



Phase mixing in upper mantle shear zones: Olivine nucleation during dynamic recrystallization of orthopyroxene and clinopyroxene porphyroclasts

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Small grain size and a well-mixed phase assemblage are key features of upper mantle (ultra)mylonitic layers. In those layers, Zener pinning inhibits grain growth, which could lead to diffusion creep. This increases the strain rate for a given stress significantly. Prerequisite is phase mixing which can occur by dynamic recrystallization (dynRXS) plus grain boundary sliding (GBS), metamorphic or melt/fluid-rock reactions, creep cavitation plus nucleation, or by a combination of those processes. In order to get insights into the interplay of phase mixing and dynRXS we investigate microfabrics (EBSD, optical microscopy) displaying the transition from clasts to mixed assemblages. Samples are taken from the Lanzo peridotite shear zone (Italy).

Olivine dynamically recrystallizes from protomylonitic to ultramytonitic samples. Its grain size varies systematically between monomineralic (~20 μ m) and polymineralic layers (~10 μ m). Olivine is the dominant mixing phase for both, dynamically recrystallizing orthopyroxene (ol~55vol.%) and clinopyroxene clasts (ol~45vol.%). In contrast, recrystallizing olivine clasts show little evidence of phase mixing. In phase mixtures, olivine neoblasts show weak (J-index ~1.8) C-Type and weak (J-Index ~1.5) B-type CPO's. Both types suggest the presence of water during deformation.

Isolated, equiaxial orthopyroxene clasts are present in all samples. DynRXS of opx starts in mylonites. Some clasts and tips of extensively elongated opx bands (max. axial ratios 1:50) are bordered by fine-grained (min. ECD~5 μ m) mixtures of olivine, opx \pm anorthite/ cpx/ pargasite. Mixing intensities seem to depend on the connection to the olivine-rich matrix. Clast grain boundaries are highly lobate with indentations of secondary phases (mostly olivine). Opx neoblasts have no internal deformation and show large misorientations close to their host clast (misorientation angle >45° at ~20 μ m distance). Their grain shape is either flat and elongated or equiaxial. Both shapes have lobate boundaries. Their CPO depends on the host clast orientation. In ultramytonites, opx bands disappeared completely.

Clinopyroxene porphyroclasts dynamically recrystallize in protomylonite to ultramytonite samples. Olivine is the dominant mixing phase (~45vol.%). Cpx mixed area grain sizes tend to be coarser (~10 μ m) than in corresponding opx areas (~6 μ m). Ultramytonitic cpx-ol assemblages have a higher mixing percentage (phase boundaries/grain boundaries ~70%) than mylonitic assemblages (~40%).

In the mylonitic layers, clusters of cpx neoblasts form 'walls' parallel to their host grain borders. Olivine neoblasts between these clusters show no CPO. The overall cpx CPO varies from [001] perpendicular and [010] parallel to the foliation with (J -Index ~2.5) to [100] perpendicular and [001] parallel to the foliation (J-Index ~1.2).

Beside few thoroughly mixed areas, bands of cpx+ol and of opx+ol are still distinguishable in ultramylonitic layers. This suggests their origin to be dynamically recrystallized opx and cpx clasts. Therefore, phase mixing is assumed to occur simultaneously to clast recrystallization. Beside a small gradient of opx/cpx abundance depending on the distance from their host clast there is little evidence for phase mixing by dynRXS+GBS only. High abundances of olivine neoblasts at grain boundaries of recrystallizing clasts and their instant mixed assemblage with host phase neoblasts suggest phase mixing being strongly dependent on olivine nucleation during dynRXS of opx and cpx.