Dislocation creep of dry orthoenstatite aggregates under high *P-T* conditions

*Yumiko Tsubokawa[1], Tomohiro Ohuchi[1], Yuji Higo[2], Yoshinori Tange[2], Tetsuo Irifune[1]

1. Ehime University Geodynamics Research Center, 2. Japan Synchrotron Radiation Research Institute

Large-scale tectonic processes such as subduction of slabs depend critically on the rheological behaviour of major mantle minerals. Because olivine is the most dominant mineral under the lithospheric conditions, viscosity of dry olivine have been considered to control the strength of the oceanic lithosphere. However, this assumption needs to be reconsidered because olivine is too strong to allow the operation of plate tectonics (Kohlstedt et al., 1995). Ohuchi et al. (2011) showed that orthoenstatite, the second most abundant mineral, could be much weaker than olivine at lithospheric temperatures. Creep strength of polycrystalline orthoenstatite needs to be considered when we discuss the strength of lithosphere because mechanical data on single crystals give the upper/lower limits of the strength of orthoenstatite.

In order to determine the flow-law parameters for dislocation creep of orthoenstatite under the lithospheric conditions, deformation experiments of dry orthoenstatite aggregates were conducted at high temperatures (up to 1473 K) and high pressures (1.8-4.7 GPa) using a deformation DIA (D-DIA) apparatus combined with synchrotron X-ray radiation. Orthoenstatite aggregates, fabricated from powdered natural single crystals, were fired under controlled oxygen fugacity conditions near the FMQ-buffer to remove dissolved water in the samples. Applied differential stress and axial strain were measured using monochromatic X-ray diffraction patterns of orthoenstatite and radiograph images, respectively.

At a constant strain rate ranging from 7.7×10^{-6} to 5.2×10^{-5} s^{-1} , a steady-state creep strength (200-1200 MPa) was achieved at a strain higher than 4% during the uniaxial compression. The water content of samples was mostly less than 50 ppm (H/Si) through a sample deformation. Steady-state creep strength at each experimental conditions followed the power-law dislocation creep with the stress exponent n~3. TEM observations showed development of dislocations with the Burgers vector of either [001] or [0kl] in the recovered samples. The n and the activation energy (Q^* ~170 kJ/mol) , and Burgers vector determined in this study are comparable to those for the [001](010) slip system of dry orthoenstatite (Ohuchi et al., 2011). Viscosity of dry orthoenstatite is ~10 times lower than that of dry olivine (calculated from the flow law by Karato and Jung, 2003) under our experimental conditions (in the case of uniform stress at lithospheric conditions), suggesting that operation of plate tectonics is possible if the strength of a subducting slab is controlled by orthoenstatite.

Keywords: Deformation experiments, Orthoenstatite, Dislocation creep, Lithosphere

©2019. Japan Geoscience Union. All Right Reserved.