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Magmatic controls on detachment fault formation at South China Sea rifted margin

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Lithospheric thinning initiates continental rifting and eventual break-up, driven by the interplay of tectonic, magmatic and surface processes. Recent findings from IODP expeditions and seismic surveys reveal that the northern South China Sea (SCS) margin exhibits distinctive features not typically alinged with classic magma-poor or magma-rich margins, including widespread detachment, syn-rift magmatism and a notably rapid transition from continental margin to seafloor spreading. However, the role of magmatism in the formation of detachments, which is key for elucidating the evolution of rifted margins, remains poorly understood. Here we use 2D numerical models to simulate the thermo-mechanical evolution of continental rifting, incorporating melt generation, emplacement and associated heat release. Our models reproduce the main observations from the northern SCS margin, including the hyper-extended crust, crustal boudinage, lower crust exhumation and dome structure. Particularly, we demonstrate that the thermal weakening related to the magmatism promotes the ductile lower crustal flow, which converges beneath a ‘rolling-hinge’ type detachment, facilitating the formation of core complex. Unlike magma-poor margins, the initial elevated lithospheric temperature by prior plate subduction and syn-rift magmatism from decompressing melting shape the ‘intermediate’ nature of the SCS margin. This work could provide valuable insights into how tectonic deformation and magmatism interact in continental rift systems around the globe.