A PRELIMINARY ASSESSMENT OF THE URANIUM POTENTIAL OF SOUTHERN MELVILLE PENINSULA, DISTRICT OF FRANKLIN

Project 760047

Y.T. Maurice
Resource Geophysics and Geochemistry Division

Maurice, Y.T., A preliminary assessment of the uranium potential of southern Melville Peninsula, District of Franklin; in Current Research, Part A, Geol. Surv. Can., Paper 79-1A, p. 281-287, 1979.

Abstract

Widespread uranium enrichment in the lake sediments and waters of southern Melville Peninsula is traced to felsic igneous rocks that intrude the Penrhyn Group of metasediments. Some of these intrusives locally contain high concentrations of radioelements and they should be examined for associated vein-type uranium mineralization or uraniferous late magmatic differentiates. A rock suspected to be a radioactive skarn was discovered near a granitic pluton. Contact metasomatism could represent an important uranium ore forming process in southern Melville Peninsula.

Intense metamorphism of the Penrhyn sediments and relatively low uranium content of the nearby basement has drawn attention away from the Penrhyn unconformity as a possible host of uranium mineralization. A younger unconformity in the northwestern part of the survey area, however, may have greater potential as it overlies a uranium enriched basement and is marked by a thick regolith. The uranium content of basement rocks in that area appears to increase towards the unconformity and uranium enrichment seems to be partly fracture-controlled suggesting remobilization.

Introduction

In 1977, a 30 000 km^2 area, comprising most of southern Melville Peninsula (Fig. 45.1) was the object of reconnaissance lake sediment and water geochemical and airborne radiometric surveys carried out under the Uranium Reconnaissance Program (U.R.P.). The reader is referred to papers by Darnley et al. (1975) and Hornbrook and Garrett (1976) for details on the methodology employed in these surveys. The geochemical data were published in mid-1978 (Geological Survey of Canada, 1978a, 1978b) and the radiometric results are expected to be released in early 1979. Some preliminary radiometric data were available to the writer prior to the 1978 field season and these proved to be of great value at the planning stage of the follow-up program described in this paper.

Due to the shortness of the field season, it was only possible to examine a small fraction of the areas that were considered to warrant further investigation. This report is therefore preliminary; much additional field work as well as further analyses of the samples collected during the past field season will be required before final judgment can be passed on the uranium potential of this region.

General Geology

Southern Melville Peninsula includes part of the Foxe Fold Belt which comprises an Archean basement, composed essentially of granitoid gneissic rocks overlain unconformably by Early Proterozoic Penrhyn metasediments (Fig. 45.1). These consist of a mixture of paragneiss, schist, marble, calc-silicate gneiss, quartzite and minor amphibolite. A grey-green micaceous rock, possibly a meta-regolith, occurs at the base of the Penrhyn Group in certain areas (Okulitch et al., 1977).

The Penrhyn metasediments, as well as the basement complex, have been intruded by granitoid plutons before, during, and after the regional metamorphism that took place during the Hudsonian orogeny. Intrusive rocks are extremely widespread and their intermixing with the metasediments is very complex. In composition, they range from granitic to granodioritic and quartz-monzonitic. They generally exhibit a low colour index and their texture is highly variable ranging from aplitic to coarsely pegmatitic (Reesor et al., 1975).

Metasediments and metavolcanics of the Prince Albert Group occur in the northern part of the survey area (Fig. 45.1). These rocks have been described by Heywood (1967) and Schau (1975). They are Archean in age and comprise various units of greenstone, amphibolite, paragneiss, schist and quartzite; they also host economically interesting iron formations (Wilson and Underhill, 1971).

A gently dipping, slightly metamorphosed clastic sedimentary sequence (unit 16 of Heywood, 1967) rests unconformably on the Prince Albert Group and the granitic basement in the northwest corner of the survey area. Frisch (1974 and in prep.) reports a thick (up to 25 m) regolith at the base of this formation; it is overlain by granite- and quartz-pebble conglomerate, sericite schist, quartzite, marble and arkose. The sequence is at least 850 m thick. The age of these rocks is uncertain but indications are that they are younger than the Penrhyn, possibly post-Hudsonian.

Interpretation of the Reconnaissance Data

Uranium dispersion pattern

The reconnaissance lake sediment results show that the surficial environment of southern Melville Peninsula is, on average, considerably richer in uranium than most other areas of the Canadian Shield where similar surveys have been carried out (Table 45.1; see also Cameron and Hornbrook, 1976, Fig. 14).

