Depositional Evolution of Turbidite Lobe Complex in 2D High-Resolution Seismic

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Abstract

Turbidite deposits are very important petroleum reservoir rocks in so many basins around the world. In the Brazilian marginal basins is not different. The Campos basin is the most prolific and, produces hydrocarbon from deepwater deposits, almost 90% of the national production, which is approximately two mllion barrels/day. The modern Almirante Camara Deepwater System in the Campos basin is an excellent analog to the Tertiary turbidite deposits at the same basin. Therefore an investigation was conducted to understand the evolution of the processes that forms the lobe portion of this modern system. Approximately 1,200km of high-resolution 2D lines were acquired and interpreted which results were enriched with information of 27 piston-cores and sonar image at the same area. The excellent vertical and lateral resolution of the seismic allowed the interpretation and mapping of five lobes which thickness is roughly 30 meters each. Their limits presents onlaps at the proximal areas and laterally; whereas the downlap is typical at the distal part of each lobe. The comprehension of the architecture of such lobes (channelized) is of paramount importance to understand the compartimentalization of the old productive ones; therefore a much more efficient management of the field can be done.

Introduction

Although the Brazilian oil reserves may double with pre-salt calcareous reservoirs recently discovered, the understanding of siliciclastic reservoir depositional models in deep/ultra-deepwaters of Brazilian margin basins is extremely important, mainly because the present reserves in turbidite sandstones are approximately 90%.
Therefore, the turbidite lobe complex of the Holocene/Pleistocene Almirante Camara system, located in Campos's basin, was investigated as an analog model (Fig. 1)

Geological View

The Almirante Camara system probably has been developing since the Tertiary times, in Campos basin, however, in this study, only the modern system, which is settled in the Northeast part of the basin, is considered. The system consists of a canyon that reaches the present platform where sediments can be caught (Fig.2). The canyon widens down slope to form a low sinuosity channel complex within a trough which is controlled by a salt wall. (Fig.2). This channel complex feeds a complex of terminal lobes (Fig. 2), on a low gradient slope (~0.5 degree), which are, together with the channel complex, within the Plateau de Sao Paulo, an area strongly affected by halokynesis with Aptian consists of 80 strike and 13 dip, which parameters of acquisition and processing are shown in tables 1 and 2.

Methods

The 2D lines were localized and acquired on a grid based on a sonar image of the fan. The set of lines consists of 80 strike and 13 dip, which parameters of acquisition and processing are shown in tables 1 and 2 respectively.

Table 1 – Acquisition parameters

Source	Single Air-Gun (10.5 cubic inch)
Number of Channels	24
Distance between receptors	6.25 m
Distance between shots	12.5 m
Cable lenght	143.75 m
Covering	6
Source depth	1-2 m
Receptors depth	2 m
Rcord lenght	4.5 s
Sampling interval	0.5 ms
Initial offset	50-60 m
Low cut filter	3 Hz
High cut filter	Open
Expected frequency	Up to 250 Hz
Total km	1,411.0 Km

Table 2 – Processing parameters.

Pass band filter (Step 1)	Butterworth – Low Cut 10/60 Hz e High Cut 450/60 Hz
Deconvolution	Spike; window lenght: 200 ms
Gain	Window lenght: 500 ms
Velocity analyses	One/km
Pass band filter (Step 2)	Butterworth – Low Cut 15/36 Hz and High Cut 240/48 Hz
Migration	Phase shift migration
Deconvolution	F-X

Results

The lobe complex (10x20km) consists of five individual lobes (Fig. 3) and associated chaotic facies, the oldest lobe being Pleistocene. Acquired 2D high resolution seismic data (Fig. 4) calibrated with more than 27 piston-cores for sedimentary facies and biostratigraphy, allowed the mapping of the depositional architecture of those individual lobes which are highly controlled by halokynesis. Evaporites nearly form a ring of diapirs/domes and walls that delineate the sea-bed morphology, where the turbidite lobe complex is forming. All lobes, which actually are depositional sequences, present seismofacies which truncate each other as a result of the backstepping and lateral compensation of the lobes. The reflectors onlap older surfaces updip and downlap downdip, whereas both lateral extremities of the lobes are onlapping older lobes or chaotic sequences.

