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Influence of heterogeneities within the lithosphere on the deformation pattern of continental rift systems.

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Understanding how heterogeneities within the lithosphere influence the deformation pattern in continental rifts still remains a challenge and is of real importance to constrain continental break-up. We have selected the Main Ethiopian Rift in East Africa and the Rio Grande Rift in the south-western U.S. These two rifts are perfect natural laboratories to investigate the effect of inherited as they share similar structural characteristics but develop above different kinds of lithosphere-scale heterogeneities. From a structural point of view both rifts show similar length (1000km), width (50 to 70 km) and asymmetry. The Main Ethiopian rift is the NE-SW trending plate boundary between the Nubian and Somalian plates that has been developing for the past 11 Ma above a palaeo-Proterozoic lithospheric-scale weak zone re-heated by the Afar hotspot, whereas the Rio Grande Rift is the eastern “boundary” of the Basin & Range system which has been developing for the past 30 Ma in the frame of a westward-retreating Farallon subduction zone. However, the Rio Grande Rift shows evidence of low angle normal faulting whereas the Main Ethiopian Rift shows steeply dipping (with a mean close to 70°) normal faults. The Main Ethiopian Rift shows larger volume of erupted lavas than the Rio Grande Rift. Combined with a structural analyses of both rifts, we present here a series of 2D cross sections numerical models that allow better understanding of the influence of initial heterogeneities such as 1) the rheological state of the crust; 2) the presence of a crustal-scale to lithospheric-scale discrete weak or strong zone, 3) the effects of the presence of magma. We illustrate that rheological boundaries are not reactivated if the rheological contrast it too high, which is the case of the Rio Grande Rift that developed to the east of the North American Craton within thinned lithosphere. We also illustrate that the width of the weak zone do no have any influence on the exhumation of the asthenospheric mantle. The temperature at the base of the lithosphere is the parameter controlling the asthenosphere rising.