DISPERSION HALOES AROUND RARE-METAL PEGMATITES: A CASE STUDY OF THE DIBS LCT PEGMATITE, MANITOBA, CANADA

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Keywords: exploration, indicator mineral and chlorite

INTRODUCTION

Lithogeochemistry is a well established exploration tool for rare-metal pegmatites. In particular the Li, Rb and Cs contents of the host rock have been successfully used to locate hidden rare-metal pegmatite bodies. However, a problem with this method is the occurrence of false positive anomalies, which have been interpreted to be caused by minerals along fractures, but the mineralogical control on the distribution of Li, Rb and Cs in the host rock is poorly understood. If fracture minerals are the cause of false positive anomalies an intriguing question is: can fracture mineral chemistry, instead of being a problem, be used in exploration? The objective of this study is to characterize the geochemical dispersion around a representative LCT pegmatite and evaluate exploration techniques for rare-element pegmatites. Three types of data are compared: lithogeochemistry, matrix mineral chemistry and fracture mineral chemistry.

GEOLOGICAL SETTING OF THE DIBS PEGMATITE

The Dibs pegmatite is a highly fractionated LCT pegmatite that contains significant concentrations of rare metals, most notably Li and Ta. It is an excellent candidate as a site to evaluate exploration techniques because it occurs completely below the surface. It has an overall dimension of roughly 100x500 m, with a maximum thickness of approximately 65 m, as delineated by fifteen diamond drill holes (Galeschuk and Vanstone, 2005). The Dibs pegmatite is representative of LCT pegmatites in the Bernic Lake field; it is concentrically zoned consisting of a border zone, wall zone, upper intermediate zone, central intermediate zone, lower intermediate zone and quartz ±K-feldspar core. Lithium mineralization occurs predominantly as petalite in the upper intermediate zone, and Ta-Sn mineralization is hosted principally by the central intermediate zone (Galeschuk and Vanstone, 2005). It is a large pegmatite in its own right, but it is significantly smaller

and less complicated than the Tanco pegmatite, and as such it is better suited for use as a natural laboratory to evaluate different exploration techniques.

LITHOGEOCHEMISTRY

The Dibs pegmatite intruded into metabasite that is part of the Bernic Lake Formation. Lithogeochemical samples of metabasite were taken from drill holes that cut the Dibs pegmatite at approximately 10 to 20 meter intervals distal to the pegmatite and at smaller intervals near pegmatite contacts. Lithogeochemical samples were selected from fracture-free portions of drill core in order to evaluate the "homogeneous" dispersion around the Dibs pegmatite. The metamorphic assemblage consists of fine- to medium-grained green amphibole, plagioclase, quartz, biotite and ilmenite.

Lithium, rubidium and cesium values increase, essentially as a power function, toward the contact with the Dibs pegmatite (Fig. 1) and at the upper contact the metabasite contains up to 2256 ppm Li_2O, 184.5 ppm Rb_2O and 72.4 ppm Cs_2O, which is a clear indication of the LCT character of the underlying Dibs pegmatite. It is also important to note the strong enrichment of Li, Rb and Cs at the bottom of the hole. This was interpreted that an additional pegmatite must be present at depth, and in fact this hole was deepened and an additional pegmatite lens was discovered at depth. Nb and Ta are only enriched at contacts indicating their low mobility; As and Tl are intriguing because both show dispersion patterns around the pegmatite, but the anomalies are relatively weak; lastly, there was an expected enrichment of fluorine, but this was not observed and F does not appear to be a good indicator element for LCT pegmatites.

WHOLE-ROCK MINERAL CHEMISTRY

The trace element contents of "metamorphic" minerals were determined by LA-ICP-MS at the University of Manitoba. It is clear from Figure 1 that Li, Rb and Cs are concentrated in biotite, which contains an order of magnitude more Li than the whole-rock and nearly two orders of magnitude more Li than amphibole. Several grains of biotite and amphibole were analyzed from each sample and amphibole shows the greatest spread of values. It could be predicted that the enrichment of Rb and Cs in biotite will be even more pronounced, since these elements are incompatible in amphibole, quartz and plagioclase. However the Rb and Cs contents of amphibole were below the detection limit for nearly all of the grains analyzed. The detection limit itself is not a constant, but in most cases the detection limits for both Rb and Cs is better than 0.1 ppm. Figure 1 also shows the distribution of Rb and Cs in biotite in comparison to the whole-rock, confirming that these elements are concentrated in biotite.

