

URANIUM DISTRIBUTION IN LAKE SEDIMENT AND WATER, EAST-CENTRAL LABRADOR (PARTS OF NTS MAP AREAS 13J/K/N AND O)

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ABSTRACT

A detailed, high-density lake-sediment and water survey (819 sample sites) was conducted in 2005, over parts of seven, 1:50 000-scale NTS map areas, in east-central Labrador. From earlier surveys, several uranium occurrences are known in the area, which is currently being intensively explored. The bedrock ranges in age from Archean to the Proterozoic, and in metamorphic grade from unmetamorphosed to high grade; rock types include gneisses, intrusive, volcanic and sedimentary. The primary objective of the survey was to provide the necessary geochemical mapping in aid of mineral exploration and the results of the uranium data are presented here. Statistical analysis and symbol maps showing the distribution of uranium in sediment and water indicate that there are several prospective areas remote from known mineralization.

INTRODUCTION

Working from Postville, Labrador, a high-density lake sediment and water survey, using a float-equipped helicopter, was conducted over seven, 1:50 000-scale NTS map sheets in 2005. These included all or parts of 13J/11, 13J/12, 13J/13, 13K/9, 13K/16, 13N/1 and 13O/4 (Figure 1). The region is known to host several uranium occurrences and was selected particularly for its potential for further discovery of uranium mineralization although there is also potential for base-metal mineralization. A previous reconnaissance lake-geochemical survey by the Geological Survey of Canada indicated anomalous levels of uranium (Friske *et al.*, 1993a, b and c). A nominal sample density of 1 per 4 km² was used although the presence of some very large lakes and areas without suitable lakes reduced the effective sample density. A total of 819 sites were sampled. Both lake-sediment and water samples were collected at 751 sites, sediment samples without water samples at an additional 66 sites and water samples without sediment from 2 sites. Sample depths for lake sediment varied from 0.5 m to 28 m. Sediment samples were analyzed for a suite of 48 elements. Waters were analyzed for pH, conductivity and 25 elements including uranium, copper, nickel and zinc.

The bedrock ranges in age from Archean to Proterozoic, and the metamorphic grades vary from unmetamorphosed intrusive rocks to high-grade Archean gneisses. Most rocks are felsic although some mafic phases are also present. Earlier survey work have indicated many uranium occurrences in the survey area.

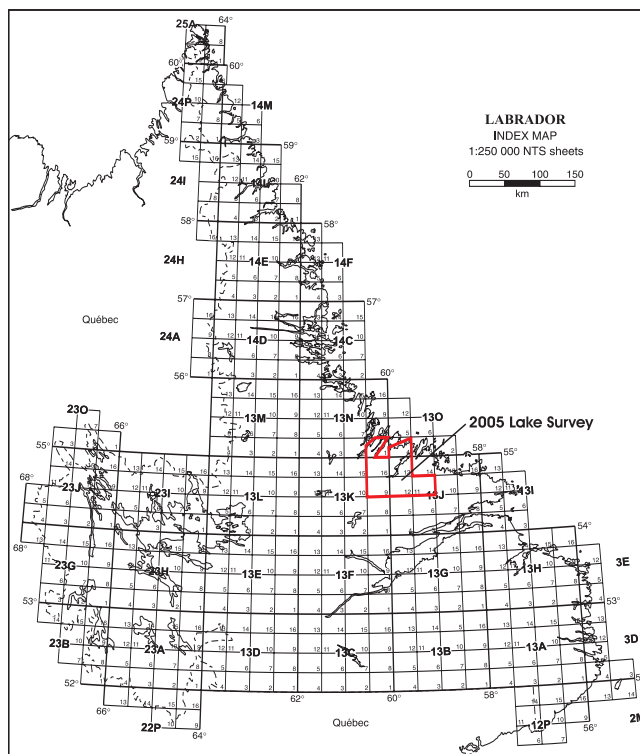


Figure 1. Location of survey area.

This paper not only emphasizes the geochemistry of uranium but also provides summary statistics of all geochemical data, correlation analyses of selected sediment and water data, histograms and symbol maps showing the distri-

bution of uranium in sediment and water. For a more complete discussion of the survey the reader is referred to McConnell and Ricketts (2008).

LOCATION, ACCESS AND PHYSIOGRAPHY

The survey is located in east-central Labrador. There is no road access within the survey area. The town of Postville is approximately in the centre of the survey area and is 180 km north-northeast of Happy Valley–Goose Bay. Access to Postville is by year-round scheduled flights from Happy Valley–Goose Bay or by coastal boat in summer and fall. Float plane and helicopter charter services are available in Happy Valley–Goose Bay. Most of the terrain is moderately rugged and tree covered. Also seen are large areas of burnt-out forest, boulder terrain and barrens.

PREVIOUS GEOCHEMICAL SURVEYS

The area was included in the Labrador reconnaissance-scale surveys, which had a sample density of 1 per 14 km² (Friske *et al.*, 1993a, b and c). Sediment analyses included 41 elements, as well as U, F and pH analyses of water. The strongest uranium in sediment anomaly is located in north-west (NTS map area 13J/12) and northeast (NTS map area 13K/9) where four samples having a range of 109 to 368 ppm uranium were found within an 8 km radius. Three other samples located in NTS map areas 13N/1 and 13O/4 have high uranium values. Uranium data from water in the regional survey seem to have a stronger association with known mineralization than do uranium data from sediment.

GEOLOGY AND MINERALIZATION

The surveyed area is underlain by rocks of the Archean Hopedale Block, the Paleoproterozoic Makkovik Province and the Grenville Province. The geology and descriptions provided here are derived from the 1:1 000 000-scale geological map of Labrador by Wardle *et al.* (1997). More recent and detailed 1:50 000 mapping of NTS map area 13O/03 was released this year (Hinchey, 2007). The following described units are used as a base for the maps of the geochemical symbol plots. With the exception of a large pluton of Paleoproterozoic granite and some mafic volcanic, metavolcanic and mafic intrusive rocks, most of the rocks to the west of Kaipokok Bay are Archean. The oldest of these are mafic gneisses (AMmgn) derived from intrusive and volcanic rocks and include the Weekes amphibolite. The next oldest map unit (AMtgn) includes tonalitic to granodioritic migmatitic orthogneisses. The next youngest and most widespread of the Archean units (AMgrn) includes tonalitic and other gneisses. The youngest is the Kanairiktok Intrusive Suite (AMgd) and includes granodiorite, tonalite and minor granite. Included with the Archean package are mafic

volcanic and volcanoclastic rocks, lesser sedimentary and felsic volcanic rocks and mafic–ultramafic sills all at green-schist to amphibolite facies (Ammv).

