Zoë Roseby

British Sedimentology Research Group: Gillian Harwood and Steve Farrell Memorial Funds Case for Support

I am currently a second year PhD student funded by SPITFIRE, a NERC funded Doctoral Training Partnership (DTP) based at the University of Southampton, involving the National Oceanographic Centre and British Antarctic Survey. My PhD project aims to reconstruct the processes and deglacial history of the Anvers Palaeo-Ice Stream Trough, western Antarctic Peninsula shelf. The limited temporal observations of modern ice stream behaviour make it difficult to fully understand the key controls on ice stream retreat. Palaeo-ice stream reconstructions, which focus on the rate and style of retreat following the last glacial maximum, provide an essential insight into the future of contemporary ice streams as they respond to atmospheric and ocean warming[1]. This reconstruction will additionally provide data to ground-truth ice stream numerical models that simulate ice stream retreat and identify the driving factors[2].

By combining the facies of marine sediment cores and the palaeoenvironmental changes archived within them, with corresponding acoustic sub-bottom profiles and multi-beam swath bathymetry data, I aim to reconstruct the history of the last deglaciation of the trough in high temporal and spatial resolution. A network of sediment cores, collected along two transects, will allow me to constrain the style and rate of retreat of the Anvers Palaeo-Ice Stream, from the outer to the inner shelf and the spatial variability of retreat along and across the trough. Sediment types deposited during ice stream retreat are often difficult to interpret and, as a consequence, the reconstruction of the processes that led to their deposition is often challenging. This is due to the complex and highly variable processes occurring proximal to the grounding line of ice streams. My PhD project will seek to refine the distinction between subglacial and glaciomarine transitional facies and between seasonally open marine and sub-ice shelf facies. Figure 1 is a schematic diagram illustrating the processes that form sub-glacial, transitional and open marine sediment facies. Over the first year of my PhD I have used a multi-proxy approach to assign a depositional environment for each facies within the sediment cores under investigation. Figure 2 is an example of the data collected for one of the twelve cores under investigation.

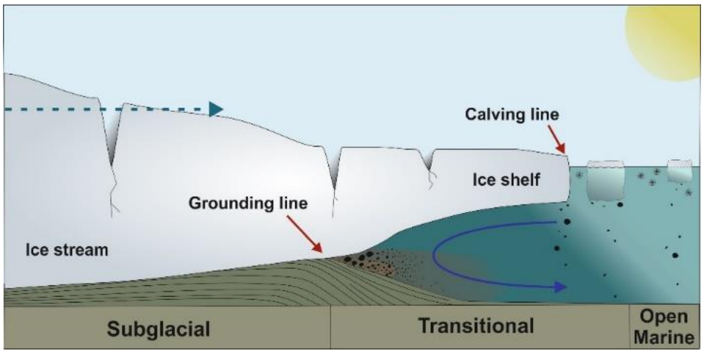

Figure 1: Schematic diagram showing the depositional processes acting in a subglacial, transitional and open marine environment.

A crucial component of glacial reconstructions is dating the timing of grounded ice retreat. This is achieved through dating the transition between sub-glacial and open marine sediments, as highlighted in Figure 2. A detailed retreat chronology allows us to understand the rate of deglaciation and the ability to relate this to regional and global forcing mechanisms, such as increases in atmospheric and/or ocean temperatures and sea-level rise. We can additionally use dating to interpret subglacial sediment transport and deposition rates, which aids our understanding of the timescales and processes that form depositional features such as grounding zone wedges. A scarcity of preserved biogenic calcium carbonate within Antarctic marine sediments renders this difficult, as ^{14}C dating of calcareous shells and foraminifera is considered to be the most reliable method for dating sediments deposited during the last 40 ka[1]. This problem has meant that past studies have often relied on dating the acid insoluble fraction of the organic matter (AIOM) of the sediments[3]. Whilst AIOM dating frequently provides realistic dates for ice retreat from some sectors of the Antarctic shelf, the resulting ages still have considerable error bars and, in some sectors, are thousands of years older than the corresponding ^{14}C ages of calcareous microfossils dated from the same sediment samples[3-5]. AIOM dating involves the combustion and dating of all of the acid-insoluble organic matter within the sediments, and often is unable to remove the entire contamination effect caused by the supply of reworked, fossil organic carbon which was produced much earlier than the time of sediment deposition[3]. Professor Brad Rosenheim and his group at the University of South Florida (USF), have developed a novel method that minimises the effect of this contamination by fossil carbon on the ^{14}C dates from organic matter. This is achieved through ramped pyrolysis; when the sediment is subjected to combustion under increasing temperatures to thermally break down the bulk organic matter. The gradual temperature increase allows for the separation of the more thermochemically reactive younger constituents, which are preferably combusted under lower temperatures, from the reworked more stable older constituents, so that these separate components can be dated independently. This method has been shown to improve AIOM dating of Antarctic shelf sediments in general[4], and specifically provides viable chronologies for sediment cores recovered from Anvers Trough[5].

