High pressure shear deformation experiments on MgO periclase under pressure up to 120 GPa: Toward understanding anisotropy in the lowermost mantle

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Earth’s lowermost mantle shows intriguing seismic anisotropy, which can be attributed to deformation-induced lattice preferred orientations (LPO) of lower mantle minerals. Ferropericlase is one of the major minerals in the lowermost mantle and owing to its relatively weak rheological strength and high elastic anisotropy, ferropericlase has drawn much attention from geophysicists as a candidate mineral that contributes significantly to the seismic anisotropy in the lowermost mantle. However, strain rate controlled deformation experiment on ferropericlase under pressure conditions of the lowermost mantle, which is essential to understand the possible role of ferropericlase in the formation of seismic anisotropy, has been hindered by technical difficulties. Here, we conducted high pressure shear deformation experiments at controlled constant strain rates on MgO periclase under pressure up to 120 GPa, by using recently developed rotational diamond anvil cell (rDAC) combined with x-ray micro-beam diffraction (XRD) measurements at BL47XU, SPring8. For some experimental runs, an external resistive heating technique was also employed for deformation under a high temperature condition of ~500 K. Texture analysis of ferropericlase was conducted from in situ XRD patterns by using the software package MAUD. Inverse pole figures of ferropericlase after shear deformation experiments indicate inversion of the slip system from {110}<110> to {100}<110> with increasing pressure and temperature, suggesting {100}<110> is the only active slip system of ferropericlase in the lowermost mantle. Shear deformation of ferropericlase with {100}<110> slip would lead to the formation of LPO showing shear wave splitting of $V_{SH}>V_{SV}$ for lay paths parallel to the core-mantle boundary, which is consistent with the observed seismic anisotropy at the region surrounding large low shear velocity provinces.

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