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Millennial-scale surface and subsurface palaeothermometry from the NE Atlantic, 55-8 kyr BP; evidence for warmer summers during Heinrich events?

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We present high-resolution, multi-proxy palaeoceanographic records from NE Atlantic sediment core MD01-2461 (51º 45'N, 12º 55'W, 1153m water depth) which detail upper-ocean climate and circum-North Atlantic ice sheet activity during the period 55 to 8 kyr BP. Mg/Ca analysis of the planktonic foraminifera *Globigerina bulloides* and *Neogloboquadrina pachyderma* sin. record surface ($\sim$30m water depth) and subsurface ($\sim$150m) calcification temperatures respectively. Mg/Ca of polar species *N. pachyderma* sin. (Mg/Ca_{Nps}) appears to record mean annual subsurface conditions, displaying a strong relationship with the relative abundance of *N. pachyderma* sin. (%) within the planktonic assemblage. Mg/Ca of *G. bulloides* (Mg/Ca_{Gb}) records summer sea surface temperature (SST).

The Mg/Ca_{Gb}-based SST record provides evidence for warmer summer surface ocean conditions associated with each of the last five Heinrich (H) events (H5-H1) in the NE Atlantic, with exceptional warming (>5ºC) recorded at H1. Meltwater stratification, identified through multi-species oxygen isotope analysis, and thermal isolation may

have facilitated such elevated SST. However, we cannot discount the possibility of either: (i) the presence of occasional warm surface waters advected from the western tropical North Atlantic or, (ii) the temperate ecological niche of *G. bulloides* having aliased the Mg/Ca_{Gb} record towards increased SST. The optimal temperature range of *G. bulloides* may have prevented Mg/Ca_{Gb} from recording summer SST below 6-7˚C, notably during the H events, when both Mg/Ca_{Nps} and faunal records suggest significant cooling. The contradictory warming trend within Mg/Ca_{Gb} may therefore reflect *G. bulloides* blooms during anomalously warm summers associated with the H events.

Nonetheless, if these observations prove robust then the occurrence of such warm conditions immediately preceding and concurrent with H layer deposition has significant implications for our understanding of the climatic conditions under which Laurentide ice sheet collapse occurred. Moreover, these records may support an external H event trigger, fitting theories incorporating ice shelf collapse and subsequent ice stream advance in response to climatic warming.