Tectono-stratigraphic analysis of Carbonate Rift Reservoirs in Lagoa Feia Group – Southwestern of Campos Basin - Seismic Attributes and Well Profile Integration

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Abstract

The Carbonate reservoirs recognized at the rift section in Campos Basin are represented by rudstones facies (coquines) of Lagoa Feia Group. This sequence is dated between the Upper Barremian and Upper Aptian and comprises the main source rock of the basin (Jequiá shales) as well as facies like rudstones, grainstones and bioclastic packstones. In the southwestern portion, the rudstones reservoirs represented the main production of oil discoveries at the mid-70s, however, current discoveries of new and highly relevant oil accumulations in the rift section of the Campos and Santos , on coquines reservoirs, lets us re-started the studies about this kind of play.

The objective of this research is to perform a geophysical characterization of Lagoa Feia Group in the southwestern of Campos Basin, using well correlation techniques, seismic data (3D) and seismic attributes, in order to evaluate the answer of the geophysical data to the carbonate rift reservoir (coquines) distribution based on tectono-stratigraphic analysis.

The results show that the carbonate reservoir in Lagoa Feia Group are distributed along the whole Campos Basin with the highest thickness inside semi-grabens structures that can be associated with the Rift phase and the paleo-margin basin.

Introduction

The carbonate rift reservoirs in the southwestern portion of the Campos Basin represented great oil production discoveries in the mid-70s and since that data several studies have been made in order to better known these kind of reservoirs. Over the years a natural decline in production on this reservoirs re-direct the studies efforts to Albian carbonates and Oligo-Miocene turbidities reservoirs, also oil producer in the basin. However, the current findings of new and highly relevant accumulations in the rift section of the Santos and Espírito Santo Basins indicate that studies related to coquines reservoir distribution are necessary in order to better understand the main factors that would conditioned the distribution of carbonate rift reservoirs in offshore Brazilian basins.

The complexity to determine the distribution of carbonate reservoirs is associated with the wide variation of its facies and diageneses in a short distance in both main directions, vertical and horizontal plane. It is necessary and highly strategic broadening the tectonic-chrono-stratigraphy understanding and look for techniques that allow advances in the characterization and distribution of the physical properties of these reservoirs along the geological time and space.

The analyzed area (Figure 1) is located in Campos Basin 80 Km far from de cost with approximately 500 Km^2. The area comprises the offshore production fields of Pampo, Linguado, Trilha and Bicudo. The carbonates rocks reservoir consists in rudstones, grainstones and bioclastic packstones of Coqueiros Formation with presence of some shales, shale-sand, marls and conglomerates between these layers.

The main objective is to apply tectono-stratigraphic analyses based on geophysical characterization, well correlation techniques, 3D seismic interpretation and seismic attribute maps.

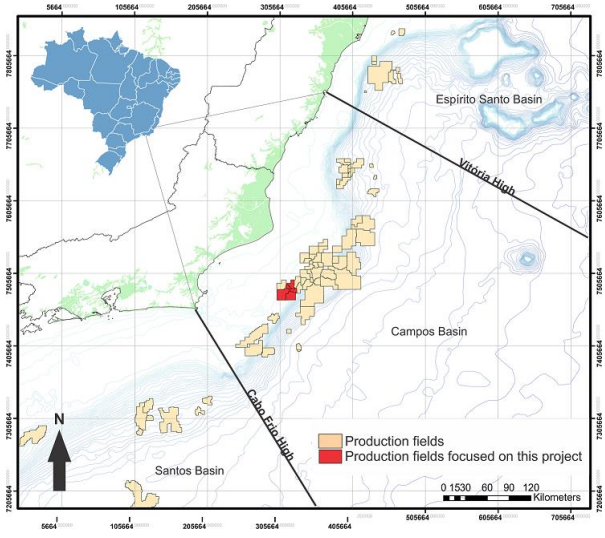

Figure 1. Project location area showing the production fields and the structural limits in Campos Basin.

Method

The study was developed using a set of 3D seismic data and 24 wells data folders (Figure 2) provided by the Agencia Nacional do Petroleo (ANP) through BDEP (Banco de Dados de Exploração e Produção) following the policy of providing data to develop researches in Brazilian public universities. This project was leading in three main stages using *Decision Space** Desktop (Landmark) software.

