Foraminiferal response to early Eocene climate variability in the North Sea Basin

Peter STASSEN[1,2], Etienne STEURBAUT[1,2] & Robert P. SPEIJER[1]
1 Department of Earth and Environmental Sciences, KU Leuven, Celestijnenlaan 200E, B-3001 Heverlee, Belgium.
2 Directorate Earth and History of Life, Royal Belgian Institute of Natural Sciences, Vautierstraat 29, B-1000 Brussels, Belgium.

The early Eocene greenhouse world was marked by multiple transient hyperthermal events, of which the Paleocene-Eocene Thermal Maximum (PETM) was the most prominent. The biotic impact of the less prominent hyperthermals following the PETM has been primarily studied in deeper water setting, while documentation of the foraminiferal responses in shallower shelf settings is still quite sparse, hampering the assessment of potential variability in marine ecosystem responses to Eocene global warming events. We present the lithologic, biotic and geochemical expression of these events in the Kallo reference core, located in northern Belgium. This core represents an extensive and almost complete record of the classical Ypresian Clays, deposited at the southern shelf edge of the North Sea Basin. Our stable isotope records, based on benthic foraminifera and bulk organic material, reveal a succession of carbon isotope excursions (CIE), correlatable to the deep-sea records of DSDP Site 550 (Gulf of Biscay) and ODP Site 1263 (Walvis Ridge). They are accordingly labelled H1 to P? (in accordance to the Ypresian astronomical time scale, Westerhold et al., 2017) and integrated within the holostratigraphic data of the Ypresian Clays (e.g. Steurbaut, 2006).

In this mid shelf setting, these CIE's correspond to distinct variations in lithology and characteristic foraminiferal assemblage changes (Figure 1). The occurrence of only agglutinated foraminifera in the basal layers, corresponding to the Lower Orchies Member (Mbr.), is linked to stagnant bottom waters in an enclosed basin. During the H1-CIE (ETM-2), a lowermost incursion of planktic foraminifera coincides with the permanent establishment of calcareous benthic foraminiferal faunas, indicative of intensified basin ventilation. This transgressive interval (Middle Orchies Mbr) is also characterized by elevated sediment accumulation rates. In the aftermath of the I1-CIE, correlatable with the top of the Upper Orchies Mbr., a more diverse benthic foraminiferal fauna appears and planktic foraminifera become consistently present (see Steurbaut et al., 2016 for subdivision of the Ieper Group).

Fully marine conditions were established during the deposition of calcareous silty to fine sandy clays (Roubaix Mbr), which is also marked by reduced sediment accumulation rates. Major regional biotic events are recorded during the K-CIE (ETM-3), recognizable by an influx of *Subbotina patagonica* and an acme of *Asterigerina bartoniana kaasschieteri*. The latter is considered indicative of deposition in a shallow tropical sea and may thus represent a basin-wide expansion of its habitat. In addition, transient blooms *Uvigerina* species seem to correspond to these minor CIE's, suggesting increased organic fluxes to the sea floor. Planktic foraminiferal abundances rapidly decline after the L-CIE and the basin becomes sediment-starved as indicated by multiple levels enriched in glauconite.

The onset of the Early Eocene Climatic Optimum (EECO) coincides with the basin-wide deposition of a transgressive clayey sediment (Aalbeke Mbr.) and renewed bottom water stagnation, resulting in a complete absence of benthic foraminifera. Carbon isotope excursions in the bulk organic record indicate a relationship with the M- and N-CIE's for this interval, as defined on foraminifera in the deep-sea record. The succeeding siltier levels (Kortemark Mbr.) contain a less diversified calcareous foraminiferal fauna, partially influenced by uplift of the basin, and reappearance of triserial planktic species. A more clayey interval (Egemkapel Mbr.) interrupts this shallowing trend and probably correlates to the P-CIE. A major unconformity,

due to a major tectonic uplift of the basin, marks the deposition of fine sand (Egem Mbr.). These sediments represent deposition in a broad shallow marine embayment during the EECO, contrasting earlier episodes of widespread deposition of clay and silt.

Our results thus indicate that also the lesser Eocene hyperthermal events are reflected in distinct biotic and lithologic changes at the southern edge of the North Sea Basin. Yet, the overall evolutionary impact of this sequence of global warming events seems to be limited. Foraminiferal assemblage changes mainly reflect dissimilar paleoenvironmental responses to short episodes of global warming in a regional context. Nonetheless, the presented data also emphasize the potential application of hyperthermal event stratigraphy, enabling correlation over a wide range of marine settings in the North Sea Basin and adjacent North Atlantic shelf areas.

