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# Metastable garnet in the subducted oceanic crust in the lower mantle

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The subducted slab is mainly composed of oceanic crust and the underlying peridotite layer, in which garnet and silicate spinel are the major constituent minerals, respectively, at the depth of 500-600 km. As the slab descends into the lower mantle, garnet and spinel decompose to perovskite plus aluminous phase (post-garnet transformation) and perovskite plus ferro-periclase (post-spinel transformation), respectively. These transformations involve density increase by about 10%, and therefore greatly affect on dynamics of the slab in the deep mantle. Recent high-pressure experiments on phase equilibrium suggest that oceanic crust is buoyant only between 660-720 km depth because the post-garnet transformation occurs at around 720 km depth (Hirose et al., 1999; Ono et al., 2001). However, metastability in these transformations under subduction zone conditions must be considered to understand the depth of transformations. In order to clarify kinetics of these transformations, we performed high-pressure and high-temperature in-situ X-ray diffraction experiments combined with microstructural observations of the recovered sample. Here we report results on the post-garnet transformation kinetics of pyrope and discuss presence of metastable garnet in the oceanic crust.

In-situ X-ray diffraction experiments were carried out using sintered-diamond multi-anvil apparatus MAX-III installed at KEK-PF, Japan. Edge length of the sintered-diamond anvil is 10 or 14 mm. Two pyrope garnets with different chemical compositions were used as the starting material. One is synthetic polycrystalline pyrope Mg3Al2Si3O12, and another is natural polycrystalline pyrope with a composition of (Mg0.72Fe0.17Ca0.11)3Al2Si3O12. These pyrope garnets dissociate to Mg-perovskite + corundum, and Mg-perovskite + Mg-perovskite Ca-perovskite + stishovite + NAL-phase, respectively. We observed kinetics of the post-garnet transformation at 27.0-31.0 GPa and 1273-1600K. Time-resolved X-ray diffraction profiles of the sample were taken every 10-500 seconds during the transformation. Transformation microstructures of the recovered sample were examined using SEM and TEM.

Post-garnet transformation of synthetic pyrope occurred by grain-boundary nucleation and growth mechanisms. Perovskite and corundum grew with rectangular and granular shape, respectively, thus dissociated post-garnet assemblages do not show the lamellar texture as observed in the post-spinel assemblages (e.g., Kubo et al., 2000). These observations suggest that the growth requires long-range diffusion in the post-garnet transformation. Obtained kinetic data indicates that the growth rate is time-dependent and significantly decreases with time contrary to the post-spinel transformation (Kubo et al., 2002). Time-dependent growth rate was also confirmed in experiments using natural pyrope garnet as the starting material. Consequently, the growth in the post-garnet transformation is much slower than that in the post-spinel transformation.

Observed differences in kinetics of these transformations might have important implications for dynamics of the subducted slab at the top of the lower mantle. Kubo et al. (2002) suggests that growth distance in the post-spinel transformation reaches more than 1 mm at 1000K in 10^5 years (the slab could descend vertically by 7 km with a vertical subduction velocity of 7 cm/year). It is not thought that metastable spinel exists so much. On the other hand in case that grain size of garnet is 1 mm, and temperature of the oceanic crust in the lower mantle is 1600K, the post-garnet transformation proceeds only by about 20% in 10^6 years and about 30% in 10^7 years. Thus, metastable garnet possibly exists and generates positive buoyancy force in the oceanic crust in the lower mantle, which might cause separation of the oceanic crust from the peridotite layer and formation of stagnant garnetite layer at top of the lower mantle.