



PhD Research Studentship

Phytoplankton response to climate and sea-level change in a greenhouse ocean: *Cretaceous dinoflagellate cysts as proxies of palaeoenvironmental change, from subtropics to subarctic*

Supervisors: Profs Ian Jarvis, Martyn Waller (Kingston University)
Drs Martin Pearce, Bruce Tocher (StatoilHydro)

Dinoflagellates are unicellular algae that range in size from 0.025 - 0.25 mm, possess two flagella which move them through the water, and have a variety of lifestyles. Most are planktonic, living in the surface waters of the oceans where they are an important part of the food chain. The majority are plant-like, feeding by photosynthesis; the remainder are heterotrophic and feed on other organisms. The motile dinoflagellate is quickly destroyed by bacterial action after death, but many species form a resting cyst (dinocyst) that is composed of highly resistant organic material. Dinocysts have a record dating back to the Triassic, and their disparate inferred palaeoecologies, and facies-independent preservation makes them one of the most powerful emerging palaeoenvironmental tools.

This project will study Cretaceous dinoflagellate cysts. It seeks to develop models that quantify sea-level, water depth and palaeoclimate change based on spatial and temporal trends in dinocyst assemblages. Successions in geographically widely separated areas will be studied to isolate local biogeographic, climatic, preservational, and tectonic influences. One key aim is to evaluate the response of dinocysts to major palaeoceanographic events in widely different climate regimes, ranging from the subtropics to the subarctic. While focussing on a well-characterised Upper Cretaceous interval, it is anticipated that results will be applicable to other Mesozoic, Tertiary and Quaternary sequences.

Why a Cretaceous study? The Late Cretaceous was a period of extreme warmth, accompanying high levels of atmospheric CO₂, perhaps ten-times greater than the present day. Sea levels up to 100 m higher than today, led to the flooding of continental margins and interiors, while sea-level variation on Milankovitch time-scales indicates the likely presence of ephemeral Antarctic ice sheets. Sea-level and climate fluctuations influenced phytoplankton evolution, ocean chemistry, and the loci of carbonate, organic carbon, and terrigenous sediment burial. Study of this deep-time, ultimate greenhouse environment, offers great potential for better predicting the operation of a late 21st century Earth system subject to extreme global warming and high sea-levels.

Cretaceous sediments yield well-preserved dinocyst assemblages that provide a record of the response of organic walled plankton to environmental change. This study will focus on an interval of major sea-level change, the Turonian – Coniacian (93.5 – 85.8 Ma). The first-order sea-level rise that took place through the Cenomanian resulted in widespread deposition of open marine sediments in inner shelf environments, represented by the onset of chalk sedimentation throughout Europe.

An episode of oceanic anoxia (OAE2) accompanied maximum sea levels during Cenomanian / Turonian boundary times (Pearce et al. 2009). The subsequent Late Turonian sea-level fall, estimated to be up to 100 m, is the highest amplitude second-order cycle in the Mesozoic. The following transgression represents the major phase of continental flooding on many platforms, and is marked by the onset of chalk sedimentation in areas as far apart as North America and Kazakhstan.



Material and Methods Upper Cretaceous Chalk successions in England are probably the best documented sections of this age in the world (e.g. Jarvis et al. 2006, 2008). These will be studied to provide a starting point to assess and quantify the response of dinocysts to sea-level and climate change. Samples will be obtained from southern and northern England, and a transect of North Sea and Norwegian margin wells. The student will undertake fieldwork in the UK, France, Germany, and North Africa. Potential subarctic localities will be sought. Sections will be logged and sampled. Samples will be returned to the laboratory where optimised palynological methods (Lignum et al. 2008) will be employed to separate the dinocyst assemblages for analysis. Species

identification using light and scanning electron microscopy (SEM) will be used to obtain quantitative data on assemblage compositions. Selected samples will be analysed for oxygen and carbon stable isotopes and elemental composition to augment literature data on the study intervals, where necessary. Comparison of dinocyst trends to sea-level change within a sequence stratigraphic framework for multiple Turonian – Coniacian sections, will enable relationships to be identified and quantified. Interpretations will be quantified using statistical techniques, particularly cluster analysis. Geochemical data will be used to provide stratigraphic (chemostratigraphy and sequence analysis) and palaeoenvironmental ($\delta^{18}\text{O}$ palaeotemperature, $\delta^{13}\text{C}$ palaeoproductivity proxies) constraints to aid interpretation of the dinocyst data (cf. Pearce et al. 2009).

