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Strain rate dependent calcite microfabric evolution at natural conditions

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Crystal plastic deformational behaviour of calcite has been the focus of many experimental studies. Different strain rates, pressure and temperature conditions have been addressed to investigate a wide range of deformation regimes. However, a direct comparison with natural fault rocks remains difficult because of extreme differences between experimental and natural strain rates.

A flanking structure developed in almost pure calcite marble on Syros (Cyclades, Greece). Due to rotation of a planar feature (crack) a heterogeneous strain field in the surrounding area occurred resulting in different strain domains and the formation of the flanking structure. Assuming that deformation was active continuously during the development of the flanking structure, the different strain domains correspond to different strain-rate domains. The outcrop thus represents the final state of a natural experiment and gives us a great opportunity to get natural constraints on strain rate dependent deformation behaviour of calcite. Comparing the microfabrics in the 1 to 2.5 cm thick shear zone and the surrounding host rocks, which formed under the same metamorphic conditions but with different strain rates, is the central focus of this study.

Due to the extreme variation in strain and strain rate, different microstructures and textures can be observed corresponding to different deformation mechanisms. With increasing strain rate we observe a change in dominant deformation mechanism from dislocation glide to dislocation creep and finally diffusion creep. Additionally, a change from subgrain rotation to bulging recrystallization can be observed in the dislocation creep regime.

Crystallographic preferred orientations (CPO) and the grade of intracrystalline deformation were measured on a FEI Quanta 3D FEG instrument equipped with an EDAX Digiview IV EBSD camera. At all strain rates clear CPOs developed leading to the assumption that calcite preferentially deforms within the dislocation creep field. However, we can also find clear evidence for grain size sensitive deformation mechanisms at smaller grain sizes (3.6 μm) consistent with experimental observations and determined flaw laws.

The results of this study are compared with experimental data, closing the gap between experimental and natural geological strain rates.