HIGH RESOLUTION RECORD OF ICE RAFTED DETRITUS IN CENTRAL NORTH ATLANTIC DEEP-SEA SEDIMENT CORE V30-100

Honors Thesis

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Abstract

High resolution records from North Atlantic deep-sea sediments have been instrumental in documenting millennial scale climate fluctuations during Marine Isotope Stages (MIS) 4-1, including variations in concentrations of ice rafted detritus (IRD) related to massive iceberg discharges from Northern Hemisphere ice sheets. We have analyzed 149 closely spaced samples from the top 2 meters of North Atlantic piston core V30-100 (44°06.5'N, 32°30'W) and produced detailed records of %IRD (%lithics=(#lithic grains >150 microns)/(#lithic grains >150 microns + #planktic foraminifera >150 microns)*100), IRD per gram (lithic grains >150 microns per gram sediment), and planktic forams per gram (whole planktic foraminifers >150 microns per gram sediment).

%IRD reveals 4 distinct intervals of >80% IRD coupled with consistently very low forams per gram at 40-48cm, 80-88cm, 137-149cm, and 179-184cm separated by long intervals of significantly lower IRD (<20%). The IRD per gram (lithics per gram) is consistently above 3000 lithics per gram during the intervals of high %IRD but show considerably more variability. %IRD and lithics per gram show a distinct lack of correlation at higher values. This is likely due to the influence of changes in planktic foram production affecting our proxies of IRD input.

Upon analysis of our high-resolution IRD records with the low-resolution carbonate record from V30-100 as well as our detailed comparison to other IRD records from the Central North Atlantic (Hemming, 2003) suggests that the 4 intervals of high %IRD in V30-100 correspond to well documented Heinrich events that occurred in the North Atlantic during the last glacial interval (MIS 4-2). We have correlated the high IRD event centered around 180cm to H5, and the interval centered around 145cm to H4. The IRD events centered around 85cm and 45cm have been correlated to H2 and H1, respectively. If these correlations are correct, H3 has not been recorded in V30-100.

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Introduction

The generation of high-resolution records of North Atlantic deep-sea sediments has proven useful as evidence of millennial scale climate oscillations that occurred during the most recent Marine Isotope Stages (MIS 4-2). During the last glacial cycle, six separate events of significantly increased iceberg calving have been identified by massive inputs of sediment transported to the center of the North Atlantic Ocean by icebergs that broke off continental ice sheets. Indicators of these events, called Heinrich events, are a sharp increase in lithic fragments, called Ice-Rafted Detritus (IRD), and a decrease in the concentration of planktic foraminifera (forams) found in the ocean sediment (Heinrich, 1988).

We have analyzed 149 closely spaced samples from the top 2 meters of North Atlantic piston core V30-100 (44°06.5’N, 32°30’W) (figure 1) and produced detailed records of %IRD, IRD per gram, and planktic forams per gram. The upper 100cm of the core was sampled at a 4cm interval and the 100-200cm section was sampled at a 1cm interval.

The main purposes of this study are to (1) generate three proxies to document changes in IRD input and foraminiferal abundance, (2) use these proxies along with magnetic susceptibility measurements, to identify Heinrich Events, and (3) compare the record of IRD input in the V30-100 core to core V23-14 a nearby core with a set of previously identified and well-dated Heinrich Events (Hemming, 2003).

