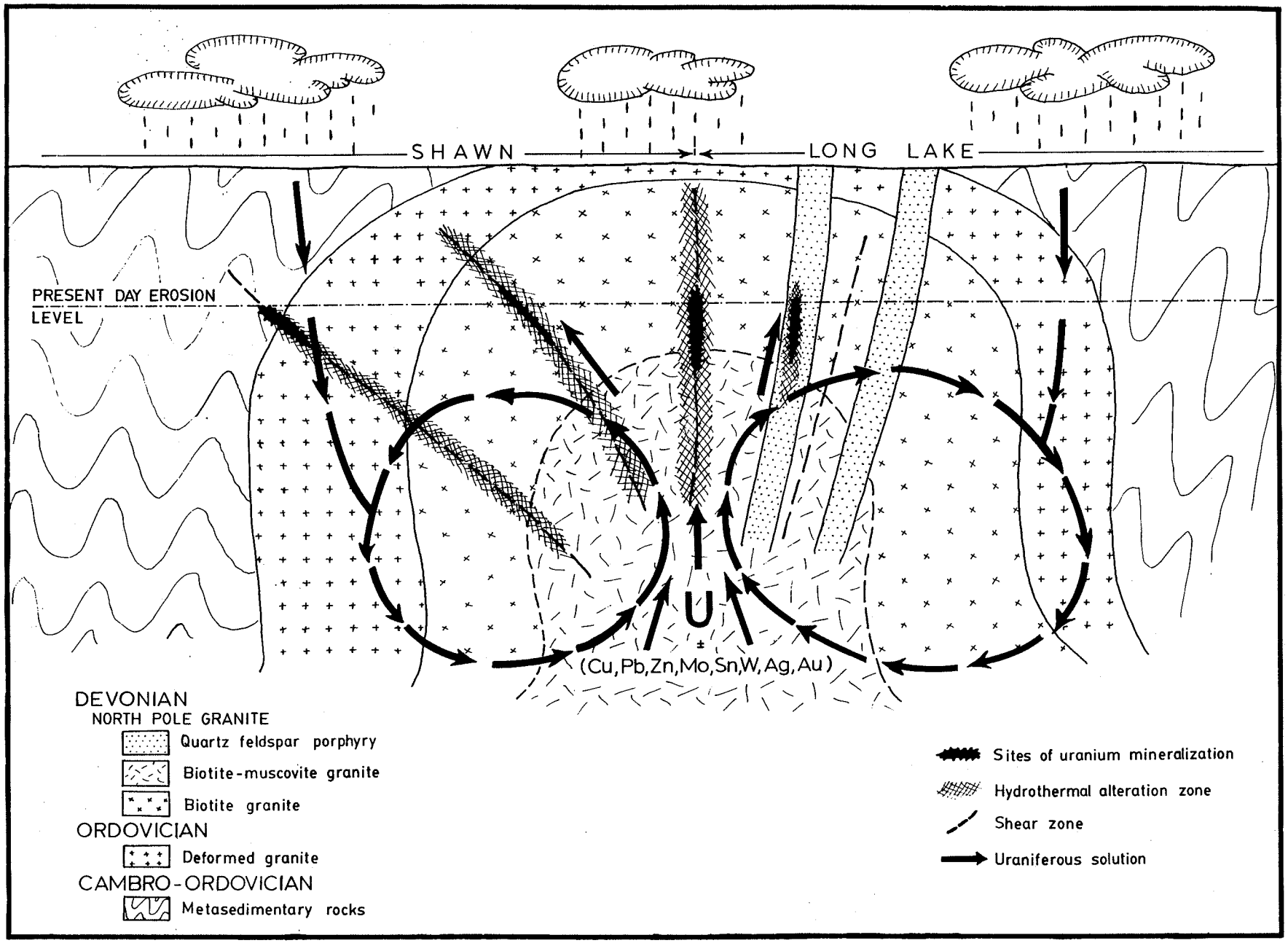

SHAWN
LONG LAKE
PRESENT DAY EROSION LEVEL
U ±
(Cu,Pb,Zn,Mo,Sn,W,Ag,Au)
DEVONIAN
NORTH POLE GRANITE
Quartz feldspar porphyry
Biotite-muscovite granite
Biotite granite
ORDOVICIAN
Deformed granite
CAMBRO-ORDOVICIAN
Metasedimentary rocks
Sites of uranium mineralization
Hydrothermal alteration zone
Shear zone
Uraniferous solution

Figure 11

stain, are the only visible alteration products. It is likely that uranium, in this zone is derived from the leaching of the rhyolitic ash-flow tuff (average U = 5.0 ± 4.5, Hassan, 1984) by oxidizing groundwater. An autoradiograph of a sample taken from this unit (Hassan, 1984), indicates that these rocks contain uranium in uraninite. This may suggest that the rhyolitic ash-flow tuff is a possible source for uranium in this area. Uranium measured across a vertical section at this occurrence by Hassan (1984) shows gradual increases from top to bottom of the rhyolitic ash-flow tuff unit. This suggests that uranium may have been leached during weathering of the ash-flow rhyolite. Weathering of these rocks by downward percolating water could yield large quantities of the uranyl ion, which could then be transported along columnar joints developed in these rocks and redeposited in the paleosoil layer and the unconformity. The paleosoil is characterized by fine-grained clay minerals and organic matter which could have served to adsorb uranium. The unconformity surface is also a suitable site for concentration because uranium-bearing water could move along it and be reduced by organic material, derived from vegetation that may have existed on the paleosurface. Radioactivity is particularly pronounced at places where 'reduction spots' in siltstone are evident.

Although it is possible that the uranium deposited at Manners Sutton and York Mills was derived internally from the volcanic pile by leaching, transportation and redeposition, its derivation from the Devonian Pokiok Batholith or the Silurian metasedimentary rocks is also possible. A hydrothermal convection cell may have developed within the Pokiok Batholith and perhaps led to the depletion of a considerable amount of uranium from the granite. Uranium is expected also to have been leached from the granite by oxidized meteoric water percolating through fractures in the granite. The uraniferous fluid was transported to the volcanic pile through shear zones. The uranium content of this fluid may have been enhanced during its movement through the Silurian metasedimentary rocks and the Mississippian volcanic rocks. When this fluid reached the rhyolitic rocks, it mixed with uranium-bearing groundwater moving in the volcaniclastic sedimentary and volcanic rocks, through porous and permeable media such as shear zones, unconformity surfaces and bedding or layering planes. When such fluids cooled uranium was deposited near these positions.

5.5.4 Uranium Concentration in the Long Lake Area

The uranium mineralization in the Long Lake area (Fig. 11) includes two major vein-type uranium occurrences (Long Lake and Shawn). These occur along shear zones crosscutting the granitic rocks of the Devonian North Pole Granite. Three additional vein-type uranium occurrences (Add, Serpy, Bear), which are probably genetically related to the North Pole Granite, are also formed nearby along shear zones in the Ordovician granitic rocks.

The models discussed for vein-type uranium mineralization in the Hercynian granitoids of Western Europe (Simpson et al., 1979) and in the uranium deposits at Millet Brook of Nova Scotia (Chatterjee et al., 1982) appear well suited for the Long Lake uranium deposits.

The uranium (± other elements) was mobilized and concentrated in the area, perhaps by the Devonian North Pole Granite. In addition to being the source for uranium, the granite probably provided the hydrothermal fluids and the energy required to activate the proposed hydrothermal cell within the granite.

Uranium was probably enriched initially in the highly differentiated two-mica phase granite of the North Pole Granite, during its generation by partial melting of crustal rocks. As this granite was emplaced in the epizone, its uranium content may have increased through contamination of the melt by Cambro-Ordovician metasedimentary rocks.

A hydrothermal convection cell is proposed to have developed within the granite following the Acadian Orogeny. The Acadian Orogeny produced fracture systems prerequisite for hydrothermal fluid mobilization within the granite and the surrounding rocks. This hydrothermal cell is indicated by intense alteration haloes surrounding the mineralization along shear zones.

Meteoric water and magmatic water are probably the major fluid resources of the hydrothermal cell. The temperature variation between the cold meteoric water and the hot magmatic water may have helped to retain the continuity of the hydrothermal cell circulation.

SECTION SIX

SUMMARY, CONCLUSIONS AND GUIDELINES FOR FUTURE INVESTIGATIONS

6.1.0 Summary and Conclusions

Figure 1, shows the locations, elemental associations and depositional types for eighty-two uranium occurrences in New Brunswick. On this map, seven uraniferous domains have been outlined from the previously published lithotectonic framework of the province. The marked agreement between the uraniferous domains and these lithotectonic zones suggests that the uranium was concentrated in direct response to the major geological events of the zones.

Of the seven uraniferous domains, only three presently appear favourable for economic uranium deposits; the Miramichi Anticlinorium, the Fredericton Trough and the Carboniferous Basin domains. The first two domains are essentially suitable for magmatic and magmatic-related, vein-type uranium deposits similar to those discovered in Europe, U.S.A. and Nova Scotia. The third domain is suitable for supergene, sedimentary-type uranium deposits similar to those discovered in the Colorado Plateau, U.S.A.

