Geophysical Analysis of the Tectonic-Stratigraphic aspects of Roncador Field – Campos Basin – Brazil.

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Abstract

Roncador Field, located at the Northern part of Campos and discovered in 1996, represents an important hydrocarbon oil producer, from its main reservoirs at Upper Cretaceous (Maastrichtian, 72.1 - 66 m.y.), mainly in turbidites.

The main issue is that the area would be susceptible to oil spills because its fault system would affect the sea bottom and open the reservoir, in this sense, the objective of this research is to perform a geophysical characterization of the geological faults on the marine substrate, and define its geological evolution related to the main reservoir level; using techniques such as well correlation and seismic data (2D) interpretation, in order to generate structural contour maps.

During the analysis of the available seismic profiles, two geological faults with regional expression were identified, the main azimuth is NW-SE, and the dip slip is about 90 meters. Both faults were confirmed at potential maps and this fact indicates a possible reactivation of the rift system. In another hand, an analysis of the influence of the salt domes, that generate the halokinetic movement, confirm that the Maastrichtian reflector was highly deformed by it. The Maastrichtian configuration would define another kind of play that is the stratigraphic reservoir layer closed by the salt dome.

Introduction

Campos Basin is located in the Southeastern coast of Brazil and it covers an area about 100,000 km². It is separated from Espírito Santo basin by the Vitoria High to the North and from Santos basin by Cabo Frio High to the South.

The Roncador Field (figure 1) represents one of the most important worldwide discoveries of the 90's. The field is located in the Northern part of Campos Basin, 130km off the coast, at water depths range from 1.500 to 1.900 m, and contains an area of 397,6km².

The main reservoirs are located at Upper Cretaceous layer - Maastrichtian, in turbidites, and its trapped is considered mixed structural-stratigraphically (figure 2).

The discovery well (1-RJS4386A) found, in 1996, a net sandstones of 153m of Maastrichtian reservoirs, divided into five main zones of exploration, separated by interbedded shales. This giant field contains large volumes of hydrocarbons, evaluated in 9.2 billion barrels (bbl).

Only the uppermost reservoir zone shows a anomaly that can be detected on seismic profiles, which makes the geophysical characterization of the reservoirs zones not possible (Rangel, et. al., 2001).

