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Reprint of Anatomy of Labrador Sea Heinrich layers

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ABSTRACT

Heinrich layers (H-layers) are distinct, decimetre to centimetre thick layers of ice-rafted debris (IRD) that were deposited in the North Atlantic during the Late and middle Pleistocene. H-layers (H-layers) are characterized by high detrital carbonate and low foraminifera contents. In the Labrador Sea, H-layers reach metre thickness in some proximal core sites near the iceberg source of the Hudson Strait ice stream and show five distinct depositional facies involving sediment lofting and low-density turbidity currents as sediment delivery processes besides ice rafting. Thick massive ice-rafted layers (type I H-layers) occur in the most proximal parts of H-layer 3 and older H-layers. Within 300 km distance from the assumed Hudson Strait ice stream terminus, H-layers somewhat more distal than type I H-layers consist predominantly of stacked thin layers of graded muds containing IRD (type II H-layers). The graded muds that are spiked with IRD resulted from the deposition of fine-grained lofted sediment that collected dropstones and grains under the iceberg route. At greater distance from the Hudson Strait outlet on the slope and rise south of the strait, H-layers on the levees of tributary canyons to the Northwest Atlantic Mid-Ocean Channel (NAMOC) consist of alternations of thin mud turbidites with intercalated *laminae* of IRD (type III H-layers). On the levees of NAMOC, type IV H-layers consist of *layers* of IRD alternating with fewer fine-grained spill-over turbidites, because the spill-over frequency from the deep channel was less than that from the less deep canyons on the slope. Type V is made up of bioturbated hemipelagic muds with coarser IRD and occurs in regions between canyons not reached by spill-over turbidity currents and in distal regions of the open ocean or on seamounts. Transport of significant portions of the sediment in H-layers by suspended sediment columns lofted from sand-carrying fresh-water turbidity currents (type II) and by low-density turbidity currents (types III and IV) explains the high percentage of detrital carbonate in the fine (< 63 μm) grain-size fractions (> 80% of the total detrital carbonate of the bulk sediment), which cannot be derived from icebergs alone. It also explains the low magnetic susceptibility and low grey levels on the colour scale compared to H-layers in the North Atlantic east of Greenland. The anomalously great thickness of individual H-layers on the slope and rise off the Hudson Strait as documented in isopach maps reflects the combined effect of the various processes involved in their deposition. Four hypotheses for the origin of H-events are discussed — (i) the binge–purge model, (ii) the subglacial outburst–flow model, (iii) the external forcing model, and (iv) the catastrophic ice-shelf break-up model

1. Introduction

Heinrich events (H-events) are episodes of intensified iceberg-drift in the North Atlantic during which distinct, decimetre to centimetre thick layers of ice-rafted debris (IRD) were deposited that have been identified in Late Pleistocene deep-sea sediments (Heinrich, 1988; Bond et al., 1992; Broecker et al., 1992). Six conventionally recognized H-events (H1 to H6) occurred during the last glaciation between 10 and 67 ka (Fig. 1). H0 was identified as a Heinrich-like event on the SE Baffin Shelf (Andrews et al., 1994), and Rashid et al. (2003a) introduced an eighth event H5a between H5 and H6. Heinrich (1988) in his original work on episodic ice-rafting in the eastern North Atlantic identified 5 additional layers prior to the last glaciation extending the H-layer stratigraphy in time back into the penultimate glaciation at 130 ka. Rasmussen et al. (2003) detected twelve H-layers in a core from the southeastern Labrador Sea off Newfoundland also dating back to 130 ka at termination 2. Hiscott et al. (2001) using a core from the southwestern Labrador Sea extended the H-layer record back 340 ka to H-layer 13. Heinrich-like events can be traced back to ~640 ka during Marine Isotope Stage (MIS) 16 in the middle Pleistocene (Hodell et al., 2008; Naafs et al., 2011, 2013). Heinrich layers (H-layers) show specific characteristics compared to normal hemipelagic sediment with IRD,

