DETAILED RECORDS OF IRD INPUT FROM CENTRAL NORTH ATLANTIC SEDIMENT CORE VM28-89 DURING THE LAST GLACIAL CYCLE (MARINE ISOTOPE STAGES 4-2)

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Background

During the last glaciation, from 14,000 to 70,000 years ago, six separate events of major Iceberg-Rafted Detritus (IRD) deposition are recorded in North Atlantic sediment cores as an abundance of ice rafted lithic fragments and a decrease in foraminifera (forams) (Broecker et al. 1992). These major pulses of IRD are named Heinrich events, and are interpreted as short periods of higher temperatures causing catastrophic iceberg discharge from Greenland and the Laurentide ice sheet which bring eroded bedrock sediment and terrestrial sediment with them.

To find thick sections of IRD in sediment cores, we turn to the Ruddiman IRD belt, an area between 40° and 55° longitude in the center of the North Atlantic, Core VM28-89 is located at 44°32'N 32°35'W in the Atlantic Ocean at a depth of 3643m. This "belt" has the conditions necessary to record Heinrich and Heinrich-like events, it is mostly only reachable by the largest pulses of iceberg rafting and it is sensitive to climate warming, as it is at the location where the cold current from the NW Atlantic and warm current migrating north from the equator meet and deflect east, this mechanism of currents creates an area of increased input of IRD called the IRD belt (Figure 1).

Sharp increases of IRD and a decrease in concentration of foraminifera in a sediment core are indicators of Heinrich events (Heinrich, 1988), these indicators are accompanied by a decreased δ18O in planktic forams, which is a proxy for global temperature increase and indicates an increased heat transport to the subpolar North Atlantic. Because these spikes in IRD correlate so well with climatic data seen in the δ18O record of planktic forams (Hodell et al., 2010), we can use IRD as a proxy for glacial cover and climate fluctuations.

Purpose

1) Document the changes in IRD input using the following proxies:

a) %IRD ((number of lithic grains >150µm / (number of lithic grains >150µm + number of Planktic foraminifers >150µm)) x 100);

b) # whole planktic foraminifers, >150µm per gram of sediment (forams/gram);

c) % coarse fraction (>63µm);

d) # lithic grains, >150µm per gram of sediment (lithics/gram)

2) Evaluate these proxies in terms of a previously identified series of Heinrich events.

3) Compare our core to the previously published V23-14 core to the west in the North Atlantic.

