Geophysical reservoir characterization at the Cabo Frio High (Southern Campos Basin)

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Abstract

The Cabo Frio High is a structural feature that separates two major sedimentary basins in Brazil: Campos and Santos Basin. This structural condition defined the kind of petroleum play found at the south of Campos's basin as Peregrino, Maromba and Papa-Terra oil fields, which are recent discoveries (2005) that produce oil from turbidite reservoirs. This research aims to perform an overview of the kind of reservoirs present in those fields; the objective is oriented to get a better geological comprehension and a possibility of new exploratory targets on this area. The applied method includes analysis of magnetometric and gravimetric maps, well correlation and 2D and 3D seismic interpretation. Structural Maps of the seafloor, top of the main reservoirs and the basement were generated and, as a result, a horizon´s high deepening was observed to the southeast. The potential method´s maps present the main faults systems (NE-SW, NW-SE) and a main magmatic intrusion at southeast of Papa-Terra field. The volumetric analysis performed over the basement´s structural map showed a high density of fractures that would be a new exploratory target, however, petroleum system conditions must be analyzed on this area.

Introduction

The study area is located at the Campos Basin, which is the leader producer of oil and natural gas in Brazil, accountable for over 80% of the national production of hydrocarbons. This basin is situated in the southeast portion of Brazil, in the northern coast of Rio de Janeiro, bordered to the north by the Vitória´s Arch and to the south by Cabo Frio High; the whole basin contains an approximate area of 100,000 km^2, by a water depth of 3000 m (Rangel & Martins, 1998).

Along the Cabo Frio High, there are at least four important oil fields: Papa-Terra, Maromba, Peregrino and Polvo, all of them considered recent discoveries, because their commercial production has been started in 2005 (Figure 1). Based on the geological complexity of the area, and its geological evolution, a structural analysis of the region could contribute to the knowledge of the geological elements of the petroleum system that define the existence of these fields.

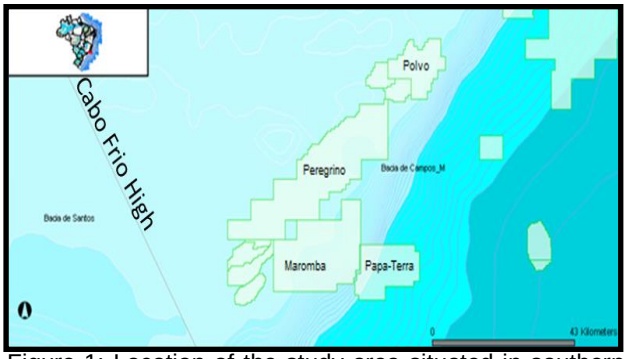

Figure 1: Location of the study area situated in southern Campos Basin.

The oil fields evaluated in this research are oil producer from 14° to 22° API, the main oil reservoirs are turbidites, and Peregrino is recognized as the main producers of Campos Basin. The study area has also geological interest because it is highly influenced by magmatic events associated to the oil potential of these fields.

Due to the scenario described above, it is justified to spend some time in the geological knowledge of the south of the Campos Basin, because of its high potential and its structural-stratigraphic heterogeneity in relation to the north of this basin.

Objective

The objective of this research is to characterize the main reservoirs in the South of Campos Basin, in order to increase the geological understanding of the area and interpret where could be new exploratory targets.

Method

The project was developed using a set of seismic data and wells provided by the Agencia Nacional do Petróleo (ANP) through the policy of providing data to public universities (Figure 2). The project was leading in three main stages:

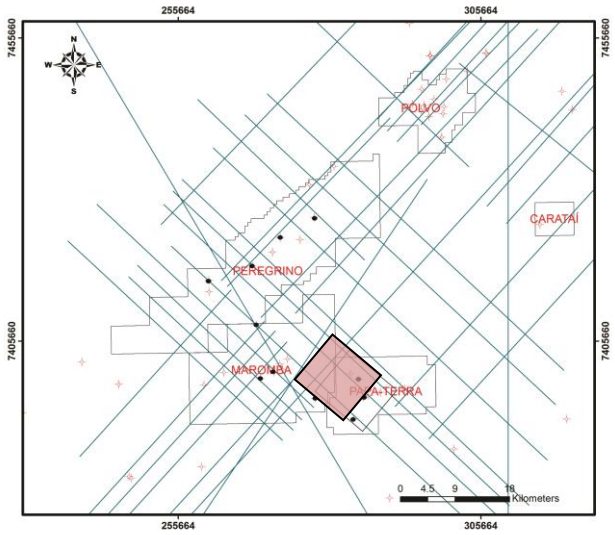

Figure 2: Database used in this research: Wells (black points), 2D seismic (blue lines) and a 3D seismic (red square).

1. Analysis of potential methods

The methods of magnetometry and gravimetry were used for regional analysis of the study area in recognition of the main structures associated to the Cabo Frio High.

At this stage, it was observed the basement of the stratigraphic sequence and its discontinuities; in the next steps, it was checked whether they are associated with structural features.