The bedrock south and east of Kaipokok Bay is dominantly Paleoproterozoic felsic intrusive and extrusive rocks. Most of the known uranium occurrences are associated with these rocks. Eleven units are identified on the geology map. The most extensive of these (P3gr) is the Trans-Labrador batholith that includes granite, quartz monzonite, granodiorite, syenite and minor quartz diorite.

Mineralization in the area is principally of two commodities – copper and uranium (Geological Survey of Newfoundland and Labrador, 2007). Most copper occurrences are found immediately to the east and west of Kaipokok Bay (see Figure 6) and they typically consist of chalcopyrite in metavolcanic and metasedimentary rocks of the Aillik Group.

The uranium mineralization in the survey area may be loosely grouped into three types. The four occurrences west of Kaipokok Bay are associated with pegmatites intruding the enclosing Archean gneisses. Most of the occurrences immediately east and to the south of Kaipokok Bay are associated with Aillik Group sedimentary rocks and felsic to mafic volcanic rocks. The third group consists of hydrothermal mineralization in Paleoproterozoic granites and granodiorites to the east of Kaipokok Bay.

SURFICIAL GEOLOGY

The most recent surficial mapping for the area is that of Fulton *et al.* (1980 a and b). Portions of the present survey area that have been covered by their mapping include NTS map areas 13J/11, 13J/12, 13J/13, 13K/9, 13K/16 and 13O/4. The surveyed area is covered by a thin (<1 m) layer of till, but there is considerable exposure of bedrock, particularly on rugged highlands. The striations, drumlins or drumlinoid ridges and crag-and-tail features recorded in the survey area indicate the most recent ice advance was toward the northeast.

SAMPLE COLLECTION

Samples of organic lake sediment were collected from 775 sites; unfortunately a shortage of water sample bottles precluded the collection of water samples in the northern part of NTS map area 13J/12, where four high values of uranium in the lake sediment have been reported (see Section Uranium Distribution in Lake Sediment and Water, page 5). Additionally, approximately one site in 20 was sampled in duplicate. These duplicate samples were collected about 50 m apart. Generally, smaller lakes were sampled (in this sur-

vey) than was the case for the earlier GSC reconnaissance survey, in which the objective had been to obtain a more regional geochemical perspective. Normally, the centre of the lake (or if apparent from the air, the central basinal portion of the lake) was sampled. In some deep lakes (>25 m), no sample was retrieved from the lake centre and a sample from a shallower site closer to shore was obtained. The collection procedure involves landing a float-equipped 206-B Jet Ranger helicopter on the lake surface and dropping a weighted tubular sampler fitted with a nylon rope for retrieval. A butterfly valve in the bottom of the tube opens upon impact with the sediment and closes upon retrieval, trapping the contained sediment. Samples are stored in water-resistant Kraft paper bags. Markings on the rope permit determination of the sample depth. Other observations made during sampling include GPS coordinates of the site, the nature of vegetation surrounding the lake, sediment colour, texture and composition, and water colour.

Samples of lake water were collected before the sediment sampler was dropped to avoid water contamination. Samples were collected in purified, 125 mL Nalgene bottles. These were filled by immersing the bottles about 40 cm below the lake surface. Prior to sampling, the bottles were acid leached in the laboratory, and washed with distilled and deionized water. Sampling of a typical site took about one minute between touchdown and takeoff.

SAMPLE PREPARATION AND ANALYSES

Preparation

Lake sediments were partially air-dried in the field prior to shipping to the Departmental laboratory in St. John's for final oven-drying at 40°C. The samples were then disaggregated using a mortar and pestle before being screened through a 180 micron stainless-steel sieve. The fine fraction was retained for chemical analyses. To monitor analytical precision, five percent of the samples were randomly selected, split and included as blind duplicates in all analytical procedures. Water samples were stored in a cool environment prior to shipping to St. John's. At the laboratory, waters were filtered using a 0.45 µm millipore filtration apparatus.

Analyses

Lake sediment was analyzed using four methods for 48 unique elements plus loss-on-ignition. In addition, 15 of these elements were analyzed using a second method for a total of 64 separate determinations. The methods of analyses are tabulated in Table 1. Elements that are analyzed using two methods, one of which gives preferable results for reasons of improved detection limit or precision, are distinguished by an asterisk. All analyses except INAA were performed in the geochemical laboratory of the Department of

Table 1. Analytical methods for lake-sediment samples

ELEMENTS	METHOD	DIGESTION/ PREPARATION
(Ag) As, Au, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Lu, Mo, Na, Nd, (Ni), (Rb), Sb, Sc, Sm, (Sr), Ta, Tb, Th, U, W, Yb, (Zn), (Zr)	Instrumental Neutron Activation Analysis (INAA)	5 to 10 g in shrink-wrapped vial (total analysis)
Al, (As), Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Dy, Fe, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni*, P, Pb, Rb*, Sc, Sr*, Ti, V, Y, Zn*, Zr*	Inductively Coupled Plasma Emission Spectrometry (ICP-ES) ¹	Hf-HClO ₄ -HCl (total digestion)
Ag*	Atomic Absorption Spectrometry (AA) ²	HNO ₃
F	Fluoride-ion specific electrode with digital ion analyzer ²	2:1 Na ₂ CO ₃ :KNO ₃ flux, fusion
Loss-on-ignition (LOI)	Gravimetric using muffle furnace raised to 500°C	

* indicates preferred method of analysis

() indicates less favoured method of analysis; use alternative

¹ Finch, C.J., 1998

² Wagenbauer *et al.*, 1983

Table 2. Analytical methods for lake-water samples

ANALYSIS	METHOD	PREPARATION
pH	Corning combination pH electrode	None
Conductivity	Corning conductivity sensor	None
Ca, Fe, K, Mg, Mn, Na, Si, SO ₄	ICP-emission spectroscopy ¹	Filtration (0.45 μm) and HNO ₃ acidification
Al, Ba, Be, Co, Cr, Cu, Li, Mo, Ni, P, Pb, Sr, Ti, V, Y, Zn	ICP-ultrasonic nebulizer ¹	Filtration (0.45 μm) and HNO ₃ acidification
U	ICP-mass spectrometry	Filtration (0.45 μm) and HNO ₃ acidification