4)Investigate the relationship between %IRD and IRD per gram

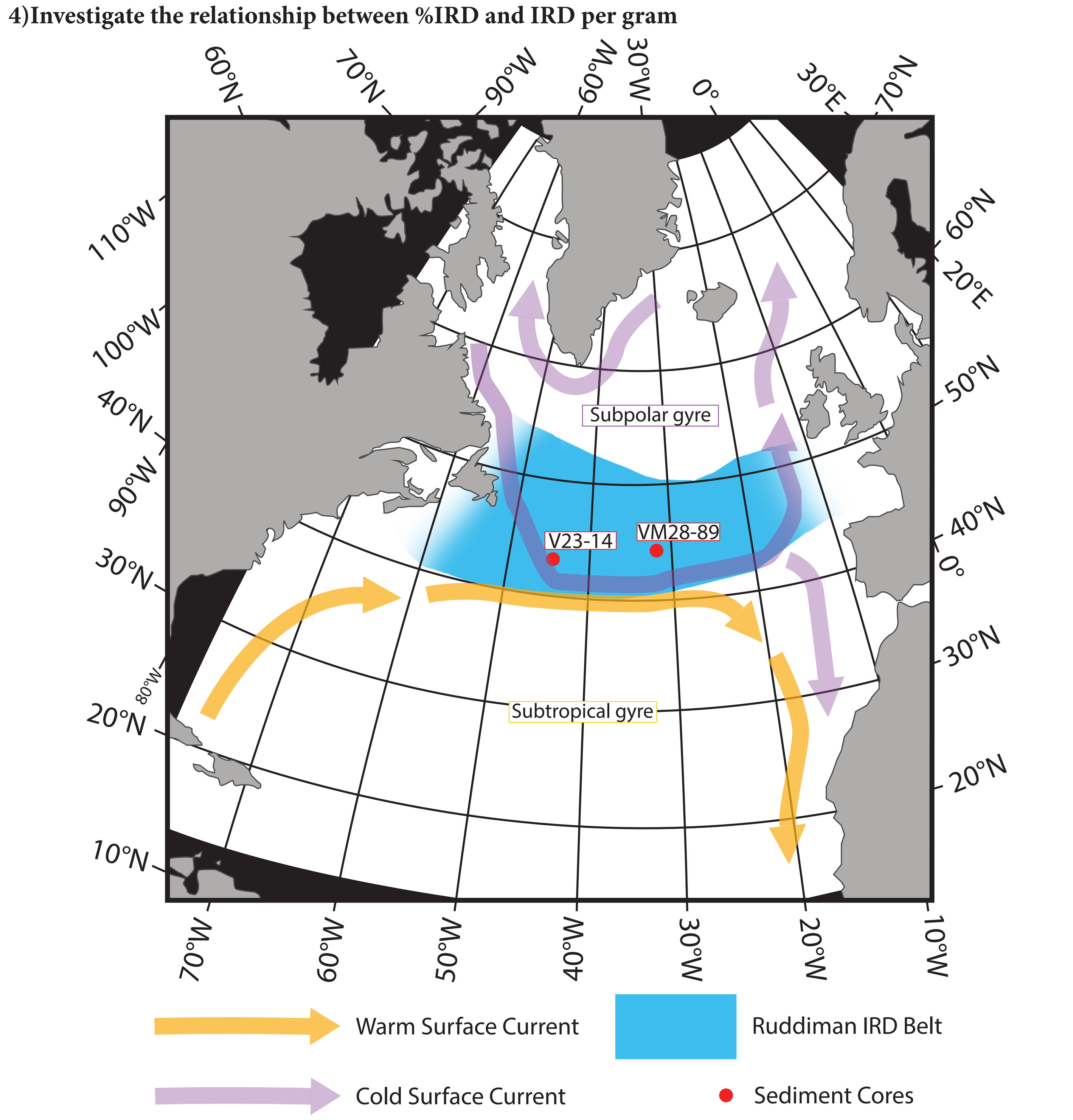

Figure 1: A map of the North Atlantic showing the inferred movement of the surface current at the LGM, Ruddiman's IRD belt, and the location of the sediment cores VM28-89 and V23-14. Modified from D. Seidov, R. Prien and M. Weinelt, 1996, using information from Ruddiman, 1977, and B. D. A. Naafs et. al., 2013.

Methods

Samples were taken in the VM28-89 core with a 1 cm interval 8cm-119cm downcore.

For each sample:

-A coarse fraction of >150 µm was acquired using a sieve

-Then split until it contained between 300 and 500 planktic forams

-The IRD fragments in the split of each sample were counted differentiating between detrital carbonates, volcanic fragments, and other lithics using visual and chemical properties.

-These proxies were used to generate plots that were compared to the equivalent plots from other cores in the North Atlantic including the well dated V23-14 to identify Heinrich events (Figure 3).

Results

Figure 2 is a multi axis plot of the four proxies we generated for VM28-89, from 8 cm to 119 cm, the %IRD reveals two relatively long intervals of >90% IRD and very low forams/gram between 42-71 cm and 91-113 cm separated by intervals of very low (10-25%) IRD and higher forams/gram. Lithics/gram exhibits much higher frequency fluctuations during these same intervals reaching upwards of 6,000 lithics/gram in the upper long interval and up to 12,000 lithics/gram in the deeper long interval.

The %IRD data from our core (VM28-89) and the core we are comparing to (V23-14) are compared at the top of figure 3. In V23-14 the %IRD reveals two relatively long intervals of >90% IRD and very low forams/gram between 40-70 cm and 100-128 cm that are chronostatigraphically interpreted as H2 and H4 respectively, and a shorter length peak at 8-15 cm is interpreted as H1 by Hemming & Hajdas. Lithics/gram and coarse fraction weight are both lower during intervals of high %IRD.

Tentative correlations of our results to the chronologic framework of V23-14 (Hemming & Hajdas, 2003) suggests that our two intervals of very high %IRD correspond to Heinrich Events H2 and H4. In both cores, H0 is missing, likely due to the coring mechanism, and, in VM28-89, H1 is missing as well, presumably for the same reason.

