Preliminary experiments on two-phase grain growth kinetics in perovskite and periclase aggregates at lower mantle conditions

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It is known that most parts of lower mantle are seismologically isotropic except for near the core-mantle boundary. Because both perovskite and periclase, which are major constituents in the lower mantle, are elastically anisotropic, the missing anisotropy in the lower mantle suggests that the deformation mechanism is thought to be diffusion creep. In the case of diffusion creep, grain size is one of important parameters affecting viscosities in the lower mantle. In order to discuss the grain size of the lower mantle, it is necessary to understand grain growth kinetics in perovskite and periclase aggregates.

In the present study, we have carried out grain growth experiments on two-phase aggregates of perovskite and periclase with changing their volume fractions at 25 GPa and 1873-2073K for 4-1200 min. High-pressure and high-temperature experiments were conducted using Kawai-type multi-anvil apparatus (QUDES) at Kyushu University. Starting materials are sintered mixtures of fine grained forsterite and enstatite. They transform to perovskite and periclase aggregates under lower mantle conditions. We have examined grain growth rates using two kinds of perovskite and periclase aggregates. One is that the bulk composition is near olivine, in which volume fractions of perovskite and periclase are 70:30 (Pv70Pc30) after the phase transformation. Another is that the bulk composition is between pyrolite and chondrite models, in which volume fractions of perovskite and periclase are 84:16 (Pv84Pc16) after phase transformation. Microtextures and grain sizes of recovered samples were observed using SEM.

We observed that the grain size of perovskite in Pv84Pc16 is generally larger than that in Pv70Pc30 at the same temperature and annealing time conditions. The grain growth kinetics is represented as $G^{n}-G_{0}^{n}=kt$, where G is the average grain size at annealing time t, G_{0} the initial average grain size, k the grain growth rate constant, and n the grain growth exponent. As a preliminary result, the n values of Pv84Pc16 and Pv70Pc30 at 1873K were determined to be 10.5 and 11.7 in perovskite, and 11.7 and 5.0 in periclase, respectively. These values imply very fine grain sizes in the lower mantle due to slow grain growth rates, which cannot explain the viscosity of the lowr mantle observed by geophysical observations.