IAPETUS

NERC DOCTORAL TRAINING

Understanding dates and fates: disentangling carbon sources in sediments through radiocarbon analyses

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Durham University, Department of Geography
In partnership with Glasgow University, the Scottish Universities Environmental Research Centre (SUERC) and the NERC Radiocarbon Facility

Supervisory Team	**Dr Erin McClymont, Durham University (https://www.dur.ac.uk/geography/staff/geogstaffhidden/?id=9778)** **Dr Bob Hilton, Durham University (https://www.dur.ac.uk/geography/staff/geogstaffhidden/?id=7667)** **Dr Philippa Ascough, Glasgow University / SUERC (http://www.gla.ac.uk/research/az/suerc/ourstaff/ascoughphilippa/)** **Dr Charlotte Bryant, Glasgow University / NERC Radiocarbon Facility (http://www.gla.ac.uk/centres/nercrcl/staff_CLB.htm)**

Key Words	**Radiocarbon, chronology, organic geochemistry, marine sediments, carbon cycle**

Overview

Radiocarbon (^{14}C) dating is the most versatile technique for archaeologists, palaeo-environmental and earth scientists seeking to precisely date the timing of events and the rates of processes over the last 50,000 years. For example, the ^{14}C content of samples can be used to provide a chronological framework for a sediment sequence and/or as an ultra-sensitive tracer to disentangle the source and turnover time of different carbon-bearing components in environmental systems. However, reliable interpretation of ^{14}C results can be challenging due to the difficulties in finding suitable material for analysis (i.e. with known provenance and representative of the event or layer being studied). This is because in some sedimentary sequences it may be difficult to isolate macrofossils or carbonate shells in sufficient quantities due to poor preservation and/or abundance. As a consequence, increased uncertainty and/or misleading information can be provided about environmental processes and pathways.

The aim of this research project is to exploit recent technological developments in sample processing and analysis in order to develop new methods for the isolation and purification of key target organic compounds from heterogeneous sediments. By dating specific organic compounds, a more detailed understanding of the organic matter sources and their transport pathways to a sediment sequence can be deduced; such insights are key to understanding the operation of the global carbon cycle.

Isolation and purification of target compounds or fractions of organic carbon offers the potential to advance ^{14}C analysis across a wide range of sediment types, and to tackle questions of carbon cycling as well as of chronology. However, samples sizes for this type of work are small (10s to 100s micrograms of C) and thus avoiding contamination during measurement is challenging. Recent improvements in gas and liquid chromatography technology have enabled more efficient isolation and trapping of these target compounds e.g. marine algal biomarkers (alkenones, sterols), microbial biomarkers (isoprenoidal glycerol diether glycerol tetraethers) and soil markers or higher plant markers (n-alkanes, branched tetraethers). This project will utilise the capabilities at Durham University plus sample preparation and ^{14}C analysis at the NERC Radiocarbon Facility and Scottish

Universities Environment Research Centre (SUERC) to develop and apply methods of compound specific ^{14}C analysis in sedimentary archives.

The overall aim of this PhD studentship is to i) develop analytical methods to identify target organic carbon components for ^{14}C analysis in coastal marine sediments, and ii) apply this methodology to refine existing marine sediment sequence chronologies. The test site for these methods spans river outlets in Taiwan, extensively studied and sampled by Co-I Hilton to understand overall catchment dynamics (including source-pathway-sink processes for organic materials). Specifically, the student will address the following objectives:
O1. Develop quality control protocols, including establishing standard reference materials
O2. Optimise protocols for extraction of target compounds from marine sediments
O3. Apply the developed technologies to a proximal marine sediment sequence with a well constrained chronology to test hypotheses about the ages of marine, terrestrial, and thus bulk, organic carbon.

Terrestrial organic matter of varying ages can be transported vast distances to the oceans, where it is deposited in marine sediments. Photo: Juliane Müller.

Methodology

The overall focus is the extraction, purification and analysis of organic compounds, including using:

- Microwave technology
- Liquid and gas chromatography systems
- Mass spectrometry for compound identification and quantification
- Radiocarbon measurement using accelerator mass spectrometry (AMS).

Timeline

Year 1: Literature review; write and defend Year 1 Research Proposal; training in laboratory techniques (Durham); Sample preparation.
Year 2: training in additional purification techniques (SUERC); develop and test methods for isolation of marine and terrestrial compounds from modern river outlet sediments (Taiwan); apply new methods to isolate target compounds from existing sediment core; perform initial AMS analyses (SUERC).
Years 3/4: Finalise down-core compound isolation and analysis (Durham and SUERC); data interpretation and synthesis; drafting and complete of manuscripts and thesis.

Training & Skills

The student will be trained in a variety of techniques, to include (i) sedimentology; (ii) bulk elemental and isotopic geochemistry analysis by elemental analyser and isotope ratio mass spectrometry (EA-IRMS); (iii) solvent extraction; (iv) compound class fractionation and purification by HPLC; (v) compound identification and quantification by GC and GCMS; (vi) purification and concentration of analytes for ^{14}C analysis; (vii) pretreatment techniques for ^{14}C analysis of small samples; (viii) measurement of sample $^{14}C/^{13}C$ ratios by AMS; (viiii) data analysis and interpretation using statistical approaches. 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, to support the development of a well-rounded scientist. S/he will attend national and international conferences, networking events and outreach activities, developing an important network for feedback and future employment.

References & Further Reading

Ahad, J.M.E. et al. (2011) Sources of *n*-alkanes in an organic-rich, urbanized estuary: Insights from molecular distributions and compound-specific stable and radiocarbon isotopes. *Marine Chemistry* 126, 239-249.35.
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Further Information

Dr Erin McClymont
Department of Geography
Durham University
Erin.mcclymont@durham.ac.uk