EGU2020-9462, updated on 08 Dec 2022
https://doi.org/10.5194/egusphere-egu2020-9462
EGU General Assembly 2020

Strain dependent microfabric evolution of experimentally deformed synthetic eclogites

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Deformed eclogites often reveal interconnected layers of omphacite and intercalated elongated garnet clusters. The evolution of such fabrics is usually associated with strain localization and rheological weakening. To better understand the onset of strain localization in eclogite, we experimentally investigate the strain-dependence of microfabrics in omphacite-garnet aggregates. Eclogites were synthesized by hot-pressing omphacite-garnet powders (with a volume fraction of 25% garnet) in a piston-cylinder press at 3 GPa and 1100 °C for 24 h. These synthetic eclogites were then axially shortened by ~3.5%, ~4.7%, ~17% and ~40% in a Griggs-type deformation apparatus at 2.5 GPa, 900°C, and a strain rate of $6.4 \cdot 10^{-6}$ s^{-1}. The low-strain experiments document microstructures developing near the material's yield point at ~4% axial strain, whereas the highly strained samples reached nearly mechanical steady state with minor strain weakening. The recovered samples were analyzed using an X-ray microtomography instrument (µCT) which provides quantitative volume, shape and spatial arrangement data in three dimensions. By utilizing optical light microscope, scanning electron microscope and electron backscatter diffraction analyses in combination with the µCT data we identified the dominant deformation mechanisms operating at different strains and linked them to the microfabric. At low strain, omphacite exhibits a weak shape preferred orientation (SPO) and garnet tends to form clusters. The highly strained samples show a strong foliation with elongated omphacite crystals exhibiting a pronounced SPO and garnet clusters being arranged into elongated layers perpendicular to the maximum compressive stress. A reduction in grain size and an increase in density of low-angle grain boundaries with increasing strain indicate deformation of omphacite by dislocation creep. Elongated garnet clusters show brittle deformation in the form of micro-cracking. Evidence for minor crystal-plastic deformation in garnet occurs locally at the proximity of the grain boundaries where high differential stresses tend to localize resulting in increased misorientation. Similar to naturally deformed eclogites, we observe a layering of omphacite and garnet in our experimental samples, in which omphacite generally accommodated most of the strain while garnet grains behaved essentially like rigid bodies.