

Responses in Lake Sediments and Waters to Occurrences of Rare Earths and Rare Metals in the Canadian Shield

Introduction

In this article, 25 documented occurrences of rare earth element/rare metal (REE/RM) mineralization, or of current exploration activity for these commodities, in Canada (Fig. 1) are examined. These occurrences, all hosted in rocks of the Precambrian Canadian Shield, are compared in terms of their geochemical response in lake sediments and, where applicable, lake waters. The article was inspired during research of companies active worldwide in REE/RM exploration, and is based on research directed towards discovery of new deposits of these elements in Newfoundland and Labrador in eastern Canada.

The geochemical responses to REE/RM mineralization are described empirically, with limited reference to the host geology of the deposit, even if known. This approach is not meant to imply that such information is not relevant in the full evaluation of a geochemical anomaly in any element. The scope is further constrained by the overlap, or lack thereof, between documented REE/RM deposits and exploration plays on the one hand, and available lake sediment and water geochemical data on the other. For example, no lake geochemical data are readily available for Quebec's Kipawa REE camp or Lacorne pegmatite district (where there are numerous Li plays, as well as a former and probable future Li producer); for the Clay Howells carbonatite and Separation Rapids pegmatite in Ontario; or the Tanco mine in Manitoba.

Examples are drawn from the western (NW Saskatchewan) to the eastern (Labrador) extremities of the Canadian Shield. It has not been possible to document dispersion from every known occurrence or group of occurrences, and it is acknowledged that the examples cited may not be entirely representative. Furthermore, some of the data sets from Ontario and Quebec include in excess of 60 analytical parameters and the behaviour of each parameter has not been studied exhaustively.

Since the article comprises a description of the response to known mineralization, speculation about the significance of anomalies not known to be related to REE/RM mineralization is kept to a minimum, although it is hoped that

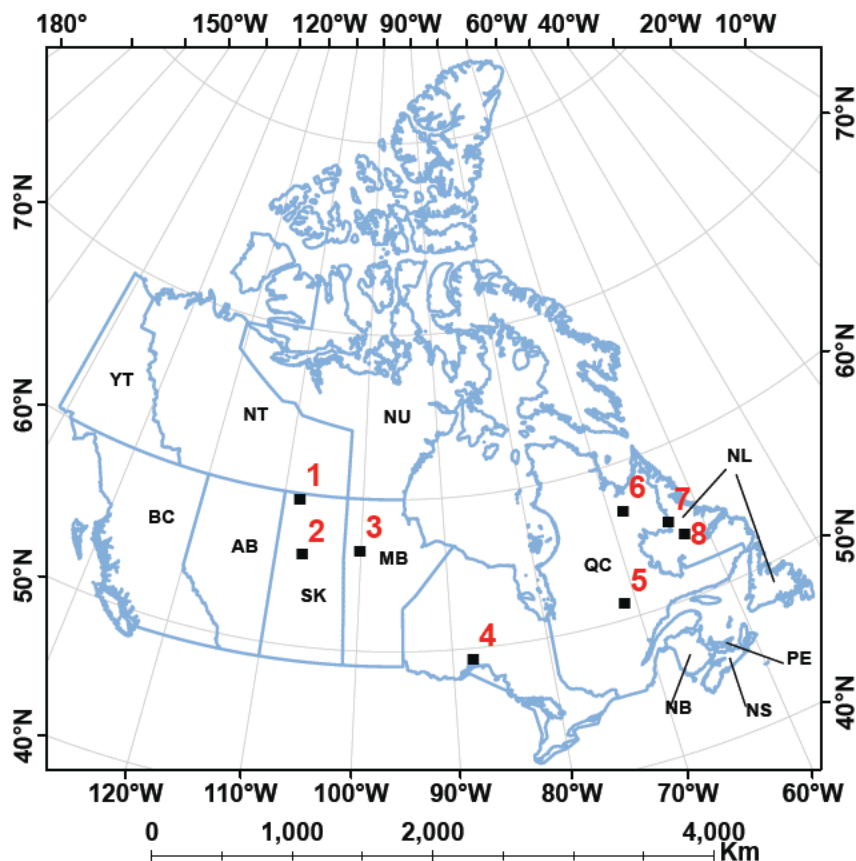


Figure 1: Locations of REE/RM occurrences from Figures 2 to 9. 1: Northwestern Saskatchewan (Hoidas Lake, Hazleton Lake, Alces, Archie); 2: Central Saskatchewan (Sunlite); 3: Eden Lake, Manitoba; 4: Georgia Lake, Ontario; 5: Kwyjibo, Quebec; 6: Erlandson, Quebec; 7: Misery Lake/Ytterby, Quebec/Labrador; 8: Red Wine Mountains, Labrador.

the signatures described in this article will have utility in the identification and evaluation of anomalies of hitherto-unknown provenance.

Definitions of REE and RM

REE/RM are defined as the lanthanide rare earths (plus Y, which is commonly listed separately for both chemical and economic reasons), Li, Nb, Ta, Cs, Rb, Be, Zr, Sc and Hf (although occurrences of the last two elements are rarely documented). The study does not concern itself with four other elements that are occasionally described as rare metals: Sn, In, Ge and Ga.

