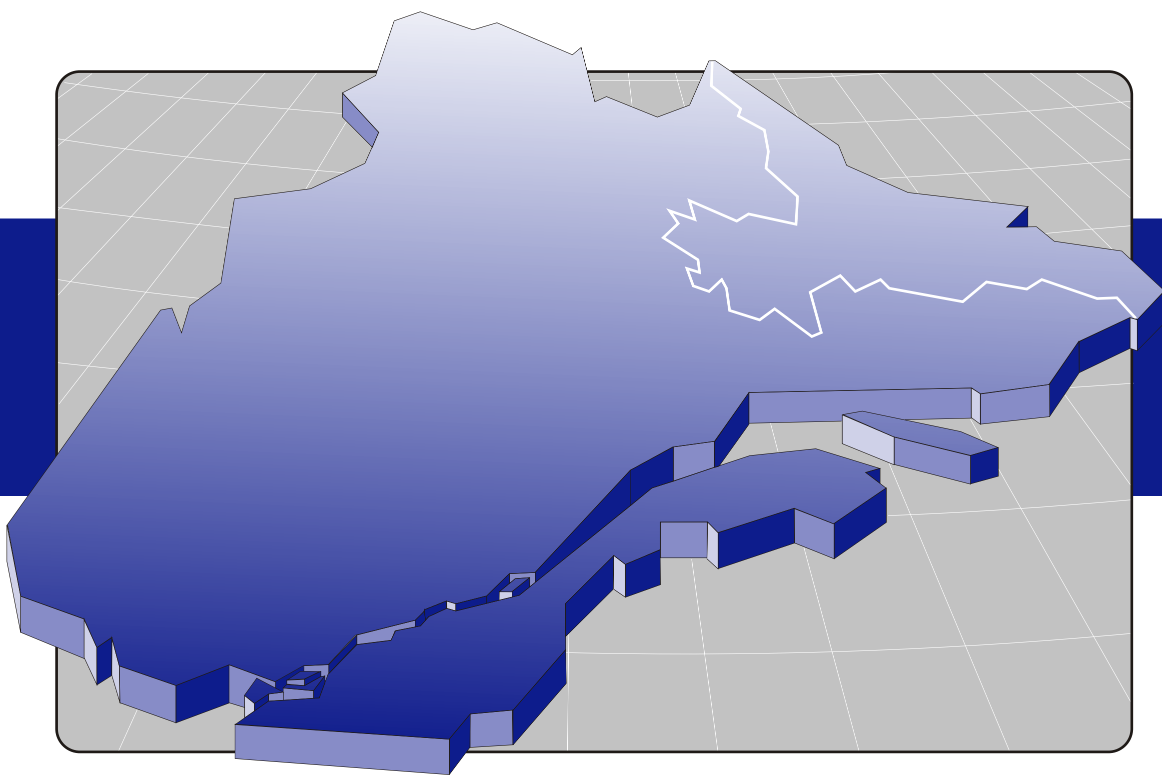
Rare Metal Potential in the Abitibi and Pontiac Subprovinces

Lucie Ste-Croix and Pierre Doucet

PRO 2001-09



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Service à la clientèle de l'exploration et du marketing
Chantal Dussault

Responsable des documents de promotion
Alain Simard

Édition
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INTRODUCTION

The recent interest for rare metals and the need to discover new sources have prompted us to review exploration work already carried out in the Abitibi and Pontiac subprovinces. The growing demand for rare metals and the drop in production from certain traditional sources have resulted in a significant increase in the price of certain rare metals; consequently, the industry is now seeking new sources of rare metals and encouraging exploration. Rare metals (lithium, beryllium, tantalum, cesium, niobium and rubidium) are used in miniaturized electronic circuits, in the aeronautical industry, in steel, ceramics, glass and superalloys.

The Abitibi and Pontiac subprovinces have seen very little exploration for rare metals (Figure 1). Most of this work dates back to the 1950s, and was focussed on the search for lithium and molybdenum. Several tantalum, beryllium and lithium showings were identified in the vicinity of the La Corne and La Motte plutons (Figure 2), in the Abitibi Subprovince. Others are located in the Lac Simard area (Figure 3), in the Pontiac Subprovince. More detailed exploration work is needed to fully assess the rare metal potential of these regions.

This document presents a global review of the metallogeny of rare metals, their characteristics and uses, as well as the classification of host pegmatites. A brief description of showings associated with the Preissac-La Corne Batholith, showings in the Lac Simard area and other showings in the Abitibi and Pontiac subprovinces is provided. Certain rare metal prospecting tools are described. This document is designed to serve as a basic tool in the search for rare metals, and a reference source for the reader.

MAJOR PEGMATITE FIELDS IN THE WORLD

The Greenbushes orebody (Sons of Gwalia Ltd.), in Australia, is a giant Archean pegmatite dyke that contains a substantial amount of lithium, tin and tantalum. It hosts half of the world's tantalum reserves, and is the largest producer of tantalum (Partington and McNaughton, 1995). Reserves at Greenbushes amount to 160M tonnes at a grade of 0.0214% Ta2O5, equivalent to 75 million pounds. The Wodgina orebody (Sons of Gwalia Ltd.), also in Australia, contains 35M tonnes of reserves at a grade of 0.0402% Ta2O5, equivalent to 31 million pounds. The combined production of these two mines in 2000 totalled 1.6 million pounds. The Tanco orebody (Cabot Corporation) in Manitoba, is one of the richest tantalum deposits ever mined. Reserves are estimated at 2.07M tonnes at 0.216% Ta2O5, equivalent to 9.8 million pounds. About 135,000 pounds of tantalum concentrate are produced each year, essentially derived from reprocessed slags. The chemistry of Tanco pegmatites is similar to that of Preissac-La Corne pegmatites. The mineralogy of accessory minerals is however different (Boily, 1995).