2. Well Correlation

At this stage, it was generated the graphic display of the geophysical logs acquired from the association of different profiles (RHOB, ILD, GR and DT) and it was identified the formation lithology, main formation tops and the main reservoir levels.

This analysis is the base for the stratigraphic correlation between the wells available in the study area. Thus, it is possible to observe the distribution of stratigraphic layers, lateral continuity of the reservoir and structural sections.

3. Seismic Interpretation

The software used for seismic interpretation was Decision Space (Landmark).

Though the sonic and density log curves, a synthetic profile of the well was built, in order to calibrate the well information with the seismic data.

After the well-tie stage, the faults and the main stratigraphic intervals were interpreted along the seismic data with the aim of understanding the structural context and the reservoir distribution in the study area (Figure 3).

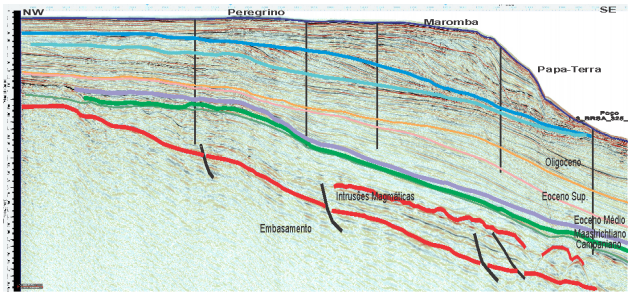

Figure 3: Interpretation of a 2D seismic section through Peregrino, Maromba and Papa-Terra fields.

Contour structural maps were generated on the top of the reference levels in Papa-Terra field (3D seismic cube) and structural seismic attributes were created in order to highlight the geological discontinuities in the field with more influence of basaltic spills.

Results

From the analysis of the potential maps, it can be observed that Polvo, Peregrino and Maromba oil field are situated on gravity high, while the Papa-Terra field is located on a low gravity (Figure 4). By integrating these data with magnetometric map, there is a high magnetometric at east of Papa-Terra field, which can be interpreted as magmatic intrusions.

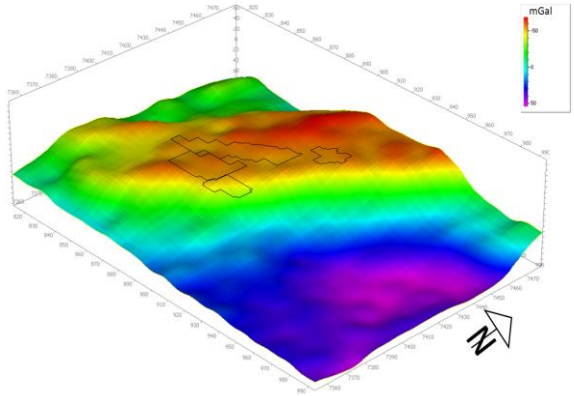

Figure 4: Gravimetric map of the study area.

These maps also show the rift section of the study area and the main lineaments with direction NE-SW and NW-SE represented in the magnetometric map (Figure 5).

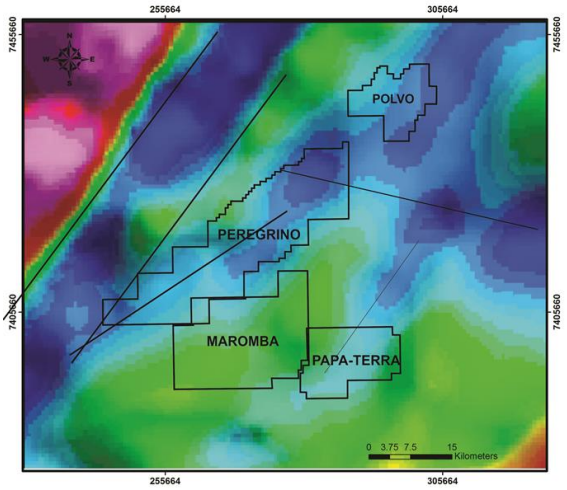

Figure 5: Magnetometric map of the study area. The black lines represent the mean lineaments.

The seismic interpretation of the reservoirs of Peregrino, Maromba and Papa-Terra field shows mixed traps (structural-stratigraphic) and the highest structural position in the Peregrino oil field (Figure 6).

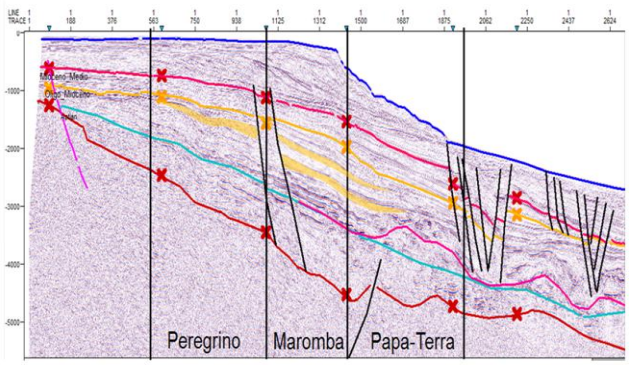

Figure 6: Reservoir interpretation in a 2D seismic line through the Peregrino, Maromba and Papa-Terra fields.