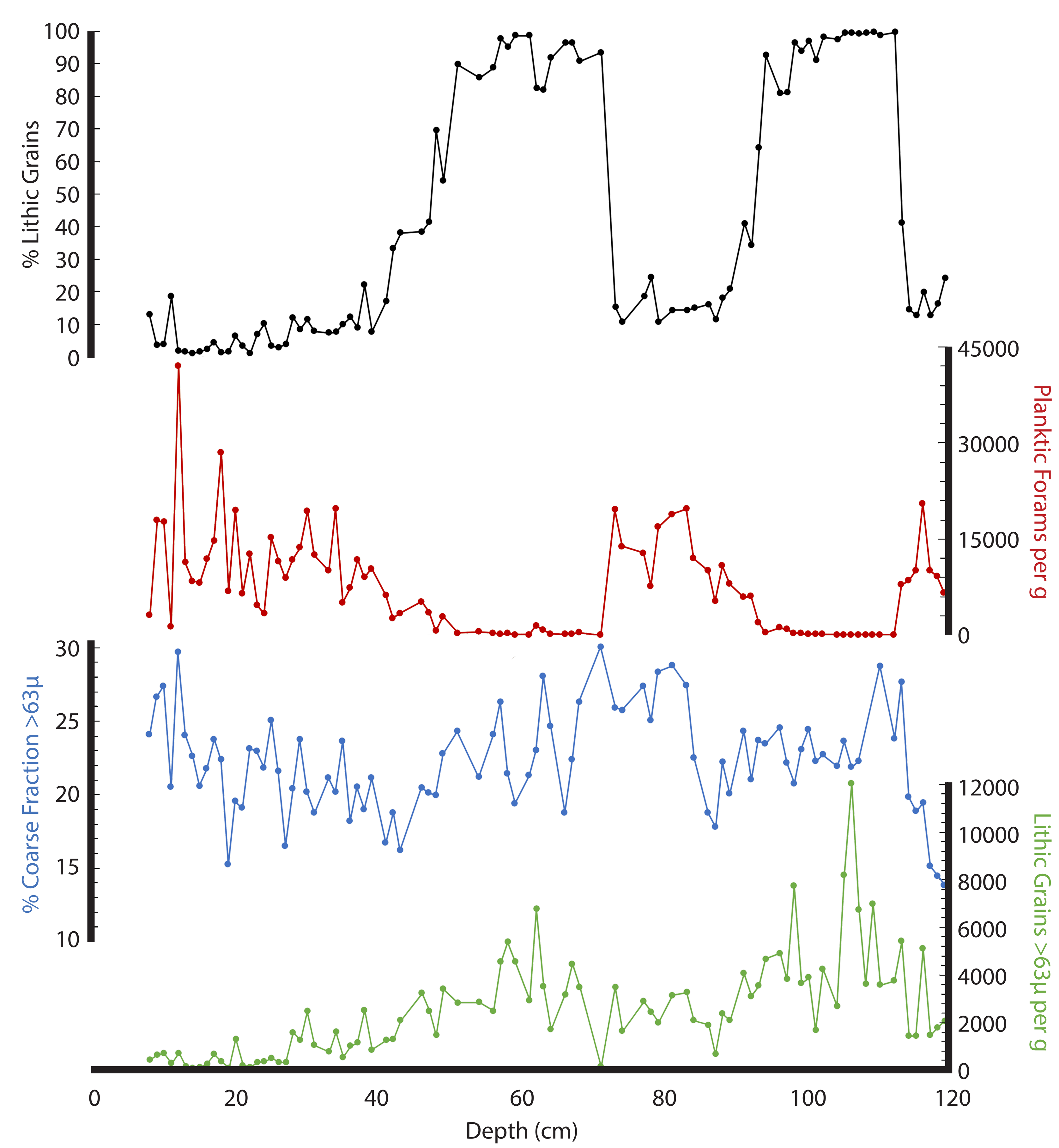

Figure 2: A multi axis plot that displays change in (from top to bottom) %IRD ((number of lithic grains >150µm / (number of lithic grains >150µm + number of Planktic foraminifers >150µm)) x 100); ; Planktic foraminifers, >150µm per gram of sediment (forams/gram), the >63µm size faction weight in grams; and Lithic grains, >150µm per gram of sediment (lithics/gram) downcore in VM28-89.