USE AND DEMAND FOR RARE METALS

Rare metals are generally concentrated in peralkaline and peraluminous volcanic rocks, in granites and granitic pegmatites, in alkaline ultramafic complexes and carbonatite complexes. The rare metal market is dominated by a small number of important producers and consumers. Global consumption is weak compared to known reserves and resources throughout the world (Pollard, 1995). However, demand for some of these metals is expanding (see Table 1 in appendix).

ORE DEPOSIT SETTINGS

Fertile Archean granites are confined to volcano-sedimentary belts and mobile sedimentary troughs, in a collisional tectonic environment. Metamorphic conditions vary from the greenschist facies to the lower amphibolite facies. The emplacement of fertile plutons predates the regional dynamo-thermal metamorphic peak and the emplacement of granitoid batholiths. Intrusions often follow fault systems, lithological contacts or any other steeply dipping regional structural element. These granites are siliceous, peraluminous, depleted in iron, magnesium and calcium (Cerný and Meintzer, 1985).

Granitic pegmatites are exclusively related to the H plutonic suite defined by Rive (1990) in the Pontiac Subprovince and the central part of the Abitibi Subprovince. This suite is composed of dominantly leucocratic syn- to late tectonic biotite-muscovite granodiorite and muscovite monzogranite plutons (Figure 1). Pegmatites occur near batholithic contacts, at a maximum distance of 1 to 2 km from monzogranitic intrusive walls, in the country rocks. Their geochemical signature shows elevated quantities of rubidium and tantalum, and their Rb/Sr ratio is high. Monzogranites contain the following accessory minerals: cordierite, andalusite, sillimanite, tourmaline, colombo-tantalite, beryl, monazite, triphylite and molybdenite (Cerný, 1991a ; Boily, 1992).

Mineral Indicators

Assessing pegmatites present within plutons may serve as an indicator for pegmatites in country rocks (Cerný, 1991a ; Boily, 1992). When pegmatites are found in a favourable setting, the following minerals may serve as indicators (Boily, 1992):

1) rosette-textured albite or platy cleavelandite: presence of spodumene in the pegmatite or surrounding pegmatites;

2) brownish or greenish muscovite: beryl pegmatites;

3) pale green to yellowish or silver muscovite: spodumene pegmatites;

4) lepidolite: fluorine-rich fluid, more likely to contain Li, Be, Cs, Rb, Ta;

5) black tourmaline: barren pegmatite or beryl pegmatite, especially in the Pontiac, may be absent as is the case in the Preissac-La Corne area;

6) greenish beryl: barren pegmatite;

7) whitish to pinkish beryl: spodumene pegmatite;

8) holmquistite: found along the borders of lithium-bearing pegmatites. In the vicinity of the former Québec Lithium mine (Figure 2), holmquistite occurs in the intermediate to mafic country rock, at a distance of a few centimetres to one metre of lithium-bearing pegmatites.

GRANITIC PEGMATITES IN THE ABITIBI SUBPROVINCE

Preissac-La Corne Area

CLASSIFICATION

According to the classification of Cerný (1991a; 1991b), the Preissac-La Corne area (Figure 2) is characterized by the presence of rare element pegmatites assigned to the LCT family (lithium, cesium, tantalum) and the albite-spodumene type (Tables 2a and 2b in appendix).

REGIONAL AND LOCAL GEOLOGY

The Preissac-La Corne Batholith is a syn- to late kinematic (2672-2643 Ma) intrusion located in the Southern Volcanic Zone of the Archean Abitibi greenstone belt, in the Superior Province of the Canadian Shield (Figure 1). This batholith was emplaced along the La Pause anticline in mafic to ultramafic volcanic rocks and sedimentary rocks of the Malartic Group (Figure 2). This emplacement presumably occurred during the last stages of development of the Abitibi greenstone belt. The batholith is bounded to the north by the Manneville fault and to the south by the Cadillac-Larder Lake fault, which separates it from the Pontiac Subprovince (Figure 1). Regional metamorphic conditions reached the greenschist facies. In the immediate vicinity of the plutons, a hornblende hornfels contact metamorphism is observed. The Preissac-La Corne Batholith is a composite intrusion comprising two major suites (Mulja ***et al***., 1995a):

1) an early suite represented by metaluminous calc-alkaline diorites-granodiorites, inversely zoned with a more mafic core and more felsic borders;

2) a late suite composed of peraluminous monzogranites including the La Corne, La Motte, Preissac and Moly Hill plutons (Figure 2). The La Corne and La Motte plutons are less evolved and are composed of biotite-muscovite monzogranite. The Preissac and Moly Hill plutons, more evolved, are composed of muscovite-garnet monzogranite. An aureole of granitic pegmatites classified as rare element pegmatites is observed around three of the four plutons (Boily, 1992 and 1995).

The late monzogranitic suite contains rare metal minerals, suggesting an enrichment in these metals in the parent magma of monzonites and pegmatites. The concentration is variable, but this suite is systematically enriched in rare lithophile metals relative to the early suite. The La Corne and La Motte biotite and biotite-muscovite monzogranitic plutons contain less silica but more iron and lithium that the Preissac and Moly Hill muscovite-garnet monzogranites. The latter are however enriched in niobium and depleted in rubidium relative to the La Corne and La Motte plutons (Boily, 1992 and 1995).

