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Enhancing rates of erosion and uplift through glacial perturbations

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Research over the past decade has shown that the pattern of modern rock uplift in the Swiss Alps correlates with both long-term (thermochronometers) and short-term (cosmogenic nuclide-derived denudation rates, sediment loads, lake fills) measures of erosion. This correlation has been attributed alternately to isostatic causes (compensation to erosion and/or glacial unloading) and tectonic forces (ongoing collision and partial delamination). Of these potential driving forces, only isostatic compensation to erosion fits all available structural, geodetic, and flexural models.

We explore this uplift-erosion relationship by analyzing river channel steepness for Alpine rivers. Zones of oversteepening, and hence enhanced stream power, are associated with glacial erosion and deposition during LGM and earlier glaciations, resulting in the focusing of erosion into the inner gorges which connect hanging tributary valleys to the main glacial trunk valley. These inner gorges are transient zones in which fluvial and hillslope processes are in the process of re-adjusting this glacially perturbed landscape. Bedrock properties also play a major role in the response time of these adjustments. Glacially generated knickzones are located within 5 km of the trunk stream in the Rhone valley where resistant lithologies dominate (gneiss), whereas the knickzones have migrated as much as 10 km or further in the less resistant rocks (buendnerschists) of the Rhine valley.

We suggest that the rock uplift pattern is controlled by surface denudation as set by the glacial-interglacial history of the Alps. Rapid, focused erosion results in rapid rock uplift rates in the Central Swiss Alps, where glaciers were most active. An interesting ramification of this reasoning is that in the absence of glacial perturbation, both rock uplift rates and denudation rates would be substantially lower in this isostatically compensated mountain belt.