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Data Sources

The lake geochemical data were derived from three sources:

- The Geological Survey of Canada's National Geochemical Reconnaissance (NGR) lake-sampling program (Hornbrook, 1989) sampled parts of Alberta, Saskatchewan, Northwest Territories, Nunavut, Manitoba, Ontario and Labrador (as well as Nova Scotia and New Brunswick, which are not considered here as they are not underlain by Canadian Shield) at a density of approximately one sample per 16 km². Sediment samples were originally analyzed for up to 15 elements by various methods, whose details may be found at http://gdr.nrcan.gc.ca/geochem_ngr/format_lake_sediment_e.php, whereas waters were analyzed for U and F-, plus pH (http://gdr.nrcan.gc.ca/geochem_ngr/format_lake_water_e.php).
- Subsequently, and subject to agreements between the Canadian federal government and individual provinces and territories, some archived samples were analyzed by neutron activation for a 27-element package that included the REE/RM elements Ce, Cs, Eu, Hf, La, Lu, Rb, Sc, Ta,

Tb, and Yb. This reanalysis is continuing, with the recent (McCurdy et al. 2010) and upcoming (McCurdy pers. comm.) release of additional data for selected samples from northern Manitoba.

- Lake sediments have also been collected by the geological surveys of Ontario and Quebec in a number of programs since the 1970s, at a variety of densities, and analyzed for various packages ranging from a limited suite of AAS analyses to multielement INA, ICP-ES and ICP-MS packages. A number of programs in Ontario also involved the collection of water samples; no water analyses are available from the Quebec surveys. The current study has made use of certain web-accessible lake-sediment geochemical data downloaded from the websites of both provincial governments: http://www.mndmf.gov.on.ca/mines/ogs/ims/pub/digcat/mrd_e.asp in Ontario, and http://sigeom.mrnf.gouv.qc.ca/signet/classes/I1102_indexAccueil?l=a in Quebec.

Mineral-occurrence data are derived from web-accessible mineral deposit databases for the provinces and territories, as specified in Table 1 (*see page 4*). The data are probably not all-encompassing, because mineral occurrences tend not to be documented as soon as they are discovered. Information regarding foci of REE/RM exploration activity was sourced from the most recently available Canadian and American Mines Handbook (CMH; Giancola 2010). Identification of active projects was followed up with visits to company websites, where they exist. The latter do not conform to any recognized standard of clarity, and information regarding property and mineral-occurrence location varies in its precision and usefulness.

The sources of all of the geochemical and mineral-deposit data are listed in Table 1. For each of the web pages listed in the table, a certain amount of experimentation, on the part of the user, will still be necessary in order to locate the data because the design of the pages is being constantly improved, and also because certain pages are generated by servlet and have no direct URL that can be specified here.

In every case, it is advisable to make the approach in designing the initial query as broad as possible, particularly in selecting commodity types. For example, in searching for rare-earth deposits it is prudent to specify REE as a group, as well as individual elements (Y, La, Ce etc.) if they are offered as search criteria. It is also to be expected that the definitions of REE and RM will vary from database to database.

Definition of an Anomalous Value

Any exercise in the identification of geochemical anomalies requires a definition of what constitutes an anomaly. As a regional first-pass method, the author has found the following definitions useful (although it is not intended to advocate their universal application, applicability, or statistical validity) and they will be applied here.

Note: This EXPLORE article has been extracted from the original EXPLORE Newsletter. Therefore, page numbers may not be continuous and any advertisement has been masked.

