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# Impact of lithosphere rheology on 3D continental rift evolution in presence of mantle plumes: insights from numerical models

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We implement fully-coupled high resolution 3D thermo-mechanical numerical models to investigate the impact of the laterally heterogeneous structure and rheological stratification of the continental lithosphere on the plume-activated rifting and continental break-up processes in presence of preexisting far-field tectonic stresses. In our experiments, the “plumes” represent short-lived diapiric upwellings that have no continuous feeding from the depth. Such upwellings may be associated with “true” plumes but also with various instabilities in the convective mantle. The models demonstrate that the prerequisite of strongly anisotropic strain localization during plume-lithosphere interaction (linear rift structures instead of axisymmetric radial faulting) refers to simultaneous presence of a mantle upwelling and of (even extremely weak) directional stress field produced by far-field tectonic forces (i.e. ultra-slow far field extension at $< 3$ mm/y). Although in all experiments the new-formed spreading centers have similar orientations perpendicular to the direction of the main far-field axis, the models with homogeneous lithosphere show that their number and spatial location is different for various extension rates and thermo-rheological structures of the lithosphere: relatively slow extension (3 mm/year) and colder isotherm (600-700°C at Moho depth) at the crustal bottom lead to the development of single rifts, whereas “faster” external velocities (6 mm/year) and “hotter” crustal geotherm (800°C at Moho depth) result in dual (sometimes asymmetric) rift evolution. On the contrary, the models with heterogeneous lithosphere (thick cratonic block with cold and thick depleted mantle embedded into «normal» lithosphere) and the plume centered below the craton, systematically show similar behaviors: two symmetrical and coeval rifting zones embrace the cratonic micro-plate along its long sides. The experiments where the initial plume position has been laterally shifted with respect to the craton center, demonstrate a fundamentally different development, since in this case the upwelling plume is deflected by the cratonic keel and preferentially channeled along one of its sides, leading to the coeval appearance of a magma-rich rift above the deviated plume head and an amagmatic rift on the top of the opposite craton side. The degree of the rift asymmetry is disproportionately related to the amount of the initial offset of the plume head position. Instead, small variations of initial size, temperature and buoyancy of the mantle plume do not have any significant impact on system evolution. Models with two plumes of different size shifted in opposite directions produce similar asymmetrical rift evolution except that the magma-poor rift branch is situated strictly above the deflected head of the smallest plume (i.e. outside the in craton). This situation more accurately reproduces the observations dual rifting around Tanzanian craton where the tomography data hint for the presence of several mantle upwellings that are potentially connected to the same large plume at depth.