

Evolution of Late Cenozoic Climate: Exploring the Links between Tibetan Plateau Uplift and Changes in the Asian Monsoon (Ref IAP-17-120)

Newcastle University, School of Geography, Politics & Sociology

In partnership with **CASE partner: NERC Isotope Geosciences Laboratory, British Geological Survey**

Supervisory Team

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Key Words

1. Japan Sea
2. Diatom isotopes
3. Miocene-Pliocene-Pleistocene
4. IODP Expedition 346
5. Asian monsoon variability

Overview

The onset and intensification of the monsoon allied with the tectonic evolution of the Himalayan-Tibetan Plateau (HTP) comprises perhaps the most significant processes affecting global climatic conditions during the Cenozoic, but the lack of explicit evidence for a causative relationship remains a major problem in Earth science. Demonstrating any linkage between climate and tectonics is impossible without a better understanding of when and how the monsoon developed. With this information, such developments can then be correlated, or not, to either tectonic uplift and extension, or other possible Cenozoic climate drivers.

Significant changes have been documented in Asian climate during the last 15 Ma; with key phases of HTP uplift and extension linked to the onset and intensification of the Asian monsoon system. These changes in ocean-atmosphere dynamics have been proposed as key drivers for atmospheric CO₂ content, the continental aridification of central Asia, and expansion of C₄ grasses. Moreover, during the last 15 Ma the North Pacific regions became a mass opal (biogenic silica) sink, and its deposition reflects the tightly coupled interplay between climatic, tectonic, oceanic and ecological events. Early Cenozoic cooling and lower pCO₂ led to the build-up of Antarctic ice, rearranging ocean circulation and

impacting deep-water formation, especially in the Pacific. As a consequence, the development of Antarctic Bottom Water altered North Pacific Si budgets by upwelling dissolved Si and Si-rich nutrients from the Southern Ocean. This change in Si in the North Pacific is also documented in the Japan Sea, which underwent rhythmic (orbital?) opal deposition from the mid-Miocene onwards. After the initiation of opal deposition, changes in opal accumulation rates in the later Miocene and Pliocene have been proposed to be sensitive proxy to HTP uplift and an enhanced monsoon system.



The overall aim of the project is to construct late Cenozoic (Miocene to Pleistocene) proxy records of oxygen, silicon and carbon isotope composition of

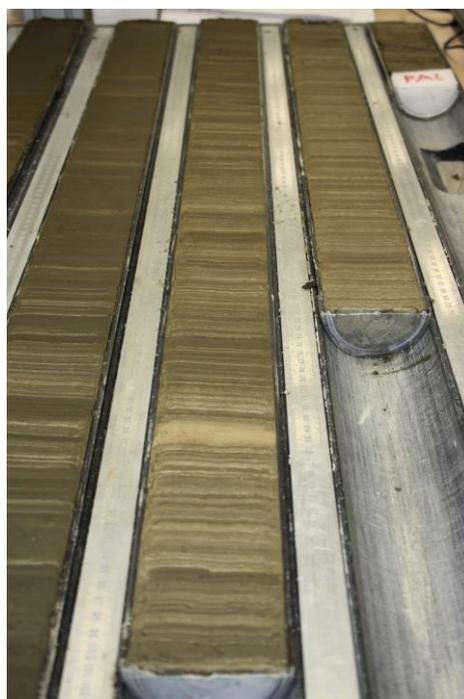
ocean water and palaeoproductivity in the Japan Sea. The proximal location of the Japan Sea makes it an ideal site for recording both palaeoceanographic and East Asian continental changes. Crucially it is located in a region that is sensitive to long-term monsoonal changes and HTP uplift. This is particularly important in light of recent modelling and data syntheses, which highlight the insensitivity of other oceanic basins to HTP uplift (western Pacific, South China Sea, Indian Ocean), all of which have traditionally been used as data sources for Asian monsoon evolution and HTP uplift history.