A trend of U-enriched values follows the Penrhyn rocks as shown in Figure 45.2. There seems to be a certain amount of uranium dispersion away from the sedimentary belt towards the northwest, but this likely reflects the drainage pattern and/or glacial smearing. The strongest values along this trend (>50 ppm U) nearly all occur within the Penrhyn Group.

A second zone of U-enriched values occurs over Archean rocks in the northwestern part of the survey area (Fig. 45.2). This zone comes in contact with the Late Precambrian sedimentary formation in that area.

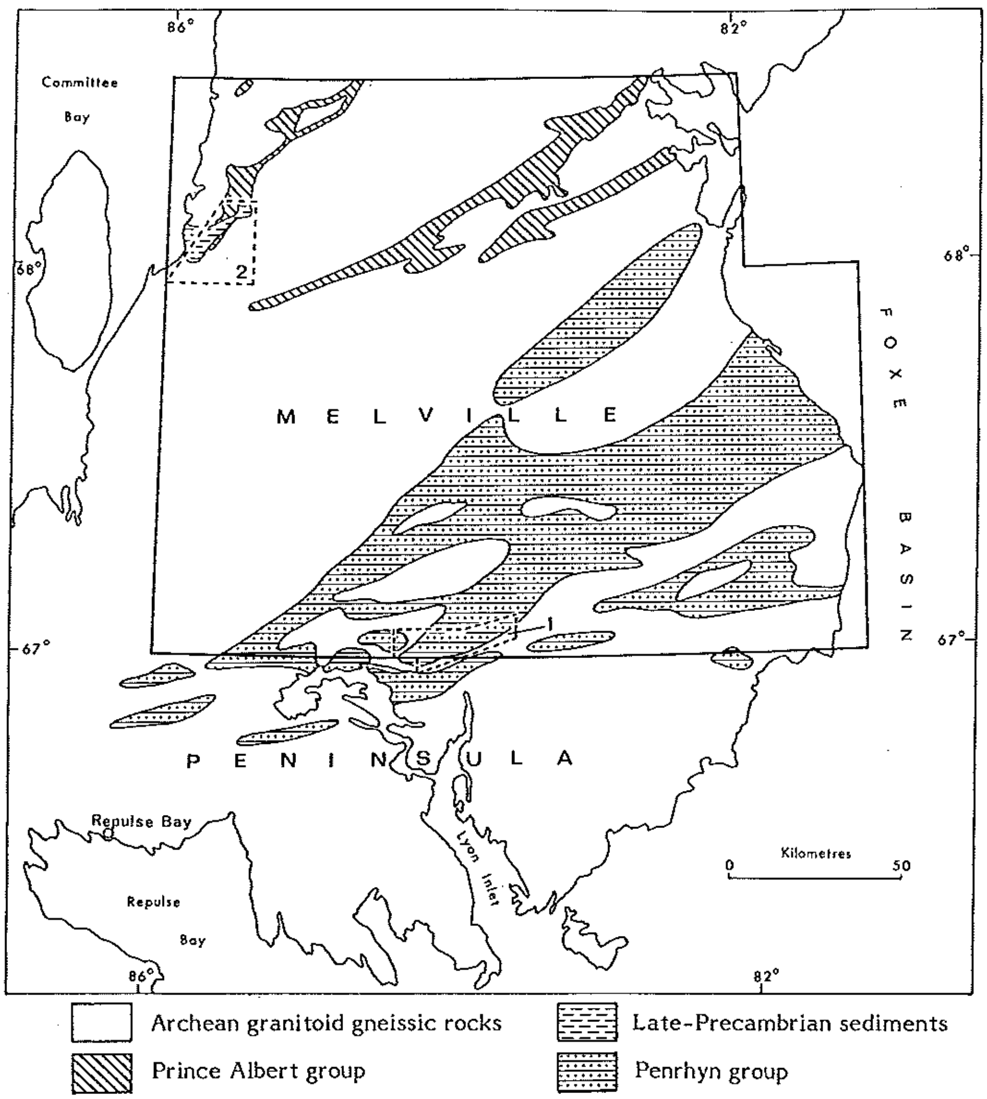

Figure 45.1. Regional geology of southern Melville Peninsula.

Interelement relationships

Factor analysis was used to examine interelement relationships in lake sediments and waters on a regional scale. The five factor model, which accounts for 79 per cent of the data variability, is presented in Table 45.2.

The first factor shows a strong relationship between the base metals and Fe and Mn. This reflects the presence of base metal sulphides in the Penrhyn metasediments. Cameron (1979) discusses the distribution of some of these elements.