Responses in Lake Sediments ... *continued from page 2*

Table 1. Location of online mineral deposit and lake geochemical databases

Province/ territory	Database	URL	Access via	Output format	Notes
Alberta	Mineral Deposits	www.ags.gov.ab.ca/publications/pubs.aspx?series=dig	Links page	Zipped SHP	
	Lake sediment/ water geochemistry	http://gdrdap.agg.nrcan.gc.ca/geodap/home/Default.aspx?lang=e	Queryable database	Zipped SHP	1,2
Saskatchewan	Mineral Deposits	www.infomaps.gov.sk.ca/website/SIR_Geological_Atlas/viewer.htm	Interactive GIS map	Zipped SHP	
	Lake sediment/ water geochemistry	www.infomaps.gov.sk.ca/website/SIR_Geological_Atlas/viewer.htm	Interactive GIS map	Zipped SHP	1,3
Northwest Territories	Mineral Deposits	http://www.nwtgeoscience.ca/	Interactive GIS map	Zipped SHP	4
	Lake sediment/ water geochemistry	http://gdrdap.agg.nrcan.gc.ca/geodap/home/Default.aspx?lang=e	Queryable database	Zipped SHP	1,5
Nunavut	Mineral Deposits	http://nunavutgeoscience.ca/apps/showing/showQuery.php	Queryable database	CSV	4
	Lake sediment/ water geochemistry	http://gdrdap.agg.nrcan.gc.ca/geodap/home/Default.aspx?lang=e	Queryable database	Zipped SHP	1,5
Manitoba	Mineral Deposits	http://geoapp2.gov.mb.ca/website/geo1m/viewer.htm	Interactive GIS map	Zipped SHP	
	Lake sediment/ water geochemistry	http://gdrdap.agg.nrcan.gc.ca/geodap/home/Default.aspx?lang=e	Interactive GIS map	Zipped SHP	1,6
Ontario	Mineral Deposits	www.geologyontario.mndmf.gov.on.ca/	Queryable database	HTML	
	Lake sediment/ water geochemistry	http://gdrdap.agg.nrcan.gc.ca/geodap/home/Default.aspx?lang=e	Queryable database	Zipped SHP	1,7
	Lake sediment/ water geochemistry	http://gdrdap.agg.nrcan.gc.ca/geodap/home/Default.aspx?lang=e	Links page	Zipped files in various formats	8
Quebec	Mineral Deposits	http://sigeom.mrnf.gouv.qc.ca/signet/classes/I1102_indexAccueil?l=a	Queryable database	HTML, KMZ	
	Lake sediment/ water geochemistry	http://sigeom.mrnf.gouv.qc.ca/signet/classes/I1102_indexAccueil?l=a	Queryable database	Zipped SHP	9
(Newfoundland and) Labrador	Mineral Deposits	http://gis.geosurv.gov.nl.ca/resourceanatlas/viewer.htm	Interactive GIS map	Zipped SHP	
	Lake sediment/ water geochemistry	http://gis.geosurv.gov.nl.ca/resourceanatlas/viewer.htm	Interactive GIS map	Zipped SHP	10

Notes

1. NGR data
2. Coverage restricted to area of northeastern Alberta underlain by the Canadian Shield: NTS map sheets 74D, 74E and 74M
3. Two high-density surveys conducted by provincial government at Cluff Lake and McLean Lake
4. Requires user ID
5. Coverage < 100%
6. Shield-underlain areas north of 53°30' N. Very few samples analyzed for INAA; no water analyses north of 58°00'N
7. Complete coverage between 44°30' and 48°00'N; almost complete coverage west of 84°00'W and south of 49°30'N. Almost no coverage north of 49°30'N.
8. Data files from 40 Ontario government high-density lake surveys over selected areas between 46°30'N and 52°00'N. Considerable overlap with NGR coverage though certain areas of NW Ontario are covered which were unsampled by NGR program.
9. C\$0.02 per sample
10. Also available from <http://gdrdap.agg.nrcan.gc.ca/geodap/home/Default.aspx?lang=e>

• Anomalous indicates that the sample's content exceeds the 97.5-percentile, in a particular population of samples, of the element in question. This threshold is close to the proportion of samples in a normal distribution that exceed the mean plus two standard deviations; the latter statistic was chosen as a means of deriving the threshold for this very reason (Hawkes & Webb 1962; Garrett 1989).

- Elevated indicates that the sample's content is less than or equal to the 97.5-percentile, but exceeds the 90-percentile, in a particular population of samples, of the element in question.
- Background refers to all values less than or equal to the 90-percentile, in a particular population of samples, of the element in question.

Responses in Lake Sediments ... *continued from page 4*

In any geochemical population whose frequency distribution approximates some permutation of the normal distribution, there will always be values that are defined as “anomalous” or “elevated” in this way, whether or not they are either statistically or geochemically anomalous, and whether or not they have any spatial or genetic relationship with enrichment of that element in bedrock. Nevertheless, this method has the advantage of rapid map generation, and once they are plotted, the significance of samples that appear to be anomalous in an element of interest can be assessed by examining their relationship to the behaviour of other elements, or their spatial relationship to known geology, or to one another.

The population of analytical values from which the percentiles are derived is also a judgment call. In the present investigation, 90- and 97.5-percentiles were calculated for each preparation- and finish-specific analytical parameter from three data sets:

- The entire NGR Canadian Shield database, for samples from Alberta, Saskatchewan, NWT, Nunavut, Manitoba, Ontario and Labrador
- A database for all samples collected by the Ontario Geological Survey and compiled from 40 separate data sets
- Four Quebec databases for selected samples, representing each of the Superior, Grenville and Churchill Provinces, and the New Quebec Orogen (Labrador Trough).

Because web-accessible geochemical data posted by the Province of Quebec are unique in Canada in not being free, to derive summary statistics from the entire Quebec database would have incurred an unsustainable expense; hence the use of selected data, some of which were kindly provided by Charles Maurice, here.