The non-cataclastic, post-Acadian Devono-Carboniferous granitic rocks which are emplaced in both the Miramichi anticlinorium and in the Fredericton Trough are apparently the major sources for uranium in these areas. Part of the uranium released from the granitic rocks, presumably by weathering, is likely to have been transported either in solution or in detritus to the Carboniferous Basin domain.

The uranium deposits of New Brunswick appear to have developed as a result of the Acadian Orogeny. Hence, the Devono-Carboniferous rocks appear to form a time-bound zone (uraniferous epoch) in New Brunswick and therefore represent valid targets for uranium exploration. The Acadian Orogeny appears to have mobilized uranium and other metals from zones deep in the earth's crust and transported them to near surface zones. The Acadian Orogeny also produced suitable mechanisms and environments for uranium migration and deposition.

6.2.0 Guidelines for Future Investigations

To date, none of the uranium occurrences have been mineable. However, the possibility of locating economic uranium deposits in the Miramichi Anticlinorium, Fredericton Trough and in the Carboniferous Basin domains appears to be realistic. Future research should concentrate on the recognition of appropriate geological, geochemical and geophysical 'signatures' that lead to the identification of new uranium deposits.

Among the essential data that are required for completing the uranium resource assessment in New Brunswick is detailed geological mapping and geochemical and geophysical investigations of the post-Acadian plutons. These investigations should include, as a first step, a detailed radiometric survey (U, Th and K) in order to evaluate the favourability of these plutons for uranium mineralization.

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APPENDIX I

GEOLOGY OF URANIUM AND ASSOCIATED ELEMENTS IN NEW BRUNSWICK

II. Aroostook-Matapedia Anticlinorium Domain

III. Chaleur-Bay Synclinorium Domain

IV. Miramichi Anticlinorium Domain

V. Fredericton Trough

VIIA. Carboniferous Basin (Plaster Subbasin)

VIIB. Carboniferous Basin (Moncton Subbasin)

VIIC. Carboniferous Basin (Central Carboniferous Subbasin)

II. AROOSTOOK - MATAPEDIA ANTICLINORIUM DOMAIN

	LOCATION (lat., long, NTS* no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
1	47°45'50" 67°55'20" 210/15W	Popelogan	Felsic volcanics			0.02% U_3O_8 (equiv.) 5 x B.G*2		Devonian quartz porphyry		-Rock assays -Radiometric surveying -Trenching	McAllister, 1954	1. Radioactivity occurs at the contact between Devonian quartz porphyry and basalts and in weathered, altered boulders of basalt. 2. The entire body of quartz porphyry has 1.5x to 1.75x background. The basalt has normal background values. At the contact of quartz porphyry and basalt radioactivity is 5x background.

*1 NTS - National Topographic System
*2 B.G. - Background

III. CHALEUR-BAY SYNCLINORIUM DOMAIN

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
2	47°54'30" 66°01'30" (210/16E)	Durham Centre	Felsic volcanics		Pb			Devonian felsic volcanic rocks			Gross, 1957	
3	47°59'55" 66°42'34" (210/15E)	Atholville	Felsic volcanics	Uranium oxides	Pyrite	2.3% U_3O_8 (equiv.)		Devonian felsic volcanic rocks		-Radiometric surveying -Rock sampling - DDH*	Dunsmore, 1977 Gross, 1957	1. Gangue minerals (quartz, kaoline, and calcite). 2. Up to 0.04% U_3O_8 (equiv.) detected in the Silurian slates hosting the felsic volcanic rocks.
4	47°51'16" 66°56'13" (210/15W)	Cox Brook	Veins	Uraninite, pitchblende	V, Hydrocarbon	Grab sample: 2.5% U_3O_8 (equiv.) Chip sample: 0.21% U_3O_8 (equiv.)	Kaolinization	Radioactive material present in irregular veinlets (0.3-1.25cm wide) and in disseminated specks and streaks along narrow fractures in the Devonian felsite dyke intrudes into U. Ordovician black slates and slaty argillite.	The felsic dyke is emplaced near the axis of a large syncline of Paleozoic rocks plunging NE. The felsite dyke has been offset by faults striking N70°E and dipping steeply N.	-Radiometric surveying -Rock assays -Trenching -Short drill holes	Gross, 1957 Lang et al., 1962	1. The showing is located about 0.8km south of a granite mass. 2. The felsite dyke weathers to a light buff or white mass of clay-like material.
5	47°07'00" 67°05'00" (210/3E)	Left	Felsic volcanics		Cu, Pb, Zn, Mo, Ag. Pyrite, Magnetite, Chalcopyrite, Galena	stream sediments (av) U = 13.5ppm Cu = 33ppm Mo = 10ppm Pb = 55ppm		The property is underlain by a series of rhyolite (v.f. grained, flow banded and breccia), basalt (vesicular and pillow) and metasedimentary rocks which have been intruded by a m.g. quartz-diorite and diabase dyke.	An E-W fault is inferred to the south of the southern boundary of the property.	-Rock sampling -Stream sediments -Soil sampling	Warner, 1980	The rhyolite-metasedimentary rocks interface is believed to be a favourable site for Cu, Pb, Zn and Ag mineralization of the volcanogenic sulphide type.
6	47°04'30" 67°04'00" (210/3E)	Stew	Veins		Cu, Pb, Zn, Mo, Ag, Au Galena, Sphalerite, Pyrite, Chalcopyrite, Bornite	Stream sediments: U up to 204ppm Cu up to 34ppm Pb up to 235ppm Zn up to 725ppm Soil samples: U up to 124ppm Cu up to 254ppm Pb up to 840ppm Zn up to 2200ppm Ag up to 2.40ppm	Kaolinization Sericitization Limonitization Manganization Hematitization	Devonian felsic volcanic rocks consisting of massive white rhyolite, dark rhyolite agglomerate, feldspar porphyry and rhyolite tuffs.	The volcanic rocks as well as the adjacent meta-sedimentary rocks are openly folded, faulted and to some extent fractured. Faulting and fracturing have a NW-SE and E-W trend respectively.	-Stream sediments -Soil sampling -Water sampling	Burns, 1980a Burns, 1980b Robertson, 1979a	The grade of mineralization increases where the faults intersect the metasedimentary rocks and the massive dark rhyolite.

*DDH - Diamond-drill hole

III. CHALEUR-BAY SYNCLINORIUM DOMAIN

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
						Outcrops and float rock samples: U up to 4.2ppm Cu up to 264ppm Pb up to 5680ppm Zn up to 4640ppm Ag up to 4.2ppm Trench samples: (rhyolitic ignimbrite) Cu=0.014% over 1.65m Pb=0.38% over 1.65m Zn=0.36% over 1.65m Au=0.42% over 1.65m						
7	47°04'53" 67°03'00" (210/3E)	Evy	Veins		Cu, Pb, Zn Mo, Ag, Chalcopyrite Galena, Pyrite	Stream sediments: U up to 124ppm Cu up to 375ppm Zn up to 1400ppm Au up to 1.3ppm Mo up to 8ppm Pb up to 133ppm Rock samples: U up to 4.2ppm Cu up to 264ppm Pb up to 5680ppm Zn up to 4640ppm Au up to 4.2ppm		Devonian felsic and mafic volcanic rocks and siltstone	As in Stew	-Stream sediments -Water sampling -Soil sampling -Rock sampling -Radiometric surveying	Burns, 1980a Burns, 1980b Robertson, 1979a	The rocks in the area are very poorly exposed.
8	47°45'10" 66°15'45" (210/3E)	Blue Mountain	Stream sediments		Pb, Zn, Ag Au	Stream sediments: U up to 184ppm Zn up to 1020ppm Pb up to 325ppm Ag up to 1.2ppm Heavy mineral assay: Au up to 245ppm Rock samples: Rhyolite (massive) U = 0.6ppm Pb = 20ppm Zn = 21ppm Ag = 0.1ppm Rhyolite (flow laminated) U = 0.8ppm Pb = 12ppm Zn = 4ppm Ag = 0.1ppm In-situ gamma-ray spectrometry (6 rhyolite samples) eU = 3.9ppm eTh = 22.9ppm K = 6.2% eU/eTh = 0.15		Devonian felsic and mafic volcanic rocks and sedimentary rocks.	Several east-north-easterly trending lineaments identified on air photographs. A postulated major E-W transverse fault is also recognized.	-Stream sediments -Water sampling -Soil sampling -Heavy mineral assays -Rock sampling -Radiometric surveying	Ford, 198 Gittings, 1980 Robertson, 1979b	Pb-Zn-Ag-U anomal are detected along N-NE trending fractures. The most promising soil anomaly is located at the junction of two of these fracture sets and a postulated E-W transverse fault.

