# Characterization of Macae Albian Reservoirs in Garoupa Field – Campos Basin – through Seismic and Well Profiles Integration

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## Abstract

Large oil reserves were recently found in carbonate reservoirs, therefore it is important to understand the physical properties of this rock and its behavior in response to seismic and petrophysical interpretations in order to reduce the risks of exploration.

The objective of this research is to perform a geophysical characterization of the physical properties of reservoir rocks (Macae Group – Garoupa field), using well correlation techniques and seismic data (2D / 3D), in order to evaluate, quantitatively, the answer of the geophysical data to the presence of the carbonate reservoir.

The methodology tested here depends on the relationship between the reservoirs elements. In some cases, like Garoupa oil field the obtained answer from attributes maps is hardly controlled by the kind of fluid inside the pore.

Another important element to characterized the Garoupa accumulation is defined by its structural definition, limited by two main faults with the main direction NW-SE.


## Introduction

The Garoupa Field (figure 1) represents the first commercial hydrocarbon discovery at Campos Basin (1974) in the Albian carbonates of Macae Group.

Large oil reserves were recently found in carbonate reservoirs, therefore it is important to understand the physical properties of this rock and its behavior in response to seismic and petrophysical interpretations in order to reduce the risks of exploration.

Apart from research to discovery of new reserves, the investment in mature fields is extremely important. The complexity of the Garoupa field joint to its maximum exhaustion, caused by the amount of years in commercial production, it is interesting to be evaluated. In this sense new studies on old oil fields would determine how new technologies could contribute to increase the life of the field.

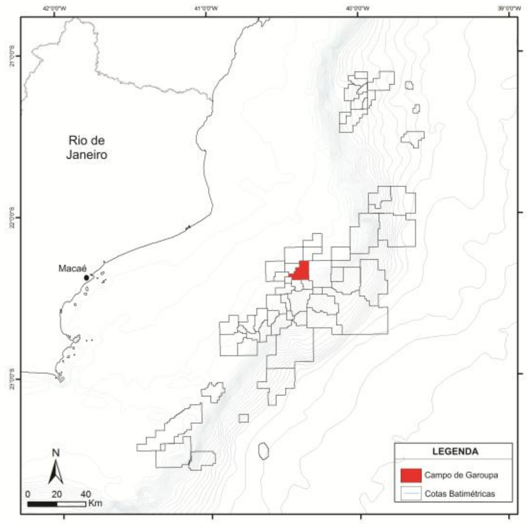


Figure 1: Location of the Campos Basin with emphasis on the Garoupa Field.

With an area of approximately 16 km², the Garoupa field still produces oil with a density between 29 ° and 32 ° API (CPRM, 2003). The reservoirs consist in calcarenites of Quissamã Formation where the top is located ate 3130 m and also they are structured in an anticline bounded by thrust listric faults one to the West and another at the East (Figure 2). The column of oil in the field is approximately 145 m with porosity ranging from 17 to 22% (Tigre, 1988).

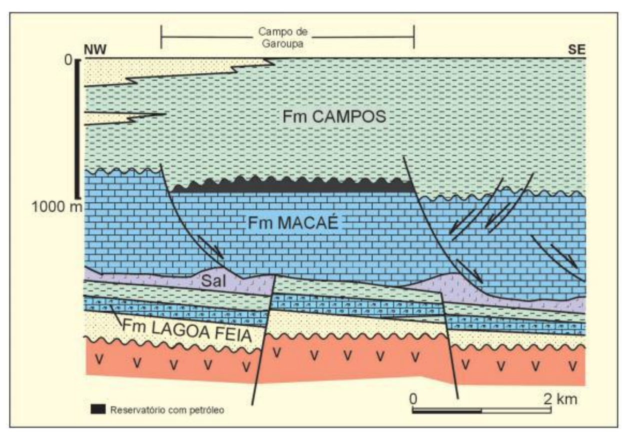


Figure 2: Schematic geological section with stratigraphic-structural configuration of the Garoupa field - Campos Basin. (Source: CPRM, 2003).

