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# The thermal and magmatic consequences of the transition from distributed stretching to localized thinning during rifting

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During rifting, crustal thinning is accompanied by mantle thinning in order to guarantee isostatic compensation. This assumes that the lower crust and lithospheric mantle viscosities are low enough so that they can flow on time scales that are of the order of a few tens of thousand years. However, it is not the case when the lower crust is brittle with a viscosity in excess of 1023 Pa.s. In that case, to guarantee compensation the asthenospheric mantle must upwell and thin the lithospheric mantle in excess of crustal thinning. This leads locally to depth dependent thinning and to the formation of a buoyant instability in the lithosphere that may cause stretching, thermal and plastic softening of the mantle lithosphere as well as rapid upwelling of the asthenosphere in the early stages of rifting.
We use numerical experiments with initial crustal thickness, thermal age and plastic weakening parameters that leads to the formation of such an instability. The experiments include melt production and transport. With initial and boundary conditions close to that inferred from some magma poor margins we find that the modeled structural and subsidence history in the distal part of the margin significantly deviates from the classical Mckenzie model of uniform extension. We describe a new mechanism to weaken the lithosphere by the formation of an unstable crustal root under a keystone (block H) bounded by two major border faults that leads to differential thinning of the crust and mantle lithosphere as well as faster asthenospheric upwelling (narrow near-asymmetric margins). The transition from stretching to thinning may be associated with the formation of block H and of an associated buoyant crustal root. The thinning phase following the formation of block H is causing a period of uplift and crustal heating associated with an increased heat flow in the mantle lithosphere. The instability generates fast mantle upwelling in the asthenosphere and may cause the production of melt by decompression. This may also be associated with uplift until the lithospheric mantle is exhumed or asthenospheric upwelling occurs and the initial storage of melt in the upper lithospheric mantle. We further analyze the effect of melt storage and production on the transition from continental breakup to oceanic crust.