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Forced regression as an effect of a mid-Oligocene cooling - a case study from the North Sea Basin

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The study area is located in the western part of the Norwegian-Danish Basin at the northern flank of the Ringkøbing-Fyn High. The regional subsidence of the North Sea Basin during the Cenozoic occurred mainly in the Central Graben, west of the study area. There are no indications of Cenozoic basement faulting taking place. However, the area is characterized by a large number of salt structures (pillows, walls and diapirs) which were periodically active during the Cenozoic and partly controlled the deposition.

The Oligocene deposits within the Norwegian shelf and Central-Eastern North Sea Basin constitute prograding siliciclastic clinoforms of over 1km thickness. The Oligocene clinoforms overlay the Eocene hemipelagic clays. The shift in the sedimentation pattern at the Eocene/Oligocene boundary coincides with the pronounced cooling of the global climate.

Previous studies have subdivided the Oligocene succession into a low resolution, but robust, sequence stratigraphic framework. The Oligocene sediments originated from the northeast, and the depositional maxima of the 3rd order sequences migrated westwards parallel to the pinch out of the Zechstein salt onto the Paleozoic Ringkøbing-Fyn High.

The objective of this study is to elucidate the factors controlling the deposition of the Oligocene sequence comprising high angle clinoforms, and to generate a depositional model for that particular unit.

The 3D seismic survey NODAB_R is located above the mid-Oligocene depocentre. The Nini-1 well, where dinoflagellate cysts were examined, contains the most complete mid Oligocene section studied in the North Sea Basin.

Linear submarine channels have developed at the base of the clinoform unit and also during the subsequent forced regression.

The same unit yields the cold water dinoflagellate genus Svalbardella spp., which suggests the influence of the cooler climate on the depositional pattern of the sequence. Furthermore, the timing of the appearance of Svalbardella, based on the dinoflagellate cyst biostratigraphy, suggests an affinity with the Oi-2a cooling event.

Paleoenvironmental analysis suggests rather variable conditions during the deposition of the unit, but within the deep/outer neritic, marine environment. The integration of 3D seismic and biostratigraphic analysis focused on palaeo-temperature and palaeo-environments enables us to demonstrate that the deposition of the unit is an outstanding example of forced regression due to climate cooling.

The study emphasizes that even in a complex and well-studied area as the North Sea the focused implementation of biostratigraphy and 3D seismic analysis enables an unambiguous identification of climate-induced changes in the relative sea level during deposition of this particular interval.