¹ Finch, C.J., 1998

Natural Resources in St. John's. The INAA analyses were performed by ActLabs. To enable the user to readily distinguish the method of analysis for a given element, a suffix is attached to the element symbol when used in most tables and figures. The key to the suffixes is as follows:

1. Instrumental Neutron Activation Analysis (INAA), *e.g.*, U1
2. ICP-ES after HF-HClO₄-HCl digestion, *e.g.*, Cu2
6. Silver by AA after HNO₃ digestion (Ag6)
9. Fluoride-ion selective electrode (F9)

In the foregoing, "ICP-ES" refers to inductively coupled plasma-emission spectrometry and "AA" is atomic absorption spectrometry. Thus, Zr2 is zirconium analyzed by ICP-ES/HF-HClO₄-HCl whereas Zr1 is zirconium analyzed by INAA.

Lake water was analyzed for conductivity, pH, SO₄ and 24 elements using the methods noted in Table 2. Uranium in water was analyzed by SGS Lakefield Research Limited using ICP-mass spectrometry. All other analyses were done in the Department of Natural Resources Laboratory, St. John's.

DATA QUALITY

To ensure the reliability of the analytical data, three methods of determining data accuracy and precision were employed. During sample collection, pairs of sediment samples and pairs of water samples were obtained from lakes. Duplicate samples were taken about 50 m apart. Analyses of these site duplicates give an appreciation of within-lake data variation. Thirty-five lakes were sampled for sediment duplicates and thirty-two for water duplicates. Data from one of these pairs of water duplicates were excluded from statistical analysis because water from one of the sample

pair is thought to have been contaminated; analyses of phosphorous and several metals in one of the two samples were extremely high. At the analytical stage, a standard of known composition was inserted within every batch of 20 samples and a sample split, or laboratory duplicate, was similarly included. For the sediment samples, international reference standards composed of lake-sediment material were used, notably LKSD-1, LKSD-2, LKSD-3 and LKSD-4. For water, standards used were both naturally occurring water and synthetic standards created in the laboratory to predetermined compositions. The results of these standards were monitored and found to be satisfactory for most elements.

Site duplicates are useful because they give an appreciation of overall data variance occurring at both the sampling and analytical stages. Since they consist of samples from the survey itself, they may reveal limitations in the data that are specific to the area and which may not show up in the reference standards. Scatter plots of analyses of uranium in sediment (U1) and uranium in water (Uw3) along with their Spearman correlation coefficients (*r*) are shown in Figure 2. Both media show very strong correlations: *r*=0.95 for U1 and *r*=0.88 for Uw3. These robust correlations indicate that users can place a high degree of confidence in the reproducibility of both the sampling and the analyses.

RESULTS

DESCRIPTION AND DISCUSSION

Statistical Analysis

Summary Statistics. To quantify the range and distribution characteristics of the element populations, summary statistics have been calculated for the sediment and water

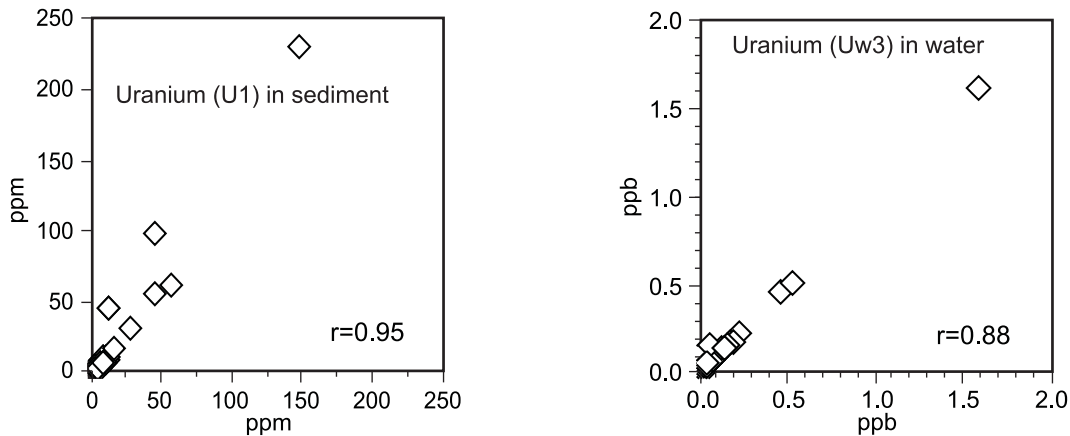


Figure 2. Scatter plots of uranium in sediment and in water in site duplicates.

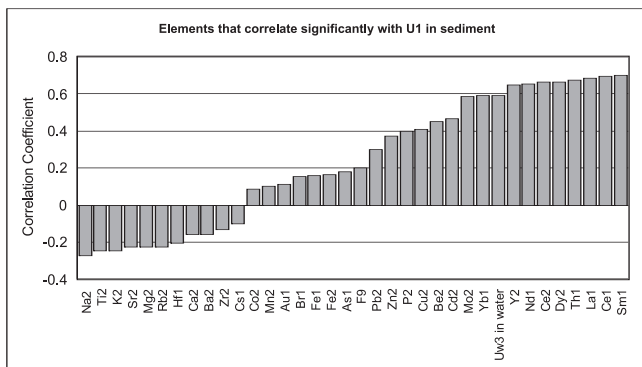


Figure 3. Spearman correlation coefficients for uranium and selected elements in lake sediment.

data and most of these are tabulated in Tables 3 and 4. Statistics tabulated include the median, arithmetic mean, geometric mean, arithmetic standard deviation, logarithmic standard deviation, and minimum and maximum values. Because the distributions of most element populations are more log-normal than normal, the geometric means as well as arithmetic means are given.