The Preissac Pluton

The Preissac pluton consists of muscovite-garnet or muscovite-biotite monzogranite (Figure 2). There is no pegmatite aureole around this pluton, and most quartz veins are barren. The Preissac pluton rarely outcrops, and its borders could offer a certain mineral potential (Boily, 1992 and 1995). This pluton contrasts with the other three due to the presence of an additional monzogranitic phase. This phase is represented by fine-grained dykes containing up to 3% garnet, 5% muscovite and the absence of biotite (Mulja ***et al***., 1995a). Two molybdenum-bismuth mines operated here in the 1960s:

1) the Cadillac Molybdenite mine (Anglo-American), where production totalled 2 Mt at 0.36% MoS2, and reserves stand at 507,000 tonnes at 0.19% MoS2 and 0.030% Bi;

2) the Preissac Molybdenite mine, where reserves are estimated at 1.25 Mt at 0.53% MoS2-Bi (Boily, 1992 and 1995).

The Moly Hill Pluton

This pluton is composed of biotite, biotite-muscovite and muscovite monzogranite (Mulja ***et al***., 1995a; Figure 2). Only one important orebody is known, the Moly Hill orebody, with 269,000 tonnes of reserves at 0.21% MoS2 and 0.079% Bi. A few pegmatites with disseminated beryl and colombo-tantalite are observed (Boily, 1992 and 1995).

The La Corne Pluton

This pluton comprises three monzogranitic facies: the biotite facies (nearly the entire pluton), the biotite-muscovite facies and the muscovite ± biotite ± garnet facies (Figure 2). It is cross-cut by pegmatites and aplites, dominantly oriented E-W. A strong proportion of pegmatites occur between the biotite and the biotite-muscovite facies. These pegmatites are mainly lithium-bearing with niobium-tantalum, molybdenum and beryllium, and contain up to 2% beryl with more or less colombo-tantalite and molybdenite. This type of pegmatite hosts two former mines and a few important showings. The Québec Lithium mine, located in the aureole of the pluton, contains reserves of 18 Mt at 1.30% LiO2. Thirteen homogeneous spodumene dykes were mined. The dykes are oriented E-W, parallel to the Manneville fault (Figure 2). Spodumene accounts for 15 to 25% of the volume of the pegmatites. The rest consists of albite, microcline, quartz and muscovite. Accessory minerals are lepidolite, beryl, spessartine, colombo-tantalite, molybdenite, bismuthinite, native bismuth and betafite. The Molybdenite Corporation mined quartz veins and quarz-muscovite-potassic feldspar veins with molybdenum and bismuth mineralization (Boily, 1992 and 1995).

The La Motte Pluton

This poorly exposed pluton is composed of two facies: biotite, and biotite-muscovite-garnet (Figure 2). The contact between the pluton and surrounding biotite schists is characterized by a complex zone of aplites and pegmatites in the east, a concentration of irregular quartz-molybdenite veins to the south, and by a contact metamorphic zone to the north (cordierite, garnet, staurolite, sillimanite) (Mulja ***et al***., 1995a). Several pegmatites are present along the northern and southern contacts. These pegmatites contain beryl, colombo-tantalite and minor spodumene. Molybdenite veins observed in the western part occur within the muscovite-garnet facies. A few spodumene-rich pegmatitic dykes similar to those at the Québec Lithium mine were also reported. A few colombo-tantalite showings are located along the southern contact of the La Motte pluton (Boily, 1992 and 1995).

MORPHOLOGY AND SPATIAL DISTRIBUTION OF PEGMATITES

Pegmatites in the Preissac-La Corne area are composed of albite, potassic feldspar, quartz, muscovite, garnet, beryl, spodumene, molybdenite and colombo-tantalite; biotite is absent (Mulja ***et al***., 1995a). The pegmatites are zoned, with the exception of lithium pegmatites, and generally form irregular bodies. Dykes vary from 5 cm to 10 m in width, and 90% of all pegmatites are less than 30 cm thick.

The spatial distribution of pegmatites in the Preissac-La Corne area is as follows (Boily, 1992 and 1995; Mulja ***et al***., 1995b; Figure 2):

a) beryl and colombo-tantalite pegmatites are found in the core of parent monzogranites, and on either side of the contact between these monzogranites and the country rocks. The mineralogy of beryl pegmatites includes beryl, garnet, ferrocolombite and traces of gahnite;

b) spodumene pegmatites occur almost exclusively in the country rocks. They are composed of spodumene, minor microcline and garnet, while beryl and lepidolite are absent, and manganotantalite is sometimes observed. These pegmatites are unzoned or exhibit subtle zoning with large perthite crystals in the internal portion. The mineralogy of spodumene-beryl pegmatites includes spodumene, with more or less lepidolite and traces of black tourmaline and pyrophanite. These pegmatites are zoned with, from the borders inwards, garnet-rich aplite, an albite-perthite-quartz-muscovite assemblage, and massive quartz in the core;

c) molybdenite pegmatites are restricted to hydrothermal veins in the internal margin of muscovite-garnet facies rocks (especially in the case of the Preissac and Moly Hill plutons). Molybdenite is mainly concentrated in albitite dykes and quartz veins associated with spodumene pegmatites in the country rock.

RARE METAL POTENTIAL

The Lac des Hauteurs area (La Motte pluton) offers good exploration potential (Figure 2 and Table 3). It is characterized by the presence of pegmatites with beryl, colombo-tantalite and spodumene mineralization. Only one showing has reported grades (showing 6; Figure 2), whereas the remaining showings are mineral occurrences. This deposit reportedly contains a resource of 4.36 Mt at a grade of 0.3% beryl and 0.001% colombo-tantalite (Boily ***et al***., 1989).