Results

The responses to the REE/RM occurrences are listed in Table 2 (*see pages 6 and 7*). Responses are categorized and coded as follows:

1. Elevated and/or anomalous values localized over, around or down-ice of occurrence(s); strong contrast with surrounding background samples, even when not numerous
2. Many elevated and anomalous values in occurrences' vicinity and possibly elsewhere, not associated with known mineralization; possible application as regional pathfinder
3. A few elevated and anomalous values in occurrence's vicinity; probably inapplicable as pathfinder

The absence of a particular element from an anomalous association may be due to analyses of that element not being available for samples from the region in question, rather than an absence of signature. For example, no REE/RM analyses are available for lake sediment samples collected over the

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Responses in Lake Sediments ... *continued from page 5*

Table 2: Lake-sediment and water responses to REE/RM mineralization

Occurrence	Approx location	Host	Deposit type	Metal Associations in Occurrence	Analyses	Strength of Response			Source
						1	2	3	
Hoidas Lake (SK)	59.9° N 107.8° W	Tonalite gneisses, amphibolite, granitic mylonites, and diorites (Churchill Province: Ena Domains)	Late-magmatic to hydrothermal vein	REE, Ba, Sr, Ti	NGR NGR INAA NGR U _w , F _w		Ce, La, Mo, Sm, Th	F _w	1, 2, 3
Alces (SK)	59.7° N 108.0° W	Granite & gneiss (Churchill Province: Beaverlodge Domain)	Pegmatite	REE, Th	NGR NGR INAA NGR U _w , F _w		Ce, F _w , La, Mo, Sm, Th,		2
Hazleton Lake (SK)	59.8° N 109.9° W	Granite & gneiss (Churchill Province: Zemplak Domain)	Pegmatite	REE, Nb, Ta	NGR NGR INAA NGR U _w , F _w	Yb	Ce, F _w , Mo, Sm, Tb, Th, U		2
Archie (SK)	59.5° N 107.7° W	Metasediment (Churchill Province: Beaverlodge Domain)	Placer and Paleoplacer	REE, Th, Ti, Sr	NGR NGR INAA NGR U _w , F _w				2
Sunlite (SK)	56.1° N 106.8° W	Churchill Province (Mudjatik [South] Domain)	Pegmatite	REE, Nb, Ta	NGR NGR INAA NGR U _w , F _w	Cs, Rb, Ta, U, Yb	Ce, F _w , La, Mo, Sm, Tb, Th		2
Nueltin Lake (NU)	60.3° N 99.8° W	Churchill Province Mudjatik (South) Domain	Metamorphic	REE, Th	NGR NGR U _w , F _w		F _w , Mo, U		2
Eden Lake (MB)	56.0° N 100.2° W	Churchill Province (Chipewyan Domain)	Carbonatite	REE	NGR NGR U _w , F _w	F _w , Mo, U, U _w			1, 4
Georgia Lake (ON)	49.4° N 87.9° W	Superior Province (Quetico Subprovince)	Pegmatite	Li, Be, Cs, Nb, Rb, Ta	NGR NGR INAA NGR U _w , F _w OGS (MRD243)		Cs	Li	1
Seymour-ZigZag Lakes (ON)	50.5° N 88.1° W	Superior Province (Wabigoon / English River Subprovinces)	Pegmatite	Be, Li, Ta, Nb	W: OGS (MRD56) E: NGR NGR INAA NGR U _w , F _w	Ce, Eu, La, Lu, Mo, Nd, Sm, Tb, Y, Yb	Cs, Nb, Th		1
Coldwell Complex (ON)	48.8° N 86.5° W	Superior Province (Wawa Subprovince)	Alkalic Complex	Nb, Zr, REE	NGR NGR INAA NGR U _w , F _w	Ce, Eu, F _w , La, Lu, Sm, Ta, Tb, Yb			1
Prairie Lake (ON)	49.0° N, 86.7° W	Superior Province (Wawa Subprovince)	Carbonatite	Nb, P, Ta, U, REE	NGR NGR INAA NGR U _w , F _w				1
Lac Walker Region (QC)	50.5° N, 67.1° W	Grenville Province (Migmatite)	Unknown	Nb-Ta-Zr-REE	AA U (fluor)		Mo, U		2
Lac Manitou Region (QC)	50.9° N 65.3° W	Grenville Province (Paragneiss)	IOCG	Cu, REE, Nb, Mo, Ag, Fe, Th, Zr, Ti	ICP-MS		Cd, Cr, Cs, Cu, Hf, Mg, Nb, Rb, Th, Ti	Ba, Be, Ca, Ce, La, Li, Y	2
Kwyjibo (QC)	51.1° N 71.3° W	Grenville Province (Grey gneiss)	IOCG	Fe, Cu, REE, Au	ICP-MS		Ce, La, Nb		1
Crevier (QC)	49.5° N 72.8° W	Grenville Province (syenite, monzonite)	Carbonatite	Nb, Ta, U, Ti	AA U (fluor)	Nb, Sc, Sr, U			1, 2