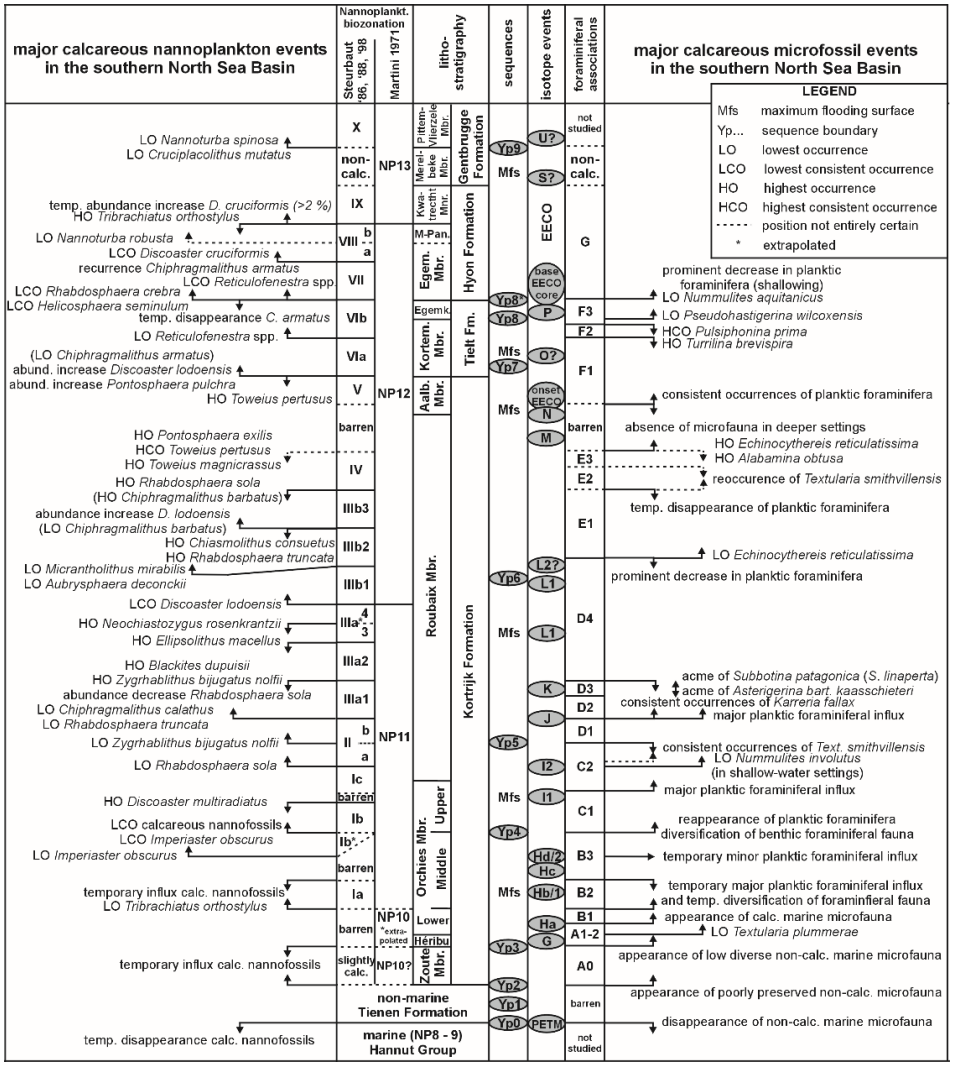

Figure 1. Proposed regional stratigraphic correlation scheme for a mid-shelf setting (Belgian Basin) based on carbon isotope excursions, nannoplankton and microfossil associations.

References

Steurbaut, E., 2006. Ypresian. In: L. Dejonghe (Editor), Current status of chronostratigraphic units named from Belgium and adjacent areas. Geologica Belgica, 9: 73-93.

Steurbaut, E., De Ceukelaire, M., Lanckacker, T., Matthijs, J., Stassen, P., Van Baelen, H. & Vandenberghe, N., 2016. Lithostratigraphy of the Ieper Group, 76 p.

Westerhold, T., Röhl, U., Frederichs, T., Agnini, C., Raffi, I., Zachos, J.C. & Wilkens, R.H., 2017. Astronomical calibration of the Ypresian timescale: implications for seafloor spreading rates and the chaotic behavior of the solar system? Climate of the Past 13, 1129-1152.