

Project Title	Sedimentation patterns in the tropics during the Toarcian (Early Jurassic) period of extreme environmental change
Host University	The Open University
Theme	Organisms & Ecosystems Dynamic Earth
Key words	Global warming, Jurassic, sequence stratigraphy, palynology, vegetation, palaeoenvironmental change, fieldwork
Supervisory team	PI: Angela Coe (The Open University; Angela.Coe@open.ac.uk) Co-I: Luke Mander (Open University; Luke.Mander@open.ac.uk) David Kemp (Aberdeen University/University of Geosciences, Wuhan David.Kemp1@abdn.ac.uk)
Is the PhD suitable for part time study?	Yes

Project Highlights:

- Address fundamental question about the response of the terrestrial and marine plants during extreme climate change
- Fieldwork on Jurassic rocks in Morocco
- Training in palynology, sequence stratigraphy, high-resolution analysis, palaeoclimate studies and field skills suitable for a wide range of employment

Overview:

The Toarcian (Early Jurassic, 183 Ma) period of extreme environmental change was characterised by a 7-10°C global warming, mass extinction, eustatic sea-level rise, major perturbations to the global carbon cycle and fundamental changes to the hydrological cycle¹⁻⁴. The scale of the climate change is equivalent to that predicted for 2099 under the high emission scenario of IPCC 2013⁵ making this event a useful analogue for extreme warmth. Almost all the studies to date of this event have concentrated on mid to high latitude sections, particularly NW Europe where de-oxygenation was prevalent⁶ and led to the high accumulation of organic matter and the formation of an important hydrocarbon source rock. This widespread accumulation of organic matter throughout NW Europe has also led to the event being classified as an oceanic anoxic event (OAE). A key part of understanding the climate system is the low latitudes thus the little studied sediments deposited in the tropics during the Toarcian will be the focus of this study.



Figure 1: Cyclic Toarcian strata in Morocco that will be the focus of this study. Cliff is c. 100 m high.

New low palaeolatitude sections of the Toarcian event have been located by this research group in Morocco. Our initial high-resolution stratigraphical study of these sections has identified a clear carbon-isotope excursion and the presence of climate cycles at Milankovitch frequencies as well as indications of large-scale changes in the ratio of terrestrial to marine organic matter. The proposed project will complete palynological analyses of the high-resolution samples already at the Open University to quantify the relative changes in flora and terrestrial runoff on a millennial to Milankovitch timescale during the event. These data will contribute towards a better understanding of the climate feedbacks during extreme climate change. The palynology analyses will also be combined with new field and laboratory studies along a proximal to distal depositional profile in this key palaeogeographical position in order to decipher the wider impact of the event on sedimentation and relative sea-level change.

Methodology:

- **Establish the changes in continental runoff on a millennium to Milankovitch scale in the tropics during the Toarcian OAE** by analysing and quantifying the pollen, spores and dinoflagellates from high-resolution samples in a marine section.
- **Investigate the flora in this tropical region before during and after the event to gain a better understanding of the environment** through palynological analysis.
- **Identify the changes in sedimentation due to climate fluctuations along a proximal to distal profile** using sedimentological and sequence stratigraphical techniques.
- **Assess the links between changes in eustatic sea-level, climate and the flora** by correlating the sequence stratigraphy of the Moroccan sections with those published from other sections around the world.
- **Understand the millennial-scale changes in sedimentation and flora in the tropics during the Toarcian OAE** by integrating and synthesizing the data.

Training and skills:

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 high-resolution graphic logging, sample collection and preparation, sequence stratigraphy, palynology, statistics and data analysis. The successful candidate will be encouraged and supported in applying for an internship of a month or more and to take part in career-enhancing opportunities such as teaching, microfossils analysis, science communication and understanding policy.

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.

Partners and collaboration (including CASE):

This project will involve collaboration with Dr David Kemp (Aberdeen University/University of Geosciences, Wuhan) including the possibility of studying in China for a few weeks.

Potential CASE partner with Halliburton as this project is investigating an important hydrocarbon source rock and reservoir interval.

Possible timeline:

Year 1: Conduct fieldwork in Morocco including detailed fieldwork training with supervisors. Analyse some of the existing high-resolution samples at the OU for palynomorphs.

Year 2: Analyse data from fieldwork in Morocco. Complete palynomorph analysis. Prepare manuscript on palynomorphs. Complete 2nd field season.

Year 3: Finish interpretation and synthesis, complete sequence stratigraphical interpretation. Prepare thesis and further manuscripts. Possibly suspend PhD studies for several months to complete internship.

Further reading:

[1] Cohen, A. S., Coe, A. L. and Kemp, D. B. (2007) The Late Palaeocene–Early Eocene and Toarcian (Early Jurassic) carbon isotope excursions: a comparison of their time scales, associated environmental changes, causes and consequences', *Journal of the Geological Society*, 164, pp. 1093–1108.

[2] Caswell, B. A. and Coe, A. L. (2013) Primary productivity controls on opportunistic bivalves during Early Jurassic oceanic deoxygenation, *Geology*, 41(11), pp. 1163– 1166.

[3] Kemp, D. B., Coe, A. L., Cohen, A. S. and Weedon, G. P. (2011) 'Astronomical forcing and chronology of the early Toarcian (Early Jurassic) oceanic anoxic event in Yorkshire, UK', *Paleoceanography*, 26, pp. PA4210.

[4] Them, T. R., Gill, B. C., Selby, D., Gröcke, D. R., Friedman, R. M. and Owens, J. D. (2017) 'Evidence for rapid weathering response to climatic warming during the Toarcian Oceanic Anoxic Event', *Nature - Scientific Reports*. Nature Publishing Group, 7(5003), pp. 1–10.

[5] IPCC. (2013). Climate change 2013. IPCC, New York.

[6] Ruvalcaba Baroni, I., Pohl, A., van Helmond, N. A. G. M., Papadomanolaki, N, Coe, A. L., Cohen, A. S., van de Schootbrugge, B., Donnadieu, Y and Slomp, C. P. (2018). Ocean circulation in the Toarcian (Early Jurassic), a key control on de-oxygenation and carbon burial on the European shelf. *Paleoceanography and Paleoclimatology*, 33 (9), pp. 994-1012.

Further details:

Applicants should have a strong background in, and enthusiasm for field geology including the ability to work independently in the field in Morocco after initial training. In addition the student should be interested in microfossil analysis and microscope work. A driving licence is essential and a good

command of French would be advantageous. 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 **Angela Coe** at the Open University (Angela.Coe@open.ac.uk).

Applications must include:

- a cover letter outlining why the project is of interest and how your skills are well suited to the project
- 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>
- and an Open University application form, downloadable from: <https://tinyurl.com/y73hrfou>

Applications should be sent to STEM-EEES-PhD-Student-Recruitment@open.ac.uk by 12pm (noon) on 21st January 2019