IV. MIRAMICHI ANTICLINORIUM DOMAIN

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
9	46°35'50" 66°45'40" (21J/10W)	Otter Brook	Magmatic		Mo, W	Stream sediments: U up to 2540ppm Rock samples: 35 granitic samples U=21.1ppm (aplitic) U=11.8ppm (non-aplitic) Drill hole samples: U up to 1002ppm Th = 2496ppm W = 60ppm Mo = 360ppm	Hematitization	Devonian/Carboniferous calc-alkaline quartz anzonite (Burnt Hill Stock). There are a few small (<1m) aplite dykes and pegmatite pods. Rapikivi texture and miarolitic cavities are common. Accessory fluorite, beryl, molybdenite and wolfranite in quartz veins have also been identified.	Two sets of joints were identified in the granite (305/75°SW and 035/82° SE). Quartz veins (305/85°SW) were also identified in the granite.	-Soil sampling -Rock sampling -Trenching -Drilling -Radiometric surveying -VLF -Magnetic -I.P.	Butler, 1980a Hattie, 1981	Two sites were drilled near springs with anomalous U and Rn, within areas underlain by biotite monzonite. No enrichment of U, Sn or W were intersected.
10	46°45'17" 66°36'50" (21J/10E)	Catamaran Fault	Veins		Mo	Soil samples: U = 137.3ppm (B.G. = 5ppm) Mo = 9-10ppm (B.G. = 3ppm)	Hematitization Chloritization	Aplite and/or pegmatite dykes and quartz veins cutting the Devonian/ Mississippian Dungarvon Granite. The granite is K-feldspar and quartz-rich with minor biotite.	Fractures carrying veinlets of aplite and quartz are common. These fractures are stained red and minor amounts of very soft black and yellow mineralization was noted. Well developed shear zones occur parallel to the Catamaran Fault.	-Soil and siltstone sampling -Rn in soil -Rn in water -Trenching (2) -Radiometric surveying -Magnetics -Radem VLF	Adams, 1980a Adams, 1981a	Above average radioactivity was associated with the aplitic dykes and quartz veinlets relative to the granite.
11	45°35'45" 66°35'00" (21J/11)	Cleaveland	Magmatic		Cu, Pb, Zn, Mo, Sn, W, Ag, Au. Pyrite, Sphalerite, Galena.	Stream sediments: U up to 465ppm Mo up to 140ppm W up to 24ppm Rock samples (Trench): strongly greisenized granite: Zn up to 17,600ppm Pb up to 3100ppm Cu up to 275ppm Sn up to 449ppm W up to 40ppm Ag up to 6.6ppm Au up to 45ppb		Devonian/ Mississippian pinkish-grey, f.g. to c.g. biotite granite (Dungarvon Granite) intruded into a sequence of metasedimentary rocks which consist of argillites, greywackes and poorly sorted grey conglomerate.	WNW trending lineaments (which (may represent fractures) were recognized on air photographs.	-Stream sediments -Radiometric surveying -Magnetics	Bloemraad and Reid, 1980	A positive correlation exists between U and Mo in stream sediment samples.

IV. MIRAMICHI ANTICLINORIUM DOMAIN

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
12	46°38'57" 66°37'23" (21J/10E)	Rocky Brook	Magmatic		Cu, Pb, Zn, Mo Sn, W, Ag, Bi, F. Pyrite Wolframite Molybdenite Fluorite	Soil samples: U = 18.6ppm Cu = 90ppm Ag = 5.3ppm Mo up to 98ppm Sn up to 50ppm W up to 60ppm F up to 5800ppm	Greisenization	Devonian/ Mississippian quartz-biotite monzonite of Dungarvon Granite. The granite intrudes Cambro- Ordovician sedimentary and mafic volcanic rocks which are hornfelsed.		-Soil sampling -Radiometric surveying -Trenching	Gra[illegible] and Pollock, 1[illegible]8	Anomalous uranium detected in water seepage. One of these anomalies indicated as high as 1400cps (B.G. = 50-100cps). It is believed that uranium is associated with organic materials in these seepages. Most of the soil samples anomalies were almost wholly restricted to the granite.
13	47°10'15" 66°25'00" (21J/10E)	Dungarvon Group	Magmatic		Pb, Zn, Mo, Sn, Sb, W, F. Pyrite, Pyrrhotite Scheelite Manganese Hematite Sphene	Stream sediments: U up to 485ppm Rock samples(granites): U up to 13ppm Th up to 40ppm F up to 550ppm W up to 28ppm Sn up to 24ppm Radioactivity(granite): up to 11,000cps	Epidotization Saussuritization Chloritization	Devonian/ Mississippian biotite granite of Dungarvon Granite with minor aplitic dykes intruded into Ordovician volcanic and metasedimentary rocks. The granite is orange-pink, m.g. to c.g. with extensive alteration and fracturing.	Joints and/or fractures are observed in the granite.	-Stream sediments -Water sampling -Heavy mineral analysis -DDH(3) -Geophysical logging -VLF -Resistivity	Austria, 1977 Gleeson, 1979 Lafontaine, 1979a	The granite has an average uranium concentration of 7ppm and Th/U ratio of 4.
14	46°44'00" 66°37'30" (21J/10E)	McConnell Brook	Soil			Grab samples (quartz monzonite): U_3O_8 = 0.007% ThO_2 = 0.003% K = 3.6% Radioactivity (quartz monzonite): T.C. up to 60,000cpm (B.G. = 22,500cpm)	Hematitization Kaolinization	Devonian/ Mississippian biotite quartz- monzonite with minor biotite- muscovite quartz monzonite of the Dungarvon Granite. A few pegmatitic pods are observed in the quartz- monzonite.	The granite is exfoliated with shear zones along which feldspar is altered to kaoline. Structural lineaments on the property show a preferred E-W orientation.	-Soil sampling -Rn-in-soil -Rn-in-water gas -DDH -Trenching -Radiometric surveying -Magnetics	Adams, 1980b Austria, 1979 Cross, 1978a Stones, 1978	Down-hole radiometric logging of the drill holes failed to detect any uranium mineralization. High isolated values of Rn and U are encountered in water and springs but it was not found to be associated with bedrock.

IV. MIRAMICHI ANTICLINORIUM DOMAIN

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
15	46°35'00" 66°40'00" (21J/10E)	Trout Brook	Stream sediments		Sn, W	Stream sediments: U up to 590ppm Soil samples: U up to 130ppm Sn up to 47ppm W up to 40ppm Rock samples (av.): U = 12.2± 2.7ppm Th = 28.1±2.8ppm W = 11.5±7.5ppm Sn = 36±16ppm Biotite-muscovite adamellite: U = 16ppm Th = 21ppm Muscovite adamellite: U = 33ppm Th = 17ppm Adamellite (av. 12 samples): U = 5.6ppm Th = 24ppm U/Th = 4.0	Chloritization Albitization	Devonian/ - Mississippian adamellite of Trout Brook Granite which consists of porphyritic two-mica adamellite. The adamellite intruded into metasedimentary rocks.	Post-tectonic granite with sharp discordant contacts. They are typically homogeneous (non-cataclastic). They have steep walls and gently sloping and irregular roofs.	-Stream sediments -Soil sampling -Radiometric surveying -Trenching -VLF	Austria, 1977 Brule, 1982 Laanela, 1980 Lafontaine, 1980	Burnt Hill Tungsten Mine is located about 5km west of the west end of the Trout Brook Stock. Minerals found in the mine and in the adjacent area are W, Mo, Fe, Be, As, Sn and Cu. There is a good correlation between uranium and two-mica granite. Av. $K_2O/(CaO\ Na_2O)$ 1. Av. K_2O/Na_2O = 1.2
16	47°03'10" 66°53'30" (210/2W)	Shawn	Veins	Autunite	Cu, Pb, Zn, Fe Mn, Mo, Ag, Au. Molybdenite	Rock sample (altered gra[illegible]): U up to 8800ppm Cu up to 5680ppm Pb up to 6000ppm Zn up to 3580ppm Ag up to 11ppm Mo up to 8800ppm Au up to 90ppb	Silicification Sericitization Chloritization Limonitization Hematitization	Strongly veined, highly silicified Fe-rich, altered Devonian granite and quartz monzonite (North Pole Granite). This granite is intruded into Ordovician deformed granite and Cambro-Ordovician metasedimentary and metavolcanic rocks.	Claims are underlain by undeformed post-tectonic Devonian granite and foliated cataclastic granite of Ordovician age. The assumed contact between them strikes about E-W. Further NW the granitoid rocks are in faulted contact with Cambro-Ordovician metasedimentary and metavolcanic rocks.	-Stream sediments -Soil sampling -Stream wate- -Rock sampling -Heavy mineral analysis -Trenching -Radiometric surveying		The outcrop in the area are extremely scarce and the area covered by thick overburden soils. Soil anomaly in the area trend E-W.
17	47°03'10" 66°53'30" (210/2W)	Long Lake	Veins	Autunite Torbernite	Cu, Pb, Zn, Mn, Mo, Sn, Ag, Au, Bi, Cl, F. Pyrite, chalopyrite, covellite, sphalerite, galena, molybdenite, arsenopyrite, matildite, cassiterite, native bismuth.	Float samples: U = 3300ppm Mo = 120,000ppm Outcrop samples: Cu = 31,200ppm over 0.35m Pb = 3,120ppm over 0.35m Ag = 292ppm over 0.35m Core samples: Zn = 153,000ppm over 0.30m Au<5ppb	As in Shawn	The mineralization occurs mainly in altered, brecciated and fractured quartz monzonite of the Devonian North Pole Granite and in Devonian grey porphyritic rhyolite.	Prominent, repeated NW-SE faulting and shearing is believed to have resulted in Cu-Zn-Pb-Ag vein mineralization in several widely spaced NW-SE zones and also in subsequent brecciation associated with carbonate infusion in the north part of the quartz-monzonite, and with silica (jasperoid-chalcedony) to the southwest. The later phase of this faulting event is thought to have caused the emplacement of muscovite granite enriched in U, Mo and Ag under or close to Long Lake.	-Stream sediments -Rock sampling -DDH -Trenching -Radiometric surveying -Magnetics -I.P. -VLF	Crouse, 1975a Fiset and Lewis, 1980 Glackmeyer, 1973 Hauseux, 1980 Leonard, 1982 Needlands, 1971 Robertson, 1980a Skinner, 1975	Two specimens of fresh quartz-monzonite from drill core have been dated at 391 m.y. (K-Ar) and 399 m.y. (Rb-Sr)(Hauseux, 1980) An anomaly is detected on airborne gamma-ray spectrometry data over the claims area.

