A nannofossil and geochemical investigation into the top Tor hardground, a reservoir barrier/baffle in the Danish Sector of the North Sea

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In the Danish sector of the North Sea, the Maastrichtian Tor Formation and overlying Danian Ekofisk Formation hydrocarbon reservoirs are separated by an upper Maastrichtian hardground barrier/baffle and an inferred hiatus at the base of the Danian. In order to characterize this barrier/baffle, detailed nannofossil biostratigraphic and stable isotope analyses were carried out on a core from a well in the Halfdan Field.

Previous nannofossil analyses revealed that the uppermost Maastrichtian Tor Formation chalk, which could be dated as UC20dBP, was separated from the Ekofisk Formation chalk, which was dated as NNTp2E-F, by a 'mixed interval' that contained both Maastrichtian and Danian nannofossils and encompassed the hardground level. The extensively burrowed ca. 1-m-thick hardground interval was the focus of the current study, and high-resolution sampling was undertaken for nannofossils and $\delta^{13}C$ and $\delta^{18}O$ stable isotope analyses from within the multi-tiered network of *Thalassinoides* burrows.

Detailed study of the burrow fill revealed earliest Danian (NNTp1A) chalk in the deepest burrows, with younger chalk dated as NNTp2 (undifferentiated) and NNTp2D in succeeding burrows, thus confirming the presence of earliest Danian chalk that previously was thought to be absent in this area.

In the upper part of the mixed interval, isotope signatures for the host Tor chalk and the burrow fills differ significantly. This is probably due to early submarine cementation of the host chalks in contrast to late diagenesis in the porous burrow fills. Low $\delta^{13}C$ values in the burrow fills are probably due to metabolic processes within the active burrow systems and the input of light carbon from earliest Danian sediments and from late diagenetic fluids.

This study illustrates the complex history of this barrier/baffle and demonstrates that although the burrow systems remained open for much of the hiatal period, there was local preservation of earliest Danian sediments. This composite burrow infill subsequently acted as a bypass route for fluids through the hardground level.