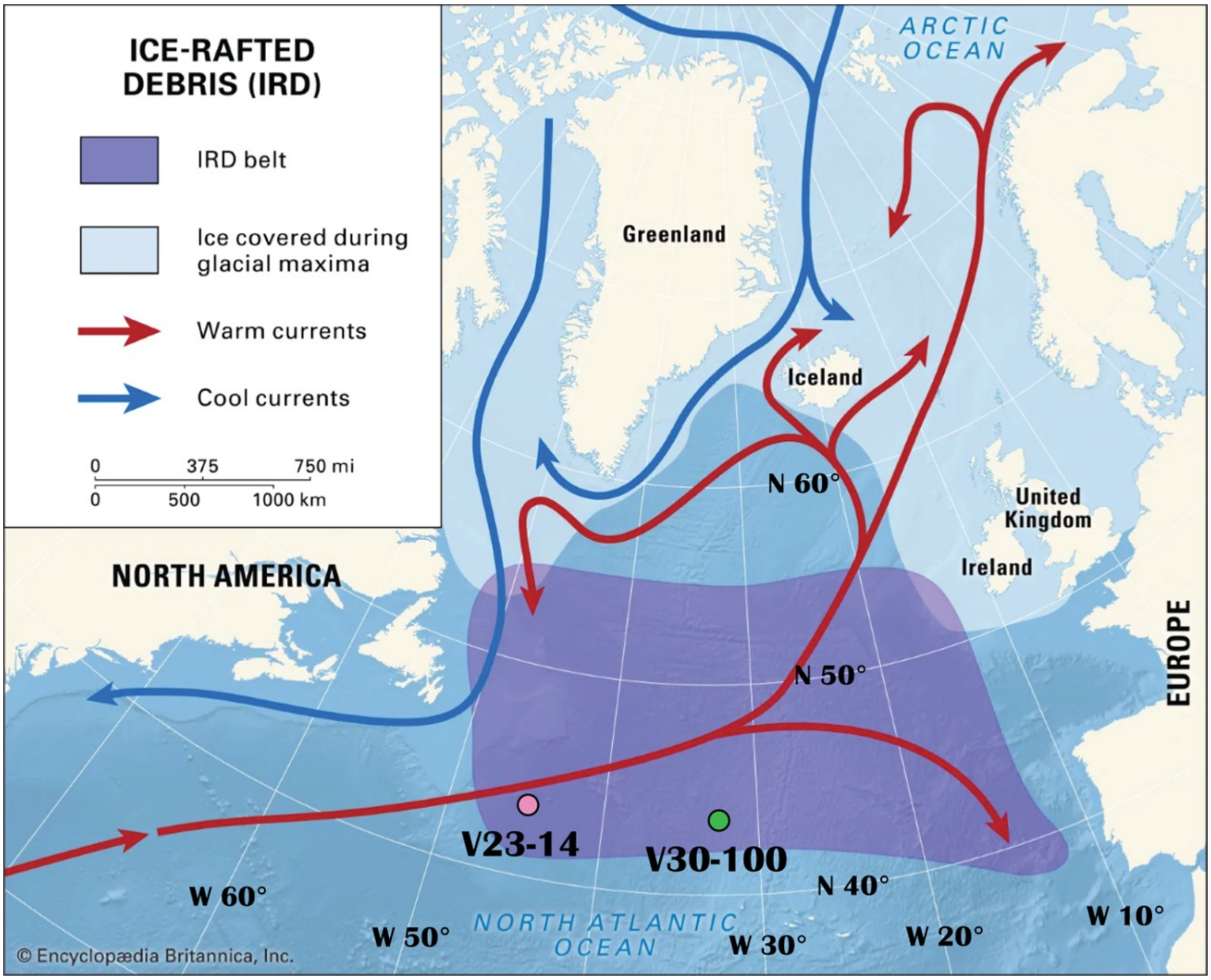

Figure 1: Locus Map

Locus map from displaying the locations of deep-sea sediment cores V30-100 at (44°06.5’N, 32°30’W) and V23-14 at (43.4°N, 45.25°W) in the Central North Atlantic Ocean. Lines with arrows indicate ocean surface circulation patterns.

