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Sand Spit From NE Brazil: High-Resolution Quaternary Analogs for Reservoir Models

Lima, Zuleide M. C., PPGG/UFRN - ANP-PRH22, Natal,RN; Andrade, Peryclys R. O., DG/UFRN - ANP-PRH22, Natal,RN; Xavier, Pedro, Petrobras - PPGG/UFRN; Vital, Helenice, DG/PPGG/UFRN/ ANP-PRH22 - CNPq Researcher, Natal,RN; Amaro, Venerando E., DG/PPGG/UFRN/ANP-PRH22, Natal, RN; and Medeiros, Walter E., DFTE/PPGG/UFRN/ANP-PRH22, Natal, RN

Introduction

Inserted in a recent coastal landscape, the Quaternary northeast margin of Brazil developed under high wave energy conditions which promote an intense longshore drift and sandy-spit formation along the coast. The Galinhos spit is the aim of this work. Galinhos is located most precisely in the northern coast of the State of Rio Grande do Norte at the Potiguar Basin which includes an offshore and an onshore segment (Fig. 1). It is a modern active barrier spit consisting of medium to fine-grained sand derived from adjacent shelf in a longshore transport. The current Galinhos sandy spit has an E-W direction with approximately 10 km of extension and medium width of 550 m, characterized by the complexity of their geomorphologic features, represented by beaches, reefs, barrier spits, estuaries, swamps, lagoons and dunes. The modelling of those features is directly correlated to the united performance of waves, coastal currents and winds, related with the variations of the sea level occurred during the Quaternary Period. The scenic potential of that landscape, associated with the wealth of the existent natural resources, has motivated an accelerated soil occupation, mainly in the last years. We can emphasize the intense performance of the oil activity, once Galinhos is in the area of influence of the Guamaré Oil Pole, area of exploration of PETROBRAS as well as the activities of the salty industry and more recently the carcinoculture.

