Paleodrainage mapping of the São Paulo southern continental shelf on the Santos basin

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Abstract

The occurrence of a paleodrainage was mapped in the continental shelf of São Paulo through previous studies by using bathymetric and sedimentological data. These studies defined the existence of paleochannels. More recently, with the use of high resolution and low penetration seismic was possible the identification of its recent paleo geographic characteristic. With the aim to know the geometry and sismo-stratigraphic characteristics of the region, cruises mapped southward paleochannels of the inner continental shelf of São Paulo. These cruises were comprised by subsurface geophysical data over four parallel profiles to the coastline between the isobaths of 20 to 55 meters associating data with paleodrainage and relate them to marine transgression and regression events. The equipment used in data collection was the Sub Bottom Profiler 3.5 KHz. Furthermore, in the processing of seismic records was used SonarWiz 5.0, where internal reflectors were determined in sedimentary package. The data collected led to the identification of seismic stratigraphic, high concentration of paleochannels and a gas curtain in the seismic registers. The localization of the paleochannels mapped was concentrated in the central portion of the seismic lines, in front of the river outfall. These results strongly suggest a pattern of extension of current alluvial courses to the outer regions of the platform, dug in regressive periods. The data of this study should be considered preliminary for new surveys, aiming for a more precise characterization of the subject. With the coring of the paleochannels, the understanding of the composition and origin of the sediments would be possible, and a higher quality, detailed map of the region could be made.

Introduction

The present characteristics of coastal regions are a result of the geologic succession, from sea level variations and morphodynamic changes occurred during the quaternary period. Therefore, the sedimentological study from shelf seas allows the comprehension of the paleodynamics.

The subsurface study of the shallow submarine areas have been of extreme importance in the last decades due to the rising human activities and increasingly intense in coastal regions. It is worth noting that some of this activity are prospection of mineral resources and the establishment of constructions as drilling platforms, cables and submarine pipelines (Souza, 2006).

Studies using bathymetric and sedimentological data conducted by the Oceanographic Institute (IO) of the University of Sao Paulo (USP) mapped the occurrence of a paleo-drainage and defined the existence of paleochannels (Conti & Furtado, 2006). At the present using high-resolution and low piercing seismic it is possible the identification of the paleochannels recent paleogeographic characteristics.

The proposed work was motivated by the need of knowing the geometry and the seismostratigraphic charactersitics of the associated region to the paleodrainage, and thus understand the geography of the paleochannels related to the events of marine regression and transgression to which the continental shelf was exposed during the last glacial period.

The environmental area has the fundamental need in the knowledge of the recent geology and geomorphology of the continental shelf, which is of interest in oil industries and engineering, due to the fact that offshore structure fixation are held directly over the oceanic bed. Details on subsurface structures of shallow depth are needed in the formulation of projects of oceanic engineering and knowledge of the location and geometry of features may have a fundamental and significant contribution in these projects.

As for the paleodrainage distribution, it can be observed that it has a good correlation between that current outfall of the main drainage channels and the axis of the main paleochannels. Such results strongly suggest a pattern of elongation of the fluvial courses to the most outer region of the platform, dug during regression periods (Conti & Furtado, 2006).

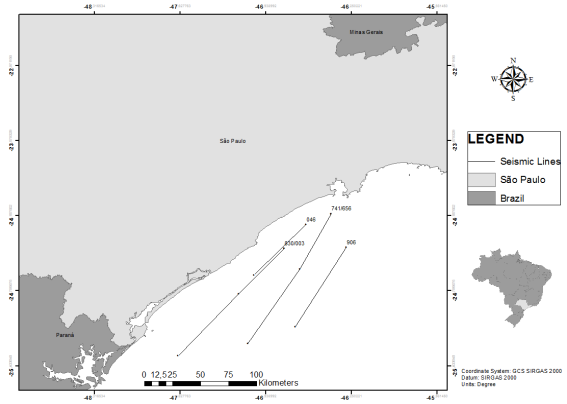

Figure 1. Location of seismic profiles in Sao Paulo coast

The survey and mapping study of paleochannels allows the reconstruction of old drainage systems and, usually, link them to the courses of current fluvial drainage systems (Weschenfelder et al., 2010).

