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Thermochronological evidence for a continuous transition from ductile to brittle deformation in the Simplon low-angle normal fault, Central Alps

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Major low-angle normal faults juxtapose different structural levels of the crust that record both brittle and ductile deformation. However, field relationships alone cannot establish if these different responses to deformation represent parts of a single continuous process or if they correspond to two separate events, with the later, more discrete brittle detachment exhuming a fossil ductile shear zone from depth.

The Simplon fault is one of several well exposed low-angle detachments that developed in the Alps as the result of orogen-parallel extension during the Oligo-Miocene. It shows a transition in the footwall from a broad ductile mylonite zone to a discrete brittle detachment with identical kinematics. Although it is generally accepted that the brittle detachment was active during the late Miocene, the absolute age of the ductile shear zone has not been unequivocally determined and has remained controversial, with some models proposing an earlier Lower Oligocene development (e.g. Steck and Hunziker 1994) and others considering it to be part of a continuous transition from ductile to brittle behaviour during exhumation in the Miocene (e.g. Grasemann and Mancktelow 1993).

New $^{40}Ar/^{39}Ar$ dating of white mica and biotite from both footwall and hanging wall provides tighter constraints on the timing of ductile shearing, exhumation and cooling related to the Simplon fault. In the southeast, recrystallized muscovites from high

grade mylonites yield cooling ages reflecting shear zone activity from 20 to 14 Ma. The age of new white micas that grew synkinematically in the mylonites varies from 14 Ma in the SE to 10 Ma in the NW, indicating a lateral and temporal evolution of distributed deformation within the Simplon fault. Zircon fission track ages reflect different exhumation paths from footwall and hanging wall and indicate a transition to brittle faulting mainly localized on the detachment at around 8-12 Ma.

Overall the new data argue for a continuous transition from ductile shearing to a more localized zone of brittle deformation within the same geological framework over a period of ca. 15 Ma during the Miocene. The Simplon fault is therefore an example of a telescoped crustal section of a single major low-angle fault rather than a two-stage structure involving exhumation on a brittle fault of an earlier inactive ductile shear zone.

References

Grasemann, B., Mancktelow, N.S. 1993. Two-dimensional thermal modelling of normal faulting: the Simplon Fault Zone, Central Alps, Switzerland. Tectonophysics 225, 155-165.

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