

THE USE OF FRACTURE MINERALS TO DEFINE METASOMATIC AUREOLES AROUND RARE-METAL PEGMATITES

Robert L. Linnen¹, Carey Galeschuk² and Norman M. Halden³

¹Department of Earth Sciences, Western University, London, ON, Canada, N6A 5B7, rlinnen@uwo.ca

²Department of Geological Sciences, University of Manitoba, Winnipeg, MB, Canada R3T 2N2

³Mustang Minerals, P.O. Box 670, S18-24 Aberdeen Ave., Pinawa, MB, Canada R0E 1L0

Introduction

Lithogeochemistry is one of the most common techniques employed in the exploration for a wide variety of ore deposit types, including rare-metal pegmatites where Li, Rb and Cs contents are the most useful elements. However a problem with this method is that, rocks are heterogeneous, in part because alteration minerals occur along veins and fractures. Where these vein and fracture minerals are enriched in indicator elements, this can be a problem because they generate false positive anomalies. 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 compare the dispersion characteristics of lithogeochemical, matrix mineral chemistry and fracture mineral chemistry around a representative lithium-cesium-tantalum (LCT) rare-metal pegmatite.

Geological Setting of the Dibs pegmatite

The Dibs pegmatite lies within the Bernic Lake pegmatite field in southeastern Manitoba, Canada. 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 & Vanstone, 2005). The pegmatite intruded basalt and gabbro of the Bernic Lake Formation and it was selected for this study because it is entirely buried.

Methodology

One drill hole that intersects the pegmatite near its center is examined in this study. Eight metabasite samples were selected above the pegmatite and five samples below it. After the rock samples were ground, fused pellets were made with

lithium metaborate before acid dilution and analysis by ICP-MS for major and trace elements. Separate splits of powders were used to analyze lithium by total digestion ICP. Trace elements in minerals were determined by LA-ICP-MS at the University of Manitoba using Si, determined by electron microprobe, as an internal standard.

Results

Lithogeochemistry

Lithogeochemistry is a well-established exploration method (Ovchinnikov, 1976) that has been employed by Tanco Ltd since the 1970's and the Dibs pegmatite was discovered by drilling surface lithogeochemical anomalies. Typically Li, Rb and Cs typically are the best indicator elements and it is well established that the mobility of the alkalis is in the order $Li > Rb > Cs$ (Galeschuk and Vanstone, 2005). Furthermore, in the Bernic Lake area Galeschuk and Vanstone (2005) established threshold values of 13 ppm for Li, 29 ppm for Rb and 5.8 ppm for Cs.

Figure 1 shows the downhole distribution of Li, Rb and Cs in DDH 98-YT-02. Li_2O content at the top of the hole is 28 ppm Li, thus this hole was collared above an anomalous Li lithogeochemical anomaly. By contrast Rb_2O and Cs_2O are both at or below the threshold values, 17 and 5.4 ppm, respectively.

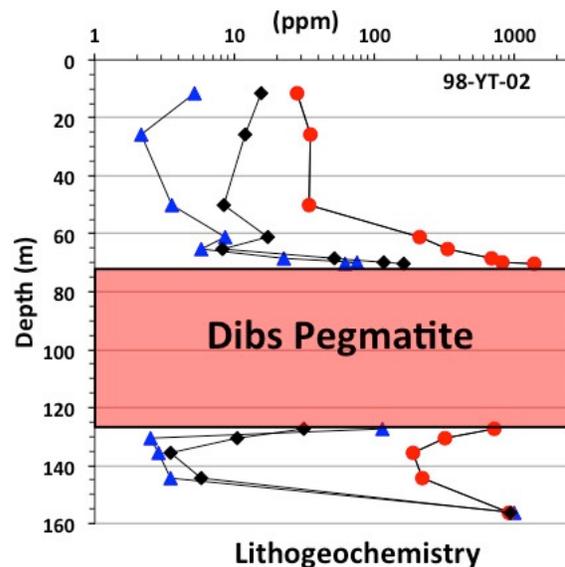


Figure 1. Lithogeochemistry of the Dibs pegmatite aureole

Distribution of Li (red circles), Rb (black diamonds) and Cs (blue triangles) in the Dibs pegmatite aureole

Lithium, rubidium and cesium values increase toward the contact with the Dibs pegmatite and at the upper contact the metabasite contains up to 2954 ppm Li_2O , 176 ppm Rb_2O and 65 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 hole 98-YT-02. This was interpreted that an additional pegmatite must be present at depth, and in fact Tanco went back to this hole, deepened it and an additional pegmatite lens was discovered.