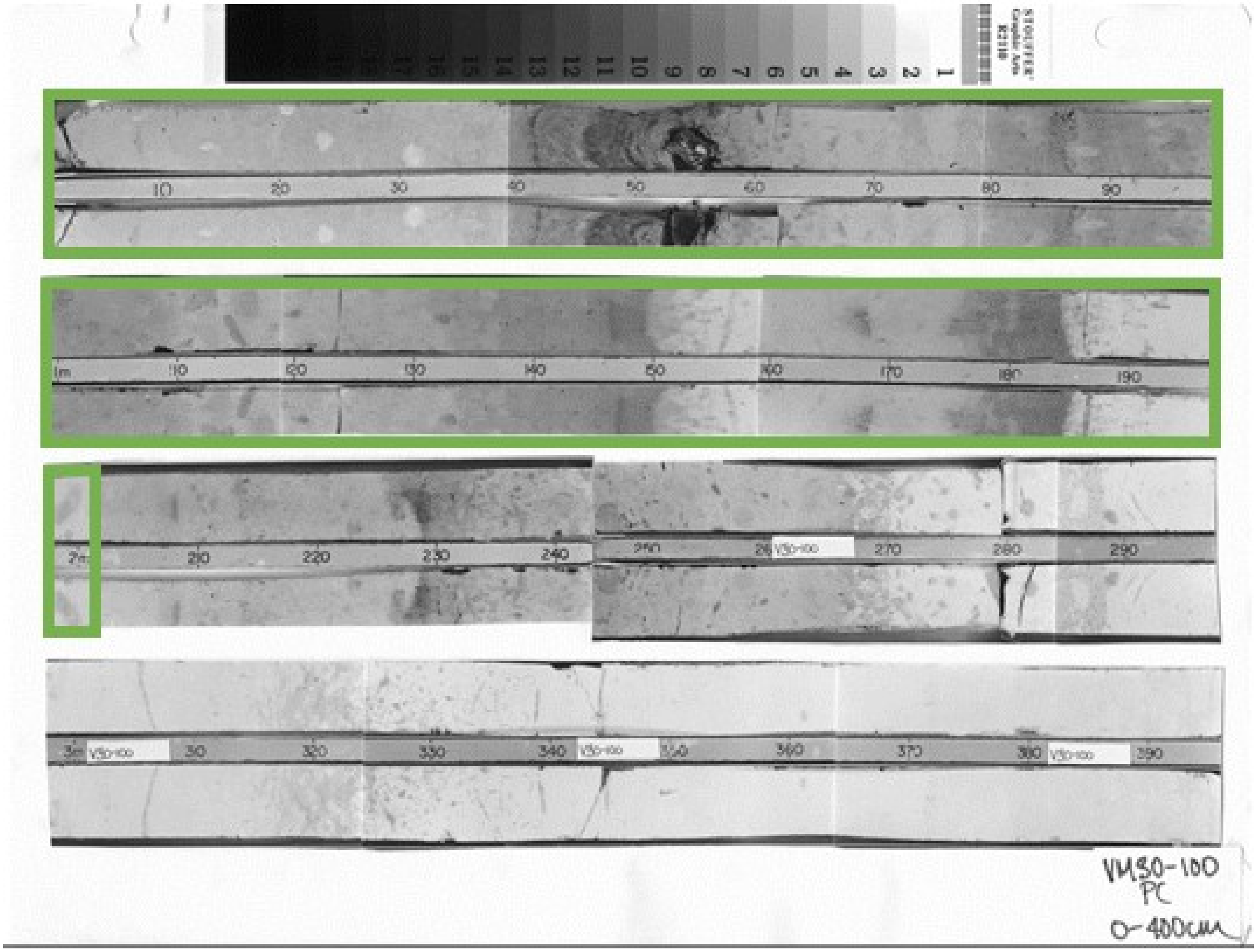

Figure 2: Scanned image of V30-100

A scanned image of the upper 400 cm of the V30-100 core. The segment analyzed in this study (0-200cm) is highlighted in green. The 0-100cm segment of the core was previously analyzed at a 4cm. The 100-200cm section was analyzed at a 1cm interval to generate a higher resolution record.

Methods

The Vema 30-100 core has a sample interval of 1 centimeter. Prior to this study, each of the samples was cleaned and processed. For this study, samples from the 100-200cm segment of the core were analyzed. This data will then be combined with existing, lower resolution data from the upper 100cm of the core that was taken at a 1cm interval. Each sample was sieved to >150 microns. The portion of the sample that was <150 microns - >63 microns was collected from the sieve and placed in a separate vial.

The >150 microns size fraction was then be split using a micro splitter until there were between 300 and 500 forams in the sample. The number of whole planktic foraminifers and lithic grains were then counted and recorded for each sample. The sample was placed on a slide for any further analysis. The data collected from each sample was used to calculate detailed records of %IRD (%lithics= (#lithic grains >150 microns)/ (#lithic grains >150 microns + #planktic foraminifera >150 microns) *100), IRD per gram (lithic grains >150 microns per gram sediment), and planktic forams per gram (whole planktic foraminifers >150 microns per gram sediment). These calculations were then plotted as a function of depth in the core.

