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Central South Atlantic kinematics: a 3D ocean basin-scale model of the Walvis Ridge and Rio Grande Rise

Bird, D. E., Department of Earth and Atmospheric Sciences, Houston Texas, and Bird Geophysical, Houston Texas
Hall, S. A., Department of Earth and Atmospheric Sciences, Houston Texas

Prior to the breakup of western Gondwana, ca. 130 Ma, the Tristan da Cuhna mantle plume produced the eastern South American Parana, and western African Etendeka, flood basalts. As the South Atlantic basin opened, the ridge-centered plume produced seaward extending hotspot tracks: Rio Grande Rise on the South American Plate, and Walvis Ridge on the African Plate. Several ocean floor edifices on the hotspot trends appear to produce lower than expected amplitude free air gravity anomalies, suggesting that they are composed of lower density material.

We have constructed a 3D gravity model of the South Atlantic basin to examine variations in crustal density associated with the hot spot trends. The model, which encompasses a region that extends from 46°S to 10 °S and from 20°E to 60°W, comprises the following layers: water, sediment, crust, and upper mantle. Variable density sediment and upper mantle layers are incorporated to estimate density changes related to sediment thickness and compaction, and upper mantle temperatures, respectively. The initial Moho horizon is estimated from isostatic equilibrium calculations; however the isostatic effect is scaled away from the seafloor spreading center to simulate the active spreading center. Three open-file grids were used to generate the model: satellite-derived free air gravity, global topography, and sediment thickness of the world.

Inverting the model for crustal density reveals a distribution of low-density areas: along the coasts, the seafloor spreading axis, and along the Rio Grande Rise and Walvis Ridge hotspot trends. Coastal and spreading axis low density areas are thought to be related to continental crust and high temperature upper mantle. Hotspot track low density areas might be related to variable densities within the volcanic edifices, variations in their crustal thickness, or upper mantle densities beneath them. Detailed 2D models approximate reasonable density and geometry limits along select transects. Holding the African Plate fixed, we have rotated the South American Plate for 16 times corresponding to Chrons C5, C6, C13, C18, C21, C25, C31, C34, five interpolated times (ca. 89, 93, 100, 105, and 112 Ma), and Chrons M0, M2 and M4. Reconstructions, displaying inversion results illustrate the development of the hotspot tracks as the South Atlantic opened, suggest that Tristan da Cuhna was a ridge-centered plume until about 30 Ma.

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