The effect of water on post-garnet phase transformation in MORB and dynamics of subducting slab at 660km

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Subducting lithosphere consists of upper Mid-Ocean Ridge basaltic (MORB) layer and lower peridotite layer, and minerals in the slabs transform to high-pressure phases as the slab descends into the deep mantle. For example, spinel in the peridotite layer transforms to denser perovskite lithology around mantle transition zone. However, garnet, which is a major component in MORB layer, decomposes into perovskite bearing lithology in uppermost lower mantle. This difference of the depth where the perovskite appears causes a density crossover between MORB layer and surrounding mantle and induces the buoyancy force.On the other hands, subducting slabs are the place where water is transported into the mantle by hydrous phases, fluid inclusion, or impurity. Water has great influences in physical properties of minerals such as the melting point, transport properties, and phase relations even if only small amount. Although some studies have been made to determine the phase boundary of the garnet-perovskite transformation in dry-MORB system, little is known about an influence of water on this phase boundary. The purpose of this study is to examine the effect of water on the garnet-perovskite transformation in a hydrous MORB composition and discuss the density profiles of the subducting MORB layer.

High pressure and high temperature in-situ X-ray diffraction experiments were performed using a uniaxial 800-ton press (MAXIII) installed in the synchrotron radiation beamline BL14C at Photon Factory (PF) at the National Laboratory for High Energy Physics (KEK) and SPEED1500 installed in the beamline BL04B1 at SPring8. A $LaCrO_3$ cylinder with a graphite X-ray path was used as the heater and temperature was measured by a W3%Re-W25%Re thermocouple. Pressure was calibrated using the equation of state for gold (Anderson et al., 1989) from observed unit cell parameter of gold, which was mixed with sample by weight ratio of 20:1. The starting material was a synthetic anhydrous MORB glass and Ag30%Pd70% or platinum is adopted for the capsule material. About 10 wt.% of distilled water was added to the sample before the welding the capsule to prevent the formation of metastable phase when hydrous compositions are added by hydroxide such as blucite or gibbsite.

Six quench runs and two in-situ runs were performed. In the quench runs, we anneal the sample at desired P-T conditions and determine the stable phase in each condition to prevent the effect of sluggish kinetics of the transformation. In another in-situ run, we made isothermal compression or decompression and checked whether the change of diffraction pattern was occurred. There is no significant disagreement between two methods of the experiments. No peaks from minerals were observed under 1173K, and Ca-Mg-Al (CMA) perovskite was growth first at 1273-1373K in all runs. CMA-Perovskite was decomposed into garnet or perovskite bearing assembly at 1373-1473K. The phase boundary of the garnet-perovskite transformation in hydrous MORB can be expressed as $P\ (GPa) = 15.96 + 0.004T(K)$. This is about 2GPa lower than that of the dry MORB, which was determined by in-situ experiments (Litasov et al., 2004). Thus, water would enhance the subduction of the MORB layer into the lower mantle.