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Knickpoint retreat rates from cosmogenic 10Be; 30 exposure ages from western Scotland with implications for paraglacial bedrock incision

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When a bedrock river is perturbed by accelerating rock uplift the perturbation is not transmitted instantaneously to the whole landscape; the new base level information must first spread through the channel network to hillslopes. Under detachment-limited conditions the new base level information is spread via knickpoint retreat, the rate of which ultimately governs response times to perturbation and therefore landscape evolution. Yet, owing to difficulties with measuring rates of erosional processes, knickpoint retreat rates are not widely documented.

We examine bedrock river response to rapid, continuous rock uplift due to glacio-isostatic rebound following retreat of the Late Devensian icesheet from northern Britain. From four rivers in western Scotland, we infer knickpoint retreat rates from 30 measurements of cosmogenic 10Be concentrations on abandoned, fluvially-sculpted bedrock surfaces downstream of Holocene knickpoints. These data are among the first direct evidence that terrace exposure ages increase downstream consistent with the progressive abandonment of bedrock surfaces in the wake of a retreating knickpoint. We reflect upon our results in the context of paraglacial conditions that we infer to have involved initially high sediment flux declining over the Holocene. A simple unit stream power model is used to demonstrate how knickpoints affect erosional capacity along transient reaches. Bedrock channel width is insensitive to substrate erodibility, but we document here a sharp reduction in channel width at knickpoints, which is largely responsible for up to order-of-magnitude increases in stream power per unit area of the channel bed.

The high rates of bedrock river incision that we document for postorogenic western Scotland are comparable to those reported for landside-dominated mountain belts. However, rather than stemming from towering relief or high-magnitude rock uplift, these rapid erosion rates seem to be the product of high sediment flux following icesheet decay. We speculate that paraglacial bedrock incision may contribute significantly to postglacial sediment flux in many high latitude landscapes.