Early seafloor spreading in the South Atlantic Ocean: M-series isochrons north of the Rio Grande Fracture Zone?

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ABSTRACT

South of the Rio Grande Fracture Zone (RGFZ), which intersects the South American and African continents at the northern limits of the respective Rio Grande Rise and Walvis Ridge hotspot tracks, Mesozoic magnetic isochrons (M-series), M11 to M0 (~136 to ~125 Ma), have been identified and mapped by several workers since 1979. We examined new magnetic data, acquired in tandem with long-offset, long record seismic reflection data by ION-GXT, and correlated similar anomaly features north of the RGFZ, offshore Brazil. Integrating these results with earlier work, that utilized open-file magnetic anomaly data offshore South America and Africa, we interpret and map magnetochrons M4, M2 and M0 (~130, ~128 and ~125 Ma) north of the RGFZ, offshore Brazil and Angola.

Recent tectonic reconstructions of the South Atlantic between Africa and South America have partitioned the ocean basin into Equatorial, Central, and Austral segments, with the RGFZ being the boundary between Central and Austral segments. Diachronous opening of the South Atlantic has been proposed: 1) seafloor spreading in the Austral segment was facilitated by an intraplate boundary in South America that extended southeastward from the Andean Cochabamba – Santa Cruz bend to the RGFZ, followed by 2) sea floor spreading north of the RGFZ after M0 (~125 Ma). Unpublished evidence for this boundary is interpreted from remote sensing data, however the Parana flood basalts obscures much of the hypothesized boundary. Our results are inconsistent with recent tectonic interpretations for the earliest opening of the South Atlantic and suggest that, although the ocean basin may have opened from south to north, seafloor spreading may also have begun earlier north of the RGFZ.

KEYWORDS: South Atlantic, seafloor spreading, magnetics.

1. Introduction

Opening of the South Atlantic began in the southernmost part of the ocean basin around M11 time (~136 Ma) (Rabinowitz & Labreque, 1979) and progressed northward over time. In the central part of the basin, just south of the Rio Grande Fracture Zone (RGFZ), M4 is the oldest identified geomagnetic isochron ("Chron") and it is thought that seafloor spreading north of RGFZ began after M0 (~125 Ma) (Moulin et al., 2009; Eagles, 2007). However, Jackson et al. (2000) report that both M4 and M0 have been mapped north of RGFZ on the African side, offshore Angola. Unfortunately, sparse coverage of open-file magnetic data has made it difficult to identify conjugate anomalies over offshore Brazil. Recently, however, new marine magnetic data acquired by ION-GXT in 2008 (FIG.1 & FIG.2), have made it possible to carry out a more detailed analysis of anomalies over the Brazilian margin, We have examined these data and have been able to correlate linear magnetic anomalies that we identify as Mesozoic Chrons.

