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Cycles of brittle deformation and fluid pulses in an active fault: A window through space and time

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A prominent NW-SE striking fault was studied in the western Swiss Alps (Gemmi Pass). It is 2.5 km long, runs perpendicularly to the regional fold axes and cuts through the Helvetic nappe stack. Geomorphology and trenching indicate a postglacial activity of this fault. In the trench, for example, a 20 to 30 cm thick loess layer overlaying moraine material shows disruption and displacements directly above the fault. The position and orientation of the fault speaks against gravitational reactivation. The area analyzed is characterized by high uplift rates (1.5 mm/a near Brig, Schlatter & Marti 2002) and a concentration of earthquake occurrence (e.g. Deichmann et al. 2004), indicating that the fault might still be active. A close examination of the fault rocks, however, reveals a long term evolution of this fault starting already at a late stage of Alpine nappe emplacement and related deformation.

The fault is characterized by a high density of fault-parallel joints and veins that become less abundant away from the fault zone. Initially the fault originated as a-c joints forming an array with variable widths of 10-20 m. With progressive deformation, the joints connected in the center of the array generating a major 1-3 m wide large-scale fault zone. Deformation associated dilatancy and the presence of a fluid resulted in filling of the newly formed cavities by calcite. Cathodo-luminescence on the vein filling shows zonation and subsequent disruption by brittle deformation as it is indicated by the existence of discrete cataclastic areas. Several cylces of veining and brittle deformation can be observed. Changes in cathodofacies suggest variations in fluid chemistry pointing to episodic fluid pulses. The youngest deformation features in these fault rocks are micro-scale faults impregnated by iron-hydroxide bearing minerals. Kakirites are absent which suggests that they have low preservation potential in carbonate rocks. This could be due to syndeformational dissolution of the fine grained fault gouge, or recent erosion.

To summarize, this example of an active fault allows to study active and ancient deformation structures/processes that occurred at shallow and greater depth, respectively. We expect that the episodic cycles of brittle deformation and fluid pulses forming veins and cataclasites equivalent to the older structures observed at the surface, were ongoing at a few kilometers depth during the time of post-glacial activity. Given the regional seismicity pattern we might conclude that such veining and cataclasite formation in depth is still recurring and in concert with this earthquake activity.

References:

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