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Grain Boundaries in Forsterite: How do they move to produce shear?

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The plasticity of the upper mantle is fundamental to understand how mantle convection couples with plate tectonics. As olivine comprises 60 % of the upper mantle with a strong elastic and plastic anisotropy, one needs to characterize the rheology in olivine aggregates at mantle conditions. Many experiments at high pressure and high temperature have been performed. However, olivine rheology at lithospheric conditions is still poorly understood. As the pressure-temperature conditions increase from the shallower to the deeper parts of the mantle, plasticity of olivine appears to evolve, leading to fabric transitions that can potentially weaken anisotropy. Hence, knowledge of the type and strength of fabric produced by plastic deformation of olivine polycrystals is required in order to link seismic anisotropy with mantle convection.

The development of different textures in olivine assemblages has been to date largely interpreted in term of changes in the dominant slip system activity inside grains in response to changes in P-T conditions and loading, but our present understanding of dislocation creep mechanisms is not sufficient to explain some fabric changes. Recently, it has been proposed that grain boundary (GB) sliding may also produce fabric in olivine in response of differential rotation of the grains. GB activity may consequently influence the viscosity of the mantle and control the Earth's plate tectonic processes. GB displacement is at the heart of the plastic properties of polycrystals. However, it represents one of the least known parameters in GB physics and this contribution is not taken into account in any micromechanical model currently available (Finite element models, VPSC Models…).

We address the question of the GB mobility in polycrystalline olivine under stress and to quantify its contribution to the plasticity of olivine. Olivine aggregates are deformed in multianvils press in different conditions, the displacement of the GBs is measured by scanning electron microscopy done before and after the experiments. After deformation, GB migration inducing shear are measured. Those data are required in micromechanical models to incorporate the contribution of GB to the plasticity of olivine and ultimately for the viscosity of the mantle.