Geodynamic modelling of the Tertiary development of the Faroes-Shetland Basin: A failed continental breakup basin?

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Continental breakup is often thought of as the extreme end member of continental lithospheric stretching and thinning where the lithosphere is stretched to zero thickness by pure shear deformation. However, this hypothesis has proved to be difficult to reconcile with observations of crustal structure and subsidence histories of rifted margins. We present a new model of continental lithosphere thinning leading to breakup and seafloor spreading initiation. In this model, lithospheric rupture is achieved by an upwelling and divergent flow-field acting within continental lithosphere and asthenosphere, rather than by pure shear. The model predicts lithospheric structure and subsidence histories that can account for the observations at rifted margins and sites of incipient seafloor spreading. We show that the Faroes-Shetland Basin (NE Atlantic) can be successfully modelled as a site of failed continental lithosphere breakup. The Faroes-Shetland Basin lies to the North of the UK, coaxial with the Moere Margin which formed by seafloor spreading initiation on the Aegir Ridge at 55Ma (Figure 1). A successful geodynamic model for the formation of the Faroes-Shetland basin must satisfy the present day structure of the basin, as well as paleobathymetric constraints, including subaerial indicators at ∼55Ma. Intracontinental rifting type models for the basin usually assume formation by large scale Mesozoic and Paleocene pure-shear stretching and subsequent thermal relaxation. However, fault heave estimates and the subsidence history of the basin derived from flexural backstripping and paleoenvironmental mapping do not support this model. At ∼55Ma, the Faroes-Shetland Basin lay at the propagating tip of the Aegir ridge. Post-Paleocene subsidence has been successfully modelled by thinning of the continental lithosphere due to an upwelling divergent flow- field propagating upwards within continental lithosphere and asthenosphere. Unlike at the Aegir ridge, where the flow-field successfully ruptured the whole lithosphere, the flow-field under the Faroes-Shetland Basin appears to have thinned the lithosphere and lower crust only, failing to initiate seafloor spreading. Subsequent thermal re-equilibrium has caused the basin to subside to the present day.

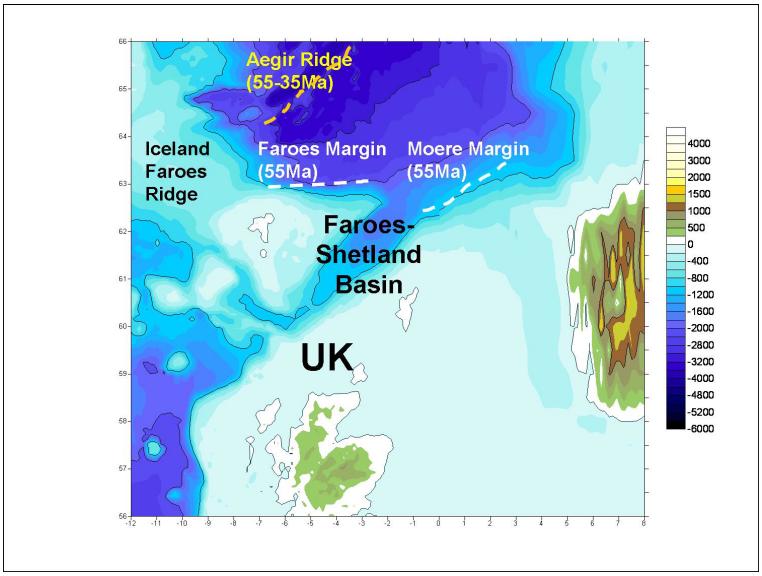

Figure 1. Map of region around the Faroes-Shetland Basin. The Moere and Faroese Margins began seafloor spreading close to 55Ma. We propose a model where the Faroes-Shetland Basin underwent most of the continental breakup process, but failed to initiate seafloor spreading.