Foraminifera: a tool for elucidating past and recent climate change in marine Arctic Canada

Research Questions and Methodology

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Introduction

Over the past five decades, polar regions such as the Canadian Arctic Archipelago (CAA) have experienced pronounced changes associated with recent climate warming, such as sea ice decline (ACIA, 2005; IPCC, 2007). Such relatively recent and open-ended environmental shifts have motivated research regarding past climate variability to understand how polar marine environments responded to previous high-magnitude changes such as glacial to interglacial transitions. MacEwan University's RAPIDE (Researching Arctic Palaeoceanographic Indicators of Deglacial Environments) program seeks to apply multiple sedimentological, stratigraphic, and micropalaeontological approaches to elucidate the timing and style of marine-based deglaciation and subsequent oceanographic evolution through the CAA.

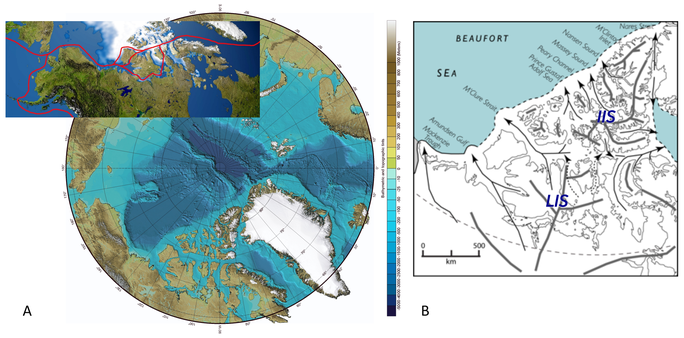

Fig. 1) A Gateway from the Atlantic to Pacific ocean via the Northwest passage (ngdc.noaa.gov,Jakobson, 20112). Fig. 1) B Depicts the extent of the Laurentide and Innuition ice sheets at the last glacial maximum(Lakeman et al., 2014)

The study areas (Fig. 2), constitute the marine channels of the CAA, a major gateway for water and heat exchange between the Arctic and Atlantic oceans (Pienkowski, 2014). This region has changed considerably since the Last Glacial Maximum (LGM; c.26 ka BP), with ice sheet retreat and subsequent and ongoing evolution of oceanography, sea ice, and ecosystems.

Foraminifera (single celled protists) constitute the main proxy used in the RAPIDE program to reconstruct past environmental conditions. These reconstructions are developed via assemblage and biogeochemical ($\delta^{13}C$ and $\delta^{18}O$) analyses, including water temperatures, sea ice conditions, and ecosystem productivity, in the eastern (Lancaster Sound/Baffin Bay) and western (M'Clure Strait) entrances to the historical Northwest Passage.

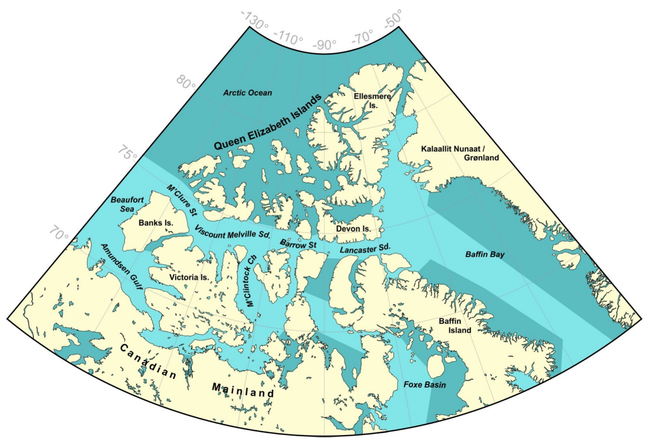

Fig.2. Map of Arctic Canada showing the approximate current study for the RAPIDE project as investigated during ArcticNet cruises in 2016 and 2017; specifically highlighted in lighter blue.