Outcomes Results will provide a basis for interpreting dinocyst assemblages as sea-level, water-depth and palaeoclimate proxies. This will have extensive applications in both petroleum exploration and development, and academic research. Additional outcomes will be: (1) improved high-resolution biostratigraphic database for the study intervals; (2) correlation between North Boreal and Tethyan Realm biostratigraphies; (3) integrated chemostratigraphic – biostratigraphic frameworks for the Turonian – Coniacian; (4) better understanding of environmental controls on dinocyst assemblages.

Training and career progression The student will receive training in field sampling and logging, palynological and geochemical sample preparation and analysis, dinocyst identification and taxonomy, chemostratigraphic methods, interpretation of palaeoenvironmental proxies, research methodologies and data analysis. They will participate in the University's post-graduate training programme.

The project is offered in collaboration with StatoilHydro, Norway, and will be co-supervised by Drs Martin Pearce (Staff Geologist, Biostratigraphy) and Bruce Tocher (Research Manager). The student will be expected to spend time in the StatoilHydro offices in Bergen, where they will gain valuable experience working in a commercial environment and will be trained in industrial methods and applications of biostratigraphy. On successful completion of the PhD, the combination of academic and industrial experience should provide the student with the experience necessary to pursue a career in the petroleum industry, consultancy, teaching or research.

Selected references

- Jarvis, I., Gale, A.S., Jenkyns, H.C. & Pearce, M.A., 2006. Secular variation in Late Cretaceous carbon isotopes: a new $\delta^{13}\text{C}$ carbonate reference curve for the Cenomanian – Campanian (99.6–70.6 Ma). *Geological Magazine*, **143**: 561-608.
- Jarvis, I., Mabrouk, A., Moody, R.T.J., Murphy, A.M. & Sandman, R.I., 2008. Applications of carbon isotope and elemental (Sr/Ca, Mn) chemostratigraphy to sequence analysis: sea-level change and the global correlation of pelagic carbonates. In: M.J. Salem & El-Hawat, A.S., *The Geology of East Libya, Volume I*. Earth Science Society of Libya, Tripoli, 369-396.
- Lignum, J., Jarvis, I. & Pearce, M.A., 2008. A critical assessment of standard processing methods for the preparation of palynological samples. *Review of Palaeobotany and Palynology*, **149**: 133-149.
- Pearce, M.A., Jarvis, I. & Tocher, B.A., 2009. The Cenomanian – Turonian boundary event, OAE2 and paleoenvironmental change in epicontinental seas: new insights from the dinocyst record. *Palaeogeography, Palaeoclimatology, Palaeoecology*, in press: <http://dx.doi.org/10.1016/j.palaeo.2009.06.012>.
- Prince I.M., Jarvis, I., Pearce, M.A. & Tocher, B.A., 2008. Dinoflagellate cyst biostratigraphy of the Coniacian – Santonian (Upper Cretaceous): New data from the English Chalk. *Review of Palaeobotany and Palynology*, **150**: 59-96.

Applications

The studentship is full time (3 years for PhD, subject to satisfactory progress) and includes a stipend of £14,000 per annum and tuition fees for a Home/EU student (£3,500 per annum). Applicants eligible for overseas fees would have to cover the difference between the Home/EU tuition fee and the tuition fee for an overseas student (£10,350 per annum). The appointee will be expected to support teaching (maximum of 6 hours per week), which will be additionally funded.

Prospective candidates should have a first class or good upper second class degree in an appropriate discipline. Applicants should send a CV and provide a covering letter detailing their suitability for the particular project they wish to apply for. Please ensure that the details of two academic referees, who can provide references prior to interview, are included.

Contact details

Formal applications should be addressed to:

Prof. N. Walford, Postgraduate Tutor, School of Geography, Geology and the Environment, Kingston University London, Penrhyn Road, Kingston upon Thames, Surrey KT1 2EE *Email:* nwalford@kingston.ac.uk

Further information concerning the project may be obtained from:

Prof. Ian Jarvis, Geography, Geology and the Environment, CEESR, Kingston University London, Penrhyn Road, Kingston upon Thames KT1 2EE, UK. *Tel:* 020 8547 7526. *Email:* i.jarvis@kingston.ac.uk

Applications must be received by 20 July 2009. Candidates will be interviewed mid-August. The studentship will be available beginning October 2009.