Strong dependence of U-in-water on pH is shown in factor 2. The pH conditions are generally neutral to slightly acidic in southern Melville Peninsula except within the Penrhyn Group where they range from acid (pH 5-6) in proximity to oxidizing sulphidic zones, to weakly alkaline (pH 7-8) in areas of crystalline limestone bedrock. U-in-water anomalies (1.0 to 3.0 ppb), that coincide with anomalies in the lake sediments occur in the south and central parts of the Penrhyn where carbonate rocks are particularly abundant. Elsewhere the U concentration in lake waters seldom exceeds 0.5 ppb. Fluorine also varies with U-in-water and pH, but F levels in the lakes of southern Melville Peninsula are low; the significance of this association is not clear but is probably unimportant from a mineral exploration viewpoint.

The organic content of the lake sediments influences the distribution of Hg as indicated by factor 3.

The U-Pb association (factor 4) has been observed in other parts of the Canadian Shield (Maurice, in press). The sympathetic relationship of these two elements and their widespread enrichment in the lake sediments in southern Melville Peninsula probably reflects their enrichment in certain rock types, namely the felsic intrusives. The Pb distribution is further complicated by its association with the base metals (factor 1).

Factor 5, As-Mo, is probably related to the base metal sulphides. Although both components show relatively low geochemical relief in southern Melville Peninsula, Laporte (1974) reported high concentrations of Mo in drill intersections and soils near base metal occurrences within the Penrhyn Group.

Follow-up

Objectives

High concentrations of uranium in the lake sediments and waters in southern Melville Peninsula most likely reflect uranium enrichment in the bedrock. This is confirmed by the airborne radiometric data which generally show a high level of radiation in the areas of anomalous lakes. It is not known whether any of this uranium exists in economic concentrations.

The main objectives of the follow-up were (1) to determine which rock type(s) is responsible for the high uranium background and widespread lake sediment and water anomalies, and (2) to investigate whether favourable conditions for economic concentrations of uranium exist in southern Melville Peninsula.

Selection of study area and methodology

With respect to the first objective, traversing at random in areas of strong geochemical anomalies would have been sufficient. However, in order to focus on possible economic targets it was essential to apply discriminant parameters to select areas for follow-up. Geochemical indicators are often useful but since there were no known uranium occurrences that could be studied in southern Melville Peninsula, the nature of the element assemblages in the mineralization sought was unknown. Furthermore, the dispersion patterns for most potential pathfinders were complicated by numerous metalliferous concentrations in the rocks (i.e. base metal sulphides), most likely unrelated to uranium.

The most satisfactory procedure to identify potential areas in the Penrhyn Group was to use the airborne radiometric data in conjunction with the uranium geochemistry. Radiometric anomalies that occurred within or in proximity to geochemical anomalies were selected for detailed work. Priority was given to anomalies with high eU/eTh ratios and an attempt was made to select areas from different geological environments.

Table 45.1

Abundance of Uranium in lake sediments in various parts of the Canadian Shield

Area	Map number (NTS)	no. of samples	U in lake sediments geom. mean (ppm)
Baffin Island	36B-C	406	10.4
Baker Lake	55M	688	4.7
	65P	656	4.4
Ennadi Lake	65A	779	14.5
	65B	853	17.3
	65C	894	12.1
Labrador	13B	1026	0.8
	13F	825	1.7
	13G	832	0.8
	13H; 3E	758	1.5
	13J-O	865	5.9
Manitoba	54L	458	1.3
	54M	461	7.0
	64I	929	3.4
	64P	907	6.4
	64J-K-N-O	3661	8.0
Melville Peninsula	46N; 47B	1108	19.6
	46O-P; 47A	1098	16.9
Nonacho Lake	75C-F-K	2685	9.2
Ontario	31F	166	6.1
	42D-E	915	3.6
	52A-H	922	2.3
Saskatchewan	63M; 64D	3844	4.9
	64L-M	2019	6.3

In the northwestern part of the survey area, the existence of an unconformity adjacent to U-enriched basement rocks and the presence of a thick regolith at the paleosurface, was thought to constitute a favourable situation; detailed work was planned in that area.

The work performed consisted of ground traverses chosen to incorporate anomalous lake basins and/or radiometric anomalies; special care was taken to run traverses over such features as contact zones, structures, unconformities gossans, etc. In several cases, detailed lake waters were collected and analyzed prior to traversing in order to better define the anomalies. The water samples were analyzed in a field laboratory for U and pH. The uranium determinations were performed using a Scintrex UA-3 laser fluorimeter (Robbins, 1978).

