Interpretation of High-resolution Airborne Magnetic Data of Offshore Campos Basin and Onshore Adjacent Basement.

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Abstract

Several anomaly-enhancement techniques were applied to a joint high-resolution airborne magnetic dataset comprising the onshore and offshore Cabo Frio platform, Rio de Janeiro state (Figure 1). That approach allowed the identification of several subtle basement faults and the definition of the tectonic framework.

We identified new NW-SE faults that may be associated to Early Cretaceous transfer zones that segment the obliquely rifted Atlantic margin. That segmentation has important implications for risk factor of deep-water petroleum systems of Campos Basin.

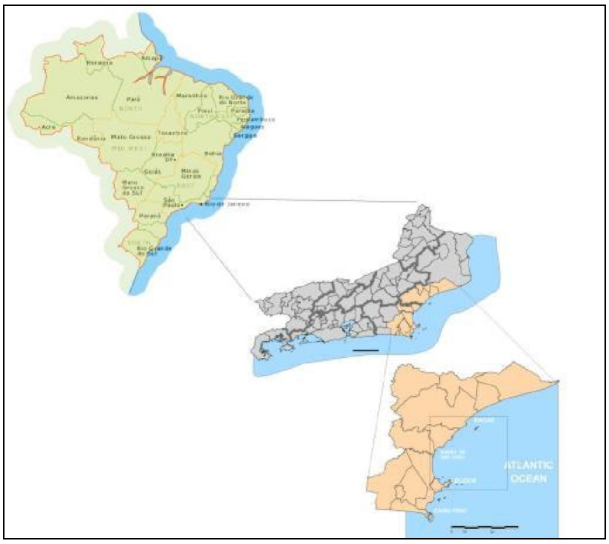

Figure 1 – Location map of the studied area.

Introduction

The Campos Basin is the most prolific Brazilian oil-producing basin. Six petroleum systems have been recognized, all are believed to be sourced from lacustrine rocks within the Early Cretaceous rift system, which charge suprasalt Tertiary turbidite reservoirs in combination traps (Szatmari et al., 1985; Mello et al., 1994).

The oilfields are mainly located in the deep water portion of Campos Basin (Figure 2), where the main exploration risks of the petroleum system include:
(a) Identification of Early Cretaceous source rocks;
(b) the viability of migration pathways through thick salt layers; and
(c) the mechanism for hydrocarbon charging of suprasalt turbidite reservoirs in a deepwater mud-prone system.

To address these issues, it is necessary to understand the regional tectonic framework and evolution of the southeast Brazilian margin. As pointed out by Zalán and Oliveira (2005) this portion of the Brazilian continental margin did not constitute a typical passive margin as one would expect from the premises of Plate Tectonics.

Several events took place since the Atlantic opening event, leading to the formation, in the Paleocene-Miocene, of a series of SW-NE striking onshore grabens along corridors parallel to the present coastline. SE-NW striking transfer faults forms the limits between grabens, these faults were reactivated in the Late Cretaceous and in the Cenozoic, during ongoing turbidites sedimentation, accompanied by abundant volcanism and deep-seated folds attributed to lithospheric buckling. Cobbold et al. (2001) attribute these transfer zones to the combined effects of far-field stresses and hot-spot activity. This is corroborated by the analysis of several seismic lines that show upper Cenozoic tectonic activity in the western border of Campos Basin (Mohriak e Barros, 1990).

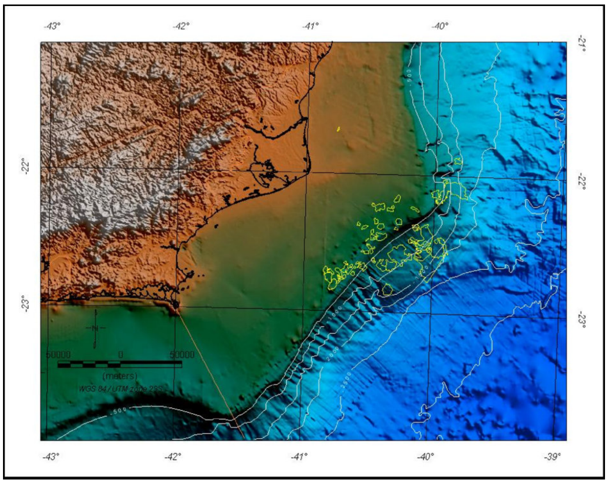

Figure 2 – Topography and bathymetry of the studied area: Onshore adjacent basement and offshore portion of Campos Basin. Known oilfields are represented in yellow.