Results

Generation of our high-resolution record reveals 4 large peaks in the abundance of lithic grains (figure 3) at 40-48cm, 80-88cm, 137-149cm and 179-184cm. These intervals of >80% lithics are divided by intervals of much lower lithic input (<20%). There is one anomalous point in the %lithics data at 152cm. The spikes in %lithics align with increases in magnetic susceptibility (figure 6) and significant decreases in foram abundance (figure 5). Only 4 spikes in magnetic susceptibility are detected in the core. There is also a gap in this data from around 50cm to 75cm. Magnetic susceptibility data was collected prior to this study so the reason for this gap is unknown. During intervals of high %lithics, measurements of forams per gram are near 0. The lithics per gram plot (figure 4) shows more variability than %lithics but are consistently about 3000 lithics per gram during the high %lithics events. The data from the 100-200cm portion of the core is higher resolution and shows significantly more detail than the 0-100cm portion.

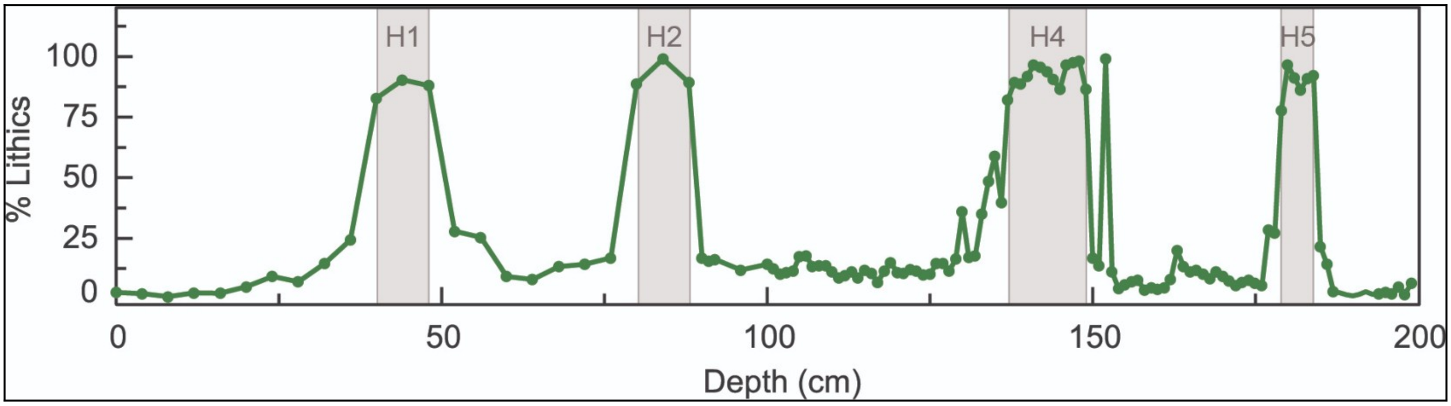

Figure 3: % Lithics Plot

The %lithics plot reveals 4 distinct intervals of >80% lithics coupled with consistently very low forams per gram at 40-48cm, 80-88cm, 137-149cm, and 179-184cm separated by long intervals of significantly lower lithics (<20%). There is an anomalous outlier at 152cm.

