Late Cretaceous sub-tropical Pacific Ocean clumped-isotope palaeothermometry

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Carbonate clumped-isotope palaeothermometry data are presented for the <38 micron coccolithophore-bearing fraction of Late Cretaceous (Campanian to Maastrichtian) sediments recovered from Shatsky Rise Ocean Drilling Program Site 1210, presently situated in the northwest Pacific Ocean. The predominantly coccolithophore composition of the sediments enables reconstruction of photic zone surface-ocean palaeotemperatures. Site 1210 occupied a sub-tropical palaeolatitude in the Pacific Ocean during the Late Cretaceous that resulted in relatively high sedimentation rates for an open-marine setting. Site 1210 Late Cretaceous sediments comprise nannofossil ooze that has not undergone sufficient sub-seafloor diagenesis to cause lithification and conversion into chalk or limestone, making these sediment cores ideally suited for novel application of clumped-isotope palaeothermometry. Clumped-isotope data were generated using the ETH automated mass spectrometry method of Schmid and Bernasconi [1].

The novel clumped-isotope dataset is discussed in terms of a number of critical palaeoceanographic objectives and interpretations: 1) determination of absolute Late Cretaceous sub-tropical Pacific Ocean palaeotemperatures and associated reconstruction of latitudinal palaeotemperature gradients, both via comparison to other published palaeotemperature data; 2) assessment of whether an orbital-forcing control on the sub-tropical surface ocean is evident within the clumped-isotope palaeotemperature record; and 3) use of clumped-isotope palaeotemperatures in combination with conventional $\delta^{18}O$ values in order to deconvolute a temporal seawater oxygen-isotope composition record, specifically to test the hypothesised occurrence of cryosphere development, and associated glacioeustatic sea-level change, proximal to the Campanian to Maastrichtian stage boundary.

[1] Schmid & Bernasconi (2010) *RCMS* **24**, 1955-1963.

Ocean redox dynamics during the end-Permian extinction and Early Triassic recovery

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The Permian Triassic mass extinction is widely regarded as the most severe of the Phanerozoic extinctions. The event was associated with major carbon cycle disruption, not only at the Permian Triassic Boundary (PTB) but also for the entire Early Triassic. These disturbances are recorded in the $\delta^{13}C$ record of both carbonate and organic carbon, which show a series of positive and negative carbon isotope excursions (CIEs) throughout the Eary Triassic. These fluctuations are also linked to minor extinctions in the Early Triassic and a delay in total species recovery until the Middle Triassic. One leading hypothesis invoked to explain these changes is oceanic anoxia, which provides a kill mechanism that is also potentially linked to observed changes in the carbon isotope record. Multiple anoxic events have indeed been identified in various sections around the world. However the link between the globally recorded CIEs and the development of anoxia is not clear, with no consistent relationship emerging.

Here we present a new record of anoxia from the Arabian platform using Fe-S-C systematics. This mixed sequence of continental margin carbonates and clastics records a shelf to basin transect for the PTB and Early Triassic, which demonstrates the distinct CIEs mentioned above. The use of Fe-speciation in tandem with carbon isotopes places the local record of anoxia in a global context, thus helping elucidate the timing, development and stability of anoxia.

Initial data show sustained anoxic, non-sulphidic (ferruginous) conditions across the PTB for both slope and basin settings. Subsequently anoxia appears restricted to the positive CIEs. Here, non-sulphidic conditions were again dominant, which is in contrast to a growing body of evidence indicating euxinic conditions for the PTB. S-isotope systematics provide further insight into controls on the observed environmental conditions at this time. Together, our approach provides a detailed examination of ocean redox variability during this interval of extreme environmental disturbance, thus enabling a greater understanding of C-cycle feedbacks and biological consequences.

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