Ice sheet - ocean interaction in the eastern North Atlantic: searching for millennial-scale climate events at the western Porcupine Bank

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Introduction

The evolution and demise of the former British Irish Ice Sheet (BIIS) is a useful past analogue to establish responses of a marine-based ice sheet in a warming world. Considerable research was undertaken in the Porcupine Seabight located southwest of the former BIIS close to the last glacial Irish Sea stream (e.g. Peck et al. 2007). Several millennial-scale variabilities have been identified with relations to locally sourced ice (e.g. BIIS) and signatures from further afield (e.g. Heinrich events sourced by e.g. Laurentide Ice Sheet – LIS).

Owen (2010) and Toms (2010) also linked millennial-scale changes to Heinrich events and input coming from the BIIS on slope deposits of the Porcupine Bank situated at the western margin of the BIIS. Ongoing work seeks to improve the knowledge focussing on Marine Isotope Stages (MIS) 2 to 4 in areas of the Porcupine Bank providing the highest resolution of the last glacial. Millennial-scale events can be identified by the presence of ice rafted debris (IRD) and foraminifera assemblage data can be applied to provide evidence about Heinrich events (predominant appearance of cold water species) as well as to determine oceanographically and climatically conditions associated with either event.

Material and Methods

Core CE14004_26GC was collected from the western Porcupine Bank (52°44.0936'N, 15°23.6345'W - 2901.3m water depth) by a gravity corer on the RV Celtic Explorer in March 2014 (FIG. 1). The site is located at the north-eastern border of the IRD belt and about 400 km west of the former BIIS margin.

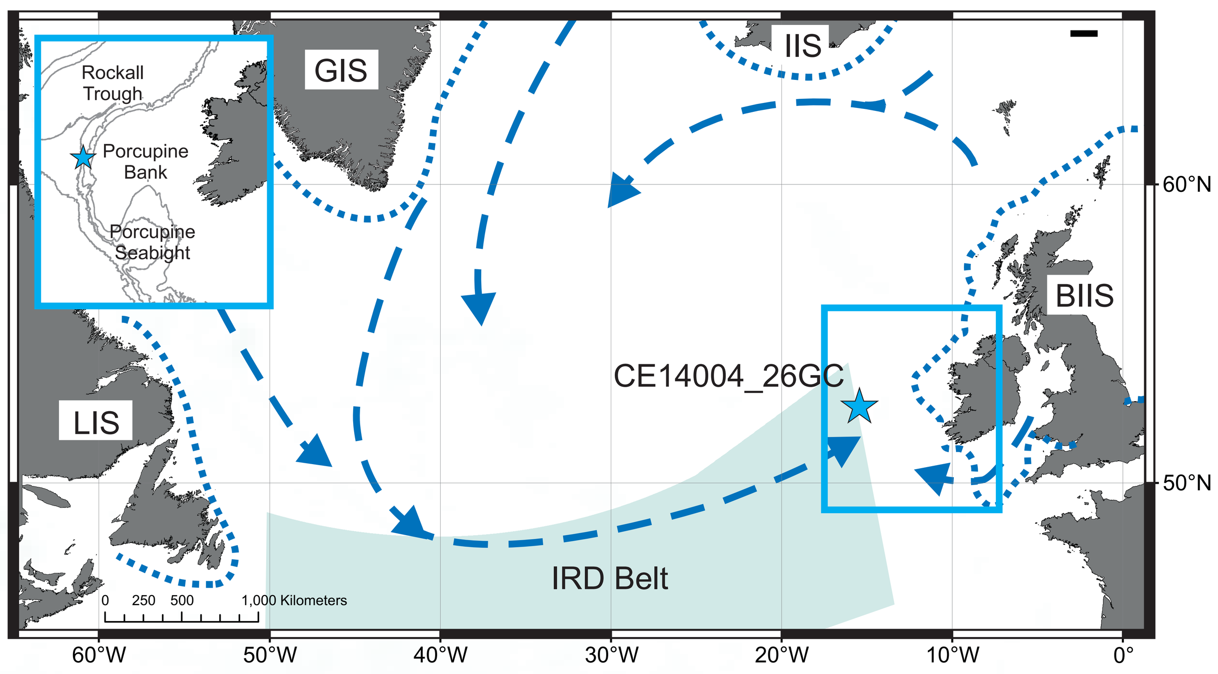


Figure 1: Location of core CE14004_26GC. Blue shade marks primary IRD accumulation zone and dashed lines likely routes of icebergs derived from circum-North Atlantic ice sheets (modified after Peck et al., 2007). Dotted line illustrates the last glacial ice sheet limits of the BIIS (after Chiverrell and Thomas, 2010) and the other ice sheets (after Peck et al., 2007). BIIS - British Irish Ice Sheet, GIS - Greenland Ice Sheet, IIS - Icelandic Ice Sheet, LIS - Laurentide Ice Sheet.

