Turbiditic System in Foz do Amazonas Basin during the Upper Cretaceous

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Seismic interpretation in Foz do Amazonas Basin led to the recognition of a mud-rich turbidite system during the Campanian age that has developed over a buried structural paleo-high on a homocline profile of the sea bottom. This turbiditic system consists by meandering channels associated with levee constructions that bypassed the paleo-high located in the area and both are very well imaged in 3D seismic data. High amplitude reflection packets (HARP) occur at the base of these meandering channels, characterizing a progradation of these channels over the sheet sands. Seismic volumetric attributes showed meandering channels with several kilometers long. Crevasse splays deposits are observed flanking these meandering channels on the external bends of the levees.

Introduction

The Foz do Amazonas Basin, situated at the northernmost part of the Brazilian Equatorial Margin (Fig. 1), has a complex evolution which is linked to the Central Equatorial Atlantic Ocean opening. The break up took place during the Upper Albian and after this, a transgression characterized by deposition of shales, which lasted until the Cenomanian, has occurred. At this time, a package of sediments deposited in the proximal part of the basin, identified in wells located in the platform area, was interpreted as potential source rocks. Then, a regressive sequence took place in the basin lasting until the Middle Campanian.

The Turonian-Santonian interval is characterized by a channelized system, represented by cut and fill and bypass features in the shelf and canyons in the slope. Along the slope area, a confined channel system is observed and interpreted as a sand-rich turbidite system. Sand sheets deposition are expected to occur outwards the 3D coverage area, in deeper parts of the basin. This depositional system seems to have been active until the end of the Santonian age.

From Early Campanian, the first deposition in the area is characterized by high amplitude reflection interpreted as HARP (High Amplitude Reflector Packets) according to Damuth (2002). Superimposed to the HARP, a predominantly reflection free sequence was identified and interpreted as a shaly sequence of a progradational meandering channel and levee system.

In the Early Maastrichtian, a new change in the depositional system has occurred, establishing a different channelized turbidite system.

The objective in this paper is to characterize, using seismic data, the Campanian sequence in deep water settings.

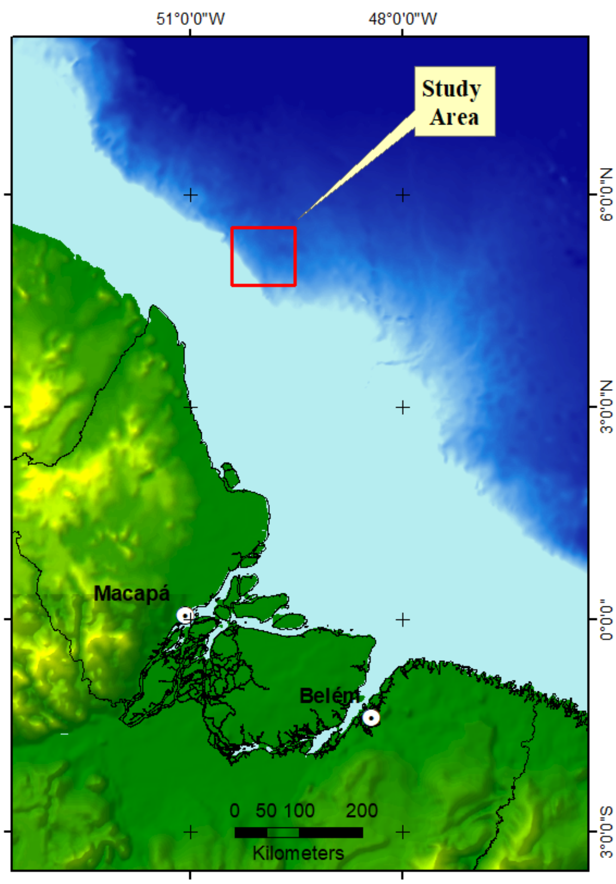

Figure 1 – Location map of the Foz do Amazonas Basin and study area.

