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Geomorphic controls on Pleistocene knickpoint migration in Alpine valleys

Kerry Leith (1,2), Matt Fox (3,2), Jeffrey R Moore (4,2), Julian Brosda (1), Michael Krautblatter (1), and Simon Loew (2)

(1) Chair of Landslide Research, Technische Universität München, Munich, Germany, (2) Geological Institute, ETH Zurich, Zurich, Switzerland, (3) Berkeley Geochronology Center, UC Berkeley, Berkeley, USA, (4) Geology and Geophysics, University of Utah, Salt Lake City, USA

Recent insights into sub-glacial bedrock stress conditions suggest that the erosional efficiency of glaciers may reduce markedly following a major erosional cycle [Leith et al., 2013]. This implies that the formation of large glacial valleys within the Alps is likely to have occurred shortly after the onset of 100 ky glacial-interglacial cycles (at the mid-Pleistocene Revolution (MPR)). The majority of landscape change since this time may have therefore been driven by sub-aerial processes. This hypothesis is supported by observations of hillslope and channel morphology within Canton Valais (Switzerland), where major tributary valleys display a common morphology along their length, hinting at a shared geomorphic history. Glaciers currently occupy the headwaters of many catchments, while the upper reaches of rivers flow across extensive alluvial planes before abruptly transitioning to steep channels consisting of mixed bedrock and talus fan deposits. The rivers then converge to flow out over the alluvial plane of the Rhone Valley. Characteristically rough topographies within the region are suggested to mark the progressive transition from a glacial to fluvially-dominated landscape, and correlate well with steepened river channel sections determined from a 2.5 m resolution LiDAR DEM. We envisage a landscape in which ongoing tectonic uplift drives the emergence of Alpine bedrock through massive sedimentary valley infills (currently concentrated in the Rhone Valley), whose elevation is fixed by the consistent fluvial baselevel at Lake Geneva. As fluvial incision ceases at the onset of glaciation, continued uplift causes the formation of knickpoints at the former transition from bedrock to sedimentary infill. These knickpoints will then propagate upstream during subsequent interglacial periods. By investigating channel morphologies using an approach based on the steady-state form of the stream power equation, we can correlate steepened channel reaches (degraded knickpoints) across most major tributaries south of the Rhone River. The timing of apparent uplift events correlates well with that of cool Marine Isotope Stages derived from global oxygen isotope data up to the beginning of MIS 12. A weak correlation up to the beginning of MIS 18 suggests initial glacial incision may have occurred some time during MIS 14 - 20, and valley development has since been driven by fluvial processes.

Leith, K., J. R. Moore, F. Amann, and S. Loew (2013), Sub-glacial extensional fracture development and implications for Alpine valley evolution, J. Geophys. Res. Earth Surf., doi:10.1002/2012JF002691.