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Sediment sources of northern Québec and Labrador glacial deposits and the northeastern sector of the Laurentide Ice Sheet during ice-rafting events of the last glacial cycle

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ABSTRACT

Provenance studies of anomalously high-flux layers of ice-rafted detritus (IRD) in North Atlantic sediments of the last glacial cycle show evidence for massive iceberg discharges coming from the Hudson Strait region of the Laurentide Ice Sheet (LIS). Although these so-called Heinrich events (H events) are commonly thought to be associated with abrupt drawdown of the LIS interior, uncertainties remain regarding the sector(s) of this multi-domed ice sheet that conveyed ice through Hudson Strait. In Northern Québec and Labrador (NQL), large-scale patterns of glacial lineations indicate massive ice flows towards Ungava Bay and Hudson Strait that could reflect the participation of the Labrador–Québec ice dome in H events. Here we evaluate this hypothesis by constraining the source of NQL glacial deposits, which provide an estimate of the provenance characteristics of IRD originating from this sector. Specifically, we use $^{40}Ar/^{39}Ar$ ages of detrital hornblende grains in 25 till samples distributed along a latitudinal transect (lat. 58°) extending east and west of Ungava Bay. The data show that tills located west and southwest of the Ungava Bay region are largely dominated by hornblende grains with Archean ages (>2.6 Ga), while tills located east of Ungava Bay are characterized by grains with early Paleoproterozoic ages (2.0–1.8 Ga), although most samples contain a few Archean-age grains. IRD derived from the NQL region should thus be characterized by a large proportion of Archean-age detrital grains, which contrasts significantly with the predominant Paleoproterozoic $^{40}Ar/^{39}Ar$ ages (1.8–1.6 Ga) typically reported for the dominant age population of hornblende grains in H layers. Comparisons with IRD through the last glacial cycle from a western North Atlantic core off Newfoundland do not show evidence for any prominent ice-rafted event with the provenance characteristics of NQL glacial deposits, thereby suggesting that significant ice-calving event(s) from the Labrador–Québec sector may have been limited throughout that interval. Although these results tend to point towards a relative stability of this ice dome during H events, our study also indicates that further provenance work is required on IRD proximal to the Hudson Strait mouth in order to constrain with a greater confidence the sector(s) of the LIS that fed ice into Hudson Strait during H events. Alternatively, these results and other paleogeographic considerations tend to support models suggesting that part of the Ungava Bay glacial lineations could be associated with a Late-Glacial ice flow across Hudson Strait.

1. Introduction

The greater Hudson Strait region was subject to important ice-dynamic events during the last glacial cycle, notably in the form of large drainage episodes of glacial ice through Hudson Strait (e.g. Andrews, 1998), with concomitant massive iceberg discharges in the North Atlantic ocean that have had a strong impact on climate (Bond et al., 1992; Broecker et al., 1992). These so-called Heinrich events (H events) are also significant in terms of ice sheet dynamics because the composition and sedimentological characteristics of the associated ice-rafted detritus (IRD) imply sudden and episodic collapses of the Laurentide Ice Sheet (LIS) (Andrews and Tedesco, 1992; Dowdeswell et al., 1995; Gwiazda et al., 1996; Hemming et al., 1998, 2000;

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see also Hemming, 2004 for a review). Other North Atlantic ice sheets appear to have released icebergs in approximate synchroneity (Grousset et al., 1993, 2000, 2001; Bond and Lotti, 1995; Scourse et al., 2000; Knutz et al., 2001, 2002, 2007; 2003; Jullien et al., 2006; Peck et al., 2006, 2007), but their contribution to IRD concentrations was small with respect to the LIS. Although multiple mechanisms have been suggested to explain the cause/origin of H events (e.g. Hemming, 2004), most glaciological and paleoclimatic proxy-based models put forward to explain these large iceberg discharges involve drawdown of large amount of ice from the central part of the LIS (MacAyeal, 1993; Alley and MacAyeal, 1994; Alley et al., 2005; Marshall and Koutnik, 2006). The spatial distribution of glacial lineations and patterns of post-glacial rebound (e.g. Peltier, 2002; Tarasov and Peltier, 2004), however, indicate that Hudson Bay was not the area with the thickest ice, but was rather surrounded by three important ice domes that fed the margins as well as the interior of the LIS (Fig. 1a) (Dyke and Prest, 1987). Extensive mapping of glacial striations on multifaceted rock outcrops and boulder tracing of lithological indicators of glacial transport indicate large-scale displacements of these ice domes during the last glacial cycle (Parent et al., 1995; Veillette et al., 1999; Clark et al., 2000; Jansson et al., 2002; McMartin and Henderson, 2004; Veillette, 2004). These reorganizations of the ice divide system likely reflect important ice-surface changes of the LIS, which could be related to the postulated ice sheet collapses during Heinrich events (Clark et al., 2000; Dyke et al., 2002).