Foraminifera as a proxy

Foraminifera are classified as a amoeboid protists and can be used as an indirect measure of environmental conditions. This study focuses on using foraminifera as a proxy to discern marine systems and glaciation patterns over the Holocene epoch. This approaches takes advantage of the fact that abundance and type of foraminifera are characteristic of particular environments (Murray, 2000). Characterizing modern foraminiferal assemblages plays an important role in further interpretations in that, in order to understand past environments we must first be able to interpret the contemporary habitats of these forams. Uncovering present species ecosystem relationships and environmental tolerances allows for more accurate interpretations of palaeoclimates. Although forams have been used previously as a proxy in the CAA, this study provides a more robust baseline for palaeo-interpretations based upon a comprehensive investigation of modern CAA foraminiferal distributions. Foraminiferal specimens will also be essential for compilation of species for taxonomic purposes, including generating an atlas of foraminiferal species by Anna Pienkowski and Alix Cage.

Sample collection

Samples used for this research were acquired during ArctNet expeditions in the CAA aboard the CCGS Amundsen, during summers 2016 and 17. Samples consist of piston, gravity and box cores, ≈37 inclusive samples from 2016 and ≈50 from 2017. Samples are retained at MacEwan University as well as the Geological Survey of Canada (GSC). Sample sites were selected based on ArcticNet cruise plans and logistic opportunity.

Methods

Preparation of samples

For micropalaeontological analyses samples were wet-weighed (10 cc), then wet-sieved at >63µm, oven dried at 45°C and finally dry weighed.

Picking & identifying foraminifera

A total of ≧300 benthic and planktonic foraminifera per sample, are being manually picked, whenever possible. As the microfossils are picked, two major groups were differentiated: planktonic foraminifera and benthic foraminifera. The latter was further separated into two sub-categories: agglutinated and calcareous specimens and the former into individual morphotypes. Identification guidelines included Eynaud (2011), El baini Altuna (In review), and direction form Alix Cage (Keele University).

PLANKTONIC FORAMINIFERA

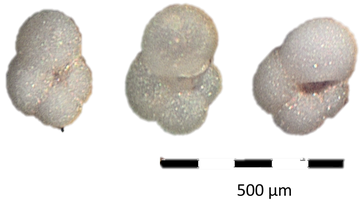

Fig. 3. Planktonic foraminifera; *Neogloboquadrina pachyderma* sensu Darling et al. (2006) Morphotype 1, 3, 1 respectively (Eynaud, 2011). Light Microscopy images.

Stable Isotope Analysis

Stable isotope analysis (**$\delta^{13}C$ and $\delta^{18}O$**) currently being undertake using laser ablation ICP mass spectrometry at Cardiff University (Wales, UK). The results will be useful in:

1. Determining water **temperature**
2. Calculating oceanic **salinity**
3. Evaluating **ice conditions**

Desired outcomes

- To map modern species distributions in seabed sediments in an Atlantic-Arctic transect (Baffin Bay to NWP; ~100 box core samples; recovered in 2016 and 2017
- To link modern distributions to measured environmental parameters (e.g., sea ice duration)
- To obtain biogeochemical data (isotopes of O & C tracing temperature, ecosystem productivity) from selected species (~90 samples)
- To Combine the information from assays (species-environment relationships; isotopic values; carbon dates) to directly interpret past environments

BENTHIC FORAMINIFERA

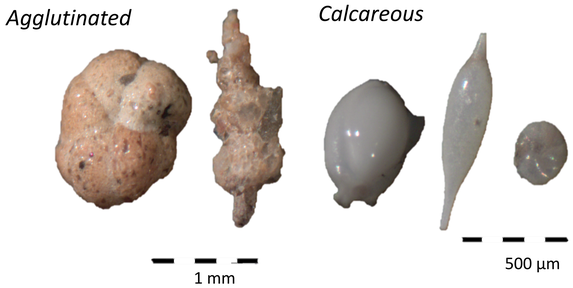

Fig. 4. Example species of benthic foraminifera. From left to right *Cribrostomoides* sp., *Reophax scorpiurus* (Monfort, 1808), *Pyrgo* sp., *Lagena gracillima, Bucella frigida ?* (help with identification from Alix Cage (Keele University)).

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