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Tectonics and landscape evolution in the Gurktal Alps: New data, models and open questions

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The Gurktal Alps are a key region to understand the tectonic and geomorphological evolution of the Eastern Alps but their exhumation, erosion and (de)glaciation history remain poorly constrained. Here we present (a) new low-temperature thermochronological data and thermokinematic models that provide new insights into the tectonic evolution of the Eastern Alps (Wölfler et al., 2023), (b) the first catchment-wide ^{10}Be-derived erosion rates from the Nock Mountains (Hampel et al., submitted) and (c) the first ^{10}Be surface exposure ages from glacially polished quartz veins (Wölfler et al., 2022).
With respect to the exhumation history, our thermochronological data and thermokinematic models revealed that Austroalpine units located at a high structural level and farther away from the Adriatic indenter cooled through the zircon fission track (ZFT) closure temperature in the Late Cretaceous and have resided at depths of ≤6-7 km since then. Thermokinematic modelling constrained that these units experienced enhanced exhumation between ∼99 and ∼83 Ma due to syn- to late-orogenic Late Cretaceous extension. After a phase of slow exhumation, the exhumation rate increased to ∼0.16 km/Ma at ∼34 Ma due to the onset of the Europe-Adria collision. In contrast, ZFT ages from units at a lower structural level and near the indenter indicate cooling during the Eocene. These units were rapidly exhumed from ∼44 to ∼39 Ma during an Eocene phase of shortening prior to the Europe-Adria collision. After slow exhumation between ∼39 and ∼18 Ma, the exhumation rate increased to ∼0.27 km/Ma in the wake of Miocene escape tectonics in the Eastern Alps.
A comparison between exhumation rates derived from thermochronology and catchment-wide ^{10}Be erosion rates reveals that long-term and short-term erosion rates are remarkably similar. In the central Nock Mountains, the average ^{10}Be erosion rate (~170 mm/ka) is almost identical to the average exhumation rate since the Oligocene (~160 mm/ka). The southern Nock Mountains show a higher ^{10}Be rate (~200 mm/ka) and a higher long-term exhumation rate (~270 mm/ka). The agreement between short-term and long-term erosion rates suggests that average erosion rates in the Nock Mountains did not change significantly during the late Cenozoic.
Our ^{10}Be exposure ages from glacially polished quartz veins provide the first quantitative age constraints on the deglaciation history in the Gurktal Alps, where mapped and modelled LGM and Late-Glacial ice extents show large discrepancies. According to our data, deglaciation of the Gurktal Alps occurred between 16 and 14 ka, which questions the mapped LGM extent (van Husen, 2011) but agrees with predictions from ice-sheet models (Seguinot et al., 2018). This finding suggests that ice-sheet models may have overestimated the LGM ice extent in the easternmost Alps. Our results highlight the need for more age data from the eastern Alps and for a reappraisal of the LGM ice extent and the deglaciation history. Our own future work will include additional sampling in the former region of the Drau valley glacier and in the Lavanttal Alps.

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