Magnetic susceptibility and X-ray imaging

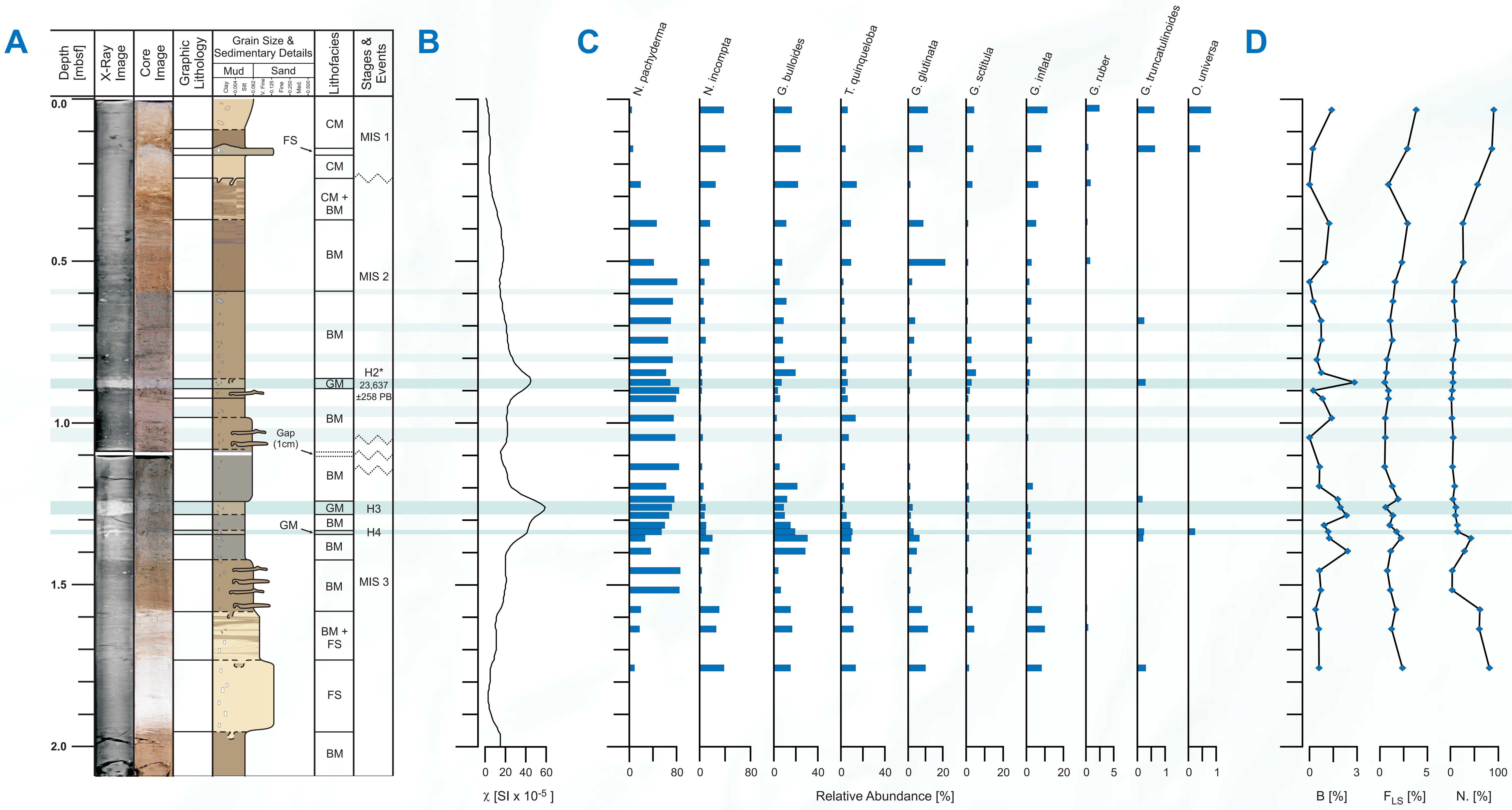
Whole core scans with a measuring interval of 1 cm were conducted using a GEOTEK multi-sensor core logger (standard configuration) at the Irish Sediment Core Research Facility (ISCORF), Maynooth. Magnetic susceptibility has proven valuable in identifying IRD and Heinrich events in marine sediments (e.g. Toms, 2010). Especially, Heinrich events are characterised by sharp amplitudes in the magnetic susceptibility (e.g. Chi and Mienert, 1996).

