The 517th Geodynamics Seminar

Strength of dry orthoenstatite aggregates under the lithospheric conditions

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Large-scale tectonic processes depend critically on the rheological behavior of its constituent minerals. Because olivine is the most abundant mineral of Earth's upper mantle, 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). Recently, it is suggested that orthoenstatite, the second most abundant mineral, could be much weaker than olivine at lithospheric conditions (Ohuchi et al., 2011).
In order to determine the flow-law parameters for dislocation creep of orthoenstatite under the lithospheric conditions, dry orthoenstatite aggregates were deformed in uniaxial compression geometry at high pressures (1.8-6.6 GPa) and high temperatures (1273-1473 K) using the deformation DIA (D-DIA) apparatus combined with synchrotron X-ray radiation. 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. Steady-state creep strength at each experimental conditions and TEM observations showed that orthoenstatite deformation in dislocation creep regime. The stress exponent (n ~3) and the activation energy (Q* ~180 kJ/mol), 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, suggesting that operation of plate tectonics is possible if the strength of a subducting slab is controlled by orthoenstatite.

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