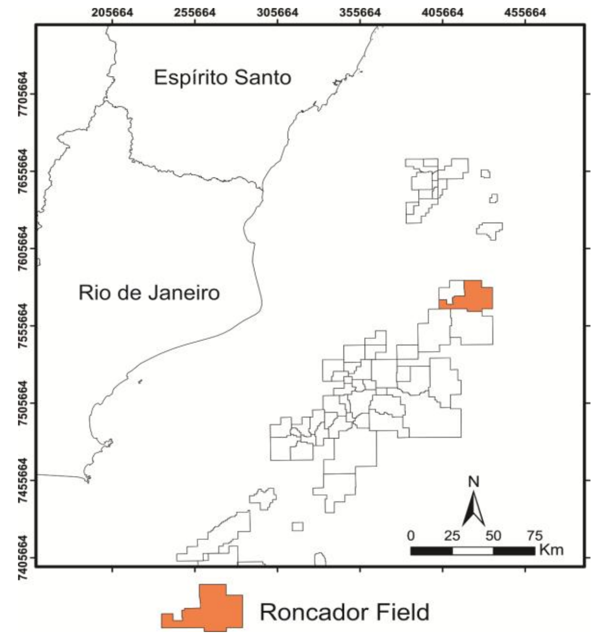

Figure 1 - *Location of the Campos Basin with emphasis on the Roncador field.*

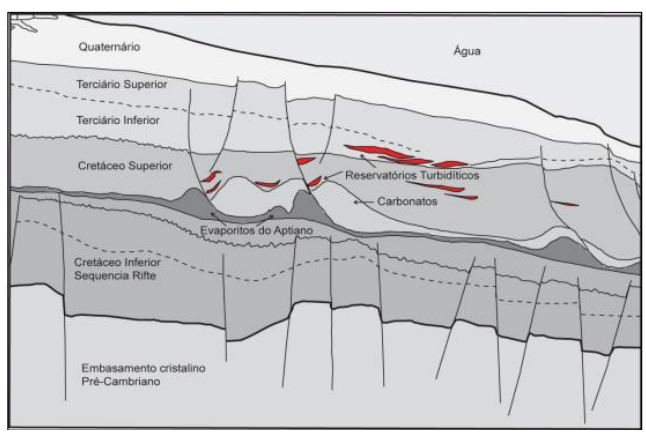

Figure 2 - *Schematic geological section with stratigraphic-structural configuration of the Campos Basin. (Source: Rangel et.al. (1998).*

The main problem at the region is related to the Neotectonics fault system that would reach up the sea bottom and causes an environmental accident, for this reason, the study of this kind of deformation will improve the production strategies.

Objective

The objective of this research is to perform a geophysical characterization of the geological faults system that would affect the sea bottom and its relationship with the main reservoir level at Upper Cretaceous. Also, a brief analysis of the influence of the saline domes - halokinesis - in Maastrichtian layer is proposed.

Method

The project was developed using a set of seismic data and wells obtained from the Agência Nacional do Petróleo (ANP) through the policy of providing data to public universities for performing researches. The project was lead in four main stages:

1) Database acquisition and organization.

In this phase occurred the research and compilation of studies from the Campos Basin and Roncador Field in terms of geological and structural evolution, as well as, theoretical principles of geophysical methods.
Moreover, this stage was defined by the organization of a database comprising 933,8 km of seismic data 2D in .SGY format, 3 wells with its composite profiles, complemented by the analysis of gravimetric and magnetometric maps. Historical production and basic curves in .las format (1RJ_0305_RJ, 3AB_0002_RJS and 3RJS_0334_RJ), were also included at the study.
All the seismic sections were interpreted and used in the analysis, the seismic calibration was done using the 1RJ_0305_RJ well in order to get the stratigraphic tops at the seismic data (Figure 3)

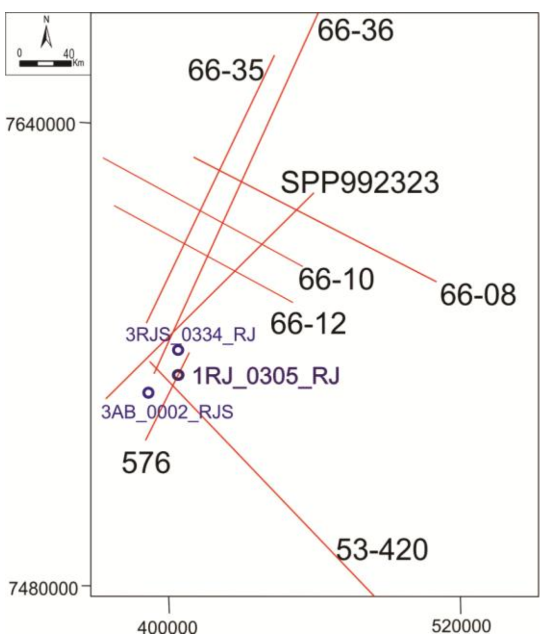

Figure 3 - *Localization - in coordinate system - of seismic lines and wells.*

2) Well analysis

From the basic curves in .las format, there were made profiles for the graphical visualization of gamma ray (GR) Resistivity (ILD), density (RHOB) and sonic (DT), whose integration with the composite profiles and history data well, allowed the interpretation of the horizons Emboré, Fm. Campos, Oligocene, Cretaceous, Macaé - Shallow Water and Aptian.
In this profile, different interval velocities of the seismic waves - for each layer - were found.
The seismic data are obtained as a function of time (in milliseconds), while well profile is defined in meters. The time-depth conversion was performed by the calculation of stratigraphic layer depth using the velocity and depth measured on the sonic profile (DT).

