AGU FALL MEETING
San Francisco | 15–19 December 2014

T53D-04: Asymmetric and dual 3D rift evolution over mantle plumes in presence of far-field stresses. Insights from ultra-high resolution numerical models

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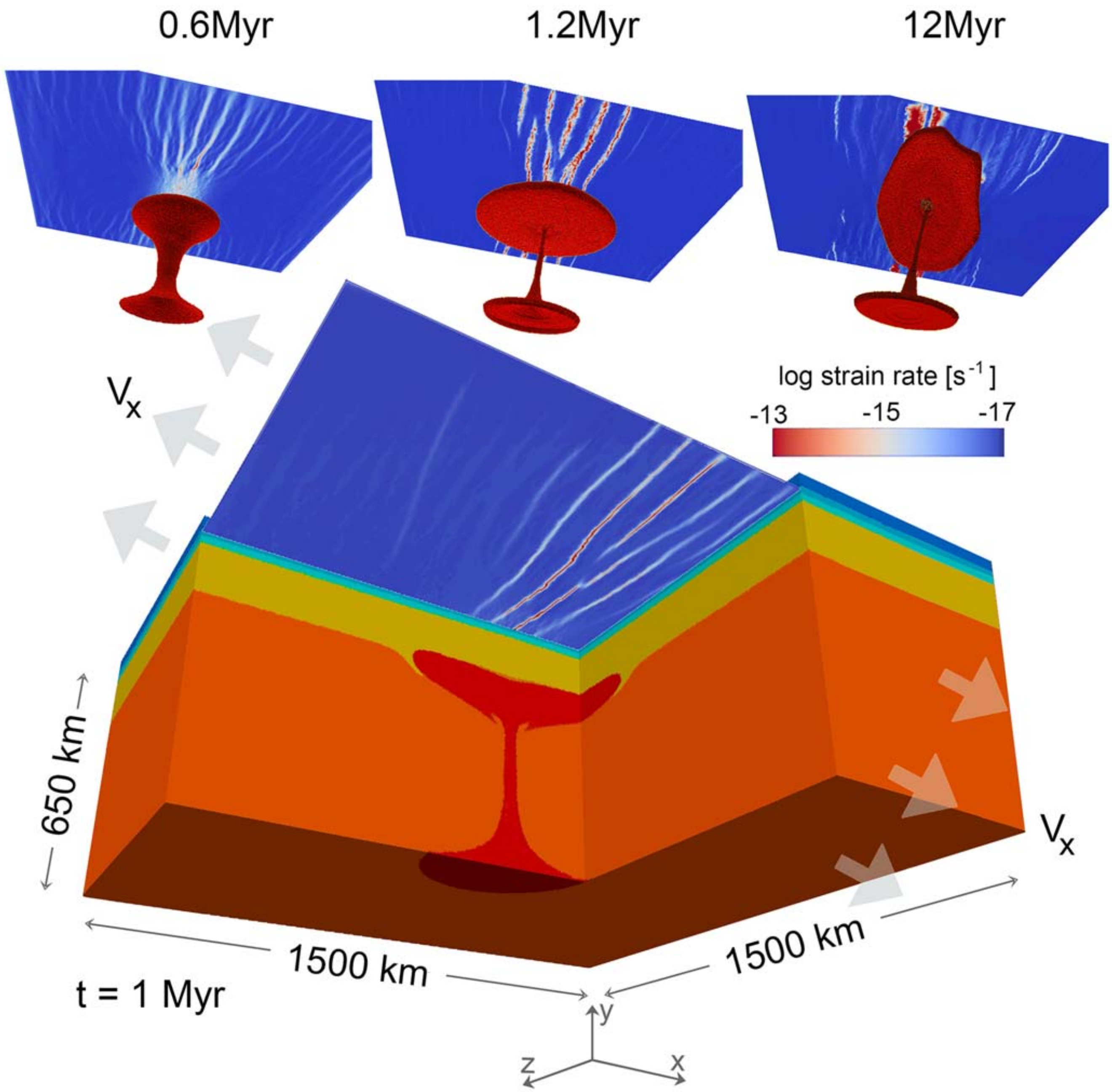
Identification of mantle contribution to rift topography and structure is difficult, especially in the continents while volcanic activity (considered a prime signature of mantle upwellings) is not systematically detected in the areas of presumed active rifting. It can be argued therefore that complex brittle-ductile rheology and stratification of the continental lithosphere result in screening and deviation of mantle upwellings as well as in short-wavelength modulation and localization of surface deformation induced by mantle flow. This deformation is also affected by far-field stresses and hence interplays with the “tectonic” topography. Testing these ideas requires fully-coupled high resolution “tectonic grade” 3D numerical modelling of mantle-lithosphere interactions, which so far has not been possible due to conceptual and technical limitations of earlier approaches. We present here new ultra-high resolution (500^3) 3-D experiments on rift topography and structure over mantle plumes, incorporating a weakly pre-stressed (ultra-slow spreading) rheologically realistic lithosphere. The results show complex surface evolution, which is very different from symmetric patterns usually assumed as the canonical surface signature of mantle upwellings. In particular, the topography exhibits strongly asymmetric small-scale 3D features, which include narrow and wide rifts, flexural flank uplifts and fault structures. In presence of a craton, a double rift system forms with coeval development of a magma-rich rift branch above the plume head and a magma-poor one along the opposite side of the craton. Our results thus suggest a dominant role for rheology structure and intra-plate stresses in controlling dynamic topography, mantle-lithosphere interactions, and continental break-up processes above mantle plumes while reconciling the passive (plume-activated) versus active (far-field tectonic stresses) rift concepts as these experiments show both processes in action and demonstrate the possibility of developing both magmatic and amagmatic rifts in identical geotectonic environments.



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