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Using 10-Be in sediment to understand the long-term behavior of the Greenland Ice Sheet ()

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We have used in situ and meteoric cosmogenic 10-Be, measured in sediment and rock, to understand better the history and erosional processes of the Greenland Ice Sheet over the many thousand to several million-year time scale. Measured concentrations of in situ 10-Be constrain Holocene emergence histories at the head of Igaliku fiord in southern Greenland. We sampled two well-preserved gravel beach ridges that are the highest marine deposits. Below one beach ridge, we sampled 4 quartzite outcrops at progressively lower elevations and above a nearby beach ridge, we sampled an erratic boulder and the underlying bedrock. We also sampled a beach ridge at a similar elevation at Qassiarsuk on Tunulliarfik Fiord about 20 km away. The data show rapid emergence after 11 ky. All three beach ridges (average and standard error of 6, 6 and 10 clast ages) have the same age (10.98±0.09, 11.07±0.51ky, and 10.96±0.33 ky). Ages of outcrops below the beach ridges are in stratigraphic order and show steady emergence; the outcrop just above modern high water has an age of 8.80 ky. The bedrock/boulder ages from above the beach ridge are slightly younger (10.45 and 10.73 ky, respectively), consistent with inheritance of about 1400 atoms/g 10-Be in beach clasts. Low levels of inheritance in deglacial beach gravels are consistent with the 10-Be content of clasts collected directly from the GIS in western Greenland. Most clasts have the equivalent of only a few hundred to a few thousand atoms/g 10-Be. Sand-sized sediment collected from outwash streams exiting the ice margin at Kangerlussuaq (western Greenland), Narsarsuaq (southern Greenland), and Tasilaq (eastern Greenland) has two to five thousand atoms/g of 10-Be - several times the median

amount of in situ 10-Be measured in clasts collected from the ice. These data indicate efficient erosion by the ice sheet of both pre-glacial and interglacial regolith at least near the ice sheet margins. In contrast, chemical and meteoric 10-Be analysis of 17 samples of silt contained in the basal 6.5 meters of the GISP2 ice core collected from the summit of the Greenland Ice Sheet suggests very low rates of erosion and the existence of an ancient soil. The GISP2 silt has high concentrations (60 to 380 million atoms/g) 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. The survival of this ancient, preglacial soil below the ice sheet is consistent with the ice at Summit, Greenland having been frozen to the bed for most, if not all, of the Quaternary. The lower concentrations of 10-Be measured in most marginal sediment samples indicate higher rates of bedrock erosion away from the center of the ice sheet.

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