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Extreme crustal thinning, deformation coupling and exhumation faulting offshore Norway

Per Terje Osmundsen (1,2), Gwenn Péron-Pinvidic (1), Erik Fjellanger (3), Duncan Erratt (4), Jørg Ebbing (1,5)

(1) Geological Survey of Norway, Geodynamics, Trondheim, Norway (per.osmundsen@ngu.no), (2) University Centre in Svalbard, N-9171 Longyearbyen, (3) Esso Norge AS, P.O.Box 60, N-4064 Stavanger, , (4) ExxonMobil Ltd., Leatherhead, Surrey KT22 8UX, U.K. , (5) Norwegian University of Science and Technology, N-7491 Trondheim.

The magmatic Northeast Atlantic margin offshore Norway displays well-imaged examples of architectural elements related to a magma-poor, Jurassic-Cretaceous phase of hyperextension. These include a moderately thinned platform area, a necking zone characterized by extreme amounts of crustal thinning and very deep 'sag′ basins underlain by strongly extended continental crust or upper mantle. The necking zone displays lateral variations between rift salients with 'core complex′ geometries and more planar, large-magnitude, low-angle normal faults that appear to have incised into the former. Displacements and displacement gradients associated with the low-angle normal faults had magnitudes that compare to the thickness of the continental crust. Lateral displacement gradients attest to fault growth and controlled the response of the margin for tens of millions of years. The location of the taper break at the outboard end of the necking zone, commonly close to the point of embrittlement or 'coupling point′ for thinning deformation, varies according to the crustal-scale displacement gradients. The basin configuration above the taper break commonly involves a continent-dipping stratal wedge banked against a large-magnitude normal fault, separated by an unconformity from an overlying, basin-dipping divergent reflector package that downlaps onto the top of deep-seated, proximal fault blocks. Outboard of the necking zone, arrays of deep-seated, rotated fault-blocks likely represent dismembered H-blocks. The deepest parts of the sag basins are characterized by flat-lying reflectors to the base of the seismic sections, but the distal parts of a 'flat zone′ in the south Vøring basin reveals the cutoff and trailing edge of a large extensional allochthon or continental ribbon, the Rån Ridge. In the northwest, the Rån Ridge is bound by a large, northwest-throwing normal fault, whereas the continentwards-dipping southeast flank of the ridge is onlapped by progressively younger Cretaceous strata. Internally, the Rån Ridge shows deformation features that attest to extension that likely pre-dates the exhumation stage and thus the isolation of the ridge as an extensional allochthon. Based on long-offset seismic sections, the relationships between the ridge, a trailing array of smaller allochthon and an underlying, originally subhorizontal 'exhumation′ fault can be studied in some detail. The geometry of deep-seated supradetachment basins related to exhumation faulting is well imaged in some of the long-offset seismic data and attest to the rotation of allochthon on the basal detachment fault during 'exhumation stage′ tectonics.