Unravelling 'Oceanic Anoxic Events' using high-resolution $\delta^{238}U$

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The Mesozoic 'Oceanic Anoxic Events' (OAEs) are some of the largest carbon-cycle perturbations of the Phanerozoic. These events are typified by the widespread accumulation of organic carbon (OC) as marine black shales. It is not clear, however, to what extent OAEs represent an increase in preservation potential through restricted circulation, or an increase in organic productivity, where the oxidative degradation of primary producers drives oxygen depletion.

The development of $^{238}U/^{235}U$ ($\delta^{238}U$) as a proxy for seawater oxygenation has the potential to address these questions because it gives an independent indicator of global redox changes that can be isolated from other processes. The isotope fractionation of U is strongly redox-dependent, whereby the heavier ^{238}U isotope is sequestered into organic-rich sediments under anoxic conditions. Although the application of $\delta^{238}U$ in deep-time is being increasingly utilized, published $\delta^{238}U$ data for OAE-2 (Cenomanian-Turonian) [1] and the Permo-Triassic Mass Extinction [2] demonstrate high stratigraphic variability that makes it difficult to clearly resolve global-scale redox changes.

We present new $\delta^{238}U$ data for OAE-2 carbonate sediments from the European shelf sea and Tethyan Ocean (Eastbourne Chalks and Raia del Pedale platform carbonates) at high temporal resolution (~5–10,000yr). We demonstrate that the high variability previously seen in $\delta^{238}U$ resolves into clear systematic trends that show striking coherency between locations and correlation with other OAE-2 chemo-stratigraphic records.

These data show clear changes in global oxygenation on 50-100 kyr timescales, before and, repeatedly, during the OAE-2 positive carbon-isotope excursion (CIE). Comparison to other published records identifies distinct intervals where coupling occurs between silicate weathering and anoxia, demonstrating the link between nutrient flux and productivity as drivers of global anoxia. In other instances, however, no coupling is seen and alternative explanations are required. These datasets highlight an intra-OAE complexity that has not previously been recognized.

[1] Montoya-Pino et al., 2010. Geology, 38, p315-318. [2] Brennecka et al., 2011. PNAS, 108, v43, p17631-17634