Follow-up in the Penrhyn Group

Area 1 (Fig. 45.1) is one of several selected for detailed follow-up within the Penrhyn. About 250 lake water samples were collected and the results are shown in Figure 45.3. The area was chosen because (1) it contains a good selection of geochemical and airborne radiometric anomalies, (2) the radiometric anomalies are characterized by high eU/eTh ratios and (3) the reconnaissance data indicated that uranium was present in substantial amounts in the lake waters because of generally alkaline conditions.

Figure 45.3 indicates that there is generally good correspondence between the geochemical and radiometric data. Four ground traverses were carried out on the basis of these results and in all cases, radioactive felsic intrusives were encountered (localities 1 to 4, Fig. 45.3). These rocks intrude Penrhyn sediments, mostly crystalline limestone and paragneiss, but, in this area, the sediments in contact with the intrusives were not found to be radioactive or to have been affected in any way by the igneous activity.

The most interesting occurrence was found at locality 1 (Fig. 45.3). The radioactive rocks seem to underlie most of the area within the 5 ppb U contour line. Near the western edge of the intrusion, felsic sills intrude crystalline limestones. The sills are sometimes highly radioactive, and some show secondary uranium minerals. Chemical or mineralogical analyses of rock samples from that area are not available at the time of writing but radiometric analyses performed in Ottawa estimated the amount of uranium and thorium of one sample at 1200 ppm eU and 400 ppm eTh. In the field, readings of up to 2000 ur* were recorded on these sills. The main intrusive body gave field readings in the order of 500 to 900 ur. For comparison, nearby limestones produced less than 25 ur.

The granitic rocks at localities 2, 3 and 4 are not as radioactive: up to 175 ur at locality 2, 450 ur at locality 3, and 250 ur at locality 4. Nevertheless, they probably contain sufficient uranium to account for the anomalies detected in their vicinity. At all these localities, the uranium minerals appear to be disseminated rather than concentrated in fractures.

Several other radioactive occurrences have been found within the Penrhyn Group (Table 45.3). All are related to felsic intrusives penetrating Penrhyn sediments except at locality 5 where a radioactive skarn-type rock within metasediments was found in contact with a granitic intrusive. The skarn is soft, dark green and appears to be very local. The maximum radiometric response from this rock, measured in the field, was

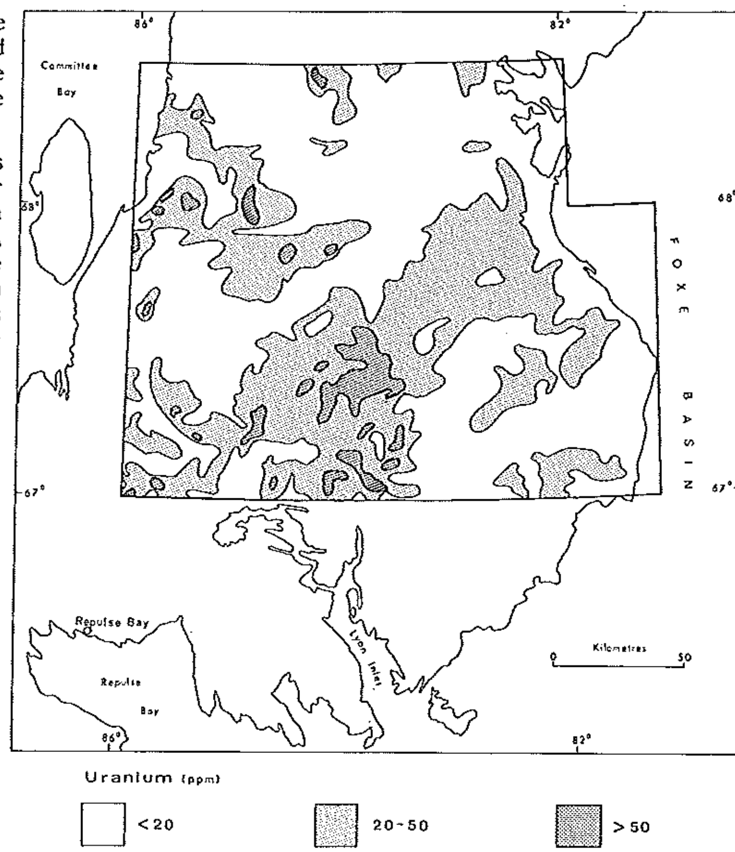

Figure 45.2. Uranium distribution in lake sediments for 1977 U.R.P. survey in southern Melville Peninsula.