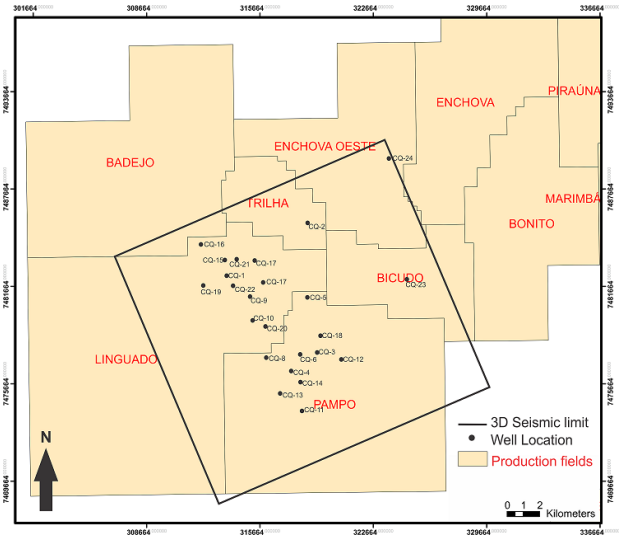

Figure 2. 3D seismic limit and well location

1. Well Profile Interpretation

This phase was characterized by research and compilation studies from rift phase from Campos Basin and the comprehension of its main Aptian carbonates reservoirs, in terms of geological and stratigraphic evolution, theoretical principles of geophysical methods and analogs reservoir characterization.

Using the basic curves in .las format, it was made a visualization comprising logging depth interval of interest (Lagoa Feia Group); among the well profile, it was interpreted: gamma ray data (GR) Resistivity (ILD), density (RHOB) and sonic profile (DT), whose was integrated with the composite profiles and history data well. This well corraletion process allowed the highest detail interpretation of Lagoa feia group and its subdivision carbonate reservoirs, following Baumgarten, 1985 and Dias el al., 1988 the stratigraphic division were based on eletro-radiactive markers (electrofacies).

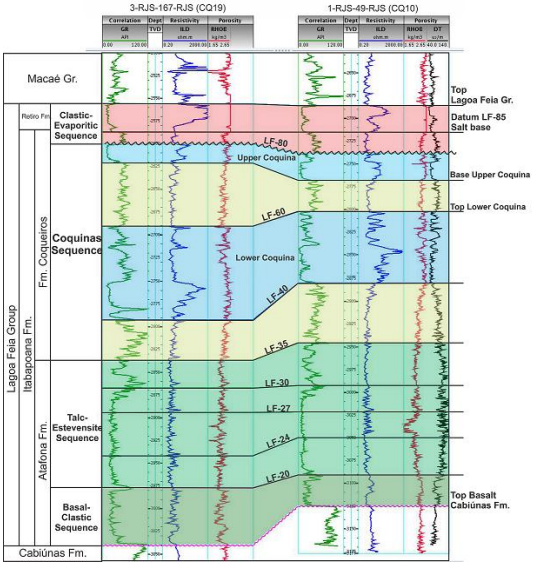

Figure 3. Well profile interpreted marks (by Baumgarten, 1985 and Dias et al., 1988)

The well correlation was carried out by the main stratigraphic markers and layers recognition, through the lateral correlation of this stratigraphic layers, the applied principle was the recognition of the same physical properties among the profiles, as illustrated in the Figure 3 in order to define the distribution of the reservoirs along the study area.

2. 3D Seismic interpretation and well profile integration

A synthetic seismogram was built using the sonic and density profile per each interpreted well, this allowed the calibration between the rock interpreted information (stratigraphic markers) and the seismic data. The calibration was used as a parameter to define the position in time-depth of the interest horizons.

The depth-time conversion of each stratigraphic marker was performed by the calculation position in two-way-time (seismic cube), based on depth measured on well, and its relationship with the upper horizons - thickness, and the interval velocity measured on the sonic profile DT.

After this, the stratigraphic intervals of carbonates reservoirs were recognized in seismic cube and interpreted along the seismic data. These interpretations allow the comprehension of structural context, mapping reservoir top and base at the study area. The attribute maps interpretation based on those interpreted horizons helped the distribution of these reservoirs in three-dimensional environment.

