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The Mesozoic-Cenozoic passive continental margin off North Norway: Metamorpic core complexes and extensional basin formation controlled by long-lived Late Caledonian – Devonian structural inheritance

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The Lofoten-Vesterålen area on the North Norwegian passive continental margin is characterised by sedimentary basins in composite asymmetric grabens, controlled by ESE- and NW-dipping listric normal faults that detach into the underlying basement. Rifting started in the Permian, with the main rift phase from the Late Jurassic, generating ESE-dipping faults that were successively truncated by Late Jurassic to Early Cretaceous NW-dipping normal faults and further developed as syn-rift and post-rift basins in the Late Cretaceous and Early Palaeocene. These basins are bounded by the Lofoten and Utrøst ridge basement horsts.

Detailed seismic interpretations and new potential field data indicate that the Træna, Vestfjorden and Ribban basins, which flank the Lofoten and Utrøst ridges, have elongate spoon shapes with axes plunging gently to the SW. This spoon shape is consistent with low-angled Late Caledonian/Devonian structures in North Norway; the Nesna, Sagfjorden and Kollstraumen zones. Thus, we suggest that the Mesozoic composite, basin-and-ridge structure of the Lofoten-Vesterålen margin was inherited from Late Caledonian to Devonian trough-like depressions. Potential field data furthermore indicate that the Sagfjorden shear zone continues below the Ribban and Vestfjorden basins as low-angle detachments separating low-magnetic Caledonian nappes from underlying high-magnetic Palaeoproterozoic basement. Such detachments make a perfect grain for localization of Mesozoic brittle faulting.

In seismic sections offshore Lofoten and Vesterålen, major basin bounding faults detach towards distinct intra-basement reflectors. These reflectors form undulating bright zones or stacked lateral bands and occur under basins, but rarely under horsts. We interpret them as thrusts between imbricate, downtrown Caledonian thrust sheets, overlying detachments. This configuration resembles the onshore post-Caledonian Nordfjord-Sogn detachment in South-Western Norway, and the Kollstraumen detachment along the Møre Trøndelag Fault Complex, which both were reactivated in the late Paleozoic and the mid/late Mesozoic.

The islands of Røst and Værøy in outermost Lofoten comprise zones of basement mylonites interpreted to be part of a Permian metamorphic core complex rooted in a bowl-shaped Devonian detachment. It was exhumed during Permian extension, and then likely kept near surface during Mesozoic-Cenozoic events. This detachment likely was at a higher, now eroded, level above the massive main Lofoten ridge northwards.

These observations indicate that the Lofoten-Vesterålen margin was shaped by Late Caledonian/Devonian detachments that became templates for crustal stretching and for underlying metamorphic core complexes. The core complexes were finally exhumed by normal faulting along the flanks of the Devonian depressions. Comparison with the Basin and Range province indicates that late stage exhumation by brittle normal faulting is a common mechanism of exhuming metamorphic core complexes in passive margin settings.