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# Paleoclimatic and paleoenvironmental records of the Oligocene–Miocene transition, central Jylland, Denmark

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ABSTRACT

A multidisciplinary study of the Oligocene/Miocene (O/M) transition was carried in two boreholes (Harre-1 and Horn-1) from the Danish land area in order to improve the understanding of the paleoclimatological and environmental changes across the Mi-1, the earliest Miocene cooling event. Dinoflagellate cyst (dinocyst) biostratigraphy, supported by re-evaluation of the foraminiferid biostratigraphy, a new set of magnetic data and stable carbon isotope ($\delta^{13}C$) records were applied to improve the age model for the studied succession; as well as the positioning of the O/M boundary. These data further enabled a correlation of the two investigated profiles with the well-established stratigraphical framework for the Danish area.

The BIT index (an organic proxy indicating the relative input of soil-derived organic matter), dinocyst assemblages and palynofacies have been applied for establishing the paleoenvironmental changes across the Oligocene/Miocene (O/M) boundary. Our data indicate a shallowing upward trend in the latest Oligocene, resulting in the establishment of a very restricted marine setting in the earliest Miocene. Our study confirms that the O/M boundary is located at a sequence boundary (the local sequence boundary B — SB B) and corresponds to an increase in terrestrial organic matter input.

A mean air temperature record based on the MBT′/CBT proxy reveals an ~2 °C drop in temperature at the O/M and the sequence boundary. Our findings confirm previous suggestions that this sequence boundary is a result of the glacio-eustatic sea level fall related with the Mi-1 cooling event. The unconformity at the sequence boundary probably correlates with the coldest part of Mi-1, and thus no deposits from this period have been preserved. This suggests that the temperature drop might have been greater than 2 °C.

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## 1. Introduction

The type section of the Oligocene/Miocene (O/M) boundary, and thus the base of the Neogene, is defined in the Lemme–Carrosio section (northern Italy) at the base of Chron C6Cn.2n (Steininger et al., 1997). At many localities the O/M transition coincides with a distinctive positive excursion (>1‰) in oxygen isotope ($\delta^{18}O$) composition of deep sea benthonic and planktonic foraminifera (Pekar and Miller, 1996). The isotope excursion is indicative of a prominent global cooling event, known as Mi-1 (Miller et al., 1991, 1998). The cooling maximum, related with the Mi-1 event, falls within Chron C6Cn and spans the NP25/NN1 boundary (Miller et al., 1991; Pekar and Miller, 1996).

In contrast to the well-known paleoclimatic records based on the oxygen isotopic ($\delta^{18}O$) composition of benthonic or planktonic foraminifera from Atlantic deep marine successions (e.g. Miller et al., 1991; Pekar and Miller, 1996; Lear et al., 2004), climatic records based on macroflora and terrestrial palynomorphs of the O/M transition onshore Europe are relatively few (Utescher et al., 2000; Mosbrugger et al., 2005; Kürschner and Kvaèek, 2009; Larsson et al., 2010). The terrestrial palynomorph record from a single site in the eastern North Sea Basin (the Dykær outcrop; Fig. 1) suggests a rather stable, warm–temperate climate during the O/M transition, with a warming trend from the O/M boundary interval to the Early Aquitanian. Unfortunately, an unconformity at the O/M boundary is present at this locality, and thus an assessment of the global cooling on local paleoclimate may be hindered (Larsson et al., 2010).

During this period of climatic deterioration close to the O/M boundary the Antarctic ice cap expanded (Roberts et al., 2003) and the volume of the Eastern Antarctica Ice Sheet is estimated to have been 1.1–1.2 times larger than today (Naish et al., 2008; Pekar and Christie-Blick, 2008). The installation of a cooler climate induced a eustatic sea-level drop of ~40 ± 15 m (apparent sea level fall) (Lear et al., 2004; Pekar et al., 2006; Naish et al., 2008; Pekar and Christie-Blick, 2008; Wilson et al.,

