Echo Facies Distribution in Vitoria Bay, Southeast Brazil

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This paper was prepared for presentation during the 11th International Congress of the Brazilian Geophysical Society held in Salvador, Brazil, August 24-28, 2009.

Abstract

A high resolution geophysical survey and sediment sampling were carried out in Vitoria Bay in order to acoustically map the seabed and to establish the sediment distribution. Integrated analysis of sonograms and seismic records allowed the recognition of 4 distinct echo facies. These facies are related to different seabed material and can be used to interpret the main sedimentary processes acting along the Bay.

Introduction

High resolution acoustic methods have been extensively applied to map the seabed morphology, facies distribution and the subsurface geological layers. They have also been used to indirect investigations of sedimentary processes in shallow seas and coastal bays (Morang *et al*, 1997; Ayres Neto, 2000; Souza 2006; Quaresma *et al*, 2000; Paolo & Mahiques, 2008). The acoustic method is based on the return of the echo signals across an interface with acoustic impedance contrast. The intensity and characteristics of the returned echo is related to bed material (grain size, rock outcrop, bed compaction etc), subsurface sedimentary layers (reflection coefficient, sediment thickness, etc.), bed morphology, incident angle, attenuation of acoustic waves, water depth, etc (Morang *et al.*; 1996; Ayres Neto, 2000). In order to acoustically map the seabed, echosounders, sidescan sonars and subbottom profilers have been used. Acoustic facies or echo facies can be described as a group of acoustic characteristics of the reflected signal. These characteristics are usually described, for example, as strong or weak signal reflection patterns in the case of sidescan sonar records and hyperbolic, no penetration, and others, in the case of sub-bottom profiler records. Hence, acoustic records obtained from sidescan sonars and subbottom profilers can be used to indicate not only changes in bed sediment distribution, but also to interpret prevailing sedimentary processes (Damuth, 1980; Morang *et al*, 1997; Ayres Neto, 2000; Souza 2006; Quaresma *et al*, 2000; Belo *et al*, 2003; Catanzaro et al., 2004).

The main objective of this work is to acoustically map the bed over Vitória Bay. Distinct seismic and sonographic echo characters were defined and described as different acoustic facies types and related to sediment grain size and texture.

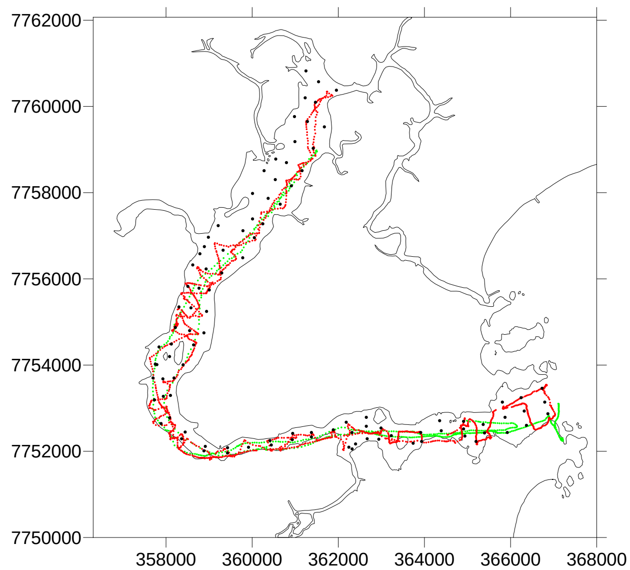


Figura 1: Study area showing samples location (black dots), sidescan sonar transects (green lines) and seismic transects (red lines).

Method

This research used an integrated approach in order to relate bed sediment distribution with acoustic data. 101 sediment samples were collected using a Van Veen sampler. Sediments were wet and dry-sieved to establish the main grain size and sand, mud, gravel contents. Sidescan sonar and high resolution seismic surveys were undertaken along the entire bay, performing about 150km sidescan and seismic lines. Seabed imaging was obtained with an Edgetech sidescan sonar model 4100 operating on 500kHz. Seismic data was acquired using a Stratabox 10kHz transducer. Geophysical data was processed and interpreted using SonarWizMAP-4 software (Chesapeak Technology). Sonographic patterns and seismic echo character were classified according to acoustic character (backscatter intensity), bed morphology and degree of penetration (seismic only), folowwing Damuth (1980).

