EGU24-13072, updated on 17 Feb 2025
https://doi.org/10.5194/egusphere-egu24-13072
EGU General Assembly 2024

Poseidon's seismic breadcrumbs: ultracataclasite vein evolution within a granodiorite along the Naxos Detachment System

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Ultracataclasites and pseudotachylytes often reflect localized deformation due to coseismic slip and the temporal evolution of seismogenic fault zones. Interaction of these structures and their mechanisms of nucleation and propagation into crustal rocks remain poorly constrained. Herein we conducted a microstructural analysis on a series of ultracataclasitic veins within a deformed granodiorite on Naxos, Greece. The island is a classical Miocene Cycladic metamorphic core complex, with migmatites and the granodiorite at its core. The Naxos detachment dissects the granodiorite, producing a strong N-S stretching lineation and SCC' fabric indicating top-to-N kinematics. The granitoid cooled rapidly from crystallization (650-680°C) at c. 12 Ma to <60°C by c. 9 Ma. The investigated ultracataclastic veins are slightly anastomosing and oblique to the main foliation fabric in the granodiorite. Petrographic analysis of the granodiorite shows a coarse-grained (50 µm–2 mm) host rock matrix primarily composed of quartz, albite, orthoclase, hornblende and biotite, intersected by the fine-grained (5–60 µm) ultracataclasitic veins of the same composition. Quartz grains within the host rock occur as inequigranular, interlobate to amoeboid shaped grains exhibiting a shape preferred orientation that defines the foliation and appears to flow around larger feldspar porphyroclasts. Bulging and subgrains within the quartz grains are indicative of dynamic recrystallization. Albite occurs as subhedral porphyroclasts displaying undulose extinction, subgrains with fuzzy boundaries, tapered deformation twins, and bookshelf microfracturing. Orthoclase porphyroclasts within the host rock are subhedral to sigma-shaped, exhibiting undulose extinction with small subgrains (<50 µm) near the clast rims and vein margins. All feldspar porphyroclasts in the host rock are heavily fractured with increasing density proximal to the veins. Electron backscatter diffraction (EBSD) mapping of quartz, albite and orthoclase directly crosscut by the ultracataclastic veins reveals variations in relative phase deformation. Larger host rock quartz grains (50–300 µm) reveal internal lattice distortions (max. misorientations of ~20° relative to the grain average orientation) and low angle grain boundary (LAGB) development, with LAGB density and misorientation degree increasing towards grain edges. Smaller quartz grains (5–25 µm) display a moderate crystallographic preferred orientation and minimal misorientation (max. 8°). EBSD mapping of albite and orthoclase porphyroclasts (100 µm–1 mm) evinces crystal-plasticity in the form of a linear to heterogeneous misorientation pattern, with a maximum misorientations of ~38° and ~27°, respectively. Smaller grains of albite and orthoclase (<50 µm) with scattered orientations occur at clast rims and vein tips, and display a

maximum misorientations of ~10° and ~15°, respectively. The localized subgrain structures observed in the feldspar are suggestive of dynamic recrystallization. The veins crosscut these recrystallized zones, suggesting propagation occurred after recrystallization of the feldspar. LAGB development is also observed in the feldspar clasts with increasing density towards the clast rims. The co-occurrence of fractures from dislocation and crystal-plastic microstructures in the feldspar porphyroclasts is indicative of fracture propagation in the brittle-ductile regime of feldspar (450–600°C). It remains equivocal whether the ultracataclastic material was injected into pre-existing fractures or the injection of the material induced fracturing within the host rock.