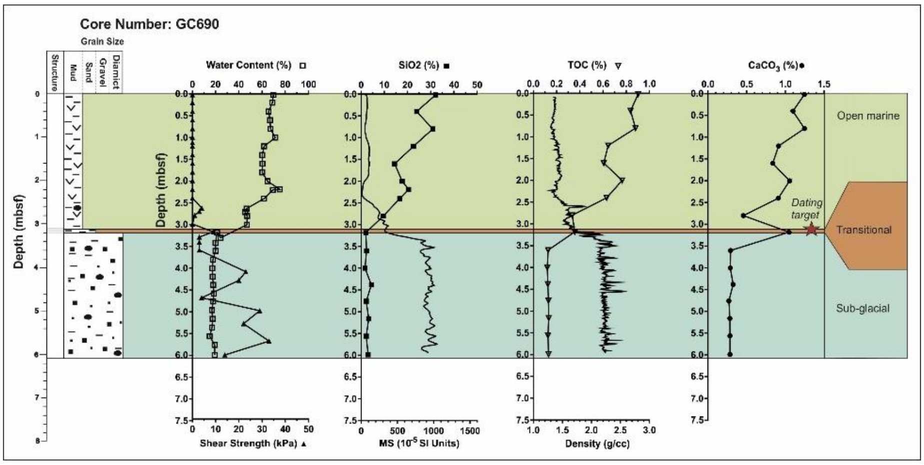

Figure 2: Core log, sediment structure and plots of water content, shear strength, biogenic opal, magnetic susceptibility, total organic carbon, density and calcium carbonate content for core GC690. The red star indicates the sediment horizon in this core we intend on dating, this marks the transition from grounded to floating ice.

I am writing this grant request to support a six week visit to the United States, where I will spend four weeks preparing samples with Professor Rosenheim at USF, and a final two weeks dating samples within the National Ocean Sciences Accelerator Mass Spectrometry Facility (NOSAMS) at the Woods Hole Oceanographic Institution (WHOI). The analytical fees at USF and NOSAMS will be generously covered by the Rosenheim group, with a contribution from personal funds. I must, however, additionally pay for travel and accommodation over the duration of my visit. Whilst I am supported by a NERC DTP grant, this is insufficient to cover the entire cost of this trip in addition to the other expenses I will have throughout my PhD. This research trip would allow me to make major progress with my PhD project and would give me the opportunity to learn a novel dating method that will provide vital age constraints for the deglaciation of Anvers Trough. The chance for me to collaborate internationally with scientists in world class research institutes such as USF and WHOI is an exciting prospect and would provide me with important skills and connections that would be advantageous for my personal development and future career, such as establishing the ramped pyrolysis dating method in the UK.

1 Bentley, M.J. *et al*. A community-based geological reconstruction of Antarctic Ice Sheet deglaciation since the Last Glacial Maximum. Quaternary Science Reviews **100**, 1-9 (2014).
2 Jamieson, S. S. R. *et al*. Ice-stream stability on a reverse bed slope. *Nature Geosci* **5**, 799-802 (2012).
3 Andrews, J. T. *et al*. Problems and Possible Solutions Concerning Radiocarbon Dating of Surface Marine Sediments, Ross Sea, Antarctica. *Quaternary Research* **52**, 206-216 (1999).
4 Rosenheim, B. E. *et al*. Antarctic sediment chronology by programmed-temperature pyrolysis: Methodology and data treatment. Geochemistry, Geophysics, Geosystems **9**, (2008).
5 Rosenheim, B. E. *et al*. Improving Antarctic Sediment 14C Dating Using Ramped Pyrolysis: An Example from the Hugo Island Trough. *Radiocarbon* **55**, 115-126 (2013).