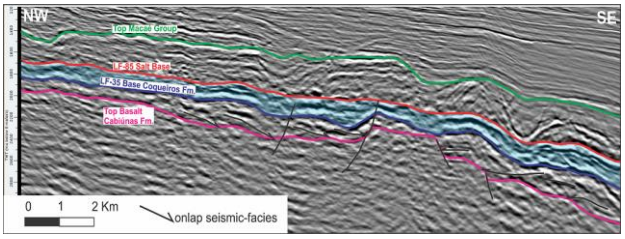

Figure 3. Seismic Section showing the horizons interpreted

3. Correlation attribute maps and tectono-stratigraphic analyses

Structural maps were generated using the top and the base of the two main carbonate rift reservoirs levels identified on Coqueiros Formation (Lagoa Feia Group) and on the top of economic basement (Cabiúnas Fm.). It is possible to interpret these maps like pseudo - structural maps in time and correlated with some attribute seismic data, considering that the water layer is almost constant along this region.

A huge volume of attributes maps were generated with the aim of verify the correlation between lateral changes and distribution on the main carbonate reservoir with the seismic data properties among these maps it is possible to mention the *Total Energy* and *Amplitude_H*.

Results

The stratigraphic background is limited by four stratigraphic sequences (Dias et al., 1988) that can be recognized and delimited based on well profiles and sismo-stratigraphic data. Each deposicional sequence limit is associated to unconformites or stratigraphics markers following Baumgarten, 1985 division. The Basal Clastic sequence that is deposited above the basaltic rocks (Cabiúnas Fm.) is limited on top by the LF-20. The Talco Stevensite sequence is limited on top by the LF-35 and is composed by lacustre sediments of Atafona Fm. The Coquinas sequence is limited on top by evaporitics deposits and is composed by Coqueiros Fm. sediment's focused on this project. Between this stratigraphic interval could be describes two main carbonates reservoirs: Upper Coquina and Lower Coquina, those are limited by the marks LF-80 and LF-60 on the top respectively.

This sequence is superimposed by the Clastic-Evaporitic sequence and those are by the Macaé Group carbonates.

Six stratigraphic layers were correlated along the study area (Figure 5a, b, c and d), considering the Evaporitic Clastic sequence on the top; the two main subdivision reservoirs on Coquinas sequence, that are the main objective of this research; and, Talco Stevensite and Clastic Basal sequence as just one undivided layer.

The stratigraphic datum used in the sections and well correlations was Clastic-Evaporitic sequence base LF-80. In all the sections (Figure 5a, b, c and d) is possible to observe that the Talco-Stevensite and Basal-Clastic sequence have an increased thickness when inside the lower structure (grabens and semi-grabens) and is thin or absent when above high structures (horsts). On the seismic section (Figure 7a and b) is possible to interpret the onlap seismic-facies on Talco-Estevensite sequence against the Cabiúnas Formation extrusive rocks.

The Coquinas Sequence shows a most homogenous distribution of its thickness, as can be visualized on the Figure 6 that presents this sequence's isopach map, however, a little higher thickness associated with the lower structures is still observed.

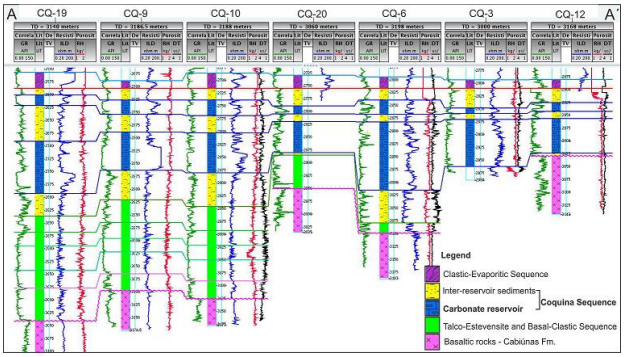

Figure 5a. Section A – A'

