Assessing ocean deoxygenation during the Palaeocene-Eocene Thermal Maximum

SERGINIO REMMELZWAAL1,2*, SOPHIE DIXON3, IAN PARKINSON1, DANIELA SCHMIDT1, FANNY MONTEIRO2, PHILIP SEXTON1, MAUENLA FEHR4, CAROLINE PEACOCK5, RACHAEL JAMES6

1School of Earth Sciences, University of Bristol, Bristol, UK, (*correspondence: serginio.remmelzwaal@bristol.ac.uk)
2School of Geographical Sciences, University of Bristol, Bristol, UK
3Department of Earth and Environmental Sciences, The Open University, Milton Keynes, UK
4Institut für Geochemie und Petrologie, ETH Zürich, Zürich, Switzerland
5School of Earth and Environment, University of Leeds, Leeds, UK
6Ocean and Earth Science, University of Southampton, Southampton, UK

In recent years oxygen minimum zones have been expanding and are projected to continue to grow in size and number due to rising temperatures. Ocean deoxygenation has far-reaching consequences for marine life and therefore it is essential to assess the mechanisms of deoxygenation by evaluating past climate events. We applied an emerging redox proxy, Cr isotopes, and Ce/Ce* anomalies in planktic foraminiferal calcite to assess the variation in redox state during the Palaeocene-Eocene Thermal Maximum (PETM), an episode of dramatic warming 56 million years ago akin to modern anthropogenic climate change. We followed published cleaning (Barker et al., 2003) and analytical (Bonnand et al., 2011) procedures to obtain the foraminiferal Cr and Ce signatures. Both Cr isotopes and Cr concentrations show marked changes over this interval in both shallow and open ocean settings indicating wide-spread reductions in dissolved oxygen concentrations. Open ocean stations (ODP sites 1210 and 1263 in the Pacific and South Atlantic, respectively) point towards deoxygenation caused by rising temperatures and changes in ocean ventilation. Cr data are corroborated by Ce/Ce*. A strong correlation between δ53Cr and the size of the benthic foraminiferal δ18O excursion as well as dissolved benthic oxygen level simulations from the climate model eGENIE suggest temperature is the principal driver of open ocean deoxygenation during the PETM.