

Mid-Cenomanian Event I vs. the CTBE: geochemical and palaeoenvironmental contrasts between two major Late Cretaceous carbon isotope events

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Cenomanian times (100.5–93.9 Ma) represent perhaps the best documented episode of eustatic rise in sea level in Earth history and the beginning of the Late Mesozoic thermal maximum, driving global expansion of epicontinental seas and the onset of widespread pelagic and hemipelagic carbonate (chalk) deposition. Significant changes occurred in global stable-isotope records, including two prominent perturbations of the carbon cycle – Mid-Cenomanian Event I (MCEI; ~96.5–96.2 Ma) and Oceanic Anoxic Event 2 (OAE2; ~94.5–93.8 Ma). OAE2 was marked by the widespread deposition of black shales in the deep ocean and epicontinental seas, and a global positive carbon stable-isotope excursion of 2.0–2.5‰ $\delta^{13}\text{C}$ in marine carbonates. Osmium isotopes and other geochemical evidence indicate that OAE2 was associated with a major pulse of LIP-associated volcanism, with coincident changes in eustatic sea level, rising atmospheric pCO_2 and warming climate, but including a transient phase of global cooling – the Plenus Cold Event.

MCEI, by contrast, shows a $<1\text{‰}$ $\delta^{13}\text{C}_{\text{carb}}$ excursion, and has no associated black shales in most areas, yet it also displays evidence of two episodes of cooling, comparable to the Plenus Cold Event. MCEI represents a major breakpoint on long-term carbon-isotope profiles, from relatively constant to very slowly rising $\delta^{13}\text{C}$ values through the Lower Cenomanian, to a trend of generally increasing $\delta^{13}\text{C}$ values through the Middle and Upper Cenomanian. This represents a significant long-term change in the global carbon cycle starting with MCEI. Here, we present new high-resolution elemental data and $^{187}\text{Os}/^{188}\text{Os}$ isotope results for MCEI from an English Chalk reference section at Folkestone. Our results are compared to published $\delta^{13}\text{C}_{\text{carb}}$, $\delta^{18}\text{O}_{\text{carb}}$, $\delta^{13}\text{C}_{\text{org}}$ stable isotope and neodymium isotope $\epsilon\text{Nd}(t)$ data from the same section. Elemental proxies (Mn, Ti/Al, Zr/Al, Si/Al) define key sequence stratigraphic surfaces, providing a basis for refining relative sea-level curves. Cyclical small-scale transgressive events within the mid-Cenomanian TST of depositional sequence Ce IV are accompanied by coupled increases in $\epsilon\text{Nd}(t)$ and decreases in $^{187}\text{Os}/^{188}\text{Os}$ ratios. Os_i ratios of 0.8–0.9 prior to MCEI, rise to 1.2 in the lower peak of the isotope excursion, coincident an influx of boreal fauna and the lowest $\epsilon\text{Nd}(t)$ values in the section (<-10), and show a stepped fall thereafter. Highly unradiogenic Os_i values of ≤ 0.2 occur immediately above MCEI, in an interval of high $\epsilon\text{Nd}(t)$. These geochemical data are interpreted to represent cyclical changes in water mass sources and distribution in the Chalk sea, driven by sea-level and climate change. The remarkably low Os_i values recorded following MCEI indicate a dominance of hydrothermal/mantle-like sourced Os in southern England waters at that time.