Results and Discussion

Integrated analysis of sonograms and seismic records allowed the recognition of 4 distinct echo facies. Echo facies type 1 is characterised by uniform to irregular low/medium backscatter and sandwave sonographic patterns associated with an irregular to flat high reflective seismic echo character with no penetration This echo facies is mainly associated with sandy beds, being present at bay entrance and areas with higher hydrodynamic energy. It indicates sediment transport and the formation of large bedforms. Echo facies type 2 is associated with uniform low backscatter with locally irregular bedforms (ripple marks) sonographic pattern. Seismic echo character presents high penetration of the acoustic signal, showing several internal seismic reflectors. This echo facies occurs in the inner area of the Bay, being to related to muddy to sandy-mud beds. It can be interpreted as areas of typical mud-estuarine sedimentation and areas where erosion is taking place along the main channel.

Echo facies type 3 is described by uniform and flat low backscatter sonographic pattern associated with a low reflection character of the seismic echo, followed by a free-reflection layer limited by a strong seismic reflector. This echo facies is predominantly associated with muddy beds and its distribution occurs mainly along high impacted areas, where dredging activities and sewage outfall take place. This can probably induce high flocculation processes leading to higher sedimentation rates. The free-reflection layer could be associated with fluid mud deposits.

Echo facies type 4 is characterised by irregular/rough high backscatter sonographic patterns, while seismic echo characters are associated with irregular and hiperbolic strong reflectors with no acoustic penetration. This echo facies represents rock outcrops.

Table 1 presents a review of the 4 distinct echo facies with echo characters examples. Figure 2 shows the distribution of echo facies over Vitoria Bay.

Conclusions

Integrated analysis of sonograms and seismic records allowed the recognition of 4 distinct echo fácies. These facies are related to different seabed material and can be used to interpret the main sedimentary processes acting along the Bay.

Acknowledgments

The research was financially supported by the Fundação de Amparo a Pesquisa do Estado do Espírito Santo (FAPES) and by a small grant provided by COPES-PETROBRAS.

References

Souza, L.A.P. & R.L. Moura, 2005. Sonar de varredura Lateral aplicado ao estudo de áreas recifais: o exemplo de Abrolhos. In: Congresso Internacional da Sociedade Brasileira de Geofísica – CISBGf, 9. Salvador, BA, . Anais. CD- ROM.

AYRES NETO A. 2000. Uso da sísmica de reflexão de alta resolução e da sonografia na exploração mineral submarina. Rev. Bras. Geof., 18 (3): 241-256.

BASTOS AC, QUARESMA VS, DALMASCHIO RG, CARMO D A, SOUZA PM, LIMA B, POZZI F. 2007. Dinâmica Sedimentar e Morfologia de Fundo do Sistema Estuarino de Vitória, ES. Congresso da Associação Brasileira de Estudos do Quaternário. 1: 2007, Belém. Anais... Belém: ABEQUA, 2007.

BELO WC, DIAS GTM, DIAS MS. 2003. O Fundo Marinho da Baía da Ilha Grande, RJ: O Relevo Submarino e a Sedimentação no Canal Central. Revista Brasileira de Geofísica, 20 (1): 5-15, 2002.

BLOTT SJ, PYE K. 2001. GRADISTAT: a grain size distribution and statistic package for the analisys of unconsolidade sediments. Earth Surface Processes and Landforms, 26: 1237-1248.

DAMUTH JE. 1980. Use of high-frequency (3,5 - 12 kHz) echograms in the study of near bottom sedimentation processes in the deep sea: a review. Marine Geology, 38: 51-75.

MORANG A, LARSON R, GORMAN L. 1997. Monitoring the coastal environment; part III: geophysical and research methods. Journal of Coastal Research, 13(4): 1064-1085.

PAOLO FS, MAHIQUES MM. 2008. Utilização de métodos acústicos em estudos de dinâmica costeira: exemplo na desembocadura lagunar de Cananéia. Rev. Bras. Geof., 26(2): 211-225.

QUARESMA VS, DIAS GTM, BAPTISTA NETO JA. 2000. Caracterização da ocorrência de padrões de sonar de varredura lateral e sísmica de alta frequência (3,5 e 7,0 khz) na porção sul da Baía de Guanabara – RJ. Rev. Bras. Geof., 18(2): 201-214.

SOUZA LAP. 2006. Revisão crítica da aplicabilidade dos métodos geofísicos na investigação de áreas submersas rasas. Tese, Instituto Oceanográfico da USP, São Paulo.