Additionally, the occurrence of major ice-flow patterns that converge towards Hudson Bay and Hudson Strait could also reflect disintegration paths associated with Heinrich-type drawdown episodes of the LIS. This is well illustrated in Northern Québec and Labrador (NQL) where the numerous fields of glacial lineations that characterize the Ungava Bay region (Fig. 1b) were linked to a major ice-draining event (or several synchronous events) of the north-eastern sector of the LIS that may have contributed to the massive iceberg discharges associated with H events (Jansson et al., 2003). The contribution of the Labrador–Québec ice dome to H events during the Last Glacial cycle and the significance of the NQL glacial flutings in such events, however, remain largely unconstrained. Overall, little is known on the sector(s) of the LIS and associated ice-flow paths that conveyed ice to the Hudson Bay/Strait region during H events, and this represents an important limitation in our understanding of the LIS in the context of H events.

Here we document the provenance of NQL glacial sediments (tills) representing the sediment source carried by Ungava Bay ice streams and other regional ice-flow trajectories, which ultimately delivered ice and associated IRD to the ocean. For this purpose, we use the single-step laser fusion $^{40}Ar/^{39}Ar$ method to date 241 detrital hornblende grains from 25 samples roughly located on the

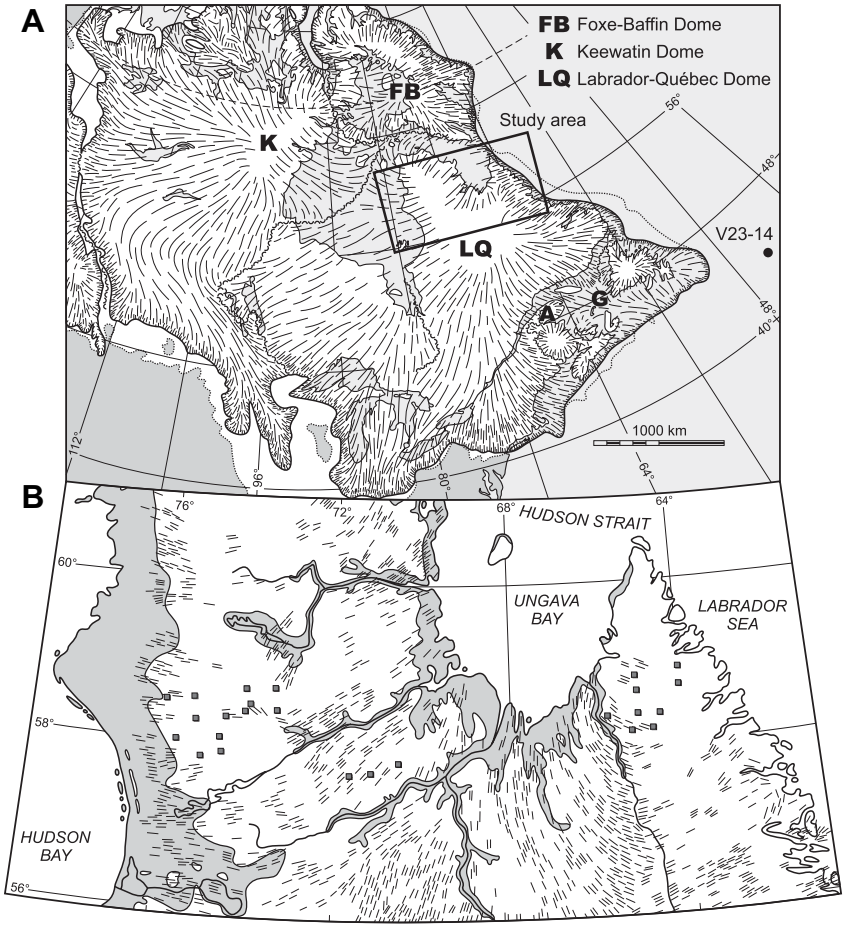

Fig. 1. A) Schematic configuration of the Laurentide ice sheet around the last glacial maximum (after Dyke and Prest, 1987; Dyke et al., 2002). Thin and discontinuous lines represent glacial flow-lines coming from three main ice-dispersal centers located around Hudson Bay. Glacial flow-lines are based on the trend of glacial lineations that were mapped from drumlins and glacially molded outcrops from aerial photographs and field observations. Continuous lines within the ice sheet mark the approximate extent of each sector. V23–14 indicates the name and location of the marine core used in this study. The letters A and G designate the Appalachians and the Gulf of St-Lawrence regions, respectively. B) Details of glacial lineations in the study area (modified from Prest et al., 1968; Clark et al., 2000). The extent of the post-glacial marine limit is shown by a light gray zone around the coasts. Location of till samples is marked by dark gray squares.