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Sensitivity of rift mode to thermal-tectonic regime: what is the force required for lithospheric rupture?

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Why are not all rifts successful? Here we use viscous-plastic thermo-mechanical finite element models of lithosphere extension and passive margin formation to explore the role of inherited lithosphere structure and fertility on styles of rifting. Reference thermal-mechanical conditions are established for contrasting tectonic regimes such as 1) 'Archean Cratonic', 2) 'Proterozoic Cratonic', 3) 'Stable Phanerozoic', 4) 'Tectonic Platform', 5) 'Orogenic, and 6) 'Back Arc' lithosphere based on constraints from seismic tomography on lithosphere thermal thickness, on petrological evidence on fertility and hydration of crust and mantle lithosphere, and on the associated mechanical properties for these regimes. The end-member regimes are associated with characteristic surface heatflow, lithosphere thickness, and mantle lithosphere / lower crustal strength distributions. The sensitivity of rift style to these conditions is tested using viscous-plastic finite element models and a catalogue of expected system behaviour is established. Focus is on the evolving force required for extension under these various conditions as compared to available driving forces, on the ability of the lithosphere to localise deformation, and on the resulting styles of lithosphere extension. Though orogenic or magmatic weakening will assist lithosphere weakening, simple calculations show that the integrated strength of Phanerozoic lithosphere with hydrostatic fluid pressure in its frictional-plastic parts is lower than available plate tectonic driving forces, which is, therefore, expected to rupture without requiring these processes.