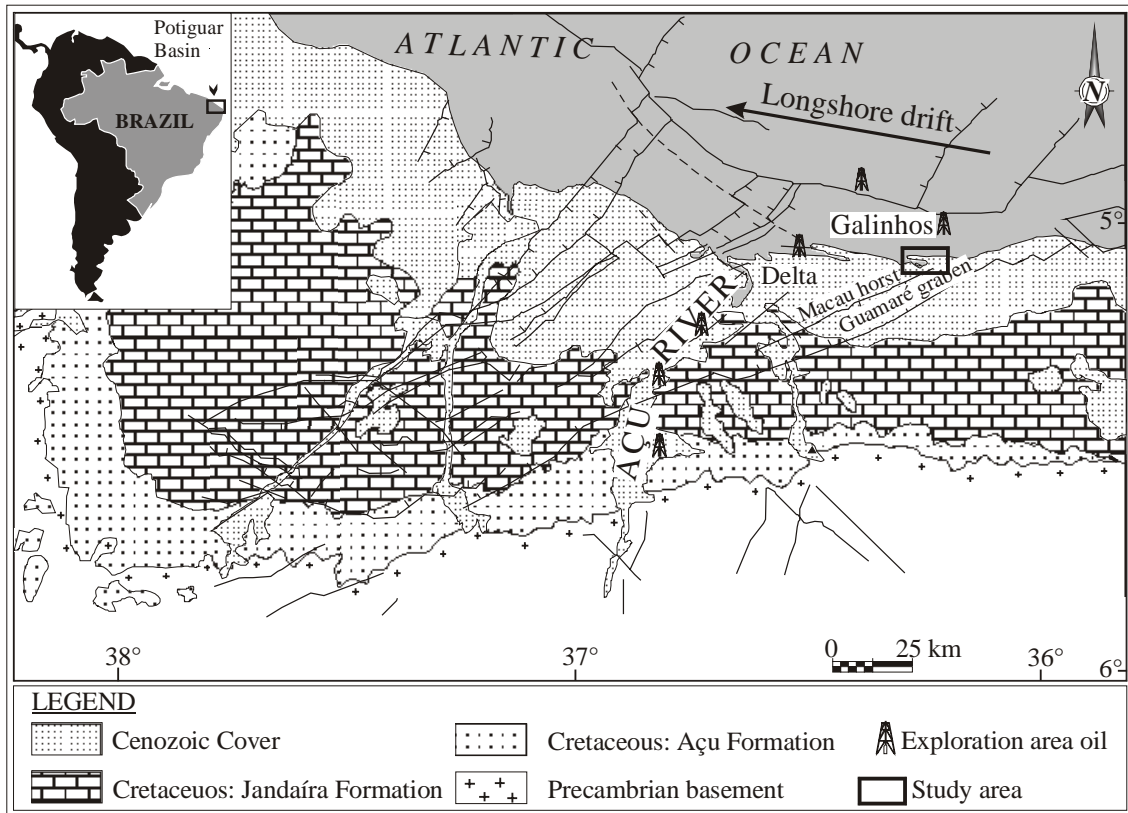


Figure 1 - Geographical location of the studied area.

In this way, inserted in the general objectives of the project “Environment Monitoring of Coastal Areas under Influence of the Guamaré Oil Pole (MAMBARÉ)”, this work consisted of a high resolution data set composed of remote sensing images, as vertical aerial pictures and satellite images, of different periods (1954, 1967, 1988 and 2000), Ground Penetration Radar radargrams and field works. This data set allows us to develop a detailed understanding of the Galinhos barrier-spit system evolution.

Methodology

The procedures and research techniques that were used for the remote sensing are the following ones:

- a) Compilation of the basic cartographic and bibliographical material: topographical charts, previous thematic maps, publications of similar themes, pictures aerial photographs, images of satellites and other document sources;
- b) Geoprocessing of the cartographic material (base raster and vector), in preparation for the analysis procedures and integration;
- c) Stages of the field study, as support to the monitoring of the coast line and making of the thematic charts: recognition of the main geodynamics, geomorphologic and geological features, fixing of the control points in the land, through GPS;

- d) Treatment of the digital products of remote sensing (aerial pictures, images Landsat) through techniques of digital processing of images (colored combination, methods of indexes, directional filtering, mosaics, etc.);
- e) Integration of vectorial data and images thematic multitemporals (raster and vector) through systems of geographical information (ER-Mapper, Idrisi).

Methodological procedures for Ground Penetrating Radar - Ground Penetrating Radar (GPR) is a geophysical electromagnetic technique that measures the time of propagation of a radar pulse in the subsurface of the earth. For geological purpose surveys, the utilized frequencies are usually in the range from 15 to 500 MHz. The measured quantity in the ground surface - the two-way propagation time of the wave pulse from the earth's surface to an obstacle in the subsurface - may be plotted and interpreted in a very similar manner as is done with seismic data. Usually, the investigation depths of GPR surveys are in the range from 1 to 30 m. In the Galinhos spit, six GPR profiles using the 200 MHz frequency were performed, two long profiles approximately perpendicular to the coastline and crossing the spit and four profiles parallel to the coastline. Topographic leveling was also performed along the same profiles. The equipment used was a SIR System 2, manufactured by GSSI (Geophysical Survey Systems, Inc.). Due to attenuation, spherical divergence and dispersion, GPR signals suffer changes of amplitude and form with depth. In order to correct these effects, the data were submitted to a processing flux very similar to those applied to seismic reflection data.

Results and considerations

Products of remote sensing are applied with success in the whole world in the study of the historical changes of the coastline, for the instantaneous registration of located configurations in temporary scale (Frihy, 1988; Lima *et al.*, 1993; White & El Asmar, 1999; Maia & Cunha, 2000; Noernberg, 2000; Lima *et al.*, 2001).

The analysis of the data of remote sensing showed that the spit of Galinhos registered a growth of approximately 230 m in the end west, from 1954 to 1988 and a regression of 330 m from 1988 to 2000 in its coastline. However in the central portion of the spit where Galinhos village is located showed a continuous narrowing of approximately 70 m from 1954 to 2000 in a north-south direction. Among the applied processings, the ones that showed better results for identification of the interface earth / sea were NDWI and the colored composition RGB 432. The application of directional filters allowed us to observe submerged features such as sandwaves and photo linings (Fig. 2). This last one was also observed in the aerial pictures, with direction NE-SW; the interpretation of these photo linings in the image products indicated the most favorable place for the application of GPR.

