DH partitioning experiment among high-pressure polymorph of olivine

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Mantle is known to have homogeneous hydrogen isotope composition with δD = -80 ˜ -60 ‰based on the analysis of MORB and OIB [1, 2]. The reason of the depletion of deuterium compared to the present ocean has been explained by the existence of isolated primordial reservoir in the mantle [1], evolution by the subduction of deuterium-poor hydrous mineral through the geological timescale [3], and addition of cometary water after the formation of ocean [4]. Hydrogen isotope partitioning factor among minerals is a key in these discussions, but little is known under high pressure and high temperature of mantle conditions. In this study we focused on DH partitioning between olivine and wadsleyite, which is a main constituent of upper mantle and mantle transition zone (MTZ). High pressure experiments suggest that wadsleyite and its high pressure polymorph of ringwoodite can contain significant amount of water up to 3.3 wt.% thus MTZ has an ability to keep water up to several times of ocean [5]. Finding of Ringwoodite with 1.4 wt.% H_2O in a diamond inclusion also reveals hydrated MTZ at least locally [6].

The partitioning experiment was conducted using Kawai-type multianvil press at GRC, Ehime University. Powder of $Mg(OH)_2$ and $Mg(OD)_2$ was mixed with synthetic olivine so that the starting composition is equivalent to $Mg_{1.8}Fe_{0.2}SiO_4$ + 1.0 wt.% HDO. The sample was sealed in the Au75Pd25 capsule and kept at 1300 °C and around 13 GPa, which is the condition of olivine and wadsleyite coexist. The recovered sample was polished and analyzed by micro-focused X-ray diffractometer, Raman spectroscopy and EPMA. Hydrogen isotope composition was determined using SIMS at Kyoto University.

To test for equilibrium, partitioning experiments are made with changing duration times from 1 h to 72 h. The fractionation factor decreases with increasing of duration time. After keeping for 30 h, $1000\ln\alpha_{\text{Olivine-Wadsleyite}}$ seems to reach almost equilibrium around -60 ‰. Assuming that the δD of olivine of upper mantle to -80, the δD of wadsleyite at MTZ become -20 to 0, which is more comparable to the composition of the ocean. The present result shows that the depletion of deuterium of upper mantle can be explained as a result of DH fractionation between upper mantle and MTZ.

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