Rheological and microstructural development in olivine aggregates during dislocation creep under hydrous conditions

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Since hydrogen plays an important role in dynamic processes in the mantle, we conducted high-strain torsion experiments on aggregates of Fe-bearing olivine [$(Mg,Fe)_2SiO_4$; Fo50] under hydrous condition. We deformed samples to high enough strain, $\gamma \approx 5$, to achieve a steady-state microstructure.

A non-linear, least-squares fit to the stress versus strain rate data yielded a stress exponent of $n \approx 5$ and a grain size exponent of $p \approx 0$, indicating that our samples deformed by dislocation creep. Fabric analyses of the polycrystalline olivine samples, determined using electron backscatter diffraction (EBSD), demonstrate that the lattice preferred orientation (LPO) of olivine changes as a function of strain due to competition among three slip systems: (010)[100], (100)[001], and (001)[100]. Observed strain weakening can be attributed to geometrical softening due to development of a LPO, which reduces the stress by ~1/3 from its peak value in constant strain rate experiments. The evolution of fabric can be applied to investigations of upper mantle seismic anisotropy especially in a mantle wedge or in a shear zone, locations in which hydrous conditions prevail.

Reference□M. Tasaka, M. E. Zimmerman, and D. L. Kohlstedt (2016), JGR, 121, doi:10.1002/2015JB012134.