Correlation Analysis. Spearman correlation analysis was run on uranium in sediment (U1) against other sediment variables as well as uranium in water (Uw3). The results of the variables that were significantly correlated with uranium (either positively or negatively) were ranked and are shown as a graph in Figure 3. Some of the negative correlations can be explained in terms of magmatic differentiation. Magnesium and calcium, for example, are negatively correlated with uranium and are more enriched in mafic rocks than in felsic rocks. Uranium in this area is found predominantly in felsic rocks. At the other end of the spectrum, the highest positive correlations are with Be, Mo, Y, Th, the rare-earth elements and uranium in water (Uw3). Most of these are incompatible elements, and like uranium itself, are more concentrated at the felsic end of magmatic differentiation. Uranium does not correlate strongly with Fe or Mn suggest-

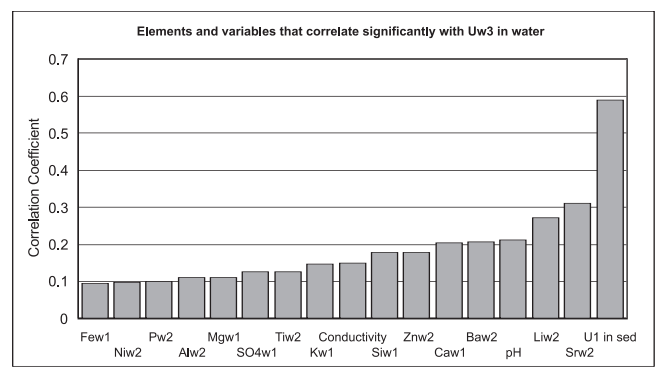


Figure 4. Spearman correlation coefficients for uranium and selected elements and variables in lake water.

ing that anomalous enrichments of iron/manganese oxides will not significantly increase the uranium values in sediment.

Similar correlation analysis was performed on uranium in water with the analytical variables measured in water. A graph of the ranked correlation coefficients is shown in Figure 4. Correlations are much weaker than those in sediment with only four correlations being >0.20 . Uranium in sediment and water, as noted above, correlates strongly at 0.59 indicating that data from either medium are a good proxy for the other.

Uranium Distribution in Lake Sediment and Water

The nature of the distribution of uranium in the two sample media is shown graphically as histograms (Figure 5). The X-axes are logarithmic scale and the shape of the distributions is approximately log-normal in both sediment and water although both show a slight positive skew.

Symbol plots of the distribution of uranium in sediment and in water are shown in Figures 6 and 7 respectively. Also shown are occurrences of U, Ni, Cu and pyrite mineraliza-

Table 3. Summary statistics for lake-sediment data (variable units are ppm unless otherwise noted)

Element	Median	Mean	Mean	Standard	Standard	Minimum	Maximum
		Arithmetic	Geometric	Deviation Arithmetic	Deviation Logarithmic		
Ag6	<0.1	0.09	0.06	0.18	0.25	0.05	3.4
Al2, wt. %	2.93	3.22	2.72	1.73	0.27	0.17	7.95
As1	1.5	2.7	1.0	5.92	0.64	0.2	110
As2	<2	2.8	1.8	5.29	0.34	1	85
Au1, ppb	<1	0.9	0.6	2.01	0.27	0.5	25
Ba1	290	291	164	248.58	0.56	25	3400
Ba2	211	273	228	171.96	0.26	35	940
Be2	1.0	1.5	1.0	2.18	0.35	0.1	33.1
Br1	29.0	33	27	20.48	0.30	0.5	300
Ca1, wt %	<1	0.8	0.6	0.79	0.23	0.5	7
Ca2, wt. %	0.85	0.99	0.85	0.55	0.25	0.14	3.4
Cd2	0.2	0.3	0.2	0.42	0.35	0.1	8.5
Ce1	102	139	105	122.98	0.32	7	1120
Ce2	117	153	118	124.06	0.31	5	1016
Co1	8	12	8	14.39	0.42	1	153
Co2	10	14	9	15.29	0.38	1	182
Cr1	26	30	22	22.46	0.40	2	260
Cr2	29	32	27	22.14	0.28	1	220
Cs1	<1	0.5	0.3	0.75	0.38	0.2	5
Cu2	27	37	28	41.09	0.30	4	775
Dy2	4.9	7.1	5.2	8.62	0.31	0.3	108.8
Eu1	1.3	1.5	1.3	1.02	0.28	0.2	10.3
F9	181	213	173	140	0.29	23	990
Fe1, wt.%	1.67	2.20	1.57	1.98	0.37	0.1	24.8
Fe2, wt.%	1.95	2.58	1.78	2.39	0.40	0.12	26.47
Hf1	1	1.9	1.2	1.91	0.41	0.5	11
K2, wt. %	0.31	0.55	0.33	0.56	0.46	0.04	2.82
La1	60	80	61	72.06	0.31	4	750
La2	71	95	72	90.60	0.32	4	941
Li2	4.2	6.7	4.2	6.60	0.45	0.1	53.6
LOI, wt.%	32.6	32.1	27.9	14.18	0.27	1.2	97.4
Mg2, wt.%	0.28	0.39	0.29	0.33	0.34	0.03	2.22
Mn2	300	512	289	951.39	0.44	23	16890
Mo2	5	8.3	5.2	11.30	0.40	1	140
Na1, wt.%	0.35	0.60	0.37	0.58	0.44	0.04	2.58
Na2, wt.%	0.44	0.72	0.44	0.71	0.46	0.04	3.19
Nb2	4	4.9	4.1	2.89	0.28	1	22
Nd1	39	52	37	49.54	0.38	2	540
Ni2	18	22	18	27.27	0.24	2	612
P2	1149	1370	1158	803.02	0.26	168	4437
Pb2	10	12	10	12.66	0.26	1	271
Rb1	<5	12	4	21.22	0.56	2	96
Rb2	13	21	13	19.43	0.46	1	105
Sb1	<0.5	0.08	0.03	0.14	0.46	0.02	1.3
Sc1	4.7	5.1	4.7	2.30	0.20	0.8	14.4
Sc2	5.8	6.4	5.7	2.99	0.21	0.4	19.9
Se1	<1	0.5	0.5	0.73	0.09	0.5	17
Sm1	7.6	9.7	7.6	8.76	0.29	0.6	96
Sr2	76	112	86	87.27	0.31	14	466