Methodology

In this work, a data set consisting in public well data, public 2D seismic survey (in time domain) and a 3D seismic survey (in depth domain) were used for a regional study to delineate the prospectivity for hydrocarbons at the northernmost area of the Foz do Amazonas Basin (Fig. 2). Geological information was tied to the seismic data by check shot data obtained from wells located in the platform area (specially 1-APS-44-AP). The results in terms of regional seismic stratigraphy were used to characterize the ages of the seismic sequences interpreted in the study area. Once the regional sequences were interpreted, they were identified in the pre-stack depth migrated 3D seismic data (CGG/Spectrum broadband) to better understand the age distribution along time and look for exploration opportunities.

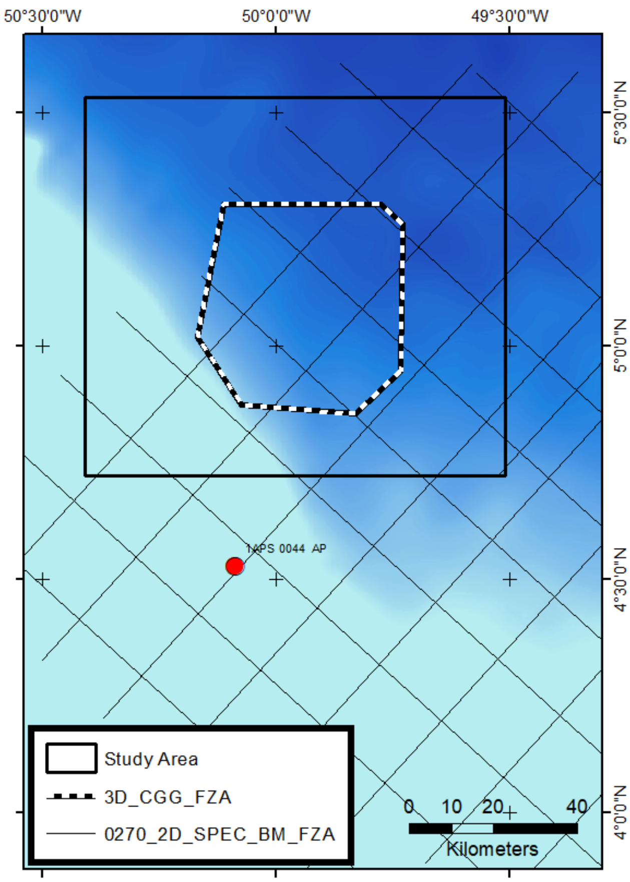

Figure 2 – Data set used.

The sequence interpreted as Campanian showed both positive and negative anomalies (where positive polarity is black) which called the attention upon the amount of different geometries that were investigated using many different maps and seismic attributes, such as: maximum amplitude, coherency, sweetness and especially relative acoustic impedance. Finally, geobody extractions made possible a more accurate characterization of the sandstones distribution from a 3D perspective, leading to a robust definition of the deep water settings in the study area.

Turbidite Depositional System

The interpretation of the 3D seismic data led to the recognition of many different sedimentary features concentrated in the Campanian Sequence which allowed a good understanding of how deep waters sedimentation acted at that time. Architectural elements such as HARPs, channels, levees, crevasse splays (figures 3 and 4) and sand sheets (Fig. 6) were identified showing a close relationship that made possible the recognition of a mud rich system acting until then. Next, we are going to discuss the main features in more details:

HARP was the first sedimentation that occurred in the area bypassing a structural paleo-high (Fig. 4). According to Damuth (2002), HARPs are more laterally extensive high-amplitude reflection packets at the base of channel-levee systems that are interpreted as coarse grained sediments deposited either from flows spreading laterally outward a channel mouth or from flows that pass by through a levee during initiation of a channel-avulsion event (i.e. crevasse splays) (Fig. 5). The seismic reflection interpreted as a HARP is characterized by a low acoustic impedance compared to sediments that are sit above it.

