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Detachment faults at passive margins: examples from Norway

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At passive margins, the thinning of continental crust from a thickness of 30-40 to less than 10 kilometres commonly results in a zone of taper that borders a wide zone of extremely attenuated continental crust, which, in turn, borders the continent-ocean transition. The taper area is thus a principal boundary that separates the proximal from the distal parts of the margin, and the evolution of this zone determines much of its later history. Along parts of the Mid Norway rifted margin, the taper area is well imaged by long-offset seismic reflection data. The North Atlantic passive margin is a type example of a magmatic margin, with breakup in the Eocene around 54 Ma. Breakup was, however, preceded by several magma-poor extensional phases that in the Mid Norway case include Devonian late/post-Caledonian extension, Permo-Triassic stretching and a phase of extreme Jurassic-Cretaceous crustal thinning. Along the SE borders of the rift, 'top basement´ detachment faults with heaves in the order of 15-40 kilometres evolved in at least two stages to become the boundaries between moderately thinned (20-30 km thick) crust and 100-200 km wide, highly extended areas with crustal thickness generally between 2 and 12 km. These areas evolved into the deep Møre and Vøring basins. In the footwalls of the basin-flank detachments, rocks from the lower and middle crust were exhumed in extensional domes that, in turn, became incised by a younger set of normal faults. In the Slørebotn Subbasin area, a warped-back detachment fault is overlain by an array of fault-blocks that underwent up to 50o of rotation in the Late Jurassic. This detachment was subsequently incised and deactivated by planar normal faults that incised the extensional culmination on the basin side. Under the most highly thinned areas, a more distal set of deep-seated (basin-floor) detachments incised and extended remnant crust and, probably, the upper mantle, leaving as little as <5 kilometres of continental crust to be preserved under thick syn- and post-rift deposits. We suggest that basin-flank detachments hold the potential to reduce the crustal thickness down to the critical value required for embrittlement. Offshore Mid Norway, this stage may have been reached in the Early Cretaceous. The large-magnitude Jurassic-Early Cretaceous faults show variable relationships to earlier structures and basins. Abrupt truncation of older faults and basins by Jurassic-Cretaceous basin-flank detachments can be observed along the margins of the Trøndelag platform. Gneiss-cored extensional culminations are well known from the onshore Palaeozoic extensional systems, and in the offshore, seismic and potential field data suggest the presence of such structures underneath Palaeozoic-Early Mesozoic basins in the Trøndelag Platform area as well as in the footwalls of Late Jurassic-Early Cretaceous detachment faults. A fundamental control on the margin geometry by late/post-Caledonian structures is indicated by the trends of the large-magnitude fault systems and, locally, by observations related to deep-seated extensional culminations. Variations in displacement magnitude and geometry of the basin-flank detachments controlled variations in the thinning gradient for the crystalline crust (crustal taper). An accumulating body of evidence indicates that this, in turn, controlled not only the location of deep post-rift basins, but also the behaviour of the onshore parts of the margin in the post-rift phase.