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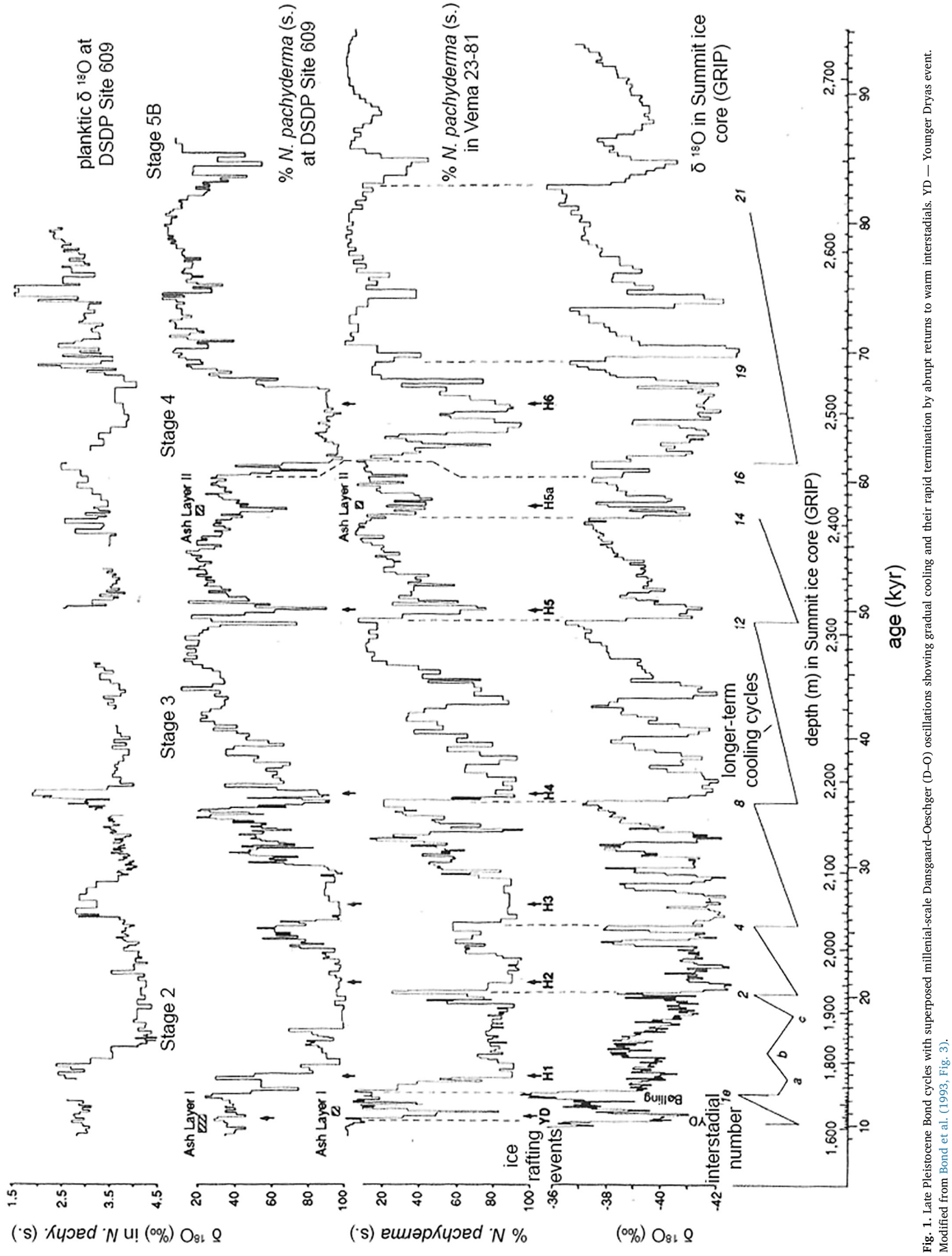

Fig. 1. Late Pleistocene Bond cycles with superposed millenial-scale Dansgaard–Oeschger (D–O) oscillations showing gradual cooling and their rapid termination by abrupt returns to warm interstadials. YD — Younger Dryas event. Modified from Bond et al. (1993, Fig. 3).