



After the ice: Geomorphic processes and rates in Alpine settings following deglaciation

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The modern Alpine landscape is inextricably linked to its glacial past. Repeated glaciations during the Pleistocene have excavated large volumes of rock and sediment to create typical glacial valley topographies. Mapping of the Pleistocene bedrock surface reveals abundant over-deepened valleys, bedrock knobs, and narrow slot canyons. This bedrock surface is overlain by up to 100s of meters of glacial till and stream sediments, representing the cumulative glacial deposition up to the Last Glacial Maximum, LGM. The effect of repeated glacial-interglacial cycling is the creation and preservation of locally transient landscapes. These can take the form of either sediment sinks such as over-deepened valleys and cirque basins, or sediment sources such as over-steepened streams and supra-threshold hillslopes. Throughout the European Alps, many modern streams either flow on or are incised into these glacial surfaces. The valley flanks of large glacial valleys and incised rivers are an important sediment source in the Alps. Post-glacial rates of mass wasting from inner gorges are commonly 4-10x higher than for the surrounding landscape. Large scale landsliding and sackungen are also prevalent, and can result in extreme pulses of sediment delivery to the streams.

Variations in the long-profile geometry of Alpine streams indicate where the channels have been most perturbed. The highest density of over-steepened stream segments coincides with the thickest LGM valley glaciers, and zones of rapid modern rock uplift. Based purely on stream power calculations, these should also be highly erosive reaches. Basin averaged erosion rates also reach maximum values where the density of over-steepened streams is the highest. This all points to the importance of not glacial erosion or fluvial erosion individually, but the combination of the two. The high erosion rate measured in the European Alps result from fluvial and colluvial processes acting on a glacially perturbed landscape.