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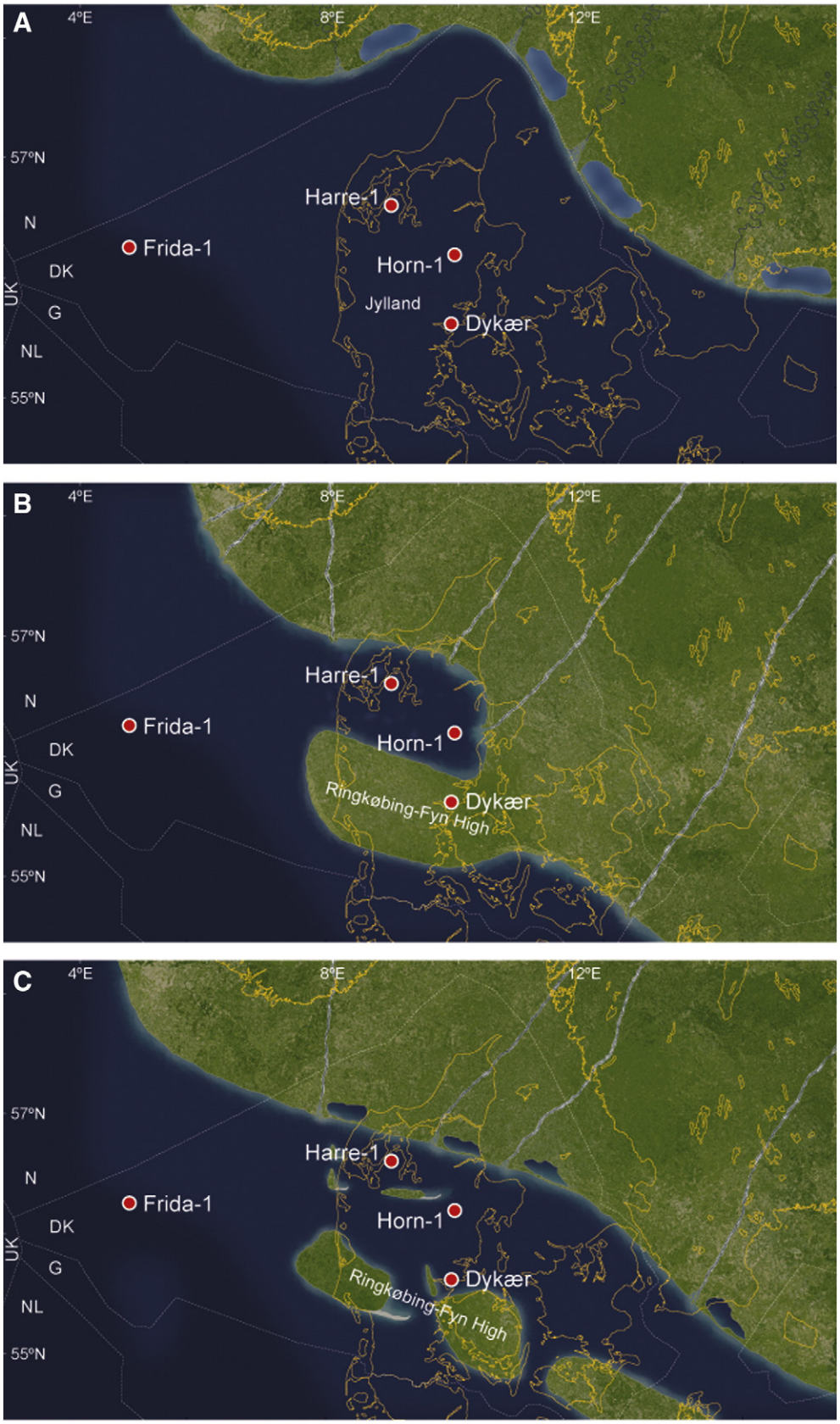


**Fig. 1.** Paleogeography in the eastern North Sea Basin, (A) latest Chattian, (B) the Oligocene/Miocene boundary, and (C) earliest Aquitanian. Modified from Dybkjær et al. (2012).

2009). In many worldwide settings, the Mi-1 event coincides with an unconformity (Pekar and Miller, 1996; Naish et al., 2008). Also, in the eastern North Sea Basin (onshore and offshore Denmark), a sequence boundary (a boundary surface in the following referred to as SB B; for details see text below and Fig. 2) of the latest Oligocene–earliest Miocene age was previously linked to the sea level fall caused by the Mi-1 cooling

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