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Do fracture zones define continental margin segmentation? — Evidence from the French Guiana margin

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ABSTRACT

Plate reconstructions suggest that the French Guiana margin in the west equatorial Atlantic is a highly segmented margin with both rift- and transform-style features. We describe here the results of modelling coincident multi-channel and wide-angle seismic, gravity and magnetic data acquired along two transects of this margin. The resulting models not only highlight the degree of structural segmentation but also demonstrate the effect of trans-tension on margin evolution.

As a whole, the margin is characterised by 35–37 km thick pre-rift continental crust which is separated from unusually thin oceanic crust (3–4 km) by thinned continental and/or transitional regions. To the north, the margin exhibits a 320 km wide zone of thinned continental crust adjacent to a narrow ocean–continent transition, and is interpreted as a transform margin where the wide zone of thinned crust is a result of profile orientation being highly oblique to the direction of rifting. Approximately 240 km to the south, the margin is characterised by a 70 km wide zone of thinned continental crust which is wider than typical for transform, and narrower than typical for rifted margins. This crustal structure is interpreted to reflect a "leaky" transform formed by trans-tensional extension.

These observations suggest that fracture zone influenced geometry of equatorial Atlantic rifting, did not produce a well-defined margin crustal structure, but instead resulted in margin segments which display characteristics of both rift and transform tectonic processes. The associated abundance of fracture zones has likely also affected the post-rift evolution of the margin, and provided topographic basement highs which acted as sediment dams to the northwards flux of sediment from the Amazon.

1. Introduction

A diverse range of rift-related structures are observed at the passive continental margins of the Atlantic; a consequence of variation in mantle temperature, rate and extent of rifting, rift geometry and lithospheric thickness. Observed structures have resulted in margins being classified according to: the orientation of the rifting direction relative to that of subsequent oceanic spreading – rift to transform (e.g. Whitmarsh et al., 1996; Edwards et al., 1997); the degree of rift-related magmatism – volcanic to non-volcanic (Mutter, 1993); the distance over which continental crustal thinning occurs – wide to narrow (Davis and Kusznir, 2002); and whether or not transition zones of exhumed mantle or intruded crust are observed (Dean et al., 2000; Hopper et al., 2006). While the two-dimensional aspects of the mode of formation of these structural end-members is relatively well understood, to better understand their three-dimensional inter-relationships, or the margin segmentation, study of along-strike continuity of features is required, together with correlation of features between conjugate margin pairs.

Large-scale segmentation is observed along the margins of the eastern Atlantic, e.g. in their magmatic characteristics which vary, north to south, from volcanic (Rockall – Morgan et al., 1989) to non-volcanic (Iberia – Dean et al., 2000; Congo-Zaire-Angola – Contrucci et al., 2004) to volcanic (Namibia – Bauer et al., 2000). However the nature of the along-strike transition between these end-member types is poorly known. Similarly, these margins are structurally segmented by rift- and transform-style structures; the latter related to long-lived first- and second-order offsets in the Mid-Atlantic Ridge (MAR) which can be traced to each margin as fracture zones or fracture-zone-like features. The relatively narrow width of these zones suggests that the transition from rift- to transform-style structures is similarly abrupt. However, to date, existing studies have focused on better understanding of the origin and evolution of end-member margin characteristics, rather than addressing the nature of the transition between them.

In order to understand the origin and development of along-strike segmentation, the western equatorial Atlantic margin was chosen for study because the satellite-derived gravity anomaly indicates that the crustal basement fabric is dominated by fracture zones (Fig. 1), whose intersection with the margin is reflected in the free-air gravity anomaly as small offsets in the 'edge effect' high. In addition, this