The chemin Preissac area (La Motte pluton; near showings 20 and 21) demonstrates an excellent potential for lithium and tantalum (Figure 2 and Table 3). One showing (showing 20) yielded a grade of 0.65% Ta2O5. The Raymor deposit is unique in that the spodumene pegmatites cut ultramafic lavas, and the spodumene is blackish. Reserve calculations performed during Raymor's prefeasibility study yielded 4.55 Mt at 1.14% LiO2, from 0 to 700 m depth (Boily ***et al***., 1989).

The Rivière Harricana area (La Motte pluton; near showings 8 and 9), the sector north of La Corne (between the La Motte and La Corne plutons) and the road leading to Lac La Motte (La Motte pluton; near showings 22a, b and c) host several lithium-rich deposits (Figure 2 and Table 3). Grades vary between 0.78% and 1.6% LiO2. These areas offer good potential for lithium (Boily ***et al***., 1989).

In the vicinity of Highway 111 North (between the La Motte and La Corne plutons), mineralized pegmatites cut accross volcano-sedimentary rocks and intermediate to mafic phases of the La Corne Batholith (Figure 2 and Table 3). Several colombo-tantalite showings are reported in this area, including showing 13a which contains between 1 and 5% colombo-tantalite. The area is therefore very interesting for tantalum (Boily ***et al***., 1989).

The area around Lac Baillargé (La Corne pluton) contains Li, Be, Ta and Mo showings hosted in roughly zoned pegmatite associated with aplite zones (Figure 2 and Table 3). Three showings (35a, 35b and 48) are particularly interesting; lithium grades up to 2.48% LiO2 and reserves of 2 Mt at 1% LiO2 are reported. Several outcrops of mineralized pegmatite are present south of Lac Baillargé. The presence of holmquistite is noted and the granodioritic country rock is strongly silicified; these factors outline the favourable potential for rare metals (Boily ***et al***., 1989).

The Lac Chaptes area (La Corne pluton) has some of the most spectacular outcrops in the region, given the great mineralogical diversity and the quality of outcrops (Figure 2 and Table 3). It contains the only pollucite showing in the area (showing 16, Valor). It is also one of the rare lepidolite showings. The Massberyl prospect (showings 15a, b and c) contains an estimated resource of 667 tonnes per vertical foot at a grade of 1.35% Be (Boily ***et al***., 1989).

The area around the former Québec Lithium mine (La Corne pluton) is very promising for lithium and tantalum (Figure 2 and Table 3). Numerous unreported showings with potential Li, Be or Ta mineralization occur along the northern contact of the La Corne Batholith and the Manneville fault. The degree of fracturation in the country rock and the batholith is favourable to the concentration of pegmatitic fluids (Boily ***et al***., 1989).

Other areas in the Abitibi subprovince

Uranium pegmatites in Bressani Township are located in the southeasternmost part of the Abitibi Subprovince (Figure 1). According to the classification proposed by Cerný, these pegmatites fall in the NYF family (niobium-ytterbium-fluorine), the rare earth type and the gadolinite sub-type. Compared to albite-spodumene pegmatites and rare earth pegmatites, the amount of lithium, boron and cesium is lower, whereas the amount of niobium increases relative to tantalum (Tables 1a and 1b).

A spodumene mineral occurrence is reported a few kilometres southwest of Lac aux Goélands (Figure 1). The spodumene is hosted in a pegmatite that cuts the Monts Dalhousie gabbro and anorthosite complex. There is very little information available on this showing.

GRANITIC PEGMATITES IN THE PONTIAC SUBPROVINCE

The Pontiac Subprovince lies to the south of the Abitibi Subprovince, and extends down to the Grenville Front (Figure 1). It contains terrigenous sedimentary rocks, mafic to ultramafic volcanic rocks and plutonic rocks metamorphosed from the greenschist facies to the lower amphibolite facies. Numerous pegmatite dykes associated with late intrusive phases cut accross the granitoids and sediments (Boily ***et al***., 1989). Two granitoid suites are present in the Pontiac Subprovince: the oldest consist of monzodiorite, granodiorite and syenite, and the youngest is composed of muscovite-garnet granite (Ducharme ***et al***., 1997).

Pontiac pegmatites appear to belong to two families: one with beryl and the second with radioactive minerals. The beryl family is represented by minor mineral occurrences where very little beryl was observed. The second pegmatite family (with radioactive minerals) is found in the Lac Simard area (Figure 3 and Table 4). They are zoned, whitish, and contain spodumene, some colombo-tantalite, lepidolite, beryl and uraniferous minerals. The presence of radioactive minerals and other minerals characteristic of the albite-spodumene type (LCT family) suggests that these pegmatites are part of a hybrid family, halfway between the LCT and NYF families. There appears to be a rough regional zonation from east to west:

1) eastward, the hybrid family (Be, Li, Ta, U);
2) in the centre, an LCT family (Li, Ta, Nb);
3) westward, another LCT family (Li).

Three showings attract our attention given the presence of reported tantalum concentrations. Showing 1 (Figure 3 and Table 4) contains lepidolite and colombo-tantalite; grades of 0.2% and 0.172% Ta2O5 were reported. At showing 2, the following grades are noted: 0.42% U3O8 and 0.77% Nb, 0.25% Ta and 0.91% Nb and 0.71% U3O8. At showing 3 (Île du Refuge in Lac Simard), very high uranium and tantalum grades are reported: 83% U3O8 with 5.8% Ta2O5 and 2.1% Li. The last two showings are very interesting for the discovery of rare metals in the Lac Simard area.