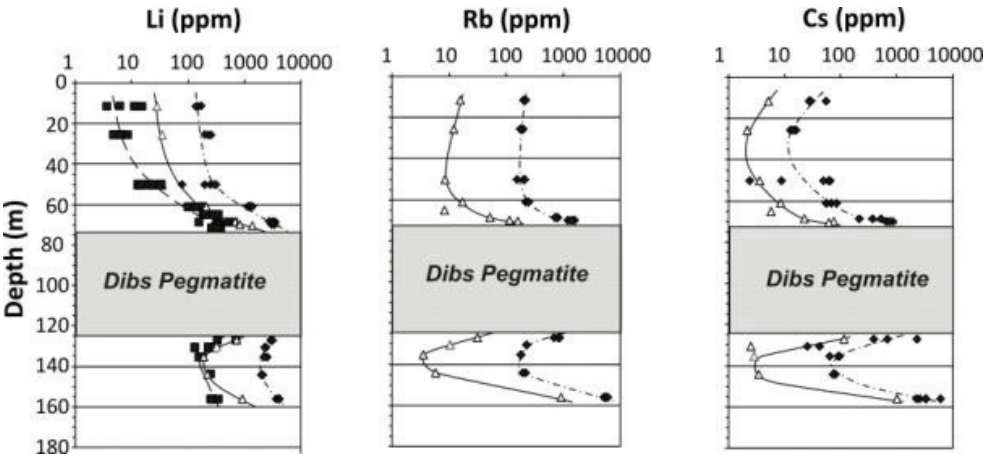

Figure 1 Comparison of whole-rock lithogeochemstry of the metabasite surrounding the Dibs pegmatite with Li-Rb-Cs contents of biotite and Li contents of amphibole. White triangles are lithogeochemistry data, black squares are amphiboles and black diamonds are biotite.

FRACTURE MINERAL CHEMISTRY

There are two dominant fracture types. The first type is ductile shear fractures that contain tremolite and the second more common type is planar (brittle), open-space filled fractures with the assemblage chlorite-titanite-carbonate-clinozoisite. Quartz tourmaline and biotite are rare fracture mineral in the Dibs drill holes. Pegmatites in the Bernic Lake area are interpreted to be late-syn-tectonic, related to both shearing and brittle fractures. Thus, if the shear fractures recognized in this study pre-date pegmatite emplacement, shear minerals should not be enriched in Li, or other indicator elements.

Figure 2 shows the Li content of fracture (shear) amphibole compared to matrix amphibole in the same sample. Several points can be made. First, all amphiboles contain Li, which is controlled primarily by the distance away from the pegmatite. Some of the matrix (metamorphic) amphibole defines a foliation whereas other amphibole is randomly oriented. The fact that matrix amphibole contains Li indicates that the Dibs pegmatite was emplaced late syn-tectonic. The brittle fractures in the Dibs drill core could be either synchronous with the Dibs pegmatite, or post-date it. In either case the dispersion caused by fluid flow along fractures may be a useful exploration tool. In Figure 2 it is clear that the fracture (shear amphibole) contain similar Li contents to matrix amphibole, in highly metasomatized metabasite adjacent to the pegmatite, and are enriched in Li relative to matrix amphibole distal to the pegmatite. Amphibole could potentially be used as an indicator mineral but, as will be shown below, chlorite is a much more common fracture mineral and contains an order of magnitude more Li than amphibole and consequently shows much more potential as an indicator mineral.

