Oceanographic, vegetation and climatic change at the Palaeocene–Eocene boundary in the North Sea region

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We present stable isotopic and micropalaeontological data across the Palaeocene–Eocene boundary from North Sea core 22/10a-4. The core was recovered from the central North Sea ~200 km from land, and the section investigated spans ~26 m of predominantly shale with occasional thin turbiditic sand beds. This expanded succession is thought to have been deposited in an estimated palaeo-water depth of ~500 m, with no major hiatuses. High resolution bulk rock total organic carbon isotopes ($\delta^{13}C_{TOC}$) reveal a negative carbon isotope excursion (CIE) of ~5‰, which takes ~2 m to reach the most negative values of the core of the CIE. The onset of the CIE, identified by the first shift towards more negative values, occurs close to the first appearance of *Apectodinium augustum* along with high abundances of other *Apectodinium* species, and defines the onset of the Palaeocene–Eocene Thermal Maximum (PETM). The $\delta^{13}C_{TOC}$ of the CIE shows no substantial recovery, indicating at most 3 precession cycles of the CIE may be preserved. The dark shale becomes laminated during the CIE, suggesting a temporary period of bottom water anoxia supported by the disappearance of benthic foraminifera. A large increase in the proportion of amorphous organic matter (AOM) occurs around the same time as the first *Apectodinium* and the CIE onset, and probably indicates an increase in the preservation of marine organic matter perhaps due to anoxia and lack of scavenging benthos. However, as AOM occurs both within and outside of the laminations, its occurrence may more likely indicate higher primary productivity within the CIE. Associated with these changes is a shift in the dinoflagellate assemblages. Open marine / neritic *Spiniferites*, *Glaphyrocysta* and various chorate cysts below the CIE are replaced by *Cerodinium*, *Lejeunia* and other peridinoid cysts leading up to and within the CIE suggestive of elevated nutrients and lower salinity. These records are therefore consistent with an increase in regional precipitation and oceanic nutrient supply. Furthermore, terrestrial spores and pollen show a significant shift away from abundant *Inapertuapollenites hiatus*, bisaccate pollen and *Caryapollenites* before the CIE, to abundant *Alnipollenites*, *Laevigatosporites* and *Plicapollis pseudoexcelsus* within the CIE, suggesting that a significant shift in vegetation occurred in Northwest Europe in concert with the CIE onset and appearance of *Apectodinium*.