Experimental study on chemical interaction at the core-mantle boundary

*Takashi Yoshino[1]

1. Institute for Planetary Materials, Okayama University

The core-mantle boundary (CMB) is the biggest physicochemical discontinuity in the Earth's interior. Abundance of siderophile elements in the Earth's mantle is much higher than that predicted from the partitioning study at low pressure. Chemical interaction across the CMB after core formation is one of candidates to realize the observed geochemical affinity as well as late veneer hypothesis. Hayden and Watson (2007) suggested that the diffusivities were high enough to allow transport of a number of siderophile elements over geologically significant length scales (tens of kilometres) over the age of the Earth based on grain-boundary diffusion of siderophile elements through polycrystalline MgO. On the other hand, enrichment of iron may occur at the bottom of the mantle, leading to low seismic-wave velocities and high electrical conductivity. Otsuka and Karato (2012) suggested that iron-rich melt could be transported 50 to 100 kilometres away from the core–mantle boundary by a morphological instability, providing an explanation for the iron-rich regions in the mantle. Thus there are potential fast pathways for chemical communication at the CMB. However, the dominant lower mantle mineral is not periclase but silicate minerals such as bridgmanite. In this study, validity of these processes in bridgmanite or post spinel experimentally investigated.

A study on the metal infiltration to bridgmanite, postspinel and ferropericlase was also performed using a Kawai-type multianvil press at 25 GPa and temperatures of 1600-2000 °C. Although significant penetration of metallic phase through the grain boundary was observed in only ferropericlase aggregates, iron alloy penetration to bridgmanite and postspinel was not observed. This result indicates that capillary force and morphological instability to enrichment does not contribute to the enrichment of iron and siderophile elements in the Earth's silicate mantle.

A study on the grain boundary diffusion of siderophile elements (W and Re) in bridgmanite and postspinel was performed using a Kawai-type multianvil press at 25 GPa and above 1600 °C. The grain boundary diffusion of W in post spinel is faster than that in bridgmanite, and is only effective under highly oxidized condition. Such oxidized state at the core-mantle region is realized by accumulation of the sinking slab. Although the core-mantle interaction after the core formation can change W isotope in the mantle through the convection, it would be limited.

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