Project title: Reconstruction of glacial-interglacial monsoon hydroclimate variability (CASE)

Project code: OU1

Host institution: The Open University

Theme: Dynamic Earth

Key words: Monsoon, Planktonic foraminifera, Geochemical proxies, IODP Exp 353, palaeoclimate

Supervisory team: Pallavi Anand (Open University: pallavi.anand@open.ac.uk), Francis Jenner (OU: francis.jenner@open.ac.uk), Phil Sexton (Open University: phil.sexton@open.ac.uk) and Melanie Leng (British Geological Survey: mjl@nigl.nerc.ac.uk)

Project Highlights:
- Reconstruct monsoon response to climatic forcing
- Novel geochemical proxy applications using planktic foraminifera
- Collaboration with international team of IODP Expedition 353 scientists

Overview:
The northern Indian Ocean constitutes the region with the strongest hydrological cycle on Earth. This involves large inter-hemispheric exchanges of mass and energy between the ocean, atmosphere and continents that has direct impact on ~2 billion people [1]. The resultant strong seasonal monsoon winds deliver rainfall and surface runoff in to the Bay of Bengal (BoB), causing marked seasonal variability of surface salinity [1]. The overall aim of the proposed project is to reconstruct seasonal changes in Indian Summer Monsoon (ISM) precipitation during the glacial interglacial cycles of the late Pleistocene (e.g. Marine Isotope Stage (MIS) 5, 9 or 11) and Pliocene. The project will quantify the relative sensitivity of ISM to external (e.g., insolation) and internal climate forcing factors (e.g. global ice volume, northern or southern hemisphere climate and greenhouse gas concentrations). Specific objectives are to:
- reconstruct sea surface temperature and salinity gradients from north to south in the BoB using coupled oxygen isotope, δ18O and trace element composition of planktonic foraminifera [2]
- assess seasonal variability in sea surface salinity using δ18O and trace element composition of single planktonic foraminifera shells during peak glacial and interglacial intervals
- quantify the relative sensitivity of ISM precipitation to external and interhemispheric climate forcing factors [3-4].

This project will focus on one of the core regions of Monsoon precipitation. The student will have priority access to age calibrated samples from International Ocean Discovery Programme (IODP) expedition 353 (from sites U1446 in the Mahanadi Basin and U1448 in the Andaman Sea) in the BoB. Additional legacy ODP samples from the Arabian Sea may also be included, if required, to address outlined objectives.

Figure 1: Site locations in the northern BoB (U1446) and Andaman Sea (U1448) sites (IODP expedition 353).

Methodology:
The washed deep-sea mud samples will be picked for two seasonally distinct planktic foraminiferal species. Shell mass and size of the foraminifera will be measured to determine changes in calcification. Additional foraminifera from these samples will be utilised for (a) δ18O and (b) trace element/Ca (e.g. Mg/Ca, Ba/Ca, U/Ca) measurements. Coupled δ18O and trace element measurements on bulk planktonic foraminifera samples will permit the reconstruction of variability in sea surface temperatures and δ18O of seawater (in response to salinity changes) for selected
glacial-interglacial intervals. Additionally, several single foraminifera tests from glacial and interglacial time slices will be analysed using a unique microanalytical combination of laser ablation for trace elements and δ¹⁸O of single shells (at British Geological Survey), both on the same specimens. This approach will allow the successful candidate to assess changes in monsoon seasonality between peak glacial and interglacial intervals.

**Training and skills:**
The student will have the opportunity to take part in an international research programme and will be encouraged to participate in IODP or other expeditions. This project will offer extensive networking opportunities with international scientists involved in IODP Expedition 353. Through the CENTA partnership, training will be provided in two labs. Specific skills that will be acquired during this project:
- Conducting research on unique, recently recovered deep-sea sequences (IODP Exp. 353)
- Micropalaeontological and geochemical analyses
- Data handling and interpretation from a wide variety of sources
- Scientific communication through writing, poster and oral presentations to academic and non-academic audiences
- Online teaching opportunities via the Open University Virtual Learning Environment are also available, including teaching on the new Massive Open Online Courses (MOOCs).

NERC CENTA students are required to complete 45 days training throughout their PhD including a 10 day work placement. In the first year, students will be trained as a single cohort on environmental science, research methods and core skills. Throughout the PhD, training will progress from core skills sets to master classes specific to CENTA research themes.

**Partners and collaboration**
This project is a CASE studentship with Prof. Leng at BGS. This project benefits from external collaborations with IODP expedition 353 scientists including Kaustabho Thirumalai and Steve Clemens (USA). In addition, Dr. Diwakar P. Naidu (NIO, India) has available surface samples (core-tops) that will provide unique opportunity to ground truth proxies within the project. Laser ablation work will be developed at the OU in collaboration with Dr. Ed Hathorne (GEOMAR).

**Possible timeline:**
**Year 1:** Training in sample processing of core materials, microfossil identification and analytical techniques. Write NIGFSC grant in April. Visit BGS/NIGL for oxygen isotope training and analyses of U1446 samples. Run test samples for solution and laser ablation work.

**Year 2:** Present results at Geochemistry Research in Progress meeting. Visit BGS/NIGL for single test oxygen isotope work and carry out laser work. Generate records of temperature and salinity gradients from north to south on millennial and seasonal time scales. Prepare manuscript on salinity variability in response to monsoon hydroclimate.

**Year 3-3.5:** Finish remaining analytical work, data analyses, prepare manuscripts and present results at an international conference. Write up final thesis and draft additional manuscripts.

**Further reading:**


**Further details:**
Students should have an understanding of Earth System with enthusiasm for learning and applying multi-proxy geochemical tools. Experience of palaeoclimate research is desirable. The student will join a well-established team researching on palaeoclimate proxies at the Open University and BGS.

Please contact [Pallavi Anand; Pallavi.anand@open.ac.uk] for further information.

Applications should include:
- a cover letter outlining why the project is of interest and how their skills match those required,
- an academic CV containing contact details of three academic references
- a CENTA application form, downloadable from: [http://www.centa.org.uk/media/1202/centa-studentship-application-form.docx](http://www.centa.org.uk/media/1202/centa-studentship-application-form.docx)
- and an Open University application form, downloadable from: [http://www.open.ac.uk/students/research/sites/www.open.ac.uk.students.research/files/docuents/Application%20form.docx](http://www.open.ac.uk/students/research/sites/www.open.ac.uk.students.research/files/docuents/Application%20form.docx)

Applications should be sent to [STEM-EEES-PhD-Student-Recruitment@open.ac.uk](mailto:STEM-EEES-PhD-Student-Recruitment@open.ac.uk) by 5 pm on Monday 22nd January 2018.