The youngest lobe, number 5, is the most prominent, better imaged either by seismic and side-scan sonar because is the most close to the seafloor and contains active channels, which are presently being eroded and filled. Lobe five has being constructed since the Upper Pleistocene (?) through three channels which have migrated by avulsion toward the Northeast, depositing sands and muds in a backstepping pattern in each active channel at once. The thickness of this lobe reaches 55m. Therefore, the very shallow channel deposits and the corresponding overbank ones are very similar to the “classic channel-levee” of the modern big deepwater fans, keeping/regarding the respective scales. However, it is preferred to call this architectural elements as lobes because the average ratio between width and thickness of channels is 27, that is, the channels are extremely wide and the margins of the channels are very difficult to be observed in outcrops

Conclusions

Our opinion is that much of the known unchannelized lobes observed in outcrops, even in foreland basins, can have a shallow and wide channel, therefore being truly channelized lobes. It does not mean unchannelized lobes do not exist, if so, they seem to be of small sizes.

Lobe 4 is the smallest one, lying between lobes 5 and 3. It extends further the lobe 5 and seems not be channelized like this, with thickness ranging from 5 to 25m.

Lobe 3 and 2 are very similar in extension, occurring further the study area and because the seismic reflectors are concordant, being the lobes separated by a stronger reflector, possibly representing a thicker mud bed. The thickness of both lobes is up to 70m.

The chaotic 2 unit is the package of deformed sediments, which is stratigraphically equivalent to the lobes 2 and 3. This sequence was formed due to the lateral adjacent slope slide/slumping that affected the regular beds of the both lobes.

Lobe 1 is the basal sequence lying on a thick chaotic 1 sequence (Fig. 4), on which the younger sequences have also developed. Lobe one is actually a long shallow trough occurring along the lobe extension, with thickness up to 25m. It is the lobe that less presents the shape of lobes, however the internal reflectors are similar to the other lobes.

Seismic facies identified in the high resolution lines were also identified in the corresponding 3D conventional data like the Almirante Camara canyon, which has been aggrading since the lower Miocene, possibly being a pathway for older deep-water deposits that accounts for giant oil fields. Therefore, a wide possibility of better understanding the depositional architecture in the Tertiary/Cretaceous models of the salt influenced Brazilian basins can be greatly improved**.**

Acknowledgement

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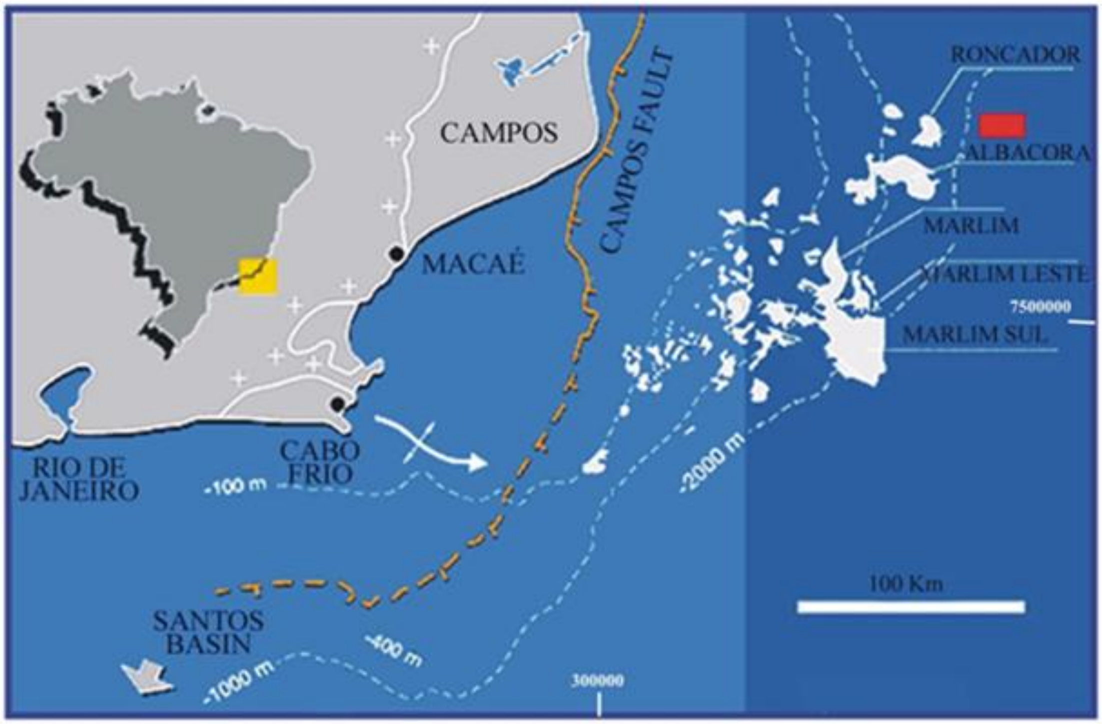

