Deformation of bridgmanite and post-spinel two-layered sample under lower mantle conditions with DT-Cup apparatus

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Abstract

Viscosity jump at 800- to 1200-kilometers depth was reported by geophysical observation recently (Rudolph et al., 2015). Due to the absence of phase transition in the main minerals, chemical deviation is one candidate explanation for the viscosity jump. A perovskitic lower mantle is consist of more than 93 vol.% bridgmanite (Murakami et al., 2012), on the other hand, subducted harzburgite layer contains ˜20 vol.% of ferropericlase (Irifune and Ringwood, 1987). Ferropericlase is likely much weaker than bridgmanite may significantly reduce the bulk viscosity of bridgmanite and ferropericlase aggregate (Yamazaki and Karato, 2001). Therefore, the viscosity of bridgmanite and ferropericlase aggregate is critical for us to understand the viscosity profile in the lower mantle.

To identify the bulk viscosity of bridgmanite and ferropericlase aggregate, two-layered sample of bridgmanite and post-spinel (bridgmanite plus ˜ 30 vol.% of ferropericlase) aggregates were deformed simultaneously. We prepared starting material of bridgmanite and post-spinel aggregates with grain size of 5-10 um at high pressure and high temperature in a Kawai-type high-pressure apparatus. Then the deformation experiments were conducted in the DT-Cup apparatus which is a development of the Kawai type multi-anvil press (Hunt et al., 2014).We deformed bridgmanite and post-spinel two-layered samples up to strain of ˜0.2 at 1500 ∘C and 25 GPa. As the identical uni-axial stress during deformation, the strengths of bridgmanite and post-spinel are inversely proportional to their strains.

The recovered bridgmanite and post-spinel samples showed virtually identical strain, which indicates similar strengths of them. Lattice preferred orientations (LPOs) of bridgmanite phase in both bridgmanite and post-spinel samples are similar developed, the slip plane of (100) is consistent with the slip system reported by Tsujino et al. (2016). Our result indicates chemical deviation in ferropericlase proportion is unable to be responsible for the viscosity jump in the lower mantle under current condition. The discordance between this study and Girard et al. (2016), who reported a marked softening of post-spinel aggregate with shear strain up to 1.0, highlights the possible importance of large shear strain in controlling the bulk viscosity.

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