Complementary information on sedimentary structures was provided by X-ray imaging of core material at the School of Health Sciences, Newtownabbey.

Foraminifera assemblage data

Samples have been taken in average every 6 cm with a higher resolution over key features. The residues of the wet sieved samples (63 micron sieve) were oven-dried and the foraminifera picked out using a stereo microscope (Leica MZ6). Following the CLIMAP protocol (CLIMAP, 1984), foraminifera assemblage data were determined from a random sub-sample containing about 300 to 500 specimens from the >150 micron fraction.

Results



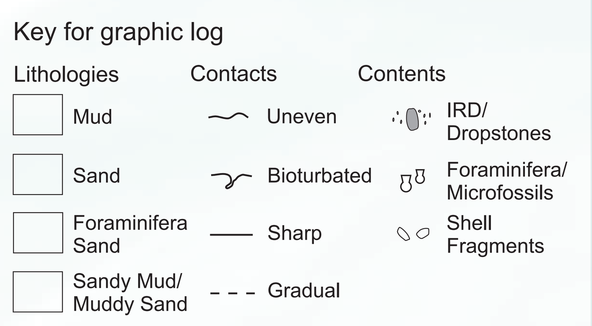


Figure 2: Summary of the results of core CE14004_26GC. A) Log profile including X-ray and core images. Lithofacies adapted from Toms (2010); BM - brown mud, CM - calcareous mud/sandy mud, GM - grey muds, FS - foraminifera sand. Estimated correlations between lithofacies and marine isotope stages (MIS) and Heinrich events (H) shown. H2 is verified by a radio carbon date (*) correlated from a nearby core (Toms, 2010). B) Magnetic susceptibility (χ). C) Foraminifera assemblage data. Foraminifera species sorted by relative abundance. D) Benthic to planktonic foraminifera ratio (*B* after Arrhenius, 1952), fragmentation index (F_{LS} after Le and Shackleton, 1992) and the *N. incompta to N. pachyderma* ratio (here N. ratio). A dominance of *N. incompta* (> 90 %) reflects temperatures over 11ºC, while a nearly absence (< 5%) reflects temperatures below 5ºC (Darling et al., 2006). Between 5 and 90 % the temperature increases nearly linear (Darling et al., 2006).

Conclusions

1. Identification of Heinrich events

Dense areas in the X-ray images correlate well with peak values in the magnetic susceptibility verifying Heinrich events. A corrected radio carbon date for the first peak gives an age of 23,637±258 PB confirming H2. Accordingly, the following two zones can be H3 and H4.

2. Indicators for further millennial-scale events

Throughout the complete last glacial IRD can be found, occasionally accumulated as distinct layers. These layers then often correlate to changes within the core, the magnetic susceptibility or the benthic to planktonic ratio.

3. Mixing signals from foraminifera data

The last glacial is dominated by the cold water species *N. pachyderma* with higher abundance shortly before or after Heinrich events. This differs from the assumption that Heinrich events are dominated by *N. pachyderma*, especially with the appearance of warm water species during these events. Still, changes during the Heinrich events are visible in the foraminifera data, particularly in the benthic to planktonic ratio and fragmentation index.

Future Work

Further investigations need to be undertaken in relation to the identified millennial-scale climate events. Accordingly, additional cores providing higher resolutions will be examined and definite age models applied. Additionally, oceanographical and climatological hints derived from local sea surface temperatures (SST) and salinities (SSS) can be useful to correlate IRD to millennial-scale events without analysing the provenance of the IRD. Therefore, an approach combining stable isotopes ($\delta^{18}O$) and trace elements (e.g. Mg/Ca) will be adopted.

References and Acknowledgments

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