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Reservoir Characterization using Seismic Amplitude and Facies Analysis : A Case Study

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ABSTRACT

In the deep water regions of Campos basin, the hydrocarbon accumulations are mainly controlled by stratigraphic traps. Giant oil fields producing from turbidites deposited in Tertiary submarine fans have been found in the last decade in this basin. Amplitude maps play an important role in defining stratigraphic features. This paper presents a combined analysis of amplitude maps and seismic facies maps based on a wavelet classification obtained from neural network technology. The objective is to obtain more detailed information about the reservoir distribution in order to get better success rates.

Turbidite sandstones are responsible for 77% of brazilian recoverable oil volume and 50% of recoverable gas volume (December, 1997). Stratigraphic control on petroleum accumulation is the preponderant factor on turbidite reservoirs. In Campos basin, turbidites from the Tertiary regressive marine sequence respond for 60% of recoverable oil volume and 55% of recoverable gas volume. The identification of reservoir geometry, sandstone limits and the main heterogeneities, like faults and unconformities, is of fundamental importance for exploratory and explotatory purposes.

The use of seismic data has contributed significantly to a better knowledge of reservoir characterization. In the last few years, there was an enormous increase in the number of seismic attributes available and their use. This paper presents some results achieved combining amplitude and seismic facies maps in Campos basin. Amplitude maps have been widely used in oil industry, as it is an important tool for stratigraphic and structural features recognition (Varela and Esteves, 1990). The amplitudes values can be extracted along one horizon or summed over a window. The latter provides the concept of a formation attribute (Brown, 1996). The map shown in Fig. 1 is an average amplitude map calculated over a constant interval of 30 ms, parallel to an interpreted horizon of reference. The zone of interest below this horizon corresponds approximately to the reservoir. The main stratigraphic features include: (1) turbidite complex with channels and lobes, in which even small distributary channels over the turbidite lobes can be traced; (2) a huge sand sheet progradation and associated fringe; (3) a younger canyon cutting older sediments in the west-east direction. Structural features comprise faults (4) and the occurence of anomalous amplitude related to gas cap at the highest positions of the reservoirs (5).

Using the shape of the seismic trace and other attributes over the same interval in a 3D data volume may help the understanding of the geology and the distribution of stratigraphic and structural patterns. The neural network technology method, which classify the wavelet form, has been applied successfully to our set of data. The Stratimagic software, developed by CGG-Petrosystems, allows the user to create maps of classical attributes like amplitude over an interval (Fig. 1) and maps showing the application of the neural network method. The result is a seismic facies map showing the distribution of wavelet with a similar shape, gathered into different classes, calculated over a constant interval around a reference horizon (Fig. 2). Based on a robust-pattern recognition method (Neural Network Technology licensed from Elf Aquitaine), the process will identify over a constant interval based on an interpretation, a set of model traces, which are the representation of the variability of of the real seismic traces, from a subset of 3D seismic data. This model is applied, after validation, on the whole set of data, in order to obtain the seismic facies map, which relates each trace to a facies class. The result is the identification of significant features, in the interval of interest, and provides the geoscientists with a map of organization of geological patterns. The user will act on the process by defining the thickness of the interval in miliseconds, the number of model classes and the number of extracted traces for the model generation.

Figure 3 summarizes the methodology applied to the mapped reservoir level. The colors represent the five different classes of wavelet relative to the sandstone reflector. Besides the better definition of the fault plans in the seismic facies map (figure 2), the classes emphasize some stratigraphic features. The portions in purple are close related to sandstone signature associated with small channels (1); lobes cut by small distributaries (2); sand sheet front (3); and canyon cutting sand sheet deposits (4). Green and yellow are related with thick sheetlike sandstones (5); and brown, represents the encasing shales (6).

The process of mixing maps like amplitude and seismic facies maps help us to analyze the correlation between the two attributes and has achieved good resolution in Campos basin. The map of figure 4 is the result of the superposition of average amplitude map and the seismic facies map shown before. Note that stratigraphic features are better defined in this map, in which can be observed details like distributaries over the sheet sand lobe (1) and older canyons in the southern part of the area covered by the 3D (2). All the features pointed out before were preserved and more accurate information was achieved.

CONCLUSION

In order to recognize stratigraphic features it is imperative to work with amplitude maps. Seismic facies maps adds information as it classifies the available traces into classes. The combination of amplitude and seismic facies maps gives more detailed information about the reservoir geometry and sandstone limits.