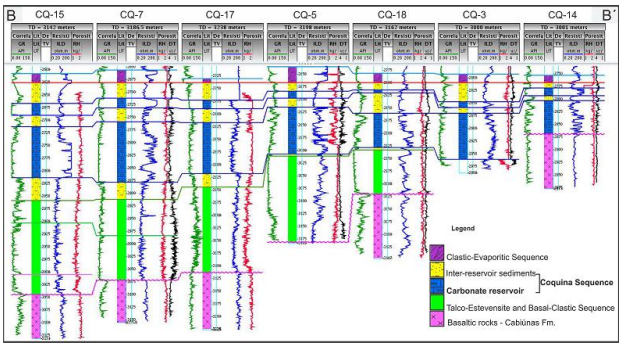

Figure 5b. Section B – B'

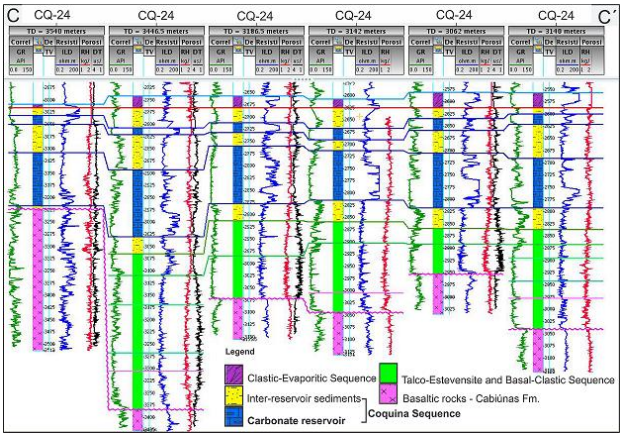

Figure 5d. Section C – C'

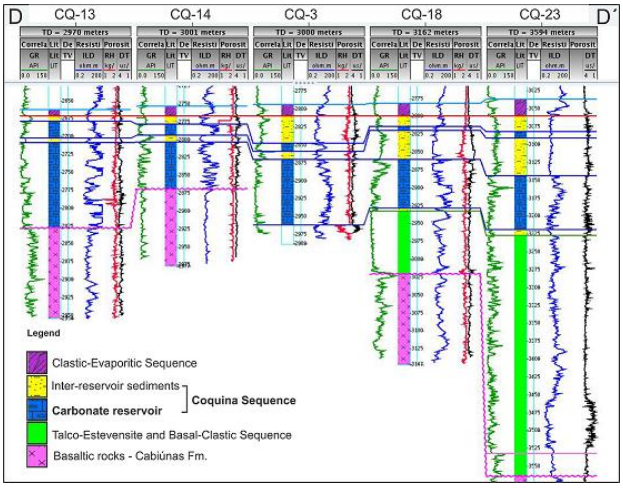

Figure 5d. Section D – D'

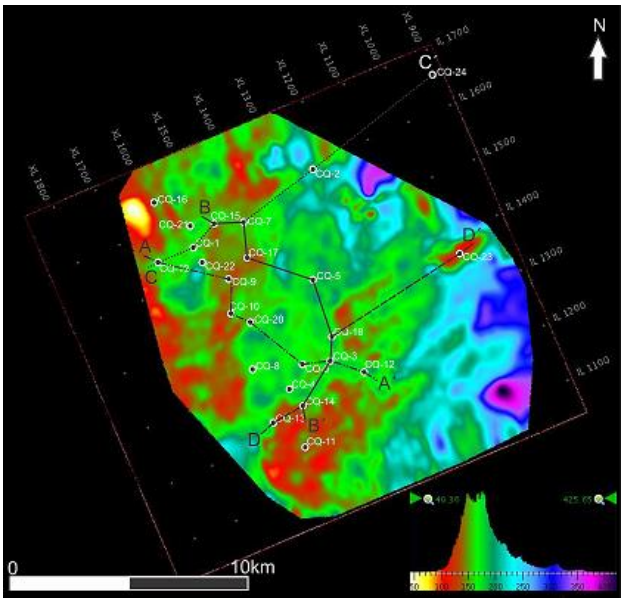

Figure 6. Isopac map in time(ms), between the top and base of Coquinas Sequence and the correlation sections location.

The seismic sections on Figure 7a and b shows that Lagoa Feia sediments advanced from N-NW to S-SE thought *onlaps* over the basaltic surface as Baumgarten, 1985 was interpreted. The structural base map of the Coquinas sequence (Figure 8) shows that a higher structure on the southwest of the area, which is associated with basaltic basement and it is near of one paleo-margin basin interpreted by the seismic data and the attribute map on Figure 9.

