Reconstruction of distinct faulting events in the Eastern Alps by low-temperature geochronology

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By applying distinct thermochronological methods with closure temperatures ranging from ~200° to ~40°C we reveal the thermochronological evolution of the eastern part of the Eastern Alps. Zircon and apatite fission track, and apatite U/Th-He thermochronology were carried out on host rocks and fault- related rocks (cataclasites and fault gouges) directly adjacent to the undeformed host rock along two major fault zones in the Eastern Alps – the Lavanttal Fault zone, and the Mölltal Fault. This provides the reconstruction of faulting activity and a general cooling and exhumation history of fault zones and adjacent units.

Along the Lavanttal Fault Zone Apatite fission track protolith ages range between 51.1±2.3 and 37.7±4.3 Ma. Single grain ages from cataclasites display two dominant age clusters around 56.1±4.2 and 8.6±2.6 Ma. The apatites of the younger age population are characterized by reduced track lengths and low Dpar values (< 2µm). These ages are interpreted to reflect faulting- related resetting along the Lavanttal Fault Zone. The apatite fission track ages also document that crustal blocks in the eastern parts of the central Eastern Alps do not show significant vertical movement during the main phase of orogen- parallel lateral extrusion. U/Th-He ages show a weighted mean age within the host rock of 11.8±0.8. We presume that this age reflects the final cooling of the Austroalpine basement through the He partial retention zone (~40°C) and the related final exhumation. The timing of this faulting increment also coincides with a phase of disintegration of the Styrian and Lavanttal sedimentary basins. Continuous subsequent faulting along the Lavanttal Fault Zone is documented both by partial annealing of AFT single grain ages and total resetting of U/Th-He ages within cataclasites. From these data fault activity can be recorded for a time span of at least 10 Ma from Early Middle to Lower Miocene times, i.e. from ~12 to ~2 Ma.

Along the Mölltal Fault fission track and apatite (U-Th)/He data constrain and refine the near-surface exhumation of the southeastern part of the Tauern Window and neighbouring Austroalpine basement units. Two Phases are distinguished. During phase 1 exhumation on both sides of the Mölltal Fault conforms with the period of lateral extrusion and tectonic denudation of the Tauern Window between 22 and12 Ma. The jump to higher ages occurs within the Austroalpine unit along the Polinik fault zone, which therefore defines the boundary between the tectonically denuded units and the rather stationary orogenic lid. Phase 2 is defined by very young (U-Th)/He ages in the Sonnblick dome within the Tauern Window, showing a second exhumation pulse at around 6 Ma, which is interpreted as a result of local tectonic complications along an extraction fault.

Based on these data we conclude that the units at the eastern margin of the Eastern Alps, adjacent to the Lavanttal Fault Zone, did not show significant vertical movement during the formation of the Tauern Window during orogen-parallel extrusion in Early Miocene times. Final cooling and exhumation, however, is recorded from the Tauern Window to the Eastern margin of the Alps from 12 Ma onwards, probably related to final phase of faulting affecting the entire Eastern Alps east of the Tauern Window.