



Geophysical analysis of the main reservoir at Estrela do Mar oil field – Santos Basin - Brazil

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Abstract

The Estrela do Mar field is considered a marginal hydrocarbon field because its production history, but this condition is maybe justified by the absence of geological and geophysical studies oriented to better define the effective reservoir facies. The area is located in the Santos Basin in the Southeastern portion of the Brazilian continental margin. In order, to better define the reservoir facies distribution at Estrela do Mar region geophysical and geological data was integrated through the use of seismic data and wire logs such as gamma ray (GR), resistivity (ILD), density (RHOB) and sonic (DT) logs for the all the 4 available public wells. As result, it was possible to generate a correlation section to identify the main formations and reservoirs in the field; contour structural maps for each one of the reference stratigraphic units (Aptian top, Albian top, Albian-Cenomanian turbidites, Oligocene-Miocene and Sea Bottom) and seismic attributes maps were generated for the oil producer levels to better describe potential reservoirs in the Estrela do Mar field. The results shown that the Tombo Member (Albian-Cenomanian) that is a turbiditic sequence contained in the Itanhaem Formation is a good reservoir (8% and 30-meter-thick) because it propitious stratigraphic and structural framework, the RMS Amplitude attribute map also shows a regional distribution of the Tombo Member but it is less heterogeneous at the Southeast portion of the study area.

Introduction

Discovery in 1991, the Estrela do Mar field is distributed in an area of 32.7km², and is located in the Santos Basin, in the Southeastern portion of the Brazilian continental margin (Figure 1).

There is a lack of information about the Santos Basin despite the prolific potential, specially about the Estrela do Mar field, further data is important to better define the known reservoirs and to further explore new possibilities.

The objective of this paper is to characterize possible reservoirs and its regional distribution in the Estrela do Mar field applying well correlation and seismic data integration techniques, seismic attributes are also include in the analysis.

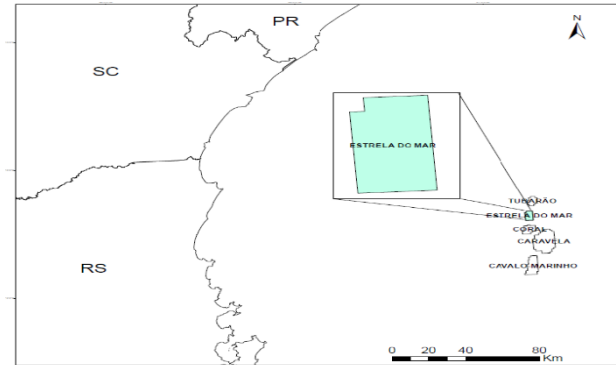


Figure 1: Localization map of the Estrela do Mar field.

The Santos Basin was formed during the Mesozoic drift between South America and Africa, and its stratigraphic framework is comprised by three super sequence that corresponds to a rift, post rift and drift stages as defined by Moreira et al 2007, described by the author as follow:

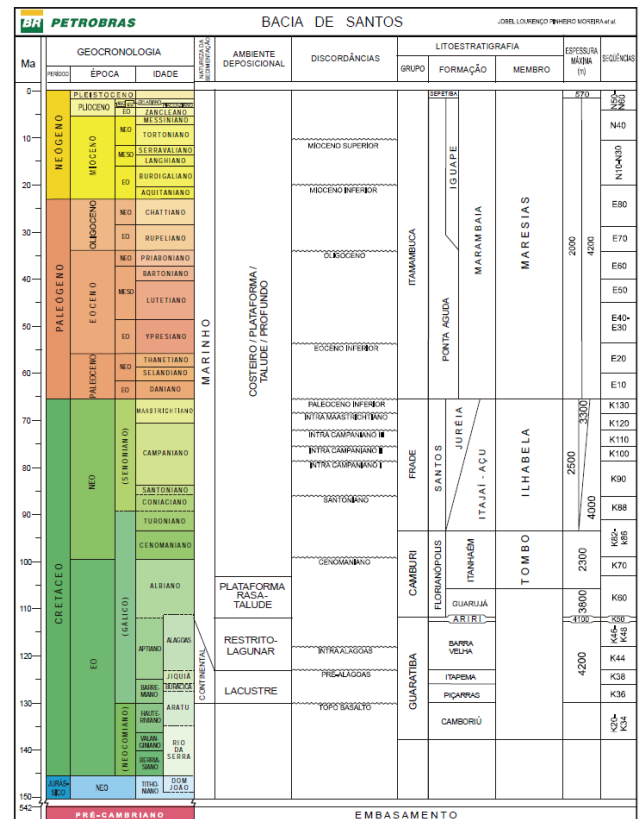


Figure 2: Stratigraphic chart of the Santos basin. (Source: Moreira et al 2007)