Table 3. Continued

Element	Median	Mean Arithmetic	Mean Geometric	Standard Deviation Arithmetic	Standard Deviation Logarithmic	Minimum	Maximum
Ta1	<0.2	0.2	0.1	0.52	0.32	0.1	4.6
Tb1	<0.5	0.7	0.4	1.08	0.41	0.2	11
Th1	5.8	7.2	6.0	5.09	0.26	0.2	51.8
Ti2	1500	1857	1493	1200	0.30	110	6227
U1	6.6	13.9	5.6	36.47	0.65	0.1	730
U1/Th1 ratio	1.10	1.74	0.94	3.85	0.54	0.01	80.22
V2	49	51	43	26.68	0.28	2	168
W1	<1	0.4	0.2	1.02	0.27	0.2	13
Y2	27	41	29	54.13	0.32	2	811
Yb1	2	3.0	2.1	3.95	0.34	0.1	53.8
Zn2	64	79	62	87.55	0.29	6	1764
Zr1 wt. %	<0.02	0.02	0.01	0.03	0.28	0.01	0.55
Zr2	27	36	27	26.86	0.33	3	156
Lake area (km ²)	0.07	0.19	0.08	0.36	0.56	0.01	3.29
Lake depth (m)	4.5	5.5	4.2	4.20	0.33	0.5	28

Table 4. Summary statistics for lake-water data (variable units are ppb unless otherwise noted)

Element	Detection Limit	Percentage of samples <D.L.	Median	Mean Arithmetic	Mean Geometric	Standard Deviation Arithmetic	Standard Deviation Logarithmic	Minimum	Maximum
Al	1	0	65	69	57	38.1	0.32	1	270
Ba	0.1	0	2.1	3.5	2.1	6.61	0.38	0.1	81.2
Be	0.1	99	<0.1	<0.1	<0.1	0.01	0.03	0.1	0.2
Ca, ppm	N.A.*	0	0.84	1.09	0.89	1.00	0.27	0.12	10.18
Co	2	100	<2	<2	<2	0.06	0.02	1	1
Cr	0.5	94	<0.5	<0.5	<0.5	2.26	0.22	0.2	4.4
Cu	0.5	58	<0.5	1.4	<0.5	2.98	0.55	0.2	18.5
Fe	10	24	26	47	24	76	0.50	5	1052
K, ppm	0.01	0	0.15	0.17	0.13	0.17	0.39	0.01	1.16
Li	0.1	58	<0.1	0.13	<0.1	0.12	0.33	0.1	0.8
Mg, ppm	N.A.	0	0.32	0.36	0.31	0.32	0.22	0.08	2.38
Mn	0.5	41	0.7	1.3	0.7	1.91	0.49	0.2	24
Mo	1.0	91	<1.0	<1.0	<1.0	0.45	0.17	1	3
Na, ppm	N.A.	0	1.42	1.64	1.48	2.69	0.19	0.70	9.78
Ni	1.0	31	2	2	1.4	4.68	0.37	1	50
P	5	64	<5	5.2	<5	7.2	0.35	2	70
Pb	2.0	99.7	<2	<2	<2	0.23	0.07	0.2	6
Si, ppm	N.A.	0	0.37	0.44	0.29	0.35	0.49	0.01	2.46
SO ₄ , ppm	0.01	0	0.06	0.08	0.06	0.15	0.37	0.01	0.76
Sr	N.A.	0	4.2	4.8	4.3	2.94	0.20	0.5	27.8
Ti	0.1	78	<0.1	0.2	<0.1	0.49	0.43	0.1	6.0
U	0.005	0	0.082	0.140	0.085	0.20	0.41	0.005	2.64
V	0.2	83	<0.2	<0.2	<0.2	0.11	0.19	0.1	1.1
Y	0.1	93	<0.1	<0.1	<0.1	0.13	0.22	0.1	1.4
Zn	1.0	53	<1.0	1.3	<1.0	1.71	0.32	0.5	22
Conductivity, μ S	N.A.	0	16.36	18.1	16.6	17.80	0.19	7.2	81.1
pH	N.A.	0	6.35	6.34	N.A.	0.39	N.A.	3.81	7.7

* N.A. not applicable; ** pH is defined as a logarithmic value

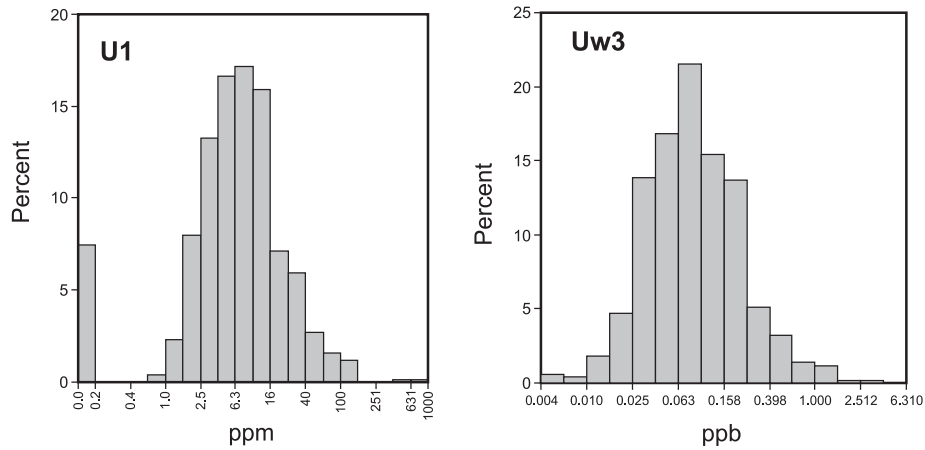


Figure 5. Histograms of uranium in lake sediment (U1) and in water (Uw3)