USEFUL EXPLORATION TECHNIQUES

Geochemistry is the most useful exploration technique to distinguish barren pegmatites from fertile pegmatites (Boily, 1992). Various geochemical methods may be used:

1) geochemistry near intrusive walls (K, Rb, Li, Cs, F, Cl and B) is effective to a distance of 100 m from the pegmatite/wallrock contact;

2) geochemistry of the heavy fraction of stream sediments is useful on a regional scale;

3) geochemistry of fertile granites: at least 4 to 5 facies need to be sampled in each pluton in order to adequately assess its rare metal potential.

Geophysical methods such as gravity and magnetics may be useful to detect the presence of pegmatites.

CONCLUSIONS

The vast majority of exploration work carried out in the Preissac-La Corne area was performed in the 1950s, and was oriented towards the discovery of lithium and molybdenum. There is very little recent work. Numerous outcrops do not appear to have been investigated or do not show any evidence of work. Others aren't even inventoried. We would like to attract the reader's attention to the La Motte and La Corne plutons, where the exploration potential for tantalum and lithium is very good. An integrated approach involving mapping and sampling in these areas is warranted, and could lead to a rare metal discovery. In the Pontiac, the Lac Simard area remains very interesting. The most recent work dates back to the early 1980s, and essentially consisted in grassroots exploration.

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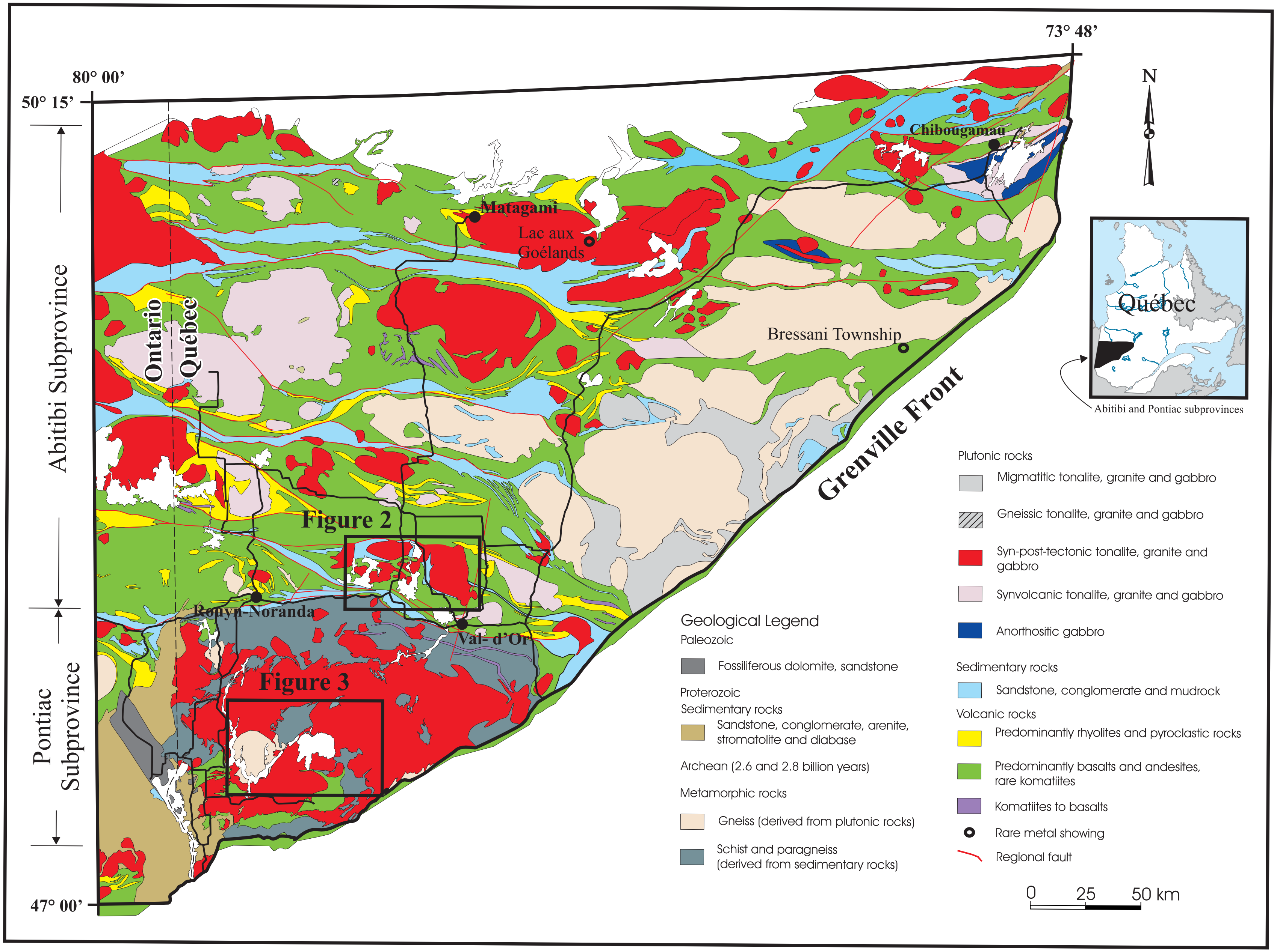

