



Palaeoenvironmental reconstruction across the mid-Barremian oceanic anoxic event in the Boreal Realm: calcareous nannofossil and geochemical evidence

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During the mid-Barremian (Early Cretaceous), the Boreal Realm experienced an episode of widespread deposition of laminated organic-rich black shales (Hauptblätterson in the Lower Saxony Basin, NW Germany and Munk Marl in the North Sea) which may correspond to a regional oceanic anoxic event (OAE).

This study focuses on changes in exceptionally well-preserved calcareous nannofossil assemblages across the Munk Marl in two North Sea cores coupled with geochemical data (bulk carbonate stable isotopes and TOC). As calcareous nannofossils are highly sensitive to environmental changes in sea-surface waters, they are excellent proxies for palaeo-sea-water temperatures, for estimating proximal and distal settings as well as for characterising nutrient fluxes through fertility changes.

No compelling carbon isotope excursion is associated with the Munk Marl but pronounced negative excursions are recorded across this interval in both investigated cores for oxygen isotopes with amplitudes of approximately 4 ‰ in the first core and 2.5 ‰ in the second. TOC values within the Munk Marl are generally very high, fluctuating between 1.82 WT% and 10.13 WT% with values peaking in its lower and upper thirds. The negative oxygen isotope excursions may indicate increasingly warmer water temperatures.

Below the Munk Marl, the nannofossil assemblages are characterized by a relatively low abundance of oligotrophic indicators (*W. barnesiae*, *Nannoconid* spp.) and warm water indicators (*C. margerelii*, *R. asper*, *W. britannica*) while the fertility index taxa (*B. constans*, *D. lehmanii*, *D. ignotus*, *Z. noeliae*) and proximal indicators (*Micrantholithus* spp.) show high abundances. In the Munk Marl, generally, both the warm water and oligotrophic species increase in abundance while the fertility index taxa drop to very low numbers in the upper two-thirds. Moreover, we observe a three-fold subdivision of the Munk Marl in the nannofossil assemblage, which matches a similar subdivision in the TOC and carbonate content. The lower third of the Munk Marl shows higher abundances of *W. barnesiae*, warm water indicators and fertility index taxa, while the middle part is dominated by higher abundances of oligotrophic nannoconids and proximal indicators. The upper third is dominated by *W. barnesiae* and warm water indicators similar to the lower part, but with a contrasting low abundance of fertility index taxa.

Above the Munk Marl, the warm water and oligotrophic indicators show relatively low abundances, while the proximal indicators increase again. The fertility index taxa also regain high abundances in one of the two investigated cores.

We interpret these data as an expression of a very warm and arid climate during deposition of the Munk Marl, along with low nutrient influx and reduced terrigenous run-off. Stable warm and arid conditions favoured strongly reduced ocean mixing and enhanced stratification of the water column, which led to bottom water anoxia.