The rift stage is formed by the Guaratiba Group that is composed by the Camboriu Formation that is mostly basaltic rocks; the Piçarras Formation that consists of clastic and carbonate rocks such as polymictic conglomerates, sandstones, shales and coquinas and the last formation of the rift stage, Itapema Formation that is composed by limestones and dark shales rich in organic matter, that are the main source rock in the Santos basin.

Ensuing the rift super sequence, but belonging to the Guaratiba Group as well, is the post rift super sequence expressed by Barra Velha Formation (Upper Aptian) that in its proximal sections composed by limestones, of stromatolites and laminated microbialites and in the distal sections it is formed by shales; subsequently is the evaporites of Ariri Formation.

The drift super sequence initiate with the Camburi Group, composed by the Florianopolis, Guarujá and Itanhaém Formations. The Guarujá Formation is an important carbonatic reservoir from the Lower Albian, composed by oolitic calcarenites, calcilutites and marls. The Tombo Member is also an important reservoir formed by tubidites.

Superimposed the Camburi Group, the Frade Group has an important formation that compose other source rocks in the basin, the Itajaí-açu Formation (Cenomanian-Maastrichtian) formed by fine-grained clastics, including dark grey shales. The Ilha Bela Member is an important turbiditic reservoir in this Group as well as the sandstones in the Juréia Formation (Santonian-Maastrichtian).

The Itamambuca Group comprises the Ponta Aguda, Marambaia and Iguapé Formations, and the uppermost Formation in the basin is the Sepetiba Formation.

Method

To execute this research were analyzed 40km² of 3D seismic data provided by the Brazilian National Agency of Petroleum, Natural Gas and Biofuels (ANP) via the free-data-transfer for research in public universities.

The Estrela do Mar field contains 4 public wells that were used in this study: 3EM 002 BSS, 3EM 003 BSS, 3EM 004 BSS and 1BSS 055 BS. (Figure 3)

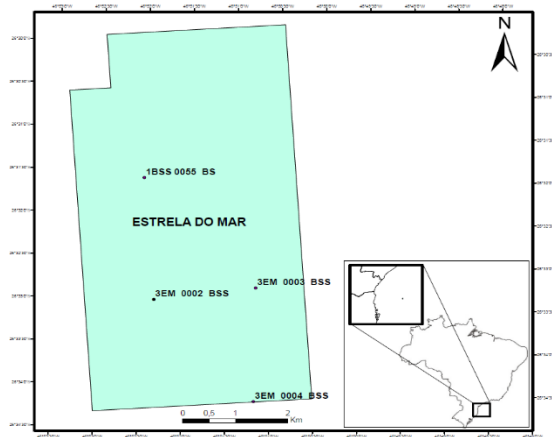


Figure 3: Localization map of the well in the Estrela do Mar field.

The database is comprised by Gamma Ray (GR), Resistivity (ILD), density (RHOB) and sonic (DT) logs for all the 4 wells, that were used to generate a well logging correlation to identify the main formations in the Estrela do mar field. (Figure 4)