This work aims the reconnaissance and mapping of paleochannels network present at the inner continental shelf in the south part of the state coast of Sao Paulo, Santos Basin, associated to the river Ribeira do Iguape discharge in the estuarine lagoon complex of Iguape, called Vale do Ribeira, with focus on the identification of seismic stratigraphic features and structures that formed the region. Also this work aims to contribute with the knowledge of the geological history of the Brazilian Continental Margin.

Method

The geophysical data sampling in the present study were performed by opportunity cruise in May, August and September 2012. In June 2014, was performed by the Oceanographic vessel Atlântico Sul, belonging to the Federal University of Rio Grande, FURG (figure 1).

The subsurface data were acquired over four profiles roughly parallel to the coastline southward the inner shelf of the state of São Paulo, which are between the isobaths of 20 and 55 m. It is considered around 407 km of high resolution seismic lines obtained with geophysical equipment subsurface profiler (Sub Bottom Profiler) 3.5 Khz Bathy2010® model SyQwest company with 20 meters deep penetration capacity in sandy bottoms, fixed to the vessel hull.

The subsurface mapping with shallow seismic data was firstly observed with processing program bathy2010, where it is possible to observe the seismic line with accelerated speed. The seismic imaging was performed in SonarWiz 5.0 software from Chesapeake Technology. This is available in Geological Oceanography Laboratory (LOG-FURG), which was defined the acoustic basement and internal reflectors in the overlying sedimentary package. In all lines were applied the withdrawal filter water column and automatic smoothing seabed noise (figure 2, 3 and 4).

Results

For the interpretation of the sub bottom profile records, it is necessary to know that the existence of acoustic reflectors is subject to variation of acoustic impedance, due to the different degrees of porosity and compaction of the bottom material. As to the signal penetration, the key parameter is the frequency. Lower frequency corresponds to greater power signal penetration, while higher frequencies allow better resolution (Ayres, 2001). Thus, through the feedback signal amplitude, it might correlate the echo intensity and the sort of sedimentary coverage of the floor and identify paleochannel.

Importantly, there is no established pattern for the classification of types of echoes, which complicates the correlation of results from different cruises.

The 4 seismic lines were recorded a large network of reflectors features, that have fluted forms thus indicating structures preterit drainage channels.