Methodology

The student will work with sediments recovered during IODP Expedition 346 and will primarily use the $\delta^{18}\text{O}$, $\delta^{30}\text{Si}$ and $\delta^{13}\text{C}$ of diatom frustules preserved in Miocene to Pleistocene sediments of the Japan Sea to reconstruct palaeoceanographic and palaeoclimatic changes over the late Cenozoic. Methods include the purification of sediments from Site U1425 and U1430 for diatom silica and analysis at 50-100 ka resolution for (i) $\delta^{18}\text{O}$ to reconstruct ocean water oxygen isotope composition at a given temperature; (ii) $\delta^{30}\text{Si}$ to track changes in silicic acid concentration and utilisation, and (iii) $\delta^{13}\text{C}$ of diatom silica to reconstruct diatom productivity. This isotope work will be undertaken at the NERC Isotope Geosciences Laboratory in the British Geological Survey.

In addition, well-established sedimentary facies and bulk geochemical analyses (biogenic silica, total carbon/organic/inorganic carbon, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) will underpin diatom isotope analysis. Once the analytical phase is complete the student will then compare their stratigraphic diatom and bulk isotope records with other emerging proxy records at Site U1425 and U1430 from project partners and IODP Expedition 346 Scientists, e.g. $\text{U}^{K_{37}}$ - and TEX_{86} -inferred SST, δD and $\delta^{13}\text{C}$ of leaf waxes (a proxy for aridity in central Asia), dust provenance chemistry, and high-resolution scanning XRF. As well as using a wealth of shipboard data. They will then place the stratigraphic diatom isotope records from Site U1425 and U1430 in the context of local (Japan Sea, North Pacific), regional (South China Sea, Indian Ocean, North Pacific and loess records) and hemispheric (North Atlantic) climate changes since the mid-Miocene to investigate the drivers of Neogene climate evolution.

This project will also include a collaboration with [Ryuji Tada](#), from the University of Tokyo, Department of Earth & Planetary Sciences, Japan.



Given the nature of the analytical programme and international aspect of IODP expeditions there will be ample opportunity for the student to work with overseas collaborators. While a large number of samples are in-hand already, it is envisaged the student will spend time at the [IODP Core Repository in Kochi](#), Japan to take additional samples as needed during the evolution of the PhD. In addition, towards the end of the PhD the student will be encouraged to apply for a [JSPS Pre-doctoral Fellowship](#) to spend time in Japan working with external supervisor Tada, where research will focus on correlation of new diatom isotope records to other high-resolution geochemical data sets from the Japan Sea and onshore stratigraphy of Miocene to Pleistocene climate variability.

Timeline

Year 1

- Review of existing literature and outputs from IODP Expedition 346
- Bulk geochemical analysis of samples from Sites U1425 and U1430
- Sediment purification of samples for diatom isotope analysis from Sites U1425 and U1430 samples.
- Identification of additional samples required to generate isotope stratigraphy.
- Core sampling at Kochi Core Centre, Japan.

Year 2

- Isotope analysis of purified opal from Sites U1425 and U1430.
- Bulk geochemical analysis and preparation of samples for diatom isotope analysis for additional samples.

- Integrate data to generate a continuous palaeoceanographic record for the Japan Sea.
- Present initial findings and interpretations at the annual UK IODP Conference.

Years 3 – 3.5

- Complete outstanding multi-proxy analysis.
- Interpretation and synthesis of your data from Sites UI425 and UI430 since the mid-Miocene, in conjunction with emerging studies from the Japan Sea
- Present results at an international conference.
- Begin write-up of thesis.

Intended outputs from the PhD are:

1. Miocene to Pleistocene record of Japan Sea palaeoceanography.
2. Understanding of biogeochemical response to Miocene global changes in climate.
3. Assessment of drivers of late Cenozoic climate in the context of Himalayan uplift and local tectonic changes.

Training & Skills

The student will be trained in a broad range of geochemical techniques and approaches to palaeoceanography. The student will receive bespoke training in laboratory skills to work with marine sediments e.g. core description, inorganic geochemistry, sedimentology and chronology. You will also receive hands-on laboratory training in isotope geochemistry through NERC Isotope Geosciences Laboratory who are world leaders in using diatom isotopes to reconstruct past climate and oceanography. You will also have the chance to attend NERC-recognised short courses on stable isotope analysis, advanced techniques in sediment core logging and data visualisation, and statistics for geoscientists. In addition, the student will be encouraged to attend the [Urbino Summer School in Paleoclimatology](#) in Italy.

References & Further Reading

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Further Information

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