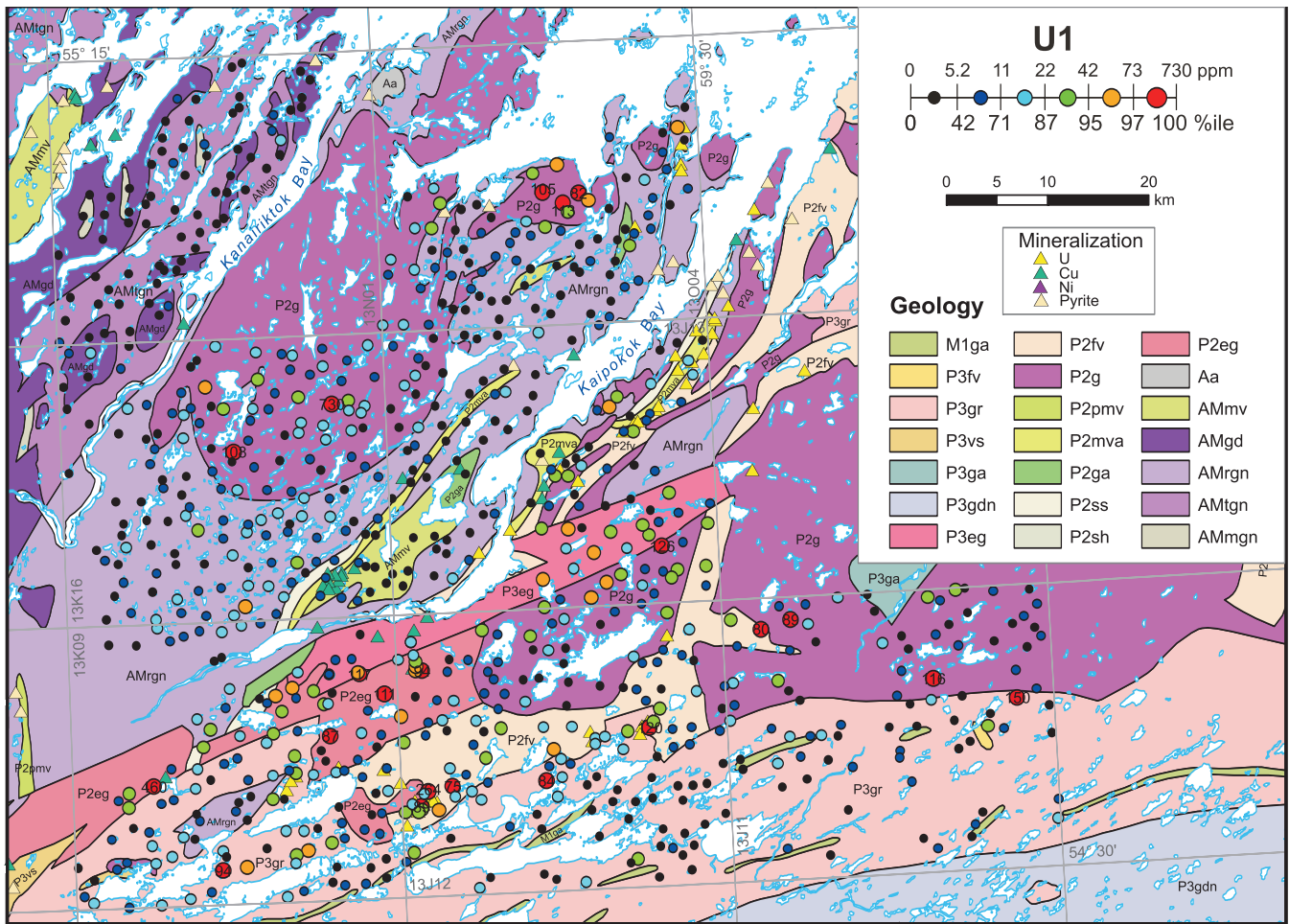


Figure 6. Uranium (U1) in lake sediment (see Wardle et al., 1997 for description of the geology units).

tion obtained from the MODS database (Geological Survey of Newfoundland and Labrador, 2007). Data were classified using natural breaks (Jenks Optimization) to depict naturally occurring divisions in the data in the hope of reflecting geochemical or mineralogical processes. The Jenks Opti-

mization is “a method of manual data classification that seeks to partition data into classes based on natural groups in the data distribution. Natural breaks occur in the histogram at the low points of valleys. Breaks are assigned in the order of the size of the valleys, with the largest valley

STRATIFIED ROCKS

MESOPROTEROZOIC

PALEOPROTEROZOIC

- P3fv Rhyolitic to andesitic volcanic rocks including ash-flow tuff and agglomerate (Bruce River Gp.)
- P3vs Volcaniclastic sandstone, arkose and conglomerate (Bruce River Gp.)
- P2fv Rhyolite, ash-flow tuff, breccia and hypabyssal rhyolite intrusions, volcaniclastic siltstone and sandstone; minor basalt (Upper Aillik Gp.)
- P2pmv Pillow basalt, basaltic pyroclastic rocks; minor siltstone and greywacke
- P2mva Schistose amphibolite derived from mafic volcanic rocks (Lower Aillik Gp.)
- P2sh Shale and sandstone
- P2ss Pelitic schist and phyllite, equivalent to P2sh (Lower Aillik Gp.)

ARCHEAN

- AMmv Mafic volcanic and volcaniclastic rocks, lesser sedimentary and felsic volcanic rocks, and mafic-ultramafic sills; at greenschist to amphibolite facies

IGNEOUS AND META-IGNEOUS ROCKS

- M1ga Olivine gabbro and metamorphic equivalents, including coronic varieties (Shabogamo and Michael gabbros)
- P3gr Granite, quartz monzonite, granodiorite, syenite and minor quartz diorite (Trans-Labrador batholith and coeval rocks)
- P3ga Mafic intrusive suites (gabbronorite, lesser diorite), some metamorphosed at amphibolite to granulite facies
- P3gdn Granodioritic orthogneiss (lesser quartz dioritic and granitic orthogneiss), commonly migmatitic; may include some meso-proterozoic rocks in areas mapped only at reconnaissance scale
- P3eg High-level, locally fluorite-bearing granites
- P2g Granite and granodiorite
- P2ga Gabbro and leucogabbro sills (Wakuach gabbro)
- P2eg Granite plutons
- Aa Anorthosite and leucogabbroic rocks
- AMgd Granodiorite, tonalite and minor granite (Kanairiktok Intrusive Suite)
- AMrgn Tonalitic and other gneisses reworked and retrograded during Makkovikian orogenesis (Windsor Harbour gneiss)
- AMtgn Tonalitic to granodioritic migmatitic orthogneisses containing abundant mafic to ultramafic inclusions and relict mafic dykes (Maggo gneiss)
- AMmgn Mafic gneisses including rocks of intrusive and extrusive origin (Weekes amphibolite)

Legend for Figures 6, 7 and 8.

being assigned the first natural break” (ESRI Support Center, 2006).

