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A 27-Myr history of marine redox oscillation during the Early Jurassic

TIANCHEN HE, ROBERT J NEWTON, CRISPIN T.S. LITTLE, PAUL B. WIGNALL AND SIMON W. POULTON

School of Earth and Environment, University of Leeds

Presenting Author: t.he@leeds.ac.uk

The Early Jurassic was a pivotal time of biological recovery and radiation after the end-Triassic mass extinction. However, this interval was continually interrupted by short-term environmental perturbations, and relationships between long-term marine oxygen variability, redox-dependent elemental cycling and climate change through the Early Jurassic are poorly understood. Here, we report highly reactive iron (Fe_{HR}) and trace metal behaviour, combined with pyrite sulfur isotope systematics, through the continuous marine mudstone succession of the Llanbedr (Mochras Farm) borehole, Cardigan Bay Basin, Wales, UK, which spans the earliest Hettangian to Toarcian (ca. 201-174 Ma) [1]. In combination with evidence from organic matter preservation and palaeoecology [2,3], these data for the first time present a complete marine oxygenation history of the Early Jurassic.

Results show strengthened bottom-water oxygen deficiency during the negative $\delta^{13}C$ excursions of the late Pliensbachian and Sinemurian–Pliensbachian transition. However, in contrast to contemporaneous widespread and persistent dysoxia/anoxia elsewhere in the European epicontinental seas, the Cardigan Bay Basin was largely oxygenated during the early Toarcian carbon isotope excursion event, with the exception of short-lived periods of anoxia. Over a longer timescale, the Cardigan Bay Basin underwent persistent marine redox instability through the Early Jurassic, leading to overall elevated Fe_{HR}/Fe_{Total} values and oscillating trace metal enrichment patterns throughout the core. Nevertheless, the presence of benthic fauna in many of the intervals of overall enhanced oxygen deficiency suggest that redox oscillations were likely short-lived.

An integrated analysis of marginal sea basins in the northern hemisphere demonstrates that these basins were characterized by persistently elevated Fe_{HR} in deep-water sediments (Fe_{HR}/Fe_{Total} > 0.38) throughout the Early Jurassic. This suggests that the wider ocean was also poised at a generally low oxygen and potentially fluctuating redox state throughout this period

[1] Hesselbo, S.P., et al. (2013), Scientific drilling 16, 81-91.

[2] Xu, W., et al. (2018), EPSL 484, 396-411.

[3] Storm, M., et al. (2020), PNAS 117(8), 3974-3982.