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Orthorhombic faults system at the onset of the Late Mesozoic-Cenozoic Barents Sea rifting

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The structures of the Late Mesozoic/Cenozoic Barents Sea rifting have been investigated with multichannel 3D seismics, covering an area of 7700 sqKm in the Hoop Fault Complex, a transitional area between the platform and the marginal basins. The main structural lineaments have been mapped in a time domain 3D surface and their activity ranges have been constrained through the sin-sedimentary thickness variations detected in time-thickness maps. Two main fault systems have been identified: an orthorhombic fault system consisting of two fault sets trending almost perpendicularly one to the other (WNW-ESE and NNE-SSW) and a graben/half-graben system, elongated approximately N-S in the central part of the study area.

While the graben/half-graben system can be explained through the theory of Anderson, this landmark theory fails to explain the simultaneous activity of the two fault sets of the orthorhombic system. So far, the models that can better explain orthorhombic fault arrangements are the slip model by Reches (Reches, 1978; Reches, 1983; Reches and Dieterich, 1983) and the odd-axis model by Krantz (Krantz, 1988). However, these models are not definitive and a strong quest to better understand polymodal faulting is actual (Healy et al., 2015).

In the study area, the presence of both a classical Andersonian and an orthorhombic system indicates that these models are not alternative but are both effective and necessary to explain faulting in different circumstances. Indeed, the Andersonian plain strain and the orthorhombic deformation have affected different part of the succession during different phases of the rifting. In particular, the orthorhombic system has affected only the Late Mesozoic-Cenozoic interval of the succession and it was the main active system during the initial phase of the rifting. On the other hand, the graben/half-graben system has affected the whole sedimentary succession, with an increasing activity during the development of the rifting.

It has been observed that, in the upper part of the succession, devoid of pre-existing discontinuities and detached from the lower part of the succession by the Upper Triassic shales, the deformation has been accommodated by the newly-formed orthorhombic system; while, in the deeper part of the succession, likely to host pre-existing weakness zones, the deformation has been accommodated through the graben/half-graben system. Hence, during the Late Mesozoic/Cenozoic Barents Sea rifting it seems that the absence of pre-existing discontinuities played a key-role in the development of an orthorhombic fault arrangement in the upper part of the succession rather than a classical plain strain system. Indeed pre-existing discontinuities in the lower part of the succession can focus the deformation, preventing the formation of new faults and in this case favouring a plain strain mode. Furthermore, the Upper Triassic detachment limited the influence of deep structures on the upper part of the succession, allowing initially for the development of an entirely new fault system. As the rifting proceeded, the deep reactivated structures propagated towards the surface and, finally, their activity became predominant on the activity of the orthorhombic system, as indicated by time-thickness maps.