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Trace element partitioning between phlogopite, apatite, amphibole and silicate melts in high-pressure experiments

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Phlogopite (PHL), apatite (AP) and amphibole (AMPH) are the principle hydrous and halogen bearing minerals in the upper mantle, occurring as major minerals in pyroxenites, glimmerites, MARID and PIC rocks. These mantle assemblages often occur as xenoliths within kimberlites, ultramafic lamprophyres and other alkaline rocks, representing source compositions for the host magmas. The extent to which these hydrous minerals are retained in the residue or partake in melting will define the trace element signatures of extracted melts. Previous studies have demonstrated that hydrous minerals are essential to produce K-rich melts such as ultramafic lamprophyres and lamproites. However, many of these exotic melts also have enriched signatures for trace elements likely to result from PHL, AP and/or AMPH in their mantle sources. To constrain the role of hydrous minerals in generating alkaline rocks we have experimentally determined mineral/melt partitioning for trace elements at known temperature, pressure and water content for magma sources.

Here we present partitioning data for 38 trace elements in several high-pressure experiments: (1) for Ca-AMPH and AP in basanites at 1 – 2 GPa; (2) for PHL, K-AMPH and AP in olivine lamproites at 1 – 2 GPa and (3) for PHL and K-AMPH in olivine lamproites at 1 – 2 GPa. Experiments were equilibrated with varying water contents from 5 – 15 wt% at oxidised conditions equivalent to FMQ. The experimentally synthesised minerals and glasses are homogeneous in their trace element and major element compositions, with improved quenching of glasses attributed to the use of a rapid quench piston cylinder (quench rates <10s). In PHL and AMPH, Sr, Ba, Eu, & HFSE range from moderately to highly incompatible (D = 0.01-0.001), HREE are moderately compatible in AMPH (D = 0.1 – 1), but highly incompatible in PHL (D = 0.001). Rb, Cs and all first row transition metals except Zn are highly compatible in PHL (D = 1 – 10). AP mineral/melt partition coefficients are close to D = 1 across the entire suite of analysed trace elements: Ni and Cr are the only highly incompatible elements in AP (D = 0.01 – 0.001) in this study.