Neotectonics in the Swiss Alps - A late Alpine to postglacially active fault at the Gemmi Pass

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The area of the central and western Swiss Alps reveals not only the highest uplift rates of Switzerland (1.5 mm/a near Brig, Schlatter & Marti 2002), but also shows a strong concentration of earthquakes (e.g. Deichmann et al. 2004). This raised the question, whether the region hosts any linear topographic expressions that can be attributed to motion along potentially seismogenic faults. The area was therefore chosen for the investigation of postglacially active lineaments. Firstly, aerial photographs from the entire area were searched for linear features, which could be of gravitational or tectonic origin. Subsequently, selected lineaments were visited in the field to study their origin. We found scarce but positive evidence for neotectonic fault movements. One particular lineament that exhibited the most promising exposures was investigated in greater detail.

This lineament is a prominent NW-SE striking fault located at the Gemmi Pass, runs perpendicularly to the regional fold axes and cuts through the Helvetic nappe stack. The position and orientation of the fault discounts gravitational reactivation.

A close examination of the fault rocks reveals a long term evolution of this fault starting already at a late stage of Alpine nappe emplacement and related deformation.

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 centre 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 is indicated by the existence of discrete cataclastic areas. Several cycles of veining and brittle deformation can be observed. Changes in cathodofacies suggest variations in fluid chemistry pointing to episodic fluid pulses.

The fault crosses a small (~60m x 30m) postglacial, sediment-filled depression, which was targeted for a large trench (15.4 m long, 2 m wide and up to 2.2 m deep) in order to verify its postglacial reactivation.

The trench bottom reached limestone bedrock almost all along the trench. The base of the sediment-fill of the depression is made of an up to 1.5 m thick dark brown moraine layer. A very constant 20 to 30 cm thick, finegrained (silt to fine sand fraction), yellow, loess-like layer was sedimented on top of the moraine. It has a sharp upper contact, whereas the basal contact to the moraine material is sometimes unclear. This yellow layer delineates the basin form as well. An up to 1.5 m thick grey-brown sequence of colluvial-like slope wash deposits is overlaying the yellow loess layer. This horizon shows onlap-structures onto the loess at both sides of the basin. The uppermost 5 to 15 cm are made up by the active soil layer.

A cataclastic fault zone disrupts the partly karstified limestone bedrock in one location on the trench floor. This 40 cm wide zone is split in the middle by an open joint or fault plane. No vertical surface displacement was seen on the bedrock surface.

Right above this fault zone, the about 50 cm thick moraine layer does not show any disturbances. However, the yellow “loess” layer, which represents a very continuous horizon in the trench with a clear upper surface, is heavily disrupted, incorporating moraine material from below and displaying flame-like structures and up to 5 cm large vertical displacements at its upper boundary. These structures can not be explained by any sedimentary or erosional processes and are not found elsewhere in the trench. These observations indicate strike-slip kinematics, which would also be favoured by the recent stress field. The overlaying colluvial-like slope wash deposits are deformed only at the boundary to the “loess” layer. Some centimetres above the contact they are not disrupted, thus sealing the movement. Samples for optically stimulated luminescence (OSL) dating of the “loess” layer and the colluvial like sediments were taken in order to limit the age of the movement. The “loess” samples yielded late-glacial ages whereas the overlying colluvial sediments are sub-recent (latest Holocene). This proves the postglacial activity along the fault.

To summarize, this example of an active fault allows studying 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 kilometres depth during the time of post-glacial activity. Given the regional seismicity pattern we conclude that such veining and cataclasite formation at depth is still recurring and in concert with this earthquake activity.

Schlatter, A. & Marti, U. 2002. Neues Landeshöhennetz der Schweiz LHN95. Vermessung, Photogrammetrie, Kulturtechnik 1, 13–17.

Deichmann, N. et al. 2004. Earthquakes in Switzerland and surrounding regions during 2003. Eclogae geologicae Helvetiae 97-3, 447–458.