Fluid Evolution and HFSE Mobilisation in the Strange Lake Granite Pluton

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Strange Lake granites and pegmatites (Québec-Labrador, Canada) display extreme enrichment in high field strength elements (HFSE) including rare earth elements (REE). The strongest enrichment is confined to pegmatites and the most altered granites, indicating a significant role for hydrothermal processes during the final stages of pluton evolution. We have modelled the hydrothermal stage thermodynamically, using results of a fluid inclusion study, involving microthermometry, Raman spectroscopy and bulk gas mass spectrometry.

Our calculation show that the evolution of the fluid was governed by gradual oxidation accompanying fluid-rock interaction during isobaric cooling. Oxidation transformed the gas component from CH_4+H_2 at ≥ 450°C, to CH_4-dominated at ~400°C, to CH_4 + higher hydrocarbon-dominated at ~350°C and CO_2-dominated at ≤ 300°C. The CO_2 component was gradually consumed by fluid-rock interaction during further cooling, and at ≤220°C the fluid only contained an aqueous component.

Changes in the gas composition lead to changes in the aqueous component, which was reflected in a significant decrease in the fluid pH during evolution. As a result, the dominant ligands available for metal transport changed from Cl^- during the early high temperature stage, to CO_3^{2-} and HCO_3^- and then H_2CO_3 during the CO_2 stage, and back to Cl^- during the latest, low temperature stage.

Fluid-rock interaction governed replacement of primary minerals by secondary ones, i.e., arfvedsonite was replaced by aegirine at 350-400°C and pseudomorphs after Na-rich zircono- and titano-silicates formed at 290-330°C. Replacement of fluorbritholite-(Ce) by bastnäsite-(Ce) occurred whenever fluorbritholite-(Ce) was brought into contact with the carbonic component of the fluid. At temperatures below 200°C, there was a second wave of arfvedsonite alteration, involving replacement by aegirine and hematite.

HFSE remobilisation is interpreted to have resulted from long-term fluid-rock interaction during a gradual increase in oxygen fugacity and decrease in pH, both of which occurred during isobaric cooling.