IV. MIRAMICHI ANTICLINORIUM DOMAIN

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
18	46°35'15" 67°05'00" (21J/11E)	Beadle Mountain	Magmatic			Grab sample (granite): U up to 23ppm Radioactivity 3 x B.G. in-situ gamma-ray spectrometry (Ford 1982) A: Two-mica adamellite (8 samples): eU = 2.1ppm eTh = 5.8ppm K = 3.6% eU/eTh = 0.43 B: Muscovite adamellite (9 samples): eU = 13.6ppm eTh = 5.8ppm K = 3.3% eU/eTh = 2.29		Devonian/ Mississippian c.g. leucocratic muscovite granite (Juniper Barrens Granite) The granite is strongly per-aluminous along with low content of TiO_2, FeO_T, MgO, CaO, Zr and Ba and high in Cs, Nb and Sn.		-Stream sediments -Rock sampling -Radiometric surveying	Chandra, 1981 Ford, 1982 Wilson, 1978 Wilson, 1980	
19	45°48'30" 67°26'30" (21G/14W)	Canterbury	Soil		Cu, Pb, Zn, Sb, Ag, Rb	Soil samples: U up to 274ppm		The underlying rocks consist of Silurian meta-sedimentary rocks.		-Soil sampling	Graham, 1980	
20	47°05'00" 66°49'00" (21O/2W)	Add	Veins		Cu, Pb, Zn, Mo, Ag Sphalerite Pyrite	Stream sediments: U up to 166ppm Mo up to 210ppm Zn up to 6100ppm Cu up to 56ppm Ag up to 1.4ppm Drill cores (DH#A1): U up to 5.1ppm Th up to 34ppm Cu up to 848ppm Mo up to 124ppm Zn up to 3040ppm DH#A2: U up to 6.4ppm Th up to 36ppm Cu up to 1630ppm Zn up to 1890ppm		Ordovician deformed granite The granite exhibits porphyroblastic growth of garnet biotite, epidote and rarely green amphibole which is thought to postdate the third phases of deformation.	Three phases of deformation observed in the rocks. The rocks are of greenschist facies which accompanied the first and second phases of deformation.	-Stream sediments -Water sampling -DDH -Radiometric surveying -I.P.	Crouse, 1979 Robertson, 1979c	Background U-Mo values in stream sediment samples throughout the claim are well above the regional anomalous levels of 20ppm U and 7ppm Mo. Nearly all water samples were found to be anomalous in U and F with values up to 2ppb U and 155ppm F.
21	47°10'15" 66°45'30"	Serpy	Veins		Cu, Pb, Zn, Mo, Sn, Ag, Au Pyrite.	Stream sediments: U up to 2095ppm Cu up to 60ppm Zn up to 136ppm Mo up to 16ppm Ag up to 1.4ppm Au up to 5ppb Rock chips: U up to 2.8ppm Th up to 32ppm Cu up to 19ppm Mo up to 2ppm Pb up to 9ppm Sn up to 12ppm	Chloritization Silicification Limonitization	Ordovician deformed granite intruded into Cambro-Ordivician meta-sedimentary rocks.	NNW-SSE faults are postulated to transect the rocks. Three phases of deformation.	-Stream sediments -Water sampling -Radiometric surveying	Crouse, 1979 Hauseux, 1980 Robertson, 1979d	

IV. MIRAMICHI ANTICLINORIUM DOMAIN

	LOCATION (lat., long, NTS no.	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
22	47°07'00" 66°48'30" (210/2W)	Bear	Veins		Cu, Pb, Zn, Mn, Mo, Sn, W, Ag, Au.	Stream sediments: U up to 160ppm Mo up to 128ppm Zn up to 400ppm Cu up to 14ppm Ag up to 1ppm Soil samples: U up to 329ppm (over 240x240m area) Mn up to 5400ppm (over 240x240m area) Mo up to 2600ppm Rock chip samples: Cu up to 7ppm Mo up to 8ppm Pb up to 15ppm Zn up to 46ppm Ag up to 0.5ppm Mn up to 230ppm Rock samples: (Ordovician granite): U up to 15ppm Mo up to 8ppm Heavy mineral assays: U up to 71ppm Th up to 59ppm Cu up to 51ppm Mo up to 7ppm Pb up to 340ppm Zn up to 186ppm Sn up to 11ppm W up to 8ppm Au up to 345ppb		Ordovician deformed granite The granite is buff to pink, m.g. equi-granular to subporphyritic in texture.	The rocks are subjected to three phases of deformation by Taconian and Acadian orogenies. Two structural lineaments are suggested to cut the property and are believed to be related to faults.	-Stream sediments -Stream water -Heavy mineral analysis -Radiometric surveying	Crouse, 1979 Hauseux, 1981a Irrinki, 1975 Robertson, 1980b	The rocks in the area have undergone a complex sequence of regional and contact metamorphic events. Rocks in the vicinity of the claims are considered to have initially undergone regional greenschist facies metamorphism which accompanied first and second phases of deformation.

V. FREDERICTON TROUGH

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
23	45°25'30" 66°20'00" (21G/8)	Welsford	Veins	Uraninite Thorite		in-situ gamma ray spectrometry: eU up to 112ppm eTh up to 766ppm Country rocks (granite): U up to 18ppm	Silicification Hematitization	Carboniferous coarse-grained granite of Eastern Charlotte Pluton	The mineralization is associated with fractures and joints within the granite.	-Rock sampling -Radiometric surveying	Chandra, 1981 Hassan, 1984	The uranium mineralization is associated with sulphide mineralization.
24	45°24'00" 66°29'00" (21G/9W)	Bald Head Lake	Magmatic		Mo, Sn Fluorite Tourmaline		Greisenization	Carboniferous coarse-grained granite of Eastern Charlotte Pluton		-Rock sampling -Rn surveying -Radiometric surveying -Airbourne and ground VLF -Magnetics	Butler, 1980b	
25	45°25'00" 66°29'00" (21G/8W)	Trout Lake	Veins		F Fluorite Tourmaline	Stream sediments: U up to 5130ppm Water samples: U up to 21.5ppb Rock samples: A: Fresh granite: 3 x B.G. B: Altered granite: U = 66ppm	Hematitization	Carboniferous granite of Eastern Charlotte Pluton		-DDH(2) -Trenching -VLF -IP	Butler, 1980c Butler, 1981	DDH and gamma log probe results did not indicate above background uranium concentration in the granite.
26	45°23'30" 66°11'30" (21G/8E)	Mount Champlain	Magmatic		Pb, Zn, Ag, F	Radiometric: T.C. up to 2000cps		Devonian granite of Welsford Complex.	A NNW/SSE fracture systems are observed in the claim and extends over 3.5km.	-Soil sampling -Trenching -Radiometric survey	Brack, 1981a	
27	45°11'00" 66°56'00" (21G/2W)	Lily Lake	Veins		Mo	Stream sediments: U up to 2960ppm	Silicification Sassuritization Carbonitization	Devonian c.g. monzonite of Western Charlotte Pluton		-Stream sediments -Water sampling -Rn surveying -DDH -Trenching -Magnetics -VLF -I.P.	Butler, 1980d	Evidence of widespread movement of meteoric water is indicated by wad dendrites observed on fracture planes.

