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Does luminescence of modern fluvial sediments vary according to erosion rate? A comparison between single-grain feldspar p-IRIR dose distributions and 10Be cosmogenic catchment-wide erosion rate in the Southern Alps of New Zealand

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The Southern Alps of New Zealand are among the world's most active mountain ranges, with extremely high rates of exhumation and erosion. This place is therefore well suited to observe and comprehend sediment production at catchment scale and to study Quaternary landscape evolution.

Common methods to quantify erosion of a landscape include estimation of the suspended sediment yield (SSY), which is a proxy for short-term erosion rates, or measurement of cosmogenic ^{10}Be concentrations in fluvial sediments, a demanding method that offers reliable erosion rates representative of larger time-span (millennial). Here, we propose single-grain post-infrared luminescence (SG-pIRIR) as a potential new proxy for erosion rates. We test this approach by comparing SG-pIRIR results with catchment-wide erosion rates obtained using conventional ^{10}Be measurements for eight catchments of the New Zealand Southern Alps.

^{10}Be results demonstrate North-South and East-West gradients in erosion rates, ranging from 0.2 to 4.0 mm/yr, with the fastest towards South-West.

The North-South gradient is consistent with existing data of Larsen et al., (2014), that present even higher rates to the south of our study area. We suggest that spatial gradient in erosion rate reflects a tectonic uplift gradient related to northward segmentation of the Alpine fault, coupled to an East-West climatic gradient, related to orographic effect.

Recently, luminescence signals have been proposed as a new tool to study exhumation, exposure histories and erosion, with various approaches including luminescence-depth profiles (Sohbati et al., 2018), luminescence thermochronometry (Herman and King, 2018) or direct relations between quartz luminescence sensitivity and erosion rates (Sawakuchi et al., 2018). Here, we tested the potential of equivalent dose (D_e) distributions obtained using SG-pIRIR as a proxy for catchment wide erosion rates.

We measured SG-pIRIR D_e distributions from modern fluvial sediments at the outlets of the eight catchments where we estimated ^{10}Be erosion rates. For each of the samples, we calculated the fraction of grains whose luminescence signal is saturated (Bonnet et al., 2019; Guyez et al., 2022) and the fraction of well-bleached grains from D_e distributions. In addition, we characterized the D_e distribution using central age model (CAM; Galbraith et al., 1999) and bootstrapped minimum age model (MAM; Cunningham et al., 2012). We found a relationship between those four proxies and erosion rates obtained from conventional ^{10}Be approaches, but also with SSY (Adams, 1980; Hicks et al., 2011) and channel steepness index. These results confirm the potential for this new tool to inform on catchment-wide erosion rates.

Further work should be undertaken to test this relation in other settings, and also to better comprehend the interplay of processes affecting luminescence signals of feldspar grains in fluvial deposits, with the perspective to use it as an independent reliable tool to reconstruct and possibly quantify erosion and transport processes in a wide range of fluvial settings.