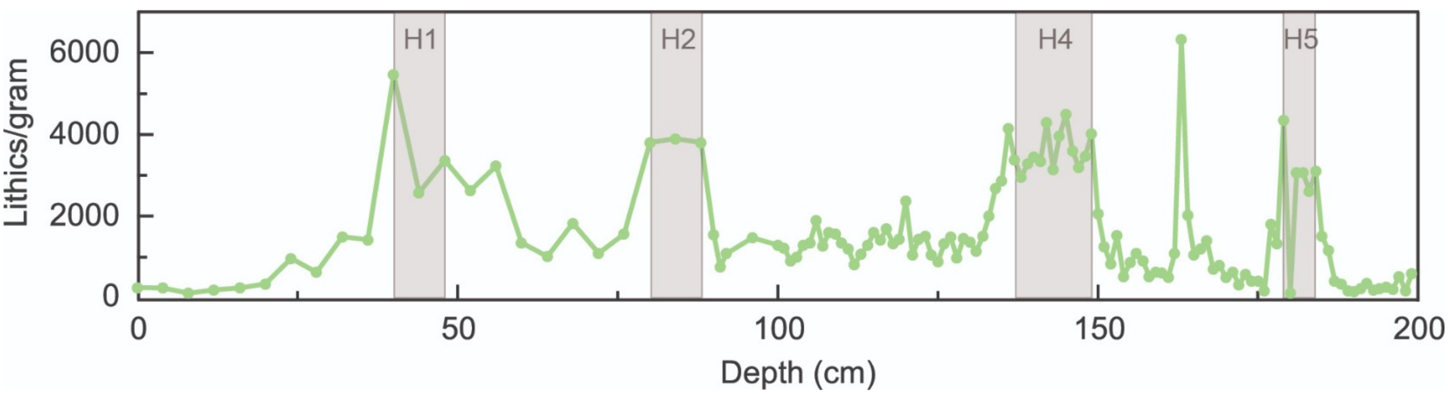

Figure 4: Lithics per gram Plot

The lithics per gram plot is consistently above 3000 lithics per gram during the intervals of high %lithics but show more variability. Where the %lithics is the highest, lithics/gram typically shows drastic increases.

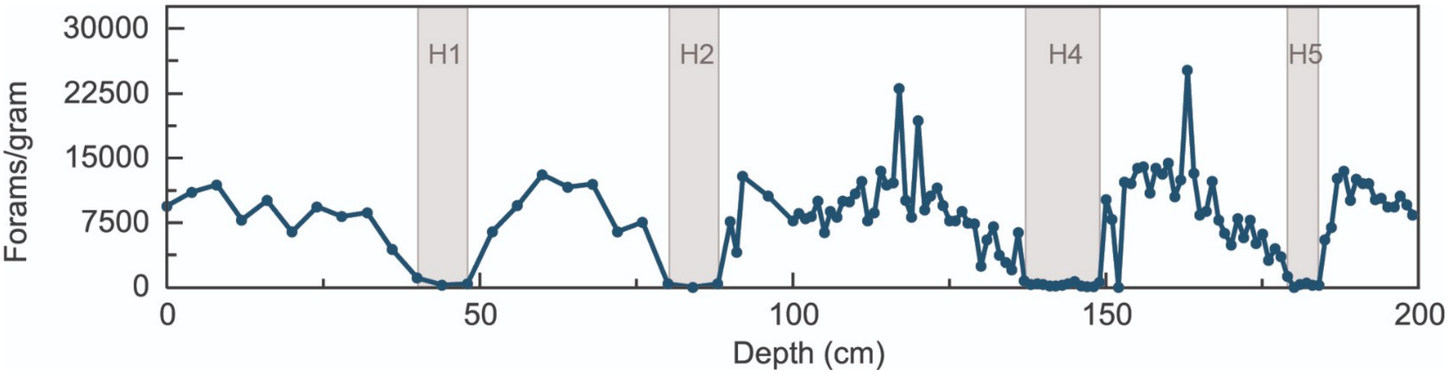

Figure 5: Forams per gram Plot

Decreases in forams per gram coincide with increases in the % lithics.

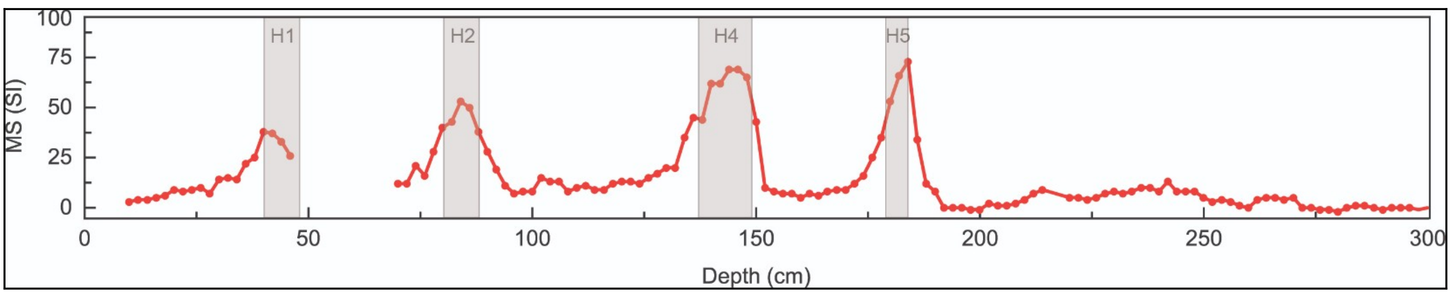

Figure 6: Magnetic Susceptibility

Magnetic susceptibility data also shows 4 drastic increases. There are no increases in magnetic susceptibility further down the core suggesting the spike in %lithics centered around 180cm is the deepest and therefore the oldest high %lithics event. There is a gap in the data between 50cm and 75cm