## Objective

The objective of this research is to perform a geophysical characterization of the physical properties of reservoir rocks (Macae Group – Garoupa field), using well correlation techniques and seismic data (2D / 3D), in order to evaluate, quantitatively, the answer of the geophysical data to the presence of the carbonate reservoir.

**Method**

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

1) Database Configuration

This phase was characterized by research and compilation of studies from the Campos Basin and Garoupa Field, in terms of geological and stratigraphic evolution, theoretical principles of geophysical methods and analogs reservoir characterization.

Moreover, this stage was defined by the organization of a database comprising 10 seismic sections 2D in .SGY format, a 3D seismic cube and 6 wells (figure 3) with their composite profiles, historical production and basic curves in .las format.

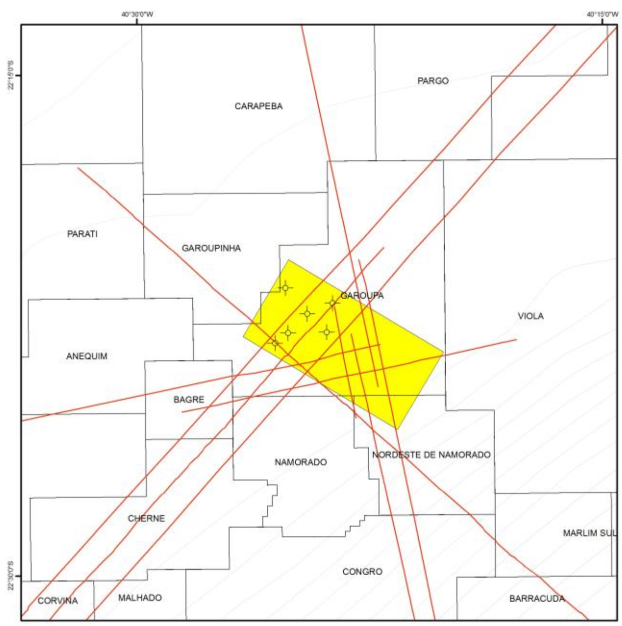


Figure 3: Localization of Wells, Seismic Lines 2D and the seismic Cube.

2) Well Correlation

From the basic curves in .las format, it was made its visualization comprising logging depth interval of interest (between 2,900 m and 3,500 m), gamma ray data (GR) Resistivity (ILD), density (RHOB) and sonic profile (DT), whose integration with the composite profiles and history data well, allowed the interpretation of the top of Macae Group, lithologies and their subdivision in reservoirs.

The well correlation was carried out by the main stratigraphic layers recognition, through the lateral correlation of layers with same physical properties among the profiles of the wells toward NE/SW, as illustrated in the Figure 4, in order to define the behavior of the reservoirs in the field and its petrophysical analysis.

3) Seismic interpretation

The software used for this step was the Seisworks (Landmark) on the Openworks- R5000 platform. Through the sonic and density profile, a synthetic profile of the well was built, this synthetic seismogram allowed the calibration of the rock information with the seismic data on the location of the well 7GP_0004_RJS and the 2D seismic Line 0038-0227. This seismic line crosses the 3D cube, and its calibration was used as a parameter for define the location of the interest horizons.

The time-depth conversion was performed by the calculation of stratigraphic layer depth using the velocity and depth measured on the sonic profile DT.

After this, the stratigraphic intervals of carbonates reservoirs were interpreted along the seismic data, in order to understand the structural context of the study area and the distribution of reservoirs in three-dimensional environment.