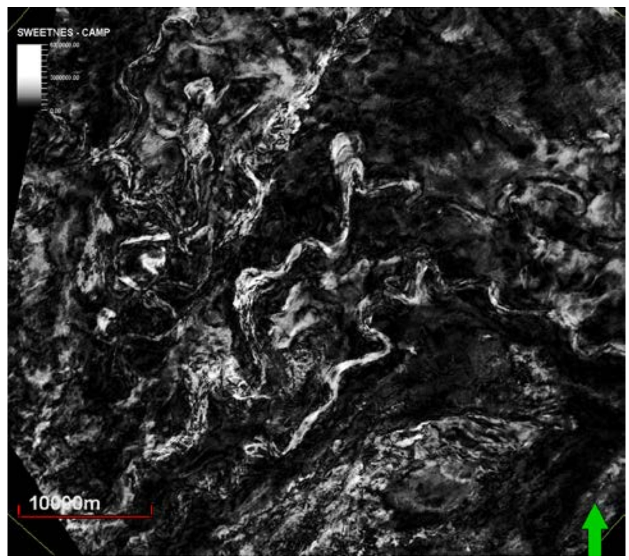

Figure 3 – Sweetness attribute extraction inside the Campanian Sequence exhibiting channelized features.

The channelized features are long and sinuous feeding splays in the distal parts of the area and they are bounded by levees (Figs. 3 e 4). During the development of this system is possible to observe crevasse splays deposited in the channel bends (Fig. 3). According Davis et al. (2005), these deposits consist of poorly sorted, structureless and ungraded, coarse or medium to fine grained sandstones with a high (30 – 50%) mud content. Individual beds are discontinuous and cannot be traced for more than 150 m laterally. The distribution of those channelized features, in terms of stratigraphy and stacking pattern, points out to a younging trend towards SE and a preferential transport direction towards the NE of the studied area (Fig. 3). Leveed channels are common depositional elements in slope and basin environments. The channels observed in this study ranges, in width, from 1 to 2 km and it presents high sinuosity (meandering). Some leveed channels are internally characterized by cut and fill architecture. Many of these leveed channels show evidence of having grown by lateral migration and in some instances, seem to have remained fixed in one position through extended periods and are characterized by vertical stacking (Posamentier and Kolla, 2003).

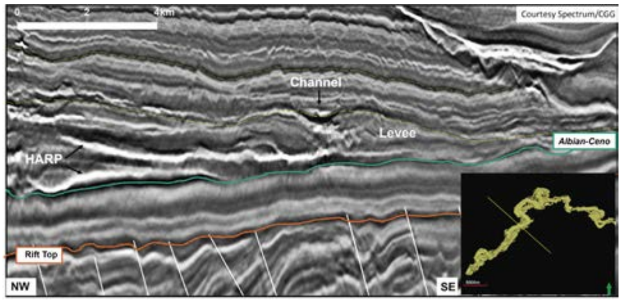

Figure 4 – 3D seismic section showing the HARP and channel-levees.

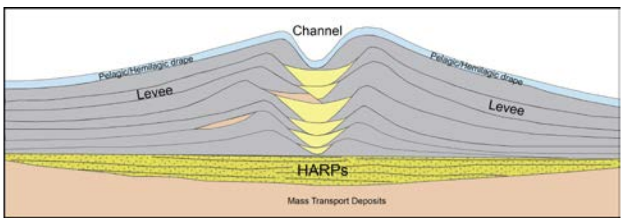

Figure 5 – Schematic diagram showing architectural elements of a channel-levee system (mod. from Damuth, 2002).

The levees are characterized by a reflection-free zone which is organized into wedge-shaped and concave-upward packages (Fig. 4). The high-amplitude reflections in the channel-fills are interpreted to represent coarse sediments laid down by high competence, high capacity turbidity and related to sediment gravity flows. The reflection-free zones probably represent fine-grained sediments deposited mainly during the waning stages of turbidity current activity (Kolla and Schwab, 1995).

Submarine channel and levees aggrade through repeated overspill events from the channel axis. The shape of the levees may therefore reflect some characteristics of the overspilling flow. It has been noted that basin floor levees typically have a relatively low-relief and taper exponentially to their termination; in contrast slope channel and levees may be much steeper close to the channel.

