Albian Carbonates reservoir facies characterization on Campos basin, based on geophysical facies analyses

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Abstract

The geophysical determination of geological reservoir facies represents a challenge on petroleum exploration and production. In this sense, the integration of well logs and 3D seismic data, on volumetric seismic analysis, would help geophysicists on the definition of reservoir and non-reservoir areas or levels. It is important to mentioned, that this process is useful on siliciclastic and carbonates reservoirs. The main objective was the definition of better practices of seismic-reservoir characterization in order to do a best approximation of the geological model on carbonate´s reservoirs; in this case, Albian reservoirs from Campos Basin – Brazil. As methodology, the reservoir core data was integrated with log data, and the scale result was integrated with geophysical facies previously classified, the geophysical classification is based on neural net routines that use 3D seismic attributes as input. As result, it was defined that attributes cubes as Chaos and Acoustic Inversion must be include as input data, because they are the key on the facies classification. A discrete facies cube is obtained, and its product was integrated with reservoir core and log data, the analysis allow the differentiation of the effective carbonate reservoir.

Introduction

The geological facies characterization based on well logs and seismic data (geophysical data) is a knowledge area that still requires research investments in order to get technical challenges. In this hand, some constrains must be considered when the goal is to predict geological information from geophysical data, because a high geological control is needed. This fact does not permit the automatic generation of geological facies from geophysical data, only applying software.

This job applies the integration of geological and geophysical data along Albian carbonatic reservoirs on Campos Basin. In this sense, this carbonatic level is a good petroleum producer in oil fields as Garoupa, Linguado, Enchova, Mexilhão, Coral, Estrela do Mar, Caravela from Campos and Santos basins, because this, represents a good exploratory plays for the three main sedimentary offshore Brazilian basins (Campos, Santos and Espírito Santo).

The analysis of reservoir carbonatic facies, mainly calcarenites, represents a challenge because its internal heterogeneity related to physical properties of the rock. On this hand, any geological prediction based on geophysical data have to include the mathematical correlation between the describe core facie and the calculated data from geophysical methods.
Usually the geological facies definition is a multidisciplinary job that includes geologists and geophysicist, based on this, along the evolution of these study seismic volumes and rock data were integrated through neural network process.
On the study area, the Albian is considered a calcareous sequence formed by calcilutites and calcarenites facies, which represents the seal and reservoir respectively. The main reservoir is formed by ooids and oncoids that represent different texture and good porosities (8-20%), more than eight association of this kind of reservoir were observe on Campos Basin.

Objective

The main objective is to define geological facies from geophysical data analysis, the applied methodology uses neural network unsupervised classification, and the result would be a better practice to define reservoir facies on carbonatic Albian Brazilian reservoirs. Another objective is oriented to apply this method to control and quantify geological uncertainty when predicted geological facies based on 3D seismic data.

Method

The method applied on the geophysical data is the traditional 3D seismic data interpretation calibrated by well data (core data, petrography, petrophysics laboratory and log data). Structural surface maps were obtained for each interest horizon level (top and base of the main calcarenites reservoir levels at Quissamã Formation).

The facies characterization was improved by the use of a neural network routine that integrates at least five seismic attributes volumes (Figure 1), the facies classification was done using an unsupervised routine, with four, six and eight classes defined by core and petrographic facies classification.

The geophysical facies results from the integration of the five seismic attributes cubes at the reservoir level through the use of the neural network, the extraction of the discrete facies that represents the reservoir is done by use of probes inside the main reservoir, and this facies are integrated with rock data by the analysis of its distribution on a correlation graphic between seismic attribute cubes on each axis and its classification (color points) defining zones of occurrences by kind of geophysical facies (Figure 2)

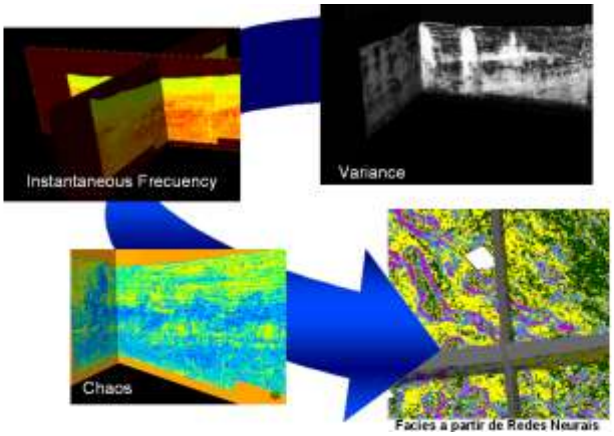

Figure 1.- Seismic atributes integrated on a Neural Network

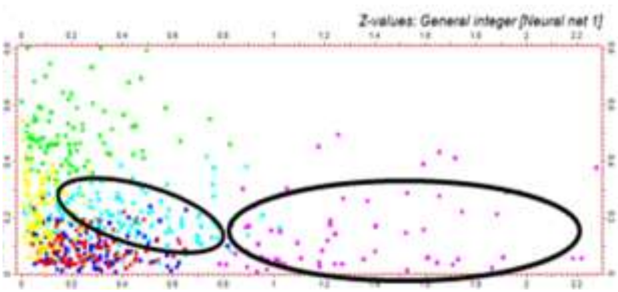

Figure 2.- Correlation attributes cubes graph, and facies classification criteria based on geophysical data.

