Seismic and Well log characterization of Eocene Turbidites in Enchova Bonito oil fields Campos Basin (Offshore Brazil).

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Abstract

This paper presents a seismic and well analysis of the 120 m (393 ft) Eocene deep water clastic succession of Carapebus Formation, at Enchova and Bonito oil fields, southwest of Campos Basin. This succession was divided into two turbidite reservoir zones: Lower Sandstone Zone (LSZ) and Upper Sandstone Zone (USZ). The reservoir characterization was based on well logs integrated with 3D seismic data; the interpretation allowed the identification of sand body geometries as channel and lobes both on well and seismic data. The seismic interpretation also provided a structural and stratigraphic framework of the area, which includes halokinetic listric faults and an Upper Oligocene unconformity, both which controlling reservoir distribution along both fields.

Introduction

Since 90´s decades the extensive use of 3D seismic as reservoir characterization tool has optimized well location and allowed the reduction of geological uncertainties (Bruhn et al., 2003). On this hand, the test of 3D Seismic interpretation integrated with seismic attributes evaluation, calibrated by well logs analyses will provide a good appreciation of the turbidity's shape on Bonito and Enchova oil fields at Campos Basin. .

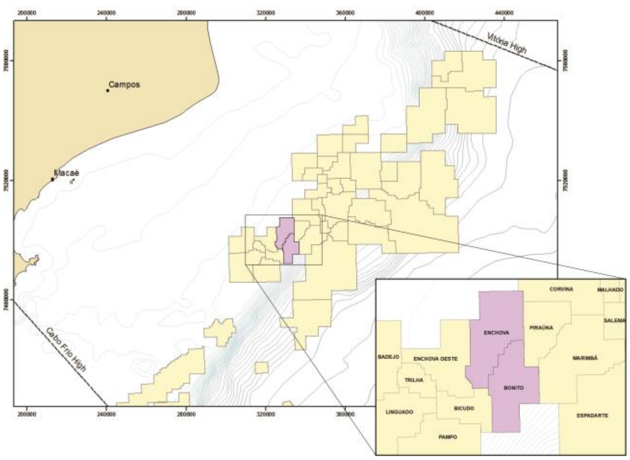
This paper aims to develop a reservoir analysis of Eocene turbidites sandstones on the previous mentioned oil fields. Turbidites are recognized as the most important reservoir type of the basin, corresponding to the 75% of the total oil production, comprising 37 oil fields, and 26 produces from Eocene Turbidites.

The stratigraphic interest's level is the Middle Eocene to Early Eocene Carapebus Formation at Enchova and Bonito oil fields, both located close to the shelf edge, at the southwest of the basin, along its production trend of the basin.

The oil production from these fields is known since 70´s decade, with production from Eocene, Cretaceous, Oligocene turbidites and Albian carbonates. The Eocene reservoirs oil volume was initially estimated to be 500 million bbl of 18º API gravity oil (Guardado et al., 1989).

The purpose of this job is to describe and interpret the shape and distribution of Eocene Turbidities, based on well log and 3D seismic data analyses. The results have been compared to the nowadays understanding of these type of reservoirs.

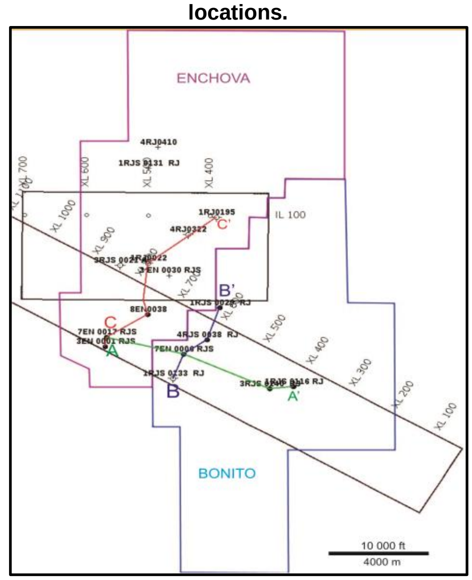
Figure 1: Location map for the Enchova and Bonito oil fields in Campos Basin context.



Data Setting:

The data set used un this work includes 15 wells with the Gamma Ray (GR), Resistivity (ILD), Sonic (DT) and Density (RHOB) logs, a 3D seismic volume, located as showed in the figure 2. The data interpretation was carried over Decision Space Desktop (Landmark) software.

Figure 2: Data distribution, and geological well sections locations.



Method:

The method or steps of work presented in this paper is based on:

1-Well log interpretation/ correlation: The well logs were interpreted in order to identify the stratigraphic markers, tops and base of stratigraphic units, that confining the reservoir interval. The lithology was also interpreted from well logs and well´s folder.