Fig. 1- Location map of the study area (red rectangle). The area is located at the Northeast of the giant petroleum fields of Campos basin, presently at the slope-toe, with water depths ranging from 2200m to 2400m.

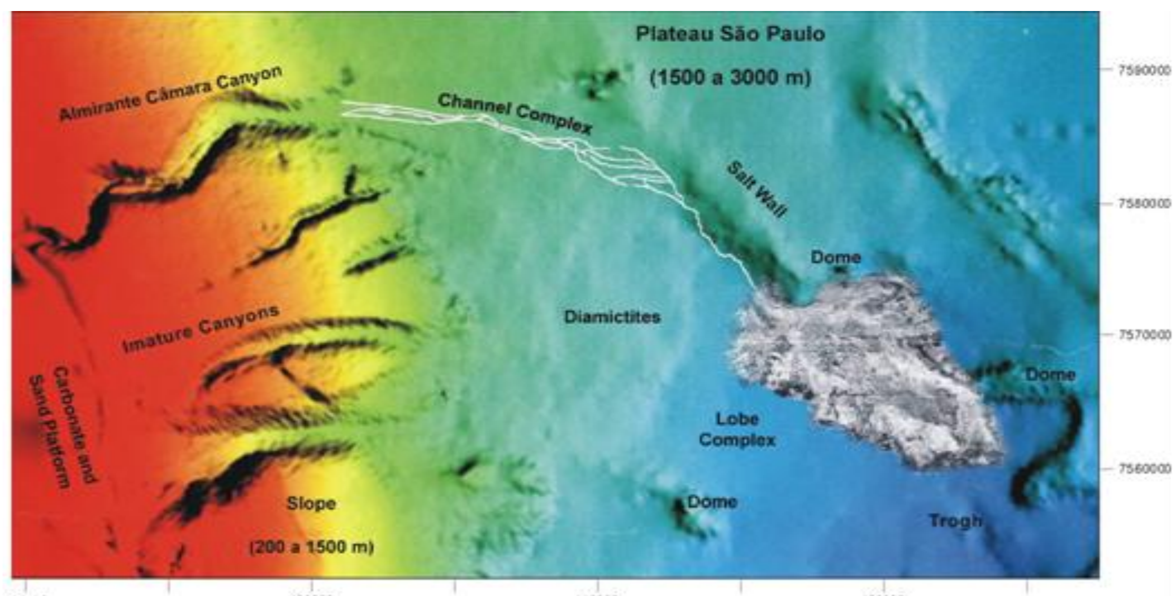

Fig. 2 - Observe the canyon, the channels complex and the lobes of the Almirante Camara system