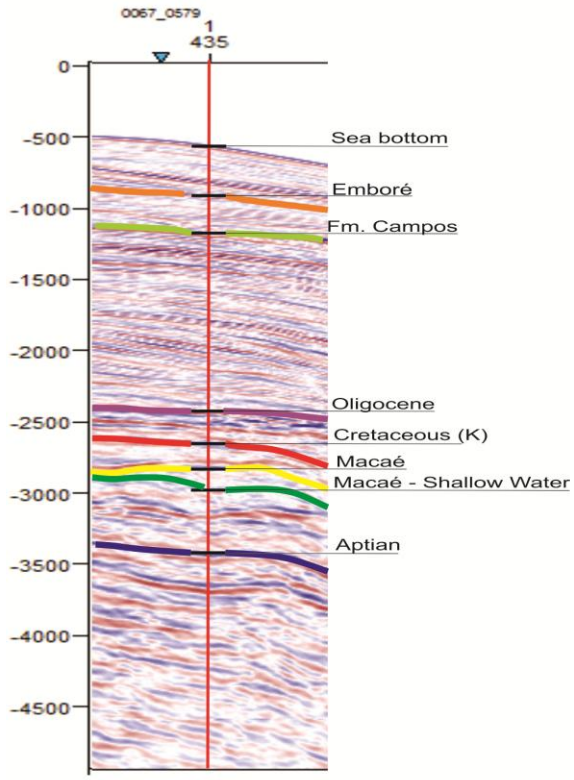

Figure 4 - *Calibration done through the well 1RJ_0305_RJ, using the time-depth conversion.*

3) Seismic interpretation and correlation

The seismic interpretation started with the calibration of the first seismic line, from which the main horizons were defined (Emboré, Fm. Campos, Oligocene, Upper Cretaceous - Maastrichtian, Macaé, Macaé - Shallow Water and Aptian) , and correlated, one by one, according to the intersection of the other seismic lines, as suggested in figure 3.
On each seismic line, the structural elements were identified, such as all the visible faults and salt domes (figure 5).
After this process, all the seismic lines were compared among themselves, in order to identify similarities in the identified structures to correlate the main fault system.

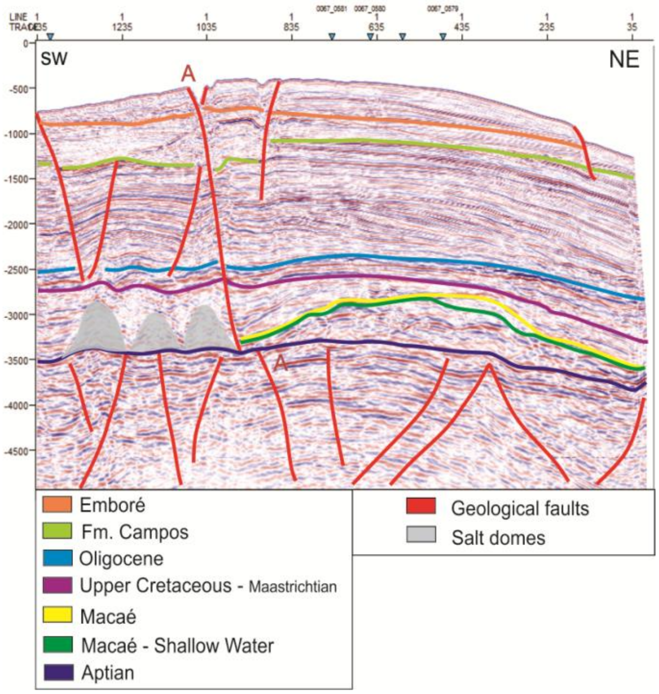

***Figure 5 -** Seismic interpretation of Seismic line 53-420, repreenting the main horizons. Empahsis to the Fault A.*

4) Maps

Contour structural maps were generated on the Sea Bottom and on top of the main reservoir level - Upper Cretaceous. It is possible to interpret these maps like the actual structural maps because the water layer is uniform along the oil field.
Also, a 3D simplified surface map of the Maastrichtian was generated.
All the maps were generated in the software Surfer 13 ®.

