Project Proposal Form – 2022 entry

Project Title	**OU2 - Global carbon cycle changes during the middle Miocene Climate Transition**
University (where student will register)	The Open University
Which institution will the student be based at?	As above
If other	
Theme (Max. 2 selections)	Climate & Environmental Sustainability ☐ Organisms & Ecosystems ☐ Dynamic Earth ☒
Key words	Miocene, climate, organic geochemistry
Supervisory team (including institution & email address	**PI: Marcus Badger (The Open University, marcus.badger@open.ac.uk)** **Co-I: Angela Coe (The Open University, Angela.Coe@open.ac.uk)** **Kirsty Edgar (University of Birmingham, k.m.edgar@bham.ac.uk)**
Is the project co-designed by a student?	Yes ☐ No ☒
Is the PhD suitable for part time study?	Yes ☒ This is a requirement of NERC

Project Highlights:

- Address fundamental questions about climate and environmental change in the oceans in the middle Miocene
- Training and application of traditional and advanced organic geochemistry techniques
- Join a vibrant research group of leading palaeoclimate researchers applying multiple proxy-based techniques across different scales in space and time.

Overview:

The middle Miocene records one of the four major cooling steps in the last 66 million years of Earth history, as the Earth's climate system moved from the greenhouse conditions of the early Eocene to the icehouse conditions of today. The cooling (Middle Miocene Climate Transition; MMCT) resulted in major growth and consolidation of the East Antarctic Ice Sheet (EAIS) and a significant increase in sea ice in the Arctic.

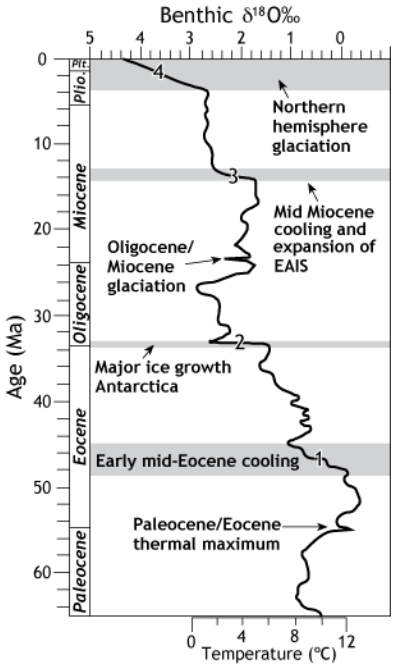

Figure 1: Summary of the change in temperature over the last 66 Ma showing the middle Miocene cooling.

Alt text: A graph showing the decline in temperature over the last 60 Ma. The mid Miocene cooling and expansion of EAIS is highlighted.

Stratigraphically complete records of the middle Miocene are rare due to strengthening of current activity during the MMCT and this has hampered our understanding of this critical period of Earth history. One stratigraphically near-complete and important record is the Monterey Formation in California. This project will use samples from the Monterey Formation now housed at the Open University. These were collected from a stratigraphically complete deep marine section of the middle Miocene that is undisturbed by either bioturbation or mass flow deposits. The deposits are rich in organic-carbon from high productivity in this upwelling zone, and we are already in possession of substantial datasets ($\delta^{13}C_{org}$ and $\delta^{13}C_{carbonate}$) which will feed directly into the proposed research.

Changes in sedimentary facies can be linked to changes in the palaeoclimate. This study will investigate the organic geochemistry of these deposits in detail and establish the links between local, regional and global changes the Earth's carbon cycle and climate during this critical interval in Earth history. Organic geochemical proxy-based measurements of terrestrial and marine temperature (using GDGT-based proxies such as the TEX_{86}, MBT/CBT), ocean productivity and terrestrial runoff, will be combined with isotope-based traces of the global carbon cycle to elucidate the dynamics of the climate system during the middle Miocene.

Methodology:

Construct a record of changes in palaeotemperature on both a million-year and millennial timescale across the MMCT cooling and the Monterey carbon isotope excursion using the TEX_{86} proxy measured from the organic molecular fossils extracted from the Monterey Formation samples.

Assess changes in ocean productivity and local land runoff using carbonate, isotope and organic geochemical techniques.

Determine the link between local, regional and global changes in the Earth's climate system by combining novel and traditional organic and isotope-based measurements.

Training and skills:

Students will be awarded CENTA2 Training Credits (CTCs) for participation in CENTA2-provided and 'free choice' external training. One CTC equates to 1⁄2 day session and students must accrue 100 CTCs across the three years of their PhD.

In addition to a wide range of generic training from CENTA2 and the Open University, the student will be trained in a number of subject specific skills. These include stratigraphy, sedimentology and organic geochemistry which has a wide range of applications. There will be the opportunity to work in state-of-the-art geochemistry labs with access to hyphenated mass spectrometry techniques. The successful candidate will be encouraged and supported in applying for a paid internship of a month or more and to take part in career-enhancing opportunities such as teaching, science communication and understanding policy.

Partners and collaboration:

The project will provide the opportunity to work within the international community of scientists working on palaeoclimate science, and work alongside scientists applying organic geochemistry to diverse questions including climate change, proxy development, and the search for extra-terrestrial life.

COVID-19 Resilience of the Project:

Samples critical for the project are already in place at the OU and onsite labwork by PhD students has been prioritised so far. Should lab work become impossible there is sufficient existing data (both in the possession of the supervisors and recently made available by the Miocene scientific community) so that a desk-based refocussing of the project would be possible.

Possible timeline:

Year 1: Review literature on Miocene climate change, train in organic geochemistry labs with supervisors. Select and process pilot set of samples from Miocene collection at the OU.

Year 2: Analyse further set of samples based on initial results. Write manuscript.

Year 3: Finish interpretation, prepare thesis and further manuscripts. Possibly take a formal study break for several months to complete internship.

Further reading:

Steinthorsdottir, M. *et al.* (2021) 'The Miocene: The Future of the Past', *Paleoceanography and Paleoclimatology*, 36(4). doi: 10.1029/2020PA004037.

Badger, M. P. S., Lear, C. H., Pancost, R. D., Foster, G. L., Bailey, T. R., Leng, M. J., & Abels, H. a. (2013). CO2 drawdown following the middle Miocene expansion of the Antarctic Ice Sheet. Paleoceanography, 28(1), 42–53. https://doi.org/10.1002/palo.20015

Holbourn, A., Kuhnt, W., Schulz, M., Flores, J.-A., & Andersen, N. (2007). Orbitally-paced climate evolution during the middle Miocene "Monterey" carbon-isotope excursion. Earth and Planetary Science Letters, 261(3–4), 534–550. https://doi.org/10.1016/j.epsl.2007.07.026

Further details:

Applicants should have a strong background in, and enthusiasm for laboratory work and the ability to work independently after initial training. The student will join a well-established team researching palaeoenvironmental change at the Open University (http://www.open.ac.uk/science/environment-earth-ecosystems/research/palaeoenvironmental-change).

If you would like to apply or require further information, please contact **Marcus Badger** at the Open University (Marcus.Badger@open.ac.uk).

Applications should include:

- an academic CV containing contact details of three academic references
- a CENTA application form, downloadable from: CENTA application
- and an Open University application form, downloadable from: Home OU application form (if you are resident in the UK) or an Overseas OU application form (if you are an international applicant).

Applications must be sent to **STEM-EEES-PHD@open.ac.uk** **by Friday 7th January 2022 (12 pm, noon)**