FIGURE 1- Simplified geology of the Abitibi and Pontiac subprovinces

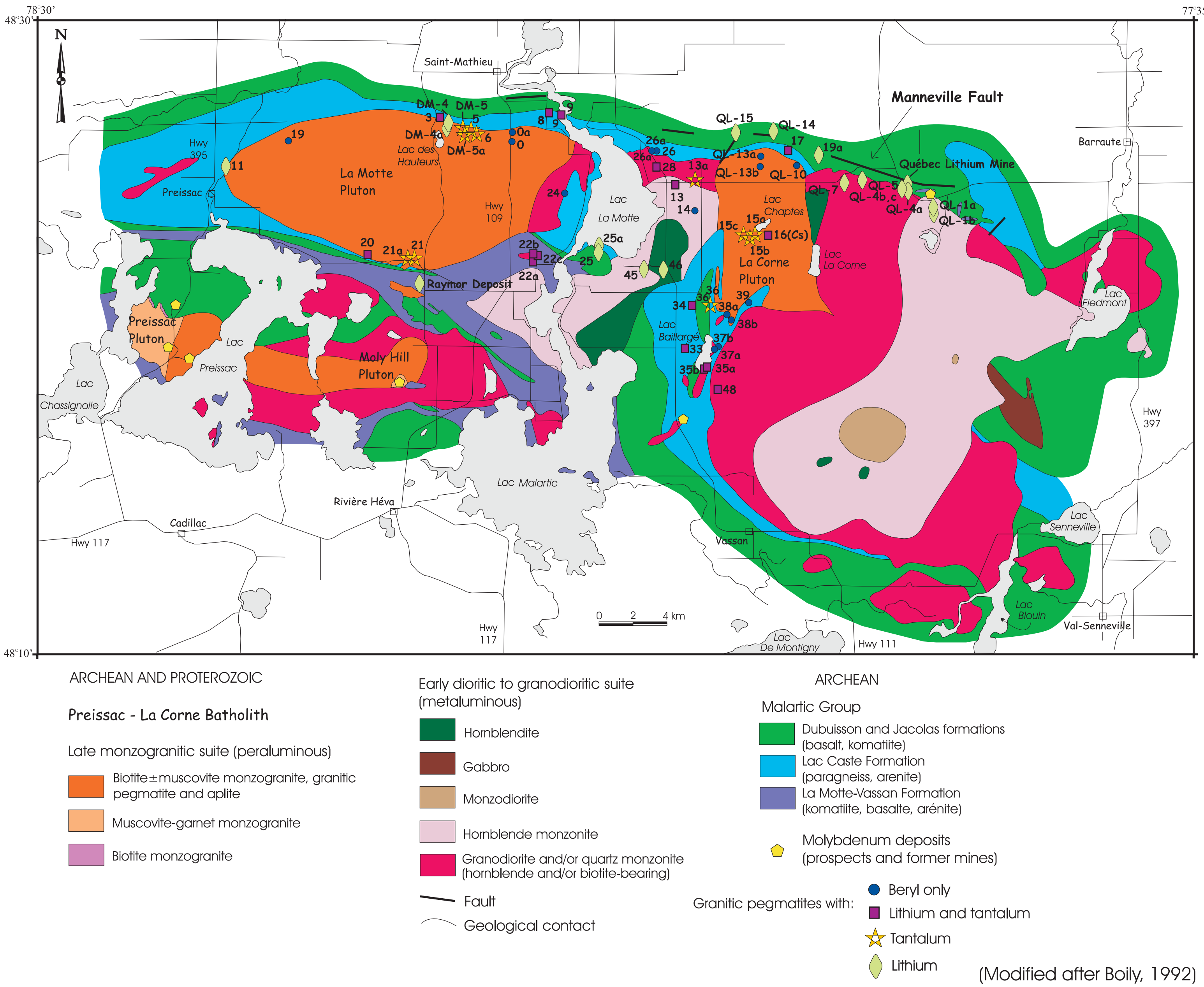

FIGURE 2 **-** Geology of the Preissac-Lacorne area

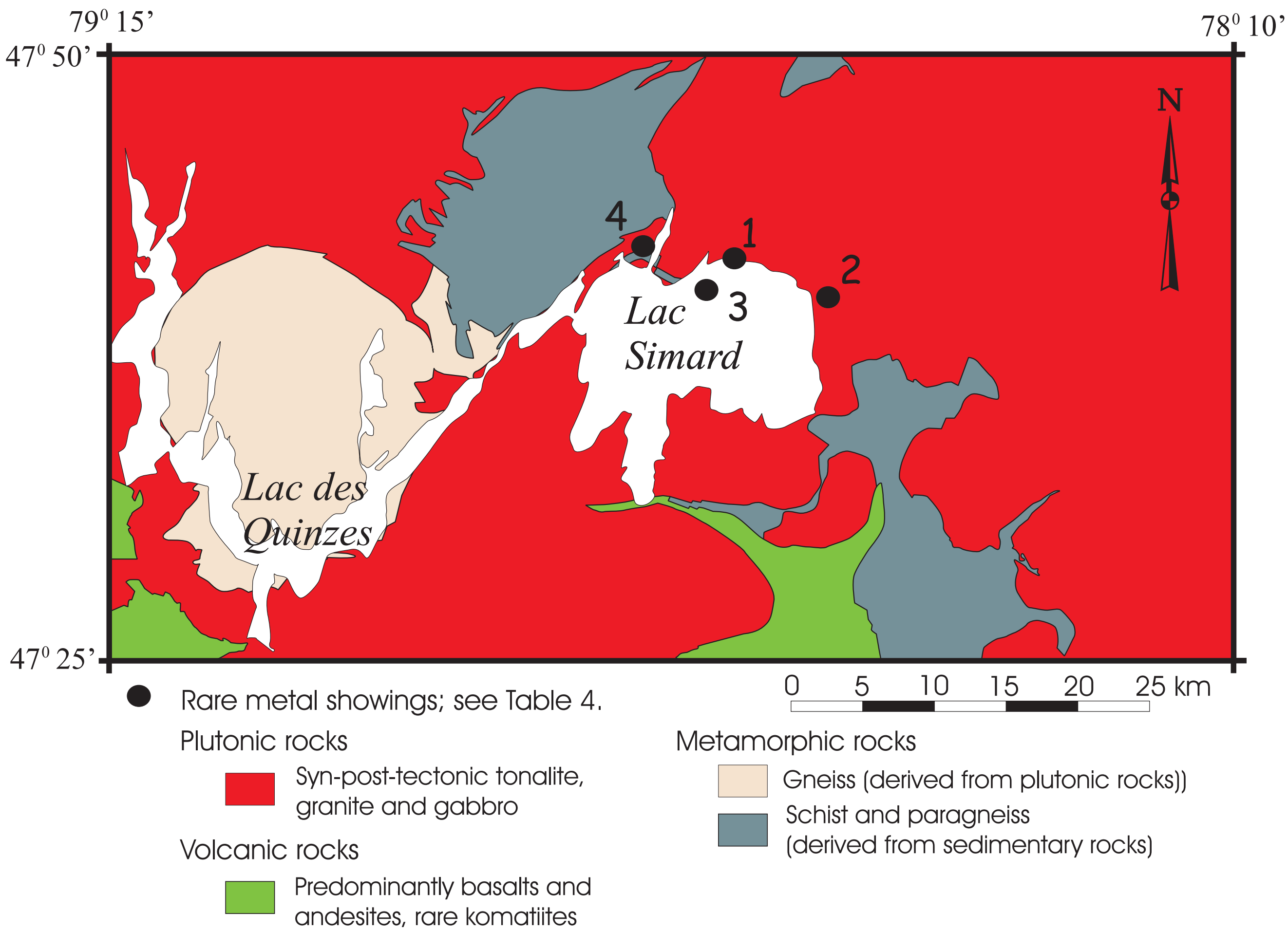

FIGURE 3 - Geology of the Lac Simard area, Pontiac Subporvince

APPENDIX: TABLE 1

TABLE 1 **-** Rare metals: characteristics, uses and demand.

Rare metal	Sources	Minerals	Characteristies	Uses	Demand
Tantalum	Secondary source : tin slags, In decline due to waning tin production in southeast Asia. Primary sources : granites and granitic pegmatites; principal producers are Greenbushes and Wodgina (Australia) and Tanco (Canada).	Colombo-tantalite and pyrochlore-microlite solid solutions.	High density metal, very high melting point, excellent resistance to corrosion by acids, highest metal capacitance per volume unit, ductile refractory metal, easily fabricated and good thermal and electrical conductor.	In electrolytic capacitors integrated to miniaturized electrical circuits (computers, wireless phones, automobiles), in corrosion-resistant chemical equipment, in superalloys for the aerospace industry and in jet engine components.	Total consumption in 2000 increased due to a strong demand, and the price of tantalum soared by about 500%. This may be explained by a strong demand, and an apparent lack of reserves (Cunningham, 2001).
Niobium	Principal source : alkaline ultramafic complexes and carbonatite complexes; principal producers are Araxa and Catalao (Brazil) and Niobec (Canada).	Colombo-tantalite and pyrochlore-microlite solid solutions.	Good thermal and electrical conductor, high melting point, good resistance to corrosion, easy to fabricate.	In jet engines, steel and superalloys.	In the first 6 months of 2000, demand for niobium-steel alloys increased relative to the same period in 1999. Current resources are sufficient to meet the demand for several hundred years at current production and consumption rates (Cunningham, 2001).
