PROJECT TITLE: Elucidating Long-term Cretaceous Atmospheric pCO₂ and Climate Sensitivity

Part of the €2 million UKRI-matched ERC grant PETRARCH: Pinpointing Earth-system Thresholds for Anoxia with New Reconstructions of the Cretaceous Hothouse.

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PETRARCH Project Background

Oxygen levels in Earth’s oceans are dropping fast due to anthropogenic nutrient input and CO₂ release, and the consequences of this for marine ecosystems are difficult to predict with current models. The Cretaceous Period (66-145 million years ago) witnessed numerous extreme ocean anoxic events (OAEs) that are thought to have been caused by pulses of volcanic CO₂ release. If we knew the exact mechanisms by which volcanism triggered global ocean anoxia, it could provide vital empirical information as to where potential future tipping points in our Earth system lie. Currently, however, our constraints on climate, atmospheric CO₂ and carbon cycling in the Cretaceous are qualitative at best, preventing OAEs from being useful analogues. The PETRARCH project aims to rectify this, by combining both new and proven geochemical proxy reconstructions with cutting-edge Earth system modelling. This PhD project fits into the wider PETRARCH project by defining the long-term evolution of late Cretaceous atmospheric CO₂ levels upon which these OAEs were superimposed. The Late Cretaceous saw the Earth cool from the hottest temperatures of the past few hundred million years to cooler temperatures towards the end-Cretaceous mass extinction event. Besides providing a concrete basis for understanding the OAEs, this PhD project will also provide a crucial constraint on equilibrium Earth system sensitivity to CO₂.

Project Aims and Methods:

This project will involve analysis the boron isotope composition of fossil foraminifera and radiolarians to reconstruct ocean pH and atmospheric CO₂ through the last 40 million years of the Cretaceous. This time period includes some of the hottest temperatures of the Phanerozoic, and as such is increasingly seen as an important time period to study, as some IPCC scenarios would see CO₂ levels in the next century that are potentially higher than at any point in the last 70 million years. At the moment, CO₂ proxy records for this time are sparse, uncertain, and often disagree with one another. The boron isotope-pH proxy – as applied to marine microfossils – is increasingly seen as an accurate and precise proxy for reconstructing CO₂, but as yet the oldest application of the
proxy is around the end-Cretaceous mass extinction, and so the time is ripe to extend our boron-based estimates further back into the Cretaceous. This PhD project will be at the vanguard of these efforts, providing crucial new constraints on climate sensitivity to CO₂. Trace element measurements made alongside these boron isotope measurements will also allow us to reconstruct ocean temperature and major ion chemistry at this time. This work will use International Ocean Discovery Program (IODP) marine drill core samples from all round the Earth’s oceans, and will avail of the state-of-the-art analytical facilities housed within the Bristol Isotope Group (BIG) lab, as well as dedicated sediment washing and micropalaeontology labs.

**Candidate requirements**

The School of Earth Sciences is a hub of interdisciplinary research; as such, we are open to intellectually diverse applicants, and welcome new perspectives. Prior knowledge of relevant subject areas like micropalaeontology, climate science, or geochemistry could therefore be helpful, but are not a fixed prerequisite. Similarly, we welcome and encourage student applications from minoritized and marginalised backgrounds, and value a diverse research environment.

**Project partners**

This project will be part of a team of two PhD students, two PostDocs and one technician funded through the PETRARCH project. It will be based at the University of Bristol's School of Earth Sciences, which is ranked 2nd in the UK in the Research Excellence Framework 2021, with 100% of research output being rated as rated as ‘world leading’ or ‘internationally excellent’. Outside of the School, it will involve frequent interaction and exchange of ideas with collaborators in the School of Geographical Sciences and the School of Chemistry. Collaborators outside Bristol include scientists in the US, Germany and France, meaning the student will immediately be linked into an international network of scientists.

**Training**

As part of the PETRARCH project, there will be outstanding opportunities for field work and associated training. We recognise the constraints field work imposes on applicants from some backgrounds, however, and field work is not mandatory (with samples provided by partners). Ample funds for international conferences and summer school attendance has been allocated, as well as funding for travel to be trained in Cretaceous foram taxonomy at the Smithsonian Institution in Washington DC. There will also be the opportunity to take part and gain experience in live culturing of radiolarians and foraminifera in the South of France. Analytically, the student will be trained in boron isotope analysis via MC-ICPMS, as well as trace element analysis via ICPMS. There will also be ample opportunity to develop teaching and mentoring skills through engagement in training our talented undergraduates, should the student wish to do so.

**Background reading and references**


**Useful links**

To apply see links at: [http://www.bristol.ac.uk/earthsciences/courses/postgraduate/](http://www.bristol.ac.uk/earthsciences/courses/postgraduate/)

Please note: If you are applying for this programme, you need to select Geology PhD as the programme choice when completing your online application form.

For information on the School of Earth Sciences: [http://www.bristol.ac.uk/earthsciences](http://www.bristol.ac.uk/earthsciences)

For information on PETRARCH: [www.petrarch-project.science](http://www.petrarch-project.science)

The application deadline is Wednesday 15 February; Interviews will take place during the period 6th to 10th of March, 2023. The preferred start date will be Oct 2023 but the funding of the project allows flexibility. Funding is available for 4 years at standard UKRI rates.