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Plume-lithosphere interactions in rifted margin tectonic settings: Inferences from thermo-mechanical modelling

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We present results from 2D and 3D thermo-mechanical studies of plume-lithosphere interactions in a rifted margin setting and compare inferences of these models with the Northern Atlantic volcanic rifted margin province. We first present a series of 2D models with three different initial locations of the plume: under the oceanic part of the rifted margin system; under the area affected by lithospheric thinning by passive rifting and under continental lithosphere which has not been affected by extension prior to plume emplacement. The style of final plume distribution appears to be controlled by its initial position with respect to different lithospheric segments and rheology of the mantle in the continent-ocean transitional zone rather than by other parameters such as external forcing and rheological structure of the mantle plume. The initial size of the mantle plume controls, to a large extent, the degree of plume head asymmetry. For a strong rheology of the overlaying transitional lithosphere, the effect of plume emplacement is mainly restricted to deep lithospheric levels. In contrast, a weak transitional mantle leads to plume-induced continental break-up when the plume head contributes to the formation of new oceanic lithosphere with asymmetrical propagation of hot plume material towards the continental segment. A common feature of most 2D models is that initially a hot plume weakens the overlying lithosphere, whereas at a later stage frozen mantle plume material is embedded into the lower part of the lithosphere, forming dense and high-velocity bodies. We extend our 2D numerical modelling study to three dimensions and investigate the first-order controls of continental break-up and plume emplacement. We demonstrate that the observed complex Iceland plume geometry with up to 400 km southern propagation can be reproduced numerically in 3D and explained by pre-imposed zones of lithospheric thinning along transform faults.