EVOLUTION OF THE SOUTH ATLANTIC: LINKING MANTLE, CRUST AND SURFACE PROCESSES

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ABSTRACT: Traditionally the formation and evolution of passive margins and associated sedimentary basins has been placed in a plate tectonic framework of lithospheric thinning and cooling. However, the margins of the South Atlantic display pronounced asymmetries and topographic anomalies that are difficult to reconcile with processes of rifting and thermal plate cooling alone. A common assumption is that currently elevated passive margins have been high since rifting, due to flexural rift shoulder uplift. It has been shown that this idea does not always hold, particularly not for the northeast Brazilian margin.The formation of the Brazilian Highlands has been attributed alternatively to changing continental-scale far-field stresses associated with Andean convergence or to the interaction of a plume tail with thick cratonic lithosphere. In contrast the Argentine Basin and margin aremuch deeper than expected based on traditional models, and the origin and time-dependence of this depth anomaly are also hotly debated. Thetiming and amount of Cenozoic uplift in Southern Africa is equally controversial, with proposed uplift histories dependenton which types of models and observations are used. We present a new generation of integrated thermo-mechanical coupled models of plate motions, lithospheric deformation, heating, and cooling in a mantle convection framework. This new model approach has been developed by linking two open-sourcepieces of software, *GPlates*(www.gplates.org) and *CitcomS* (http://www.geodynamics.org/cig/software/citcoms), to create a unified system that tracksthe deformation and thermal evolution of the lithosphere over the convecting mantle in accordance with a given plate model. *GPlates* is designed to create and modify plate tectonic models, including the history of failed intracontinental rift systems and passive margins. Crustal thickness and sediment thickness maps, as well as crustal cross-sections based on deep seismic profiles, are used to define the spatial extent of deformed lithosphere as well as its deformation history. The geometries of rigid blocks and deforming regions,together with a rotation model,define the distribution of compression/extension through space and time via deforming meshes. Surface velocities areinterpolated within the deforming mesh and exported as kinematic boundary condition to the geodynamic,finite-element models. In our tectonic reconstructions with deforming plates, the timing and the intensity of continental extension is imposed by the progressive, diachronous breakup and initiation of seafloor spreading for each major margin system, as well as transient intracontinental rifts. We investigate the interaction between mantle flow and lithospheric stretching and their contributions to surface topography in passive margins systems by imposing a tectonic model as time-dependent surface boundary condition on a mantle convection model. The contributions to topography by lithospheric stretching or thickening, thermal cooling and deep mantle flow are simultaneously modelled. Sucha model reproduces the first order asymmetries of the South Atlantic margins, and helps to quantify lithospheric and convecting mantle contributions to the creation or destruction of accommodation space, leading to a new generation of basin models. We attribute the large anomalous subsidence of the Argentinian margin to the dynamic topography induced by the historysubduction along the narrow southern portion of South America. In addition, we suggest that part of the uplift of South Africa can be attributed to its motion away from this dynamic topography low, and that the current elevation of the northeast Brazilian margin reflects its position over a large-scale mantle upwelling.