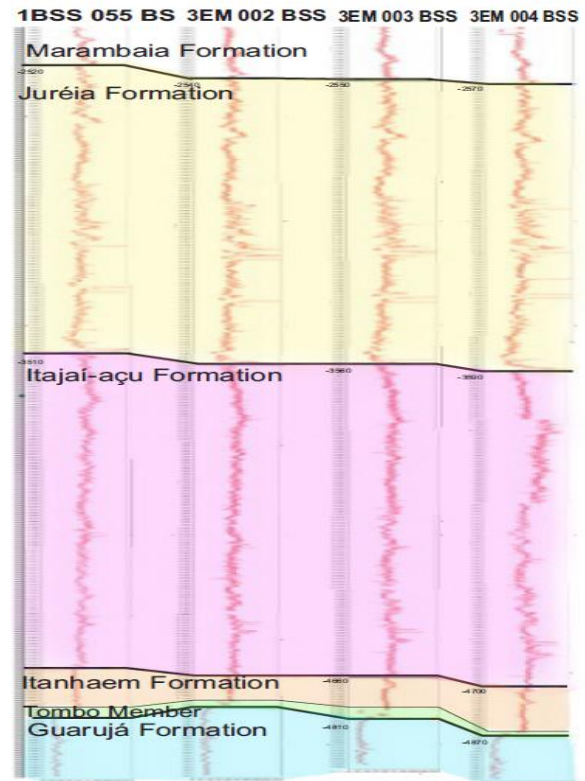


Figure 4: Gamma ray logging showing the correlation of the main formation in all the wells.

In order to generate a seismic map, the sonic profile was used to construct a synthetic seismogram to calibrate the rock information with the seismic data, for this the well 3EM 003 BSS was adopted.

The conversion of the time to depth was established through the use of the stratigraphic layer depth and velocity measured on the sonic profile.

Subsequently, the stratigraphic units in the field were established on the seismic data.

Contour structural maps were produced for each one of the stratigraphic units and seismic attributes maps were generated for the productive levels.

Results

In the seismic data was possible identify the main stratigraphic units according to the calibration of the seismic data (Figure 5). As result, there are 5 seismic reflectors surface strongly marked in the seismic data that corresponds to Juréia Formation, Itajaí-açu Formation, Tombo Member, Guarujá Formation and Guaratiba Group.

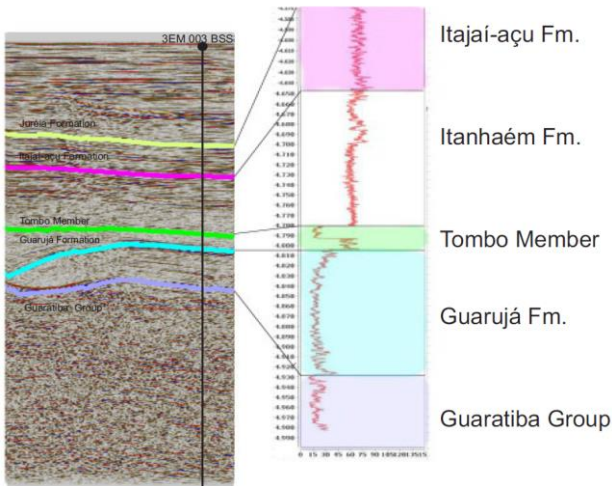


Figure 5: Correlation between seismic data and the Gamma ray logging.

The structural contour map for the Jureia and Guarujá Formation, that represents the first 2 units identified and mapped, exhibit similar structural contours maps with a main dip to the Southeast. (Figure 6)

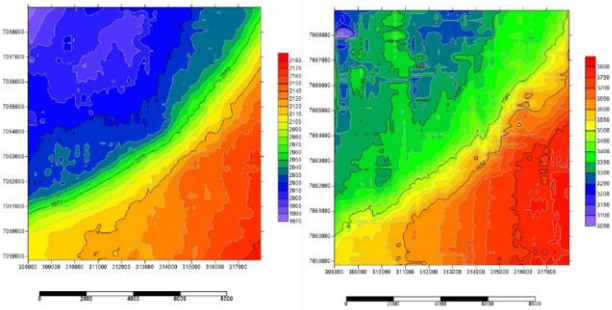


Figure 6: Contour structural map, of the Jureia Formation (Right) and Guarujá Formation (Left).

The contour structural map from the Tombo Member (Figure 7) shows a structural high at the central portion of the study area close Tubarão oil Filed, maybe this map represents the region where the Albian-Cenomanian turbidites were deposited in the top of the carbonatic sequence.

It is important to mention that the observed structural highs appears to be formed by the own evolution of the carbonatic bank and structural features like faults were not observed at this seismic volume, maybe a regional analysis would batter explain this fact.

In a qualitative analysis, when compared the geophysical facies distribution map, obtained from the RMS amplitude – attribute map, is verified that the best sandstone body (turbidite) does not coincide with the observed structural high, at this structural feature the reservoir facies are highly heterogeneous (green anomalies observed at the central and Northwest portion of the map at the figure 8).