* Unit of radioelement; a geological source with 1 ur concentration produces the same instrument response (e.g. count rate) as an identical source containing 1 ppm uranium in radioactive equilibrium (International Atomic Energy Agency, 1976).

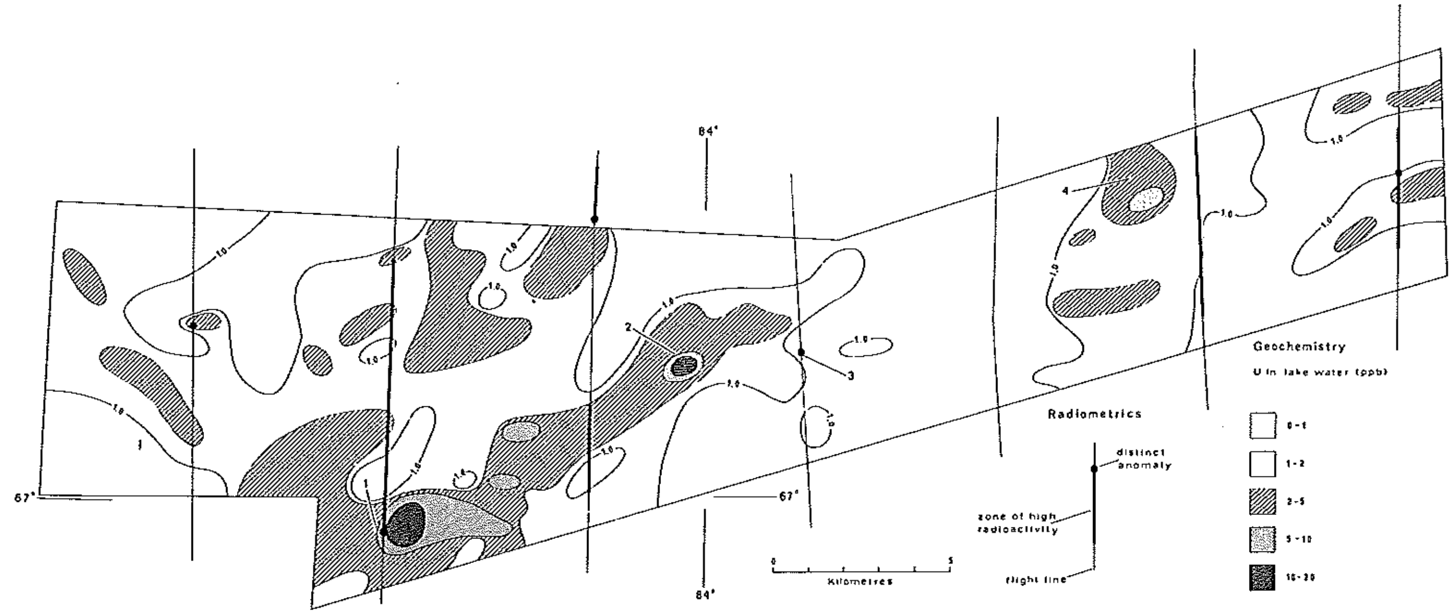

Figure 45.3. Detailed uranium in lake water and radiometric data for area 1, Figure 45.1.

450 ur. Laboratory measurements on a selected sample estimated the uranium and thorium contents at 400 ppm eU and 200 ppm eTh.

Petrological and minerological data for samples collected at locality 5 are not available at the time of writing so that one can only speculate on the nature and origin of the uranium in this rock. If, as suspected, contact metasomatism is involved, this occurrence could represent an important type of deposit to search for in southern Melville Peninsula. However, skarns and other contact metamorphic features do not appear to be common in the Penrhyn Group even though they have been reported (Hutcheon et al., 1977).

No common feature could be established among the various radioactive intrusives encountered. Their colour, mineralogy and texture are highly variable. They were probably emplaced over a long period of time as is suggested by the fact that some are foliated (preorogenic) while others are not (postorogenic).

Follow-up in the northwest corner

Figure 45.4 shows the results of a lake water survey carried out in an area that incorporates the Late Precambrian sediments (Frisch, 1974) and adjacent basement rocks (Area 2, Fig. 45.1). Because of the near absence of carbonate rocks resulting in slightly acidic lake waters, the uranium content of these waters was expected to be considerably lower than in the area underlain by the Penrhyn Group where high concentration of bicarbonate in the lake waters tends to keep the uranium in solution.

