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Shifting lithogenic provenance to North Atlantic sediments preceded the 2.7 Ma intensification of Northern Hemisphere Glaciation

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Understanding the causes and consequences of the intensification of Northern Hemisphere Glaciation (iNHG) at 2.7 Ma is complicated by a lack of constraints on the northern hemisphere ice sheet extents before they were large enough to launch significant levels of debris-ridden icebergs into the North Atlantic. Lithogenic sediment records provide a way to investigate changes in ocean and atmospheric circulation before and after the iNHG and identify dynamic changes that may reflect, and/or have expedited, early stages of substantial ice sheet growth.

We present a record of lithogenic deposition to the North Atlantic from International Ocean Discovery Program (IODP) Site U1313 spanning the past six million years, constrained using terrigenous helium-4 (^{4}He) and thorium-232 (^{232}Th) as lithogenic indicators, and extraterrestrial helium-3 ($^{3}He_{ET}$) as a constant flux proxy. The Site U1313 record exhibits a baseline increase in lithogenic $^{4}He/^{232}Th$ ratios, suggestive of a major change in lithogenic source region, from low early Pliocene values (100-275 ncc/pmm) to higher values suggestive of more North American influence (300-500 ncc/ppm), coincident with the M2 glaciation at 3.3 Ma. After this baseline shift, Site U1313 $^{4}He/^{232}Th$ ratios never return to their early Pliocene values. The 3.3 Ma baseline shift in lithogenic $^{4}He/^{232}Th$ ratios precedes a general increase in glacial period lithogenic fluxes starting at ~2.7 Ma and is not related to the introduction of ice-rafted debris (IRD), as IRD is not detected at Site U1313/ODP Site 607 until 2.9 Ma.

The observed 3.3 Ma shift in lithogenic provenance may have resulted from threshold changes in atmospheric dust transport over the North Atlantic and/or detrital delivery via deep ocean circulation that persisted into the Pleistocene. These changes coincided with a significant baseline decrease in calcium carbonate fluxes recorded in Site U1313 sediments and may have helped facilitate climatic conditions supporting northern hemisphere ice sheet expansion. If the lithogenic provenance changes at Site U1313 reflect variations in aeolian dust supply, then this record may provide indirect evidence for increasing volume of northern hemisphere ice sheets, prior to the widespread advance associated with the iNHG and increased North Atlantic IRD at 2.7 Ma.