

Deformation Experiments of Wadsleyite and Ringwoodite at P-T Conditions of Mantle Transition Zone using D-DIA Apparatus

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In order to perform deformation experiments of wadsleyite and ringwoodite at P-T conditions of the mantle transition zone, technical developments in high-pressure and high-temperature generation have been made adopting a recently devised multi-anvil 6-6 (MA 6-6) assembly with tungsten carbide (WC) anvils. Experiments were conducted at high pressures and high temperatures using a deformation-DIA (D-DIA) type cubic-anvil apparatus MADONNA-1500 and second-stage WC anvils with a truncated edge length of 3.0 mm. Generated pressures were evaluated at 1900-2000 K by phase transformations in compositions of San Carlos olivine and Mg₂SiO₄ forsterite to wadsleyite and ringwoodite, which are believed as the dominant minerals at the mantle transition zone. As a result, the pressure and temperature conditions available in a DIA-type cubic-anvil apparatus have been extended to 20 GPa and 2000 K.

Using the developed assembly with the D-DIA apparatus, uniaxial deformation experiments on wadsleyite and ringwoodite to strains of 9-15 % were achieved at 16-20 GPa and 1700 K and at strain rates of 3-6 x 10⁻⁵ s⁻¹. Crystallographic orientations of the deformed polycrystalline ringwoodite were successfully analyzed by the electron backscatter diffraction technique (EBSD) and the analysis indicated that lattice-preferred orientation (LPO) was not well developed in the sample. In this study, the deformation experiments on wadsleyite and ringwoodite were succeeded at P-T conditions of the mantle transition zone and at controlled strain rates for the first time. The present study extended pressure range of deformation experiments in the D-DIA apparatus from 10 GPa in early studies to 20 GPa at high temperature corresponding to interior of the earth. The experimental results demonstrate potential of the present deformation system composed of the D-DIA apparatus and the MA 6-6 assembly as an important tool to investigate rheological properties of deep mantle minerals under the P-T conditions of the mantle transition zone. Moreover, we will introduce a plan to install the D-DIA guide block to the beamline BL04B1 of the synchrotron facility SPring-8 in order to determine a stress and a strain (and a strain rate) of a sample during deformation using X-ray diffraction and radiograph, respectively.

Keywords: deformation experiment, wadsleyite, ringwoodite, mantle transition zone, D-DIA apparatus, multi-anvil 6-6 assembly