Results (continued)

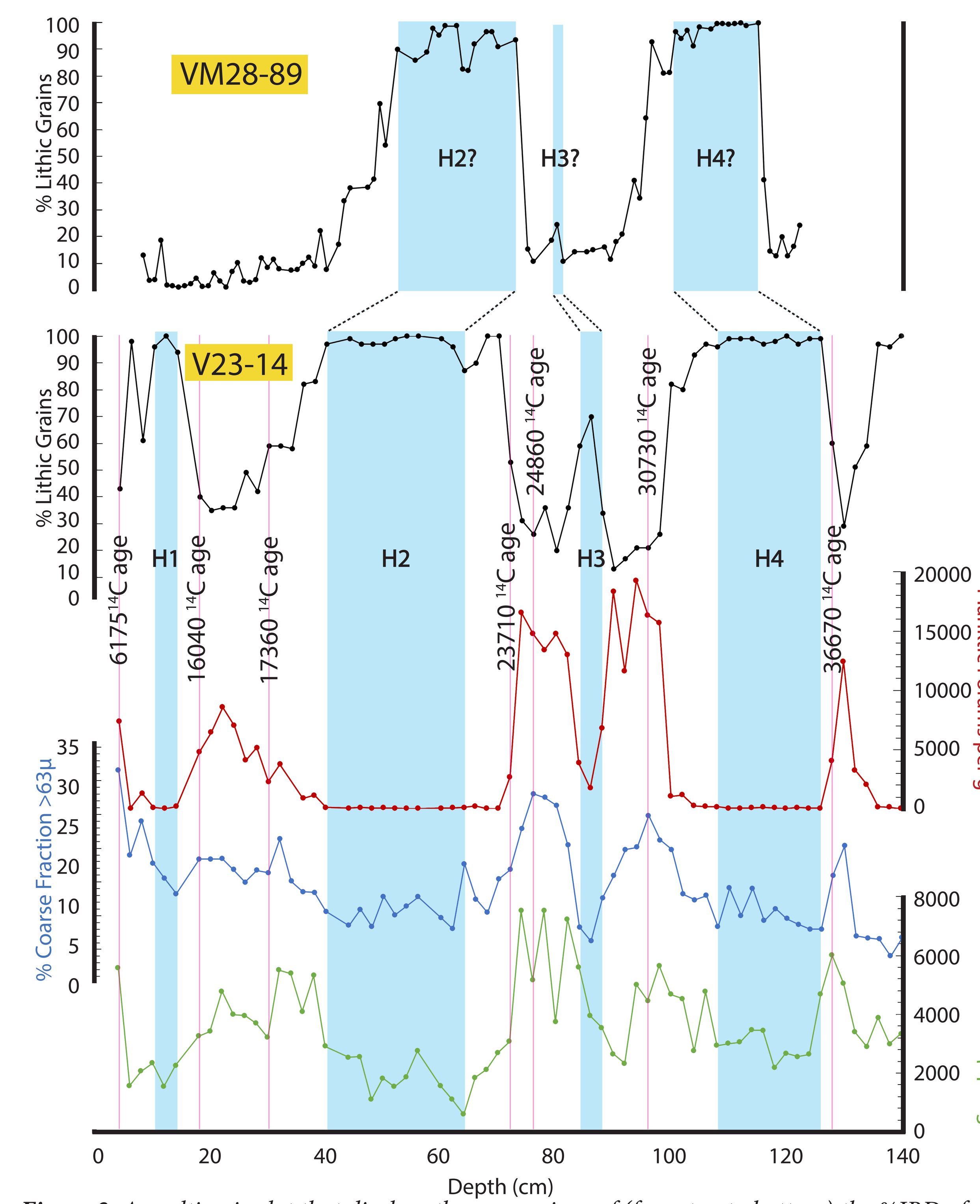

Figure 3: A multi axis plot that displays the comparison of (from top to bottom) the %IRD of VM28-89 and the %IRD of V23-14 as well as showing the Planktic foraminifers, >150µm per gram of sediment (forams/gram); the >63µm size faction weight in grams; and Lithic grains, >150µm per gram of sediment (lithics/gram).

Pink lines and dates represent the ^{14}C dated samples that were used by Hemming & Hajdas to interpret Heinrich events (marked in blue). Tentative correlations to the VM28-89 core are drawn from H2, H3, and H4. The tentative correlation of H3 has a low confidence compred to H2 and H4.