2-Petrophysical Analysis: In order to quantify and classify the reservoir internal properties as: shale volume (Vsh), total porosity (PHID) were calculated in order to get a most confident reservoir description. These properties have been linked with seismic attributes to properly evaluate its distribution.

3-Seismic Interpretation: A 3D seismic volume was interpreted on time domain, the objective was define the general stratigraphic and structural framework at seismic scale. This interpretation allows the definition of the subsurface reservoir's geometry and its major boundaries including faults.

The base and top of Eocene Carapebus Formation (contain reservoir interval) were interpreted in a grid of 20x20 meters (65 x 65 ft), that result in the contour structural map (time) of the main reservoir.

4-Seismic attributes maps: seismic attributes maps were generated, between base and top of Cararapebus Formation (40 milliseconds window) in order to reveal details of the underlying reservoirs characteristics as, sand body geometry. The link between seismic and rock attributes was established trough cross plots.

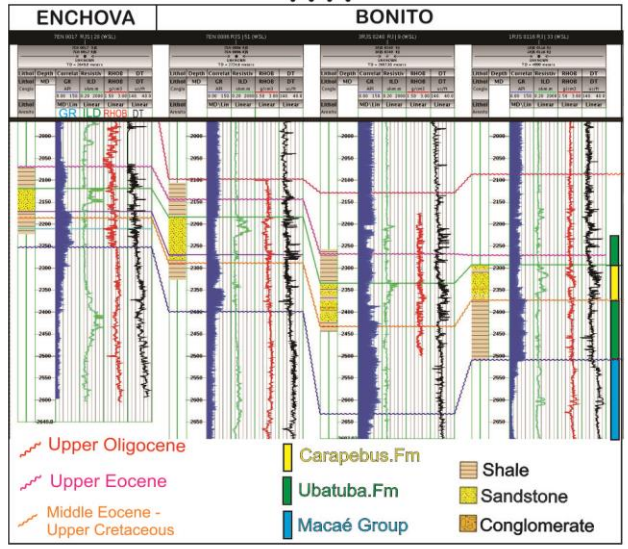
Results

Stratigraphic Analysis

The stratigraphic analysis was based on geological well sections, presented in order to describe the overall stratigraphy of the study area.

In the section A-A', is possible to observe the Eocene Carapebus Formation limited at the base by the Upper Cretaceous - Middle Eocene regional unconformity, characterized by the Gamma Ray log in the shales API values, marcable higher on Cretaceous shales (80 API) than Middle Eocene shales (65 API), this fact reflected the transition between the Transgressive Megassequence (Cretaceous) to the Regressive Megassequence (Middle Eocene).

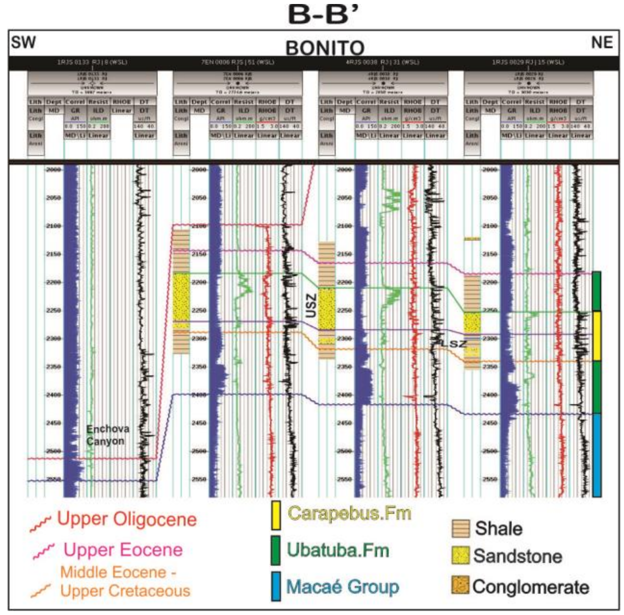
A-A'



At the same section is possible to observe the Eocene Carapebus Formation's upper contact with Ubatuba Formation, which is characterized by constant values of Gamma Ray and Density logs, representing a shale succession.

The sections B-B' shows Eocene Carapebus Formation truncated by a main unconformity which was developed during Upper Oligocene. This event is responsible for the formation of the Enchova canyon as observed by Antunes, Sonoki, and Carminatti, (1988).