V. FREDERICTON TROUGH

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
28	45°24'00" 66°35'00" (21G/7E)	South Oromocto Lake	Soil		Cu, Mo, Pb, F	Soil samples: U up to 12%	Silicification (of the meta-sedimentary rocks)	The claims are underlain by Silurian meta-sedimentary rocks which in turn overlie the St. George Batholith. The metasedimentary rocks consist mainly of dark argillites and sandstones. The batholith is mainly a biotite granite in the claim area.		-Soil sampling -Rock sampling -Radiometric surveying -Emanometry -Airborne VLF -Ground VLF -Aeromagnetics	Brack, 1981b Brack, 1982a	
29	45°52'00" 67°07'30" (21G/14E)	Pokiok	Magmatics		Mo, Sn, W Molybdenite Wolframite	Stream sediments: U up to 780ppm Spring sediments: U up to 890ppm Lake sediments: U up to 33ppm Pink two-mica granite: (8 samples) U = 12.8ppm Th = 7.0ppm Ca = 0.46% Th/U = 0.55 Mo = 32.3ppm	Hematitization Silicification Chloritization	Devonian pink two-mica granite of Hawkshaw Granite of the Pokiok Batholith	At the anomalous zone the area is transected by several lineaments. Fractures are common in the granite. The common fracture direction is 305°.	-Stream sediments -Spring sediments -Lake sediments -DH	Kuss, 1980	
30	45°13'46" 66°28'07" (21G/2)	Lepreau River	Veins			In-situ gamma-ray spectrometry eU up to 34.00ppm eTh up to 89.00ppm	Chloritization	Silurian/ Devonian rhyolite.	The rhyolite is highly fractured and jointed.	-Radiometric surveying -Chemical assay assaying -Autoradiography	Hassan, 1984	The mineralization occurs along randomly oriented fractures. The mineralization zone occurs near the contact with the granitic rocks of the Eastern Charlotte Pluton.

V. FREDERICTON TROUGH

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
31	45°51'00" 67°02'05" (21G/14E)	Lake George	Veins	Coffinite, uraninite thucholite pitchblende	Sb, Cu, Pb, Ni, Fe, Ti, V, Ag, Au, Bi, Ba, As, Mo, W. Stibnite Pyrite Arsenopyrite Tetrahedrite			Uranium mineralization is associated with the quartz-stibnite veins in Silurian shale, greywacke, and quartzite that are intruded by Devonian granitic rocks of the Pokiok Pluton.		-Soil sampling -Chemical assays -Radiometric surveying	Ruzicka and Littlejohn, 1981 Morrissy and Ruitenberg, 1980 Ruzicka and Littlejohn, 1981	Native antimony is more frequently associated with uranium mineralization than is stibnite.
32	45°34'20" 67°20'00" (21G/11W)	McAdam	Stream sediments		Sb	<u>Stream sediments:</u> U up to 48.9ppm <u>Soil samples:</u> 1) Over Silurian metasedimentary rocks: U = 2ppm 2) Over Devonian adamellite: U = 1.6ppm		The property is underlain by the Silurian sedimentary rocks and Devonian adamellite of Pokiok Batholith	The Silurian metasedimentary rocks are characterized by NE to E striking and steeply dipping foliations. The rocks are generally jointed but they lack indications of faulting.	-Soil sampling -Radiometric surveying	Austria, 1977 Lafontaine, 1979b	All of the anomalous values occur in organic-rich soil samples.

VIIA. CARBONIFEROUS BASIN (PLASTER SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
33	47°57'58" 67°28'15" (21J/14W)	Plaster Rock	Volcaniclastic Sedimentary Rocks			Soil samples: U up to 104ppm (B.G. = 9ppm) Water samples: U up to 9.78ppb In-situ gamma-ray spectrometry: eU up to 24ppm Trench samples (rhyolite): U up to 158ppm		Red and green friable shale with interbeds of red, gypsiferous shale and white, massive and fibrous gypsum of the Plaster Rock Formation.	The Plaster Rock Subbasin is interpreted by St. Peter, 1979 as an isolated, fault-generated, intermontane graben-like structure.	-Stream sediments -Soil sampling -Water sampling -Chemical assaying -Rn surveying -Radiometric surveying -Trenching	Chandra, 1981 Linz, 1979 St. Peter, 1979	St. Peter, 1979 has suggested that the rocks of the Plaster Rock Formation may be temporally equivalent to the uranium-rich Windsor Formation of southern N.B., but pointed out that they are lithologically dissimilar.
34	45°58'40" 67°27'00" (21J/14W)	North View	Shale		Cu	Rock samples a: Cu-stained carbonaceous shale: U up to 98ppm b: Red to greenish grey carbonaceous shale: U up to 38ppm Trench samples: a: Red siltstone (shale): U = 35ppm Cu = 4350ppm b: Radioactive nodule: nodule: U = 2.43% Cu = 8.32% host rock: U = 0.002% Cu = 0.08%		Red and greenish grey shale of the Plaster Rock Formation.	As in Plaster Rock.	-Well water -Geochemical surveying -Radiometric surveying -Trenching	Chandra, 1981 MacNabb and Pichette, 1978 MacNabb and Pichette, 1979 St. Peter, 1979	

VIIB. CARBONIFEROUS BASIN (MONCTON SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND TYPE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
35	46°14'00" 64°54'00" (21I/2W)	Cocagne River	Siltstone			Core holes: U up to 0.001%		Pennsylvanian siltstone		-Soil samples -Emanometer -Radiometric surveying -Drill holes	MacGibbon, 1977a	
36	46°06'43" 64°56'15" (21I/2W)	Berry Mills	Sandstone		Cu	Stream sediments: U = 40ppm Soil samples: U up to 2600ppm Cu up to 135ppm Rock samples: Carbonaceous sandstone U = 150ppm Drill cores: a: Sandstone: U = 0.30% over 0.5m b: Green and brown sandstone: U=0.088% over 0.26m Rn-in-soil survey: up to 800cph over an area of (100 x 300m)		Pennsylvanian grey-green sandstone		-Soil sampling -Rn-in-soil surveying -Radiometric surveying -DDH(3)	Krause, 1982 MacGibbon, 1978a MacGibbon, 1979a MacGibbon, 1980 Persalj, 1981 Smith, 1968	No anomalous radioactivity found at the Penn.-Miss. unconformity surface.
37	46°04'30" 64°19'15" (21I/1W)	Midgic	Sandstone		Cu, Pb, Zn, Ag Galena Chalcocite Malachite Pyrite Fluroite		Hematitization	Pennsylvanian sandstone (includes plant fragments) of the Pictou Group.	The rocks are gently folded with dips from sub-horizontal up to 10°.	-Soil sampling -Radiometric surveying -DDH(3)	Cooper, 198[illegible] Graves, 1980 Graves, 1981a	

VIIB. CARBONIFEROUS BASIN (MONCTON SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
38	46°04'55" 63°48'18" (11L/4W)	Cape Spear	Sandstone		Coal Pyrite	Rock sample: U up to 55.3ppm Drill cores: U=190ppm over 0.7m		The radio-activity is associated with yellowish-brown, reduced section in which several coal bands of approximately 2cm thick occur with pyrite in the Pennsylvanian sandstone of Pictou Group.	The rocks are gently folded with dips from sub-horizontal up to 10°.	-Stream sediment -Soil sampling -Rn-in-well water -DDH(8) -Geophysical well-logging -Rock assays (NAA)	Dunsmore, 1977 Graves, 1981b	The uranium occurs at the base of the fining-upward cycles in the sandstone.
39	46°08'05" 63°47'23" (11L/4)	Cape Tormentine	Sandstone			Rock sample: U up to 11.3ppm		The uranium mineralization occurs in pale-green sandstone at base of fining-upward cycles (Pictou Group).			Dunsmore, 1977	
40	46°12'30" 64°47'49" (21I/2W)	Shediac River	Veins	Autunite?	Pb, Cu, V, Mn, Ti Malachite, Pyrite	Main showing yielded only 1/4 lb/ton U_3O_8 on the basis of radio-activity. GSC estimated of over 3 lb/ton for the same showing. Rock sample (1) U = 0.15% Mn = 0.1% TiO_2 = 0.5% V = 0.01% Pb = 0.01% Cu = 0.01%		The mineralization is localized along bedding faults in a m.g. to c.g. red to chocolate brown arkose of the Mississippian Memramcook Formation.	The rocks of Memramcook Formation are steeply dipping to the north and strike north-easterly parallel to Shediac River.	-Rn-in-soil -Rock sampling -VLF -DDH(3)	Smith, 1958 MacGibbon, 1979b	The mineralization occurs on the south of the Kingston Uplift, in the close proximity to the Mississippian Pennsylvanian contact.
41	46°13'56" 64°47'23" (21I/2W)	McQuade Brook-Irishtowne-Scotch Settlement	Shale		Pb, Zn, F, P Pyrite Hematite Phosphate	Well waters: U up to 8ppb Grab samples (Marlstone/Albert Formation): U_3O_8 up to 0.095% ThO_2 up to 0.095% P_2O_5 up to 13.2% Gamma-ray spectrometry: eU up to 294ppm eTh up to 350ppm Chemical analysis: U up to 400ppm Rock sample (Marlstone/Albert Formation): Pb up to 540ppm Zn up to 490ppm		Dark-grey pyritic dolomitic siltstone and dolomitic shale, calcareous hematized grit of the Mississippian Albert Fm.	The claims area are located in a NE-SW trending uplifted block (Kingston uplift).	-Radiometric surveying -Rock sampling -Well waters -Trenching -Magnetics -VLF	Anonymous, 1979a Ball and Gemmell, 19[illegible]5 Hatt[illegible]e and Ne[illegible]house, 1980 McLeod and Rui[illegible]nberg, 1978 Picke[illegible]ill and Cart[illegible], 1980	One sample from the Albert shale (Pickerill and Carter, 1980) from the Scotch Settlement yields: U = 294.5ppm Pb = 406ppm Zn = 330ppm P = 49,900ppm F = 2,458ppm Some beds of Albert Fm are rich in rhyolitic clasts.

