Rheology of Ringwoodite

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It is clear that the mantle transition zone is mainly composed of ringwoodite, (Mg,Fe)2SiO4. Therefore, the knowledge of the rheology of ringwoodite is very important to understand the dynamics of the mantle transition zone including the subducting slab region. We focus on two rheological properties here i) the kinetics of grain-growth in ringwoodite and lattice preferred orientation of ringwoodite and dislocation density in ringwoodite. The grain-growth kinetics controls the grain-size of ringwoodite in the mantle. The grain-size is a key parameter for the deformation of polycrystalline materials. For example, deformation mechanism for solid material is controlled by the grain-size, and the viscosity of the materials during deformation depends on the grain-size when the deformation occurs under diffusion creep regime. The lattice preferred orientation of ringwoodite influences the geodynamical observation in the mantle transition zone such as the anisotropy of the elastic wave (seismic wave) propagation. The lattice preferred orientation is considered to be caused by the deformation under dislocation creep regime and hence the observation of dislocation is important for the understanding of the mechanisms of lattice preferred orientation and deformation.

We performed high-pressure experiments by using Kawai-type multi-anvil apparatus installed at Geodynamics Research Center, Ehime University to investigate the rheological properties of ringwoodite. In a series of grain-growth experiments, we used a lanthanum chromite heater and gold capsule. Temperatures were monitored by EMF of the thermocouple located at the center of the furnace. The double capsule method was used with two starting materials of forsterite powder and San Carlos olivine powder. The experimental conditions were ~20 GPa and temperature from 1273 to 1673 K. We tried to observe the grain size variations with increasing run duration (from less than 1 hour to more than 10 hours). After experiment, recovered sample was investigated by X-ray diffraction and/or Raman spectroscopy for phase identification. Then, the grain-size was measured on the secondary electron image of polished section by an intercept method. In a series of lattice preferred orientation study, first we synthesized polycrystalline ringwoodite from forsterite powder at ~19 GPa and 1523 K for 3 hours. This synthesized ringwoodite was used as starting material for deformation experiments. The starting material was sandwiched between alumina pistons inserted in the furnace assembly. After the deformation experiments, the lattice preferred orientation was measured by using the EBSD (electron backscattered diffraction) technique at Chiba University, and dislocation in deformed ringwoodite is observed by TEM (transmission electron microscopy). Preliminary grain-growth experiments show that the grain growth rate of ringwoodite was much slower than that of olivine and similar to that of wadsleyite. This slow grain-growth suggests that the subducting slab is soft because small grain size is expected.