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Preliminary Experiments using the Deformation-DIA Apparatus MADONNA

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It is important to study rheological properties of mantle minerals (e.g., olivine and wadsleyite) at high pressure for understanding mantle dynamics. Pressure range of the traditional deformation experiments had been limited up to a few GPa using gas medium apparatus and Griggs apparatus. The situation was changed by developments of two types of new high-pressure deformation apparatus, namely deformation-DIA apparatus (D-DIA; Wang et al., 2003) and rotational Drickamer apparatus (RDA; Yamazaki and Karato, 2001). Both apparatus have capability to generate pressure of 16-18 GPa at high temperatures (Nishiyama et al., 2007; Nishihara et al., 2008). The D-DIA apparatus has simpler deformation geometry compared with that of the RDA. This makes it easier to interpret a lattice preferred orientation (LPO) of a deformed sample. This advantage of the D-DIA apparatus motivated us to conduct deformation experiment of mantle minerals with large strain at high pressure to study their LPO. We will report results of preliminary experiments using MADONNA, which is a D-DIA apparatus installed at Geodynamics Research Center of Ehime University.

Preliminary experiments were performed using MADONNA with a 6-6 type compression system (Nishiyama et al., 2008). We employed tungsten carbide anvils, whose truncated edge length was 4.0 mm, for pressure-generation and deformation tests. Dimensions of the cubic space compressed by first-stage anvils were evaluated by compressing stainless steel blocks and measuring their dimensions after decompression. Difference between vertical and horizontal dimensions of the cubic space was less than 20 micrometers at the press loads up to 8.00 MN. The relationship between sample pressure and press load was calibrated at room temperature by measuring electrical resistance change of ZnTe (9.6 and 12.0 GPa; Kusaba et al., 1998). Pressure generation of 12.0 GPa was observed by the electrical resistance change. No blow-out occurred during the decompression process. Preliminary deformation experiments were performed using a stainless steel block at room temperature. Deformation of the stainless steel block was monitored as advancement of upper and lower anvils using displacement sensors, and also checked by measuring dimensions of the recovered stainless steel block.

These results show capability of MADONNA to conduct deformation experiments up to 12 GPa at room temperature. Further technical development is to be done toward deformation experiments of mantle minerals and rocks under pressure-temperature conditions of the mantle transition zone and the lower mantle.