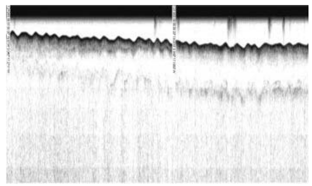
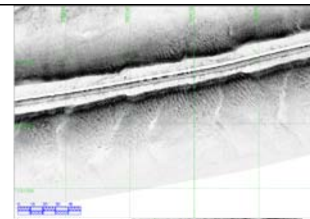
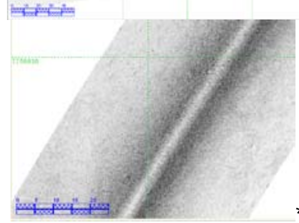
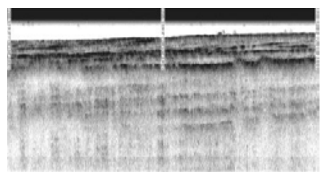
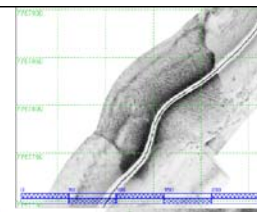
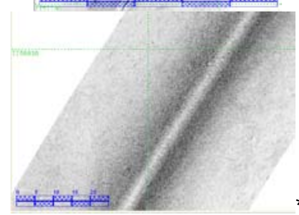
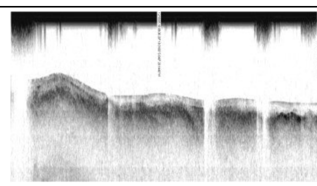
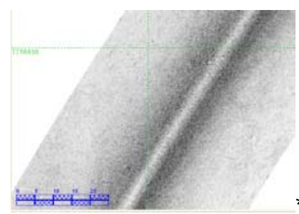
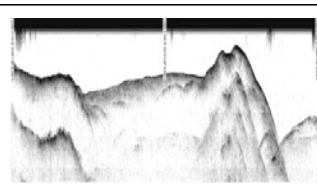
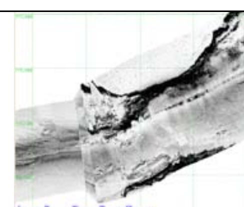
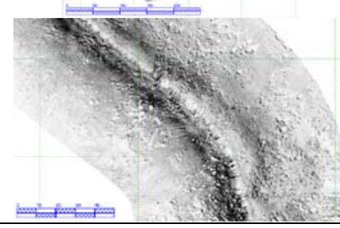
Echo Facies	Bed Material	Acoustic Character	Seismic Echo Character	Sonograms
1	Sand	uniform to irregular low/medium backscatter and sandwave sonographic patterns associated with an irregular to flat high reflective seismic echo character with no penetration .		  *
2	Mud/Sandy-mud	uniform low backscatter with locally irregular bedforms sonographic pattern. Seismic echo character - high penetration of the acoustic signal, showing several internal seismic reflectors.		  *
3	Mud	uniform and flat low backscatter sonographic pattern associated with a low reflection character of the seismic echo, followed by a free-reflection layer limited by a strong seismic reflector		 *
4	Rock Outcrop, Blocks	irregular/rough high backscatter sonographic patterns, while seismic echo characters are associated with irregular and hiperbolic strong reflectors with no acoustic penetration		 

Table 1

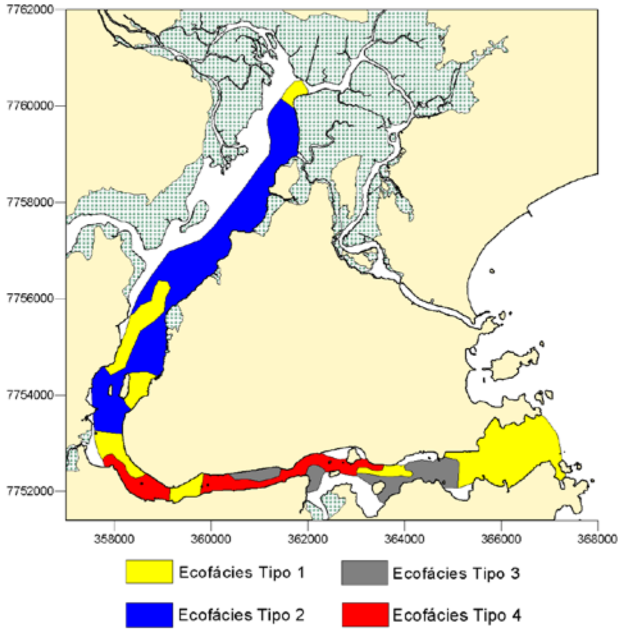


Figura 2: Distribution of echo facies over Vitoria Bay.