GPR has successfully been used in coastal studies to determine the extent, thickness, stratigraphy and internal structure of a wide range of unconsolidated sediments (e.g. Gawthorpe *et al.* 1993; Bridge *et al.* 1995, 1998; Harari 1996; Vandenberghe & van Overmeeren 1999; Neal & Roberts, 2000; Oliveira Jr. *et al.*, in press); In this work GPR was used in the elucidation of the hypothesis of evolution of the actual spit, through old systems of islands barriers. Acquisition of subsurface stratigraphic information of the Galinhos spit with GPR systems allows the identification of



Figure 2 -Landsat Image 7-ETM+ 2000 submitted to the filter Laplacian 5.ker.

washover, paleochannel, shoreface and lagoon deposits and confirmed the hypotheses of the existence of a paleochannel (Xavier *et al.* 2001). An example of a processed profile is shown in figure 3.

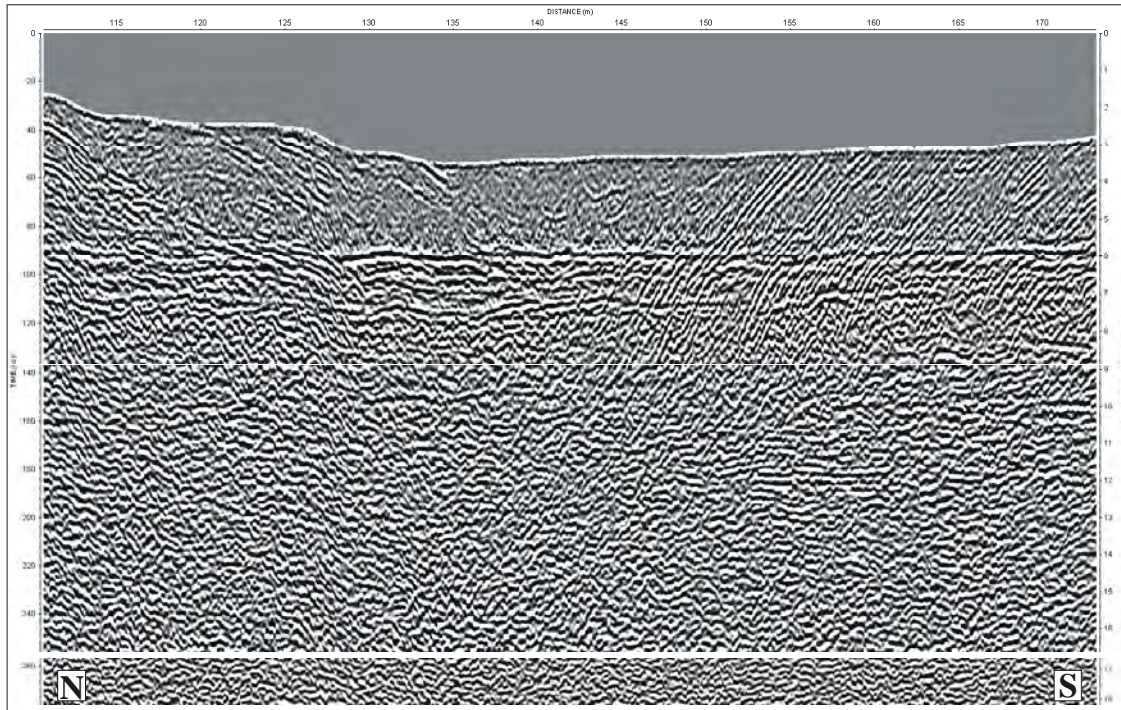


Figure 3 - Radargrama showing, in subsurface, the structure of the paleochannel in a section N-S.

These results lead us to the interpretation that the spit of Galinhos was an old system of islands barriers and provide good architectural analogues for the nearby subsurface reservoir.

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References

BRIDGE, J.S., ALEXANDER, J., COLLIER, R.E.L.L., GAWTHORPE, R.L. & JARVIS, J. 1995. Ground-penetrating radar and coring used to study the large-scale structure of point-bar deposits in three dimensions. *Sedimentology*, 42, 839-852.

