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Post-breakup rifted margin hinterland uplift predicted by a model of continental breakup and sea-floor spreading incorporating buoyancy assisted upwelling

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Many volcanic rifted margins have uplifted hinterland regions, extending over a width of several hundred kilometres and up to 3 km high. Several mechanisms have been proposed to account for the regional scale uplift but currently no single method can fully match the observations of timing and magnitude for any uplift event. The post-breakup uplift of rifted margin hinterlands may, at least in part, be a result of the continental breakup and sea-floor spreading initiation process. We present a geodynamic model of continental lithosphere thinning leading to sea-floor spreading initiation and explore the implications of this model on post-breakup continental hinterland uplift. Both pre-breakup and post-breakup processes can deform continental lithosphere. Prior to breakup, we assume deformation of the continental lithosphere occurs by simultaneous pure shear and buoyancy assisted upwelling divergent flow. Post-breakup, deformation of continental lithosphere occurs by upwelling divergent flow from sea-floor spreading. The pre-breakup induced upwelling divergent flow produces an outward flow of asthenosphere material towards the young continental margin lithosphere, thickening the continental lithosphere at distances beyond the region of localised continental breakup thinning. This may be further amplified at a young volcanic margin if there is a high ratio of upwelling velocity to divergent velocity (Vz/Vx) due to increased thermal buoyancy during the first few million years of sea-floor spreading. In regions of thickened continental lithosphere in the margin hinterland the geothermal gradient is decreased, in contrast to the elevated geothermal gradient of oceanic and thinned continental margin lithosphere. Re-equilibration of the geotherm causes warming and uplift of the thickened continental lithosphere inward of the rifted margin and subsidence offshore. We model the pre- and post-breakup deformation of the continental lithosphere using a fluid flow model which is used to advect the temperature field and lithosphere material. The amount of uplift predicted by the model is determined by the flexural isostatic response to lithosphere geotherm perturbation and crustal thinning. Significant amounts of post-breakup thermal uplift – up to 500 m – are predicted by the model due to thermal buoyancy assisted upwelling. This is further amplified by the isostatic response to erosion and tilting of the margin caused by flexural coupling between the onshore erosion and offshore sedimentation.