Project title: Late Pliocene stratification and productivity reconstructions: linking monsoon evolution and climate

Project code: OU 1

Host institution: The Open University

Theme: Dynamic Earth

Key words: Palaeoclimate, microfossils assemblage, Monsoons, bulk sediment, IODP Expedition 353

Supervisory team (list as name, institution, email address): Pallavi Anand (Open University:pallavi.anand@open.ac.uk), Phil Sexton (OU), Lyndsey Fox (NHM) and Tom Hill (NHM)

Project collaborator: Marci Robinson (USGS), Kate Littler (Exeter University) and Priyank Jaiswal (OSU, USA)

Project Highlights:
- Reconstruct stratification, productivity and runoff history of Indian monsoons during the late Pliocene
- Terrestrial and oceanic multi-proxy study
- Network with an international team of the IODP Expedition 353 at the Science meeting in India

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 late Pliocene (~3.5–2.5 Ma), when the Northern Hemisphere Glaciation (NHG) was intensifying, is poorly constrained. Although changes in the intensity of the Asian monsoon have been linked to terrestrial records [1, 2], a clear association has not yet been demonstrated. This project will apply multi-proxy methods to reconstruct stratification, productivity and monsoon runoff records for the Pliocene from the core monsoon region of the Bay of Bengal (BoB). These records will address the key question: how were oceanic stratification and monsoon runoff (related to southwest monsoon) linked to oceanic productivity (related to northeast monsoon) before, during and after the onset of NHG? The new Indian monsoon and productivity records from this project will be compared with published terrestrial records from northern Tibet [2] and Arabian Sea [3] to identify the nature of the linkage between the Indian and Asian Monsoons. Further comparison of the timing of significant change in the Indian monsoon and active uplift of northern Tibetan plateau in the north east during the late Pliocene [1] will provide valuable information about the linkages between tectonics and monsoon evolution. This project will primarily use newly drilled continuous sedimentary successions from the BoB (IODP Expedition 353 Sites U1444 and U1445 and sites U1450/U1451 from expedition 354).

Figure 1: Critical regions of monsoon precipitation [1].
This project will analyse samples from Bay of Bengal (IODP Exp. 353, Sites U1444 and U1445 and 354) and compare data from the Arabian Sea [3].

The student will reconstruct palaeo stratification and productivity changes during the onset of the NHG at ~4 kyr resolution, focusing on the following parameters:
- stratification history using planktonic foraminifera assemblage
- productivity reconstructions using benthic foraminifera assemblage from same samples
- bulk sediment chemical compositions

Methodology:
The deep-sea mud samples will be washed and larger fraction (>150 um) will be used for foraminifera assemblage work in the fully equipped laboratories at The Open University. Both planktonic and benthic foraminifera assemblage work from the same sample will be carried out. Foraminifer geochemical work (carbonate oxygen and carbon isotopes measurements) will be carried out on another split of the same sample.
Bulk sediment portable XRF will be carried out on the same sample. Coupled microfossils assemblage and bulk sediment elemental composition records will be utilised to 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, microfossils identification and assemblage work and geochemical techniques (stable oxygen and carbon isotopes and bulk sediment) at the state of the art facilities at The Open University. In addition, the student will receive specific training on identification of planktonic and benthic foraminifera species (Dr Fox) and reconstructing stratigraphy (Dr Littler). Finally the monsoon intensity record will be placed in context with the Pliocene tectonics and climate.

The student will receive project specific training and OU offers a diverse set of training courses throughout their PhD.

Specific skills that will be acquired during this project include:

- Conducting research on newly discovered deep-sea sediments (IODP Expedition 353 and 354) and working with an international team
- 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
- Co-supervise on your own devised OU’s master’s project and online teaching opportunities via the Open University Virtual Learning Environment are also available, including teaching on the new Massive Open Online Courses (MOOCs).

**Partners and collaboration (including CASE):**
This project will benefit from international collaborations and networking opportunities with IODP 353 expedition scientists. In particular there will be collaboration with co-chief scientists Steve Clemens (USA) and Wolfgang Kuhnt (Germany) and scientists working on the Pliocene for stratigraphy (Marci Robinson, USGS), grain size and tectonics (Priyank Jaiswal, OSU, USA) and oceanic productivity (Oscar Romero, AWI, Germany) proxies.

**Proposed timeline:**

**Year 1:** Obtain training in sample processing of core material for microfossils (taxonomy), inorganic geochemical and stable isotope techniques. Generate pXRF data from BoB samples and process samples to generate runoff records using elemental data. Attend IODP expedition science meeting in India.

**Year 2:** Present elemental results at the Geochemistry Research in Progress 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 an interest in earth system processes, and enthusiasm for learning new proxies and their application in palaeoclimate. The student will join a well-established team researching palaeoenvironmental change at the Open University and Exeter University.

Please contact Dr 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,
- contact details of three academic references
- an Open University application form

Applications should be sent to Science-PhD-
Recruitment@open.ac.uk by 4pm on 29th April 2016