Deformation of dry orthoenstatite under high *P-T* conditions and its implication for the variation in strength of oceanic plates

*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

The initiation of subduction is a key element to understand the evolution of terrestrial planets. Because the strength of dry olivine is too strong to allow the operation of plate tectonics (Kohlstedt et al., 1995), the reason why subduction of plates was initiated in the Earth needs to be reconsidered.We hereby experimentally evaluated the creep strength of dry orthoenstatite, which is the 2nd dominant phase in the upper mantle, at pressures of 1.4-8.1 GPa and temperatures of 1290-1470 K using a deformation DIA (D-DIA) apparatus combined with synchrotron X-ray radiation.
At a constant strain rate ranging from 6.7×10^{-6} to 5.2×10^{-5} s^{-1}, steady-state creep strength of orthoenstatite followed the power-law flow law with the stress exponent of 3.1 ±0.3. Transmission electron microscopy observations revealed developments of many dislocations and the main slip system is the [001] glide on either (100) or (010) plane. The flow law for dry orthoenstatite in this study predicts that orthoenstatite is weaker than olivine at lower temperatures due to its low activation energy. Our calculations based on the obtained flow law suggest that two dry harzburgites, which are forming a load-bearing framework of strong olivine and interconnected layers of weak orthoenstatite, give the upper and lower limits of the effective thickness of the oceanic lithosphere in the world. For the onset of plate tectonics in Archean Earth, formation of the interconnected layers of orthoenstatite could allow the initiation of the subduction.

Keywords: Orthoenstatite, Dislocation creep, Oceanic plate