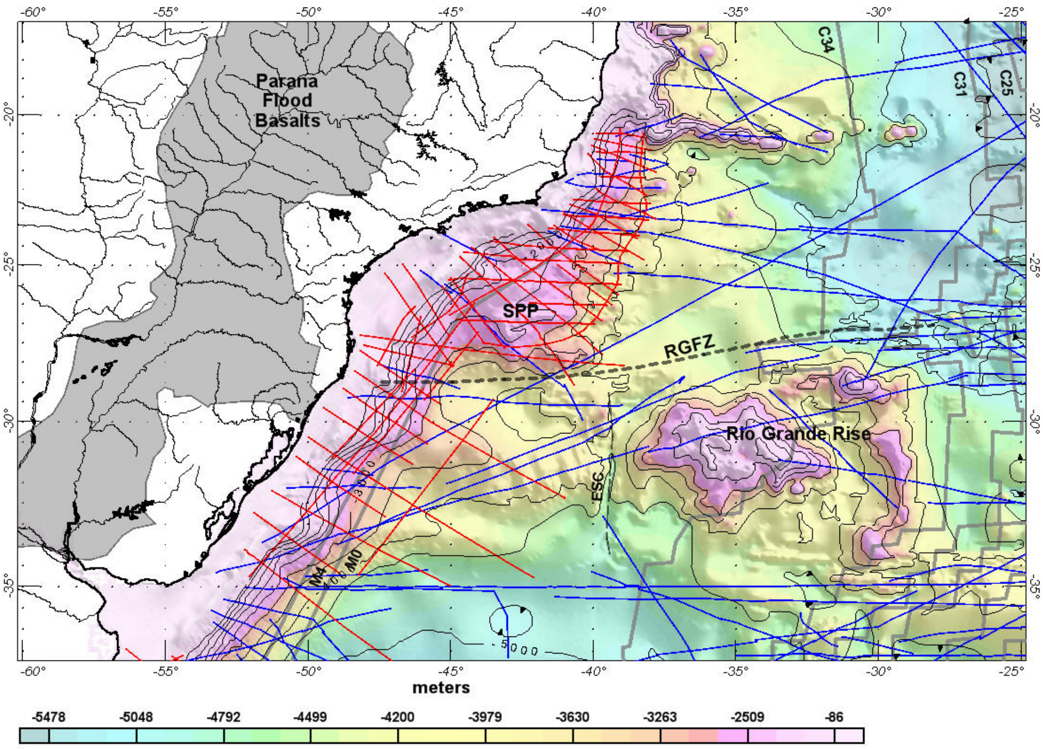

FIG.1 – Central South Atlantic topography, offshore Brazil. ION-GXT shiptracks (red lines), open-file shiptracks (blue lines), geomagnetic isochrons (thick gray lines, after Muller et al., 1997), Rio Grande Fracture Zone (RGFZ, dashed thick black line), Extinct Spreading Center (ESC, thin dashed black line), Sao Paulo Plateau (SPP), and isochrons (ages after Gradstein et al., 2004): M4 (~130 Ma), M0 (~125 Ma), C34 (~84 Ma), C31(~68 Ma), and C25 (~57 Ma). Contour interval is 500 m.

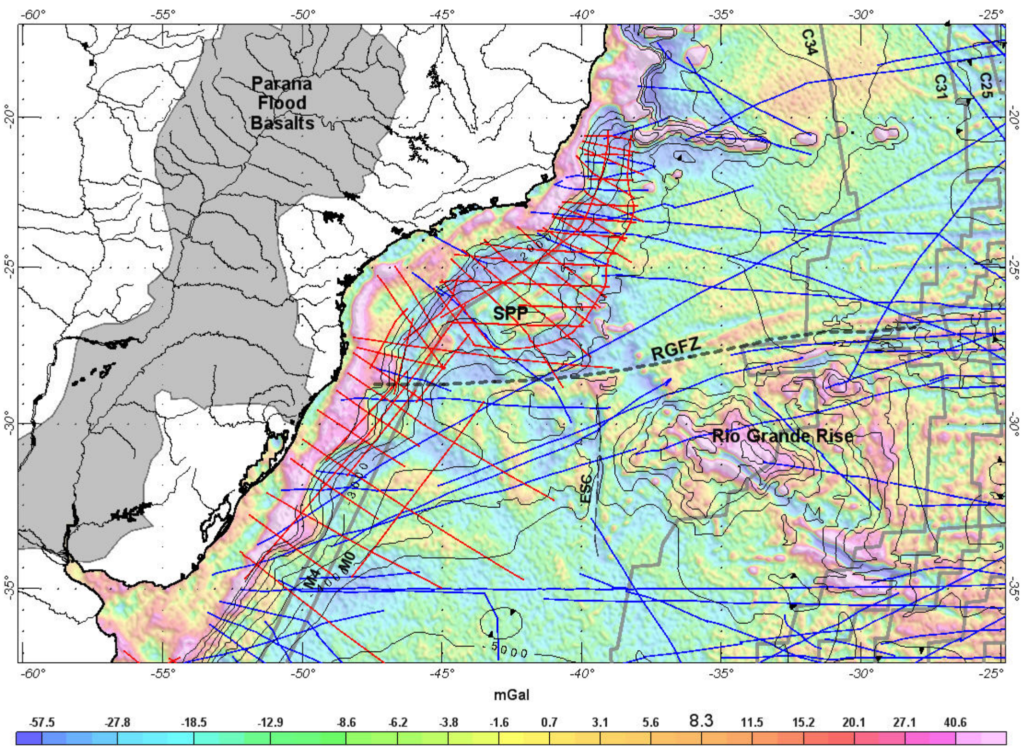

FIG.2 – Satellite-derived free air gravity anomalies over central South Atlantic, offshore Brazil. See FIG.1 caption for details.