VIIB. CARBONIFEROUS BASIN (MONCTON SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
42	46°10'00" 64°53'00" (21I/2W)	Lutes Mtn.	Conglomerate	Torbernite Pitchblende	Cu, Fe, Y Chalcocite Malachite Covellite Pyrite	Water samples: U up to 1635ppb Soil samples: U up to 227ppm Glacial tills: U up to 52ppm Rn-in-soil: >15 x B.G. Rock samples: U_3O_8 = 0.3% Cu = 1.0% Y = 0.1% Drill cores: A: U = 13.4ppm over 1.6m B: U = 64.2ppm over 1.3m C: U = 63.9ppm over 0.8m	Hematitization	Mississippian conglomerate and sandstone of Memramcook Fm.	The claim area constitutes a part of the NE-SW trending Kingston Uplift. Faults occur in the claim area with the most prominent one striking 40° and 70° and both dip steeply to NW. These faults are believed to represent possible source areas for the mineralized boulders.	-Stream sediments -Rock sampling -Rn-in-soil -Radiometric surveying -DDH(27) -Trenching -VLF -IP	Aitken, 1973 Cowan, 1977a Holtz, 1976 Nikhanj, 1972a Roberts, 1977 Roberts, 1979 Oicle, 1978	Uranium discovered in float. No definite radio-active zone in the bedrock is located. As a result the float are considered foreign to the Lutes Mtn area. A total of 38 uraniferous boulders had been discovered up to 1979.
43	45°55'00" 65°18'30" (21H/14W)	Cornhill-Glenvale	Sandstone			Stream sediments: U up to 40ppm Soil sampling: U up to 15ppm (B.G. = 1ppm)		Uranium is associated with contact between Mississippian grey Albert - red Moncton sandstone in an environment similar to the Colorado Plateau type (western U.S.A.)	The claims area occur along the Kingstone Uplift. The structure formed in post-Albert times and probably contributed to much of the intense folding in Albert and lower Moncton sediments.	-Soil sampling -Rn surveying -Radiometric surveying -Drill holes -Gravity survey	Horst, 1977a, 1977b, 1977c Horst, 1978a, 1978b, 1978c, 1978d MacGibbon, 1978b Smith, 1968	The host rock contains evaporites (halite and glauberite).
44	45°49'45" 65°26'00" (21H/14W)	Jordon Mountain	Volcaniclastic sedimentary rocks		Cu, Mn Chalcocite Malachite	Radioactivity: 4 x B.G. Soil sampling: U up to 28ppm Rock sampling: Cu up to 6% Drill-hole assays: U < 10ppm		Mississippian red sandstone and conglomerate of the Moncton Group.		Soil sampling -Fission track -Radiometric surveying -DDH -Trenching	Colucci, 1983 Constable, 1971 Horst, 1977d Horst, 1978e Lockhart, 1970	The entire area is anomalous with values ranging from 55-110cps. Drilling suggests that the property is underlain by pre-Carboniferous rhyolite tuffs.

VIIB. CARBONIFEROUS BASIN (MONCTON SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
45	45°46'00" 65°34'30" (21H/12E&13E)	Millstream-Lower Millstream	Sandstone	Coffinite	V, Mo Albertite Pyrite	Soil samples: U up to 60ppm over an area of 300 x 760m Water samples: U up to 29.5ppb Rock samples (Albertite): U_3O_8 = 0.2% Boreholes samples: a: B.H.#2 10-50ppm U_3O_8 b: B.H.#3 40ppm U_3O_8 over 1.2m c: B.H.#4 115ppm U_3O_8 over 3.1m 90ppm U_3O_8 over 0.6m 250ppm U_3O_8 over 0.3m d: B.H.#5 10ppm U_3O_8		Mississippian bituminous sandstone grit interbedded with limestone (Albert Fm.)	The area is underlain by faulted sedimentary rocks of the Albert Fm. The Middleton fault, striking NE along the length of the property is a thrust fault that has carried the Albert Fm. and successive beds u wards into fault contact with the younger Moncton Group beds.	-Soil sampling -Water sampling -Track etch -Radiometric surveying -DDH(24)	Chandra, 1981 Constable, 1975b Horst, 1977e Lockhart, 1970 MacGibbon, 1976a Ruzicka and Littlejohn, 1982 Smith, 1968	
46	45°47'00" 65°35'00" (21H/13E)	Berwick	Sedimentary rocks		Cu Albertite	Soil samples: U up to 22ppm (in clay rich soil) Radioactivity: 60-75cps (B.G. = 50-60cps) over an area 60-200m wide and 976m long Core samples: U_3O_8 up to 350ppm over 2.25m		Uranium mineralization is associated with albertite in sandstone, siltstone grit and limestone of Mississippian age.	As in Millstream-Lower Millstream.	-Soil sampling -Radiometric surveying -DDH(3)	Horst, 1977f Smith, 1968	
47	45°44'00" 65°37'00" (21H/12E)	Kennebecasis Group	Sedimentary rocks		Zn, Ni, Mo, V, B, F	Rock sample: a: Grey shale (20 samples) U = 200ppm Th = 30ppm Zn = 81.5ppm V = 137ppm Ni = 36ppm Mo = 8.3ppm F = 2097ppm b: Limestone: (12 samples) U = 24ppm Th = 3.3ppm Zn = 78.5ppm V = 45.3ppm Ni = 21.7ppm Mo = 37.3ppm F = 2303ppm		Uranium mineralization is associated with grey shale and conglomerate of Mississippian Albert Fm.		-Stream sediment -Stream and spring water sampling -Geophysical logging -DDH(5)	Workman, 1981	Several limestone samples show elevated levels in U, Th, V and Ni.

VIIB. CARBONIFEROUS BASIN (MONCTON SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
48	45°34'00" 65°48'00" (21H/12W)	Hampton	Veins		V, Albertite	Radiometric survey: U_3O_8 up to 10% Trenching chip samples: a: U_3O_8=0.049% over 0.9cm b: U_3O_8=0.053% over 0.6m c: U_3O_8=0.024% over 0.6m		Grey to black bituminous shale and siltstone of Mississippian Albert Fm.	Hydrocarbon- and uranium-bearing veins occur in or near a major fault that strikes NE and has been traced for 32km. These veins also found in shear zones striking N10°E and dip steeply toward east and other strike N30°E and dips 85°SE.	-Soil sampling -Emanometer -Radiometric surveying -Resistivity -DDH(9)	Carroll, 1977a Dunsmore, 1977 Gross, 1957 Gussow, 1953 McMurchy, 1954 Rose, 1973	It is believed that the hydrocarbon in the veins may have originated from petroleum present in the Albert Fm. The source of uranium is not known but there is speculation that it may have been leached from the Mississippian volcanic and sedimentary rocks by ground water and precipitated by the carbon in the veins.
49	45°38'00" 65°32'30" (21H/12E)	Wards Creek	Siltstone	Pitchblende	C, P Pyrite, Coal Apatite	Core samples: a: U_3O_8=42.7ppm over 0.5m b: U_3O_8=88.7ppm over 0.2m c: ThO_2=38ppm		Uranium mineralization occurs in the Mississippian Memramcook Fm. (mainly in the siltstone).		-Radiometric surveying -Trenching -DDH(11)	Gariepy, 1981 Madon, 1979	Three modes of uranium mineralization were observed: 1) Within the apatite crystal lattice of the fine-grained matrix. 2) Intergrowth as sooty pitchblende with coaly material. 3) Partially remobilized along fractures of non-radioactive clasts.
50	45°58'00" 65°15'00" (21H/14W)	Kinnear Settlement	Stream sediments							-Stream sediments -Water sampling	Nikhanj, 1972b	
51	45°58'30" 65°19'30" (21H/14W)	Havelock	Soil			Soil samples: a: U up to 40ppm (over 180x195m area) b: U up to 82ppm (in organic rich swampy areas) Core samples: U_3O_8 up to 0.001% over 1.5m (limestone)		The soil overlies the Mississippian limes one of Windsor Fm.		-Soil sampling -Water sampling -DDH(3)	Anonymous, 1979b Horst, 1977g Horst, 1977h Taylor, 1975	Several scattered anomalies (in soil) probably reflecting organic scavenging were located. Three drill holes intersected Windsor limestone and Moncton sandstone and conglomerate; no mineralization seen.