Results

When analyzed the attributes cubes included on the neural network classification, it was found that the five volume attributes are necessary to best classify the geological facies. Three of this cubes must be Chaos, Instantaneous Frequency and Acoustic Impedance for Carbonate reservoirs, in the case of siliciclastic reservoirs the Acoustic Impedance is not determinant for the classification, but if it is available is strongly recommended it inclusion on the routine. The other two volumetric attributes will be selected by the seismic interpreter.

The geophysical facies result (Figure 3) appears to show a high heterogeneity and non-regular facies distribution, but when this data is integrated with core and petrographic data the classification of reservoir facies and non-reservoir facies is possible (Figure 4) to recognize an possible actual distribution of the main carbonatic reservoir

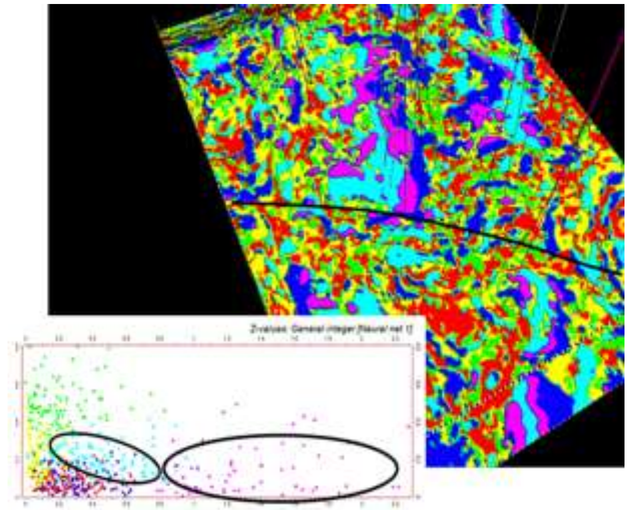

Figure 3.- Geophysical facies distribution.

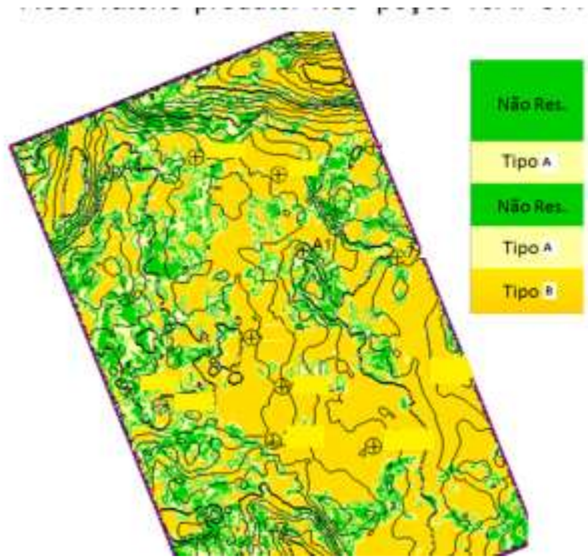

Figure 4.- Reservoir and non-reservoir facies distribution.

As result, two kinds of reservoirs were classified (Tipo A and Tipo B): the “Tipo A” is composed by oncoids calcarenites (Grainstone), with as regular to poor selection of grains that show fine to medium size, this geological facie does not show ciment, the porosity is high (24%) and 250 to 740 mD of permeability; the “Tipo B” facies is composed by bimodal calcarenite with ooids that show size fine to coarse and oncoids with a coarsesize (Oncoid´s Grainstone), porosity of 24% and permeability around 440 mD (measured on laboratory).

Finally, it is possible to characterize the textural facies changes that define the reservoir with bimodal texture that is favorable to the fabric, structural discontinuities are also characterized in order to better understand the effective reservoir distribution and its flux units.

Conclusions

At least five attributes cubes must be include on the analysis, and Chaos, Instantaneous Frequency and Acoustic Impedance are necessary to better define the carbonate reservoir facies changes and heterogeneities.

The best unsupervised classification was performed when selected in six classes, because the reservoir heterogeneities are represented with high confidence (82% of correlation between geophysical and geological facies).

The method is able to identify the fabric of the carbonate reservoir and as result the distribution of the hydrocarbon flux unit.

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