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Astronomical constraints on the duration of the early jurassic pliensbachian and toarcian stages and global carbon-cycle and climatic perturbations

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The Early Jurassic (201.3 to 174.1 Ma) is bracketed by the end-Triassic mass extinction and global warming event, and the Toarcian–Aalenian shift to (global) icehouse conditions [1, 2, 3, 4]. It is further marked by the early Toarcian Oceanic Anoxic Event (T–OAE), with possibly the largest exogenic carbon-cycle perturbation of the Mesozoic, and related changes in global geochemical cycles, climate and the environment, thought to be linked to emplacement of the Karoo–Ferrar Large Igneous Province [5, 6]. Furthermore, Early Jurassic continental rifting, with the break-up of Pangaea and the opening of the Hispanic Corridor and Viking Strait, likely initiated major changes in (global) ocean circulation and climate, possibly impacting global ecosystems and biogeochemical cycling. The time-scale and timing of these events is, however, rather poorly constrained.

Here, we present high-resolution elemental concentration data from the Mochras Borehole (Wales, UK), which represents ~1300m of possibly the most complete and expanded Lower Jurassic hemi-pelagic marine sedimentary archive known. We construct a floating ~14 Myr astronomical time-scale spanning the complete Early Jurassic Pliensbachian and Toarcian stages and biozones. Combined with radiometric and astrochronological constraints on Early Jurassic stage boundaries, we construct a new, absolute, time-scale for this interval. We further assess the duration of the Pliensbachian (~8.7 myr) and Toarcian (~5.3 myr) stages and the duration and rate of change of Sinemurian–Pliensbachian, Pliensbachian–Toarcian and Early Toarcian global carbon-cycle and climatic perturbations. With this, we directly compare Early Jurassic (specifically Early Toarcian) environmental and global carbon-cycle change to absolute time-constraints on Large Igneous Province (Karoo and Ferrar) volcanism. We furthermore discuss the nature and expression of Early Jurassic long (> 405 kyr) astronomical cycles.

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