Grain growth of Majorite

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Majorite is believed to be the most abundant mineral in the basaltic layer in the subducted slabs and main constituting minerals of mantle transition zone. The physical and chemical processes in the subducted slab depend critically upon the properties of majorite. Rheology is one of such important properties that control dynamic processes in the mantle transition zone, and it is crucial to study microstructures of majorite aggregates to address the rheology and the behaviour of the subducting slabs in the deep mantle. For polycrystalline aggregates, the grain size of the constituent crystal is one of the most important parameters that define microstructures. For example, it is well acknowledged that the transition between dislocation and diffusion creeps during deformation is essentially controlled by grain size, and the viscosity in the diffusion creep regime is defined as a function of the grain size of the constituent materials.

We believe that the grain size of majorite is a key factor to understand the rheology and resultant dynamics of subducting slabs around 660 km depth discontinuity. We thus conducted a series of high-pressure experiments at a pressure of 20 GPa and temperatures of 1673-2273 K to determine the grain growth kinetics of majorite dominant rock. In the experiments, two starting materials were prepared: one is pyrolite minus olivine powder which transformed into almost single phase of majorite at our experimental conditions and the other is MORB powder which transformed to two-phase of majorite and stishovite.

Grain-size measurements for experimental samples showed that the growth rate for single phase was higher than that of two-phase, which is consistent with the grain growth theory. This result suggests that the grain size of majorite depends on the chemical heterogeneity. Using the estimated grain size, we can assume the viscosity contrast between ringwoodite dominant rocks such as harzburgite layer and majorite dominant rocks such as basaltic layer, discuss on delamination of these two layers, and consider the density contrast between the subducted slab and the mantle transition zone