Trace element partitioning in Earth's lower mantle and geochemical consequences of partial melting at the core-mantle boundary

Kei Hirose[1]

[1] Dept. Earth & Planet. Sci., Tokyo Tech.

It has been suggested that oceanic lithosphere, consisting mainly of MORB crust and underlying mantle peridotite layer, could subduct all the way to the core-mantle boundary (CMB) and partially melt. Partial melting will lead to chemical differentiation of trace elements. High-pressure experiments under the uppermost lower mantle conditions have shown that trace element partitioning is dominated by CaSiO3-rich perovskite (CaPv) and melts in both partially molten peridotite and MORB, and solid residues that include CaPv will have a strong CaPv signature. Because of the overwhelmingly high CaPv / melt partition coefficients (more than 10 for many of the LILE), partial melting in the lower mantle causes strong enrichment of LILE in the CaPv-bearing solid phase residue. CaPv has the following partitioning characteristics: (1) Uniformly high partition coefficients for heavy rare earth elements (HREE) (e.g. 15 for Yb), decreasing toward light REE (e.g. 7 for La), (2) Systematically lower partition coefficients for high field strength elements (Nb, Zr, Ti) and Sr relative to neighboring REE, (3) High Th and U, and systematically low Pb partition coefficients. Previous high-pressure studies have shown that the stability field of CaPv above solidus temperature is much wider in basaltic composition than in peridotite, indicating that melting of subducted oceanic crust in the lower mantle could produce significant geochemical CaPv signatures. Strong enrichment in Th and U relative to Pb in CaPv would result in radiogenic Pb isotopic compositions of the CaPv-bearing solid residue. Some clinopyroxenes in plume mantle peridotite xenoliths possess trace element patterns closely resembling those of natural CaPv found in diamonds and CaPv from our experiments, suggesting that they were inherited from the CaPv-bearing precursor. In contrast, CaPv is the first phase to disappear during partial melting of peridotite at the uppermost lower mantle pressures, and its geochemical signature may not be observable in nature.

Very recently, we found that MgSiO3-rich perovskite, a predominant mineral in the lower mantle, transforms to a new high-pressure form near the base of the mantle. This post-perovskite phase is also potentially very important for the trace element partitioning in the lowermost mantle.