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Marginal plateaus and pre-breakup development of the mid-Norwegian volcanic passive margin

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The structure and tectonostratigraphic development of the mid-Norwegian volcanic passive margin have been extensively studied over last 30 years. However, an understanding of its crustal architecture and basin evolution remains incomplete and debated. A main point of a debate concerns the crustal and basin structure of the yet underexplored outer parts of the Møre and Vøring basins which are significantly covered by breakup-related volcanics. This discussion generally resides on the origin of the high-velocity (7+km/s) lower crustal body which alternatively interpreted either as a wide zone of exhumed/serpentinized mantle assuming direct structural similarities with the magma-poor Iberian margin or instead inherited high-grade Caledonian crust later intruded by breakup-related magmatic intrusions. Another important point of contention is whether the Møre and Vøring basins developed through either several discrete extensional events, or alternatively a single phase of continuous extension from Late Jurassic-Early Cretaceous necking to lithospheric breakup in the late Paleocene-early Eocene.

Recently, a new generation of high-quality 2D and 3D seismic data acquired in the outer parts of the mid-Norwegian margin allowed a better imaging of deep Vøring and Møre basins and sub-basalt domains. Also new well data allowed a better regional seismostratigraphic control. An integrated 3D/4D interpretation of new seismic data calibrated with published refraction data and tested by potential field and forward basin modelling helped to better reveal the crustal and basin architecture of the Møre and Vøring basins.

Our results support the crustal nature of the controversial high-velocity and high-density lower crustal body and associated deep reflections, which we interpret as an old exhumed high-grade Caledonian crust later mixed with breakup-related mafic and ultra-mafic magmatic material. Our seismic interpretation shows that the basins were subjected to discrete and localized Cretaceous-Paleocene rifting events which sequentially migrated laterally and towards the future breakup axis and were separated by intermediate cooling/subsidence phases. We explain this migration of the rift axes by a strain hardening due to lithospheric cooling with possible enhancement from lateral lower crustal flow.

We suggest that the outer portion of the Vøring and Møre basins represents distal “marginal plateaus” that likely formed an elevated crustal domain bounded to the east by a failed and cooling inner rift system and to the west by Cenozoic volcanic margins. The presence of such a marginal plateau may better explain (1) the observed structural styles and 3D geometries of the sedimentary successions in the outer basins (e.g. shallowing of the Base Cretaceous Unconformity), (2) the long-time lag (□80-100 Myr) between the mid-Mesozoic necking and the final (off axis) lithospheric breakup, (3) the subaerial and shallow marine emplacement of breakup-related lavas, (4) the signatures of upper crustal contamination in breakup-related flows, and (5) the relatively low magnetization of the basement in the outer basins. Our interpretations do not support the magma-poor Iberian margin model which were recently extrapolated and applied to the pre-breakup development and structural environment of the mid-Norwegian volcanic passive margin.