

Maximum water solubility of bridgmanite under the Earth's lower mantle conditions

*Sho Kakizawa¹, Toru Inoue^{1,2,3}, Ryotaro Abe¹, Minami Kuroda⁴, Naoya Sakamoto⁵, Hisayoshi Yurimoto^{4,5,6}

1. Geodynamics Research Center, Ehime University, 2. Graduate School of Science, Hiroshima University, 3. Hiroshima Institute of Plate Convergence Region Research, 4. Graduate School of Science, Hokkaido University, 5. Creative Research Institution, Hokkaido University, 6. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

The Earth initially contained ~2 wt% H₂O, if it was formed by the mixture of C1 chondrite and enstatite chondrite [Ringwood, 1977]. However, the mass of the Earth's ocean is only 0.02 wt% of that of the Earth. Thus, most of the H₂O or molecular H may have been lost from the Earth since then, or it may still be stored in the Earth's deep interior. Water significantly influences the physical and chemical properties of the mantle minerals and rocks. Therefore, it is important to clarify the effect of water to understand the evolution and dynamics of the Earth. A part of water in the deep mantle can be dissolved in nominally anhydrous minerals. Wadsleyite and ringwoodite which are the major constituent minerals in the mantle transition zone, can contain ~2-3 wt% H₂O [e.g., Inoue et al., 1995; Kohlstedt et al., 1996]. On the other hand, water solubility of bridgmanite which is the most abundant mineral in the lower mantle, is a matter of debate [e.g., Bolfan-Casanova et al., 2004; Murakami et al., 2003]. Recently, Al-bearing hydrous bridgmanite contained ~0.8 wt% water was synthesized by Inoue et al. (under review). This report suggests that lower mantle can become a water reservoir in the Earth. However, the effects of pressure and Fe content on maximum water solubility of Al-bearing bridgmanite have not been clarified yet. To determine the maximum water solubility of Al-bearing hydrous bridgmanite, high pressure and high temperature experiments were conducted under the conditions of 25-48 GPa and 1600°C. The starting materials were prepared by the mixtures of MgO, SiO₂, Mg(OH)₂, and Al(OH)₃ reagents with clinocllore [Mg₅Al₂Si₃O₁₀(OH)₈], Fe-bearing natural chlorite [Mg_{4.9}Al_{1.6}Si_{3.2}Fe_{0.3}O₁₀(OH)₈], and Fe-bearing hydrous pyrolite compositions. The water contents of the recovered run products were measured by SIMS. The water contents of Al-bearing hydrous bridgmanite increased with increasing pressure, at least up to 48 GPa. This is considered to occur the following two hydrous coupling substitutions with increasing pressure: $\text{Si}^{4+} = \text{Al}^{3+} + \text{H}^+$ and $2\text{Mg}^{2+} = \text{Al}^{3+} + \text{H}^+ + \text{V}_{\text{Mg}}$. These substitutions were dominant at low Al content, and Tschermak substitution ($\text{Mg}^{2+} + \text{Si}^{4+} = 2\text{Al}^{3+}$) became dominant with increasing Al content above Al = ~0.1 per formula unit (pfu, O = 3). The water content decreased as a result of Tschermak substitution, thus the maximum water solubility of bridgmanite is expected to be about 1.0 wt% at Al = ~0.1 pfu. In addition, the water solubility of Al-bearing hydrous bridgmanite decreased in the presence of Fe, and it became clear that it depends on the amount of Al and Fe in bridgmanite. Because of these properties, the maximum water solubility of bridgmanite in pyrolite and MORB are expected to be ~0.1 and ~0.2 wt%, respectively. When ringwoodite with high H₂O content is subducted to the lower mantle, the dehydration would occur at the top of the lower mantle. The dehydrated water should decrease melting temperature of the surrounding rocks and generates magma. Moreover, when chlorite dominant rock with high Al and low Fe content is subducted to the lower mantle, water heterogeneity would be predicted in the lower mantle, because the water content of bridgmanite generated by chlorite is significantly higher than that generated by pyrolite.

Keywords: deep mantle, lower mantle, bridgmanite, water