Lithium	Principal source : granitic pegmatites; principal producers are Greenbushes (Australia), Tanco (Canada) and Bikita (Zimbabwe). About 50% of wold production comes from Australian deposits.	Petalite and spodumene. Lepidolite and other lithium-bearing minerals are less important.	lightest soft metal, tarnishes instantly and corrodes rapidly when exposed to air or water.	In lithium metal batteries, in glass and ceramics where petalite is preferred to spodumene, given its better optical qualities, in medicine to treat depression, in pyrotechnics for the colour red.	Lithium demand for batteries in increasing. Demand for ceramic glass used namely for oven tops, should increase. Political uncertainty in Zimbabwe should result in rising demand for lithium from industrialized countries (Pearse and Taylor, 2001).
Beryllium	Bertrandite in topaz rhyolite from Spor Mountain, Utah (Brush Wellan Co.) produces 50% of world output. The United States (Utah and Alaska) own 65% of wold beryllium resources in non-pegmatitic deposits.	Beryl and bertrandite.	Grey-white, solid and hard metal, stiffest light metal, absorbs heat very well, high melting point, more elastic than steel.	In alloys to strengthen metals and beryllium-based composites, Copper-beryllium alloys are used in telecommunication, computers, electronics, automobiles, the aerospace, the aerospace industry and oil and gas markets. Beryllium oxide acts as an electrical insultor. The following varieties of beryl are precious stones : emerald (green), aquamarine (blue), heliodor (greenish yellow). goshenite (clear), red beryl and golden beryl.	Highly specialized market with low-volume outlets. A grade of 2% beryl and a tonnage varying between 100,000 and 500,000 tonnes are required to buil a profitable operation (Jacob, 2000). During the first 6 months of 2000, beryllium demand rose as a result of increased demand for copper-beryllium alloys (Cunningham, 2001).
Rubidium	Pegmatites. Tanco (Canada) is the principal producer.	Lepidolite and pollucite.	Surprising optical properties, very specific crystal vibration.	In camera glasses for missiles, potentially in anticollision devices for automobiles and airplanes, in atomic clocks and optic fibres.	Little commercial value; rubidium is easily replaced by cesium in most applications (Cunningham, 2001).
Cesium	Zoned pegmatites.	Pollucite.	Similar to rubidium.	Electronics, photoelectric cells. medical use.	A few thousand kilograms per year; weak but sustained demand (Cunningham, 2001).

