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Mid-crustal shear zone formation in granitic rocks: constraints from quantitative textural and crystallographic preferred orientations analyses

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Mechanisms leading to strain localization in the continental crust are still a matter of debate. Quantitative textural and crystallographic preferred orientation (CPO) analyses of an Alpine amphibolite facies (490°C, 7.3 kb) shear zone allow to emphasize the role of deformation mechanisms on strain accommodation and texture evolution, during mid-crustal shear zones formation in homogeneous granitoids. The studied meter-scale ductile strain gradient is developed in the Fibbia granite (Gotthard massif, Central Alps), and is characterized with increasing strain by a drastic grain size reduction and a complete recrystallization of the magmatic minerals.

Deformation starts in closed-system condition with the formation of fine-grained plagioclases (Ab-Pl) shear-bands that wrap around stronger coarse-grained quartz (Qtz)-aggregates and K-feldspar (Kfs) porphyroclasts, leading to strong local stress concentrations and high viscous strength contrast between the Qtz-Kfs-load bearing framework and Ab-Pl-softer domains. With increasing strain, Qtz and Kfs recrystallize via dislocation creep as suggested by CPOs and the development of monomineralic porphyroclast-derived banded structure. On the other hand, plagioclases-bearing shear-bands are characterized by diffusional mass transfers and grain boundary sliding deformation mechanisms. Contrasting rheological behaviours of each microstructural domain induce at this stage a high partition of the deformation.

Increasing shear strain allows fluid circulation and the opening of the system. Mylonites formation is coeval with the re-equilibration of the centre of the shear zone. The break-down of monomineralic aggregates induces stress relaxation and considerably decreases the strength of the rock. The initial load-bearing framework composed of strong monomineralic aggregates evolves toward an interconnected layer of weak multiphase matrix, where the texture is characterized by a homogeneous micron-scale grain size. Granular flow is the dominant deformation mechanism in the ultramylonite and plays an important role in the continued activity of the shear zone. Whereas that the small-scale deformation partitioning ceases abruptly in the centre of the shear zone where stress is relaxed, the shear zone margins can continue to widen via chemical softening process like thermodynamic re-equilibration of the deformed rock, and allows the shear zone to propagate laterally.