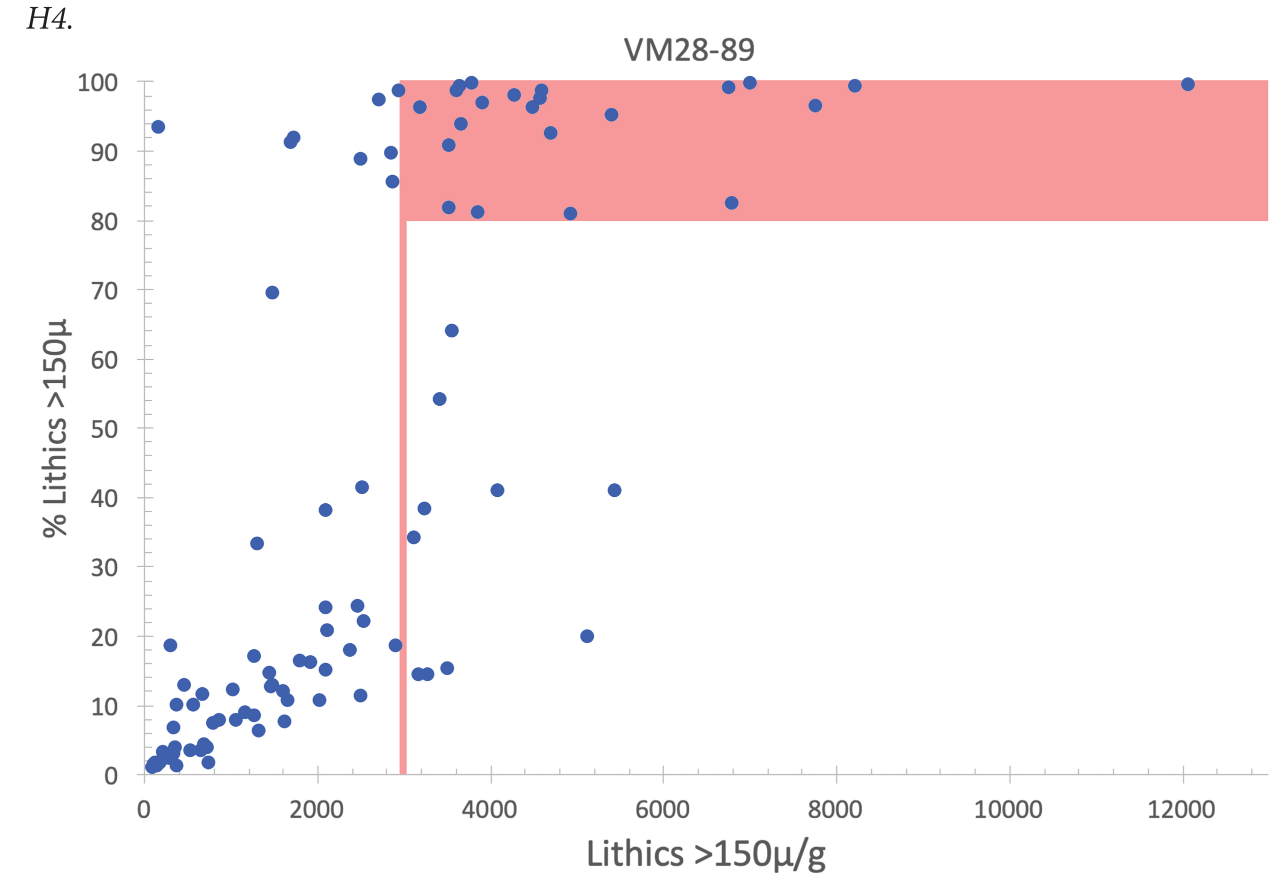

***Figure 4:** A plot showing the relationship between %IRD and lithics/gram in VM28-89. This core shows signifigant decoupling of values after 3,000 lithics/gram. So in gereral, if a sample has <3,000 lithics/gram (left side of red line), it is likely to be spread out off a linear path between 0% and 25% IRD, but in the case that it's >3,000 lithics/gram (right side of red line), the percentage will be above 80% and mostly between 90% and 100%. This distinct lack of correlation at higher values is likely due to the effects of significant changes in the input of foraminifer shells in the high %IRD intervals.*

