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The role of structural inheritance in continental rifting

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In nature we observe that passive margins tend to originate on continental collision zones. This is not surprising as continents are long-lived and therefore have undergone multiple deformation phases, producing many regions with inherited structures. Collision zones can act as intrinsic rift-localizers for several reasons: rifting at a suture may be initiated by extensional collapse of the orogen, the thicker crustal root of orogens and their associated increase in heat producing elements makes orogens thermally weak, and inherited thrust faults form large-scale heterogeneities. When investigating continental extension geodynamically, numerical experiments often simplify such inheritance and start from laterally homogeneous crustal layers with a prescribed inhomogeneity that initiates deformation. These inhomogeneities represent thermal or structural remnants from previous deformation phases and are imposed as a thermal anomaly, a variation in Moho geometry, or an inherited weak region. However, imposed initial heterogeneities do not fully capture the structural and thermal complexities of continental sutures.

Here we present 2-D numerical experiments that investigate the role of inherited crustal structures in continental rifting and passive margin formation. We first examine a series of experiments in which we explicitly prescribe collisional structures in the initial setup, such as increased Moho depth and inherited thrust faults. Different prescribed collisional structures result in different rift to break-up durations, crustal shear zone patterns, and margin symmetry. Our second series of experiments actually creates an inherited collision zone through subduction and closure of an ocean. We use this set-up to investigate how extension localizes on a former continental collision zone. Passive margin architecture strongly depends on the duration of post-collision thermal equilibration time, with a long pause between collision and initiation of extension producing wide, faulted margins that take long to break-up. We find that the two approaches of prescribing or creating a suture zone to initiate a continental rift result in different dynamics of the crust and mantle, thereby impacting rift geometry, rift to break-up duration and exhumation of subduction-related sediments and oceanic crust.