MECHANICAL & MATERIAL COLLOQUIUM

Investigation of mechanical behavior of olivine using in-situ synchrotron high-pressure deformation and its applications to understand how Earth works

by Jennifer Girard (Yale University)

Olivine, a major component of the Earth's upper mantle and the weakest mineral within it, is thought to control the mantle's rheology. Until recently, deformation of olivine single crystal and aggregate were mostly studied under steady state conditions, (when stress become independent of plastic strain). Transient creep (mechanical and microstructure response before reaching steady state) is mostly unknown. Transient creep is likely important in most of processes from which mantle viscosity is inferred including the post-glacial rebound. Transient and steady-state creep involve different microscopic mechanisms particularly for dislocation creep (e.g., different slip systems). An important question is either transient creep is caused by inter-granular or intra-granular deformation mechanism.

To investigate the mechanisms governing transient creep in olivine, we conducted deformation experiments on olivine aggregates (~5 µm grain-size) under upper mantle conditions (P=3-7 GPa, T~1200 ^{o}C) using DDIA. Strain-rate of ~10-5 s^{-1} was applied and stress was estimated using the radial X-ray diffraction for various diffraction planes in olivine as well as using pyrope stress sensor.

Our findings reveal a large pressure effect on Olivine aggregate transient response. The microscopic stress estimates from lattice strain in olivine aggregates vary significantly with crystallographic plane (hkl), suggesting dislocation creep. We use the stress from pyrope as an average stress acting on olivine and compare this stress with a variety of stress values on olivine estimated from different diffraction planes. We find that at low strain, among various stress values estimated for olivine, the average stress inferred from pyrope agrees with those with low stress levels (strength of soft slip systems), whereas at large strain, the average stress agrees with those with high stress (strength of hard slip systems). These results indicate that inter-granular mechanisms are key in controlling the transient creep behavior of olivine aggregates.

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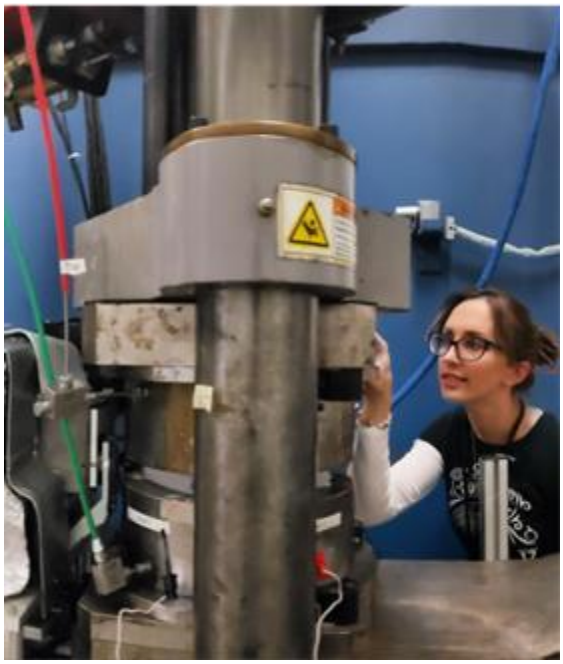

Place:
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