Trace element partitioning during hydrous mantle melting and source mineralogy of Arc basalts

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Scientific issues

Pyroxenite formed by silicic melt-peridotite interaction has been recognized as one of the sources of oceanic island basalts [1,2]. Mantle wedge can be metasomatised by aqueous fluids, hydrous melts and even supercritical fluids. All these mobile phases can bring silicon into the mantle wedge and thus likely interact with the wedge peridotite to produce pyroxenes at the expense of olivine. First row transition elements (FRTEs) are compatible to moderately incompatible in mantle minerals during the partial melting, which makes them useful in tracking mantle heterogeneities in terms of mineralogy[3]. However, mineral/melt trace elements (including FRTEs) partition coefficents at the P, T, H_2O and fO_2 conditions of arc settings are still rare. This study conducted experiments to investigate partitioning behaviors of trace elements at conditions corresponding to arc settings. The aim is to identify source mineralogy of mantle wedge using the partition coefficients of these elements.

Methods and Results

The starting composition is a synthetic high-Mg basalt doped with trace elements. The experiments were conducted on a piston cylinder apparatus at 1120-1200□, 1-2 Gpa and 5wt% H_2O with fO_2 ranging from FMQ-2.6 to FMQ+2.3. Major and trace elements were analyzed by EPMA and LAICP-MS respectively, and trace element partition coefficients were obtained from the LAICP-MS data.

The results show that Ti, Sc, Ga, and Ca have distinct partition coefficients for olivine and pyroxenes: Ol/melt is 0.008±0.002 for Ti, 0.20±0.04 for Sc, 0.013±0.008 for Ga and 0.014±0.004 for Ca; Opx/melt is 0.17±0.04 for Ti, 1.33±0.33 for Sc, 0.930±0.545 for Ga and 0.18±0.04 for Ca; Cpx/melt is 0.36±0.11 for Ti, 2.41±0.88 for Sc, 0.97±0.59 for Ga and 1.39±0.10 for Ca. These partition coefficients were used to model hydrous mantle melting to identify source mineralogy. The modelling results indicate that the mantle wedge has in general higher pyroxene proportion compared to the source of MORBs, in particular, some arc basalts may have been derived from a pyroxenite source.

[1] Sobolev, A.V et al. (2005) Nature 434,590-597. [2] Herzberg, C (2011) JP 52, 113-146. [3] Le Roux et al. (2011) EPSL 307, 395-408.