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Nano-analytics of natural quartz deformation microstructures at the brittle-viscous transition

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Identification of deformation mechanisms of quartz during mylonitization, and especially of the grain-scale interplay between brittle crystal-plastic processes, has different relevant implications: e.g., on understanding the efficiency of fluid mobility through deforming quartz that can dramatically influence the rheology and the degree of chemical exchange.

Here we present preliminary results from quartz veins deformed under greenschist facies conditions in the Schober Group (Hohe Tauern mountains in the Central Eastern Alps). The study is particularly aimed at understanding the degree of involvement of microfracturing and fluid-rock interaction during initial stages of shear localization and onset of dynamic recrystallization. SEM-cathodoluminescence (CL) imaging reveals details that are critical to the interpretation of microstructures. The study includes the first high resolution EBSD analysis based on the CMOS camera technique.

In polychromatic CL images the coarse-grained quartz vein crystals show CL intensity variations related to different deformation microstructures. Even when the optical light microscopic microstructures indicate crystal plastic deformation CL gives evidence of a precursor brittle stage at least for some of the deformation microstructure. A dark CL shade correlates with localized discrete zones of dynamic recrystallization within the protolithic coarse-grained quartz with its bright CL reflecting a change in trace element (Ti) concentrations. High fluid inclusion density along grain boundaries and subgrain boundaries in recrystallized domains suggests an important role of fluids in promoting the compositional change during quartz deformation possibly aided by the initial brittle stage.

The follow up of this preliminary study will be downscaling the analysis from micro- to nano- or even atom-scale in order to understand how aqueous fluids interact with microstructures and substructures (microcracks, grain boundaries, subgrain boundaries and dislocations) during the operation of different deformation mechanisms, and how fluids can access the interior of quartz grains eventually resulting in resetting of the trace element compositions (e.g. Ti). In addition to NanoSIMS analysis (spatial resolution 1 μm), we plan to carry out atom probe tomography (APT) in order to get information about the Ti distribution at the atomic scale.