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The interplay between structural inheritance and morphology in the Equatorial Continental Shelf of Brazil

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ABSTRACT

The primary objective of this study is to assess the control of faults of the rift and post-rift stages on the shelf morphology of the Potiguar Basin in northeastern Brazil. This aborted rift basin was generated during the opening of the Equatorial Atlantic in the Aptian. The offshore portion of the continental margin consists of a narrow (~40 km) and shallow (~70 m below present sea-level) continental shelf with a very steep continental slope (1:11). Our dataset encompasses gravity, bathymetric, shallow seismic and structural data. The results indicate that low sedimentation rates during the Quaternary period contributed to the identification of structural controls in pre-Holocene rocks. The key evidence for fault reactivation on the seafloor is the link between coastal and shelf features associated with pre-Cenozoic structures of the Potiguar Basin. During periods of low sea level, the incision of shelf valleys was readjusted longitudinally and transversally due to the structural controls. Shelf gradient breaks are associated with the occurrences of coplanar ESE–WNW-oriented faults, and uplifted and subsided areas occur in between these fault systems. The results indicate a strong correlation between the margin geometry, modern shelf surface, near-surface expression, and the rift-phase faults, which appear to be reactivated in concordance with the present-day margin stress field. We conclude that neotectonics has influenced both the sediment deposition and morphology of the NE Brazilian Equatorial margin during Quaternary times.

1. Introduction

The structural control over erosion and deposition may leave marks in the relief, such as the displacement of topographic features, differential erosion, linear scarp faces, pronounced breaks, and aligned ridges and valleys (Stewart and Hancock, 1994). On continental shelves, morphotectonic structures are rarely preserved and recognized because, generally, the ancient relief is mainly subject to subaerial, coastal and marine sediment transport. Although shelfal relief is generally smoothed by recent erosion and sedimentation (Gutierrez-Maz et al., 1996; Harrison et al., 2003; Payenberg et al., 2006; Dondurur and Çifçi, 2007), the regional geomorphological pattern may be preserved or highly dependent on structural inheritance (Menier et al., 2006; Helland-Hansen et al., 2012).

The Atlantic continental margins of South America exhibit evidence of neotectonic fault activity (e.g., Martin et al., 1986; Bezerra et al., 2001; Peulvast et al, 2006; Rossetti et al., 2007, 2011). Even so, the modern relief of the northeastern Brazilian Continental Shelf is commonly related to the high-energy sedimentary and hydrodynamic processes (Vianna et al., 1991; Testa and Bosence, 1999; Bittencourt et al., 2005; Vital et al., 2008, 2010a; Gomes and Vital, 2010). Sea level fluctuations have likewise influenced the morphogenesis of this shelf and the coastal zone (Vianna et al., 1993; Bezerra et al., 2003; Caldas et al., 2006; Stattegger et al., 2006). Although many neotectonic studies have been performed on the onshore region (e.g., Bezerra and Vita-Finzi, 2000; Bezerra et al., 2001, 2011; Nogueira et al., 2010), little is known regarding the role of faults in the geometry and morphology on the continental shelf.

This study emphasizes the role of the Neogene–Quaternary driving mechanisms on the morphotectonic evolution of the Equatorial Shelf of Brazil at a regional scale using an integrated dataset, which comprises bathymetric, gravity, altimetry, structural, and remote sensing data. We present a morphotectonic analysis of the preserved relief on the continental shelf offshore of Potiguar Basin (Fig. 1). Relief anomalies extracted from residual bathymetric and gravity data were used to assess the influence of pre-Quaternary structures on current hydrodynamic processes of the seabed. Our study identifies Quaternary fault reactivation and provides a new insight into the morphotectonic evolution of siliciclastic–carbonate shelf systems.

