Twinning and fracturing during cataclasis in carbonate fault gouge

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Gouges and cataclasites are a common product of faulting in the brittle upper crust. Natural fault gouges often contain minerals with strong anisotropies, such as cleavage in phyllosilicates and twinning in carbonates. A proper understanding of the role of such anisotropies during shearing is important to develop realistic microphysical models of brittle fragmentation and grain size reduction.

Here we present initial results of microstructural and coupled EDS-EBSD analysis on mixtures (50/50wt%) of calcite-dolomite gouges deformed experimentally in a rotary shear apparatus (SHIVA, INGV-Rome) under constant normal stress of 17.5 MPa and slip rates of 30 µm/s to 1 m/s. Simultaneous collection of EDS and EBSD data allowed twin and phase identification (calcite and dolomite) at spatial scales approaching ~1 µm. A new workflow was implemented in MTEX allowing EDS-EBSD data to be cleaned and post-processed to correctly index calcite and dolomite in >95% of cases.

At all investigated slip velocities, twins in calcite grains are mainly oriented in a direction consistent with the imposed shear sense. Microfractures are closely spaced and mainly oriented along synthetic R'-type shear planes. Only in a few cases were microfractures observed to exploit calcite twin planes. Fracturing results in elongate clast shapes (in 2D) and quantitative image analysis shows the development of two clast-shape preferred orientations: 1) clasts with long-axes subparallel to the principal R'-type fracture set, and 2) clasts with long axes subperpendicular to the principal R'-type fracture set. This may be explained by systematic fracturing of clasts along R'-planes and subsequent rotation of the newly formed, elongate grains in to a "stable" orientation during cataclastic flow. Fracturing, followed by the formation and rolling of elongate clasts would promote dilation during cataclasis and a progressive change in the frictional properties of the carbonate gouge. Incorporating these mechanisms together with other physico-chemical processes active at high slip rates will provide a more complete model of gouge friction evolution in carbonate rocks.