The results show a substantial increase in uranium in an area of granitoid basement rocks adjacent to the southern part of the Late Precambrian formation. It is of interest that the uranium concentrations increase towards the unconformity. Because the water samples were not analyzed in the field and airborne radiometric data were unavailable for that area, it was not possible to plan the ground work most efficiently. Nevertheless, the unconformity and adjacent rocks were examined at five different localities (A to E, Fig. 45.4).

At locality A, basement granites intruding a darker, gabbroic phase, were found to be slightly radioactive with maximum radioactivity concentrated along fractures (up to 120 ur). Radioactivity in the Late Precambrian sediments is low (<20 ur) except within a phyllite bed that occurs near the base within the conglomerates (up to 50 ur). T. Frisch (pers. comm.) found allanite in these phyllites which probably accounts for the increased radioactivity. Above background radioactivity was also found at locality C (Fig. 45.4) where the unconformity is very well exposed. The radiation (max. 45 ur) seem to be associated with a dark magnetite-bearing sandstone at the base of the Late Precambrian formation within inches of the unconformity.

Conclusions

Radioactive felsic igneous rocks that intrude the Penrhyn Group of metasediments constitute the bedrock source of widespread uranium enrichment in the lake sediments and waters of southern Melville Peninsula. Zones of high radioactivity were discovered in some of these intrusives and their economic potential should be examined in

Table 45.2

Varimax factor matrix of logarithmically transformed lake sediment and water data, southern Melville Peninsula, District of Franklin

Factor	Communality (%)	Components and Factor Loadings
1	39	Fe(.9), Co(.9), Ni(.8), Zn(.8), Cu(.8), Mn(.8), Pb(.7)
2	19	pH(.9), U_w(.8), F_w(.7)
3	10	LOI(.8), Hg(.5)
4	6	U_s(.8), Pb(.5)
5	5	As(.8), Mo(.7)

Note (1) pH, U_w, F_w = lake water data
(2) Only factor loadings $\geq$.5 are shown

