Materials Rheology at Extreme *P* and *T* Conditions

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Recent technical advances in large-volume high-pressure apparatuses coupled with synchrotron radiation allow investigating materials rheology at pressure (*P*) and temperature (*T*) in excess of 12 GPa and 1500°C. At high *P* and *T*, specimens of a few cubic millimetres in volume are deformed in between two alumina pistons in steady-state condition, i.e. at constant differential stress (σ) and resulting strain rate which are monitored in situ by X-ray diffraction and time-resolved radiography, respectively. Experimental *T* is measured using a thermocouple, while *P* and σ are measured from the quantification of X-ray peak shifts observed in diffraction patterns arising from polycrystalline materials placed within the cell in the compression column. *P* is deduced from materials unit cell volumes using the corresponding equations of state (EOS), while $\sigma = \sigma$BB$_{1\ \mathrm{B}}$-B$_{\ \mathrm{B}}$-σBB$_3$ is deduced from differences in the *d* spacing characterizing lattice planes in different orientations with respect to the principal stress σBB$_{1\mathrm{BB}}$ direction (see Li et al., , 2004, Phys. Earth Planet. Int., 143-144, 357). Specimen plastic strain is measured on radiographs collected on an X-ray fluorescent YAG crystal placed downstream with respect to the specimen. On the radiographs, specimen end positions are marked by X-ray absorption due to metal-foils placed in between specimen and pistons.

We used these techniques to investigate the rheology of Earth materials - $(Mg,Fe)_2SiO_4$ olivine and $CaMgSi_2O_6$ pyroxene - deformed in the dislocation creep regime at the extreme *P* and *T* conditions of the Earth upper mantle. Experiments were carried out using the Deformation-DIA apparatus (D-DIA, see Wang et al., 2003, Review of Scientific Instruments, 74, 3002) that equipped the superconducting wiggler X17B2 beamline of the NSLS (NY, USA). Run product microstructures were investigated by transmission electron microscopy (TEM). The effect of pressure on specimen plastic properties was quantified using a classical power law to interpret deformation data, i.e., through the activation volume term of an activation enthalpy. We show that increasing *P* does affect significantly olivine and pyroxenes rheology, promoting in the case of olivine a transition from dominant [100] dislocation slip at low *P* to dominant [001] slip at high *P*. This transition has strong implications on the lattice preferred orientation expected in deformed mantle rocks. We will present these results, as well as some of their consequences in terms of our present understanding of thermal convective flows in the Earth upper mantle.