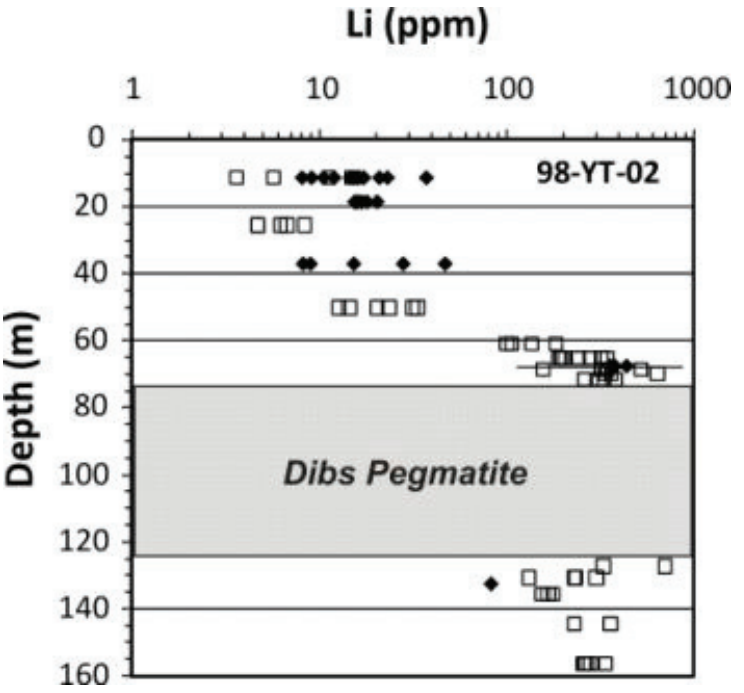

Figure 2 Comparison of the Li contents in fracture (shear) amphibole (white squares) with matrix (metamorphic) amphibole (black diamonds). The drill hole is the same as in Figure 1.

The most abundant fracture mineral in the Dibs drill core is chlorite, consequently this study concentrated on trace-element analysis of this mineral. Figure 3 shows the Li, Rb and Cs content of fracture chlorite. It is important to note that at the top of the holes, the Li contents are approximately 200 to 400 ppm Li, compared to approximately 30 ppm Li whole-rock values. With decreasing distance from the pegmatite the contrast between fracture chlorite and lithogeochemical values decrease: at the pegmatite contact fracture chlorite values have maximum Li values of 3000 to 5000 ppm, compared to maximum whole-rock values of 1500 to over 6000 ppm. This indicates that proximal to pegmatites lithogeochemistry is reliable, but distal to a pegmatite fractures chlorite is far superior to whole-rock chemistry for indicating the presence of a pegmatite. The presence of chlorite along fractures may also explain false positive lithogeochemical anomalies. For comparison roughly 5 to 15 ppm Rb and 10 to 55 ppm Cs are present in fracture chlorite distal from the pegmatite, compared to whole-rock values of approximately 10 to 15 and 5 ppm, respectively. The behavior of Rb and Cs proximal to the pegmatite is similar to Li. Fracture chlorite contains approximately 50 to 300 ppm Rb and 100 to 400 ppm Cs, compared to 100 ppm Rb and greater than 1000 ppm Cs in whole-rock analyses. In summary, fracture chlorite is superior to whole-rock analyses for showing Li and, to a lesser extent, Cs anomalies distal to pegmatites.

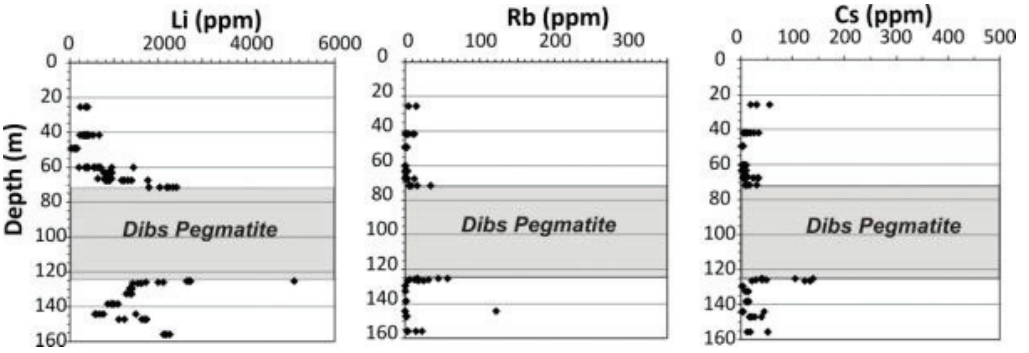

Figure 3 Li-Rb-Cs contents of fracture chlorite. The drill hole is the same as in Figure 1.

DISCUSSION

Although lithogeochemistry is a widely applied technique used in pegmatite exploration, a major drawback to this method is the occurrence of Li-Rb-Cs-bearing minerals along fractures, which complicates interpretation of the results. This study demonstrates that indicator minerals are potentially more reliable than lithogeochemistry in pegmatite exploration. Matrix biotite contained approximately 100 ppm Li at a distance of ~80 m above the Dibs pegmatite contact and fracture chlorite contains approximately 200 to 400 ppm Li at the top of the drill hole, compared to approximately 30 ppm Li whole-rock values.

REFERENCES

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