Nineteen samples fall into the highest interval of 74-730 ppm uranium in Figure 6. Four of these, all in NTS map

area 13J/12, are near known uranium mineralization. The others are found remote from known occurrences. Seven, including the one with the highest value at 730 ppm, appear to overlie Unit P2g, which is mapped as granite and granodiorite. Also of note in this group of P2g samples is the

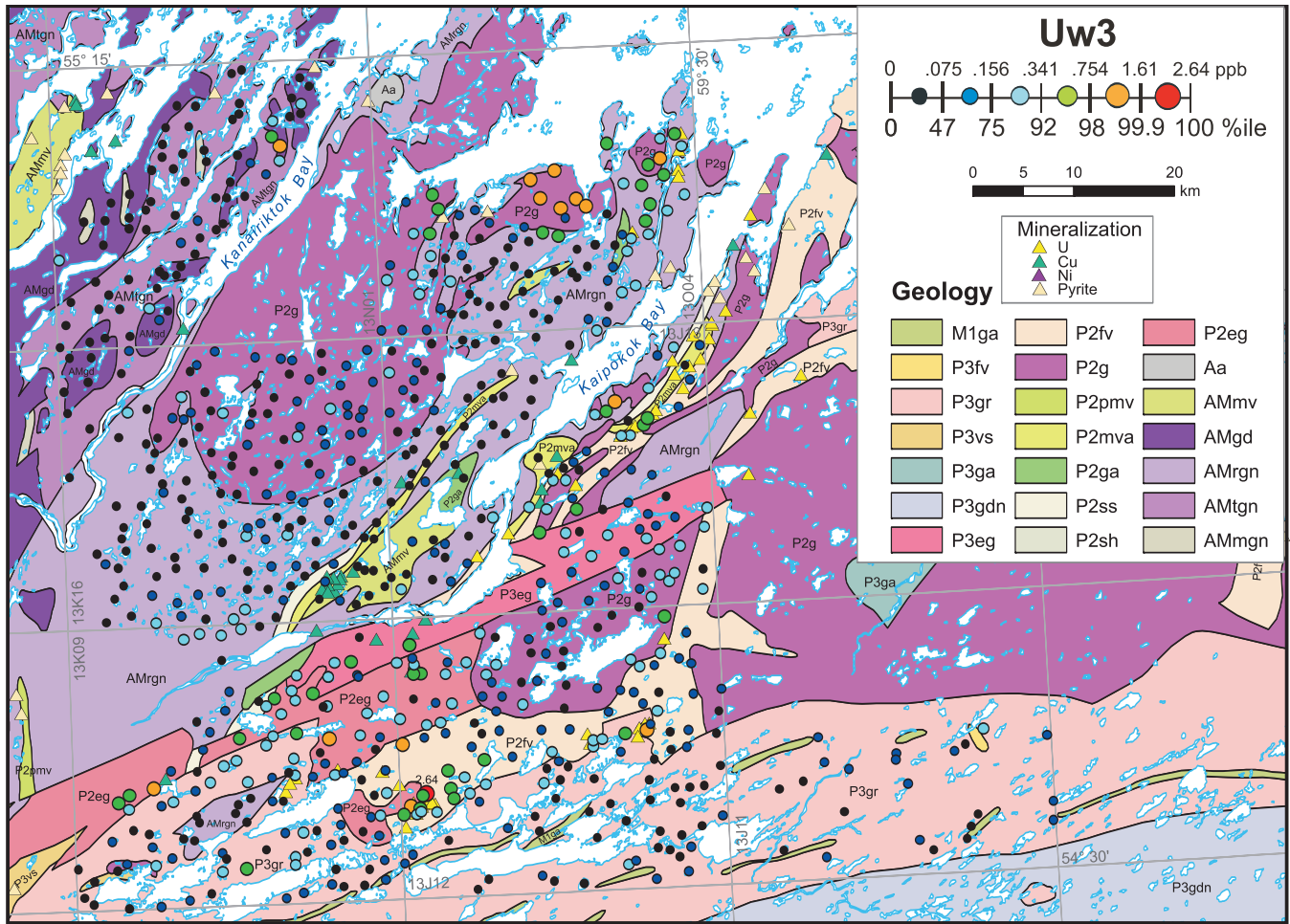


Figure 7. Uranium (Uw3) in lake water (see Wardle et al., 1997 for description of the geology units). See legend on page 9.

cluster of three high values found in the northern part of NTS map area 13O/4. Nearby are 5 other samples having elevated uranium values that suggest, at the very least, that this intrusion is quite enriched in the metal. Four more high samples overlie the mid Paleoproterozoic granite, P2eg.

The presence of one, very high value (2.64 ppb Uw3) means that there is only one sample that falls into the highest (red) interval in the uranium on the water map (Figure 7). In fact, because of the grouping algorithm applied, the red sample, all the orange and some of the green samples on the water map have the same percentile ranges as the red samples in the sediment map. To better compare the water and sediment dispersions, another map (Figure 8) was generated for Uw3 using the same percentile intervals as used for U1 in Figure 6. These two maps of U1 and Uw3 share many similarities as can be expected with a correlation coefficient between the two media of 0.59. However, they also have interesting differences that yield some different targets. Perhaps most apparent is in the northern part of NTS map area

13O/4, where there are considerably more high uranium in water values than high sediment values. To a lesser extent this is also true to the west of Kanairiktok Bay in NTS map area 13N/1. Another area that receives more emphasis in the water data is on the west side of Kaipokok Bay in NTS map area 13J/13 where there is a cluster of 3 elevated values, the highest being 1.18 ppb Uw3. Overall, uranium in the two media provides several targets for follow-up exploration.

