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Experimental partitioning of fluorine and barium in lamproites

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Abstract

The dynamic properties and melting behavior of the Earth's mantle are strongly influenced by the presence of volatile species, including water, carbon dioxide, and halogens. The role that halogens play in the mantle has not yet been fully quantified: their presence in only small quantities has dramatic effects on the stability of mantle minerals, melting temperatures, and in generating halogen-rich melts such as lamproites. Lamproites are volumetrically small volcanic deposits but are found on every continent on the planet: they are thought to be melts generated from volatile-rich mantle sources rich in fluorine and water. To clarify the mantle sources of lamproites, we present experimentally determined mineral/melt partition coefficients for fluorine and barium between phlogopite and lamproite melts. Both fluorine and barium are compatible in phlogopite [$D_{F}^{(Phl/Melt)} 0.96 \pm 0.02 - 3.44 \pm 0.33$, $D_{Ba}^{(Phl/Melt)} 0.52 \pm 0.05 - 3.68 \pm 0.43$] at a range of pressures (5–30 kbar), temperatures (1000–1200 °C), and fluid compositions (C-O-H mixtures). Using our partition coefficients, we model the melt compositions produced by potential lamproite sources, including phlogopite garnet lherzolite, phlogopite harzburgite, and hydrous pyroxenite. The results demonstrate that hydrous pyroxenites and phlogopite garnet lherzolite can produce melts with F and Ba contents similar to lamproites, but only hydrous pyroxenites fully reproduce other geochemical characteristics of lamproites including high K_2O, low CaO contents, and high F/H_2O ratios.

Keywords: Halogens, fluorine, barium, partition coefficients, lamproites; Experimental Halogens in Honor of Jim Webster