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Geometry and kinematics of non-colinear normal fault populations: The role of deep-seated crustal lineaments throughout multiphase rifting

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Non-colinear fault populations may form in rift basins subject to multiple phases of non-coaxial extension, producing a wide array of fault interactions and therefore more complex rift geometries than typically observed in single-phase rifts. However, the mechanism of formation for non-coaxial fault populations; e.g. a change in the regional extensional direction, the presence of crustal heterogeneities, or local stress perturbations; and their subsequent interactions during later tectonic events remain poorly understood.

This study uses borehole-constrained 2D and 3D seismic reflection data to examine the structural style and evolution of N-S and E-W striking non-colinear fault populations within the Farsund Basin, located offshore southern Norway. The basin is situated at the proposed western extent of the Sorgenfrei-Tornquist Zone, a deep-seated, weak crustal lineament. This lineament has experienced repeated phases of reactivation throughout its history and has exerted a strong influence over the evolution of the overlying rift system. Using isochron and quantitative fault analysis, including throw-distance (T-x) and throw-depth (T-z) plots, we examine the interactions between the non-colinear E-W and N-S fault populations throughout the multiphase evolution of the Farsund Basin.

From our analyses, we observe primarily cross-cutting and abutting fault intersections with some isolated faults. E-W striking faults predominately formed during Permo-Carboniferous extension. N-S striking faults formed during Triassic E-W extension, along with localised reactivation of E-W striking fault segments. E-W faults were then further reactivated during the Early Cretaceous, cross-cutting pre-existing structures. The underlying Sorgenfrei-Tornquist Zone controls the orientation of the E-W striking fault population. In addition, the oblique nature of the lineament to the regional tectonic regime acts to locally perturb the stress field. As a result, synchronous fault activity occurs along E-W and N-S fault segments, accommodating transtensional and transpressional stresses locally within the Sorgenfrei-Tornquist Zone.

In this study, we show how the presence of a deep-seated crustal lineament may act to significantly perturb regional stresses allowing for the formation of non-colinear fault populations. The orientations of perpendicular non-colinear fault populations form independently from one another, although they may interact during later tectonic events.