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Volcanic rifted margin asymmetry and pre-breakup sag-sequences: North Atlantic examples

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Magma-poor margins typically show pre-breakup sag basins up to 250 km width and with a paucity of faulting. These pre-breakup sag basins are often present on only one conjugate margin leading to pronounced conjugate margin asymmetry. We address the question as to whether volcanic margins also show asymmetry and pre-breakup sag sequences. The conjugate Norwegian and East Greenland rifted continental margins, formed by North Atlantic break-up at $\sim$ 55 Ma, display a large asymmetry. We use seismic cross-sections from the Vøring segment of the Norwegian rifted margin and its East Greenland conjugate in order to better understand the form and origin of this asymmetry. Conjugate margin asymmetry is evident in the differences in the width of the thinned continental crust, sediment thickness, and the distribution of lower crustal magmatic bodies (LCB). Conjugate margin profiles have been analysed to determine continental lithosphere thinning using flexural backstripping and reverse thermal subsidence modelling, and upper crustal stretching from fault analysis. The Vøring segment of the Norwegian rifted margin shows breakup depth-dependent lithosphere stretching and thinning where whole lithosphere stretching and thinning greatly exceeds that of the upper crust. Analysis of pre-breakup Cretaceous stratigraphy within the Vøring segment of the Norwegian margin requires subsidence greatly in excess of that indicated by upper crustal faulting and predicted from syn- and post-rift subsidence. We interpret the lack of sufficient faulting to explain Cretaceous subsidence on the Norwegian margin to indicate the presence of a pre-breakup sag basin analogous to those seen at magma-poor margins. The paucity of faulting compared with observed Cretaceous subsidence implies depth-dependent stretching and thinning of the pre-breakup continental lithosphere. Pre-breakup lithosphere subsidence on the Norwegian and Greenland continental margins has previously been attributed entirely to Jurassic and Cretaceous depth-uniform lithosphere stretching. Subsidence analysis suggests that the proposed sag basin development may initiate as early as Albian-Aptian. Lithosphere depth-dependent stretching, where lithosphere thinning greatly exceeds that of the upper crust, has been reported for continental breakup on the Norwegian margin at $\sim$ 55 Ma. Some recent studies have proposed the presence of a failed breakup attempt during the Albian-Aptian period (110 - 100Ma). Whether depth-dependent lithosphere stretching and thinning continued through from Albian-Aptian time to breakup at $\sim$ 55 Ma remains an important question. The breakup rupture on the west side of a broad region of depth-dependent thinned continental lithosphere may explain the asymmetry of the mid-Norwegian Greenland conjugate margins. An understand of the origins of margin asymmetry and the partitioning of breakup and pre-breakup stretching and thinning of the continental margin lithosphere is important for the prediction of subsidence and heat flow histories.