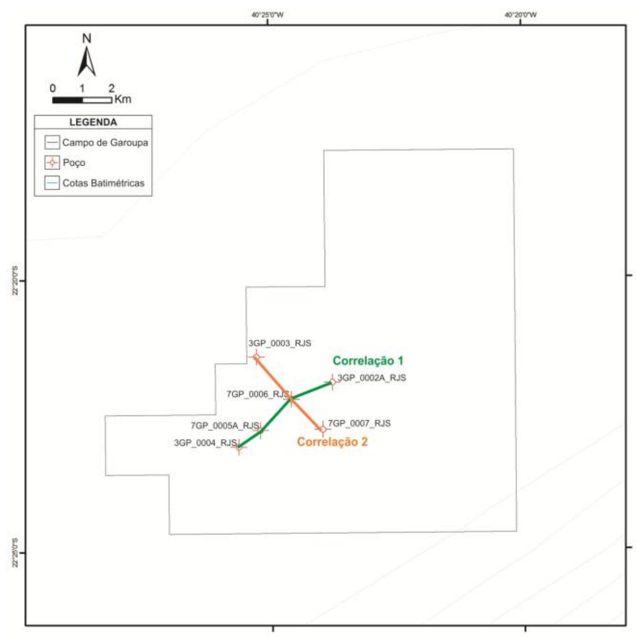


Figure 4: Localization of the wells in the Garoupa field and their correlations 1 (NE) and 2 (NW).

4) Making Maps

Contour structural maps were generated on the top of the two main reservoirs levels on the carbonate of Quissamã Fm. It is possible to interpret these maps like the actual structural maps because the water layer is uniform along the oil field.

A huge volume of attributes maps were generated with the aim of verify lateral changes on the main carbonate reservoir, among these maps it is possible to mention the RMS amplitude, average peak amplitude, average absolute amplitude, among others.

The attribute anomaly was calibrated by rock, through cross plots between seismic attribute and rock properties with the objective to determine the error of facies reservoir prediction from attributes maps analysis.

## Results

Eight stratigraphic layers were correlated along Garoupa Field (Figure 5), four of these are Quissamã regional reservoirs and this work focuses the first two reservoirs.

The two main reservoirs were interpreted on the seismic lines (Figure 6), it was observe normal and reverse faults defining the main structural high were the reservoir is located. Some of these faults appear to be movement normal and reverse through the geological history.

When observed the structural map, the carbonate platform is verified on the West portion of the field, when the main wells were drilled.

The principal attributes maps for the shallow reservoir will be configured by Maximum absolute amplitude (Figure 8), and the average through amplitude (Figure 9) and the RMS Amplitude (Figure 10).