Responses in Lake Sediments ... *continued from page 6*

Occurrence	Approx location	Host	Deposit type	Metal Associations in Occurrence	Analyses	Strength of Response			Source
						1	2	3	
Moblan (QC)	50.7° N 75.2° W	Superior Province (Granite-greenstone)	Pegmatite	Li, Be	ICP-MS		Be, Ce, La, Y	Al, Fe, Nb, P	1, 2
Eastmain (QC)	52.1° N 76.8° W	Superior Province (Late tectonic tonalitic rocks)	Pegmatite	Li, Be, Mo	ICP-MS			Mo	1, 2
Eldor (QC)	56.9° N 68.4° W	Churchill Province (New Québec Orogen)	Carbonatite	Ta, Nb	ICP-MS		Ce, La, Mo, Y		1, 2
Lac Brisson (QC) / Strange Lake (NL)	56.4° N 64.0° W	Churchill Province	Alkalic Complex	Zr, Y, REE, Nb, Ta, Be	(QC) ICP-MS (NL) NGR NGR INAA NGR U _w , F _w	(QC) Be, Cs, Th, U, (NL) Ce, Cs, Hf, La, Lu, Rb, Ta, Th, U, Yb, Fw	(QC) Sn		
Misery Lake (QC)	55.3° N 63.9° W	Churchill Province	Alkalic Complex	REE	(QC) ICP-MS (NL) NGR NGR INAA NGR U _w , F _w	(QC) Be, La, Mo, Th, Y (NL) Ce, Hf, La, Mo, Sm, Ta, Th, U, Tb, Yb, Fw	(QC) Nb		1
Ytterby 2 & 3 (QC/NL)	55.6° N 63.5° W	Churchill Province	Alkalic Complex	REE	(QC) ICP-MS (NL) NGR NGR INAA NGR U _w , F _w	(QC) Ce, La, Mo, Y (NL) Ce, La, Mo, Sm, Th,	(NL) Lu		1, 2
Red Wine Mountains (NL)	54.2° N 62.5° W	Churchill Province	Alkalic Complex	REE, Zr, Be, Nb	NGR NGR INAA NGR U _w , F _w	Ce, La, Lu, Sm, Tb, Yb F _w	Cs, Mo,		1, 2
Flowers River (NL)	55.6° N 61.1° W	Grenville/Nain Provinces	Alkalic Complex	REE, Zr, Nb	NGR NGR INAA NGR U _w , F _w	Ce, Eu, Hf, La, Lu, Mo, Sm, Tb, Yb, F _w	Pb, Zn	F	2
Port Hope Simpson (NL)	52.5° N 56.5° W	Grenville Province	Pegmatite, Alkalic Complex	REE, Zr, Nb, U	NGR NGR INAA NGR U _w , F _w		Ce, Eu, La, Lu, Sm, Tb, Yb	Ta, Th	1
Michikamats (NL)	54.6° N 64.4° W	Churchill Province	Alkalic Complex	REE	NGR NGR INAA NGR U _w , F _w	Mo, F _w			1
Pope's Hill (NL)	53.0° N 61.5° W	Grenville Province	Gneiss	REE	NGR NGR INAA NGR U _w , F _w			Ba	1

1 Elevated and/or anomalous values localized over, around or down-ice of occurrence(s); strong contrast with surrounding background samples

2 Many elevated and anomalous values in occurrences' vicinity and possibly elsewhere, not associated with known mineralization; possible application as regional pathfinder

3 A few elevated and anomalous values in occurrence's vicinity; probably inapplicable as regional pathfinder

Source codes: 1 Canadian Mines Handbook (Giancola, 2010); 2 Provincial online mineral deposit database; 3 Halpin et al. (2008); 4 Mumin (2002)

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Eden Lake or Crevier carbonatites in Manitoba and Quebec, respectively; and analyses of fluoride in lake water (Fw) are only available for the former.

Eight examples of dispersion from REE/RM occurrences are depicted in Figures 2 to 9. The surficial geochemical signature of the Strange Lake REE/RM deposit in Labrador has been described elsewhere (McConnell & Batterson 1987).

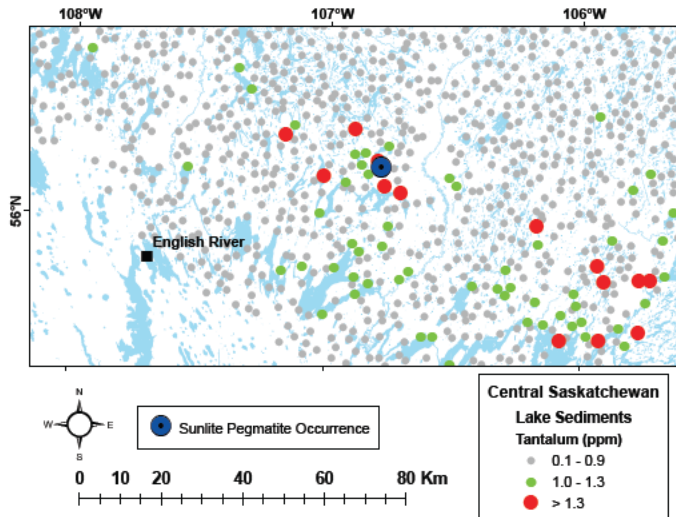


Figure 2: Distribution of Ta in lake sediments around the Sunlite Ta-Nb pegmatite, central Saskatchewan. NGR Data, INA analysis. The direct association of the deposit with the Ta anomaly is accompanied by similar responses in Cs (subdued), Rb (subdued), and there is an outer annulus of lake sediments anomalous and elevated in REE, Mo and Th and about 100 km in diameter. Ice flow directions are predominantly from NE to SW (source of data www.infomaps.gov.sk.ca/website/SIR_Geological_Atlas/viewer.htm).

