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Cenozoic structures and the tectonic evolution of the eastern North Sea

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Abundant seismic sections and well data from the Cenozoic succession in the eastern North Sea area generally reveal normal faulting, salt tectonics and localized tectonic inversion. However, inferences on the Cenozoic dynamic evolution of the region require thorough analysis of interactions between detachment surfaces withinthe sedimentary succession and basement structures. Here we define basement structures by offsets in the pre Zechstein succession. Cover structures are confined to the post Zechstein succession, or part hereof, and detach internally along surfaces in the post Zechstein succession. These structures have in the last decades been an integrated part of the discussions about subsidence and uplift of not only the interior of the basin but also of the basin margin. Abundant 2D and 3D seismic data and new depositional models enable detailed analysis and reinterpretation of where and when basement or cover tectonism took place. Our objectives are thus 1) to analyze the interaction between basement and cover structures, and if possible 2) to relate the structures to the regional tectonic evolution.
The Zechstein evaporites pinch out onto the Ringkøbing-Fyn High, which in the eastern North Sea is a Paleozoic-Mesozoic structural high separating the Northern and Southern Permian embayments. This pinch-out controls the presence of detaching cover structures and salt structures in the Norwegian Danish Basin, and the conspicuous absence of structures above the Ringkøbing-Fyn High (Clausen & Huuse 1999). Furthermore, prograding Oligocene and Miocene units in combination with thermal and loading induced differential subsidence between the basins and the Ringkøbing-Fyn High controlled the Cenozoic reactivations of the main coverfaults. The detaching cover faults generated additional accommodation space, which influencede.g. Miocene deposition and controlled the generation of second order faults. The latter detached along the top Chalk Group due to the topography generated during faulting, i.e. they are second order detachment surfaces. We conclude that the regional tectonic significance of the Cenozoic structures is of small importance, but that halokinetics and the rheological characteristics of Zechstein salt and Paleocene clays controlled the structural history along the Ringkøbing-Fyn High. A Cenozoic tectonic inversion of the Ringkøbing-Fyn High does not seem to be supported by structures.
Tectonic inversion was restricted to the Sorgenfrei-Tornquist Zone (STZ) and the Central Graben (Vejbæk & Andersen 2002). The marginal troughs of the STZ allow identification of compressional inversion during the late Cretaceous and relaxation inversion in the mid Paleocene (Nielsen et al., 2005). Structural reconstruction including decompaction in the Central Graben along the Arne-Elin trend shows that two phases of basement related inversion took place duringthe Paleocene-Eocene and the Oligocene. Halokinetics and differential compaction across the Paleogene inversion structure explain later tectonic signals, and the Neogene inversion reported by e.g. Rasmussen (2009) is therefore not required.
Our structural interpretation, which considers halokinetics and differential compaction, is consistent with the established late Cretaceous compressional inversion history of the European continent and the mid-Paleocene phase of relaxation inversion (Nielsen et al. 2005). In conclusion, the Cenozoic structures in the North Sea area do not generally support ideas on Neogene basement tectonism.

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