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Extreme environmental change during the Toarcian OAE: Evidence from stable and radiogenic isotopes

A. Cohen, A. Coe

Department of Earth Sciences, The Open University, Milton Keynes, UK
(a.s.cohen@open.ac.uk)

The Toarcian (early Jurassic) oceanic anoxic event (OAE) is characterised by the accumulation of abundant marine organic carbon at many localities worldwide. This interval was associated with a significant extinction of marine biota and with major evolutionary changes on land. Evidence from a wide range of geochemical proxy data (including C-, O-, Sr-, Os- and Mo-isotopes) indicates that the environmental changes allied with the OAE were substantial global warming, a major increase in continental weathering rates and an enhanced hydrological cycle.

One of the most compelling lines of evidence suggesting that there was a major perturbation to the global carbon cycle during the Toarcian OAE is the recognition of a widespread excursion of ~7-8 permil in the δ^{13}C of the marine and atmospheric carbon reservoirs. Recent work has shown that the C-isotope excursion involved 4 shifts each of 2-3 permil that were paced by astronomical precession (Kemp *et al.*, Nature, 2005). Whilst the individual shifts were established in ~1 ka, the entire C-isotope excursion persisted for ~200 ka. The most parsimonious explanation for the wide range of environmental changes at that time is the dissociation of large quantities of methane hydrate in 4 astronomically-paced releases each involving ~2,000 Gt C. New Mo-isotope data indicate that the areal extent of marine anoxia also expanded at that time, from a regional to global distribution, and allow us to define more precisely the nature of the OAE.

Based upon a detailed comparison, it is clear that there are many similarities between the environmental and geochemical changes that occurred during the Toarcian OAE and during the Paleocene-Eocene Thermal Maximum (PETM) ~55 Ma ago. Both events appear to have been linked in some way to the emplacement of a Large Ig-

neous Province, which may have started a series of events that led to global warming, methane hydrate release and the development of widespread marine anoxia. This contribution assesses and reviews the evidence for the processes that gave rise to both the Toarcian OAE and the PETM.