A high-precision numerical time scale for the Toarcian Stage: implications for timing of the marine Toarcian Oceanic Anoxic Event (T-OAE) and Karoo-Ferrar volcanism

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The Early Toarcian is marked by one of the largest global climatic and ocean-redox change events of the Mesozoic Era, termed the Toarcian Oceanic Anoxic Event (T-OAE; ~183 Ma). It is also characterized by major perturbations in global (bio)geochemical cycles, including the global exogenic carbon cycle. The combined massive release and sequestration of isotopically light carbon, and relative changes in the intricate balance between the two, resulted in major positive and negative shifts in organic and inorganic, marine and terrestrial $\delta^{13}C$ records..The widespread development of anoxic–euxinic conditions, combined with global warming, had major repercussions for marine ecosystem stability, resulting in global marine mass extinction. This major global change event is thought to be causally linked to the emplacement of the Karoo-Ferrar Large Igneous Province (LIP).

Although much research has focused on the climatic and environmental consequences of carbon release at this time, the duration and rate of carbon-cycle change, and the temporal and causal link to Karoo-Ferrar LIP volcanism are poorly understood.

Here, we present a high-precision astronomical time-scale for the entire Toarcian Stage in the Mochras Borehole (Wales, UK). Integrated with bio-, chemo-, and magnetostratigraphy of the same borehole and radio-isotopic constraints, this allows for important inferences on the temporal link between Karoo-Ferrar LIP volcanism and the Early Toarcian global change event.