Deformation of wadsleyite using Rotational Drickamer Apparatus (RDA)

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In order to understand nature of material transport in the Earth's deep mantle, knowledge of rheological properties of mantle constituent minerals is indispensable. Rheology of material under pressures less than 3 GPa had been investigated quantitatively using conventional deformation apparatuses such as Griggs apparatus. Recently, deformation DIA apparatus (D-DIA) was developed and has been tested to achieve steady state deformation at higher-pressure and high-temperature. However, by using D-DIA, it is still difficult to do deformation at pressures above 10 GPa.

On the other hand, Yamazaki and Karato (2001) showed that steady state deformation experiments up to 15 GPa is achievable using Rotational Drickamer Apparatus (RDA). We have further developed experimental technique of deformation by RDA, and currently it is possible to generate stable high temperature and to measure state of deviatoric stress during deformation with conjunction of synchrotron (Xu et al., 2005). Using this recent technique, we have conducted 'in situ X-ray observation of deformation at high-pressure and high-temperature' on wadsleyite for several times. In this study, we present the experimental technique and some results.

In the experiments, a pair of WC anvils with 4.0 mm truncation diameter and 20 degree slope, and pyrhophyllite gasket were used. A pair of disc heaters made of TiC + diamond composite is employed within a pressure medium consisting of Al_2O_3, MgO and ZrO_2 (total thickness = 1.0-1.2 mm). In order to minimize stress gradient within a sample during deformation ring-shaped wadsleyite sample (OD = 1.6 mm, ID = 1.0 mm, thickness = 0.4) was used. Experimental conditions were up to P = 16 GPa and T = 1800 K. Conditions of deformation were 0.04-0.10 degree/min in anvil rotation speed, 3-7 x 10^{-5} s^{-1} in shear strain rate and 0.82 in maximum sample shear strain.

In situ observation of stress and strain was carried out using synchrotron radiation at Brookhaven National Laboratory, NSLS, X17B2. To determine shear stress and uniaxial stress separately, X-ray diffraction measurements were performed at six different angles with respect to the rotation axis. Strain was determined from observation of metal foil strain marker by using X-ray CCD image.

Preliminary results suggest that strength of wadsleyite is higher than olivine by 1 order of magnitude if compared at similar physical condition. This may have great importance for behavior of slab and plume at around 410-km discontinuity.