The University of Oxford Department of Earth Sciences

EARTHSCIENCES

UNIVERSITY OF OXFORD

Tracking upper ocean circulation in the Cretaceous ocean

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Key Words	**Paleoclimates, palaeoceanography, stratigraphy, geochemistry**

Overview

Ocean circulation is a fundamental component of the modern climate system, yet may have operated very differently in the geological past, especially when palaeogeography was different, climates were warmer and sea-levels were considerably higher. During the Late Mesozoic epeiric (shelf) seaways acted as important conduits connecting different ocean basis and were major sinks for organic and inorganic carbon. Therefore, these seaways likely contributed to global heat transport and carbon cycling. However, the evolution, dynamics and oceanography of these seaways is, in many cases, not well known, with little knowledge of how circulation in the seaways related to global climatic, tectonic and oceanographic events.

During the Late Cretaceous sea-levels were extremely high and a vast 'Chalk Sea' covered much of NW Europe, resulting in the deposition of carbonate-rich pelagic sediments, such as the English Chalk. Climate variations during the Late Cretaceous occurred over both long and short time scales, yet the dynamic responses of the Chalk Sea to these changes are poorly known. Recent work in Oxford has started to unravel aspects of such changes at single localities (e.g. Zheng et al., 2013) but a broader spatial and temporal reconstruction of ocean circulation is required to fully understand the significance of the local records.

Methodology

Neodymium (Nd) has a residence time in seawater that is comparable to the mixing time of the modern ocean and, consequently, seawater Nd-isotopes are very heterogeneous, reflecting the geology of the area in which a water mass formed, particle exchange processes and local weathering inputs (e.g. Goldstein and Hemming, 2003). The spatial heterogeneity allows Nd-isotopes in seawater to act as semi-conservative tracers of different water masses. This principle can be applied to the geological record by measuring the Nd-isotopes in phosphatic fish debris (biogenic apatites, which incorporate Nd at the sea-floor) and Fe-Mn coatings. Such techniques have been used to reconstruct watermass circulation and patterns during the Mesozoic and early Cenozoic, particularly in the deep sea (e.g. Robinson et al., 2010), but with relatively little work on shelf seas.

This study will develop new records of Nd-isotopes from outcrops and cores of Late Cretaceous sediments along a latitudinal transect that spans the Chalk Sea (i.e. from France to the northern North Sea), with the aim of understanding how long- and short-term changes in tectonics, climate and sea-level impacted on circulation. Fieldwork and core sampling in the UK and Europe will be required.

Rhythmically bedded sediments of the Lower Chalk on the Isle of Wight, a potential target for sampling

Timeline

Year 1: General training in sedimentary geochemistry, field work, carbon cycling, palaeoceanography and palaeoclimatology.

Specific training in the use of metal-free laboratories and analytical methods (ICP-MS, MC-ICP-MS); start of data acquisition from existing sample sets

Identification of key records for analysis and development of sampling plans.

Year 2: Further sample collection from overseas and UK field areas; development of Nd-isotope and other geochemical (e.g. stable-isotopes, Rare Earth Element patterns) records.

Years 3 and 4: Data integration, comparison with climate records and models, thesis completion, and submission of papers for international journals & conferences

Training & Skills

The project requires a student with strong interests in geochemistry, sedimentology and stratigraphy. Additional specific training in any area will provided, including in field and laboratory techniques.

References & Further Reading

Goldstein, S.L., and Hemming, S.R., 2003, Long-lived isotopic tracers in oceanography, paleoceanography and ice-sheet dynamics, *in* Elderfield, H., ed., *Treatise on geochemistry, volume 6: The oceans and marine geochemistry*: Amsterdam, Elsevier, p. 453–489

Robinson, S.A., Murphy, D.P., Vance, D., and Thomas, D.J., (2010) Formation of “Southern Component Water” in the Late Cretaceous: Evidence from Nd-isotopes, *Geology*, 38, 871-874

Zheng, X.-Y., Jenkyns, H.C., Gale, A.S., Ward, D.J. & Henderson, G.M. (2013). Changing ocean circulation and hydrothermal inputs during Ocean Anoxic Event 2 (Cenomanian–Turonian): Evidence from Nd-isotopes in the European shelf sea. *Earth planet. Sci. Letts*, 375, 338–348

Further Information

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