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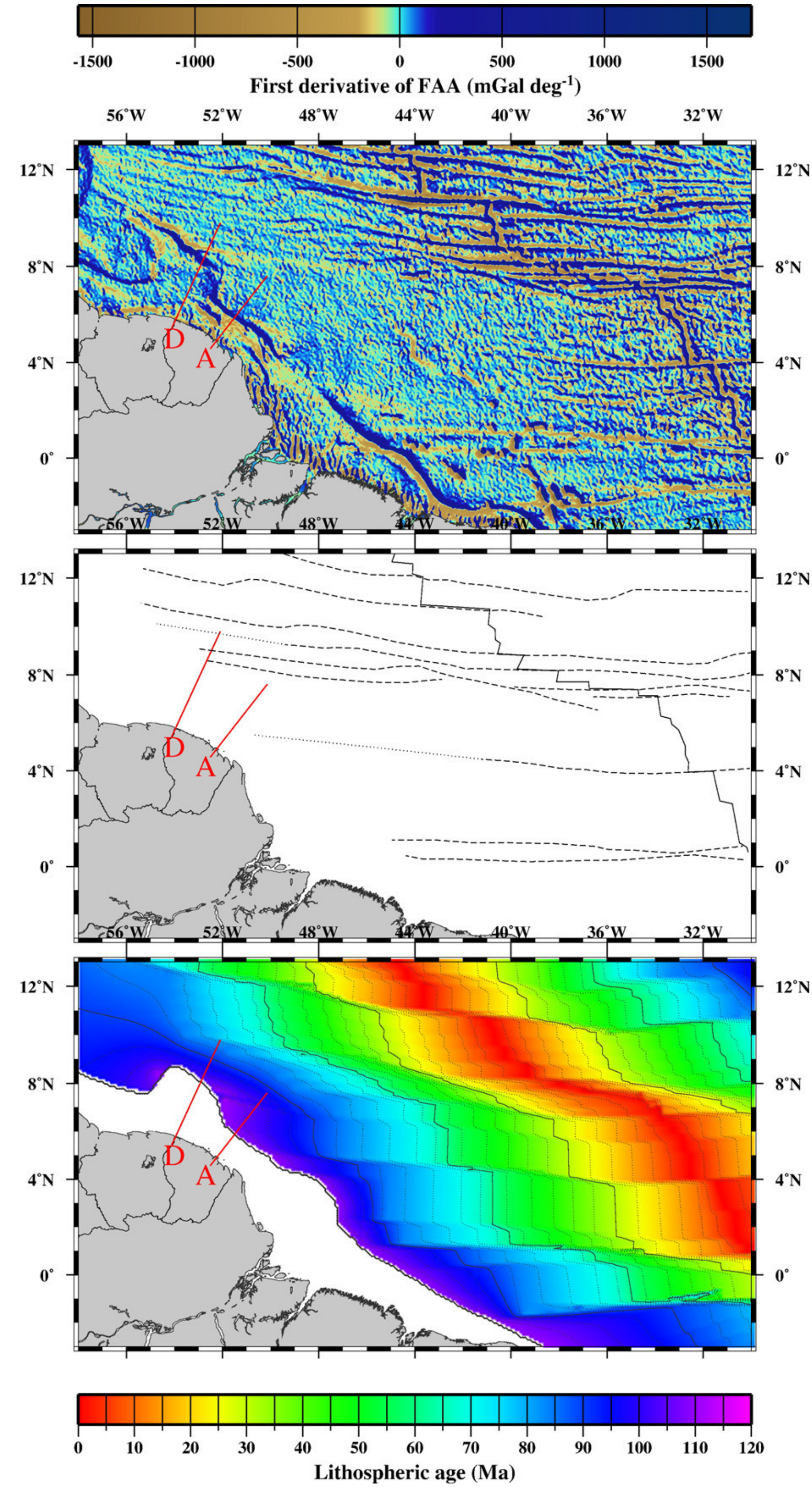

Fig. 1. French Guiana-Northeast Brazil margin. Top: Lineations observed in the first derivative of the satellite-derived gravity FAA (Sandwell and Smith, 1997) showing the locations of fracture zones which can be traced from the MAR to the continental margin. Middle: Summary of the observed fracture zones traced (black dashed) and interpolated (black dotted) towards the margin. Bottom: Müller et al.'s (1997) seafloor age isochrons, with heavy contours marking 30 Ma intervals. The location of Profiles A and D at the French Guiana margin are annotated.