VIIB. CARBONIFEROUS BASIN (MONCTON SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
52	45°54'00" 65°27'00" (21H/14W)	Dee Brook	Stream sediments		Cu, Zn Malachite Chalcocite	Stream sediments: U up to 40ppm Cu up to 35ppm Float sample: Cu = 0.94%		The property is underlain by Mississippian red conglomerate interbedded with coarse red sandstone to the east and pre-Carboniferous mafic volcanic rocks to the west.	The sedimentary rocks has variable strike ranging from N09°E to N21°W with an easterly dip of between 30° and 35°	-Stream sediments -Soil sampling -Track etch -Radiometric surveying	Cowan, 1977b Logan, 1970	
53	45°49'00" 65°27'00" (21H/14W)	Mount Pisgh	Soil			Soil samples: U up to 10ppm		The radio-activity in the soil samples is related to high clay content of the underlying sedimentary rocks of Albert Fm.		-Soil sampling -Radiometric surveying	Horst, 1977i	
54	45°47'00" 65°29'10" (21H/14W)	Harrison Brook	Soil			Rock samples: (36 samples) U up to 3.5ppm		The property is underlain by sandstone, conglomerate and ferruginous arkose of Mississippian Moncton Group.	The rocks in the property area strike N50°E and dips fairly shallow (20° to 50°) with several anticlines and synclines in the area.	-DH(1)	Horst, 1977j MacGibbon, 1976b Smith, 1968	
55	45°48'00" 65°30'00" (21H/14W)	Smith Creek	Soil		Cu	Soil samples: U up to 245ppm Cu up to 14ppm				-Soil sampling -Radiometric surveying	Colucci, 1971	
56	45°46'00" 65°29'00" (21H/14E and 14W)	Kennebecasis River	Soil			Soil samples: a: U up to 90ppm over an area of 848.5x181.8m b: U up to 48ppm over and area of 727.3x363.1m c: U up to 340ppm over an area of 181.8x60.6m		The property is underlain by Mississippian Moncton Group.		-Soil sampling -Radiometric surveying	Horst, 1977k Horst, 1978f Smith, 1968	Soil anomalies are related to swampy, organic-rich conditions (due to scavenging by organic-rich soil).

VIIB. CARBONIFEROUS BASIN (MONCTON SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
57	45°49'00" 64°57'00" (21H/15W)	Hayward Brook	Soil			Soil samples: U up to 20ppm Scintillometer survey T.C. up to 110cps				-Soil sampling -Radiometric surveying	MacGibbon, 1977b	
58	45°52'00" 64°47'00" (21H/15W)	Weldon Creek	Stream sediments			Stream sediments: U up to 37ppm				-Stream sediments		
59	45°46'00" 65°01'00" (21H/14E and 11E)	Collier Mountain	Stream sediments			Stream sediments: U up to 9.5ppm				-Stream sediments	Lockhart, 1970 Smith, 1968	
60 A	46°04'00" 65°18'00" (21I/3W)	Ridge Brook	Metamorphic			Radioactivity U = 82.7ppm (The zone of radio-activity extends for several tens of meters along the river bank and is a minimum of several meters in thickness).		Silurian grey, iron-stained, laminated argillite.			Dunsmore, 1977	This uranium mineralization was not detected by stream sediment analysis of Smith, 1968.

VIIC. CARBONIFEROUS BASIN (CENTRAL CARBONIFEROUS SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
60	47°51'01" 64°30'26" (21P/15)	Pigeon Hill	Sandstone		Cu			Grey-green fluviatile Pennsylvanian sandstone.			Dunsmore, 1977	Uranium is associated with plant debris in grey-green fluviatile sandstone.
61	47°43'50" 64°38'00" (21P/10E)	Chiasson (Shippegan Island)	Sandstone	Uraninite Pitchblende	Cu, Mn, C Hematite Barite Pyrite Chalcocite Malachite Coal	Chemical assay: U_3O_8 up to 1.47% over an area of about 90m long and 9 to 12m wide.		Buff to reddish brown m.g. arkosic Pennsylvanian sandstone.	The sandstone is highly jointed. Two sets of joints; one set striking N65°W and N25°E both dip vertically. The sandstone also folded and minor faults are developed. The folds plunge north at low angle.	-Radiometric surveying -Rock sampling	Dunsmore, 1977 Gross, 1957 Lang et al. 1962	Radioactivity in sandstone is associated with hematite, joints and plant debris. The common association of U and Cu suggests that both can be mobilized by the same aqueous solution.
62	45°46'00" 66°30'00" (21G/15E)	French Lake	Sandstone			Water samples: U > 14.0ppb Radioactivity: eU up to 4.50ppm Rock samples (sandstone): U = 2.7ppm		Sandstone of Pennsylvanian Pictou Group.	The sedimentary rocks are flat-lying to shallow dipping.	-Well water sampling -Rock assays -Radiometric surveying -Geophysical logging -DDH(3)	Chandra, 1981 Kipling, 1980a Kipling, 1980b	No mineralization was recorded in drill hole logs.
63	46°41'30" 66°26'43" (21J/9W)	Dungarvon River	Soil		Cu	Spring and stream water: U up to 14ppb Soil samples: U = 6ppm Cu = 16.7ppm		The property lies in an outlier of Carboniferous sedimentary rocks along faulted contact with Silurian sedimentary rocks.	The Carboniferous sedimentary rocks are flat to moderately dipping towards the east. The underlying Silurian sedimentary rocks have steeper dips (50-70°) and a well developed cleavage.	-Rn-in-soil -Radiometric surveying -Soil sampling	Adams, 1981b Austria, 1979 Chandra, 1981	The radioactive anomalies straddled the inferred contact (fault?) between the Carboniferous sedimentary rocks and the Silurian sedimentary rocks and this contact may serve as a channel way for migration of Rn gas.

VIIC. CARBONIFEROUS BASIN (CENTRAL CARBONIFEROUS SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
64	45°33'00" 66°55'00" (21G/10W)	Oromocto Lake	Soil		Cu Pyrite Coal			The underlying rocks are clastic sedimentary rocks of the Pennsylvanian Pictou Group.	The strata are flat to gently dipping.	-Soil sampling -Rn surveying -Lake and stream water sampling -Stream sediments -Geophysical logging -Seismic survey -DDH(12) -Trenching	Hendry, 1980 Kipling, 1979	Devonian granitic rocks occur about 10km southwest of the property.
65	45°44'00" 67°01'00" (21G/11E)	Cherry Hill (railway cutting)	Felsic volcanic rocks			Water samples: U = 1ppb Geiger counter: T.C. up to 4xB.G. over an area of 33 x 16m	Hematitization	Rhyolitic tuff of the Mississippian Harvey Fm.	A major NE-trending fault (Fredericton Fault) is located ≈270m north of the property.	-Water sampling -Rn-in-soil sampling -DDH(2)	Gross, 1957 Hassan, 1984 Phillipson, 1972	The strongest radioactivity is associated with patches of red stain for a distance of 4m along a fracture (strikes N15°E and dips 80°E) in the rhyolite. Calcite, chlorite and amethyst veins were observed in the core samples.
66	45°39'00" 67°04'30" (21G/11E)	Harvey Station (H.W. #3, 1.6km NE of Harvey Station)	Veins		F Pyrite, Hematite Fluorite	Stream sediments: U up to 9.8ppm Well water: a: U up to 8ppb (over sedimentary rock) b: U up to 148ppb (over volcanic rock) Rock samples: U_3O_8 = 0.02%	Hematitization	Rhyolite of Mississippian Harvey Fm.	A major NE-trending fault (Fredericton Fault) is located north of the property.	-Well water sampling -Radiometric surveying -Geophysical logging -Trenching -DDH	Cooper, 1978 Gross, 1957 Kuan, 1970	Radioactivity is associated with structural breaks where the felsic volcanic rocks are altered to clay minerals, soft green platy mineral or fine-grained white mica, and where quartz, fluorite, pyrite or hematite have been introduced.

VIIC. CARBONIFEROUS BASIN (CENTRAL CARBONIFEROUS SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
67	45°41'00" 67°03'00" (21G/10W and 11E)	Manners Sutton	Veins	Pitchblende Uraninite Uranospinite	F, Hg, As, Pyrite, Arsenopyrite, Hematite, Fluorite	Radioactivity: T.C. up to 1750cps Rock samples: (laminated rhyolite) U up to 3890ppm Chip samples: (rhyolite) U_3O_8=0.031% over a width of 0.8m U_3O_8=0.024% over a width of 0.5m Core samples: U up to 8100ppm over 5cm	Sericitization Montmorillonite Hematitization Argillization	Mississippian lava-flow rhyolite.	The property is very close to the Fredericton Fault. Several shear zones were observed in the property.	-Stream sediments -Soil sampling -Radiometric surveying -VLF -Trenching -DDH	Beaudin et al., 1980 Carroll, 1977b Dunsmore, 1977 Gabelman, 1981 Gross, 1957 Hassan, 1984 Kuan, 1970 Newell, 1957 Newell, 1958 Schimann, 1979	The rhyolite was heavily charged with volatiles as shown by the vicles filled with talc, kaolinite, and fluorite. Gross, 1957 and Gablemann, 1981 have revealed that radiation is more closely associated with the argillized rhyolite of the fault wall zones than with the fluorite, although the purple color of fluorite is interpreted as resulting from selective radiation damage.
68	45°40'08" 67°05'48" (21G/11E)	York Mills	Veins	Uranospinite Saleite	F Fluorite Calcite Zeolite	Chip samples U_3O_8 up to 0.036% over 3.7m wide and DDH suggest that it extends to a length of 107m. Core samples: U_3O_8 up to 0.14%	Limonitization Silicification Chloritization	Mississippian rhyolite ash flow tuff.	Radioactive material is associated with shear zone that passes through light grey to blotchy purple rhyolite tuff and also with fracture in green volcanic breccia. The shear zones is 4.6m wide, strikes N2 and dips 70°SE. The fracture strikes N20°E and dips 75°S.	-Radiometric surveying -Trenching -DDH	Carroll, 1976 Cooper, 1978 Dunsmore, 1977 Gross, 1957 Hassan, 1984 Kuan, 1970 Newell, 1957 Newell, 1958	
69	45°26'03" 66°48'43" (21G/7)	Mount Pleasant	Felsic volcanic rocks	Uraninite	Cu, Pb, Zn, Mo, Sn, W, Bi, F Pyrite, Koalin, Fluorite Chlorite	Rock samples: U up to 235ppm		Uranium mineralization occurs in Mississippian porphyritic rhyolite and ash-flow tuff rhyolite.		-Radiometric surveying	Dunsmore, 1977 Curtis, 1981 Parrish, 1977 Parrish and Tully, 1978	Specimen from granite near Mt. Pleasant contains 12ppm U, 70ppm Th and 4.1% K (Ruzicka, 1971).

