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Constraining the timing of last glacial plucking of tors on Cumberland Peninsula, Baffin Island, Eastern Canadian Arctic

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Highly-weathered rock outcrops (tors) often occur on regolith-covered, low-relief upland plateaus in formerly glaciated polar landscapes. Owing to their advanced weathering degree and lack of glacial erosional or depositional features, they have traditionally been interpreted to have escaped ice sheet coverage as nunatak refugia for flora and fauna. However, in many places terrestrial cosmogenic nuclide (TCN) exposure dated erratic blocks deposited on the regolith and the asymmetric streamlining of tor outcrops allude to past ice coverage. Complex cosmic ray exposure histories of ice cover have been deciphered using two radiogenic nuclides with dissimilar decay rates. However, while ^{26}Al/^{10}Be ratios can indicate that the rock had been previously buried by ice, the ratios alone cannot determine *when* the cover occurred. Thus, interpretation that ice cover occurred during the last glacial maximum (LGM) may be flawed.

We have developed a novel approach to interpret ratios of TCN in the context of complex exposure histories accounting for recurring burial by cold-based ice and address the problem of episodic glacial plucking. First, we establish the average exposure:cover ratio for the tor sites we visited. Assuming orbital pacing of glacial-interglacial cycles, we model plausible exposure histories of periodic exposure and burial intervals. The majority of the 26 samples collected from highly-weathered tors on Cumberland Peninsula interfjord plateaus require average relative exposure durations of 20% within a glacial-interglacial cycle (i.e., 20 ka of exposure and 80 ka of ice coverage). Three samples located along narrow, highly-weathered coastal ridges indicate ice-free conditions throughout their entire exposure history. Minimum total exposure durations range from 320 ka up to 1.8 Ma, which are approximately twice as long as previous estimates of total exposure histories. This model assumes ice coverage during LGM, but a Monte Carlo simulation has shown that several summits could also have been ice free since oxygen isotope stage 3 (i.e., the last 60 ka).

Second, we determine when the last glacial plucking event occurred. TCN concentrations decrease exponentially below surface, but the ^{26}Al/^{10}Be increase with depth due to increased muogenic production of ^{26}Al relative to ^{10}Be with depth. By modelling the variation in TCN ratio and concentrations with depth and time, we are able to constrain the timing of last plucking of any sampled surface for different thicknesses of overlying tor blocks. We can show that the samples with the longest total exposure histories likely have never been plucked. Assuming reasonable thicknesses of bedrock blocks of 50 – 120 cm (based on horizontal joint spacing), we calculate that most sampled surfaces were plucked either between 200 – 350 ka and 500 - 800 ka. This timing can further be constrained if the thickness of the plucked bedrock block can be determined independently.