Inside the fault core in the footwall of Simplon Fault Zone (Central Alps): ductile to brittle deformation history shown by fault gouge

Valentina Argante¹, David Colin Tanner¹, Christian Brandes², Christoph Von Hagke³, and Sumiko Tsukamoto¹

¹Leibniz Institute for Applied Geophysics, Geochronology, Hannover, Germany (valentina.argante@leibniz-liag.de)
²Institute für Geologie, Leibniz Universität Hannover, Callinstrasse 30, 30167 Hannover, Germany
³ University of Salzburg, Department of Geography and Geology, Hellbrunner Straße 34, 5020 Salzburg, Austria

For thorough understanding of the dynamics of mountain building processes, it is crucial to reconstruct the youngest crustal deformation history over time. Low-angle normal faults are features caused by orogen-parallel extension, which occurs in the last stage of collision. Low-angle normal faults play a key role in the exhumation of the lower crust and they are the reason for most of the seismicity within the chain.

We carried out microstructural analyses on an outcrop in the footwall of one of the major normal faults of the Alpine chain, the Simplon Fault Zone. This low-angle normal fault extended the crust by tens kilometers and it caused exhumation of its footwall, the deeper lower crust of the Alps, i.e. the Penninic nappes. The Simplon Fault Zone itself consists of a thick mylonitic zone overprinted by a narrow cataclastic zone, with the same kinematics. Its timing evolution history from ductile to brittle deformation is still under discussion. This study shows a new microstructural analysis from a fault gouge within the footwall of the northern part of the Simplon Fault Zone, and how it can reconstruct the different stages of exhumation history of this shear zone.

Results from micro-structural analyses show grain boundary migration features on folded quartz veins. This suggests that the protolith of the fault zone was at high temperature conditions, T>600°C, during dynamic deformation. This folding belongs to extension-parallel folds that affect only the ductile shear zone. The presence of greenschist facies minerals suggests that the rock was exposed to low temperature and pressure conditions (T=300-400°C, P=0.2GPa). Pressure-solution mechanisms affect both quartz and greenschist paragenesis, indicating formation in a shallow position of the shear zone. The last deformation was purely brittle, as shown by vertical calcite veins or fractures in quartz. It suggests a near-surface position of the fault.

Altogether, these multiple deformation phases within the gouge samples indicate a continuous exhumation history from high to low temperatures, with clear cross-cutting relationships. However, the lack of cataclasite features can be related to an involvement of the rocks within the fault core in a subsequent stage of deformation. To explain this we suggest a model in which the footwall maintained a high temperature over a long time, which inhibited cataclastic processes.