Aluminum and hydrogen partitioning between bridgmanite and high-pressure hydrous phases and its application to the lower mantle dynamics

*Eiji Ohtani[1], Takayuki Ishii[2], Anton Shatskiy[3]

1. Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 2. Center for High Pressure Science and Technology Advanced Research, 3. Sobolev Institute of Geology and Mineralogy, Siberian Branch of Russian Academy of Sciences

Water is transported into the deep mantle by slab subduction and influences the mantle dynamics and evolution. Discoveries of hydrous minerals in diamond such as such as phase Egg and phase δ [1, 2] indicate that water can be transported into the the mantle transition zone and lower mantle. We clarified the phase relations of $MgSiO_3$-Al_2O_3-H_2O system under the uppermost lower-mantle conditions and the partitioning of aluminum and hydrogen between bridgmanite and hydrous minerals such as hydrous phase δ-H solid solution and aluminous hydrous phase D. Bridgmanite coexists with hydrous D and phase δ-H at 25-28 GPa and 1000-1100 °C. Hydrous phase D becomes unstable above 1200 °C, while hydrous phase δ-H remains up to 1400 °C in this pressure range. Aluminum is strongly partitioned to both aluminous phase D and phase δ-H resulting in alumina depletion in bridgmanite. Fourier transform infrared spectroscopy indicates that bridgmanite contains undetectable water when coexisting with these hydrous phases, showing strong hydrogen partitioning into hydrous phases, such as phases D and δ-H. This strong partitioning of hydrogen in hydrous phases is consistent with the previous work showing strong water partitioning into superhydrous phase B and depletion of hydrogen in bridgmanite [3], The depletion of alumina in bridgmanite modifies the phase relations significantly in hydrated slabs descending into the lower mantle, i.e., the pressures of the garnet-bridgmanite and post-perovskite transformation boundaries decrease under the wet conditions where these hydrous phases coexist [4]. The dry nature of bridgmanite coexisting with hydrous phases suggests that the major water carriers in the lower mantle are hydrous phases. Bridgmanite cannot be the water reservoir at least in the upper part of the lower mantle and can result in a dry rheology of the wet lower mantle.

References

[1] Wirth et al. (2007), Earth Planet. Sci. Lett. 259, 384–99
[2] Kaminsky FV. (2017), *The Earth's Lower Mantle: Composition and Structure*. Cham, Switz.: Springer
[3] Borfan-Casanova et al. (2003), Geophys. Res. Lett. 30, 1905.
[4] Yuan et al. (2019), Earth Planet. Sci. Lett. 524, 115714.

Keywords: bridgmanite, hydrous phase δ, hydrous phase H, hydrous phase D, phase relation, lower mantle

