

Trace element partitioning between apatite and kimberlite-like melts: implications for kimberlite melt composition and emplacement

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The original composition of kimberlitic melts is largely unknown because the complex nature of kimberlites involves contamination from country rocks, loss of volatiles from exsolution during emplacement, and the lack of any quenched melts. Additionally, kimberlite bodies have varied morphologies, but the exact emplacement mechanisms of the magma in different bodies remain elusive. Apatite is a common accessory mineral found in kimberlite and has a crystal structure that allows for the incorporation of trace elements. The difference in the partitioning of trace elements between apatite and kimberlite-like melts can reveal whether the carbonate or silicate phases in the kimberlite more closely represent the original melt. Apatite is also often used as an indicator mineral of magma degassing in igneous systems. As such, it should be applied to kimberlitic systems to study the volatile behaviour during emplacement. However, two problems currently exist with partition coefficient data for apatite. First, there is controversy regarding existing data for carbonatitic melts, and second, no data are available for kimberlite-like silicate melts. Here, we examine kimberlitelike melt compositions ranging from carbonatitic to silicate in order to investigate the effect on apatite partition coefficients and the behaviour of fluids in kimberlite.

Partition coefficients for Nb, Sr, Rb, Zr, Sm, Cs, Hf, La, Yb, and Eu were examined using synthetic compositions and a piston cylinder apparatus at 1250–1350°C and 1–2 Gpa. The effects of melt composition, temperature, pressure, water, and oxygen fugacity have been tested. Four synthetic melt compositions representing evolved kimberlite melts were used: three lamproitic compositions with SiO₂ ranging from 17–23 wt.% and CO₂ from 9–33 wt.%, and a composition modelled after a magmatic kimberlite (Leslie, NWT) by subtracting 50% (volume) of the olivine component (with 14–29 wt.% SiO₂, 7–33 wt.% CO₂). The lack of sizable melt glass produced by the kimberlitic composition in our experiments restricted the partition coefficients obtained to the lamproitic run products. We present partition coefficients that address discrepancies observed in carbonatitic melts and more closely resemble those of kimberlites in order to model the possible melt composition of an original kimberlite melt. The variation of apatite stability at different run conditions allows for examination into crystallization conditions of different kimberlite bodies. Furthermore, textural and mineralogical phase relationships observed in the derived kimberlite run products are compared to natural samples. This will provide insight into the enigmatic stages of kimberlite formation that result in the variety of morphologic facies observed.