VIIC. CARBONIFEROUS BASIN (CENTRAL CARBONIFEROUS SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
70	45°30'00" 66°40'20" (21G/73 and 10E)	Duck (Juvenile Lake)	Felsic volcanic rocks		Sn, W	Radioactivity: T.C. up to 3000cps Rock samples: U_3O_8 up to 1527ppm over a 0.9m to 1.5m width.	Hematitization	Volcanic rocks of Mississippian Intermediate Flow Member (Carrow Fm).	NE and NW trending faults truncate the volcanic rocks.	-Stream sediments -Radiometric surveying -VLF -I.P. -Magnetics -Trenching	Brack, 1982b Brack, 1983 Ruitenberg and Fyffe, 1982 van de Poll, 1967	Radioactivity discovered in boulders.
71	45°33'12" 66°38'15" (32G/10E)	Shin Creek	Veins		Mo, Sn, W, Ag, Au, Molybdenite, Pyrite, Cassiterite	Radiometric: eU = 54.5ppm Core samples: Mo = 0.26% Sn = 0.017% W = 0.03% Cu = 0.05% over 1.5m Pb = 0.01% over 1.5m Zn = 0.05% over 1.5m Au = 1.4gm/tonne over 1.5m Ag = 17gm/tonne	Silicification Pyritization	The property is underlain by Mississippian volcanic and sedimentary rocks of Piskahegan Group. Uranium minerals occur locally along prominant fracture zones in altered rocks.		-Radiometric surveying -Soil sampling -DDH -I.P.	Gemmell, 1975 Lockhart, 1979 McNamara, 1980 McNamara, 1980 McNamara, 1981 van de Poll, 1967	
72	45°34'35" 66°35'05" (21G/10E)	West Mill Settlement	Volcaniclastic sedimentary rocks		Cu, Pb, F, S Fluorite	Radioactivity: (ash-flow rhyolite) U up to 10 x B.G. Rock samples: (altered porphyry rhyolite) a: U_3O_8 = 0.015% over 1m b: U_3O_8 = 0.04% Grab samples: (conglomerate) U_3O_8=0.036% over 1m Core samples: U_3O_8=0.036% over 1.2m	Hematitization Chloritization	Intensely altered volcanogenic sandstones and conglomerate of the Mississippian Carrow Fm.		-Radiometric surveying -Stream sediments -Rn and He in soil -Track etch -Geophysical logging -DDH(12)	Bucknell, 1976 Carroll, 1977b Chandra, 1981 Gemmell, 1975 Lockhart, 1979 McNamara, 1978 Ruitenberg et al., 1976 Shewman and Bucknell, 1976	
73	45°34'24" 66°34'55" (21G/10)	Pete Brook	Volcaniclastic sedimentary rock			Radiometric: eU up to 81ppm eTh up to 30ppm (over 15m of strata) Rock samples: U up to 21.3ppm	Chloritization	Intensely altered volcanogenic sandstones and conglomerate of the Mississippian Carrow Fm.		-Radiometric survey -Rock sampling	Bell, 1976	
74	45°34'00" 66°32'00" (21G/10)	Hoyt Point	Volcaniclastic sedimentary rocks			Water samples: U = 0.21ppb Rock samples average a: Sandstone U = 5ppm Th = 15ppm K = 3.3% b: Conglomerate U = 1.7ppm Th = 14ppm K = 3.3%		Volcanogenic fine-grained sandstone and gritty conglomerate of the Mississippian Carrow Fm.	The anomaly is located in the Mt. Pleasant Appendage which is a NE striking belt of Mississippian volcanic rocks and volcanic derived sedimentary rocks which dip gently (10°-15°) to the NW	-Water sampling -Rock sampling -Radiometric surveying	Chandra, 1981	

VIIC. CARBONIFEROUS BASIN (CENTRAL CARBONIFEROUS SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
75	45°35'10" 66°34'30" (21G/10)	Oromocto River	Volcaniclastic sedimentary rocks		F Hematite Fluorite	Radiometric: U up to 500ppm Rock samples: U_3O_8 up to 0.05% over a thickness of 0.65 to 0.90m	Hematitization Fluoritization	Intensely altered volcanogenic sandstones and conglomerate of the Mississippian Carrow Fm.		-Radiometric surveying -Rock samples	Bell, 1976	The radioactivity is associated with deep purple fluorite, and hematite-rich rocks.
76	45°34'00" 66°40'00" (21G/10E)	Kleef Brook	Soil			Soil samples: U up to 60ppm		The property is underlain by Carboniferous sedimentary and volcanogenic sedimentary rocks.		-Soil sampling	MacGibbon, 1979c	
77	45°42'00" 66°03'10" (21G/9E)	East Queenstown	Soil		Pb, Ag, Ba, Sr	Stream sediments: U = 6ppm (B.G. = 1-3ppm) Soil samples: U up to 145ppm Pb up to 28ppm Ba up to 990ppm Core samples: U up to 1.0ppm Ag up to 1.6ppm Ba up to 3100ppm		The property is underlain by Carboniferous sedimentary rocks.		-Stream sediments -Soil sampling -DDH(3)	Holliday, 1972	No uranium mineralization intersected in the underlying rocks by DDH.
78	46°44'30" 66°14'10" (21J/9E)	Renous Property	Soil		Coal			The property is underlain by Mississippian and/or Pennsylvanian red to grey conglomerates and sandstones.		-Stream sediments -Soil sampling -Radiometric surveying -DDH(2)	Sakrison, 1972 Villard, 1971	Anomalous uranium is detected in a two soil samples and in a quartz porphyry float believed to be derived from Devonian granitic intrusives several kilometers west of the property. DDH did not encounter economically significant source of uranium.

VIIC. CARBONIFEROUS BASIN (CENTRAL CARBONIFEROUS SUBBASIN)

	LOCATION (lat., long, NTS no.)	OCCURRENCE DESIGNATION	DEPOSIT TYPE	URANIUM MINERALS	ASSOCIATED ORE ELEMENTS AND MINERALS	ANALYTICAL VALUES AND SIZE	ALTERATIONS	HOST ROCKS	STRUCTURE AND STRUCTURAL CONTROL	EXPLORATION - EVALUATION & TECHNIQUES APPLIED	REFERENCES	REMARKS
79	46°44'00" 66°17'00" (21J/9W)	Renous River	Soil		Cu	Soil samples (av.): U = 8.3ppm Cu = 14ppm		The property is underlain by red sandstones, conglomerates and siltstones of Mississippian age.		-Soil sampling -Rn-surveying -Magnetics -VLF -DDH	Adams, 1981c	Reduction spheres around organic fragments were common in the rock outcrops.
80	46°44'00" 66°19'00" (21J/9W)	Whetstone Brook	Soil		Cu			The property is underlain by red sandstones, and conglomerate of Mississippian age.		-Soil sampling -Rn surveying -Radiometric surveying -DDH	Adams, 1982	Uranium anomalies are located in soil samples. Two potential targets were outlined. One along the margin contact between the Carboniferous and the basement rocks and the other is 400m.
81	46°46'00" 66°13'00" (21J/16E)	Monaghan Brook	Soil		Cu	Soil samples (av.): U = 5.3ppm Cu = 14ppm Core samples (av.): (Green-grey sandstone) U = 5.6ppm Cu = 30.4ppm		The claims are underlain by Carboniferous sandstone and conglomerate. These rocks contain plant fragments, fossils and pyrite.	The Carboniferous sedimentary rocks are flat to gently dipping to SE.	-Soil sampling -Rn in soil -Radiometric surveying -Magnetics -Shallow overburden drilling (55)	Adams, 1981d	The source of uranium in the soil is believed to be the sandstone or conglomerate rock units located underneath.