2. Results

We use new marine magnetic anomaly data, and integrate it with open-file marine magnetic anomaly data, to identify and map, line-by-line, Mesozoic Chrons north of the RGFZ, offshore Brazil. Several prominent magnetic features with amplitudes of ~ 250 – 300 nT can be successfully correlated along the margin (FIG.3A). Seafloor spreading models show that these prominent features correlate well with those associated with M4, M2 and M0 (FIG 3B)

3. Discussion & Conclusion

We are able to trace the subtle expression of unnamed oceanic fracture zones from free air gravity anomalies, just south of Martin Vaz Fracture Zone (north of RGFZ), eastward from the Mid-Atlantic Ridge to anomalies we identify as M0, about 250 km offshore Angola. We are also able to trace the same fracture zones westward from the Mid-Atlantic Ridge to about 200 km east of the Sao Paulo Plateau. The extent of these fracture zones on either side of the ridge indicate that seafloor spreading was both coeval and approximately symmetric on either side of the basin, and that if Mesozoic Chrons are observed on the African side, then they must also be present on the South American side.

In their thorough review of South Atlantic kinematics, Moulin et al. (2009) tabulated finite rotations for the earliest opening of the ocean basin from several workers ranging from Bullard et al. in 1965 to Eagles in 2006. We calculated South Atlantic finite rotation poles for C5 through M4 (Hall & Bird, 2007; Bird & Hall, 2009; Bird & Hall, 2010). Diachronous seafloor spreading models (Moulin et al., 2009; Torsvik et al., 2009; De Wit et al., 2008; Eagles, 2007; Nurnberg & Muller, R. D., 1991; Unternehr et al., 1988) rely upon limited evidence of seafloor spreading anomalies north of the RGFZ and some propose that as much as 150 km of dextral shear occurred along a continental transform fault that extended southeastward from the Andean Cochabamba – Santa Cruz bend to the RGFZ. Reported geological evidence for this transform is from an, "… interpretation of remote sensing data (F. Bénard, pers. Commun., 1986)", but notes that extensive basalt flows make, "direct field evidence extremely difficult to obtain" (Unternehr et al., 1988, p. 175). Our results are inconsistent with this diachronous spreading model, but instead indicate that seafloor spreading north of RGFZ was roughly coeval with seafloor spreading south of RGFZ.

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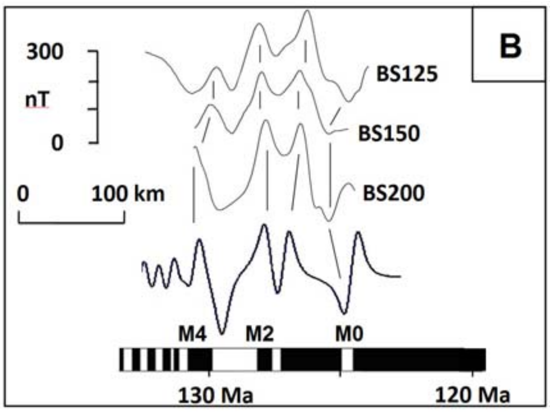

FIG.3 – **A**. Magnetic anomaly profiles over the Brazilian margin aligned so as to display line-to-line correlations of several prominent features identified as M4, M2 and M0. Profiles include ION-GXT BrazilSPAN™ ("BS") lines, Lamont-Doherty Earth Observatory cruises ("C" and "V"), and Woods Hole Oceanographic Institute cruise ("CH"). **B.** Seafloor spreading model showing a comparison between anomalies calculated for a spreading rate of 25 mm/yr with several magnetic anomaly profiles from the newly acquired magnetic data. The model is 2 km thick from a depth of 7 km.