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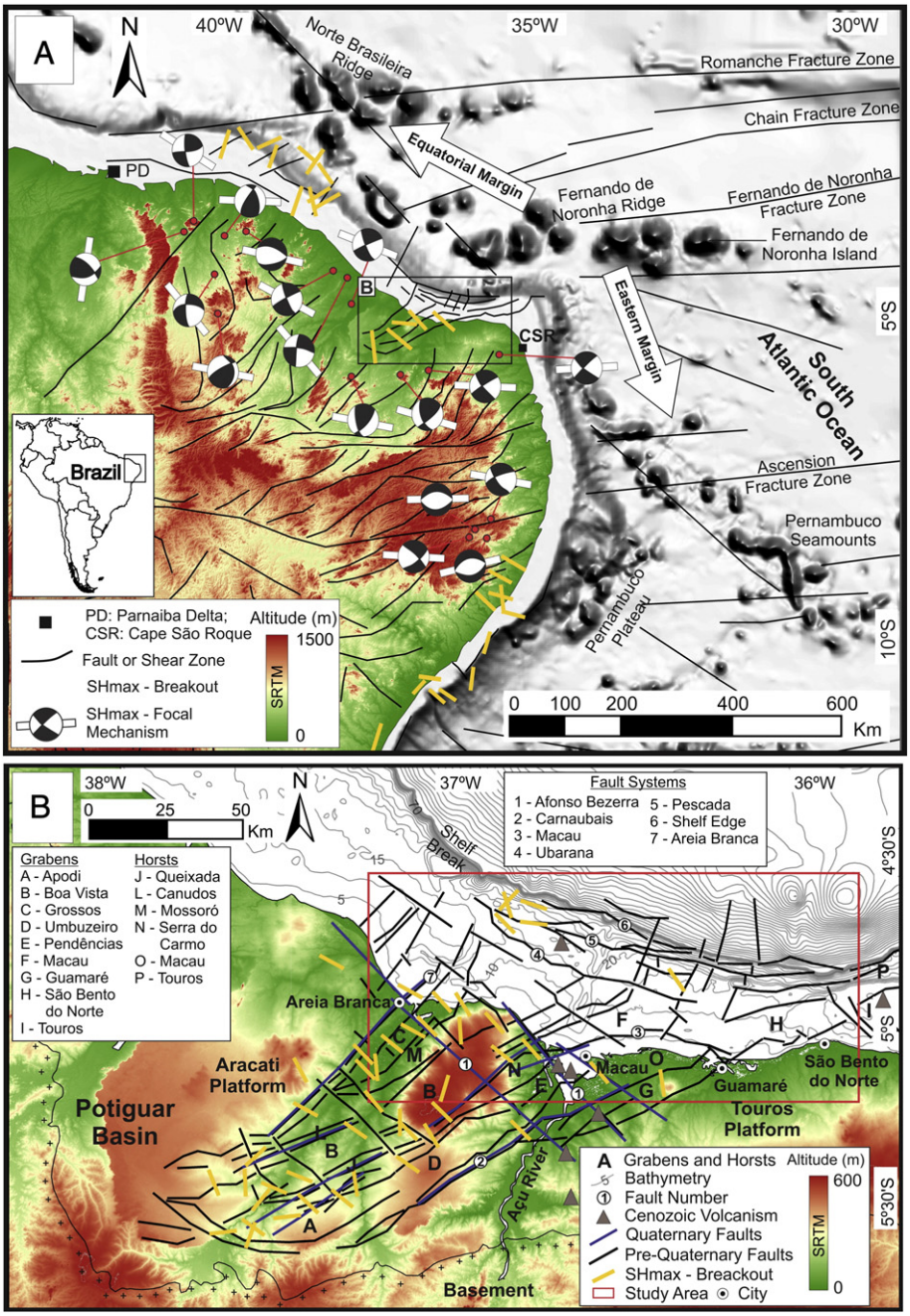

Fig. 1. Main tectonic features, present-day stress field, and morphology of the continental margin of northeastern Brazil: (A) Morphological Map of Equatorial and eastern margins showing the main structural lineaments (compiled from Schobbenhaus and Bellizzia, 2001). The orientation of maximum stress S_{Hmax} from focal mechanisms and borehole breakout data (compiled from Lima et al., 1997; Ferreira et al., 1998; Bezerra et al., 2011). (B) Geometry of the Potiguar Basin showing horsts, grabens and major fault systems from Angelim et al. (2006), as well as Cenozoic volcanism (compiled from Bezerra et al., 2011). Inset: location of study area (red rectangle).

2. General settings

2.1. Morpho-sedimentary framework

In northeastern Brazil, the margin between the Parnaíba Delta and São Roque Cape (Fig. 1) has the narrowest (minimum of 22 km) and shallowest (60 m at the shelf break in the study area) shelf with an abrupt transition to steep slopes (~11°) along the Equatorial margin (Knoppers et al., 1999). In the study area, the continental shelf represents the offshore part of the Potiguar Basin, an important petroleum province in Brazil (Milani et al., 2000).

Mixed sedimentation patterns have developed in the offshore Potiguar Basin since the Neocampanian, with proximal siliciclastic and distal carbonate depositional systems (Pessoa Neto, 2003). Based on oil-well cores, three lithostratigraphic units compose the pre-Holocene strata: (1) the Tibau Formation, composed of sandstones and conglomerates derived from systems of coastal fans and the infilling of the incised valleys; (2) the Guamaré Formation, composed of calcarenites and calcilutites, originated from the bio-constructions and the algae banks on the shelf edge; and (3) the Ubarana Formation, comprising shales, calcilutites and subordinate sandstones in the slope environment (Pessoa Neto, 2003). The modern shelf is composed of mixed siliciclastic