- _____, COLLIER, R. & ALEXANDER, J. 1998. Large-scale structure of Calamus River deposits (Nebraska, USA) revealed using ground-penetrating radar. *Sedimentology*, 45, 977-986.
- FRIHY, O.E., 1988. Nile Delta shoreline changes. Aerial photographic study of a 28 year period. *Journal of Coastal Research* (4) 597-606.
- GAWTHORPE, R.L., COLLIER, R.E.L., ALEXANDER, J., LEEDER, M. & BRIDGE, J.S. 1993. Ground penetrating radar: application to sandbody geometry and heterogeneity studies. In: NORTH, C.P. & PROSSER, D.J. (eds) *Characterization of Fluvial and Aeolian Reservoirs*. Geological Society, London, Special Publications, 73, 421-432.
- HARARI, Z. 1996. Ground-penetrating radar (GPR) for imaging stratigraphic features and ground-water in sand dunes. *Journal of Applied Geophysics*, 36, 43-52.
- LIMA, Z.M.C.; AMARO, V.E. e SILVEIRA, I.M. da. 1993. O processo fotointerpretativo no monitoramento da evolução morfológica costeira da península de Galinhos (RN). In: CONGRESSO BRASILEIRO DE CARTOGRAFIA, 17., Rio de Janeiro. Anais... Resumo expandido. Rio de Janeiro/RJ, SBC. v.2, p. 500-505.
- LIMA, Z.M.C.; VITAL, H. AMARO, V.E. 2001. Monitoramento da variação da linha de costa de Galinhos/RN utilizando fotografias aéreas e imagens LANDSAT 5 – TM e LANDSAT 7 – ETM+. In: CONGRESSO DA ASSOCIAÇÃO BRASILEIRA DE ESTUDOS DO QUATERNÁRIO, 8., Imbé. Anais... Resumo expandido. Imbé/RS, ABEQUA. p.551-553.
- MAIA, L.P; CUNHA, E.M.S. 2000. Evolução da Praia dos Artista (Natal – RN) Por Análise Temporal de Fotografias Aéreas. In: SIMPÓSIO BRASILEIRO DE PRAIAS ARENOSAS, 1., 2000, Itajaí. Anais... Resumo expandido. Itajaí/SC, UNIVALI. p. 162-163.
- NEAL, A. & ROBERTS, C. 2000. Applications of Ground-penetrating radar (GPR) to sedimentological, geomorphological and geoarchaeological studies in coastal environments. (eds) *Coastal and Estuarine Environments: sedimentology and geoarchaeology*. Geological Society, London, Special Publications, 175, 139-171.
- NOERNBERG, M.A. 2000. Monitoramento da Variação da Linha Praial no Balneário de Pontal do Sul/PR, Utilizando Imagens Multiespectrais Landsat-TM. In: SIMPÓSIO BRASILEIRO DE PRAIAS ARENOSAS, 1., 2000, Itajaí. Anais... Resumo expandido. Itajaí/SC, UNIVALI. p.105-106.
- OLIVEIRA JR., J.G.de. MEDEIROS, W.E de & VITAL, H., XAVIER, P., STATTEGGER, K. 2000. GPR Imaging of Internal Structure of a Sand Dune in Rio Grande do Norte State, NE Brazil. *Journal of Coastal Research* (CERF-JCR). ., IN PRESS.

VANDENBERGHE, J. & van OVERMEEREN, R. A. 1999. Ground penetrating radar images of selected fluvial deposits in the Netherland. *Sedimentary Geology*, 128, 245-270.

XAVIER NETO, P.; LIMA, Z.M.C.; ANDRADE, P.R.O.; Jr. OLIVEIRA, J.G.; MEDEIROS, W.E.; VITAL, H. 2001. GPR image of the Galinhos Peninsula. NE Brazil: The register of a geologic evolution from a paleochanel to a sand spit?. In: *GPR in sediments at the Geological Society and VCL*, 1. 2001, London, Resumo... London. P.40

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Abbreviations used: DG – Departamento de Geologia, DFTE – Departamento de Física Teórica e Experimental, PPGG – Programa de Pos-Graduação em Geodinâmica e Geofísica, UFRN – Universidade Federal do Rio Grande do Norte, ANP – Agencia Nacional do Petróleo.