Climate Center Proposal – January 2004

Provenance of Hudson Bay glacial deposits as a mean to constraint Laurentide ice sheet disintegration paths

Martin Roy *(mroy@ldeo.columbia.edu)* and Sidney R. Hemming *(sidney@ldeo.columbia.edu)*

Abstract. The Hudson Bay–Hudson Straight area is the site of highly dynamic glacial events, among which are the major episodes of iceberg calving at the origin of Heinrich events. The continental glacial deposits that surround this region should be particularly sensitive to changes in ice sheet configuration, and thus record information on the postulated ice sheet collapse associated with Heinrich events. Little is known about the ice flow paths that led to the disintegration of the ice sheet and, as a result, current glaciological models disagree with available geological data. In this proposal we plan to evaluate the provenance of glacial sediments using $^{40}Ar/^{39}Ar$ ages from hornblende grains of glacial deposits in order to obtain information on the path(s) of ice sheet disintegration during the last glacial cycle. The bedrock geology underlying the main ice domes of the Laurentide ice sheet (LIS) suggest that there should be ways to distinguish the material coming from the different ice domes. The results from this study will bring critical constraints on the ice flow geometry of the LIS, which are fundamental in understanding the mechanisms acting behind abrupt climate changes associated with Heinrich events (H events).

domes of the LIS have moved significantly throughout the last glacial cycle, thereby implying that the LIS was highly dynamic during that period. The multiple ice movements documented most likely reflect response to severe changes in ice sheet configuration, perhaps caused by important ice volume reduction associated with H events [7]. This clearly demonstrates that ocean and continental records of the last glacial cycle share several aspects and that they can potentially be correlated.

Constraints on ice sheet disintegration through a provenance study

Constraints on ice sheet disintegration and timing of changes in ice sheet configuration may be gathered from glacial sedimentary sequences in the Hudson Bay Lowland (HBL) of Canada (Fig. 1). This region is in a key area for climate studies because it is located near the former geographic centre of the LIS, half way between two of its main ice dispersal centers: the Keewatin and Labrador ice domes. The HBL sedimentary sequences consist of multiple glacial deposits interbedded with nonglacial sediments. Till units record ice deposition by the Keewatin and Labrador ice centers [7], and ice flow directional data from these deposits match the sequence of ice flow events documented from cross-cutting erosive features preserved on the adjacent shield rocks. A relative timing of ice flow events and ice advances may be derived from the presence of nonglacial deposits between these tills. Some of these nonglacial units contain pre-Holocene organic material from which early thermoluminescence and pollen data suggest that these sediments were likely deposited during the last interglacial [7]. A stratigraphically lower nonglacial unit suggest that HBL sequences may record events as old as marine isotope stage 7.

The Keewatin and Labrador ice domes are resting on bedrock of significantly different age: the rocks of the Churchill province (2.00-1.75 Ga) and rocks of the Superior province (>2.65 Ga), respectively [*see* 3]. Consequently, we plan to document the provenance of HBL glacial deposits using $^{40}Ar/^{39}Ar$ ages from hornblende grains retrieved from tills in order to identify the contribution of each ice domes to till deposition in this region. These $^{40}Ar/^{39}Ar$ ages should allow us to characterize the path of each ice flow events through time. These data can then be compared to the ones found in H layers, and thus better identify the sector of the LIS that conveyed ice through Hudson Straight during H events.

Implications

An attendant issue in identifying the source of IRD is to better document the source regions from which they derive. The Canadian Shield geology underlying the LIS region is a complex mixture of Archean and early Proterozoic rocks from which restricted geochronological data prevent the assignment of a particular source area within the broad geological provinces. Because $^{40}Ar/^{39}Ar$ ages obtain from the glacial sediments represent a broad spatial integration of the bedrock geology underlying the main ice domes, our approach has thus the advantages of providing information on the basement geology of the Canadian Shield as well as sorting out the last glacial cycle ice flow chronology in this region, and narrowing down the location of IRD sources. Consequently, by defining the source rock of glacial sediments in the region surrounding Hudson Bay/Straight, it may be possible to uniquely characterize the path (origin) of H layers. This would bring constraints on the ice flow patterns of the LIS and allow estimate of the volume of ice that went through Hudson Straight during H events. These issues are crucial in understanding the linkage between ice sheet dynamics and abrupt intensification of the IRD signal.

