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Microfabric development in dunite during high stress deformation and subsequent recrystallization

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The microfabric development in dunite is analyzed in non-steady state deformation and annealing experiments, which are designed to simulate earthquake-driven episodic creep in the upper mantle of the oceanic lithosphere at the base of the seismogenic zone. The samples are deformed in a servohydraulically-controlled solid medium deformation apparatus at a temperature of 600°C, a constant strain rate of 10-4s-1 (kick) and a confining pressure of 1.0 GPa. In some experiments deformation is followed by annealing for 15 h to 70 h at zero nominal differential stress, temperatures of 800°C to 1000°C (kick & cook) and 2.0 GPa confining pressure. We use coarse-grained dunite from the Almklovdalen peridotite complex (Western Norway) as starting material. The dunite comprises ca. 90% olivine, <10% orthopyroxene and small amounts of spinel and chlorite. The kick experiments yield maximum differential stress of ca. 1 GPa and < 20% of permanent strain. The resulting microfabrics are analysed by optical and electron microscopic techniques. Intragranular microcracks and micro-shear zones in olivine, which can be crystallographically controlled, developed during deformation. After annealing at 1000°C, the microfabric is characterized by very fine-grained recrystallized olivine grains with an average diameter of ca. 5 μm. The recrystallized grains are arranged along micro-shear zones and occur in aggregates surrounding olivine porphyroclasts. The area fraction of recrystallized grains is varying but generally smaller than 20%. The microfabrics from our experiments compare well with microfabrics observed from naturally deformed peridotites of the Baldissero, Balmuccia and Finero complexes in the Western Alps. Similar olivine recrystallization aggregates in naturally deformed peridotites are frequently interpreted as indicative of deformation by dislocation or diffusion creep. The microfabrics of our kick & cook experiments indicate a development through an initial stage of high stress semi-brittle deformation followed by recrystallization at low stress.