



## **Rockfall erosion in Antarctica as a significant agent of change above ice**

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The evolution of Antarctica's bedrock landscape has long been thought to be represent repeated glacial modification to an ancient pre-glacial land surface. However, significant areas of Antarctica are above current, and many past, ice elevations. These nunataks are often the steep sided upper part of buried mountains with high potential relief . They are therefore subject to hillslope erosion processes for long period of time, which in Antarctic landscapes has received scant attention ,with rates of sediment flux often assumed to be insignificant, or amongst the lowest on the planet.

We have used repeat high resolution surveys to derive face averaged rockfall erosion rates of 0.095 – 0.137 mmyr<sup>-1</sup> from 67°- 80°S along the Antarctic Peninsula, from the milder maritime influenced zone, to the high, arid, windy interior of the West Antarctic Ice sheet. These rates are in keeping with rates derived from Arctic and temperate landscapes thought to be far more active, and undergoing rapid changes to rates due to climatic warming. They are also consistent with long-term estimates of catchment wide denudation by the glaciers (not-ice streams) of the Antarctic Peninsula (0.001 – 0.08 mmyr<sup>-1</sup>). We further show using cosmogenic isotope dating of rockfall boulders (8.1, 10.5, 10.8 and 108.8 ka) deposited on a blue-ice moraine that failures have been occurring at 80°S for long periods in a mountain range that has had some slopes exposed for ~ 1.4 Ma. These findings demonstrate the importance of rockfalls for long-term debris supply to Antarctic glacier landsystems and the potential for substantial modification of nunataks between periods of ice-cover.

Although caution must be exercised in upscaling short-term, limited spatial extent derived rates to long-term estimates, in the case of the stable ice-geometry site in the Ellsworth Mountains there has been the potential for > 190 m of face retreat, and a full suite of landslide processes.