

Stability of Phase H δ -Al₁₀₀H solid solution in a hydrous peridotite and water cycle in the Earth's mantle.

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A number of high pressure and temperature (high $P - T$) experiments have been showing that various hydrous minerals can survive in a broad range of $P - T$ conditions such as the conditions of slabs subducted in the deep mantle. A subducting slab consists of three rock layers; peridotite, oceanic crust (MORB) and sediment. A hydrous peridotite layer includes various dense hydrous magnesium silicates (DHMS), which can carry water as OH⁻ or proton in their structures but all of them decompose at the uppermost lower mantle (e.g., Ohtani, 2005). However, the new phase called Phase H (MgSiO₄H₂; space group, $Pn\bar{m}$ (Bindi et al., 2014)) was predicted to be stable at pressures up to 50 GPa and was synthesized by high $P - T$ experiment (Tsuchiya, 2013; Nishi et al., 2014), suggesting that water stored in Phase H formed in a slab can be transported into the middle region of the lower mantle.

The stability field of Phase H depends strongly on Al content (Nishi et al., 2014, 2015; Ohira et al., 2014; Walter et al., 2015). Ohira et al. (2014) conducted *in-situ* high $P - T$ experiments using a laser-heated diamond anvil cell (LHDAC) in MgO-Al₂O₃-SiO₂-H₂O system simplified MORB composition. Their experiments indicated that Phase H δ -Al₁₀₀H solid solution coexisted with Al-poor bridgmanite, and water stored in this solid solution may be transported to the lowermost mantle because of the broad stability field of δ -Al₁₀₀H (space group, $Pn\bar{m}$ above 8.2 GPa (Kuribayashi et al., 2014)) extending from the transition zone to the core-mantle boundary (CMB) conditions (Sano et al., 2008).

However, the possible existence of H δ -solid solution in realistic complex systems such as hydrous peridotite and MORB compositions has been unknown.

Here, we demonstrate the phase relations in hydrous peridotite system obtained from *in-situ* high $P - T$ synchrotron X-ray diffraction measurements at BL10XU, SPring-8.

We used the gel-sample having the same composition as hydrous peridotite (bulk water content was 1.0 wt.%). LHDAC and YAG (Nd) or fiber laser were used for generation of high $P - T$ conditions. In the first run, we only used the gel-sample without laser absorbers and pressure mediums. In the second run, the sample plate was sandwiched between Ir foils, and NaCl plates were put on the outer sides of Ir foils. *In situ* X-ray diffractions were measured at the pressure and temperature ranges of 69-84 GPa and 1910-2260 K in the first run and of 49-53 GPa and 1550-2210 K in the second run. Above 69 GPa, the coexistence of major anhydrous minerals in the lower mantle, bridgmanite (Brg), ferropericlasite (Fp) and CaSiO₃-perovskite (Ca-Pv), was observed, while none of hydrous phases such as H δ -solid solution existed. On the other hand, the diffraction patterns of H δ -solid solution together with those of Brg, Fp and Ca-Pv were observed at pressures between 49 and 53 GPa, suggesting that the stability field of H δ -solid solution formed in a hydrous peridotite only extends up to the pressure conditions between 53 and 69 GPa. This decomposition boundary was consistent with the stability of pure phase H (Tsuchiya, 2013; Ohtani et al., 2014), implying that the composition of H δ -solid solution formed in a hydrous peridotite may be very close to pure-MgSiO₄H₂ Phase H.

Our results suggest the difference of water transport mechanisms between a peridotite layer and a MORB layer in a hydrous slab subducted in the lower mantle. Al-poor H δ -solid solution formed in a

hydrous peridotite layer may decompose and release H₂O-rich liquid at the middle of the lower mantle, while Al-rich H₂O-solid solution formed in a hydrous MORB layer can be transported to the lowermost mantle.

Keywords: hydrous minerals, water cycle, in-situ XRD, Phase H, δ -AlOOH