Strategy and itemized budget

We plan to first do $^{40}Ar/^{39}Ar$ analyses on strategic till samples that are currently stored at the University of Quebec in Montreal and the Geological Survey of Canada in Ottawa. The results from this study will serve laying out the basics for a larger NSF proposal in which we will require funding for re-visiting important HBL stratigraphic sections in order to sample glacial and nonglacial sediments for provenance work and new OSL dating, respectively.

BUDGET: - one week trip to Montreal/Ottawa to obtain samples (rental car/hotel/food): $1200
- 250 hornblende $^{40}Ar/^{39}Ar$ analyses at $19/analyses: $4750
Total: $5950

References

[1] Broecker W.S., 1994, Massive discharge of icebergs as triggers for global climate change: Nature, v. 372, p. 421.
[2] Broecker W.S., Hemming, S.R., 2001, Climate swings come into focus: Science, v. 294, p. 2308-2309.
[3] Gwiazda, R.H, et al., 1996, Evidence from $^{40}Ar/^{39}Ar$ ages for Churchill province source of ice-rafted amphiboles in Heinrich layer 2: Journal of glaciology, v. 42, p. 440-446.
[4] Hemming, S.R., et al., 1998, Provenance of Heinrich layers in core V28-82, northeastern Atlantic: $^{40}Ar/^{39}Ar$ ages of ice-rafted hornblende, Pb isotopes in feldspar grains, and Nd-Sr-Pb isotopes in the fine sediment fraction: Earth and Planetary Science Letters, v. 164, p. 317-333.
[5] MacAyeal, D.R., 1993, Binge/purge oscilations of the Laurentide Ice Sheet as a cause of North Atlantic Heinrich events: Paleoceanography, v. 8, p 775-784.
[6] Dyke, A.S., et al., 2002, The Laurentide and Innuitian ice sheets during the last glacial maximum: Quaternary Science Reviews, v. 21, p. 9-31.
[7] Thorleifson, L.H., et al., 1992, Hudson Bay Lowlands Quaternary stratigraphy: Evidence for early Wisconsinan glaciation centered in Quebec; Geological Society of America Special Paper 270, p. 207-221.

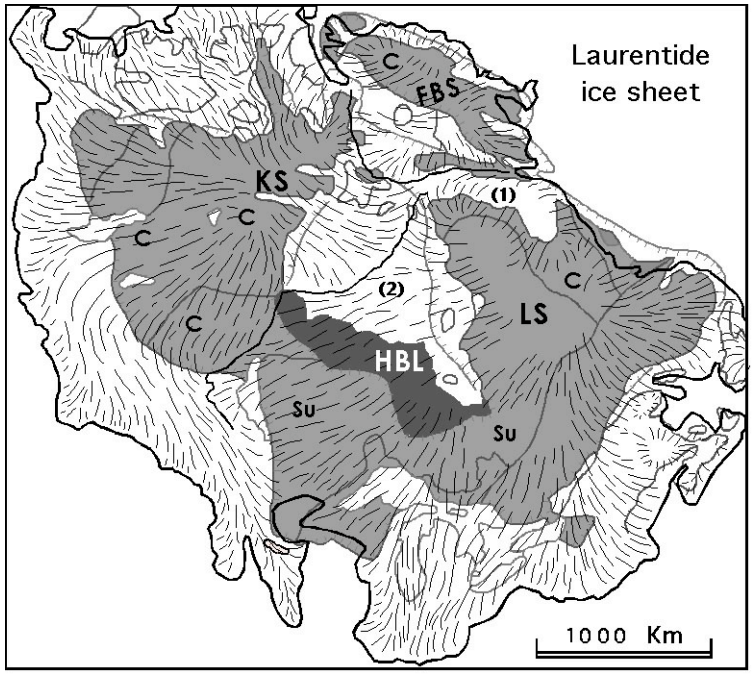

Fig. 1: Location of the Hudson Bay Lowland (HBL; dark grey area) within the Laurentide ice sheet at the last glacial maximum. Main ice dispersal centers (ice domes): KS—Keewatin Sector; LS—Labrador Sector; FBS—Foxe/Baffin Sector. Thin discontinuous lines emanating from ice domes represent flow lines. Canadian Shield is outlined by light grey area: C—Churchill province; Su—Superior Province. (1)—Hudson Straight area. (2)—Hudson Bay area.