Thermal Separation of Silicate-Fluorosilicate Melts: Trace Element Partitioning and Implications for Granite-Hosted REE Deposits

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Demand for the rare earth elements (REE) and other high field strength elements (HFSE), driven by the green energy transition, motivates continued exploration for REE deposits. Several A-type granite-hosted HFSE-rich ore deposits have been identified globally with local REE concentrations up to 40 wt %. Silicate-fluorosilicate melt immiscibility is proposed to play a key role in HFSE enrichment, however, formation of the observed compositions is hard to explain with existing experimental partitioning data. Experimental determination of two-liquid trace element partitioning is often complicated by incomplete separation of immiscible liquids and quench effects that lead to complex run-product textures. Some studies have attempted to mitigate these issues using high temperature centrifuges. However, such equipment is uncommon, limited to moderate temperatures, and does not guarantee complete phase separation.

We are developing a novel technique to fully separate immiscible melts via thermodiffusion, using the small thermal gradients (<10°C/mm) intrinsic to commonplace vertical tube furnaces. Preliminary results have successfully separated REE-doped immiscible silicate-fluorosilicate melts, with the fluorosilicate phase hosting liquidus fluorite and concentrating at the hot end of the charge. Importantly, the small thermal gradients used do not induce significant major-element gradients internal to each melt. Work is ongoing to determine trace element compositions of each phase, confirm the timescales required to achieve steady-state, and extend the range of studied melt compositions.

Silicate-fluorosilicate REE partition coefficients obtained from well separated melts, where cross-contamination during analysis can be avoided, will provide new constraints on genetic models of A-type granite REE deposits, such as Strange Lake, QC, Canada. Well-constrained genetic models are necessary to develop novel and effective exploration tools. Although our focus is REE-enriched A-type granite deposits, the thermodiffusion methods developed can be applied to other immiscible melt pairs, providing a new tool to aid the study of these challenging systems.