

The Inventory of Cosmogenic Nuclides in River Sediment and the Denudation Rates of the Central Alps of Switzerland

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We present a denudation rate North-South transect through the Swiss Central Alps, and show that denudation (chemical and physical) correlates in space with recent rock uplift rates. This result emerges from a study of in situ-produced cosmogenic ¹⁰Be in river-borne quartz from >50km² Central Alpine catchments. Quartz from river sediment has been shown to provide a spatially-averaged denudation rate that in the Alps integrates over a time-scale of 10² to 10³ years (von Blanckenburg 2005). Therefore a denudational tool is at hand that allows us to shed light on interactions between long-term topography-forming processes and short-term factors destroying topography.

However, the application of this method in presently uplifting and fast-eroding mountain belts like the Central Alps as never been evaluated in a systematic manner. We therefore took care to investigate the potential influence of shielding from cosmic rays provided by recent glaciation, to calculate a possible memory from LGM glaciation, to identify the appropriate watershed sizes for systematic sampling, and to perform corrections for snow cover and topographic shielding.

Denudation rates of transect watersheds are amongst the highest ever measured in similar complex settings. They yield a mean of 0.27±0.14 mm/yr for the Alpine foreland, where integration times are 2-8 ky, and of 0.9±0.3 mm/yr for the high crystalline Central Alps, where integration times are 0.5-1.5 ky. The measured cosmogenic nuclide-derived denudation rates are in good agreement with post-LGM lake infill rates (Hinderer 2001) and significantly higher than recent denudation rates from river loads (Schlunegger & Hinderer 2003). We attribute this discrepancy to differences in methodology and integration time scale. They are in the same range as denudation rates from apatite fission tracks that record denudation 3-5 Ma ago.

We show that denudation rates correlate with hillslopes in the Mittelland catchments, but they are independent of slope in the high Alps. We interpret this with the high Alpine landscape being at threshold hillslope, where slopes cannot increase any further before failure occurs. In general, denudation rates are high in areas of high relief, high altitude, and high rock uplift rates. All these parameters are also highest where crustal thickness is largest (Figure 1). Therefore, a major driving force for rock uplift and concomitant denudation must be isostatic compensation. However, given that crustal thickening of the Alps has all but ceased, the relief-forming events that set the rate of denudation and uplift must be presented by transient perturbations, such as glacial erosion that act on the time scale of climate cycles.

Our study is a first attempt at demonstrating that cosmogenic nuclides can be used to determine denudation rates from active, glaciated mountain belts with all their

complexities. A much higher level of detail is required, however, to link denudation rates to the geomorphic processes taking place in a specific setting.

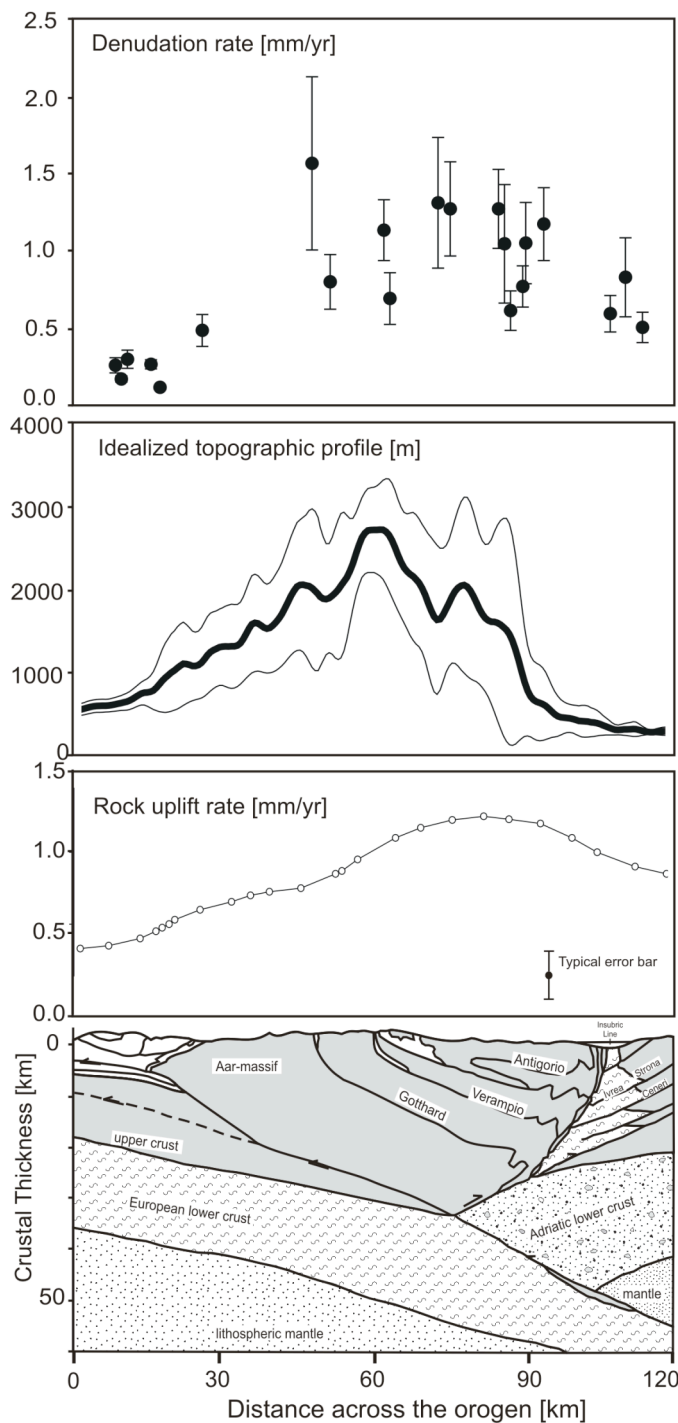


Figure 1. (A) Denudation rates from cosmogenic nuclides along a North-South Transect through the Central Alps. (B) Average elevation and range envelopes along the transect (C) Recent rock uplift rates (Kahle et al. 1997). (D) Idealised depth structure.

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