Geochemical Insights into Lithium Mineralization Potential of Pegmatites: A Case Study from Northeast Thunder Bay

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Summary

This study investigates the potential for lithium mineralization in pegmatite-hosted geological settings, focusing on a region located 190 km northeast of Thunder Bay. Using advanced geochemical analyses of 38 rock chip samples from pegmatites, the research highlights elemental ratio trends and their implications for lithium-cesium-tantalum (LCT) pegmatites. Leveraging laser-induced breakdown spectroscopy (LIBS) and elemental ratio analyses, the study identifies key indicators of advanced magmatic fractionation and rare-element enrichment, which are critical for evaluating the economic potential of lithium mineralization (Breaks, Selway, & Tindle, 2003; Selway, Breaks, & Tindle, 2005).

Theory

LCT pegmatites form through advanced fractionation of granitic magmas, concentrating incompatible elements such as lithium, cesium, and rubidium in residual melts. These elements, excluded from early-formed minerals, are enriched in late-stage minerals like muscovite, which serve as critical indicators of magmatic evolution. Elemental ratios such as K/Rb and Li/Cs provide insights into magmatic differentiation, where lower K/Rb and higher Li and Cs values signal advanced fractionation and the potential for spodumene-bearing pegmatites (Černý & Ercit, 2005; Selway et al., 2005).

Method

Thirty-eight rock chip samples of pegmatites were collected across the study area for geochemical analysis. Portable LIBS technology was employed for in-field analysis of lithium, cesium, rubidium, potassium, and other trace elements (Guezenoc et al., 2019). Data were calibrated using lithium standards to ensure accuracy. Whole-rock geochemical analyses were used to corroborate the LIBS results, focusing on key elemental ratios (e.g., K/Rb, Li/Cs) to assess pegmatite fractionation and fertility.

Workflow

Samples were systematically collected from representative pegmatite outcrops within the study area. LIBS analysis provided rapid elemental data on-site, while subsequent laboratory analyses validated the results. Elemental ratios were calculated and interpreted in the context of pegmatite evolution. Results were compared with established benchmarks for LCT pegmatites, providing a comprehensive assessment of the potential for lithium mineralization in the area (Breaks, Selway, & Tindle, 2003; Selway et al., 2005).

Results

Geochemical analysis of the 38 rock chip samples revealed significant lithium enrichment, with concentrations frequently exceeding 2,000 ppm. These values align with spodumene-bearing pegmatites and suggest advanced magmatic fractionation. K/Rb ratios predominantly fell below 30, a key indicator of highly evolved pegmatites (Breaks, Selway, & Tindle, 2003). High cesium and rubidium concentrations were also observed, further supporting the presence of fractionated melts. Muscovite samples with high lithium content displayed low magnesium and iron concentrations, indicative of cassiterite mineralization potential (Selway et al., 2005).

Observations

Elemental ratios such as K/Rb, Li/Cs, and Cs/Rb provided critical insights into the petrogenesis of the pegmatites. Low K/Rb ratios reflect significant rubidium enrichment during late-stage crystallization, while high Li/Cs ratios indicate preferential lithium concentration in residual melts. These geochemical signatures are consistent with highly fractionated LCT pegmatites, which are known to host economically viable lithium mineralization. The spatial distribution of these signatures suggests targeted zones of interest for further exploration (Černý & Ercit, 2005).

Conclusions

The study area demonstrates strong potential for lithium mineralization, supported by the advanced fractionation signatures observed in the geochemical data. Elevated lithium, cesium, and rubidium concentrations, coupled with low K/Rb ratios, highlight the presence of highly evolved pegmatites. These characteristics align with spodumene-rich LCT pegmatites, indicating the potential for economically significant lithium deposits (Breaks, Selway, & Tindle, 2003; Selway et al., 2005).

Future exploration efforts should focus on integrating detailed structural mapping to delineate spodumene-hosting zones, supplemented by geophysical methods to identify subsurface pegmatite bodies. Continued geochemical surveys, emphasizing muscovite composition and elemental ratios, will refine the understanding of pegmatite evolution and enhance resource estimation.

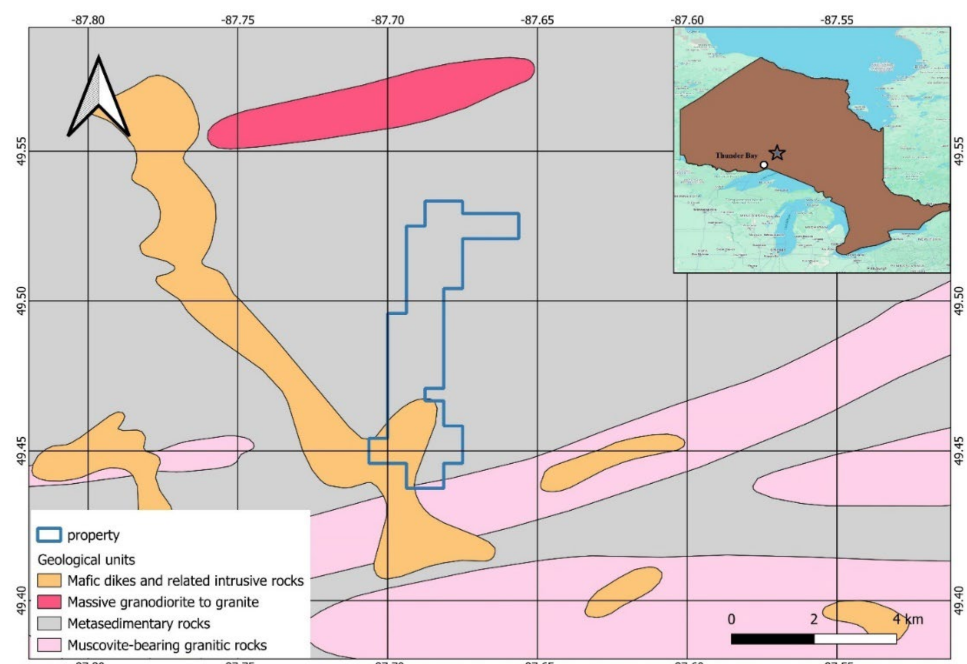

Figure 1. Location of study area (blue cadre) on regional geological map (after Stott, 2011).

References

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