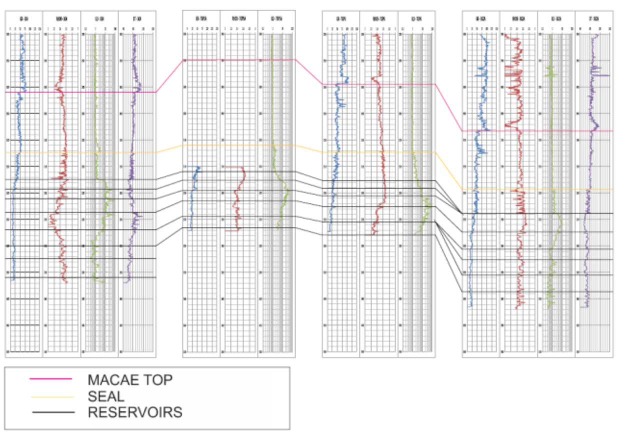


**Figure 5.- Well correlation on Garoupa Field**

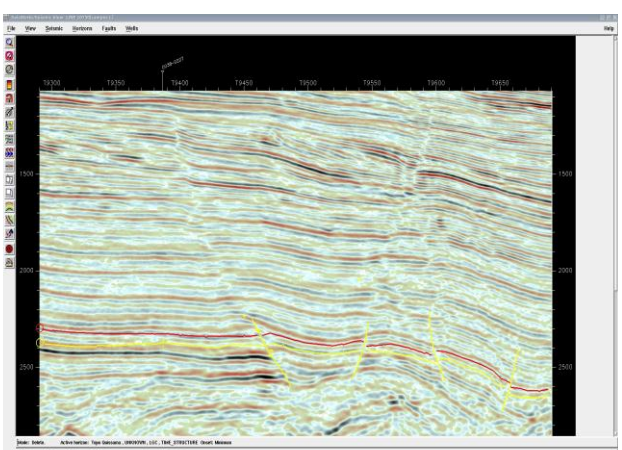

**Figure 6.- 3D Seismic interpretation along Garoupa Field**

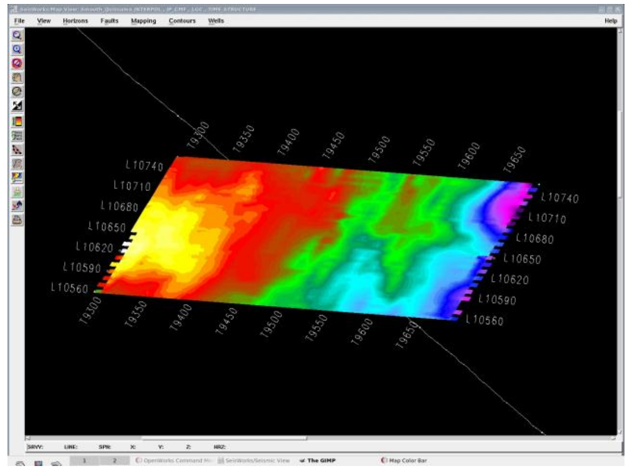


**Figure 7.- Structural map of Garoupa Field**

When observed the attributes maps, the reservoir is not clear, a main fault with NW-SE direction is identified on the three maps. A red anomaly is interpreted closed and at the right to the main fault, in the north of the geological block at the West, and it will represent the main reservoir.