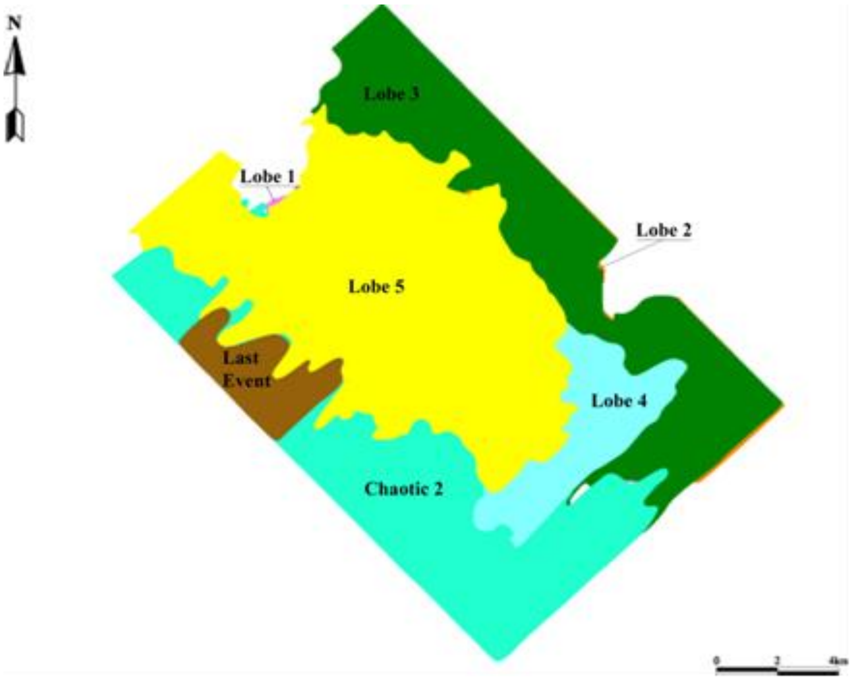

Fig. 3 – Map of the Almirante Camara lobes complex. Lobe 1 is the oldest and 5 is the youngest. A unit called "last event" one of the last depositional episodes has derived from the lateral adjacent slope, differently from the lobes deposition. Observe the retrogradational character from Southeast to Northwest, possibly caused by the sea-level rise at the end of the Pleistocene and Holocene. Even in the Holocene sand has been deposited on the lobe complex through shallow channels. Areas with not colored correspond to salt domes and walls which affect and disturb the lobe deposits.

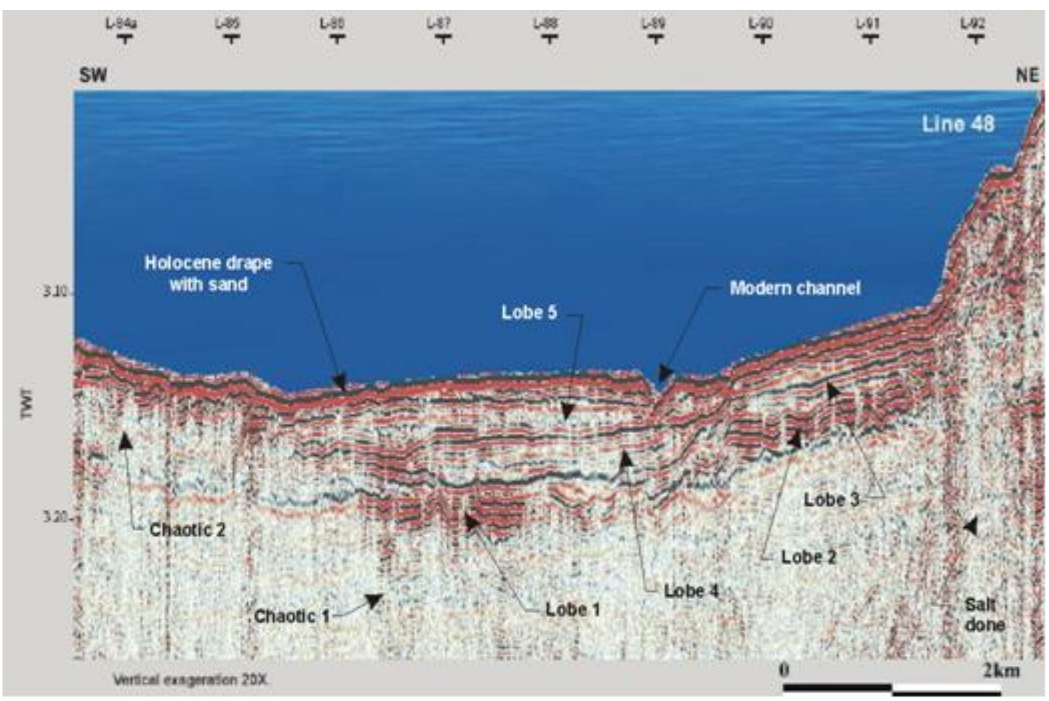

Fig. 4 - 2D high resolution seismic line, strike, showing identified lobes/sequences. Observe the present channel, overlapping lobes and the chaotic sequences.