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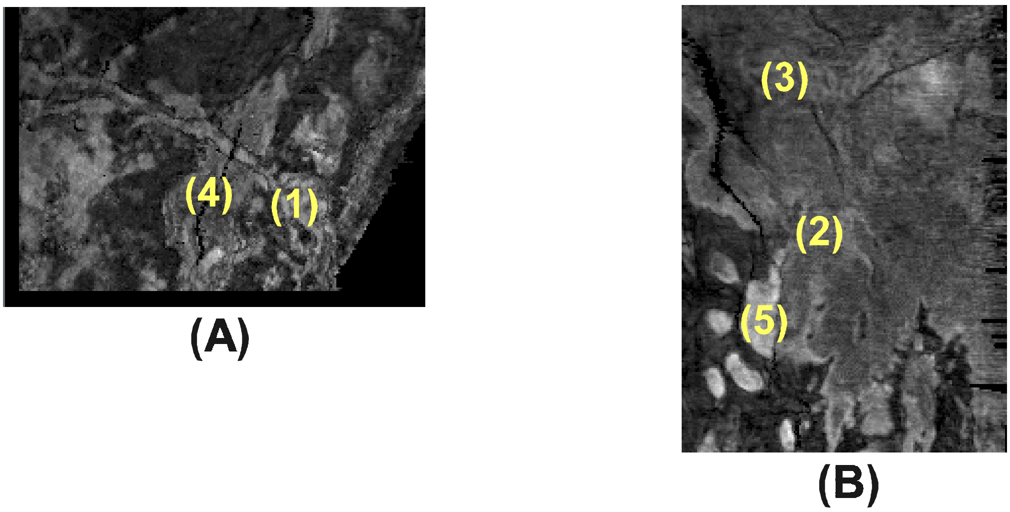

Figure 1 – Average amplitude map of Oligocene turbidite sandstone. Numbers refer to the features described on the text.

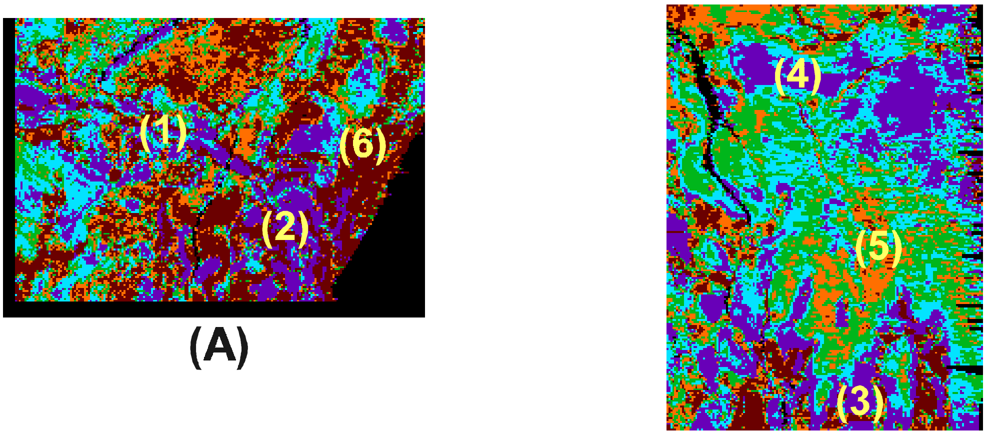

Figure 2 – Seismic facies map based on five classes of wavelet along an Early Oligocene reservoir level.

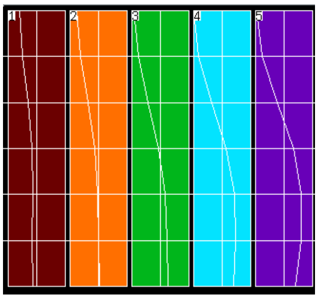

Figure 3 – Seismic Facies Classes.

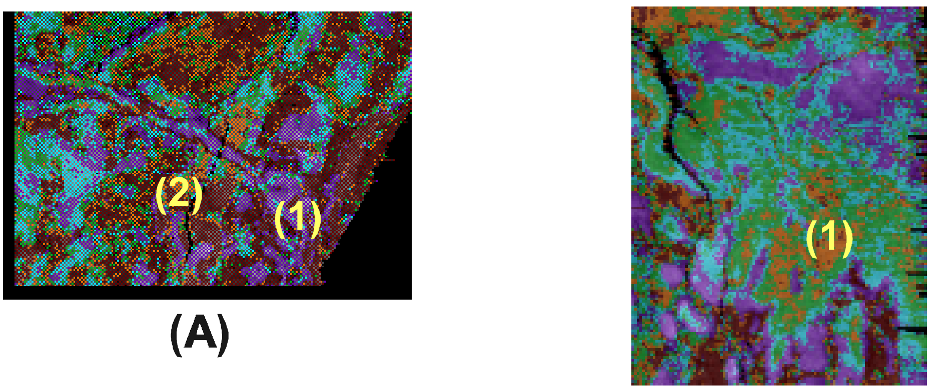

Figure 4 – Average amplitude map superposed to the seismic facies map.