In-Situ Stress-Strain Measurements of Bridgmanite at the Lower Mantle Pressure Conditions

We conducted in-situ stress-strain measurements of bridgmanite using the deformation-111 type apparatus to determine the viscosity of bridgmanite at the uppermost lower mantle conditions in the dislocation creep region. The viscosity of bridgmanite would be harder than those of olivine and its polymorphs under nominally dry conditions, which is consistent with the geophysical observation. Grain-size and stress conditions of bridgmanite at the top of the lower mantle are expected by deformation mechanism maps and geophysical observations of several millimeters and ~10⁻⁴ Pa. This grain-size suggests that the main part of the lower mantle is isolated from mantle convection as primordial reservoirs.

Rheological properties, including the viscosity of the constituent mantle minerals, are fundamental to understanding the dynamics of the Earth’s mantle. The Earth’s mantle consists of upper mantle (>410 km depth), transition zone (410 km to 660 km depth), and lower mantle (660 km to 2900 km depth), which have been distinguished by seismic and mineralogical studies. The lower mantle occupies ~ 65 vol. % of Earth’s mantle. One-dimensional viscosity-depth models of Earth’s mantle proposed from geophysical observations [7] indicate that the lower mantle is the most viscous of all mantle layers, with a viscosity of 10¹⁰–¹¹ Pa·s. In addition, viscosities contrast between the transition zone and that of the top of the lower mantle have been assessed 1-2 orders of magnitude. Bridgmanite, which is (Mg,Fe)SiO₃-perovskite with space group Pbnm, is the most abundant mineral in the Earth’s lower mantle. Therefore, it is important for understanding the Earth’s mantle dynamics to know the viscosity of bridgmanite.

In the Earth’s mantle, dominant deformation mechanisms are generally considered to be diffusion creep and/or dislocation creep. The total strain (dₑₑₑₑ) during deformation is the sum of the strains of diffusion creep (dₑₑₑ) and dislocation creep (dₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑₑ.edge}