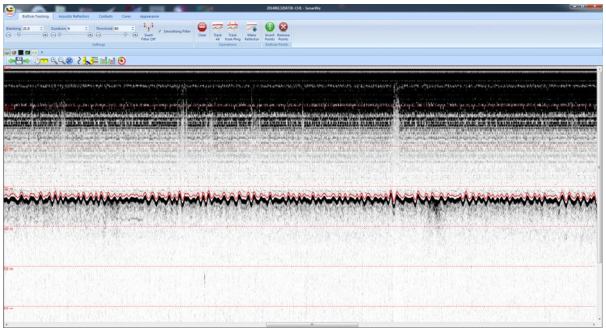

Figure 2. Raw data in SonarWiz 5.0

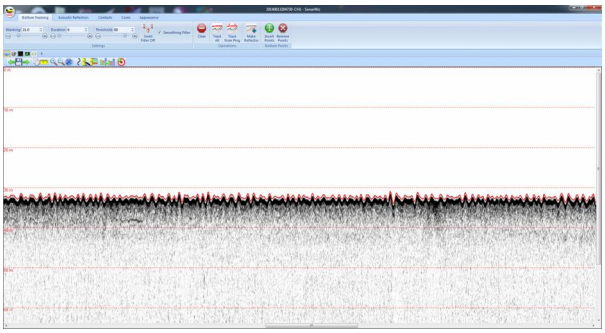

Figure 3. The withdrawal filter water column processed

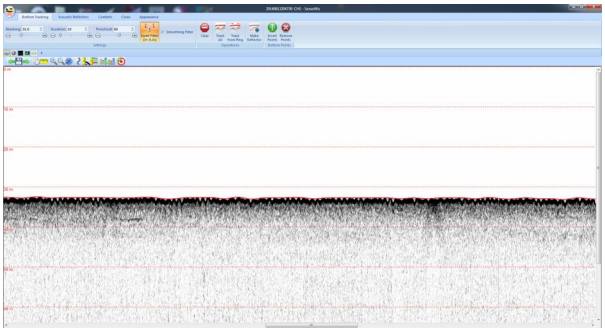

Figure 4. Automatic smoothing seabed noise processed data

The seismic line 046 of May 5, 2012 has approximately 62 km (SO/NE) and is located between the coordinates 24° 39,8354'S / 047° 01,6824'W and 24° 15,2893'S / 046° 36,6205'W. In this isobaths line between 20 and 24 m were identified 6 paleochannels with variation between 155 to 1890 m wide. The bottom of the channel has depth with variations of 8 to 14 m away to the margin. In figure 5 is shown an example of a feature that seismic line.

The seismic line 830/003 of August 2012 has approximately 129 km (SO/NE) and is located between the coordinates 25° 19,6043'S / 047° 38,3627'W and 24° 26,9023'S / 046° 47,2255'W. In this line isobaths between 25 and 30 m were identified with variations between 14 paleochannels with 125 to 2800 m wide and 8 to 25 m between the bottom and the margins of the paleochannel. In figure 6 is shown a feature that seismic line with appearance of gas curtain in register.

The seismic line 741/656 of September 2012 has approximately 135 km (NE/SO) and is located between

the coordinates 24° 10.1548'S / 046° 24.4534'W and 25° 04.9218'S / 046° 42.1958'W. In this isobaths line between 24 and 51 m were identified high concentration of 18 paleochannels with variations between 155 m to 3000 m wide and 8 to 22 m between the bottom and the margins of the paleochannel. In figure 7a is shown an example of appearance of gas curtain in register and (b) shows a the paleochannel in that seismic line.

The seismic line 906 of June 2014 has approximately 81 km (NE/SO) and is located between the coordinates 24° 26.3425'S / 046° 17.2634'W and 25° 06.5923 / 046° 42.1554'W. In this isobaths line between 48 and 55 m were identified 15 paleochannels with variations between 190 to 2040 m wide. The bottom of the channel has depth with variations of 8 to 19 m away to the margin. In figure 8 is shown an example of a paleochannel in that seismic line.

