Geophysical Research Abstracts
Vol. 21, EGU2019-7398, 2019
EGU General Assembly 2019

Numerically modelling the controls of crustal strength on microplate formation: application to the São Paulo Plateau microplate

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The São Paulo Plateau is a submarine bathymetric high located in the Santos Basin off the coast of Brazil. Observations from potential field, seismic refraction and -reflection data indicate that the plateau is likely underlain by thinned continental crust. Crustal thickness, sedimentary infill and fault patterns show characteristics of a microplate, which formed in-between the African and South American plates when the Central and Southern rift segments of the South Atlantic emerged with an offset of several hundred kilometers. The underlying reason for the formation and kinematic evolution of the São Paulo Plateau microplate, as well as the amount of rotation and internal deformation, are not well constrained.

In this study, we test the effect of crustal strength on microplate formation and evolution in a two-branch rift system. We use the Advanced Solver for Problems in Earth's ConvecTion (ASPECT) code to numerically simulate orthogonal rifting with nonlinear visco-plastic rheology. The setup consists of a 3-D box model with dimensions of 600x500x160 km (X, Y, and Z) that is extended until lithospheric breakup is completed. Extension is prescribed as a constant or time dependent outward velocity at the X-normal boundaries, while the Y-normal boundaries are free-slip, with volumetrically compensating inflow prescribed on the bottom and a free surface at the top. The two rift segments are initialized by 125 km long lithosphere-asthenosphere boundary perturbations of 17 km amplitude at the front and back boundaries that are located 200 km apart in the X-direction. Lithosphere and crustal thicknesses are constant at 120 km and 35 km respectively, and the crustal strength variations are determined by the ratio of the thickness of upper to lower crust.

Initial results indicate that a setup with strong crust evolves in two possible ways. In the first case, the fault segments grow until connected by a transform fault. In the second case, one fault stretches across the domain while the other segment dies out. A setup with weaker crust results in an overlap of the segments and a subsequent topographic high forming between them. The rift segments are connected either by a transform fault that forms and transects the topographic high, or by a rotating microplate that eventually connects to one of the plates by a rift jump. In the last case, the model is consistent with observations from the Santos Basin and allows us to constrain the spatiotemporal evolution of the microplate and the dynamics of the eastward rift jump that ultimately transferred the microplate to the South American plate.