Results

The analysis of the trap system responsible for the hydrocarbon accumulation in the Roncador field, has the remarkable the predominance of post-depositional faults, dated from 6 - 10,5 m.y. (Vincentelli, 2013).
In the seismic profiles, it is possible to observe that the majority of geological faults extends from the basin basement to the sea bottom, representing areas of geological instability - mainly due the high level of halokinetic influence on the superficial layers.
On a comparison between the structural contour map of the sea bottom (figure 6) with the map of the Maastrichtian top (figure 7), it was identified the interference of the geological faults in both - culminating with the proposition that the faults came from a halokinetic reactivation, as showed at the figure 5 - the fault A.
In the seismic profile showed at the figure 5, is observed - on fault A - a displacement between the structural features of post-salt regarding the pre-salt, resulting from the movement caused by the plastic reactivation (halokinetic). The fault´s displacement observed between the pre-salt and post-salt section represent a relative slip movement associated with Retiro Member.

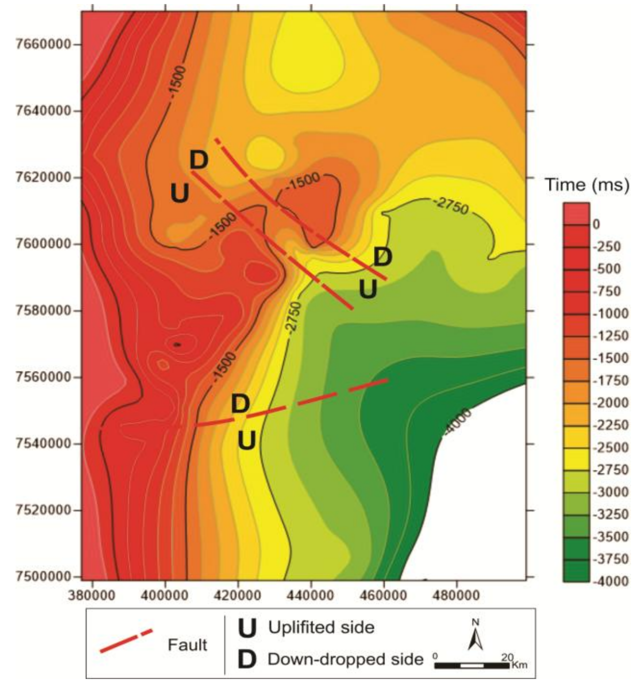

***Figure 6 -** Structural contour map of the sea bottom - emphasis on the faults found relating the map to the seismic profiles.*

