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Strain rate dependent calcite microfabric evolution - an experiment carried out by nature

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The deformation behaviour of calcite has been studied experimentally in detail. Different strain rates and pressure and temperature conditions have been used to investigate a wide range of deformation regimes/mechanisms. However, a direct comparison with natural fault rocks remains difficult because of the extreme differences between experimental and natural strain rates.

An a-type flanking structure developed in calcite-marbles of the Pyrgos unit, on Syros, provides a natural laboratory for directly studying the effects of strain rate variations at constant P-T conditions. The rocks of the Pyrgos unit underwent Eocene blueschist-facies metamorphism, resulting in coarse grained recrystallized marbles. During the subsequent greenschist-facies overprinting, the flanking structure started to form adjacent to a several meters long cross-cutting element (CE), which rotated into the shear direction, developing an antithetic offset. Comparing the microfabrics in the 1-2 cm thick CE mylonites and in the surrounding host rocks, which formed under the same metamorphic conditions but with different strain rates, is the central focus of this study.

Numerical models have shown that a-type flanking folds form with a background shear strain of only about 1-2. However, the displacement along the CE varies between 60 and 120 cm, resulting in shear strains between 30 and 120. Assuming that all the deformation took place during the same event, significant strain rate variations (1 to 2 orders of magnitude) must have occurred between the CE and the host rock.

Due to the extreme variations in strain and strain rate, different deformation mechanisms and types of dynamic recrystallization were active, leading to the development of different microstructures and textures. With increasing strain, the dominant deformation mechanism changed from twinning to dislocation glide and –climb and finally to diffusion creep. Additionally, a change from subgrain rotation to bulging recrystallization can be observed in the dislocation creep regime.

Textures and the degree of intracrystalline deformation have been measured by electron back scattered diffraction (EBSD). While the host-rock grains do not show any significant crystallographic preferred orientation (CPO), those within the CE show a clear preferred orientation of both the c- and a-axes. Depending on the degree of recrystallization, the orientation of the c-axis changes from oblique to perpendicular to the CE-boundary while the a-axes begin to form a girdle within the CE-boundary.

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