Deformation experiments of lower mantle minerals using D111 type press

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One dimensional viscosity models of the Earth’s mantle proposed by geophysical observations suggested that the lower mantle had the largest viscosity in the Earth’s mantle. In order to understand mantle dynamics in the Earth’s interior, it is important to know the viscosity of the Earth’s lower mantle. However, there are large variations of viscosity in the lower mantle between suggested models because of limitation of locations for geophysical observations. Therefore, it is important to determine viscosity of lower mantle minerals by high pressure experiments in order to discuss mantle dynamics. Bridgmanite would be the most abundant mineral in the lower mantle. This mineral could dominate the lower mantle viscosity at low strain conditions. In addition, ferropericlase, which would be the second abundant mineral in lower mantle and considered to softer than bridgmanite, might dominate the lower mantle viscosity with large shear strain condition. In this study, we conducted in-situ stress-strain measurements of uniaxial deformation experiments of bridgmanite aggregate and shear deformation experiments of post-spinel phase using D-111 type high pressure apparatus.

In-situ measurements were conducted using MAX III with D111 type guide block at PF-AR NE7A beam line. Mg-pure bridgmanite aggregates and Mg-pure post-spinel phase aggregates, which is bridgmanite and periclase mixture with 1:1 molar ratio, were used as starting material for uniaxial and shear deformations experiments, respectively. Experimental conditions are 1473-1673 K and 24-27 GPa. WC second cubic anvils with cone (6°) to take 2D X-ray diffraction, was used along X-ray path. Largest strain ε of uniaxial deformation experiments of bridgmanite reached approximately 0.3. We changed strain rate and/or temperature conditions within one uniaxial deformation experiment to determine stress-strain relationship and temperature effect precisely, respectively. Based on obtained stress exponent n and activation enthalpy H^* in this study, dominant deformation mechanisms would be dislocation creep. At normalized strain (10^{-5} /s), the creep strength of bridgmanite in this study is the largest in constituent mantle minerals reported by D-DAI apparatus. At shear deformation experiments, maximum shear strain reached around 1, which was much larger than the strain at which the hint of strain weakening of bridgmanite was observed in Girard et al. (2016) while stress of bridgmanite were almost constant until maximum strain. The obvious stress weakening of bridgmanite was not observed until shear strain ˜ 1 in this study.

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