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Water in the transition zone, lower mantle, and core

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We have conducted in situ X-ray diffraction studies of hydrous system by using both multianvil apparatus and the diamond anvil cell, and clarified the stability of hydrous phases, hydrous ringwoodite and delta-AlOOH at high pressure.

We have clarified the effect of water on the post-spinel phase boundary in MgO-SiO2-H2O systems at high pressure and temperature. The phase boundaries determined under the wet conditions revealed expansion of the stability field of ringwoodite by about 1.5 GPa at around 1500 K under the wet conditions. Further, the slope of the phase boundary become greater (dT/dP∼-2.5 MPa/K) compared to the dry conditions (dT/dP∼-0.4∼-1.3 MPa/K, e.g., [1]). Thus, the topography of the 660 km discontinuity seismologically observed may be at least partially attributed to existence of water in the transition zone.

Water can be transported also to the lower mantle by some minerals. Important candidates for the water carriers are alumina bearing stishovite and hydrous delta-AlOOH phase. Our experiments revealed that stishovite can accommodate up to 3000wt.ppm of water when it contains Al2O3 component, and aluminous bearing stishovite transforms to CaCl2 phase at pressures around 25-35 GPa [2], significantly lower than the transition pressure of pure SiO2 stishovite. delta-AlOOH phase is a unique hydrous phase to transport of water into the lower mantle. Wirth et al. [3] reported existence of phase Egg AlSiO3OH as inclusions in natural diamond. Since this phase decomposes to stishovite and delta-AlOOH at the base of the transition zone [4], the decomposition products of delta-AlOOH and stisovite can transport water into the lower mantle.

In situ X-ray diffraction experiments on the stability of delta-AlOOH and the reaction of this phase with metallic iron were made by using a laser heated diamond anvil cell. We confirmed that delta-AlOOH phase is stable up to above 150 GPa and 2000 K, and a reaction of delta-AlOOH and iron to form FeHx and Al2O3 occurs at high pressures and above 1000 K. This result indicates that delta-AlOOH phase could transport water into the base of the lower mantle, and can provide hydrogen into the core by formation of FeHx as a reaction product of the hydrous phase with iron at CMB.

[1] Katsura et al., 2003. Phys. *Earth Planet. Inter.* 136, 11–24.

[2] Lakshtanov et al., 2007. *PNAS*, 104: 13588-13590

[3] Wirth et al., 2007. *Earth Planet. Sci. Lett.*, 259, 384-399

[4] Sano et al., 2004. *J. Phys. Chem. Solids*, 65, 1547-1554.