Project title: Plio-Pleistocene monsoon driven productivity and stratification reconstructions

Project code: OU22

Host institution: The Open University

Key words: Palaeoclimate, coccolithophore, foraminifera assemblage, Monsoon, IODP Expedition 353

Supervisory team: Supervisory team (list as name, institution, email address): Pallavi Anand (Open University:pallavi.anand@open.ac.uk), Clara Bolton (CEREGE, France; bolton@cerege.fr) and Marcus Badger (OU)
Project collaborator: Marci Robinson (USGS), Kate Littler (Exeter University) and Priyank Jaiswal (OSU, USA)

Project Highlights:
- Reconstruct productivity, stratification and runoff history of Indian monsoons at Plio-Pleistocene transition
- Terrestrial and oceanic multi-proxy study
- Collaboration with international team of IODP Expedition 353 scientists

Overview:
The Indian Monsoon (a subsystem of the Asian Monsoon) is one of the best examples of coupling between solid Earth and atmospheric processes. Its evolution during the Plio-Pleistocene transition (~3.5–2 Ma), when large-scale Northern Hemisphere Glaciation (NHG) was established, is poorly constrained. Although changes in the intensity of the Asian monsoon have been linked to the intensification of NHG from terrestrial records, a clear association has not yet been demonstrated. This project will apply a multi-proxy approach to reconstruct ocean productivity, stratification and monsoon runoff records for the Plio-Pleistocene transition from the core monsoon region of the Bay of Bengal (BoB). Stratification in the BoB is mainly controlled by fresh water runoff from the summer monsoon in the northern BoB, and wind-driven mixing in the south, restricting the availability of nutrients to primary producers. However, on seasonal to orbital timescales productivity can vary due to change in fresh water input, ocean circulation and southwest monsoon intensity, as observed in the late Pleistocene [3]. The project will involve generating records of coccolithophore and foraminifera assemblages and coccolithophore size/mass variability, potentially driven by monsoon-related freshwater input and changing wind driven circulation in the BoB. These records will address the key question: How did the monsoon influence ocean stratification and productivity before, during and after the onset of NHG, and what can this tell us about the evolution of the Indian monsoons? These records will be put in context with published records [e.g. 2] to identify the nature of the linkage between the Indian and Asian monsoons.

This project will primarily use newly drilled continuous sedimentary successions from the BoB involving proximal and distal sites with respect to the river runoff (IODP expedition 353 sites U1443, U1444 and U1445).

![Figure 1: IODP expedition 353 sites in the BoB [1].](image)
The student will reconstruct palaeoproductivity, calcification, and stratification changes during the onset of the NHG at ~2 to 4 kyr (orbital) resolution, focusing on the following parameters:
- productivity reconstructions using coccolithophore assemblage data
- Coccolith morphology data will provide key information on phytoplankton evolution in
response to climate/local carbonate chemistry changes during the intensification of NHG

- stratification history using planktonic foraminifera assemblages from same samples
- bulk sediment chemical compositions

Methodology:
Tooth-pick samples of bulk sediment will be used for coccolithophore assemblage and morphology (size and mass) work at CEREGE (Dr Bolton), using state of the art automated microscope systems (Beaufort et al 2014 Nature Protocols). The sediment samples will be washed and the larger fraction (>150 um) will be used for foraminifera assemblage work from the same interval in the fully equipped laboratories at The Open University. Foraminiferal geochemical work (carbonate oxygen and carbon isotopes measurements) to develop the late Pliocene stratigraphy will be carried out on another split of the same sample as part of an ongoing IODP project (Dr Littler), as needed. Bulk sediment XRF scanned data will be used and if needed acquired for some core sections via an IODP grant. Coupled coccolithophore and foraminifera assemblages, coccolithophore mass and size data together with XRF data will help infer changes in surface water stratification and productivity and runoff in response to monsoon variations.

Training and skills:
The student will gain experience in a wide variety of laboratory techniques including deep-sea mud sample processing, microfossil identification and assemblage work and geochemical techniques (stable oxygen and carbon isotopes and XRF data) at The Open University. In addition, the student will receive specific training on coccolithophore taxonomy, sample preparation, and use of the unique automated microscopy laboratory as well as the scanning electron microscope at CEREGE (Dr Bolton).

The student will receive project specific training and OU offers a diverse set of training courses. Specific skills that will be acquired during this project include:

- Conducting research on newly drilled deep-sea sediments (IODP Expedition 353) and working with an international team of paleoceanographers
- Nannofossil and microfossil assemblages and geochemical analyses
- Data handling and interpretation from a wide variety of sources and science communication
- The opportunity to teach via the Open University, including teaching on the new Massive Open Online Courses (MOOCs).

Partners and collaboration: This project will benefit from international collaboration with scientists working on the Pliocene for stratigraphy, foraminifera assemblage (Marci Robinson, USGS), grain size and tectonics (Priyank Jaiswal, OSU, USA) and diatom productivity (Oscar Romero, AWI, Germany) proxies.

Possible timeline:

Year 1: Obtain training in sample processing of core material for coccolithophore assemblage and foraminifera (taxonomy), inorganic geochemical and stable isotope techniques.

Year 2: Present results at the UK IODP meeting and prepare a manuscript. Generate stratification and productivity records from the BoB sites. Carry out statistical analyses of generated data set.

Year 3–3.5: Finish remaining analytical work, data analyses, and present results at an international conference and write up thesis and manuscripts.

Further reading:


Further details:

Students should have a strong background in earth system processes and enthusiasm for learning new proxies. Experience of working with microfossils is desirable. The student will join a well-established team researching on palaeoenvironmental change at the Open University and CEREGE (France).

Please contact Pallavi Anand (pallavi.anand@open.ac.uk) or Clara Bolton (bolton@cerege.fr) for further information.

Applications should include:

- a cover letter outlining why the project is of interest to you and how your skills match those required
- an academic CV containing contact details of three academic references

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