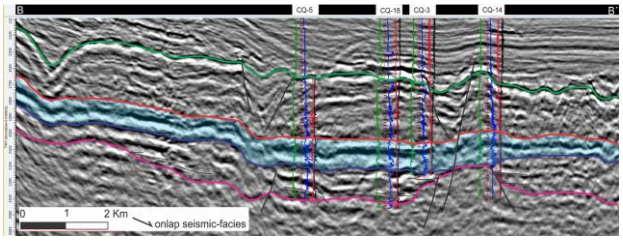

Figure 7a. Seismic section B – B

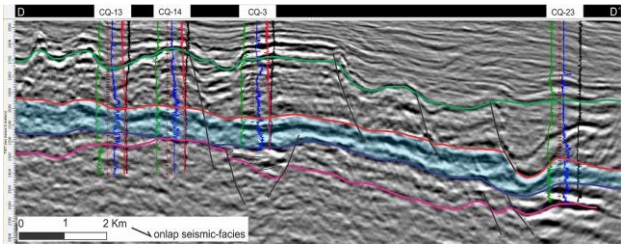

Figure 7b. Seismic section D – D

The attribute map of Total Energy (Figure 9) was built with the Coquinas sequence base and has a good correlation with the fault structures and the thickness of the lower coquinas reservoir.

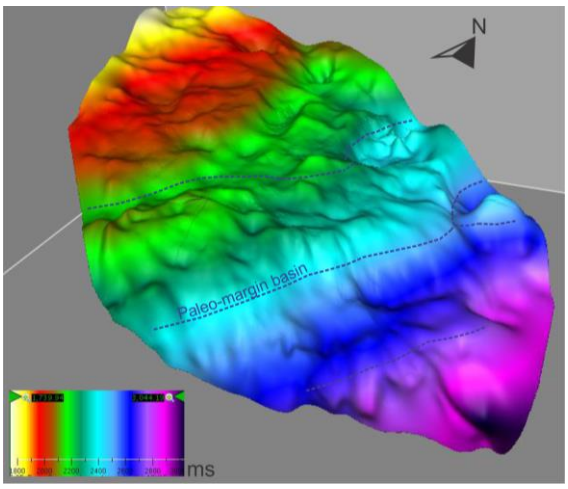

Figure 8. 3D Base Coquinas Sequence structural map in time(ms)

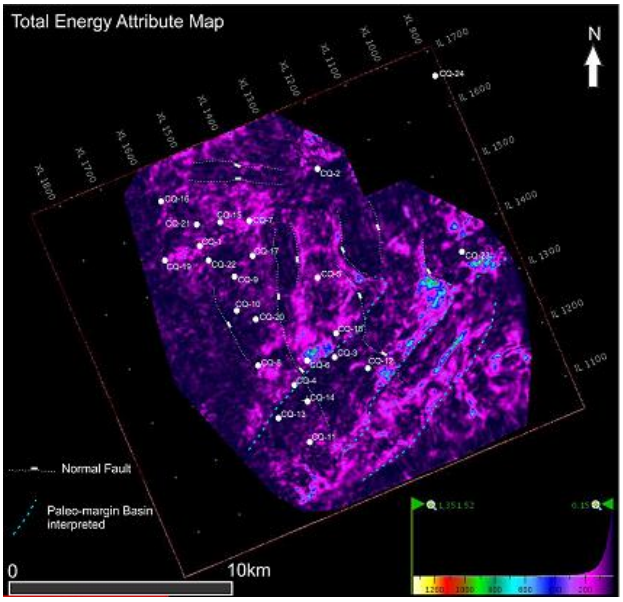

Figure 9. Total Energy Attribute map.

Conclusions

The Lagoa Feia sediments are distributed along of all Campos Basin with the highest thickness inside the semi-grabens structures that can be associated with the Rift phase.

During the Lagoa Feia sedimentation the tectono-sedimentary reservoir shapes were not submitted to significant process changes. The tectono-stratighaphic analyses of carbonate rift reservoirs (Lower and Upper Coquina) distributions shows that this sediments are associated with the paleo-margin of the basin and the syn-sedimentary faults that confining reservoirs.

Acknowledgments

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