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Long-term fluvial adaptation to post-glacial landscapes of the Ladakh Himalaya: processes, rates and timescales

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Both glacial and fluvial processes are well recognised as key elements in moulding landscapes in high mountain environments – rivers transmit baselevel change signals through such landscapes and flush sediment out of mountain belts and into basins, while glaciers are highly efficient erosional agents and producers of sediment, capping relief production and directly coupling landscape erosion to climatic change. However, little research has focussed on the manner in which these two agents of landscape change interact, especially on longer timescales.

We use a suite of catchments draining the previously glaciated Ladakh batholith in the northwest Indian Himalaya, which preserves the oldest known moraine succession in this mountain chain, to describe and quantify for the first time the rates, processes and timescales of postglacial recovery of a fluvial system across an unprecedented time interval of 10^5 – 10^6 years. Catchments which show significant modification by glacial scouring share a common long profile form, with a flattened headwater reach creating a broad convexity in the middle section of the channel, downstream of which the channel has a concave up geometry and flows entirely on loose sediment. However, channel concavities downstream of such convexities in the channel long profile are systematically and nonlinearly elevated above the expected value range of 0.3 – 0.6. The measured concavity increases with increasing glacial influence on the catchment, as measured by relative position of the long profile convexity in the long profile. This result constitutes the first direct evidence that glacial modification of the upper reaches of a catchment in the form of subglacial abrasion by glaciers can have profound first order influence on the hydraulic scaling of the channel downstream.

The exceptional age of this post-glacial landscape also allows us to show that the response time of these systems as they recover must exceed 500 ka, longer than any previously reported estimate for recovery times from glaciation, but comparable with estimates from many tectonically perturbed landscapes. Similarly, maximum rates of river incision in this landscape are $c.$ 1 mm/y, comparable with rates derived from many tectonically perturbed settings.