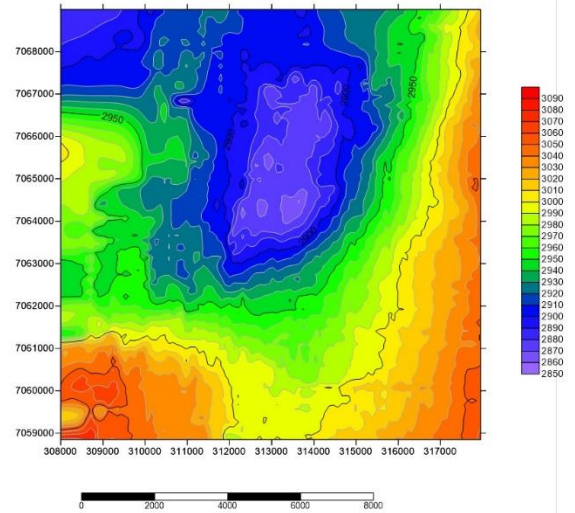


Figure 7: Contour structural map of the Tombo Member, scale in milliseconds.

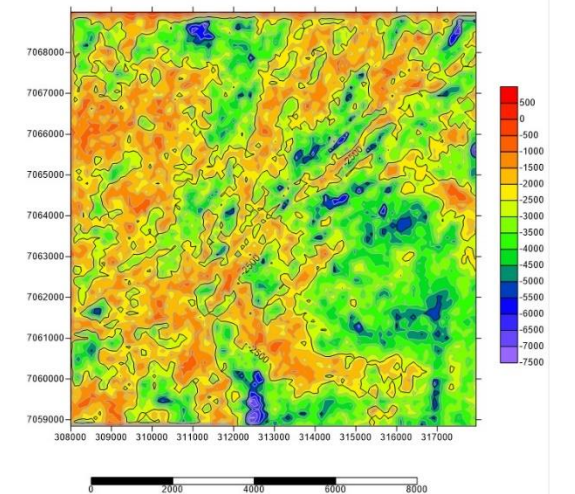


Figure 8: map of seismic attribute of Tombo Member (RMS Amplitude)

As final consideration, for the hydrocarbon potential related to Tombo Member, is possible to confirm that the main traps would be stratigraphic, located at structural lows.

The structural top of Guaratiba Group (Figure 9) shows a main structural high with azimuth mainly North to South, at the center of the area; the mentioned feature shows a smooth dip to the East associated with the Albian carbonatic bank growing, but the dip observed at the West limited represents an abrupt dip of the same shoal limit, structural features like faults are not present for this stratigraphic level, maybe this high angle dip is conditioned by the Aptian carbonates paleo-geometry.

Conclusions

The analysis of the contour structural maps and the seismic data shown that the Tombo Member, that is a turbiditic sequence between 2 carbonatics sequences (Guarujá Formation and Itanhaém Formation) and above one source rock (Guaratiba Group), contains its main

reservoir facies at the Southeast of the area, in an unexplored region. The trap is not structural as known at the literature and it would be a stratigraphic play located in a structural low, this conclusion is based in a qualitative analysis of the structural and geophysical facies maps.

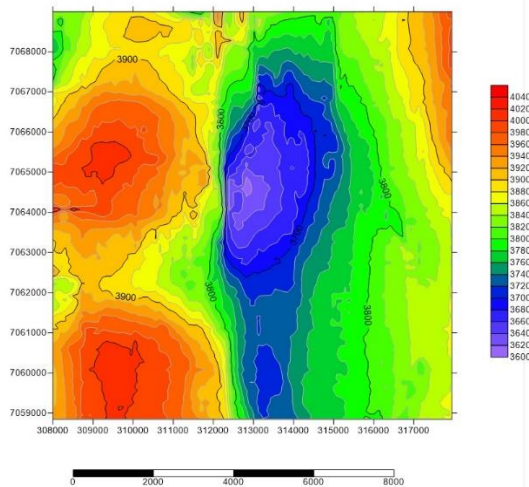


Figure 9: Contour structural map of the Guaratiba Group

Even with low porosity (about 8%), the Tombo Member at Estrela do Mar field represents a good reservoir for hydrocarbons (mainly gas and light oil), if these conditions were verified, a re-exploration of the oil field is indicated.

Acknowledgments

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