Reconstructing the Mesozoic record of extra-terrestrial dust flux: implications for seawater chemistry and the solar system

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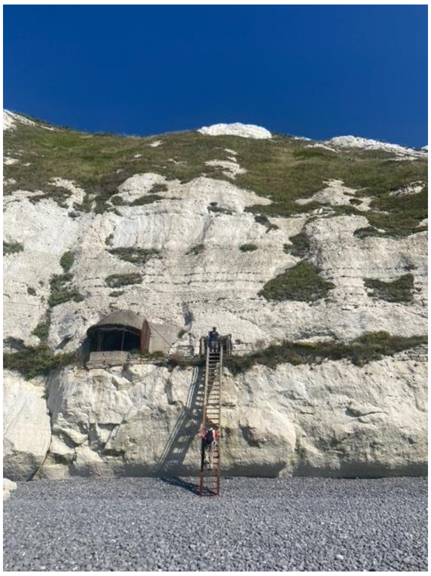
Key words:	Cretaceous, Jurassic, interplanetary dust particles, helium-isotopes, geochemistry, stratigraphy, palaeoceanography
Research theme(s):	• Oceanography, Climate and Palaeoenvironment • Planetary Evolution and Materials
Eligible courses for this project:	• DPhil in Earth Sciences • Environmental Research (NERC DTP)

Overview

Micrometeorites (<mm particles of extra-terrestrial or interplanetary dust) can be found in ancient sedimentary rocks (e.g. Suttle and Genge, 2017) and their presence can be inferred from noble-gas isotope measurements (in particular, helium and neon; Farley et al., 2012; Chavrit et al., 2016; Lucas et al., 2024). Such methods provide a proxy for the flux of interplanetary dust particles (IDPs) to Earth over geological time, an important variable to understand as it may provide insights into both extra-terrestrial and terrestrial processes in the past. Changes in the flux of IDPs might have been caused by comet showers, asteroid showers and/or asteroid collisions (e.g. Farley et al., 2012). Changes in this flux over geological time may also have importance for the supply of bioavailable iron to the oceans and, thus, capable of driving increased primary productivity and changes in seawater chemistry (e.g. Reiners and Turchyn, 2018).

It has been suggested that, during the Mesozoic Era, changes in IDP flux may have been important for the development of low-oxygen conditions in the ocean (Reiners and Turchyn, 2018). Whilst there is some evidence from the Late Cretaceous for peaks in flux rates (Farley et al., 2012), a detailed comparison between proxies for IDP fluxes and ocean chemistry has not been undertaken.



Cretaceous pelagic chalk exposed along the south coast of the UK

Methodology

This project will seek to use noble-gas signatures of pelagic sediments to reconstruct the Mesozoic record of IDP flux and see whether this record can be related to changes in seawater chemistry, reconstructed from other geochemical measurements (e.g. TOC, $\%CaCO_3$, $\delta^{13}C$) and existing databases of global biogeochemistry. These aims will be achieved by using high-resolution sample sets already available in Oxford and new sample sets to be collected from outcrops and cores. Consequently, fieldwork in the UK and potentially overseas will be required.

The project would suit a student interested in geochemistry, sedimentology, stratigraphy and palaeoclimatology. The project will build on previous and ongoing research in Oxford into the application of noble-gas isotope ratios to the sedimentary record (Lucas et al., 2024) and palaeoceanography of the Mesozoic Era.

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

Chavrit, D., Moreira, M.A., Moynier, F., (2016) Estimation of the extraterrestrial 3He and 20Ne fluxes on Earth from He and Ne systematics in marine sediments, Earth and Planetary Science Letters, 436, 10-18, https://doi.org/10.1016/j.epsl.2015.12.030

Farley et al., (2012), A record of the extraterrestrial 3He flux through the Late Cretaceous, Geochimica et Cosmochimica Acta, 84, 314–328; https://doi.org/10.1016/j.gca.2012.01.015

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

Reiners,P., Turchyn, A.V., (2018) Extraterrestrial dust, the marine lithologic record, and global biogeochemical cycles. *Geology* 2018;; 46 (10): 863–866.
doi: https://doi.org/10.1130/G45040.1

Suttle and Genge, 2017, Diagenetically altered fossil micrometeorites suggest cosmic dust is common in the geological record, Earth and Planetary Science Letters, 476, 132–142; https://doi.org/10.1016/j.epsl.2017.07.052

Further Information

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