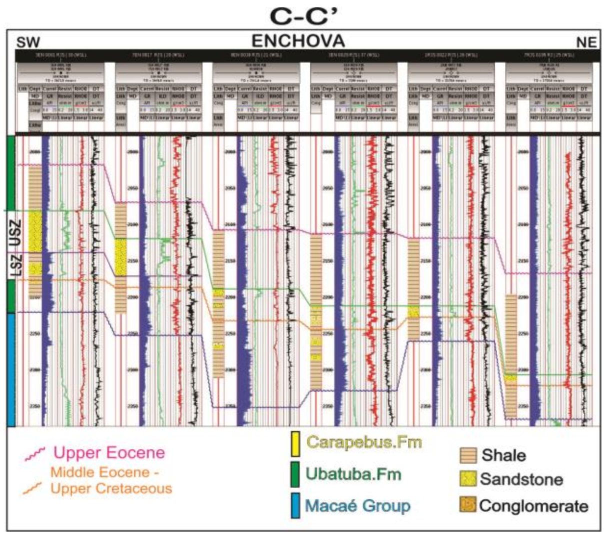
B-B'



The Eocene Carapebus succession contains two main sandstones turbidites reservoir zones, named in this paper as Lower Sandstone Zone (LSZ) and Upper Sandstone Zone (USZ), separated by a package of pelitic rocks with variable thickness on the order of tens of meters.

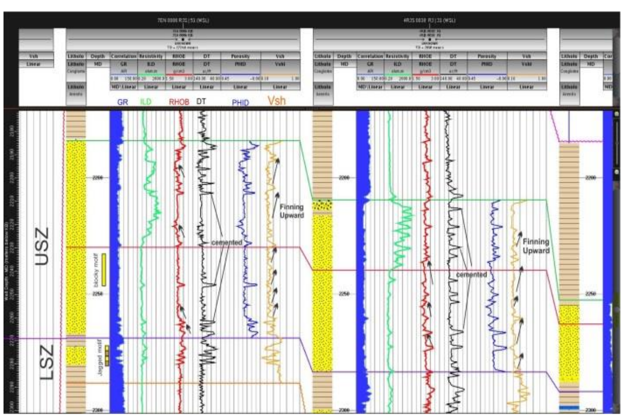
The Lower Sandstone Zone may reach a maximum thickness of 30 m (131 ft.) on Enchova and 20 meters on Bonito oil field, the well logs of this interval commonly present a jagged log motif, indicating a major presence of interbedded shales at this succession.

The Upper Sandstone Zone is thicker and more laterally, reaching 90 m (295 ft.) on 7 EN 006 RJ and 7 EN 0017 RJS, presenting a blocky log motif on gamma ray log. At the Enchova and Bonito Oil field the USZ is concentrated in the southwest portion of the field, to the northeast portion turbidite sands pinch out (Section B-B' and C-C').



A detailed analysis of this interval show finning – upward successions, marked by an upward decreasing of RHOB log, interpreted as channel fill. These successions are interbedded by high values on density and sonic logs and by anomalous, interpreted as digenetic cemented intervals, which also would represent different depositional events as described by Bruhn and Walker (1995).

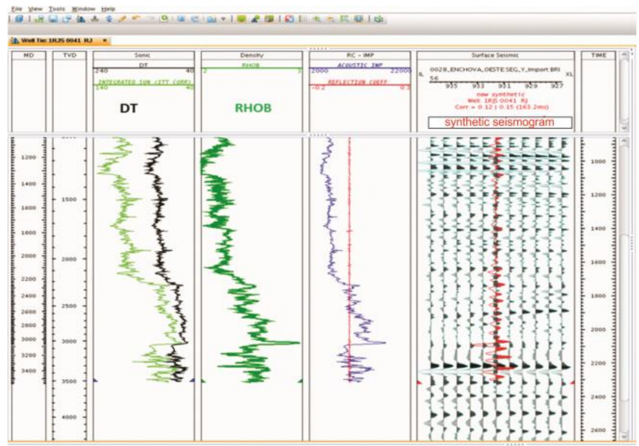
Figure 3: Detailed interpretation of LSZ and UPZ, showing finning upward successions based on RHOB and Vsh profiles, as well the cemented intervals observed on high values on sonic log.



Seismic to well tie:

The seismic well tie was performed using the Decision Space Desktop workflow, which involves the calculation of a pseudocheckshot from sonic log and the synthetic seismogram performed using density and sonic log. The synthetic seismogram was adjusted with the real seismic traces extracted at the wells locations (Figure 4), the seismic trace have been extracted from seismic on well location, with 20 Hz frequencies.

Figure 4: Example of a synthetic seismogram for well 1 RJS 0116 RJ.



