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Basement controls on the variability in structural style of normal faults: the Northern Utsira High – Heimdal Terrace, Northern North Sea

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The growth of normal faults exerts a first-order control on accommodation and sediment routing in, and the overall architecture of rift basins. Understanding normal fault growth and the controls thereof is therefore of great importance. This is because Spatio-temporal variability and complexity in the structural style along and across most active, dormant and failed rifts is quite common. However, the main controls on such variability and complexity are still poorly understood, largely due to lack of data of sufficient quality and resolution. Here we use high-quality three-dimensional reflection seismic and wellbore data to (i) evaluate the overall structural style of the northern Utsira High and Heimdal Terrace region of the Northern North Sea, and (ii) elucidate controls exerted by pre-existing basement structures on the structural style of rift-related normal faults. We identify two main normal fault sets. 'Fault set 1' trends broadly NE-SW, sub-parallel to one of the main fault segments bounding the western margin of the Utsira High. Fault set 1 is characterised by 'domino' style, NW- and SE-dipping normal faults. 'Fault set 2' trends broadly N-S, sub-parallel to the fault systems bounding the Heimdal High, and is partly characterised by congugate-style faulting, and partly by complicated synthetic and antithetic relationships. Based on our analyses, we propose that Fault set 1 developed as a result of the post-Devonian reactivation of the ductile Utsira Shear Zone, whereas Fault set 2 was not influenced by the reactivation of a pre-existing basement fabric. Instead, Fault set 2 developed broadly parallel to the South Viking Graben, a structure reflecting the principal extension axis of the Late Jurassic – Early Cretaceous rift phase. We therefore suggest that the presence/absence and geometry of pre-existing basement structures may result in the development of variable normal fault styles during a single phase of extension.