Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.30625

Reconstructing early Jurassic seafloor anoxia: U isotope record of carbonate archives from Portugal and Morocco

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Understanding past ocean deoxygenation events is crucial for contextualizing present and future ocean deoxygenation trends. Ocean anoxic events (OAEs) in Earth's history, such as the Toarcian Oceanic Anoxic Event (T-OAE, ~183 Ma) or the smaller Pliensbachian/Toarcian event (Pl/To; ~184 Ma), were often triggered by increased atmospheric carbon due to intense volcanic activity and marked by widespread seafloor anoxia. The isotopic composition of redox-sensitive elements, such as uranium (U), has emerged as a key geochemical tool for tracing the paleo-redox conditions of the oceans at both local and global scales. However, the U isotope record in the Early Jurassic is incompletely explored, and thus, it is unclear if and how U drawdown, as recorded in several individual restricted anoxic basins of the European Epicontinental Sea, correlates with globally enhanced seafloor anoxia.

In this study, we present major and trace element distributions in combination with U isotope compositions from carbonate fractions in sedimentary stratigraphies of Peniche (Portugal) and Toumliline (Morocco), covering the Pl/To event and the T-OAE. The Portuguese samples show shale-normalized rare earth element and yttrium (REY) patterns with negative Ce anomalies, positive Gd anomalies, and positive Y anomalies, which are indicative of precipitation from open ocean seawater. The U isotope signature of these samples suggests locally anoxic depositional conditions during the Pl/To event but does not indicate a global expansion of seafloor anoxia during either the Pl/To event or the T-OAE. These findings contrast with recent results from Italy, where U isotope data from time-equivalent carbonate deposits suggest global seafloor anoxia during the T-OAE [1]. Additionally, carbonate samples from Morocco underscore the importance of assessing local depositional factors when interpreting U isotope records in ancient carbonates.

Studying OAEs enhances our understanding of how marine ecosystems and ocean redox conditions respond to elevated CO_2 levels. By comparing U isotope records from several locations, we can better distinguish between global and local redox changes during past anoxic events. This broader understanding of OAEs can improve current models of oceanic and climatic changes.

[1] Remírez et al. 2024, *Proceedings of the National Academy of Sciences*, *121*(27), e2406032121.