IAPETUS

NERC DOCTORAL TRAINING

Ocean/ice sheet interactions in the North East Pacific from the warmth of the Pliocene through the icehouse of the Pleistocene

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Durham University, Department of Geography
In partnership with Newcastle University, Civil Engineering and Geosciences

Supervisory Team	• **Dr Erin McClymont, Durham University, https://www.dur.ac.uk/geography/staff/geogstaffhidden/?id=9778** • **Dr Christian März, Newcastle University, http://www.ncl.ac.uk/ceg/staff/profile/christian.maerz** • **Dr Jerry Lloyd, Durham University, https://www.dur.ac.uk/geography/staff/geogstaffhidden/?id=347**

Key Words	**Northeast Pacific, Sea surface temperatures, Pliocene-Pleistocene, Geochemistry, Ocean circulation**

Overview

The record of global climate over the last 5 million years is marked by the transition from the relative warmth of the Pliocene into a colder world (the Pleistocene) which is dominated by the onset and intensification of major Northern Hemisphere glaciations. The transitions towards an "ice house" world have been linked to changes in atmospheric CO_2 concentrations, continental configurations, and ice sheet dynamics. Recently, it has been argued that changes in sea surface temperatures and ocean circulation might allow the development of larger northern hemisphere ice sheets on long timescales (thousands/millions years) by affecting heat and moisture transport to the ice sheet source regions, whereas on shorter timescales (centuries/millennia) ice sheet advance and retreat may impact on the oceans via meltwater and sediment flux. However, our understanding of these processes is largely dominated by investigation of the large Laurentide ice-sheet in North America, and it's interaction with ocean circulation in the North Atlantic. This project will test hypotheses of ocean-ice sheet interaction over the Pliocene and Pleistocene by reconstructing the palaeoceanography of the NE Pacific and comparing the data to evidence for ice sheet advance/retreat.

The St. Elias mountain range and glaciers, as viewed from a Gulf of Alaska drilling site during IODP Expedition 341. The Northwest Cordilleran ice sheet developed here.

Previous investigations of the NW Pacific Ocean have advocated an important role for ocean circulation in driving North American ice sheet advance, yet the data available to assess ocean-ice sheet interaction closer to these ice sheets, in the NE Pacific, is largely limited to evidence for ice-rafted debris inputs to marine sediment cores. The Gulf of Alaska is bounded to the north by the St Elias mountain range, from which the Northwestern Cordilleran ice-sheet (NCIS) developed and advanced. The NCIS history is poorly understood, despite the sensitivity of the regional

climate in the modern day to ocean and atmospheric circulation in the North Pacific. Understanding the timing of NCIS advance and retreat is important for assessing whether glacial cycles had globally synchronous expressions (and drivers), and for testing existing hypotheses of how oceans and ice-sheets interact across a range of timescales. These interactions include both physical and biogeochemical processess: recent work in the Gulf of Alaska indicates that terrestrial sediments supplied from the NCIS region could be important for stimulating primary production in an otherwise nutrient-limited region, in turn affecting the potential drawdown of CO_2 into the oceans. Whether these same processes have also operated on millennial, glacial and longer timescales remains unknown.

The key research questions for this project:
1. What has been the magnitude and timing of changes in sea surface temperatures in the Gulf of Alaska over the last 5 million years?
2. Did changes in ocean circulation evolve before, after, or in synchrony with NCIS advance and retreat?
3. Has marine productivity in the Gulf of Alaska changed in response to ocean circulation change and/or inputs of terrestrial material?

Methodology

This project will exploit new, high resolution marine sediment sequences recovered during Integrated Ocean Drilling Program (IODP) Expedition 341. The extensive sediment sequences recovered present unrivalled opportunities to examine oceanography and glaciology changes over at least 5 million years.

The primary methodology employed will be the application of established organic geochemistry (biomarker) proxies using the organic geochemistry facilities at Durham Geography:

- Sea surface temperatures (U^{K}_{37} index)
- Sea ice (IP_{25})
- Biological productivity (sterols, diols, alkenones)
- Terrestrial inputs from ice/dust/rivers

In the Newcastle Geoscience laboratories the student will explore the inorganic geochemistry signatures:

- Nutrient inputs to the Gulf of Alaska

This project is also directly coupled to one based in Newcastle which is focussing on the coupling of nutrient cycles and productivity (März and McClymont as supervisors).

Timeline

Year 1: literature review; receive training in laboratory techniques; sample preparation

Year 2: reconstruct surface ocean conditions during (a) Pliocene warmth, (b) the development / intensification of the Northwest Cordilleran ice sheet, (c) the transition to longer duration and higher amplitude glacial cycles in the Pleistocene; receive training in redox proxies (Newcastle).
Years 3/4: complete data sets by fully characterising evidence for marine/terrestrial organic matter inputs; develop drafts of manuscripts for publication; draft and receive feedback on the thesis.

Training & Skills

The student will receive specialist training and support in the following techniques:

- Microwave assisted solvent extraction of lipids
- Liquid and gas chromatography (LC, GC)
- Mass spectrometry
- Trace metal digestion and analysis by ICP-MS

What has been the magnitude and timing of changes in sea s
The student will also be enrolled in a graduate training programme (Durham University) to gain a range of study skills and transferable skills. The student will attend and contribute to the programme of regular departmental seminars and discussion groups. S/he will attend national and international conferences, networking events and outreach activities, developing an important network for feedback and future employment.
Did changes in ocean circulation evolve before, after, or in s
Has marine productivity in the Gulf of Alaska changed over t

References & Further Reading

Jaeger, J. et al. (2011) *IODP Exp. 341 Scientific Prospectus*(http://publications.iodp.org/scientific_prospectus/341/)
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Further Information

Dr Erin McClymont
Department of Geography
Durham University
Durham DH1 3LE
erin.mcclymont@durham.ac.uk