The authors requested a **poster**

In Situ Cosmogenic 10Be Estimates Of Deglaciation Timing And Glacial Erosion Efficiency, Upernavik, Western Greenland

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Documenting the past behavior of the Greenland Ice Sheet is critical to understanding its future. To determine how effectively the ice sheet eroded bedrock and when the ice last melted away from northwestern Greenland, we measured in situ cosmogenic 10Be in paired bedrock and boulder samples collected outside of the present-day ice margin near Upernavik, western Greenland (72°N). Little geologic investigation has occurred at this site in the past due to inaccessibility; therefore, these measurements are the first of their kind in this area. To investigate erosion efficiency of the Greenland Ice Sheet over longer time scales and the inheritance of cosmogenic nuclides in ice-transported sediment, we also measured in situ cosmogenic 10Be in 20 cobbles removed directly from active ice at three different sites along the western ice margin between 67°N and 72°N.

Bedrock/boulder pairs from seven locations near Upernavik (72°N) were sampled in a 100-km transect stretching from the sea to the present-day ice margin, at elevations ranging between 30 and 1000 m. Cumulative probability analysis indicates that boulder samples cluster tightly around 11 ka of exposure, providing a best estimate for deglaciation of the Upernavik region. Only three of the 13 boulder samples lie outside of this cluster, two of which are from high elevations (> 750 m).

Bedrock samples have a different pattern. Cumulative probability analysis shows a pronounced cluster of bedrock samples around 14 ka, indicating that bedrock contains systematically higher 10Be concentrations than boulders. This concentration difference is likely due to inheritance (the failure of glacial ice to erode cosmogenic nuclides produced during previous periods of exposure). Two thirds of the bedrock sample population lies outside of this cluster, with exposure ages of up to 90 ka. In most cases, samples high in 10Be are from higher elevations and/or near the present-day ice margin. This suggests that high-latitude (and especially high-elevation) ice during the latest Pleistocene glaciation was only weakly erosive and failed to remove cosmogenic 10Be created during and inherited from earlier interglacial periods.

To determine the amount of inherited 10Be in icebound cobbles, clasts of rock were removed from the ice sheet margin near Kangerlussuaq (67°N), Ilulissat (69°N), and Upernavik (72°N). These cobbles were sourced up-ice of the present-day ice margin. Unlike the considerable inheritance observed in bedrock samples, these cobbles contain consistent, reliably detectable, but small (only hundreds of atoms per gram) concentrations of 10Be, the equivalent of only several hundred years of surface exposure. Ice must have retreated enough during some previous interglacial period to expose these cobbles to cosmic radiation; however, this exposure was either short in duration or the cobbles were sourced from deeply eroded bedrock.

This work allows us to conclude that: 1.) Deglaciation of the Upernavik coastline occurred around 11 ka BP. 2.) The ice near Upernavik, especially at high elevations, has spatially variable and sometimes low erosion efficiency, resulting in tens of thousands of years worth of 10Be inheritance in some bedrock samples. 3.) The presence of measurable 10Be in cobbles collected directly from the Greenland Ice Sheet indicates that, at some point in the past, the Greenland Ice Sheet was smaller than it is at present.

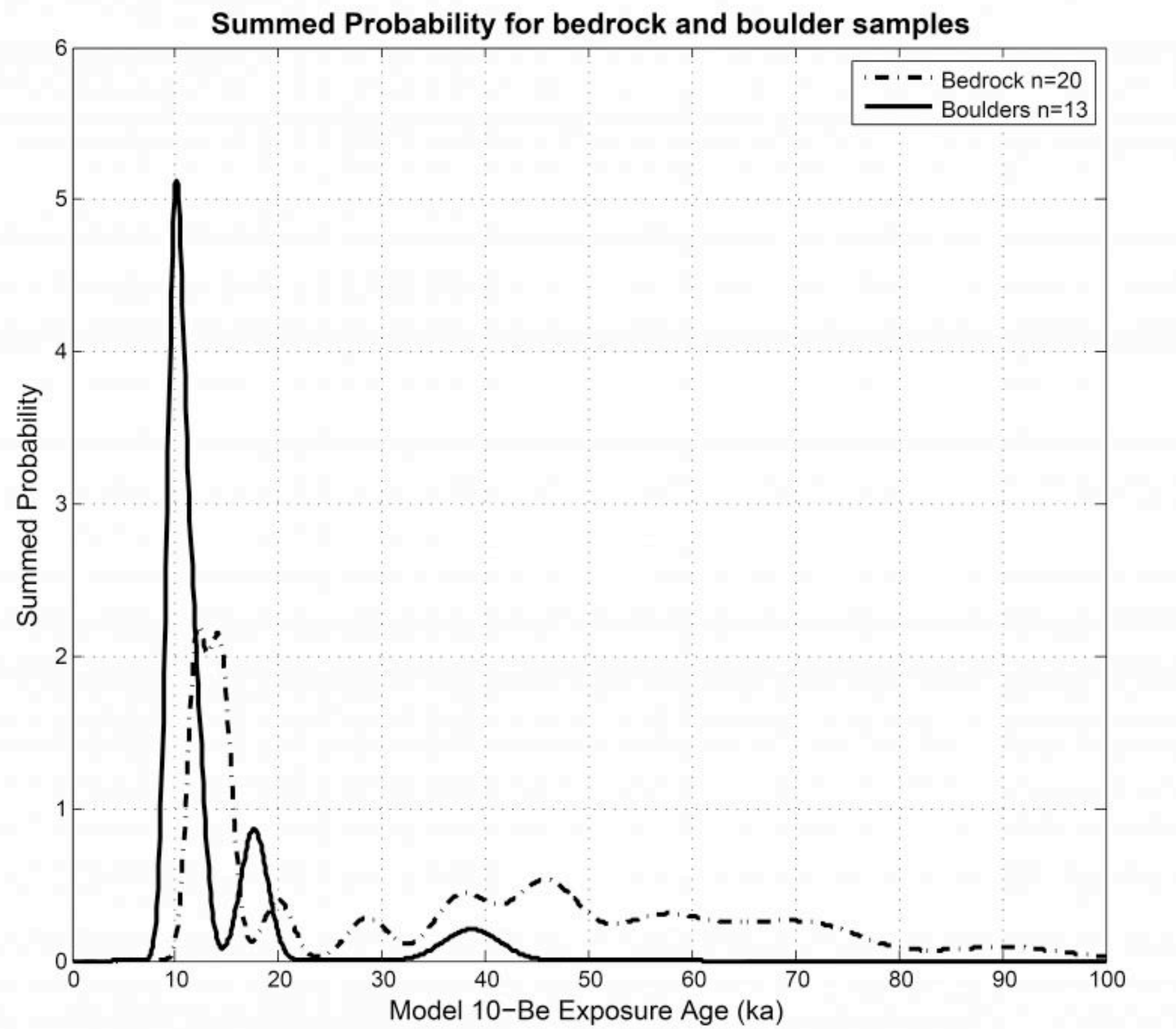

Fig 1.

Cumulative probability analysis of exposure ages of bedrock (dashed line) and boulder (solid line) samples from Upernavik, Greenland. Boulder samples show a well-defined peak around 11 ka, while bedrock samples show a more diffuse peak around 14 ka and a long tail. Modeled exposure ages were calculated using in situ cosmogenic 10Be measurements made at the Lawrence Livermore National Laboratory.

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