Cosmogenic ^{10}Be views on the basal erosion history of the Greenland Ice Sheet

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We are using the cosmogenic isotope ^{10}Be as a proxy to understand the efficiency with which the Greenland Ice Sheet erodes its bed and the history/source of glaciogenic sediment. We measured the concentration of total organic carbon, nitrogen, and meteoric 10Be, an isotope formed in the atmosphere and delivered to Earth's surface by precipitation and dry fall, in 17 samples from the basal 6.5 meters of the GISP2 ice core collected from the summit of the Greenland Ice Sheet. The silt has high concentrations (0.6 to 3.8.10^8 atoms.g^{-1}) of meteoric ^{10}Be, significant percentages of organic carbon (0.3 to 1.7%), and an average C/N ratio of ~10, all consistent with derivation from a long-lived cold-region soil.

Concentrations of meteoric ^{10}Be and total organic carbon co-vary and decrease with distance from the bed of the ice sheet, indicating that the soil is mixed by ice deformation with rock flour derived from bedrock erosion. The existence of this ancient soil for several million years after formation of the Greenland Ice Sheet indicates extremely low rates of sub-ice erosion at Summit, Greenland. Survival of the soil is consistent with the ice at Summit having been frozen to the bed for most, if not all, of the Quaternary. Meteoric ^{10}Be adhered to silt and sand in ice collected from the margins of the present-day GIS has highly variable concentrations (10^6 to 10^8 atoms/g). The lower concentrations measured in most marginal samples indicate zones of higher erosivity away from the center of the ice sheet.

Analysis of 86 clasts, collected directly from the GIS in Upernavik, Ilulissat, and Kangerlussuaq, indicates that all but about a dozen have measurable levels of in situ ^{10}Be. Most clasts have between 500 and 1000 atoms/g, the equivalent of a few hundred years of surface exposure or excavation from deep within preglacial regolith. Nine clasts have over 5000/g; these likely record either mid-Holocene exposure and reworking or less deep excavation of regolith. One clast has >100,000 atoms/g, consistent with interglacial exposure and reworking without erosion. Sand-sized sediment collected near from outwash streams existing the ice margin at Kangerlussuaq and Narsarsuaq has several thousand atoms/g of ^{10}Be. Silt, clasts, and sand appear to be sourced from different sub-ice locations.