Moraine crest or slope? An analysis of the effects of boulder position on cosmogenic exposure age



Moraine crest boulders

250 m

Fig. 1. Typical sampling approach



Tomkins, M.D¹., Dortch, J.M²., Hughes, P.D¹., Huck, J.J¹., Pallàs, R³., Rodes, Á⁴., Allard, J.L¹., Stimson, A.G¹., Bourlès, B⁵., Rinterknecht, V^{6,7}., Jomelli, V⁷., Rodríguez-Rodríguez, L⁸., Copons, R⁹., Barr, I.D¹⁰., and Darvill, C.M.¹

1 University of Manchester, **2** Kentucky Geological Survey, **3** Universitat de Barcelona, **4** SUERC, **5** CEREGE, 6 University of St Andrews, 7 Université Paris 1 Panthéon-Sorbonne, 8 Universidad de Oviedo, **9** Snow and Mountain Research Centre of Andorra, **10** Manchester Metropolitan University

Motivation

Moraine erosion can bias results of terrestrial cosmogenic nuclide (TCN) dating

Methods which minimise the probability of selecting a "**bad**" boulder have the potential to significantly improve the robustness of TCN datasets

Current criteria for boulder selection have good qualitative reasoning, but have not been tested quantitatively. These include, and are often prioritised, as follows:

Top Priority Moraine crest¹

Then... Tallest² Flat, stable surface³ Biggest¹ Embedded in matrix⁴ Well-rounded \rightarrow Ping, not a thud⁵



Models of moraine evolution predict the greatest erosion at moraine crests^{6,7,8,9}

However, these areas are preferentially sampled for TCN due to perceived stability¹



Moraine crests: priority targets or "no-go" areas for TCN sample selection?

Approach

Selected **five moraines** of varying age and geomorphology (lateral, terminal, latero-frontal)

Combined published and new ¹⁰Be TCN ages (n = 17) with rock surface weathering estimates (*R* values) generated using the **Schmidt Hammer** from boulders on moraine crests (C) and inner (IS) and outer slopes (IS). In total, 635 boulders were sampled (19,050 *R*, **Fig. 1**)

R values correlate strongly with ¹⁰Be ages for granitic rocks ($R^2 = 0.96$, p < 0.01, n = 52)¹⁰ and are used here as a **proxy for exposure age (Fig. 2)**

Calculated landform ages using **P-CAAT** (EP31D-2325, Fig. 3) and assessed the spatial distribution of "good" (within 2σ of landform age) and "bad" boulders (outside 2σ) using global and local Moran's I



Results





Pick the landform, not the boulder

Prioritise landforms that stabilised rapidly after deglaciation

Consider moraine sedimentology Matrix-poor, boulder-rich moraines (e.g. OPN) may stabilise rapidly^{4,11} while matrix-rich moraines (e.g. Aranser) may erode through time ¹²



Question 3: Are exhumed boulders more common on moraine crests or moraine slopes?

Don't over-prioritise boulder location Other criteria may be more effective at isolating "bad" exhumed boulders

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