Whole-Rock Mineral Chemistry

Figure 2 shows the trace element contents of “metamorphic” minerals. It is clear 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 2 also shows the distribution of Rb and Cs in biotite in comparison to the whole-rock, confirming that these elements are concentrated in biotite.

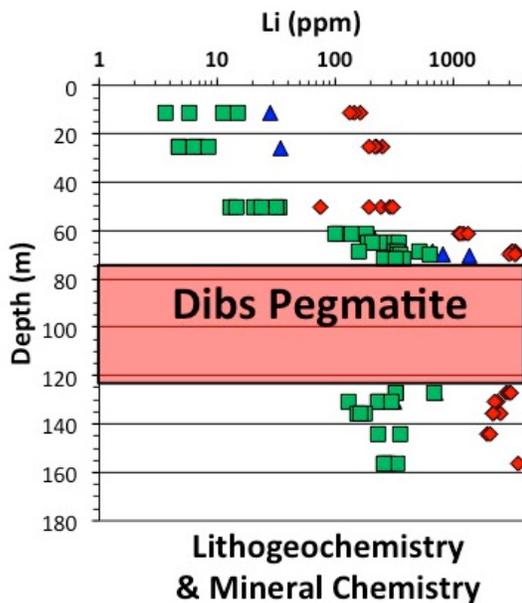


Figure 2. Comparison of Li in whole-rock and matrix minerals

Li whole-rock values are represent by blue triangles, matrix amphibole green squares and matrix biotite red diamonds

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. Pegmatites in the Bernic Lake area are interpreted to be late-syn-tectonic, related to

both shearing and brittle fractures. The Li content of fracture (shear) amphibole is similar to that of matrix amphibole in the same sample and both decrease with distance away from 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.

The most abundant fracture mineral in the Dibs drill core is chlorite. 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 lithogeochemistry proximal to pegmatites 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.

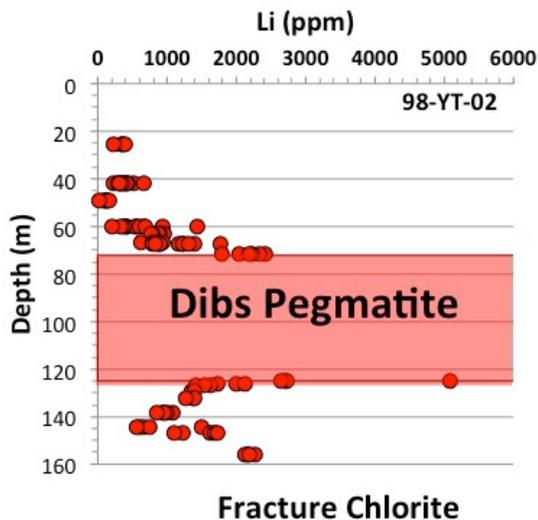


Figure 3. Li content of fracture chlorite of the Dibs pegmatite aureole

Discussion

Although lithochemistry 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 of potentially more reliable than lithochemistry 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. Given that chlorite is a common alteration mineral this method may also have applications to other deposit types.

References

GALESCHUK, C. R. & VANSTONE, P. J. 2005, Exploration for Buried Rare-element Pegmatites in the Bernic Lake Area of Southeastern Manitoba. In: Linnen R.L. & Samson, I.M. (eds) *Rare-Element Geochemistry and Mineral Deposits, Geological Association of Canada Short Course Notes 17*, 153-167.

OVCHINNIKOV, L.N., 1976, Lithochemical methods of prospecting rare metal pegmatites: *Academy of Science USSR, Dept. of Geology of USSR, Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements, Moscow, USSR*. (translated by the Department of the Secretary of State, Ottawa, Canada, 96 p.).