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Geodynamic modeling of passive margin systems from tectonic reconstructions with deforming plate boundaries

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The effect of mantle flow on surface topography has been the subject of considerable interest over the last few years. A common approach to the problem is to link plate tectonic reconstructions and global geodynamic models. An important limitation of this approach is that traditional plate tectonic reconstructions do not take the deformation of the lithosphere into account. We introduce quantitative models of surface plate kinematics that include areas of deforming continental crust. We present a series of global reconstructions including deforming plates in key areas, derived using tools developed within the open source plate modeling software *GPlates*.

In traditional plate reconstructions, the continents are represented as rigid blocks that overlap in full-fit reconstructions. Models that use topological polygons avoid continental overlaps, but plate velocities are still derived on the basis of Euler poles for rigid blocks. To resolve these issues, we use a methodology that requires at minimum two inputs; (1) the relative motions of the rigid blocks within continents; (2) a definition of the regions in which continental crust deformed between these blocks. We use geological and geophysical data to interpret the landward limit of significant extension and crustal thinning along conjugate passive margins. These boundaries are used to construct polygons along both margins that define the extent of the stretched continental crust on either side of the rift. We derive individual motion histories for each point on the conjugate continent/ocean boundaries (COBs). Joined together, these COB points form the topological boundaries of deforming domains in which each vertex moves independently. The deforming domains represented by topological meshes extend forward in time as the major rigid plates drift apart. In our tectonic reconstruction 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.

The velocity field derived from the plate reconstructions is used as a time-dependent surface boundary condition in mantle convection models that include compositionally distinct crust and continental lithosphere embedded within the thermal lithosphere. In deforming areas, the velocity field is obtained by linearly interpolating velocities from adjacent non-deforming areas within *GPlates*. We computed forward global mantle flow models using 3D-spherical finite-element code *CitcomS* to simultaneously quantify the relative contributions of lithospheric stretching, thermal subsidence, and deep mantle flow to the subsidence of passive margins. Applied to the South Atlantic, the method reproduces the first-order asymmetry of the margins. In particular, the large subsidence of the Argentinian margin is due to the dynamic topography induced by ongoing subduction along the narrow southern portion of South America. This result illustrates the importance of dynamic topography to the total subsidence at passive margins.