Effect of pressure on olivine diffusion creep rheology: Preliminary results from Deformation-DIA experiments

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The diffusion creep in olivine is considered to have important effects on the rheology and dynamics of the upper mantle. Previous studies have investigated the effects of temperature and water content as well as the grain size dependence has also been considered. However, the effect of pressure on the rheology has not been well constrained because of large uncertainties on diffusion measurements and of the limited pressure range of the past diffusion creep studies. A recent study reported the development of large Lattice Preferred Orientation (LPO) in olivine deformed in diffusion creep regime (Miyazaki et al. 2013). This result is quite surprising considering diffusion should be isotropic in a material aggregate, and thus diffusion creep usually results in no, or weak LPO (Karato and Wu 1993).

The aim of our current study is to investigate the effect of pressure on olivine diffusion creep rheology using Deformation-DIA (D-DIA) coupled with synchrotron X-ray diffraction technique to estimate in-situ rheological properties of olivine samples. Two type of samples will be investigated and compared: fine grain San Carlos olivine (~1µm) as well as synthetic olivine Sol-Gel samples with a grain size varying between 0.2-1µm. The range of grain sizes offered by synthetic olivine Sol-Gel allow us to explore diffusion creep domain reachable in typical laboratory deformation experiments (strain rate ~10^{-5}-10^{-6} s^{-1}) and thus estimate the effect of grain size on the development of LPO.

Here we present our preliminary results obtained during D-DIA deformation experiments conducted at 6-BM,B beamline at APS. San Carlos olivine (~1µm) and olivine sol gel (~1µm) were deformed simultaneously. Platinum foil placed between samples was used as strain marker during uniaxial deformation. Strain was measured from X-ray radiography image analyses collected during deformation. Stress was calculated from X-ray diffraction performed on both olivine samples as well as a pyrope stress sensor. We demonstrate that under the same P-T conditions (~3 GPa, 1000^{o}C), olivine Sol-Gel is stronger than San Carlos olivine of same composition and grain size even at lower temperature (700^{o}C).

Karato, S.-I. and P. Wu (1993). "Rheology of the upper mantle; Sinthesis." Science **260**: 771-778.

Miyazaki, T., et al. (2013). "Olivine crystals align during diffusion creep of Earth's upper mantle." Nature **502**(7471): 321.