Discussion

Analysis of our high-resolution IRD records with the low-resolution carbonate record and magnetic susceptibility data from V30-100 as well as our detailed comparison to other IRD records from the Central North Atlantic (Hemming, 2003) suggests that the 4 intervals of high %IRD in V30-100 correspond to well documented Heinrich events that occurred in the North Atlantic during the last glacial interval (MIS 4-2). The high percentage of IRD that characterizes Heinrich layers could theoretically be a product of two end-member scenarios: very low flux of foraminifera or, alternatively, very high flux of IRD. In fact, four of the six Heinrich layers from the last 60 kyr, H1, H2, H4, and H5, have very high IRD flux in cores within the IRD belt, whereas two of the layers, H3 and H6, only show a modest increase in flux or in the number of lithic grains per gram (Hemming, 2003).

The deepest high %lithics interval in the V30-100 core, centered around 180cm, was interpreted as H5 because there are no deeper spikes of increased magnetic susceptibility down the core meaning there are few lithic grains that would increase the magnetic properties of any samples. The typical carbonate sediment input for this region does not produce a magnetic signal. The data shows an anomalous point at 152cm. The reason for this outlier is unknown. The interval centered around 145cm has been correlated to H4. The IRD events centered around 85cm and 45cm have been correlated to H2 and H1, respectively (figure 3). If these correlations are correct, H3 has not been recorded in V30-100.

H3 is considered an ‘atypical’ Heinrich event. During this event, the North Atlantic received relatively less IRD input from the Laurentide ice sheet than during more typical Heinrich events like H4 (Snoeckx et al., 1999). Heinrich layers H1, H2, H4, and H5 are derived from a mix of provenance components that are all consistent with derivation from a small region near Hudson Strait. Heinrich layers H3 and H6 have different sources, at least in the eastern North Atlantic. These events appear to have a Hudson Strait source in the southern Labrador Sea and western Atlantic, consistent with a similar but weaker event compared to the big four (Hemming, 2003).

A comparison of the V30-100 core to a well-dated core nearby shows a striking similarity. The %lithics plot for the V23-14 core (43.4°N, 45.25°W) (figure 1) also shows 4 distinct intervals of increased IRD representing H1, H2, H4, and H5 as well as a small spike that is indicative of H3 (figure 7). The intervals of high %lithics in the V23-14 core are longer and occur slightly closer to the top of the core. This is likely due to the upper portion of the piston core being lost as the core was taken.