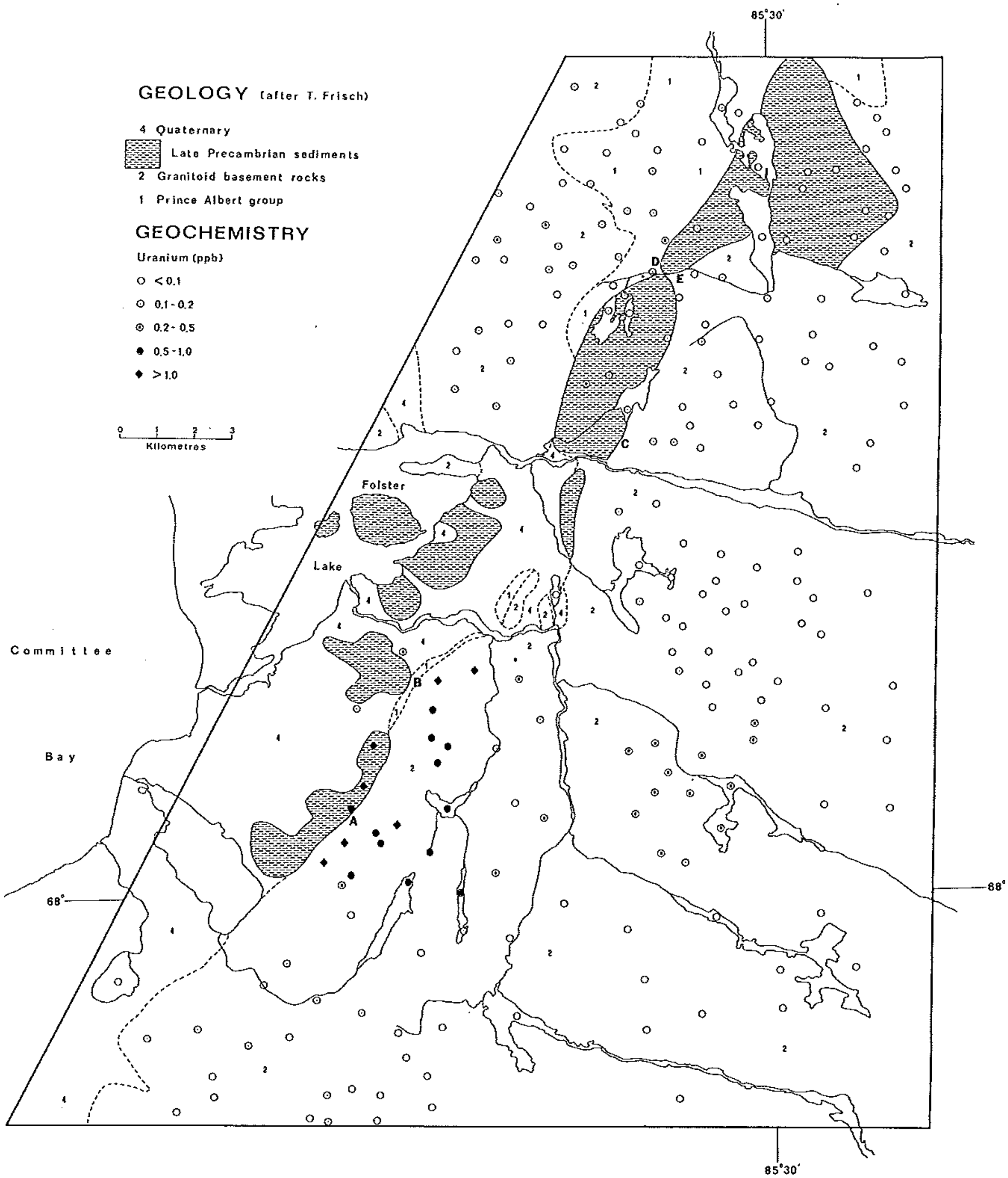

Figure 45.4. Regional geology and detailed lake water data for uranium for area 2, Figure 45.2.

the light of recent publications on the subject of uranium deposits in granites and similar rocks (Armstrong, 1974; Ruzicka, 1975; Derry, 1977). Future exploration in the area should search for uraniferous late magmatic differentiates or vein-type hydrothermal deposits more or less closely associated with the radioactive plutons. Certain types of intrusives, namely alaskite, leucocratic granite, two-mica granite, monzonite and granodiorite may be particularly favourable because similar rocks are known to host uranium concentrations in other parts of the world.

With respect to other types of deposits, two possibilities deserve further examination in southern Melville Peninsula:

1 - Skarn-type or contact metasomatic deposits

2 - Unconformity-type deposits.

The skarn-type deposits should be searched for at the contact of radioactive intrusives with highly reactive rocks such as carbonates. Preorogenic intrusives are perhaps more favourable than postorogenic intrusives as the

Table 45.3

Location of radioactive occurrences in southern Melville Peninsula

Localities	(UTM co-ordinates) Zone	Eastings	Northings	Max. radioactivity (ur)
1	16	622550	7433090	2000
2	16	629870	7437810	175
3	17	371860	7437730	450
4	17	380230	7441800	250
5	16	553340	7435630	450
6	17	374010	7483410	400
7	17	388630	7469990	450
8	16	627590	7444270	200
9	16	627670	7442230	200

Note: Localities 1, 2, 3 and 4 are shown in Figure 45.3

unmetamorphosed sediments are more likely to have undergone contact metamorphism and metasomatism than the regionally metamorphosed sediments. However, this need not be the case; the Mary Kathleen orebody, a metasomatic uranium deposit in Australia, was formed in proximity to a granodiorite which intruded regionally metamorphosed Proterozoic sediments composed essentially of calc-silicate rocks, schists and quartzites (Hughes and Munro, 1965).

Both the reconnaissance geochemical and radiometric data indicate the basement rocks in the vicinity of the Penrhyn Group to be relatively low in uranium. This situation and the high metamorphic grade of Penrhyn sediments has drawn the attention away from the Penrhyn unconformity as a possible host of uranium mineralization.

The Late Precambrian unconformity in the northwest of the study area, however, is more promising. A uranium-enriched basement adjacent to relatively unmetamorphosed and undeformed Late Precambrian sediments, and the presence of a thick regolith, is attractive. In addition, our investigations have shown an increase in the uranium content of the basement in the immediate vicinity of the unconformity with possible enrichment along fractures, suggesting remobilization.

Acknowledgments

Enthusiastic assistance in the field was provided by Michel Fortier (University of Ottawa) and Paul MacKay (Queen's University). G.E.M. Hall (G.S.C.) and Moire Wadleigh (Carleton University) skillfully performed the water analyses in the field. Larry Cotter (helicopter pilot) is also gratefully acknowledged. Special thanks are directed to T. Frisch for generously supplying unpublished geological data appearing in Figures 45.1 and 45.4. E.M. Cameron provided some useful comments on the manuscript.

References

Armstrong, F.C.
1974: Uranium resources of the future – "Porphyry" uranium deposits; in Formation of Uranium Ore Deposits, International Atomic Energy Agency, Ser. no. STI/PUB/374, p. 625-634.