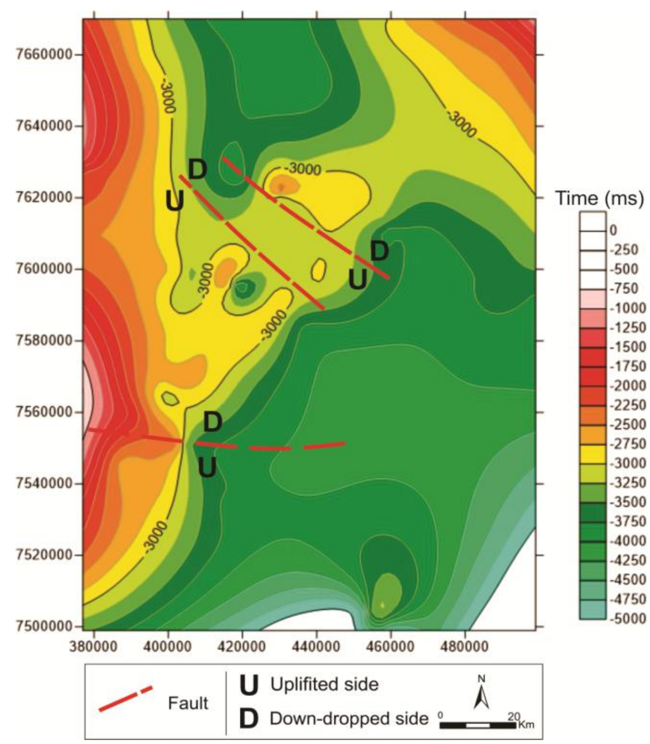

***Figure 7 -** Structural contour map of the Maastrichtian - Upper Cretaceous.*

On both structural contour maps are identified the uplifted side and the down-dropped side of the faults, observed in the seismic lines.

In the main geological faults was observed - in seismic profiles - a slip of 90 meters, on average. This measure is enough for the generation of hydrocarbon traps.

However, this fact explains the accidents of oil leakage registered in Roncador field in 2012, because this system affects the upper stratigraphic layers (shallower), making the seals of this field highly vulnerable.

In a simplified model of the top of the Maastrichtian, was possible to observe the resulting features of the halokinetic influence in this layer (figure 8), proven, as well, by the interpretation of the seismic line 66-08 (figure 9), where it is possible to observe in detail the deformation of the reflector of the Maastrichtian by the salt domes.

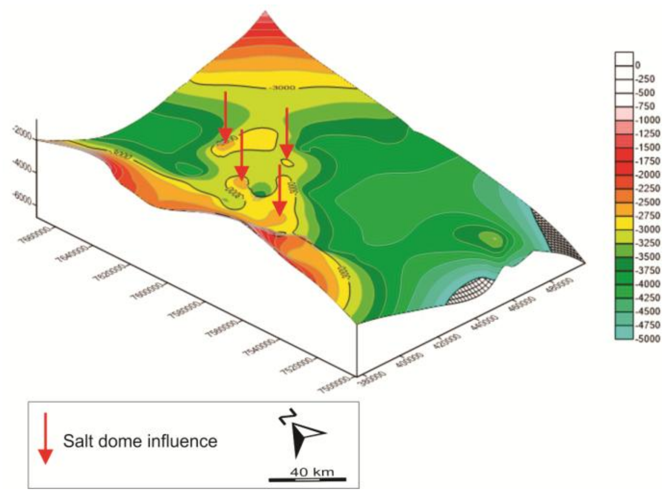

Figure 8 - *3D model of the surface of the Maastrichtian - Upper Cretaceous. Emphasis on the salt dome influence.*

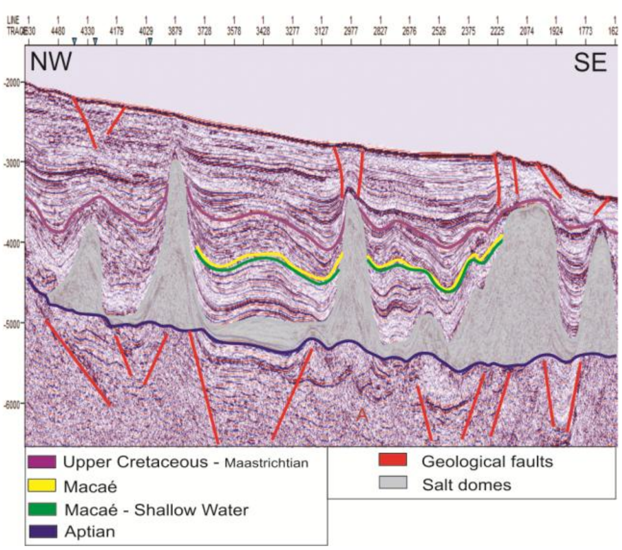

Figure 9 - *Seismic interpretation of Seismic line 66-08.*

The interpretation of potential method demonstrats the direct influence of the rift system on this field - proven by faults reactivation, ranging from the basement through the salt domes, to the sea bottom.

