Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37884

Origin of the Galaxy and Whabouchi LCT pegmatite fields (Eeyou Istchee Baie-James, Québec) revealed by trace elements and volatiles analysis in apatite

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The Eeyou Itschee Baie-James region, situated in the Superior Province, harbors giant well-exposed Archean Li pegmatites, but the Li concentration mechanisms are still poorly understood. Two major spodumene pegmatite deposits, Galaxy and Whabouchi, are well exposed and their magmatic evolution needs to be better constrained. Apatite, which is ubiquitous in these pegmatites, is a key mineral for tracing their magmatic and hydrothermal evolution due to its ability to incorporate F, Cl, S and certain rare earth elements (REE). The pegmatites of the Galaxy deposit area were sampled along a north-south section (30 km) to characterize the chemical composition of apatite, which are hereby compared to the ones of the Whabouchi deposit. In the Galaxy area, pegmatites are hosted in metasedimentary rocks evolving northward from migmatites derived from paragneiss, to clastic sedimentary rocks metamorphosed to amphibolite and greenschist facies conditions. The two generations of pegmatites that have been identified, the earliest being oriented east-west and the latest north-south, exhibit mineralogical zoning evolving from biotite-muscovite-garnet-tourmaline in the south, to muscovite-garnet-tourmaline±beryl and spodumene-columbite-tantalite in the north. At Whabouchi, the pegmatites are intruded in amphibolite facies mafic volcanic rocks.

All apatite grains are composed of Cl- and S-poor, OH-rich fluoroapatite. Those from the spodumene-barren E-W and N-S pegmatites of the Galaxy area are ∑REE-rich and show a strong negative Eu anomaly, whereas those from the spodumene-bearing pegmatites at both Whabouchi and Galaxy are less concentrated in ∑REE and show a strongly positive Eu anomaly. As for the Galaxy pegmatites, apatite from both N-S spodumene-bearing and spodumene-barren pegmatites show an enrichment in LREE, whereas the E-W pegmatites exhibit a clear difference in composition, having high HREE and the highest ∑REE content. The Sr/Y ratio, compared to the LREE content, seems to suggest that apatite mostly crystallized as a result of metasomatism, and that spodumene-barren pegmatites were emplaced in higher grade metamorphic conditions. The strongly positive Eu anomaly in apatite from the spodumene-bearing dikes is unexpected. It is possibly due to oxidation state or alteration, but determining its origin will help elucidate the mechanisms of pegmatite formation and lithium concentration.