Constraining the tempo of Mesozoic Oceanic Anoxic Events using extra-terrestrial He isotopes

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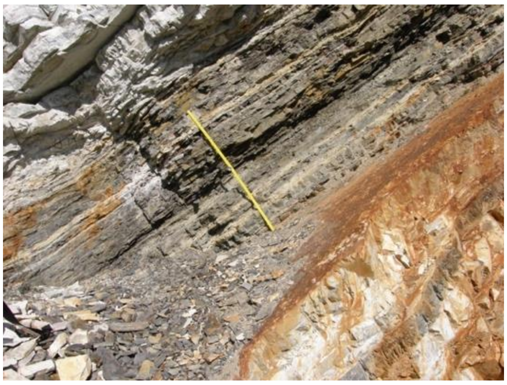
Key words:	Cretaceous, Jurassic, oceanic anoxic events, helium-isotopes, geochemistry, stratigraphy
Research theme(s):	• Oceanography, Climate and Palaeoenvironment
Eligible courses for this project:	• DPhil in Earth Sciences • Environmental Research (NERC DTP)

Overview

Reconstructing past climatic and environmental change from the pre-Quaternary rock record relies on having a robust chronology of events that can be confidently correlated from place to place. In order to do so, a good understanding is needed of how time is recorded by sedimentation at the highest resolution possible. It is necessary to be able to identify changes in accumulation rate and gaps in sedimentation.

The Mesozoic Era was a time-interval characterized by greenhouse climates and geologically brief intervals of carbon-cycle perturbation, commonly associated with widespread oceanic anoxia (the so-called "oceanic anoxic events", OAEs). OAEs are represented in the geological record by significant excursions in stable carbon isotopes and, most dramatically, by apparently synchronous increases in the concentrations of organic-carbon burial in marine and lacustrine environments in many parts of the globe (e.g. Jenkyns, 2010). An increasing number of organic and inorganic geochemical proxies are being generated in order to understand the processes that drove, sustained and terminated OAEs, but to achieve this aim a detailed knowledge of the rates of change is required, which, in many cases, is poorly constrained.

Over relatively long time-scales, Milankovitch cycles provide a method of reconstructing sedimentation rates, but this approach can be sensitive to missing or highly condensed cycles. Furthermore, this method does not allow the identification of changes in sedimentation at sub-Milankovitch resolution (i.e. less than a precession cycle: ~21000 years). An alternative approach, particularly applicable to fine-grained pelagic sediments, is based upon the concentration of extra-terrestrial helium ($^3He_{ET}$; e.g. Murphy et al., 2010; Lucas et al., 2024). Extra-terrestrial helium is supplied to sediments in the form of Interplanetary Dust Particles (IDPs) that are constantly raining onto the Earth's surface. Over shorter intervals of time (e.g. < 1 million years), the supply of IDPs (and thus $^3He_{ET}$) from space is constant and so any changes in the concentration of $^3He_{ET}$ within sediments must have been caused by changes in the amount of dilution by sediment flux (i.e. sedimentation rate). This phenomenon provides a method to identify changes in sedimentation rate at high-resolution, sub-Milankovitch scales, and detect intervals of highly condensed sedimentation.



Black shale, approximately 1 m thick, deposited during Oceanic Anoxic Event 2, interbedded with cyclically bedded pelagic limestones and cherts.

Methodology

This project will aim to apply the $^3He_{ET}$ to cyclic sediments and OAEs in the Jurassic and Cretaceous building on previous work in Oxford (Lucas et al., 2024). The project will require extensive fieldwork and sampling of cores in Europe and the UK, plus considerable geochemical work in the noble gas laboratories in Oxford. The project requires a student with strong interests in geochemistry, sedimentology and stratigraphy. Additional specific training in any area will be provided, including in field and laboratory techniques.

Timeline

Year 1: Fieldwork planning, initial training in geochemistry, and start sample collection.

Years 2 and 3: Sample collection in year 2 and data analysis

Year 4: Data integration, thesis completion, papers for international journals/conference presentation.

Training & Skills

The student will develop skills in noble gas and stable-isotope geochemistry, fieldwork, data analysis and scientific writing.

References & Further Reading

Jenkyns, H.C., 2010 Geochemistry of oceanic anoxic events. Geochemistry Geophysics Geosystems, 11, https://doi.org/10.1029/2009GC002788

Lucas, J.R., Batenburg, S.J., Hillegonds, D.J., Mabry, J.C., Jenkyns, H.C., Ballentine, C.J. and Robinson, S.A. (2024), Helium-isotope constraints on palaeoceanographic change and sedimentation rates during precession cycles (Cenomanian Scaglia Bianca Formation, central Italy). Sedimentology. https://doi.org/10.1111/sed.13197

Murphy, B.H., Farley, K.A., and Zachos , J.C., 2010, An extraterrestrial 3He-based timescale for the Paleocene–Eocene thermal maximum (PETM) from Walvis Ridge, IODP Site 1266, Geochimica et Cosmochimica Acta, 74, 5098-5108, https://doi.org/10.1016/j.gca.2010.03.039

Further Information

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