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Glacial erosion: No stones unturned?

M. Zreda

Dept. of Hydrology and Water Resources, University of Arizona, Tucson, Arizona, USA (marek@hwr.arizona.edu)

Is erosion of landscape under ice sheets significant or negligible? In the Arctic, it seems, it is both. I show evidence for cold-based margins of Greenland ice during the Last Glacial Maximum and for warm-based center at an unspecified time in the past.

Take a walk through Nyeboe Land, in the northwestern Greenland, and, as your feet sink in the soft till, your eyes are drawn to the mountains across the Nares Strait or to the margin of the Greenland ice sheet. But one of the most remarkable features in this landscape is one of the easiest to overlook – that this surface has two generations of erratics deposited at two different times. These erratics were dated by cosmogenic ^{36}Cl. One group of boulders, exclusively red granites, was deposited 27 ± 2 ky ago (ky = 1000 years); the other, exclusively gray limestones, was deposited 8 ± 1 ky ago. The small spread of individual boulder ages strongly suggests that these erratics have remained in the same position since their deposition. And the age difference suggests that there were two ice-sheet advances: the first involved a large, regional ice and wide dispersal of granitic erratics from the interior of Greenland; the second glaciation was smaller and dispersed material from the local bedrock. The preservation of the older generation of erratics is attributed to the younger ice being cold-based, and thus having a negligible eroding power. Similar landscapes that contain well-preserved older material are common in the High Arctic, suggesting that ice margins were often cold-based. This is in accord with botanical evidence showing that fragile plants can be preserved under inundating ice and exposed undestroyed centuries later (Bergsma *et al.*, 1984).

But evidence of high erosive power of Arctic ice sheets also exists. In the most unexpected place – under the cover of 3 km of ice, in the center of the Greenland ice sheet. Samples of bedrock at the base of the GISP-2 ice core were obtained and three cosmogenic nuclides were measured: ^{36}Cl (half-life of 301 ky), ^{10}Be (half-life of 1.5

My) and ^{21}Ne (stable). We expected that these nuclides, taken together, could be used to determine the last time when the bedrock was free of ice. But the samples yielded zero concentration of each nuclide! A near impossibility, since ^{21}Ne is a stable nuclide. This absence of any cosmogenic signature in the bedrock strongly suggests that any previously accumulated cosmogenic nuclide was removed by ice, thereby indicating eroding, warm-based ice in the center of the Greenland ice sheet. This results is in line with geochemical evidence from the same location indicating local erosion of the granitic bedrock (Weis *et al.*, 1997).

References:

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