In the Papa-Terra seismic cube, the horizons interpreted were seafloor, Oligocene, Eocene and the basement (Figure 7). All of them show a regional deepening to the southeast, and they are predominantly continuous along this direction. On the oil fields, it was interpreted a high density of normal faults, possibly caused by the magmatic intrusions showed in the potential methods maps.

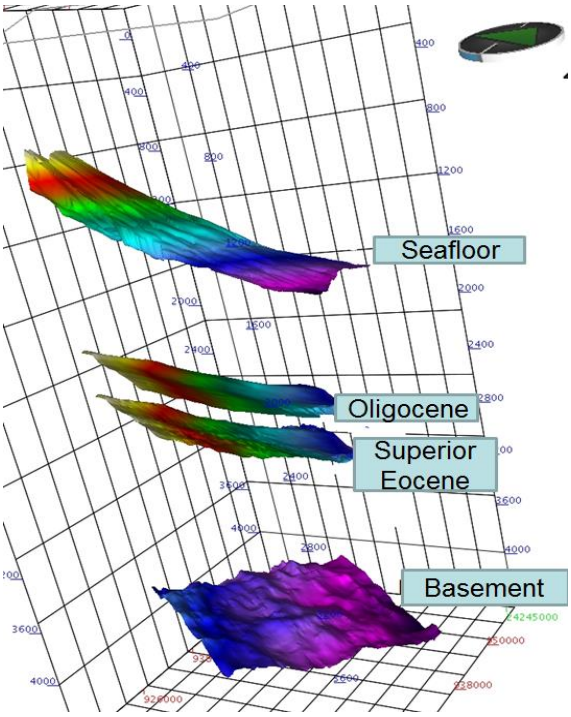

Figure 7: Structural maps of reference levels in Papa-Terra oil field.

In this context, a subsequent volumetric analysis of the Papa-Terra's basement was made in order to verify the presence of fractures that could correspond to a new exploration target, since that Campos Basin's basement is economical and the petroleum system is active in the area.

The map of the structural attribute "Dip" applied to the structural map of the Papa-Terra's (Figure 8) basement presents a high density of fractures showed in the figure 9.

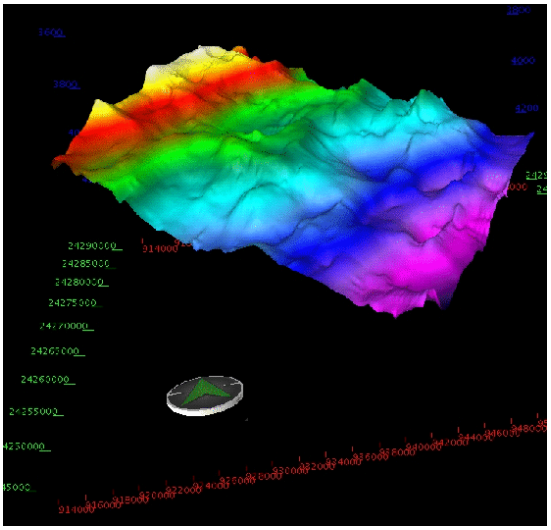

Figure 8: Structural map of Papa-Terra's basement representing the southeast deepening.

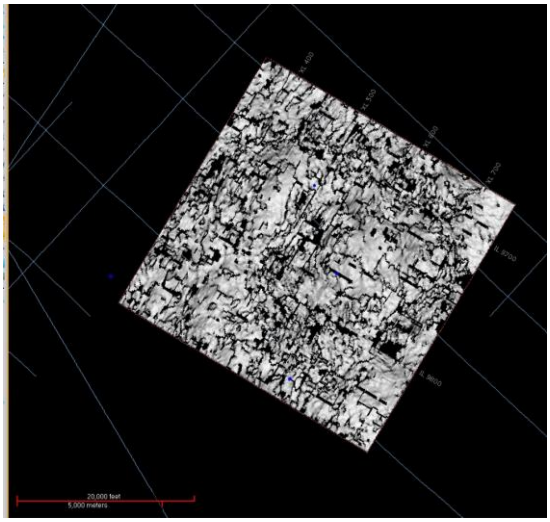

Figure 9: Dip attribute map shows the high density of fractures in Papa-Terra's basement.

Conclusions

- The interpretation of Papa-Terra's basement presents the southeast deepening;
- The Papa-Terra field presents impact of spills with the possibility of having reservoirs in fractured basalt, whereas the petroleum system is active in the area;
- In magnetometric maps, it is possible to observe a lineament system with predominant direction northeast-southwest and northwest-southeast;
- The reservoirs of Maromba, Peregrino and Papa-Terra (all turbidite) are limited by mixed traps (structural-stratigraphic), whose highest structural position is in the Peregrino field to the main recognized reservoirs.

References

RANGEL, H.D. & MARTINS, C.C. Principais compartimentos exploratórios, Bacia de Campos. In: (ed.) Searching for Oil and Gas in the Land of Giants. Rio de Janeiro. Schlumberger p.32-40. 1998.

Acknowledgments

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