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The origin of the Rio Grande Rise-Walvis Ridge (South Atlantic) revisited integrating paleogeographic reconstruction, elemental and isotope geochemistry and flexural modeling

Naomi Ussami, Carlos A. M. Chaves, Leila S. Marques, and Márcia Ernesto

Departamento de Geofísica, Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, São Paulo, Brasil, nussami@usp.br

The current view about the origin of the Rio Grande Rise (RGR) and the oldest segment of Walvis Ridge (WR) is that they represent intra-oceanic realms of over production of volcanism caused by Tristan da Cunha (TC) mantle plume. However, incompatible trace element ratios and isotope signatures of the basalts dated at 90-80 Ma (WR: site 525A and RGR: 516 F) from these non-seismic ridges are distinct from the present-day TC alkaline rocks and very similar to the high-Ti Paraná tholeiites (133-132 Ma). The EMI mantle component is characterized by relatively low ^{143}Nd/^{144}Nd and ^{206}Pb/^{204}Pb isotope ratios, both in the high-Ti Paraná rocks and WR-RGR basalts suggesting their generation from a common mantle source and rules out the participation of TC plume. Paleogeographic reconstruction of South America (SA) and Africa (AF) continents for 80 Ma brings together the western portion of RGR to the age-correspondent portion of the Walvis Ridge suggesting that the formation of RGR-WR may have a common origin. The knowledge of the lithosphere structure of the RGR-WR is fundamental to set new constraints on its origin and evolution, whether within a new forming oceanic lithosphere or they are fragments of the splitting continental lithosphere. Flexural modeling was carried out using the EGM2008 derived free-air anomalies. The flexural deformation was estimated using a 3-dimensional continuous thin elastic plate model, loaded on top by the observed RGR-WR topography and sedimentary infill of down-flexed oceanic crust. The depth of compensation was assumed at 12 km from the surface of the ocean. The predicted gravity anomaly due to the flexure of the crust-mantle interface was calculated. This flexure estimated gravity field was added to the gravity effect due to the RGR-WR relief. For an elastic plate model with an effective elastic thickness (Te) of 5 km the predicted and observed free-air gravity anomalies gives the best fit. The absence of residual gravity anomalies due to low-density crustal fragments forming the plateau is consistent with the Pb radiogenic isotope signatures of WR-RGR basalts which precludes continental crust contamination. If most of the construction of RGR-WR basaltic plateau took place around 80 Ma, then most of basaltic melts were generated close or at the mid-Atlantic ridge, which is consistent with Te = 5 km estimated for an young oceanic plate under the RGR-WR ("on-ridge") at the time of its formation. The drifting stage of the SE South Atlantic started at 100 Ma and the RGR-WR volcanism started 20 My later. Using the mean value of 1 cm/year for the South Atlantic sea floor spreading velocity an estimated distance of $\sim$ 200 km separated the SA and the AF continental plates from the main ridge axis. Due to the RGR-WR proximity to the edge of the fragmented continental lithosphere, either melting of remnants of sub-continental lithospheric mantle and/or continental edge driven convection are alternative and viable processes to generate the large volume of melt and to explain the EMI component of the RGR-WR basalts.