According to the characteristics observed in the channel-levee system described above, we consider this system as mud-rich and sandstones are confined to the axis of the channels (Galloway and Hobday, 1996).

In this study, confined channel-levees fed sand sheets. The transition from leveed channel to sand sheets is associated with a marked reduction in channel sinuosity.

Seismically, sand sheets are characterized by high relative acoustic impedance and continuous to slightly discontinuous reflections. In cross sections, these deposits appear relatively flat topped. They were built by numerous successive events of turbidity currents that go out of the 3D seismic borders. Their geometries indicate that they are positioned at the upper part of the fan that is starting to splay on the basin floor, once it is finally unconfined from the channel levee system (Fig. 6). Sand sheets reach thicknesses up to 200 m (inside the study area) and exhibit the most favorable reservoir quality in terms of sand content, lateral continuity and porosity development (Shanmungam and Moiola 1988). The Figure 7 summarizes the turbidite system identified in this study based on seismic data as described previously.

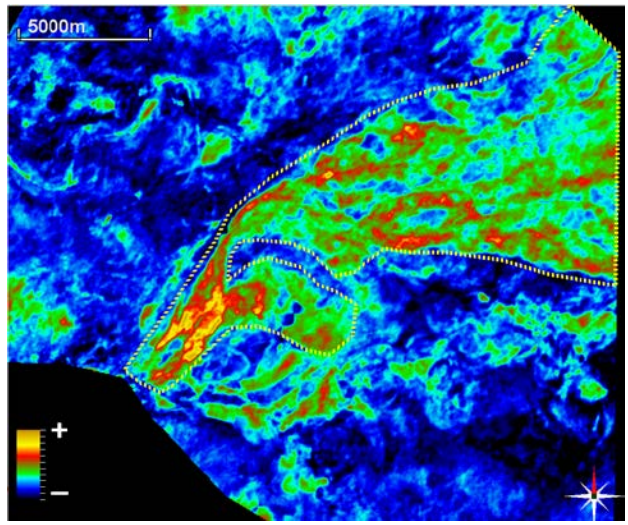

Figure 6 – Sand sheets (highlighted in yelllow) are characterized by high relative acoustic impedance.

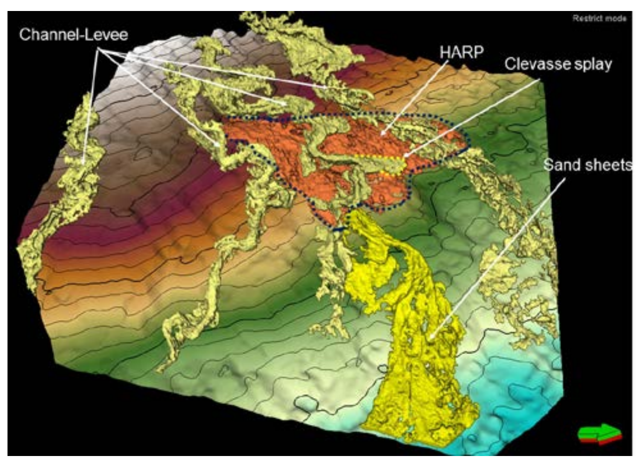

Figure 7 - HARP, channel-levee system, crevasse splays and sand sheets characterizing the Campanian Sequence.

Conclusions

The Campanian depositional system in the study area is very well characterized by a channel-levee system that has developed on deep water settings in a period of tectonic stability in the basin. Meandering channels and their related elements are distributed all over the area in a homoclinal accommodation space that allowed its development without disturbances down to the basin in NE direction, where sediments were transported to a depocenter outwards the 3D data coverage area.

The first deposition of sediments was characterized by high negative amplitude reflectors, characterized as HARP during the early stages of the turbiditic system implementation.

Above this first deposition, a channel-levee system with predominance of shales, mostly deposited on levees, built up some structures with sands confined to the axis of the channels and possibly interbedded in the levees too.

Sand sheets were interpreted in the distal part of the turbidite system as deposits with good potential for reservoirs.

Acknowledgments

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