Title:
Evolution of microfabric of faults in the Opalinus Clay from the Mont Terri Underground Research Laboratory (CH): insights from multiscale studies using Ion Beam polishing and electron microscopy.

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Main Text:

Slickensided shear surfaces are ubiquitous in deformed clay-rich materials, however the evolution of these structures is poorly understood, and the interaction of crystal plasticity in clays, particle reorientation, grain size reduction, cataclasis, mineral transformation and neoformation is subject of debate.

We studied well preserved samples from the Main Fault, a 3 m wide fault zone of approximately 10 m offset in the Mont Terri Underground Research Laboratory (CH), a site to evaluate long-term safety of radioactive waste disposal. The samples contain many slickensided shear surfaces, which can be classified according to colour, shininess, orientation, presence of steps. All slickensides show reverse dip slip movement, with tool tracks of less than two cm.

Transmitted light microscopy of ultra-thin sections show that individual slickensides appear on surfaces of fractures which form during sampling, along micro- shear zones which are usually less than 2 μm thick, containing clay particles with a strong preferred orientation subparallel to the shear zone. A number of shear zones are wider, with widths < 1 mm which contain veins with fault-parallel host rock inclusions.

Broad-ion beam polishing perpendicular to the slickensided surfaces and Scanning Electron Microscopy show that the shear zone with the transition between undeformed matrix and strongly deformed gouge is often less than 1 μm thick. In this transition zone a complex set of processes is inferred, leading to strong grain size reduction with clay particles below 100 nm, formation of

calcite-enriched zones and strong particle preferred orientation. First results by Transmission Electron Microscopy show a thickness of only 100 nm, in which parallel oriented nano-sized mica and illite particles are detected.

We discuss processes of localization during incipient faulting in mudrocks at about 1.5 km depth, episodic fluid flow and resealing, and the formation of slickensided surfaces in deformed mudstones.

References:

Nussbaum, C., Amann, F., Aubourg, C., and Bossart, P., 2011, Analysis of tectonic structures and excavation induced fractures in the Opalinus Clay, Mont Terri underground rock laboratory (Switzerland): Swiss Journal of Geosciences.