Inferring glacial history and subglacial process through analysis of cosmogenic nuclides in icebound cobbles

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Abstract

Surfaces below ice sheets preserve long-term records of glacial history and process. Here, we study the isotopic composition of cobble-sized rocks sourced subglacially and transported to the ice margin by ice flow and/or the subglacial hydrologic system. We analyzed in situ cosmogenic 10Be in 86 cobbles collected directly from ice and outwash channels at three locations in western Greenland: Kangerlussuaq, Ilulissat, and Upernavik. These cobbles were eroded from up-ice bedrock surfaces and contain 10Be indicative of the exposure, burial, and erosion history of the now subglacial landscape. Measured 10Be/9Be ratios were detectable for all but several samples (average blank 10Be/9Be = 4.2 1.7 x10-16, n = 24) and form a right-skewed distribution. Calculated 10Be concentrations are generally low (median = 1.0 x103 atoms g-1) but 6 of the 86 exceed 104 atoms g-1. One sample contains 1.1 x105 atoms g-1, two orders of magnitude above the median and equivalent to >20 ky of surface exposure at sea level. Concentrations of 10Be are not separable by sample site or type. Measured 10Be may have been produced during previous interglacial periods or the mid Holocene when the ice margin retreated, or by deep muogenic production of 10Be before glaciation of the landscape in the Pliocene. Because most cobbles preserve little inherited 10Be, we infer that the subglacial area from which the samples were sourced has been primarily warm-based. The few cobbles with more 10Be may have experienced exposure during the Holocene Optimum and/or previous interglacial periods when the ice margin retreated or may have been sourced from areas that were previously cold-based. We also sampled three cobbles from outside the current ice margin at each of the three sites. These cobbles record exposure since the last deglaciation plus any nuclides inherited from previous interglacial periods. Measured 10Be concentrations in Kangerlussuaq and Ilulissat are similar to or slightly exceed (by several thousand atoms g-1, similar to the median 10Be concentration in the icebound cobbles) expected 10Be concentrations based on deglaciation age estimates from independent studies. Measured concentrations are less than expected in Upernavik, possibly reflecting post-glacial shielding of the cobbles or inherited 10Be in samples used to estimate deglaciation timing.

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