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Variations in chemical weathering in response to large igneous province volcanism in the Early Jurassic: Osmium isotope record from the Prees 2 Borehole

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Identifying tipping points in Earth's climatic system and understanding the environmental feedback mechanisms remain fundamental challenges in paleoenvironmental research. Key environmental crises, such as major extinctions, have been a research focus, yet emerging research highlights the significance of inter-crisis intervals. The Early Jurassic (~201–175 Ma), marked by the breakup of the Pangaea supercontinent and the initiation of the Atlantic Ocean formation, was a period of significant climatic upheaval, characterised by both short-term and long-term carbon-cycle perturbations. Key events included the end-Triassic Mass Extinction (~201 Ma) and the Toarcian Oceanic Anoxic Event (~183 Ma), both linked to large igneous province emplacement, and major carbon isotope excursions. The Sinemurian–Pliensbachian Boundary Event (~191 Ma) also featured a substantial carbon isotope excursion, similar in magnitude to the end-Triassic Mass Extinction but occurring over a few million years. While research has been focused on these short-term events, the role of chemical weathering, crucial for modulating atmospheric CO_2 concentrations and stabilizing the global climate between events is not well understood.

This study, part of the International Continental Scientific Drilling Program (ICDP) project on the Early Jurassic Earth System and Timescale (JET), aims to address these gaps by investigating Earth System processes between the Rhaetian Stage (Upper Triassic) and the Early Pliensbachian Stage (Early Jurassic). Using calculated seawater osmium isotope ratios ($^{187}Os/^{188}Os_{(i)}$) we are able to trace the relative importance of chemical weathering from mantle and crustal sources. Long-term $^{187}Os/^{188}Os_{(i)}$ data broadly track changes in $\delta^{13}C_{org}$ data from the end Triassic to the Pliensbachian, with major shifts toward unradiogenic values at the end-Triassic Mass Extinction and Sinemurian–Pliensbachian Boundary Event. The observed coupling between $\delta^{13}C_{org}$ and $^{187}Os/^{188}Os_{(i)}$ isotopic changes suggests that the interplay between volcanic activity and crustal weathering played a critical role in regulating atmospheric CO_2 concentration and stabilizing the climate during periods of significant environmental stress.