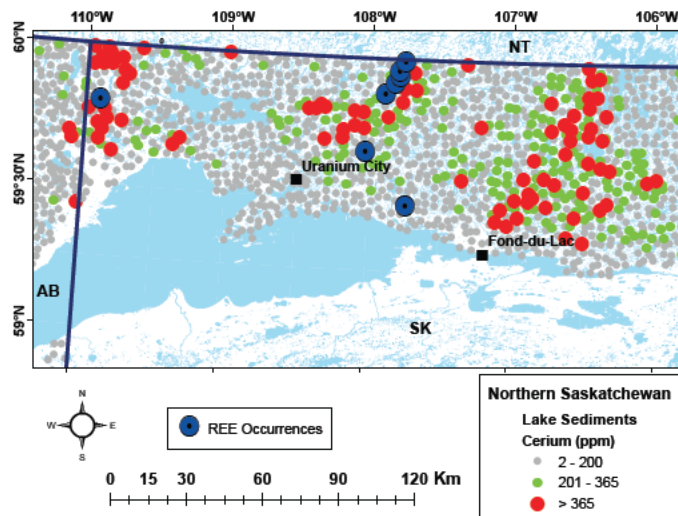


Figure 3: Distribution of Ce in lake sediments, northern Saskatchewan. NGR data, INA analysis. The Hoidas Lake REE discovery and associated occurrences, and the Hazelton Lake pegmatite occurrences are associated with regional REE anomalies but lake sediments in the immediate vicinity of the occurrences are not anomalous. Ice flow directions are predominantly from northeast to southwest (source of data www.infomaps.gov.sk.ca/website/SIR_Geological_Atlas/viewer.htm).

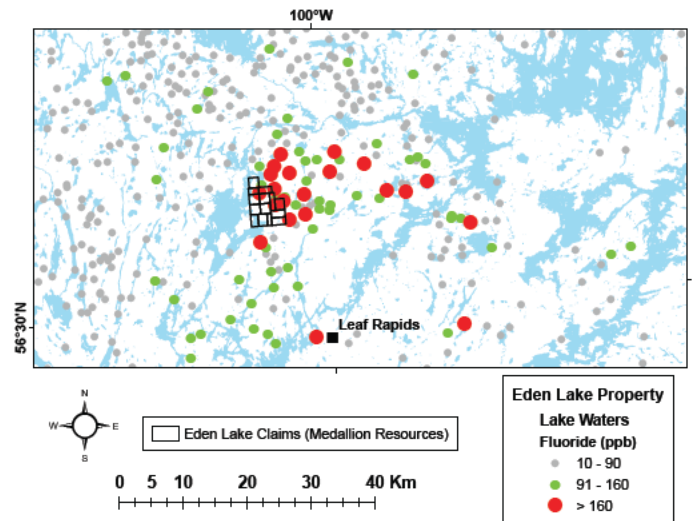


Figure 4: Distribution of fluoride in lake waters (Fw) around the Eden Lake carbonatite, northern Manitoba. NGR data, ISE (ion-specific electrode) analysis. Lake sediments from this region have not been analyzed for REE/RM. There is an anomalous U response in both lake sediments and waters, but none in Mo. Ice flow directions are predominantly from NNW to SSE and NNE to SSW (Kasczycki & Way Nee 1990).