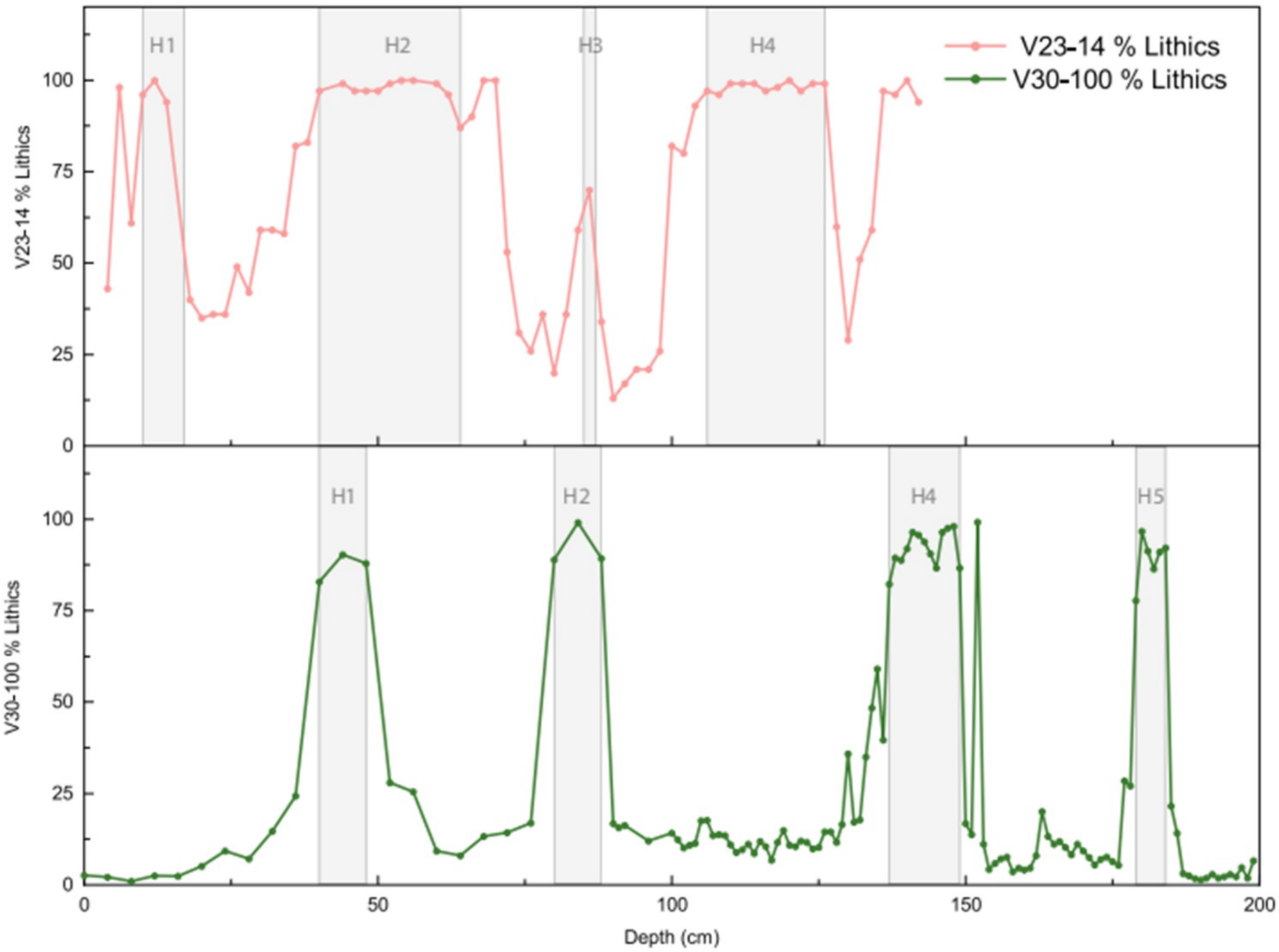

Figure 7: V30-100 and V23-14 comparison

Comparison of %lithics from the radiocarbon dated V23-14 core (pink) (Hemming, 2003) to the V30-100 core (green). Identified Heinrich event intervals in V23-14 are similar to the intervals of high %lithics in V30-100. The V23-14 Heinrich events are longer suggesting a larger IRD input at this location during the events than at the location of V30-100.

Table 1: Correlation of Heinrich Intervals

Table shows 14C ages and Heinrich layer identifications from core V23-14 compared to intervals of high IRD input in core V30-100. Heinrich event intervals are longer in the V23-14 core than in the V30-100 core. Modified from Hemming, 2003.

Heinrich Event	^{14}C age (yr) from V23-14	Interval (cm) of V23-14	Correlated interval (cm) of V30-100
H1	14,000	10-17	40-48
H2	20,500	40-64	80-88
H3	27,000	~85-87	
H4	35,000	106-126	137-149
H5	43,000	136-end	179-184

Conclusion

The high-resolution record generated through this study shows four main spikes in lithics (figure 3). These spikes coincide with significant decreases in the input of planktic forams (figure 5) which supports the interpretation of these intervals as Heinrich Events. The use of %carbonate data as well as magnetic susceptibility data for the core has enabled us to interpret the intervals of increased lithics and decreased forams in the V30-100 core as Heinrich Events 1, 2, 4, and 5. Similar to other cores from this region, Heinrich event 3 was not captured in the record of the V30-100 core. This could be for a variety of reasons but based on my investigation is likely due to decreased input from the Laurentide Ice Sheet and differences in ocean surface circulation patterns.

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Appendix