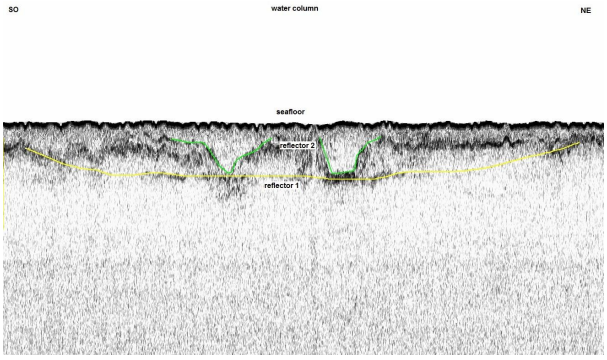

Figure 5. The reflector1 delimited the bottom of

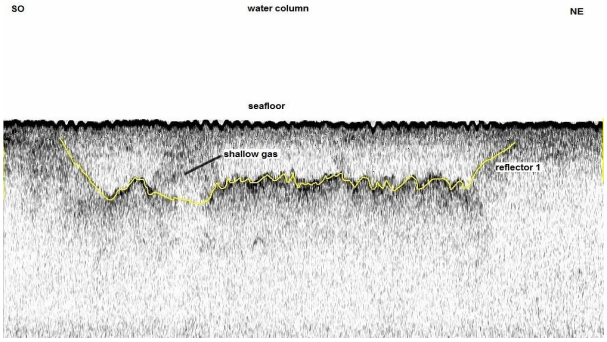

Figure 6. Appearance of gas curtain inside the paleochannel

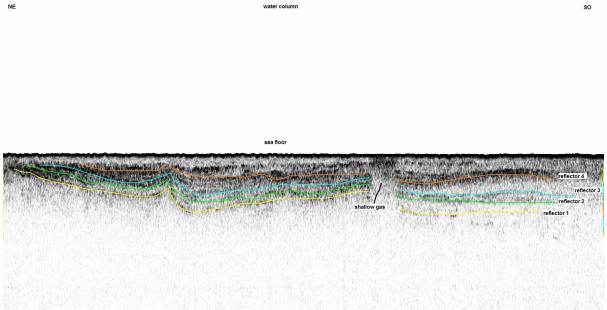

Figure 7a. Appearance of gas curtain preventing the acoustic signal

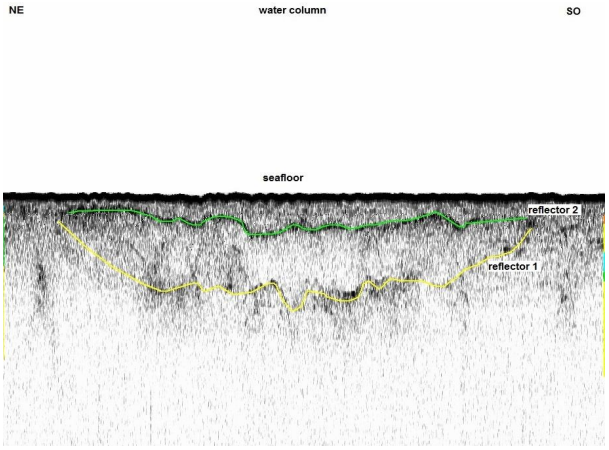

Figure 7b. The reflector1 delimited the bottom of paleochannel filled

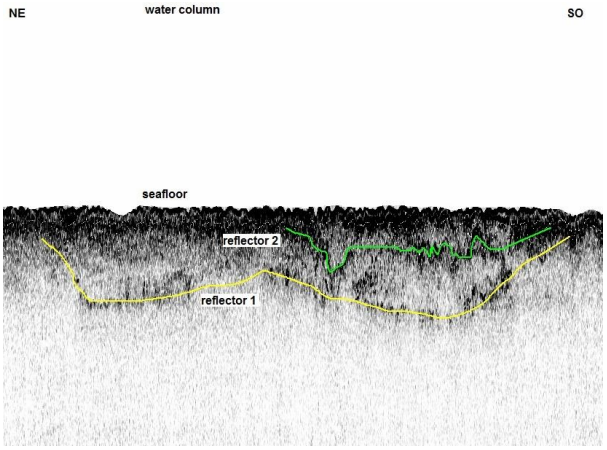

Figure 8. Reflectors delimited paleochannels

Also, it is possible to notice a high concentration of these features between the coordinates of 830/003 data 24° 50.1630'S / 047° 10.5782'W and 24° 40.1976'S / 047° 00.5583'W, the 741/656 data 24° 47.8117'S / 046° 47.0608'W and 24° 36.1608 / 046° 39.0316, the 906 data 24° 47.0413'S / 046° 30.6431'W and 24° 34.3585'S / 046° 22.4568'W. These results strongly suggest a pattern of extension of current alluvial courses to the outer regions of the platform, dug in regressive periods (Furtado & Conti, 2006).

Conclusions

The geophysical survey done with a sub-bottom acoustic profiler allowed the reconnaissance of the work field, situated at the southern internal shelf of the São Paulo state. The equipment utilized was adequate in fulfilling the proposed goal. The data collected led to the identification of seismic stratigraphic, paleochannels and a gas curtain in the seismic registers.

The localization of the paleochannels mapped was concentrated in the central portion of the seismic lines 830/003, 656/741 and 906 and presented the same proportion between them. The area is near the mouth of Ribeira do Iguape river, in the northern estuarine lagoon complex of Iguape, Such placement suggests the

lengthening of the river course when sea level was in a regressive period.

The challenges encountered in the course of this study were mainly related to the lack of registers by others seismic/acoustic methods, which would be useful to draw comparison between data of the same area. The use of a 3.5 kHz sub-bottom profiler shows good resolution of the submarine geo forms, but has penetration of a few tens of meters on the sub-bottom depending on the sediment type. The use of other methods which higher penetration would reveal other, more profound, hidden layers which would allow a better understanding of the deeper deposits.

The data of this study should be considered preliminary for new surveys, aiming for a more precise characterization of the subject. New, in-depth geological research of the area is needed. With the coring of the paleochannels, the understanding of the composition and origin of the sediments would be possible, and a higher quality, detailed map of the region could be made.

Acknowledgments

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