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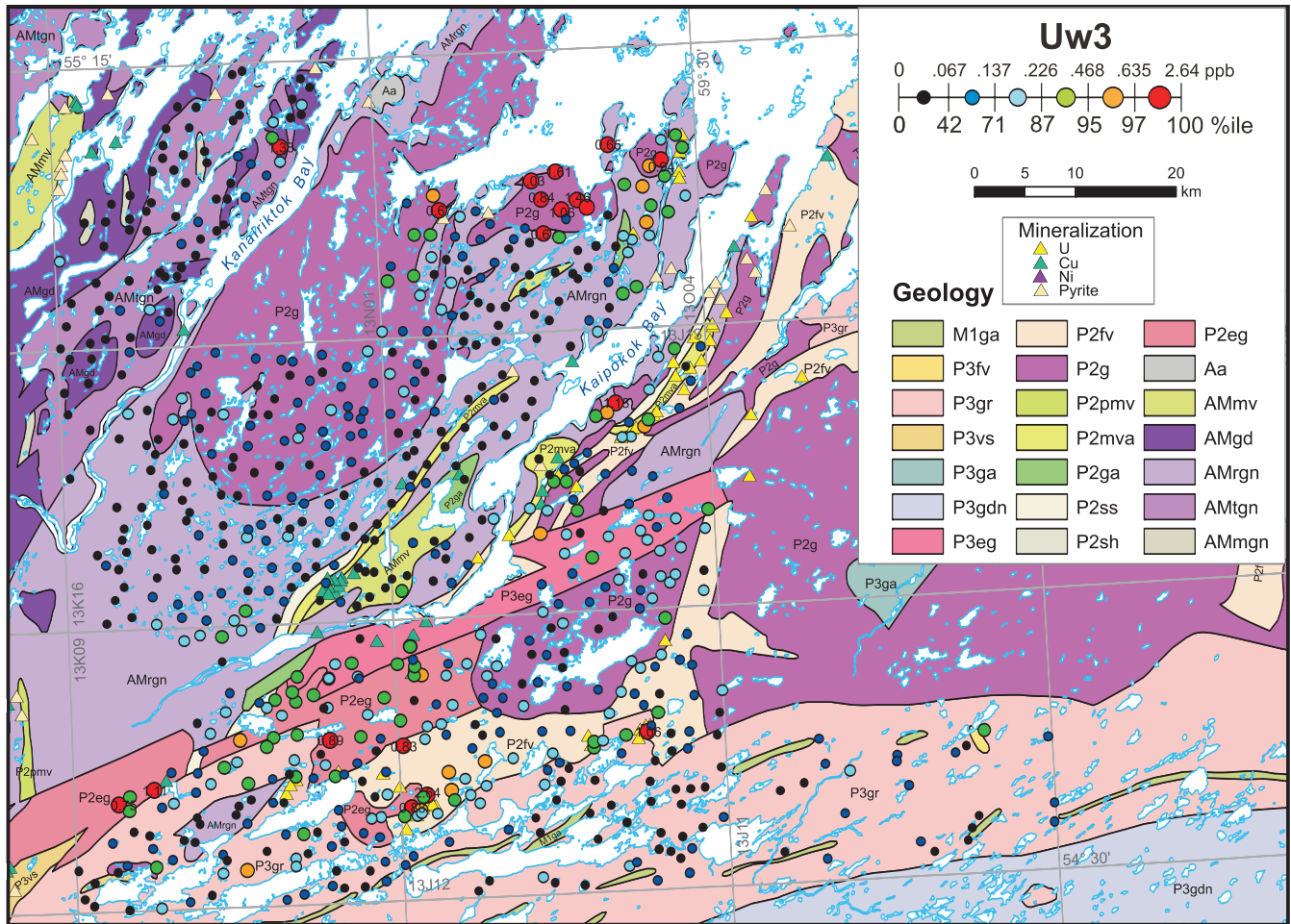


Figure 8. Uranium (Uw3) in lake water using same frequency intervals as used for U1 (see Wardle et al., 1997 for description of the geology units). See legend on page 9.

REFERENCES

ESRI Support Center

2006: <http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.search&searchTerm=natural%20breaks%20classification>

Finch, C.J.

1998: Inductively coupled plasma-emission spectrometry (ICP-ES) at the Geochemical Laboratory. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey, Report 98-1, pages 179-193.

Friske, P.W.B., McCurdy, M.W., Gross, H., Day, S.J., Lynch, J.J. and Durham, C.C.

1993a: Regional lake sediment and water geochemical data, central Labrador (NTS 13K). Geological Survey of Canada, Open File 2645.

1993b: Regional lake sediment and water geochemical data, eastern Labrador (NTS 13I, 13J and 13O). Geological Survey of Canada, Open File 2646.

1993c: Regional lake sediment and water geochemical data, eastern Labrador (NTS 13N). Geological Survey of Canada, Open File 2648.

Fulton, R.J. Hodgson, D.A. and Minning, G.V.

1980a: Surficial materials, Rigolet, Newfoundland. Geological Survey of Canada, Map 26-1979, scale 1:250,000.

Fulton, R.J. Hodgson, D.A., Minning, G.V. and Thomas, R.D.

1980b: Surficial materials, Snegamook Lake, Newfoundland. Geological Survey of Canada, Map 27-1979, scale 1:250,000.

Geological Survey of Newfoundland and Labrador
2007: Mineral Occurrence Data System (MODS).
<http://www.nr.gov.nl.ca/mines&en/geosurvey/mods/>

Hinchey, A.M.
2007: The Paleoproterozoic metavolcanic, metasedimentary and igneous rocks of the Aillik Domain, Makkovik Province, Labrador (NTS map area 13O/03). *In* Current Research. Newfoundland and Labrador Department of Natural Resources, Geological Survey, Report 07-01, pages 25-44.

McConnell, J.W. and M.J. Ricketts
2008: High-density lake sediment and water survey in eastern Labrador (NTS 13J/11, 13J/12, 13J/13, 13K/9,

13K/16, 13N/1 and 13O/4). Newfoundland and Labrador Department of Natural Resources, Open File LAB/1427, 60 pages.

Wagenbauer, H.A., Riley, C.A. and Dawe, G.
1983: Geochemical Laboratory. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, pages 133-137.

Wardle, R.J., Gower, C.F., Ryan, B., James, D.T., Nolan, L.W., Nunn, G.A.G. and Kerr, A.
1997: Digital geological map of Labrador, version 1.0. Newfoundland Department of Natural Resources, Geological Survey, Open File LAB/1226.