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Three-dimensional analysis of normal faults in the Horda Platform (North Sea): the possible influence of stress perturbations on fault geometries

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Rift-related faults often display non-rectilinear geometries, which have been interpreted as (i) the result of linkage between different fault segments -developed during a single or more tectonic phases-, (ii) as curvilinear faults due to gravitational collapse, (iii) as inherited basement trends. Disentangling these processes is generally difficult, with multi-phase rifting and reactivation of pre-existing structures being the most intuitive and commonly adopted explanations.

Here, we use 3D seismic data to reconstruct the evolution of a couple of intersecting, curvilinear faults in the Horda Platform (Northern North Sea), which is characterised by a complex history of reactivation and multi-phase extension during the Jurassic-Cretaceous rifting. By reconstructing the three-dimensional geometry of the fault planes, we highlight that one fault follows the trend of the Permian-Triassic rift along its entire length, whereas the other, strongly curvilinear, fault appears to be partially deflected from it. By using time-thickness maps and kinematic analyses, we show that the partially deflected fault initiated in the Late Jurassic, soon after the other one (which activated in the Middle Jurassic). Notably, the younger fault flexes from the inherited Permian-Triassic trend as it approaches the other, more mature, fault, getting perpendicular to -and finally crosscutting- it. Hence, the curvilinear geometry developed during the upward propagation of the fault plane during the Jurassic-Cretaceous rifting, suggesting that such change of strike was driven by the influence of the more mature fault and is not due to structural inheritance. Similar deflections can be observed also in other areas of the dataset, with incipient faults flexing towards more mature structures.

More generally, newer faults have been shown to deflect perpendicularly to pre-existing faults both in analogue and numerical models, suggesting we are facing a general process. These strike deflections suggest a stress re-orientation in the vicinity of well-developed structures, and not just simply a stress-drop as widely indicated by fault spacing and throw distribution of parallel faults. This is consistent with observations on deflected normal faults developing in correspondence to oblique basement fabrics as well as with the numerical model of the stress field by Homberg et al. (1997). Hence, our three-dimensional analysis of fault geometries suggests that the well-established concept of "fault-related stress-drop" should be broadened into the concept of "fault-related stress-reorientation".

References

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