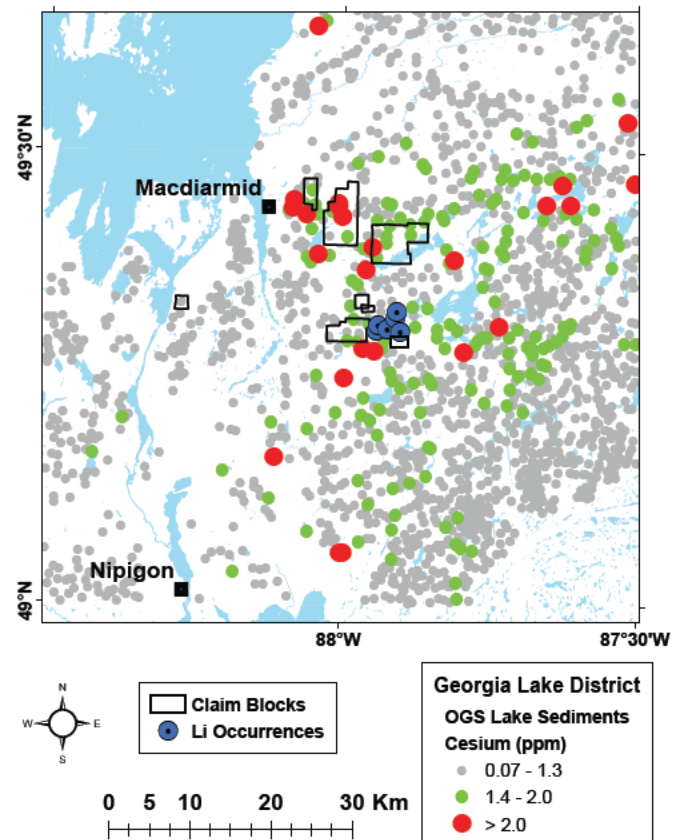


Figure 5: Distribution of Cs in lake sediments, Georgia Lake district, northwest Ontario. Ontario MNDM data, ICP-MS analysis. Cs (and to a much lesser extent, Li itself) show a spatial association with the Li-bearing pegmatites, although there are anomalies of these, and other REE/RM elements, elsewhere in the district. Ice flow directions are predominantly from NNE to SSW (Simms & Baldwin 1991).

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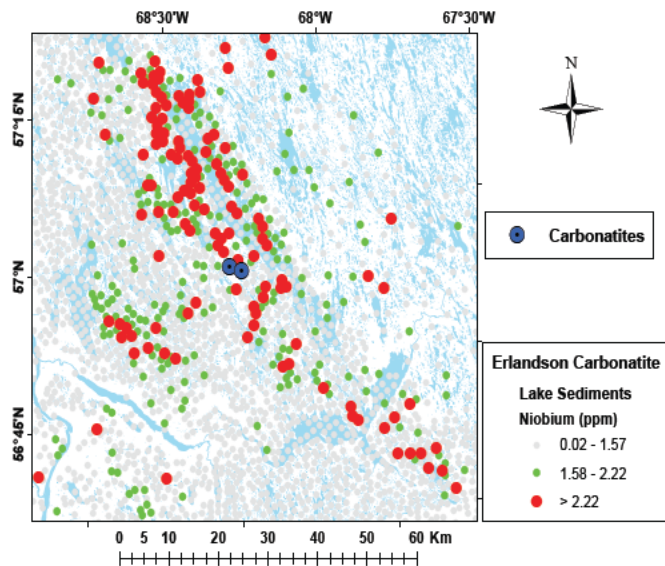


Figure 6: Distribution of Nb in lake sediments around the Erlandson carbonatites, northern Quebec. Quebec MRNF data, Labrador Trough / New Quebec Orogen subset, ICP-MS analysis. Nb shows the strongest response at both local and regional scale but the vicinity of the carbonatites is also marked by Ce, La, Mg, Mo, Sc, Sr, U and Y. There are several other strong REE/RM anomalies in the vicinity. Ice flow directions are predominantly from west to east (source of data http://sigeom.mrnf.gouv.qc.ca/signet/classes/I1102_indexAccueil?l=a)

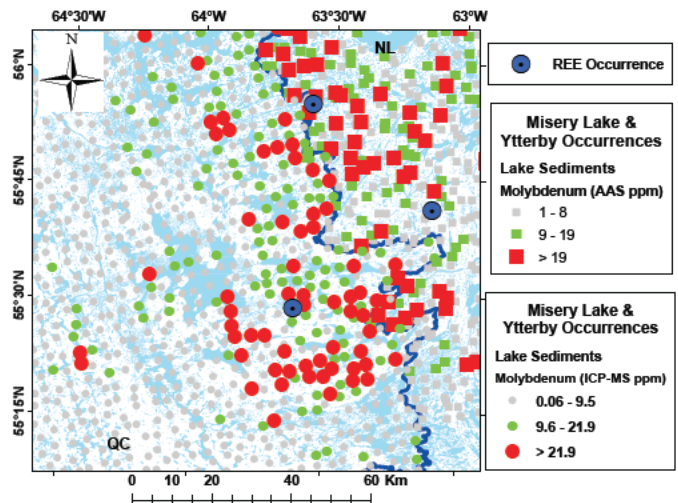


Figure 8: Distribution of Mo in lake sediments around Misery Lake (Quebec), Ytterby 2 (on Quebec-Labrador border) and Ytterby 3 (Labrador) prospects. Quebec: MRNF data, South-east Churchill Province subset, ICP-MS analysis (circles); Labrador: NGR data, AAS analysis (squares). The strong regional Mo anomaly is accompanied by anomalous responses in REE, Be, fluoride in lake waters, Hf, Nb, Ta, Th, U and Y, although not all elements were analyzed, or showed strong responses, in both datasets. Ice flow directions are predominantly from west to east (source of data http://sigeom.mrnf.gouv.qc.ca/signet/classes/I1102_indexAccueil?l=a)