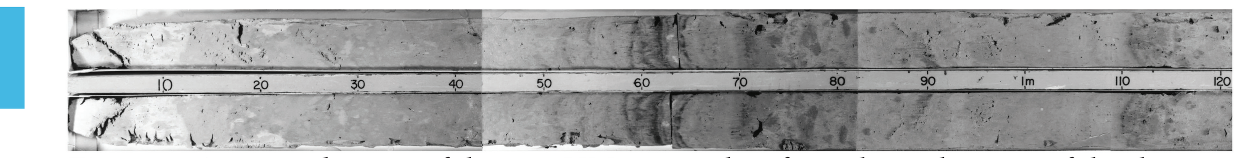

***Figure 5:** A scanned image of the core VM28-89 taken from the 28th cruise of the ship Vema owned and operated by Lamont. The core was scanned in 1971 at the Lamont Geological Observatory. This is the top 120 cm of a total 1105 cm*

Discussion

High resolution records from North Atlantic deep-sea sediment, like we have generated here, have been instrumental in documenting millennial-scale climate variations during the last glacial cycle (MIS 4 to 2) including variations of IRD concentrations related to massive iceberg discharges from continental ice sheets. Some questions about the data generated still remain.

Where the %IRD is highest, it is expected that the lithics/gram and the coarse fraction would also be at high values, and this is seen in VM28-89. This however is not seen in the V23-14 core where, when the %IRD is high, the lithics/gram and the coarse fraction are at their lowest. Although the %IRD can be correlated, the # of lithic grains across both cores has much less of a correlation, and are seemingly opposite.

Unlike IRD records from farther to the northeast and out of the IRD belt, %IRD and lithics/gram show a distinct lack of correlation at higher values (Figure 4). This decoupling is likely due to the effects of significant changes in the input foraminifer shells in the high %IRD intervals.

H3 is more prominent in V23-14 and indistinguishable in VM28-89, not sure why this is, but may have something to do with the size of ice pulses in H3. V23-14 is further west than VM28-89 and therefore farther up current (Figure 1) so it is possible the same amount of ice did not reach as far east, to check this, more high resolution records of IRD in the IRD belt should be generated. This may also account for the fact that, while having a higher sedimentation rate between H events, V28-89 has a lower sedimentation rate during H events (Figure 3).

Conclusions

- Our high resolution record records two main spikes in IRD.

- Our record being from the IRD belt shows long plateaus of sediment deposition during Heinrich events.

- Our core VM28-89, further east and further down the estimated current, has a slower sedimentation rate during Heinrich events than V23-14.

- Heinrich events 2 and 4 have been tentatively identified in our record as the first and second main plateau respectively.

- Heinrich event 3 may or may not be represented in the VM28-89 record.

-The topmost part of the VM28-89 record is likely destroyed because of a mechanical truncation caused by the use of a piston core.

References

Broecker, W., Bond, G., Klas, M., Clark, E., and Mcmanus, J., 1992, Origin of the northern Atlantics Heinrich events: Climate Dynamics, v. 6, no. 3-4, p. 265–273, doi: 10.1007/bf00193540.

Heinrich, H., 1988, Origin and Consequences of Cyclic Ice Rafting in the Northeast Atlantic Ocean During the Past 130,000 Years: Quaternary Research, v. 29, no. 2, p. 142–152, doi: 10.1016/0033-5894(88)90057-9.

Hemming, S.R., and Hajdas, I., 2003, Ice-rafted detritus evidence from 40Ar/39Ar ages of individual hornblende grains for evolution of the eastern margin of the Laurentide ice sheet since 43 14Cky: Quaternary International, v. 99-100, p. 29–43, doi: 10.1016/s1040-6182(02)00110-6.

Naafs, B.D.A., Hefter, J., Grützner, J., and Stein, R., 2013, Warming of surface waters in the mid-latitude North Atlantic during Heinrich events: Paleoceanography, v. 28, no. 1, p. 153–163, doi: 10.1029/2012pa002354.

Ruddiman, W.F., 1977, Late Quaternary deposition of ice-rafted sand in the subpolar North Atlantic (lat 40° to 65°N): Geological Society of America Bulletin, v. 88, no. 12, p. 1813, doi: 10.1130/0016-7606(1977)88<1813:lqdois>2.0.co;2.

Seidov, D., Sarnthein, M., Stattegger, K., Prien, R., and Weinelt, M., 1996, North Atlantic ocean circulation during the last glacial maximum and subsequent meltwater event: A numerical model: Journal of Geophysical Research: Oceans, v. 101, no. C7, p. 16305–16332, doi: 10.1029/96jc01079.