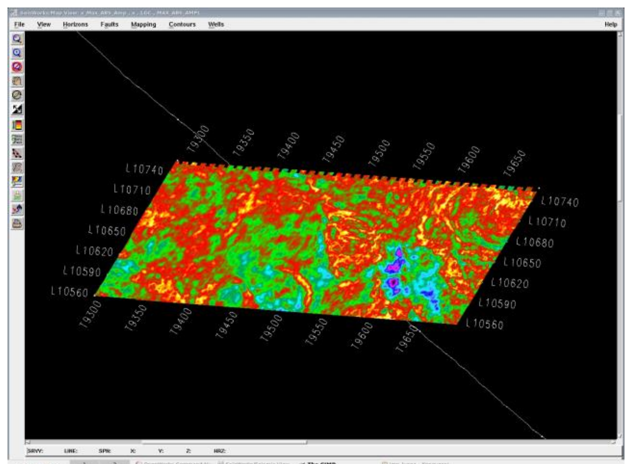


**Figure 8.- Attribute map of Maximum Absolute Amplitud for the shallow reservoir**

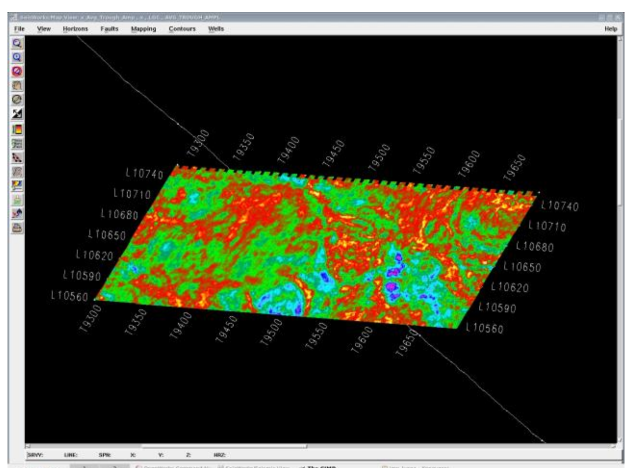


**Figure 9.- Attribute map of Average through Amplitude for the shallow reservoir**

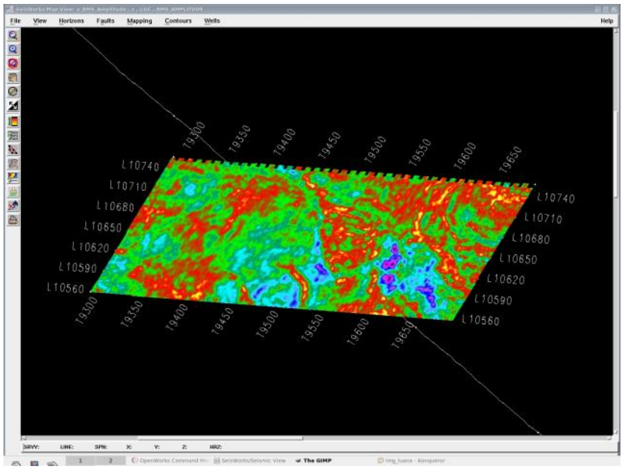


**Figure 10.- Attribute map of RMS Amplitude for the shallow reservoir**

In order to test the reservoir properties and its response on the attributes maps, the crossplots between the rock properties and attributes answer for the two main reservoirs are showed below (Figures 11, 12 and 13).

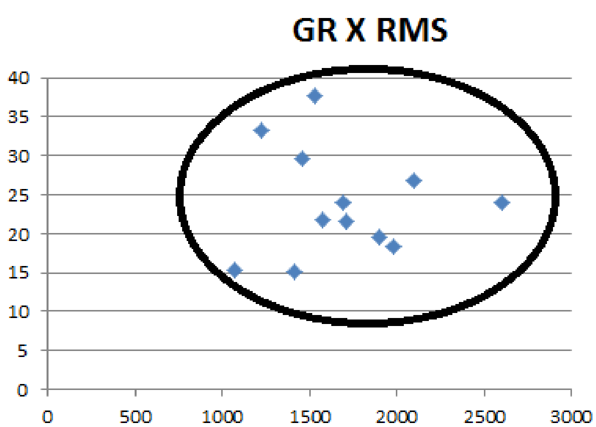


Figure 11. Crossplot between Gamma Ray Vs RMS Amplitude

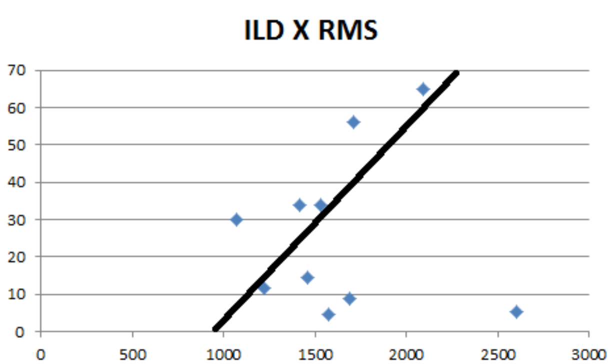


Figure 12. Crossplot between Resistivity Vs RMS Amplitude.

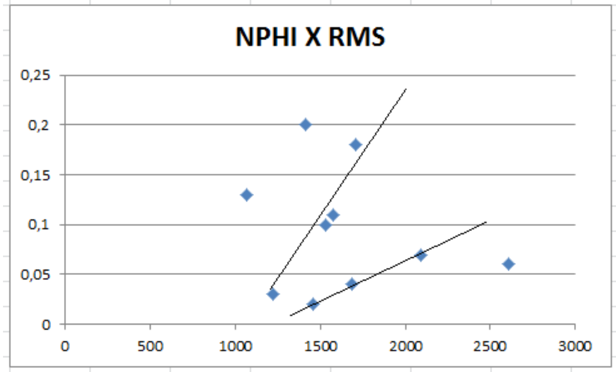


Figure 13. Crossplot between porosity and RMS amplitude.

As result, we would interpret that the best fit for attributes maps and reservoir properties for Garoupa field is through the fluid content of the reservoir. On this hand, the two shallow reservoirs are not able to be prospected using this kind of correlation and it indicates a high reservoir complexity of this field.

Finally, for carbonate fields like Garoupa in the absence of hydrocarbon we don´t expect seismic anomaly.

## Conclusions

The methodology tested here depends on the relationship between the reservoirs elements. In some cases, like Garoupa oil field the obtained answer from attributes maps is hardly controlled by the kind of fluid inside the pore.

Another important element to characterized the Garoupa accumulation is defined by its structural definition, limited by two main faults with the main direction NW-SE.

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