Figure 10 and 11 shows the magnetometric and gravimetric map, where the main faults indentified on the structural contour maps can be observed as well - culminating with the proposition of the rift system reactivation, at the maps the fault plane discontinuities are observed at the contour discontonuity.

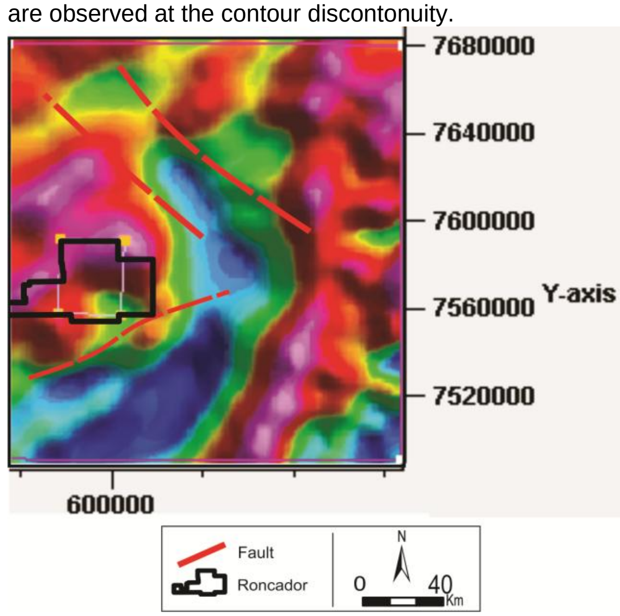

Figure 10 – *Magnetic map, hot colors (purple and red) represents highs and basalt intrussion.*

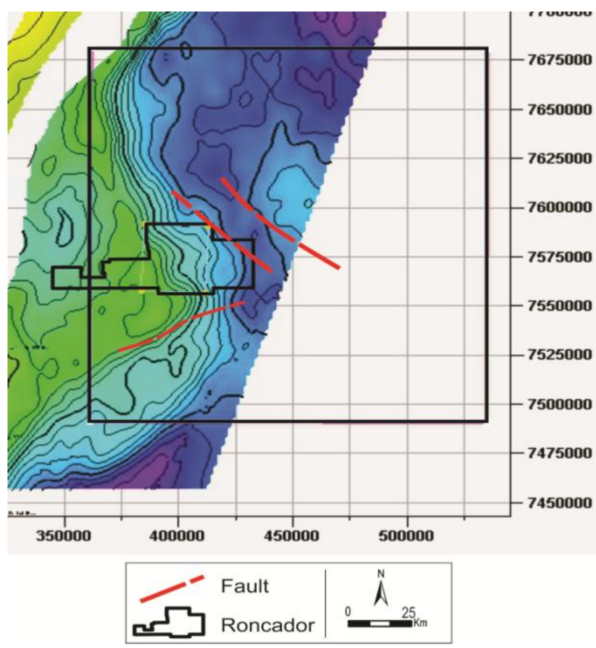

Figure 11 – *Gravimetric map representing the basement basin configuration, hot colors (green) represents structural highs.*

Conclusions

The extension of the faults from the basin basement to the sea bottom, represents areas of geological instability - mainly due the high level of halokinetic influence on the superficial layers, which makes - at the same time - the field an excellent area for trap the hydrocarbons, but a the seal is considered reasonable because the fault systems reach up the sea bottom and dip slip in average 90 meters.

The fault system observed at the sea bottom were tectonically reactivated, because the same feature is observed at gravimetric and magnetometric maps.

The high vulnerability of the hydrocarbon seals on this field - for reasons already discussed - brings the discussion of the possibility of accidents, such as oil leakage. For the reason, research on environmental and structural aspects are recommended.

Acknowledgment

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