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Long-lived reactivation in a multi-rift system: the example of the Utsira High (Northern North Sea - Norway)

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Multi-phase reactivation of fault discontinuity inherited from basement structures, played a fundamental role in the development of many long-lived rift basins. In these settings, diachronous and non-colinear extensional events can result in a very complex interacting fault systems and fracture patterns. Consequently, the characterization of geometries and timing of reactivated structures can be a hard and tricky challenge to achieve.
The North Sea rift system is formed by three distinct rift branches with the approximately straight NNE-SSW trending arm corresponding to the Viking Graben. Along the eastern margin of this branch, a prominent structural high in the Norway offshore, called the Utsira High, separates the central Viking Graben from the Stord Basin to the east. Of the two basins, the former was mainly developed during the Jurassic-Cretaceous times and the latter was also affected by the Paleozoic-early Mesozoic rifting phase. The, at least, two main extensional events promoted the development of several segments of normal and transverse faults, with different extents and orientations.
The aim of our study has been to reconstruct the structural setting and to unravel the complex multi-phase evolution of the Utsira High and the adjoining basins in its surrounds (i.e. the Central Viking and Stord Basins). With this purpose, a 3D PSTM seismic volume extracted from the Seamless multi-survey and reprocessed by Spectrum has been analysed. The good penetration and quality of the seismic data allowed us to interpret five key reflectors up to the basement that were age-constrained by means of well-tie calibration using the numerous exploration boreholes drilled in the Utsira High. Seismic attribute such as dip-steered similarity and minimum-/maximum-curvature have been extracted from the seismic volume in time domain in order to better image discontinuities and fault edges.
Pre-, syn- and post-rift sequences have been defined and studied in fine detail in several cross-sections; particular attention has been paid to the syn-rift growth wedges in the hangingwall blocks of syn-sedimentary faults, where the main age of extensional faulting has been constrained.
The orientations of the master west-dipping faults interposed between the Central Viking Graben and Utsira High, were mainly composed by NNW-SSE, NE-SW and N-S striking segments, in good agreement with the middle Jurassic/Late Cretaceous extensional stress fields. In the Utsira High area, further anomalous E-W and WNW-ESE trending faults have been identified. Those segments are linked with prominent basement discontinuities and their trend appears controlled by the orientation of the inherited pre-existing structural fabric during the reactivation episodes. In the Stord Basin, several faults principally trend WNW-ESE and show syn-sedimentary growth during the Permian-Triassic times. Further evidences of multi-phase reactivation have been also suggested from fault parameter analysis and the enhanced fault vertical linkage maturity with depth, as indicated by the increasing of vertical throws in the cover of oldest intervals of the stratigraphic sequence.