## Assessing past oxygen in the ocean using Cr isotopes as a palaeoproxy

**Supervisors:**
**Dr Ian Parkinson (School of Earth Sciences, University of Bristol) – Main supervisor**
Dr Daniela Schmidt (School of Earth Sciences, University of Bristol)
Dr Fanny Monteiro (School of Geographical Sciences, University of Bristol)
**Host institution:** University of Bristol

**Project description:** Over the last 50 years, Oxygen Minimum Zones (OMZs) and anoxic "dead" zones, have expanded and are projected to do so further in the future during climate change, with significant implication for life in the oceans and its elemental cycles. Predicting future changes in the ocean's oxygen content and distribution will depend on our understanding past records of OMZs. Chromium (Cr) and its isotopes provide a potentially powerful tool for reconstructing the redox state and hence oxygen concentrations of ancient oceans. Although there are an increasing number of studies on Cr isotopes in the marine environment, the ocean chemistry of Cr is still poorly constrained, in part because of the low concentration of Cr in seawater. There are a number of challenging open questions that need to be resolved before Cr can be quantitatively applied to the geological record, such as how isotopes are fractionated e.g. during weathering and transport or by reduction processes within the water column, and why there are significant differences in $\delta^{53}$Cr between open ocean basins and near shore environments [1].

Chromium is highly enriched in carbonates relative to seawater due to the incorporation of the chromate ion into the carbonate lattice and is therefore the primary material for reconstructing seawater records. Initial empirical studies of foraminifera carbonate indicate small but significant vital effects, which need to be assessed in detail. However, preliminary Cr studies assessing the evolution of oxygenation during the prime record of global warming in the past, the PETM (55 Ma), demonstrates the efficacy of Cr isotopes as a palaeoproxy to recover accurate past seawater Cr isotope values [2].

To this end, the student will undertake carbonate precipitation experiments, which will provide an understanding of the underlying controls on Cr isotope fractionation and element partitioning. Experiments will be performed at controlled, temperature, pH and precipitation rate, to constrain equilibrium and kinetic fractionation effects. A detailed assessment of vital effects in key foraminiferal species using modern foraminifera and seawater compositions will be performed. The new proxy will be applied to study the link between climate change and oxygen in to ocean for PETM and early Toarcian oceanic anoxic event (183 Ma). These data will be assessed by comparison with an Earth System model of intermediate complexity (GENIE), which has been successfully applied to anoxic conditions in the Cretaceous before [3] and can be used to model basinal scale Cr variations and the Cr cycle in its entirety.

[1] Bonnand, P, et al., 2013, The chromium isotopic composition of seawater and marine carbonates. Earth and Planetary Science Letters, 382, 10-20.
[2] Parkinson I, et al., 2013, Tracking changes in ocean redox during the PETM using Cr isotopes. Mineralogical Magazine, 77, 1926.
[3] Monteiro, FM, Pancost, RD, Ridgwell, AJ & Donnadieu, Y 2012, 'Nutrients as the dominant control on the spread of anoxia and euxinia across the Cenomanian-Turonian oceanic anoxic event (OAE2): Model-data comparison'. Paleoceanography, vol 27, PA4209.