Cameron, E.M.
1979: Investigation of base metal mineralization in Proterozoic metasediments, Melville Peninsula, District of Franklin; in Current Research, Part A, Geological Survey of Canada, Paper 79-1A, report 32.

Cameron, E.M. and Hornbrook, E.H.W.
1976: Current approaches to geochemical reconnaissance for uranium in the Canadian Shield; in Exploration for Uranium Ore Deposits, International Atomic Energy Agency, Ser. no. STI/PUB/434, p. 241-262.

Darnley, A.G., Cameron, E.M., and Richardson, K.A.
1975: The Federal-Provincial Uranium Reconnaissance programs; in Uranium Exploration 1975; Geological Survey of Canada, Paper 76-26, p. 49-68.

Derry, D.R.
1977: New types of deposits will provide future supplies of uranium; Canadian Mining Journal, March, p. 56–60.

Frisch, T.
1974: Geological studies in the Prince Albert Hills, western Melville Peninsula, District of Franklin; in Report of Activities, Part A, Geological Survey of Canada, Paper 74-1A, p. 163-164.

Geological Survey of Canada
1978a: National Geochemical Reconnaissance release, regional lake sediment and water geochemical reconnaissance data, Melville Peninsula, N.W.T. NGR 32A-1977 or 32B-1977, NTS 46N and part of 47B; Geological Survey of Canada, Open File 521A or 521B.

1978b: National Geochemical Reconnaissance release, regional lake sediment and water geochemical reconnaissance data, Melville Peninsula, N.W.T. NGR 33A-1977 or 33B-1977, NTS 46Ø, P and part of 47A; Geological Survey of Canada, Open File 522A or 522B.

Heywood, W.W.
1967: Geological notes, northeastern District of Keewatin and southern Melville Peninsula, District of Franklin, Northwest Territories (Parts of 46, 47, 56, 57); Geological Survey of Canada, Paper 66-40, 20 p.

Hornbrook, E.H.W. and Garrett, R.G.
1976: Regional geochemical lake sediment survey, east-central Saskatchewan; Geological Survey of Canada, Paper 75-41, 20 p.

Hughes, F.E. and Munro, D.L.
1965: Uranium ore deposit at Mary Kathleen; in Geology of Australian Ore deposits, Proceedings Eight Commonwealth Institute of Mining and Metallurgy (J. McAndrew, ed.), v. 1, p. 256-263.

Hutcheon, I., Gunter, A.E., and LeCheminant, A.N.
1977: Serendibite from Penrhyn group marble, Melville Peninsula, District of Franklin; Canadian Mineralogist, v. 15, p. 108-112.

International Atomic Energy Agency
1976: Radiometric reporting methods and calibration in uranium exploration; STI/DOC/10/174, 57 p.

Laporte, P.J.
1974: Melville Peninsula, Prospecting Permits 177 to 199; North of 60, Mineral Industry Report 1969 and 1970; Canada Department of Indian and Northern Affairs, Northwest Territories east of 104 west longitude, v. 2, p. 123-129.

Maurice, Y.T.
Methods of interpretation and follow-up of reconnaissance lake sediment data in the northern Canadian Shield; 7th International Geochemical Exploration Symposium, Denver, 1978. (in press)

Okulitch, A.V., Gordon, T., Henderson, J.R., Reesor, J.E., and Hutcheon, I.E.
1977: Geology of the Barrow River map-area, Melville Peninsula, District of Franklin; in Report of Activities, Part A, Geological Survey of Canada, Paper 77-1A, p. 213-215.

Reesor, J.E., LeCheminant, A.N. and Henderson, J.R.
1975: Geology of the Penrhyn Group metamorphic complex, Melville Peninsula, District of Franklin; in Report of Activities, Part A, Geological Survey of Canada, Paper 75-1A, p. 349-351.

Robbins, J.C.
1978: Field technique for the measurement of uranium in natural waters; Canadian Institute of Mining and Metallurgy Bulletin, v. 71, no. 793, p. 61-67.

Ruzicka, V.
1975: New sources of uranium? Types of uranium deposits presently unknown in Canada; in Uranium Exploration '75, Geological Survey of Canada, Paper 75-26, p. 13-20.

Schau, M.
1975: Volcanogenic rocks of the Prince Albert group, Melville Peninsula (47A-D), district of Franklin; in Report of Activities, Part A, Geological Survey of Canada, Paper 75-1A, p. 359-361.

Wilson, I.D.H. and Underhill, D.H.
1971: The discovery and geology of major new new iron deposits on Melville Peninsula eastern Arctic; Canadian Mining Journal, v. 92, p. 40-48.