Most all the previous published work were restricted to the analysis of regional datasets such as satellite-derived gravity anomalies, low-resolution shipboard gravity-magnetic surveys and 2D regional seismic lines (Karner, 2000, Cobbold et al. 2001, Meisling et al. 2001).

In the 2000 decade, several new high-resolution airborne magnetic surveys were acquired along the shallow water portion of the southeast continental margin (Zalán and Oliveira, 2005).

In the present work we integrate and interpret two distinct high-resolution airborne magnetic data in offshore Campos Basin and adjacent basement area (Table 1). Our main goal is the identification of the subtle NW-SE fault system in the Campos Basin and their continuity to the onshore portion.

To that end we applied several enhance techniques to the magnetic data (Lyatsky et al. 2004). That approach led to the recognition of several NW-SE faults extending from the onshore basement area to the deeper portion of Campos Basin.

High-Resolution Magnetic Datasets

The lay-out of the merged magnetic dataset is described in Table 1. The data processing consisted of: positioning of the data, removal of diurnal magnetic variation, tie-leveling, micro-leveling and decorrugation.

To compute the Total Magnetic Intensity (TMI) anomaly both grids were reduced to the same 2005 magnetic field characteristics for the area, resulting in: 1) intensity: 23423.5 nT; 2) inclination: 27.83 degrees South; 3) declination: 19.73 degrees West.

	onshore	**offshore**
Line kilometers	*41.595*	*20.776*
Line direction	*N-S*	*N 30º W*
Flight line spacing	*1.000 m*	*1.000 m*
Tie-line direction	*E-W*	*N 60º E*
Tie-line spacing	*10000 m*	*4000 m*
Average altitude	*150 m*	*150 m*
Survey date	*1978*	*2002*

Table 1 - Lay-out of the two high resolution surveys

The resulting TMI anomaly map (Figure 3) shows strong elongated northeast-southwest trending anomalies. These regional anomalies are likely to be associated with the basement rocks of the Brasiliano mobile belt (a doubly verging crustal flower structure, formed in dextral transpression), and to several NE striking diabase dikes mapped in the onshore portion (Figure 3).

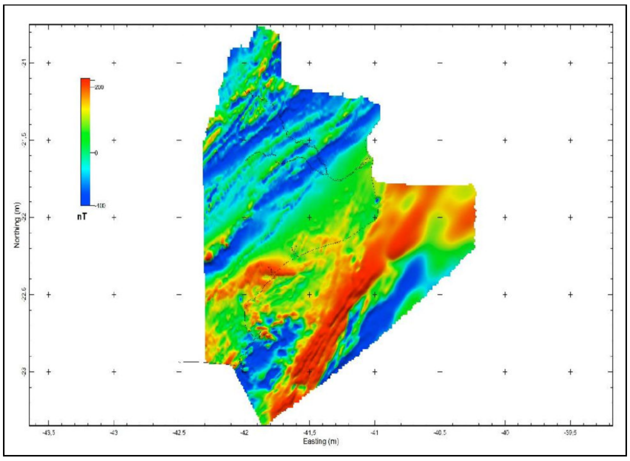

Figure 3 – Total Intensity Magnetic anomaly map, onshore and offshore merged dataset.

The northwest-southeast structures are not evidenced in this map. Subtle potential-field signatures of brittle faults and fractures necessitate further detailed data processing, using a wide variety of anomaly-enhancement techniques such as: horizontal and vertical gradients, analytic signal, directional filtering, etc.

The final choice of processing and display options depends on which types and aspects of anomalies one aims to enhance, as well as on extensive experimentation during the interpretation procedure.

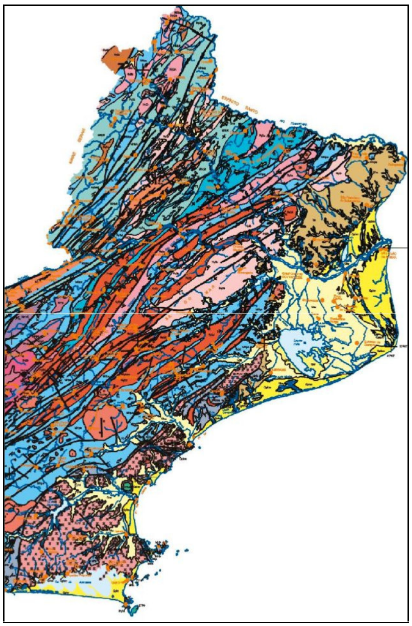

Figure 4 – Geological map of the onshore portion of the studied area. Note the marked SW-NE strike of the pre-Cambrian basement rocks and diabase dikes.

