Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.19917

Partial Melting of Hyperaluminous Metasediments: the Origin of Rare-Metal Granites and Pegmatites?

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Rare-metal granites and pegmatites (RMGPs) are characterised by unique geochemical signatures, which are marked by unusually high concentrations of Li, Cs, Ta, Sn, W, Ta, Hf, and Rb. These enrichments are up to two orders of magnitude greater than in other granites, therefore it's imperative to understand the mechanism of their formation and their evolution through the crust to better constrain rare-metal enrichment. The genetic models of RMPG formation involve the partial melting of metasediments or fractionation from the late-stage crystallization of granitic melts. In order to test these hypotheses, partial melting experiments on hyperaluminous mica-schists and metabauxites were performed in a piston-cylinder apparatus at 700 MPa and 750-800°C to explore the composition of the melts produced. The experiments produced peraluminous granitic melts with a strong enrichment in Li and Cs. In order to compare these experiments with natural systems, trace element modelling was performed on the partial melting of metasediments using bulk composition, mineralogy, and partition coefficients. Modelled Li concentrations in partial melts show an enrichment by a factor of 2, compared to an enrichment factor of up to 4.5 in experiments. Variations in the starting mineralogy, source Li concentration, and the degree of partial melting result in modelled partial melts with Li contents that are consistent with experiments. The discrepancy between the experimental and modelled results indicates the need for better constrained mineral-melt partition coefficients. Partitioning experiments were performed on natural metaluminous to peraluminous rhyolitic samples in an internally-heated pressure vessel at 675°C and 300 MPa to acquire mineral-melt partition coefficients. F and P concentrations of the starting materials were varied to investigate the effect of these elements on the distribution of Li during melting and crystallization. Concentrations of other rare-metals such as Ta, Hf, and Rb in the partial melts are inconsistent with RMGPs but are consistent with Sn-W granites. Thus, partial melts of metasediments must undergo further fractionation to form RMGPs. The fractionation modelling of the melts reveals that the partial melt must undergo a further 60%, 75%, and 98% fractional crystallization to produce the Hf, Rb, and Ta concentrations respectively, that are consistent with RMGPs.