Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.33734

Experiments and observations bearing on the origin of highly-fractionated granites and their critical metal endowment

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An important paradigm guiding the exploration of granite-hosted critical metal deposits is the association between highly evolved rock compositions (i.e., aplites and pegmatites) and critical metal enrichment. Here we integrate compositional data on aplites and pegmatites of the Devonian-aged South Mountain Batholith (SMB; Nova Scotia, Canada) with melt extraction experiments to assess models of critical metal enrichment by extreme crystal fractionation. In-progress experiments are conducted at 100, 400 and 1000 MPa at 650-850ºC using a natural granodiorite whose composition is considered least evolved in the SMB crystallization sequence. Both fused glass and seived crystalline powders are employed in separate two-step experiments. Step one is isothermal equilibration, with the sample then recovered, and re-encapsulated with glassy carbon powder and subject to the same P and T as step one. As the glassy carbon retains its porosity at high P and T, the large pressure gradient imposed by this experiment arrangement drives melt flow out of the pre-equilibrated melt-crystal aggregate into the inert carbon matrix. Experimental results at 1000 MPa, 800 and 850ºC involving a crystalline starting material demonstrate melt viscosity is sufficiently low, due to the presence of naturally-present fluxing agents (H_2O, F, alkalies), to drive melt penetration into the glassy carbon aggregate in 3-5 days. Glass compositions produced in those experiments have higher SiO_2 concentrations than the granodiorite starting material, and broadly plot along the major element compositional array defined by whole-rock compositions of more-evolved SMB samples. Trace elements, measured by LA-ICPMS, reveal significant interelement fractionation and enrichments of 10-40-fold in W, and 2-5-fold in Nb, Ta, Li, Sn and U. Distinct depletions in the LREE relative to the HREE are attributed to the presence of residual monazite. Further analyses using SIMS, will be used to quantify the volatile element (H,Cl,C and F) concentrations. Experimental results will be combined with simple crystallization models to determine the extent that both can reproduce the dataset from the natural samples, and to assess the role of extreme crystallization in producing critical metal enrichment.