Discussion

In the present work we used a target selection criteria based on the integrated analysis of the analytic signal and the directional filtering. The analytic signal enhances the boundaries of magnetic sources regardless of the direction of source magnetization and the direction of the Earth's field. Thus all bodies with the same geometry will have the same analytic signal shape.

The advantage of the directional filtering is that the detection of linear anomalies in map data is facilitated by studying the power spectrum, because the directivity of the energy in the map is preserved in the Fourier transform. The lineaments associated with individual peaks in the spectrum are then separated from the map data by directional filtering and studied independently of other map features.

In Figure 4a and 4b we show, respectively, the analytic signal and the directional filter 45 degrees, where we enhanced the NW-SE striking anomalies. In Figure 3c and 3d we show the same themes with the interpreted faults superimposed.

The proposed approach led to the recognition of several faults that extends from basement areas to the offshore portion of Campos Basin. These faults are likely to be reactivated during the several tectonic pulses that affect the region and may have influenced the sedimentation of the turbidites reservoirs of the known oilfields. Mohriak and Barros (1990) interpreted Tertiary NW synthetic faults along the Graben de São João Graben basement rocks (Figure 6). Our interpretation indicate that the structural framework of the studied area is more complex than it was pictured by the previous seismic interpretation.

Acknowledgments

We thank CPRM (Brazilian Geological Survey) for kindly providing the onshore magnetic dataset. This research has been supported by the Edital Universal grant by CNPq under contract 474878/2006-6. PTLM acknowledge a CNPq scholarship n. 302015/2007-8.

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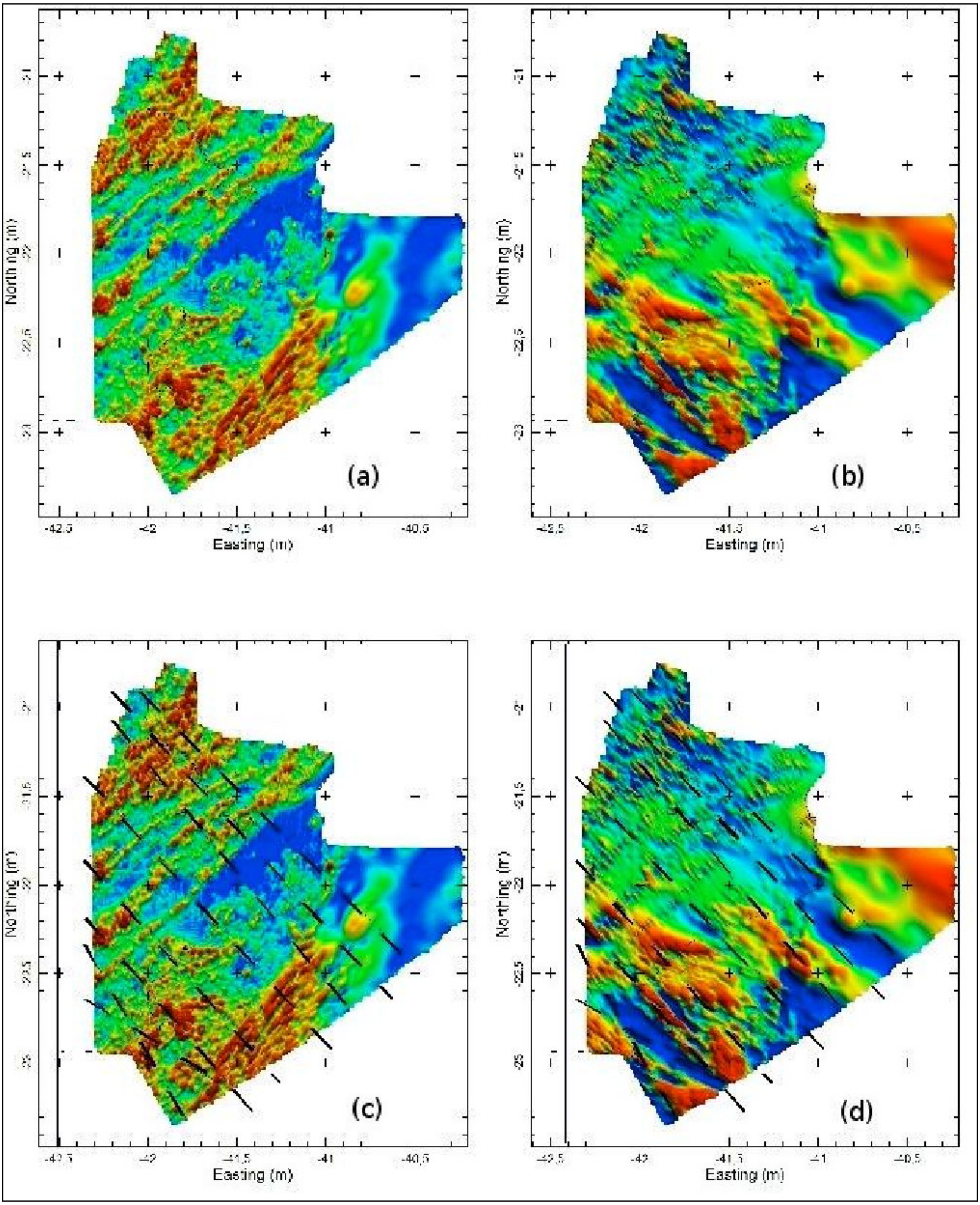