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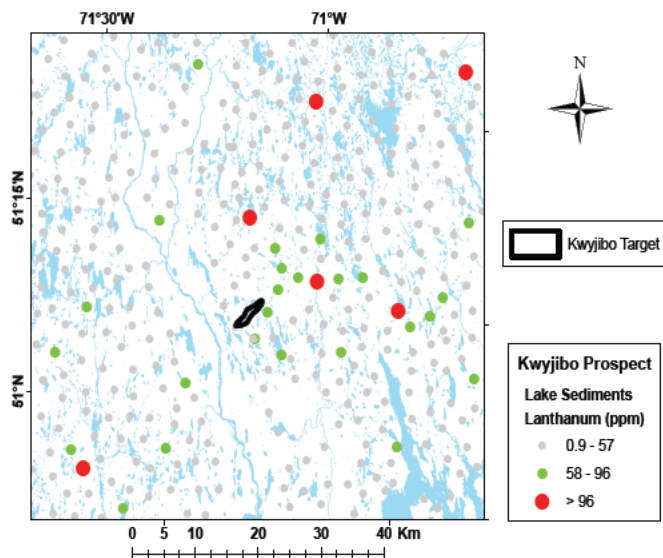


Figure 7: Distribution of La in lake sediments around Kwyjibo prospect, Quebec. Quebec MRNF data, Grenville subset, ICP-MS analysis. The anomalous response to this IOCG deposit, is also shown by Ce and very locally by Nb, although there are other REE/RM anomalies elsewhere in the vicinity. Ice-movement directions are predominantly from west to east (source of data http://sigeom.mrnf.gouv.qc.ca/signet/classes/I1102_indexAccueil?l=a)

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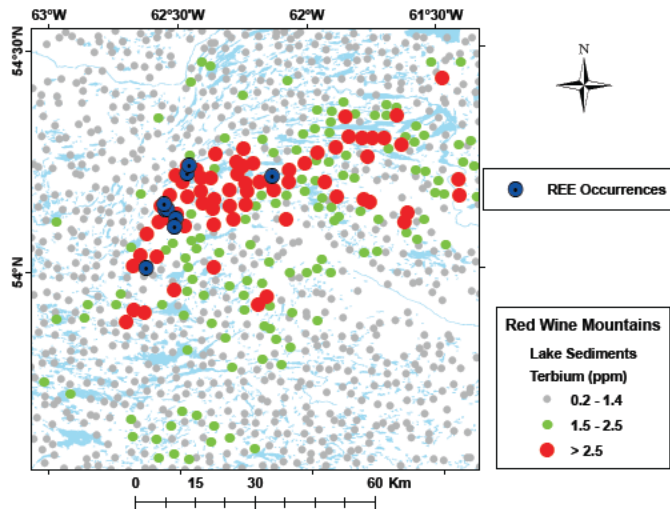


Figure 9: Distribution of Lu in lake sediments over Red Wine Mountains, Labrador. NGR data, INA analysis. Response is generally stronger, more extensive and more homogeneous, in heavy than in light REE. Fluoride in water response is localized over occurrences and to the west, but not to the east. Ice flow direction is from WSW to ENE (Klassen et al. 1992).

Conclusions

A review of the geochemical signatures, in lake sediments and waters, of REE/RM occurrences in the Canadian Shield has led to the following general conclusions:

1. Response to REE/RM occurrences varies from strong and highly focused (e.g. Eden Lake MB, Fig. 3; Red Wine Mountains NL, Fig. 8) through regional and not directly associated with known deposits (Hoidas Lake SK, Fig. 1) to no response at all (Prairie Lake ON, Popes Hill NL; not shown here).
2. Anomalous and elevated values of fluoride in lake water (Fw) are frequently associated with REE occurrences. Most sites in the NGR lake database, even those without REE/RM analyses, have Fw analyses and therefore this parameter appears to constitute a useful pathfinder.
3. Elevated and anomalous values of Mo are commonly associated with REE occurrences (of which an example can be seen at Misery Lake, QC; Fig. 7), and less commonly with RM occurrences. Therefore, in the absence of both Fw in lake water and REE analyses in lake sediment, Mo may be used as a pathfinder element.
4. Li occurrences show a poor response in lake sediments, particularly in Li itself. In Ontario, at the Georgia Lake Li pegmatite district, there is only a weak Li response. The mineralization appears to be associated there, and at the Seymour-ZigZag Lakes district, with anomalous and elevated levels of certain other elements (Cs at Georgia Lake and REE, Mo, Nb and Th at Seymour-ZigZag), but even these are lacking in the Eastmain and Moblan pegmatite districts of Quebec.
5. There are many examples of anomalous and elevated concentrations of REE/RM and pathfinder elements that are

not associated with known mineralization, as identified in the source material for this investigation.

In summary, the presence of a lake-sediment anomaly in REE, or a lake water anomaly in fluoride ion, are more than sufficient justification for a search for REE mineralization to be conducted. Molybdenum also appears to have potential as a pathfinder for such mineralization. There are many such untested anomalies in the Canadian Shield, in publicly-available data, in northeastern Saskatchewan, northern Manitoba, southeastern Nunavut and Labrador, and some of these anomalies are situated in ground that is currently unstaked.

The results of past exploration programs, often conducted in pursuit of other mineral commodities but comprising high-quality data, can often be retrieved from assessment files and used to identify targets more precisely within the geochemical anomalies (e.g. Amor 2011).

The geochemistry of lake sediments and waters appears to be less effective in the search for deposits of rare metals, and the absence of an anomaly in lake sediments and waters is not a reason, in isolation, to write off an area's REE or RM prospectivity.

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