Quantifying long-term processes of moraine evolution: Implications for cosmogenic isotope dating and moraine age interpretations

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Summary

Ice-marginal moraines are classic features of glaciated mountain ranges and can provide important information on the growth and decay of glaciers and ice sheets through the Quaternary and the palaeoclimatic drivers of glacial cycles. However, while the timing of moraine deposition can be estimated using terrestrial cosmogenic nuclide (TCN) dating, pre- or post-depositional processes (e.g. inheritance, shielding, erosion, exhumation) can profoundly influence TCN age distributions and can account for apparent TCN ages that pre- or post-date the assumed age of the landform. Many criteria exist to avoid samples influenced by geologic uncertainty, but while these have good qualitative reasoning, few have been tested quantitatively[1].

This project focused on a fundament component of TCN sample selection: the relative utility of moraine crest and moraine slope sampling. Moraine crests are preferentially sampled due to perceived stability but moraine degradation models[2] and lichenometric data[3] predict the greatest ground lowering at moraine crests as they stabilise and degrade through time. This dichotomy between model predictions and sampling procedures was tested using ^{10}Be dating and Schmidt hammer (SH) sampling of five moraines in the Pyrenees, France/Spain. In total, 645 moraine boulders were sampled (~19,050 SH R-values) across moraine crests and ice-proximal and -distal slopes, and with calibrated exposure ages estimated using a ^{10}Be-SH calibration curve[4]. Landform ages were calculated using Gaussian decomposition[5] (see Fig. 1), while the spatial distribution of calibrated exposure ages was analysed using global and local Morans I spatial autocorrelation.

These data show that there is no clear penalty to moraine crest sampling, as the distribution of calibrated exposure ages is comparable between moraine groups (see Fig. 2). Instead, differences between landforms appear far more significant than differences at the intra-landform scale, as matrix-poor, boulder-rich moraines stabilised rapidly after deglaciation (see Fig. 1B), while matrix-rich moraines deposited at the LGM exhibit strong negative skew, in line with exhumation models (see Fig. 1C). This work indicates that landform selection should be prioritised in future work.

Value

In total, this project was based on 13 days of fieldwork and was used to extend the scale and scope of my PhD analysis. BSG funding was used to support specific field costs (accommodation, travel). This work was presented at INQUA Dublin 2019 and the AGU Fall Meeting 2019 in San Francisco and was included in the PhD thesis (Doctorate awarded in April 2020). These data are currently been prepared for publication.

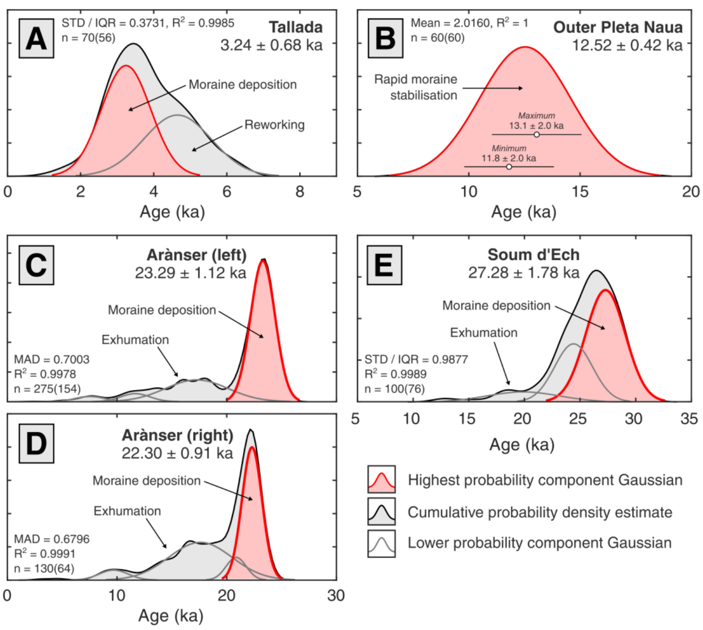

Figure 1. Gaussian decomposition of calibrated exposure ages[5].

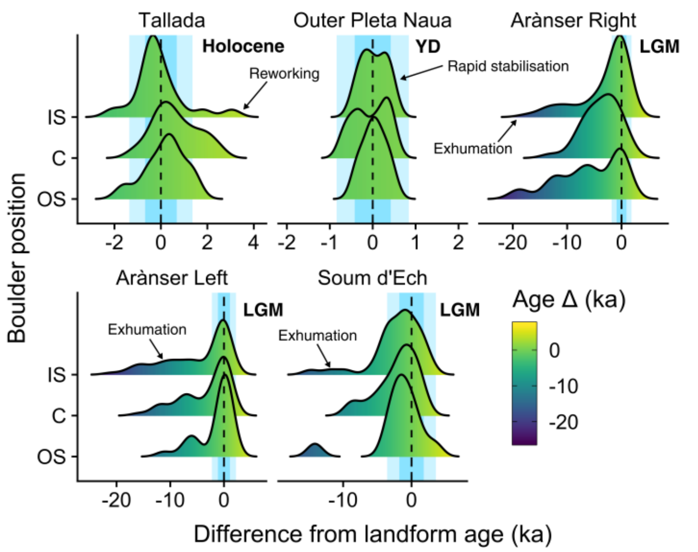

Figure 2. Distribution of calibrated exposure ages for moraine crests (C), inner ice-proximal slopes (IS) and outer ice-distal slopes (OS).

References

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