Contrasting millennial-scale sediment dynamics across the Main Divide in the Southern Alps of New Zealand

Arindam Biswas*[1,2], Louise Karman-Besson[2], Anne Guyez[3], Svenja Riedesel[4], Steven A. Binnie[5], Kevin Norton[6], Reka Fülöp[7], Bonnet Stephane[2], and Tony Reimann[4]

[1]Institute of Geography, University of Cologne – Germany
[2]Géosciences Environnement Toulouse – Université de Toulouse – France
[3]Laboratoire d'études en Géophysique et océanographie spatiales – Université de Toulouse – France
[4]Institute of Geography, University of Cologne – Germany
[5]Institute of Geology and Mineralogy, University of Cologne – Germany
[6]Geo- and Environmental Research Centre, University of Tübingen – Germany
[7]Australian Nuclear Science and Technology Organisation – Australia

Abstract

Disentangling hillslope process domains from bulk sediment signals remains a fundamental challenge. Cosmogenic nuclide methods integrate erosional signal across millennial timescale and entire catchments, lacking a grain-scale resolution to reconstruct sediment transport histories in highly eroding landscapes. We combine in-situ cosmogenic 10Be and 14C measurements with single-grain K-feldspar luminescence-based proxies (proportions of bleached and saturated grains) from modern fluvial sediments to distinguish diffusive from landslide-dominated hillslope processes and to quantify hillslope-channel coupling across catchments spanning the Main Divide in the Southern Alps of New Zealand.

In west-flowing catchments (NZW), saturated and bleached grain fractions increase and decrease, respectively, with increasing 10Be erosion rates. 10Be/14C ratios fall below the 0.31 production-rate threshold, suggesting landslide input. Additionally, short cosmogenic burial durations (_~0.3–3 ka) indicate efficient hillslope-to-channel sediment transfer with minimal intermediate storage. In the east-flowing catchments (NZE), neither luminescence proxies correlate with 10Be erosion rates. 10Be/14C ratios greater than 0.31, and burial durations are longer (_~3–9 ka), reflecting a storage-buffered, decoupled routing system. Apparent luminescence ages (NZW:_~17–64 ka; NZE:_~8–45 ka) exceed cosmogenic burial durations in both regions, in NZW due to saturated grains from landsliding, and in NZE due to partially-bleached grains from pre-burial rapid mass-wasting events that reached saturation during subsequent storage.

These findings reveal two distinct geomorphic states: an efficiently coupled, landslide-driven system in NZW and a storage-dominated system in NZE, demonstrating that integrating cosmogenic nuclide analysis with single-grain luminescence-based proxies provides a better understanding of sediment dynamics in actively eroding mountain landscapes.

*Speaker

Keywords: Erosion rate, hillslope processes, sediment storage, single grain luminescence, hillslope channel coupling