Seismic Interpretation

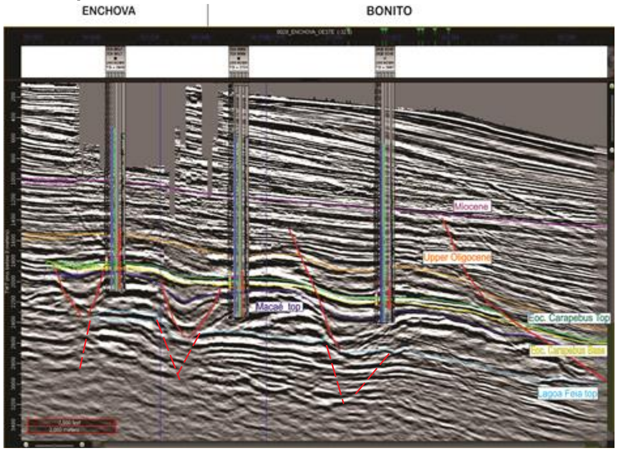
The stratigraphic units previously interpreted were integrated and interpreted on the 3D seismic data, constrained the tridimensional interpretation at the Eocene sandstones reservoirs.

Lagoa Feia Group is seismically characterized by plane parallel reflectors in its upper succession, with an intercalation of maximum and minimum amplitudes, representing the interbedded rudstones and lacustrine shales of Barremian. The base of the evaporitic sequence is a pseudo flat reflector on both oil fields.

Macaé Group are characterized steeply dipping strata, at some portions and highly faulted blocks especially in its lower units, reflecting the strongly influence of downslope gliding of the underlying evaporites, along Albian period.

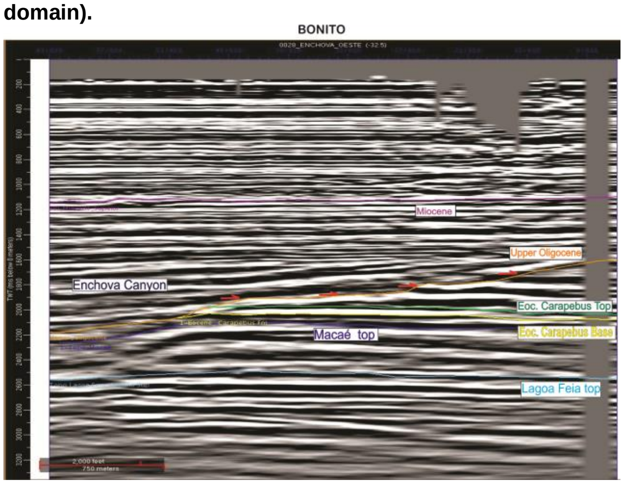
Eocene Carapebus formation, limited at the base by cretaceous Paleogene unconformity, interpreted as a zero crossing of maximum to minimum amplitudes, identified by well seismic tie, its upper limit (Eocene Ubatuba. Fm) is characterized as a low amplitude reflector (Figure 5).

Figure 5: Strike oriented seismic section (corresponding to A-A'), showing the main stratigraphic horizons and structural elements, as rift phase faults and halokinetic listric faults (location corresponds to A-A' section; TWT domain).



As described in the stratigraphic analysis, the Eocene´s sandstones are limited on western part of both fields by an Upper Oligocene canyon market by the truncation of Eocene Carapebus reflector against a high angle surface also presented by Antunes, Sonoki, and Carminatti (1988) (Figure 6).

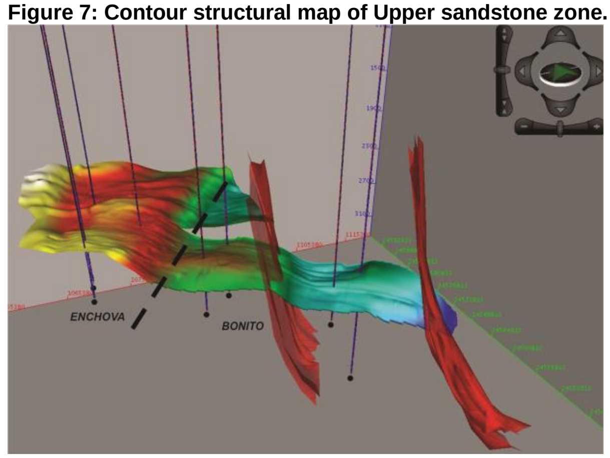
Figure 6: interpreted strike line at Bonito field, showing onlaping surfaces of Enchova Canyon, limiting Carapebus Fm. Occurrence (location corresponds to C-C' section; TWT domain).



