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Trace element partitioning between bridgmanite and silicate melt up to CMB pressure and the origin of the Hf-Nd mantle array

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Recent numerical simulations of the Moon-forming giant impact show that the Earth's mantle was once almost fully molten and covered by a deep magma ocean. Crystallization in such magma ocean and the segregation of melt from crystals must have created large-scale chemical heterogeneities in the mantle. The FeO-rich dense crystals and heavy magma residue (known as a basal magma ocean) formed at that time may still be present in the lowermost mantle and be an unsampled geochemical reservoir enriched in incompatible elements [1]. In order to quantitatively evaluate the chemical characteristics of such possible hidden reservoir, it is necessary to understand the partitioning behaviors of key trace elements under high pressures corresponding to the present lower mantle conditions. Bridgmanite is a primary lower-mantle mineral and a liquidus phase of pyrolite in the deep lower mantle pressures. The partitioning of trace elements between bridgmanite and melt has been previously examined only up to 27 GPa [2].

Here we performed melting experiments on a pyrolitic mantle material doped with some SiO_2 and trace elements (La, Nd, Sm, Lu, and Hf) at 24–132 GPa and 3300–4610 K, covering entire lower mantle conditions, using laser-heated diamond-anvil cell techniques. The bridgmanite/melt partition coefficients, D of these trace elements were determined based on the secondary ion mass spectrometry (SIMS) with high-resolution imaging techniques [3]. The results demonstrate that with increasing pressure to more than ~60 GPa, both Lu and Hf change from compatible ($D > 1$) to incompatible ($D < 1$) and D_{Lu} becomes greater than D_{Hf}. We also found that pressure effects on D_{Sm} and D_{Nd} are smaller and $D_{Sm}$is equivalent to D_{Nd}. It is known that the terrestrial Hf-Nd isotope array lies slightly above the bulk silicate earth (BSE) composition. The possible hidden geochemical reservoir formed from a basal magma ocean could have low Lu/Hf ratio (and thus low eHf) and similar Sm/Nd ratio (and similar eNd) compared to the BSE, which explains the discrepancy between the BSE and the mantle array.

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[3] Yurimoto *et al.* (2003) *Appl. Surf. Sci.*