Crystal chemical controls on rare earth element partitioning between epidotes and melts: An experimental and theoretical study

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Epidote$_{ss}$ and zoisite are considered to be modally significant solidus phases during the initial stages of fluid-absent melting of rocks with basaltic to intermediate bulk compositions in the pressure interval between 1 and 3 GPa. Because these phases are important rare earth element (REE) carriers, they are expected to exert dominant control on the REE composition of melts produced during the initial anatexis of these rocks. However, qualitative and quantitative modeling of the role of epidotes during melting processes critically hinges on the availability of mineral/melt partition coefficients.

We have therefore experimentally determined the partitioning of REE (rare earth elements) between zoisite and hydrous silicate melt at 1100°C and 3 GPa. All REE behave moderately compatible in zoisite with respect to the melt and all zoisite/melt D_{REE} show a smooth parabolic dependence on ionic radius. The partitioning parabola peaks at Nd (D_{Nd} = 4.9), and the compatibility slightly decreases towards La (D_{La} = 3.9) and decreases by half an order of magnitude towards Yb (D_{Yb} = 1.1). By application of the elastic strain model for mineral/melt partitioning to the available zoisite and allanite REE mineral/melt partitioning data and comparison with partitioning pattern calculated from a combination of structural and physical data (taken from the literature) with the elastic strain model suggests that in zoisite REE prefer the A1-site and that only La and Ce are incorporated into the A2-site in significant amounts. In contrast, in allanite all REE are preferentially incorporated into the large and highly co-ordinated A2 site. As a result, zoisite fractionates the MREE effectively from the HREE and moderately from the LREE, while allanite fractionates the LREE very effectively from the MREE and HREE. Consequently, the presence of either zoisite or allanite during slab melting will lead to quite different REE pattern in the produced melt.

Ferric iron in perovskite as an oxygen barometer for kimberlitic magmas

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The intensive variables (T, fO_2, volatile content) in complex kimberlite magmas bear on their mode of emplacement, crystallization and degassing history and diamond preservation. We are developing an oxygen barometer based on the partitioning of Fe in perovskite (Pv), a groundmass phase in many kimberlites. We hypothesize that with increasing fO_2, more Fe exists in the kimberlitic liquid as Fe^{3+} , and thus partitions into Pv, which accepts only Fe^{3+} into its crystal structure (as a Metal-$Fe^{3+}O_3$ component).

Experiments to study the partitioning of Fe^{3+} between Pv and kimberlite liquid were conducted on simple and complex kimberlite bulk compositions, using the Pt wire loop technique in a vertical tube gas mixing furnace at 100 kPa over a range of fO_2's from NNO to NNO-5 and at temperatures of 1130 to 1360°C. Perovskite crystallized over a temperature range of 1130 to 1300°C. The Fe_2O_3 content of Pv increased, as predicted, from 0.5 wt% at NNO-5 to 2.0 wt% at NNO and is only slightly affected by T and unaffected by Nb, Sr or REE substitutions (to 1 wt%) in Pv. The following equation describes the relation between fO_2 and Fe^{3+} in Pv:

$$Fe_2O_3\ \mathrm{Pv} = 0.21\ [\Delta\mathrm{NNO}] + 1.8\ \ (r^2 = 0.85)$$

The Fe_2O_3 content of Pv from natural kimberlites in the literature corresponds to fO_2 conditions of NNO-3.8 to NNO+1.0. Further work will apply this oxygen barometer to fresh kimberlites from the Lac de Gras area for which existing oxygen barometry, diamond preservation and diamond grade data are available [1].

Reference

[1] Fedortchouk and Canil (2004) J. Petrol.