Lattice preferred oriantation of bridgmanite: Implications for seismic anisotropy in the lower mantle

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The shear wave splitting ($V_{SH} > V_{SV}$) was observed in the Earth's uppermost lower mantle of Tonga-Kermadec slab region (Wookey and Kendall, 2002). The lattice preferred orientation (LPO) of lower mantle minerals formed by dislocation creep is one of the possible candidates for the cause of the observed shear wave splitting. Thus, knowledge of deformation-induced LPO of bridgmanite is the most important factor to understand the observed seismic anisotropy in the lower mantle because bridgmanite is the most dominat mineral in the lower mantle.

We carried out shear deformation experiments of bridgmanite under the lower mantle conditions (25 GPa and 1600°C) employing the deformation-DIA (D-DIA) type multi-anvil press with Kawai-type cell assembly (6-8 tpye). Dense bridgmanite aggregates, which were equigranular with typical grain size of ~15 μm and random crystallographic orientation, were used as starting materials. Both of the crystallographic orientations of the starting and the deformed samples were determined by 2D monochromatic X-ray diffraction pattern method.

In the deformation experiment, the total strain and average strain rate were evaluated to be γ ~0.7 and $\dot{\gamma}$ ~2×10^{-4} /s, respectively, from the tilting angle of the strain marker. The observation of LPO of recovered sample suggested the dominant slip system of bridgmanite is the [001](100) under the uppermost lower mantle conditions. Shear wave anisotropies $(V_{SH} - V_{SV})/V_{SV}$) with the assumption of the vertical and horizontal mantle flow were calculated basaed on the LPO of deformed bridgmanite. The result shows that the V_{SH} is ~ 1 % larger than V_{SV} in the case of horizontal flow, whereas V_{SV} is larger than V_{SH} in the case of vertical flow. It is clearly concluded that the observed shear wave anisotropy at the Tonga-Kermadec subduction zone is well explained by the LPO of bridgmanite yielded by horizontal flow.