IAPETUS

doctoral training partnership

NERC SCIENCE OF THE ENVIRONMENT

Reconstructing interglacial terrestrial climate variability & ecosystem response across MIS 19 (~790ka) from Stoneman Lake, Arizona

University of Glasgow - Geographical & Earth Sciences (Ref IAP_15_43)
In partnership with: Newcastle University - Geography, Politics, & Sociology; Northern Arizona University, U.S. – Earth Sciences & Environmental Sustainability; and University of New Mexico, U.S – Earth & Planetary Sciences.

Supervisory Team	• **Dr. Jaime L. Toney, University of Glasgow: http://www.gla.ac.uk/schools/ges/staff/jaimetoney/** • **Prof. Steve Juggins, Newcastle University: http://www.ncl.ac.uk/gps/staff/profile/stephen.juggins** • **Prof. R Scott Anderson, Northern Arizona University: https://nau.edu/cefns/natsci/seses/faculty/r-anderson/**

Key Words	**1. Palaeoclimate, 2. Biomarkers, 3. Diatoms, 4. Palaeolimnology, 5. Climate Change**

Overview

Long, continuous records of past climate change over millions of years typically come from marine and polar archives, such as ocean sediments and polar ice cores. These records extend our knowledge about how the Earth system and climate have changed over 100s of thousands to millions of years and have identified major changes in ocean circulation and glacial/interglacial conditions, which today serve as analogues to understand periods of extreme climate change, e.g., > 4˚C warming at glacial/interglacial transitions (Hansen and Sato, 2012). Relatively few archives from terrestrial environments exist that can provide similar longevity and resolution; however, a 73-m, lacustrine sediment drill-core has recently been collected from Stoneman Lake, Arizona, U.S. This record extends back over ~13 full glacial/interglacial cycles and is the focus of a large international collaboration to better understand drought occurrence during the warm and arid interglacial periods in the Southwest U.S.

The aim of this project is to reconstruct short-term and long-term climate trends across Marine Isotope Stage 19 (MIS 19) as an analogue for modern drought conditions. MIS 19 is a past interglacial period with an orbital configuration similar to the current interglacial (the Holocene). MIS 19 is represented in the Stoneman Lake core as a period of rapid sediment accumulation with evident laminations.

The successful PhD candidate will use multiproxy biomarker and palaeoecological techniques to reconstruct temperature, hydrological and ecological responses to climate drivers. He/she will work with a diverse range international project partners who have a wide range of expertise (e.g., R. Scott Anderson – palynology, Northern Arizona University; Peter Fawcett – sedimentology & stable isotope geochemistry, Uni. of New Mexico; Gonzalo Jimenez-Moreno – paleoecology, Uni. of Granada). The networks established during the course of this PhD project represent a unique opportunity to establish an international reputation and develop an unprecedented understanding of terrestrial response during MIS 19.

Students from North Arizona University, US, assisting with the drilling process

Interdisciplinary Palaeoclimatology: The PhD student contribution to the international collaboration includes development of the biomarker record and diatom analysis.

Biomarkers: He/she will be trained in the use of biomarkers in palaeoclimatology with supervisor, Dr. Jaime L. Toney, in the BECS Research Group at the Uni. of Glasgow. He/she will analyse pilot samples across MIS 19 to determine which biomarkers will provide the most useful information on palaeoclimate. Ubiquitous biomarkers, such as plant leaf waxes have already been used to understand changes in the strength of the North American Monsoon during past interglacials (e.g., Cisneros-Dozal et al., 2014; doi:10.1016/j.orggeochem.2013.07.006). Similarly, the MBT/CBT paleotemperature proxy derived from bacterial membrane lipids has successfully confined temperature change across MIS 11 in the nearby Valles Caldera record (Fawcett et al., 2011, doi:10.1038/nature09839). These and other biomarkers (i.e. long-chain diols, alkenones, compound-specific carbon stable isotopes) will be investigated across MIS 19.

Diatom Analysis: He/she will also be trained in lacustrine diatom analysis with co-supervisor, Prof. Steve Juggins, at Newcastle University. The diatom record will provide an understanding of changes in the lacustrine ecosystem and identify periods of pH, salinity, lake-level and hydrological change that will complement records of change in the terrestrial ecosystem developed by collaborators.

Overall, this multiproxy approach represents a novel opportunity to understand the effect of significant hydrologic and temperature changes over a past interglacial cycle that closely resembles the modern climate conditions prior to anthropogenic warming.

Methodology

Sediment Core Sampling & Analysis: The Stoneman Lake sediment core is stored at LacCore, the U.S. National Lacustrine Core Facility in Minnesota. The PhD student will be involved in the strategic sampling of the sediment core and provided the opportunity to join the international research team on its sampling campaign.

Biomarker Sample Preparation: Samples for biomarker analysis will be processed using standard protocols developed in the BECS laboratory. Instrumentation includes: Agilent 7890 GC-FID for biomarker quantification and GC-MS (5977) for biomarker identification, fragment ion quantification and calculation of LDI. GDGT samples will be run in collaboration with Dr. Joseph Werne, University of Pittsburgh, U.S.

Diatom Analysis: Samples for diatom analysis will be processed in the Palaeoecology Laboratory at Newcastle University and analysed using Leica DMLS photomicroscope fitted with phase contrast illumination.

Timeline

Year 1 – Pilot Samples and Training: Sept. – Dec. 2016: Literature review and techniques training. **Jan to June 2017:** Processing, analysis, and synthesis of pilot sample data. **Summer 2017:** Trip to LacCORE, Uni/ of Minnesota for networking with collaborators and strategic sediment core sampling campaign.

Year 2 – The Palaeoclimate Record: Sept 2017 to April 2018: Diatom analysis and biomarker analysis. **May to Nov 2018:** Data analysis and synthesis with collaborators and current literature.

Year 3 – Data Analysis & Thesis: Sept to Dec 2018 (continued): Data analysis and synthesis with current literature, including liaising with collaborators. **Jan to August 2019:** Time devoted to thesis production and publications.

Year 4 (6 months only) – Oct. 2019 to April 2020 Thesis completion and publications.

The PhD student is expected to use BECS existing collaborations to spend part of their degree abroad.

Training & Skills

As a member of several cutting-edge research groups that apply biomarkers and palaeoecological techniques to palaeoclimate problems described, the student will be fully trained in following organic geochemical and diatom analytical techniques by supervisors.

- Organic geochemistry and diatom analysis
- GC-FID, GC-MS, HPLC-APCI-MS
- Time-series analysis
- Relevant statistical techniques

Professional Transferable Skills: Development here will be supported through IAPETUS specific provision and the Uni. of Glasgow. Example courses include: Media Training; Insights to industry; Leadership skills; Conference skills (e.g., networking, poster and oral presentation skills); Grant writing; CV workshop

Additional Further Reading

Gaines, Eglinton, & Rullkötter 2009, *Echoes of Life – What fossil molecules reveal about Earth history*. Oxford University Press.

Killops and Killops 2005, *Introduction to Organic Geochemistry*. Blackwell Publishing,.

Smol and Stoermer (Eds.) 2010, *The Diatoms: Applications for the Environmental and Earth Sciences*. Cambridge University Press.

Further Information

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