

Rheological weakening due to phase mixing of olivine + orthopyroxene

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The formation of well-mixed, fine-grained, poly-phase rocks may lead to strain localization and play a key role in the development of the lithosphere asthenosphere boundary (LAB). To understand the mixing process in the olivine + orthopyroxene rocks, we have conducted torsion experiments on samples of iron-rich olivine + orthopyroxene aggregates at a temperature of 1200 °C and a pressure of 300MPa. We fabricated the samples with grain sizes significantly larger than the steady state grain size. The samples were deformed to total shear strains up to $\gamma = 17$. We conducted two series of torsion experiments, the first at fixed strain rate to different strains and the second at different strain rates to the same strain.

The stress exponent of $n \approx 3$ and grain size exponent of $p \approx 1$ were determined from a least-squares fit to the strain rate, stress and grain size data using a power-law creep equation; these values of n and p indicate that our samples deformed by dislocation-accommodated grain boundary sliding. Dynamic recrystallization occurred with significant grain size reduction of both phases in deformed samples. Well-mixed microstructures develop in samples deformed to higher strains at faster strain rates, whereas elongated olivine and pyroxene grains without a mixed texture are observed at lower strain and strain rate. Mixing of the olivine and orthopyroxene phases occurs due to a contribution of interface-reaction-limited diffusion (IRLD) creep [Sundberg and Cooper, 2008]. This IRLD creep process involves diffusion of metal oxides along phase boundaries oriented perpendicular to σ_1 to boundaries parallel to σ_1 resulting in the formation of new pyroxene grains along boundaries perpendicular to σ_1 and olivine grains along boundaries parallel to σ_1 . Grain size reduction due to dynamic recrystallization of olivine and orthopyroxene enhance the rate of this process.

Keywords: olivine, opx, deformation, mixing process