The figure 7 present the contour structural map of the Eocene Carapebus Formation top, also the top of the USZ, it's possible to observe that Enchova and Bonito sandstones reservoirs are contained in three separate domal structures.

In the Bonito field the listric faults delimits two domes, at the southwest portion Carapebus Fm. is limited by an NE-SW fault, limiting the LSZ and USZ occurrence.

Figure 7: Contour structural map of Upper sandstone zone.



Seismic Amplitude Maps

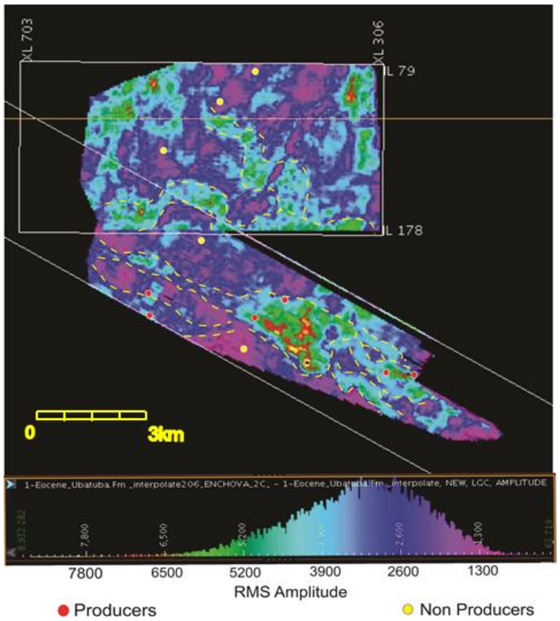
The RMS (root mean square) amplitude map revealed some geometry resembling channels occurring at the southwestern a northwestern portion of mapped area, the channels are 4 Km(13120 ft) to 5 Km (16400 ft) on extension and 600-800 m (1968-2024ft) wide. A lobate geometry is well delineated at the Bonito central area, probably related with a confined sand rich lobe, with 3 km (9842 ft) extension and 1-2 Km (3289-6561 ft) wide.

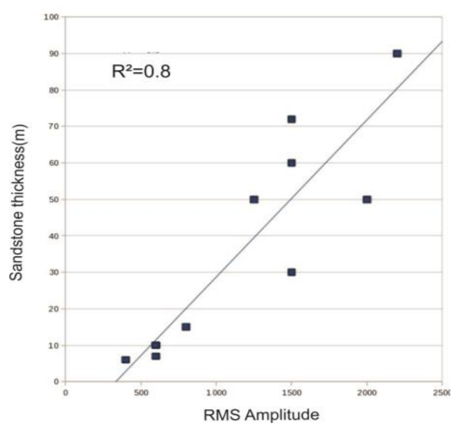
The RMS (root mean square) amplitude map revealed some geometry resembling channels occurring at the southwestern a northwestern portion of the mapped area,.

A lobate geometry is well delineated at the Bonito central area, probably related with an unconfined sand rich lobe.

The cross plot between the USZ thickness and RMS amplitudes values presented a strong positive correlation, indicated by the determination coefficient: R^2=0.8, between maximum amplitudes values and sandstones thickness, corroborating the channels and lobate geometry interpreted on attribute map. Minimum amplitudes values are probably related to regions of shale–sand and shale deposition.

Figure 7: Seismic amplitude map root mean square (RMS) extracted from a window between base and top Carapebus. Fm (40 milliseconds), horizon at the top of the lower sandstone zone. Some geometry resembling channels and lobes are interpreted.





Conclusions

- The Eocene Carapebus Formation on Enchova and Bonito Fields presents two main Turbidites zones (USZ and LSZ). The USZ reaches 90 m while LZS thickness is 40m on its thickness portion. The USZ´s well logs interpretation showed a stacking pattern characteristic channel fill complexes, exemplified by finning upward successions observed on Density and *Vsh* successions.
- The higher thickness of USZ compared with de LSZ can be associated with a higher influence of clastic sediment supply, the LSZ stacking pattern (high proportion of shale evidenced by jagged log pattern) suggests a lower clastic sediment supply on studied area.
- The amplitude maps also revealed channelized features suggesting a channel fill complex mainly on Enchova field while Bonito field can be interpreted as sand rich lobes on its north area and channel complexes on its southern are, probably related to a higher downslope and consequently increasing of energy deposition influencing channels geometries.
- The channelized features observed on Enchova Field could be the feeder of unconfined lobe presented on Bonito area. The turbidite probably spread since its downslope position of Bonito compared to Enchova field.

Acknowledgments

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