Figure 5 – a) The amplitude of the analytic signal field, derived from the total magnetic intensity anomaly data of Figure 3; b) Total magnetic intensity anomaly data of Figure 3 after directional filtering along N45W; c) analytic signal with interpreted faults superimposed; d) Total magnetic intensity anomaly data of Figure 3 after directional filtering along N45W with interpreted faults superimposed´

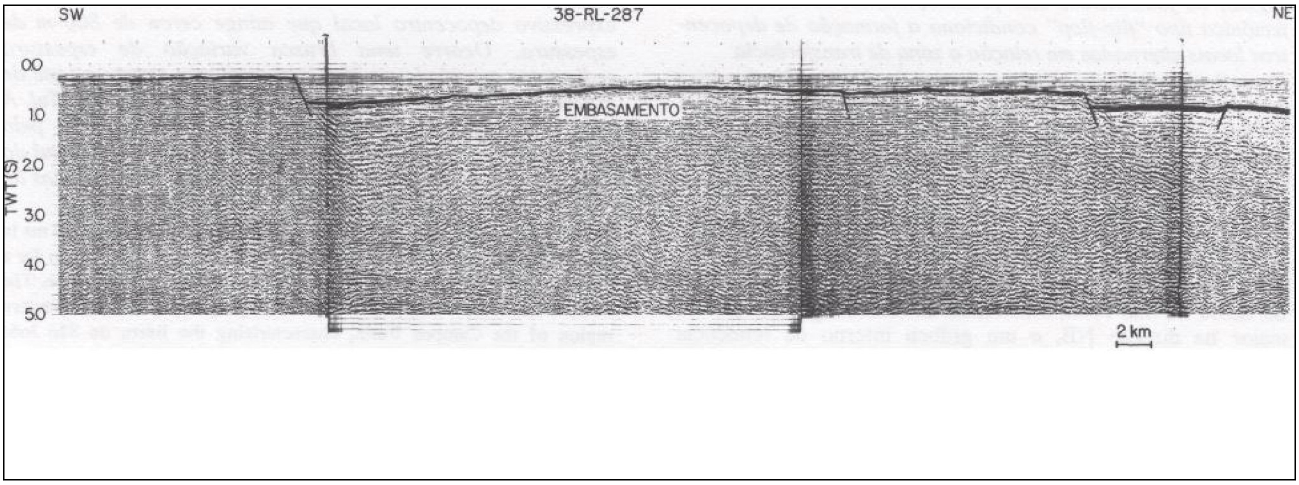

Figure 6 - Interpretation of the unmigrated seismic line 38-RL-287 (Mohriak and Barros, 1990) which trends sub-parallel to the coastline. The basement is characterized by Tertiary, predominantly synthetic faults.