APPENDIX: TABLES 2A AND 2B

TABLE 2A **-** Characteristics of rare element pegmatites (modified after Cerny, 1991a).

Family	Type of pegmatite	Geochemical signature	Pegmatite composition	Typical minor elements	Associated granites	Granite composition	Relationship with granite	Metamorphic environment	Structural traits	Examples
LCT (lithium, cesium, tantalum)	Albite-spodumene	Li, Rb, Cs, Be, Sn, Ga, Ta>Nb	Peraluminous	Li, Rb, Cs, Be, Ga, Sn, Hf, Nb<>Ta, B, P, F Weak to abundant mineralization, gemstones, industrial minerals	Late kinematic, heterogeneous	Peraluminous S*, I* or S+I type	Internal or marginal, but mainly external	Upper greenschist facies to low-pressure amphibolite facies	Sub-conformable to unconformable	Yellowknife fields (NWT). Black Hills (South Dakota), Cat Lake- Winnipeg River (Manitoba)
Hybrid (LCF+NYF)		Mixture of both types	Moderately peraluminous	Mixture of both types	anorogenic, moderately homogeneous	Subaluminous to slightly peraluminous, hybrid geochemical signature				Tordal District (Norway), Kimito (Finland), Eve-Iveland fields (Norway)
NYF (niobium, yttrium, fluorine)	Rare earths	Nb>Ta, Ti, Y, Sc, ÉTR, Zr, U, Th, F	Subaluminous to metaluminous	Y, REE, Ti, U, Th, Zr, Nb>Ta, F Weak to abundant mineralization, minerals used in ceramics	Generally anorogenic, homogeneous	Subaluminous to metaluminous, mainly A*type	Internal or marginal	Variable	Internal bodies, conformable to cross-cutting country rock	Llano Co. (Texas), South Platte district (Colorado), Western Keivy (former USSR)

S* type = derived from the partial melting of sedimentary rocks;
I* type = derived from the partial melting of igneous rocks;
A* type = anorogenic.

TABLE 2B **-** Mineralogy of albite-spodumene pegmatites and rare earth pegmatites (modified after Cerny, 1991a).

Type	Sub-type	Typical minerals	Economic potential	Examples
Albite-spodumene (LCT)	Li (Sn, Be, Nb, <> Ta, ± B)	Spodumene (cassiterite, beryl, tantalite)	Li, Sn (Be, Ta)	Preissac - La Corne (Québec)
Rare earth (NYF)	Gadolinite Y, REE, Be, Nb>Ta, F (U, Th, Ti, Zr)	Gadolinite, fergusonite, euxenite (topaz, beryl)	Y, REE, U (Be, Nb-Ta)	Shatford Lake Group (Manitoba)

APPENDIX: TABLES 3 AND 4

TABLE 3 - Showings in Preissac - La Corne area (see Figure 2).

Identification on Figure 2	SIGÉOM number	COGÎTE number	Rare metals
0, 0A		32D/08-2000	Be
3		32D/08-3	Li, Ta
DM-4, DM-4A			Li, Be
DM-5, DM-5A			Be, Ta
5		32D/08-5	Be, Ta
6		32D/08-6	Be, Ta, Mo
8	32D08 8	32D/08-8	Li, Be, Ta, Mo
9		32D/08-9	Li, Be, Ta, Mo
11	32D08 16	32D/08-16	Li
13		32C/05-13	Li, Be, Ta
13A		32C/05-2001	Ta ?
14		32C/05-14	Be
15A, 15B, 15C		32C/05-15	Be, Ta, Mo
16	32C05 16	32C/05-16	Li, Be, Cs
17	32C05 17	32C/05-17	Li, Be, Ta, Mo, Bi
19		32D/08-19	Be
19A	32C05 19	32C/05-19	Li, Be, Mo
20		32D/08-20	Li, Ta
21, 21A		32D/08-21	Mo, Ta
22A, 22B, 22C	32D08 22	32D/08-22	Li, Mo, Ta
24		32D/08-24	Be
25A		32D/08-25	Li
25			Li
26, 26A		32D/08-26	Be
28	32D08 27	32D/08-28	Li, Be, Ta
33		32C/05-33	Li, Be, Mo, Ta
34	32C05 34	32C/05-34	Li, Ta
35A, 35B	32C05 35	32C/05-35	Li, Mo, Be, Ta
36		32C/05-36	Mo, Ta
37A, 37B		32C/05-37	Be
38A, 38B		32C/05-38	Be
39		32C/05-39	Be
45	32D08 43	32D/08-45	Li, Be
46		32D/08-46	Li
48	32C05 47	32C/05-48	Li, Be, Ta, Mo, Bi
QL-01A			Li, Be
QL-01B			Li, Be
QL-04A			Li, Mo
QL-04B, QL-04C			Li
QL-05			Li, Be
QL-07			Li
QL-10			Be
QL-13A			Be
QL-13B			Be
QL-14			Li, Be, Mo, Bi
QL-15			Li, Be, Mo, Bi
Raymor	32D08 36	32D/08-38	Li
Québec Lithium	32C05 21	32C/05-21	Li

TABLE 4 - Showings in Lac Simard area (see Figure 3).

Identification on Figure 3	SIGÉOM number	COGÎTE number	Rare metals
1		31M/10-3	Li, Be, Nb, Ta
2	31M10 5	31M/10-5	U, Nb, Ta
3	31M10 10	31M/10-1000	Ta, U, Li
4		31M/10-1	Li, Ta, Nb

Ressources naturelles
Québec