Seismic amplitude signal classification applied to seafloor morphological and textural characterization.

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Abstract (Font: Arial Bold, 9)

Seabed morphological details, textural and compositional sedimentary distribution are basic information for habitat characterization, necessary for environmental assessment projects. Superficial and shallow subsurface seabed sediment samples are usually sparse and give only local, punctual information. In this work we extracted the seabed amplitude values from 2D seismic multichannel vintage data and classified this information, generating a seabed seismic amplitude map from the Chuí Megaslide region, on the southern continental slope of Pelotas Basin. The results shows the correlation of seabed seismic amplitude anomalies with the seafloor micromorphology and can be used as a first approximation for sea-bottom characterization using available seismic coverage.

Introduction

The continental slope of Pelotas Basin, in the southern Brazilian continental margin, has prominent morphological features resulted from the action of bottom currents, submarine gravitational mass transport and sedimentary fluxes. An extensive slide scar and respective mass transport deposits were described by Reis et al. (2016) near the border with Uruguai (Figure 1). The Rio Grande Cone (Figure 1) represents a large prograding depocenter, more than 10 km thick (Gomes, 1993), deformed by gravity tectonic processes (Zalán, 2005) (Figure 1). The Rio Grande Terrace (Figure 1) is an erosive feature on the upper continental slope, related to the erosive action of bottom currents (Zembruscki, S.G., 1979). The sedimentary coverage and micromorphology over these large morphological features result from the sedimentary provenance and dominant depositional processes, which are largely modified by later re-sedimentation processes related to bottom current re-working and gravitational mass-transport events. In this work, we aim to classify the amplitude of the seabed seismic signal and to associate this information to the seabed nature which reflects the impedance contrast (mostly texture and density). The results can be used in comparison with existing descriptions of seabed samples to generate automatic seabed classification using vintage seismic data in support to seafloor habitat maps.

Method

To test the methodology we had access to 2D multichannel seismic data acquired by the company Spectrum Geo do Brasil collected in the Pelotas Basin in two different surveys. A total of 7,438 km seismic data was acquired in survey I, with a 5000 in³ air gun and 12.084 km data in survey II with a 4,260 in³ air gun. Both surveys adopted a 37.7 m shot interval and 13.5 sec record length using a 12 km long hydrophone with 12.5 m group interval. For this project only the upper 500 msec of data were provided by Spectrum Geo in two different formats: (1) full-stack time migrated SEGY data and, (2) near trace SEGY data with no gain applied. Line spacing in strike and dip directions in the area of interest was nearly 10 km (Figure 2). The full-stack data was used for seabed picking and to construct the bathymetric map applying 1,500 m/sec for the seismic velocity in the water column. The seismic amplitude signal was extracted from the near trace data, since these have no applied gain, which might alter the seismic amplitude signal. After analyzing the areal distribution of seabed seismic amplitude values, we identified and mapped the distribution of the anomalous values. The seismic interpretation and seismic anomalies extraction used the software *Kingdom*® from IHS Markit and routine statistical analysis for the seismic anomalies separation used the software MatLab from MathWorks®. Figure 3 represents the adopted process flow.

Results

The seismic anomalies classification and analysis was applied to a portion of the continental margin located on the Chuí Megaslide Complex area (Figures 1 and 2). The headwall escarpment of the megaslide is more than 50 km wide near continental shelf border, in water depths circa 300 m and narrows to 35 km at 1700 m water depth before widening to more than 150 km from the 2,200 m isobath, to the end of the seismic coverage near 3,500 m (Figures 1 and 2).

The histogram representation of the seabed seismic amplitudes presents a bimodal distribution (Figure 4). We visually isolated the negative and positive anomalous values into four groups. Categories A,B and C represent negative values and category D positive values. Categories A, B and C are included inside each other, being category A the most extensive and category C the most restricted (Figure 4).

The irregular micro-morphology inside the Chuí Megaslide area is mostly represented by category 3 (amplitudes range from -6 to -12 dB). Smooth morphologies are mostly represented by category 2 (amplitudes smaller than -12 dB). (Figure 5). In this region the irregular micromorphology represents the seabed expression of debris-flow deposits characterized by internally transparent or chaotic seismic facies as observed in Figure 6. The local distribution of amplitude anomalies might otherwise be related to different sedimentary textures or densities, however to confirm this hypothesis, it is necessary to have access to direct seabed sediment samples, which were only sparsely distributed in the area.

Conclusions

The automatic seabed classification using available vintage seismic data can bring additional and valuable information for mapping submarine habitats. In areas with scarce or absent direct seabed sediment samples, the analysis of the distribution of seismic amplitude anomalies from the sea-bottom, can be used as an alternative tool to have a preliminary assessment of the seabed micromorphology and nature. The coupling of direct sediment information with the seismic amplitude signal, when available, can be used in the future to further constrain the relation between seismic amplitude signal and impedance contrast near the seabed.

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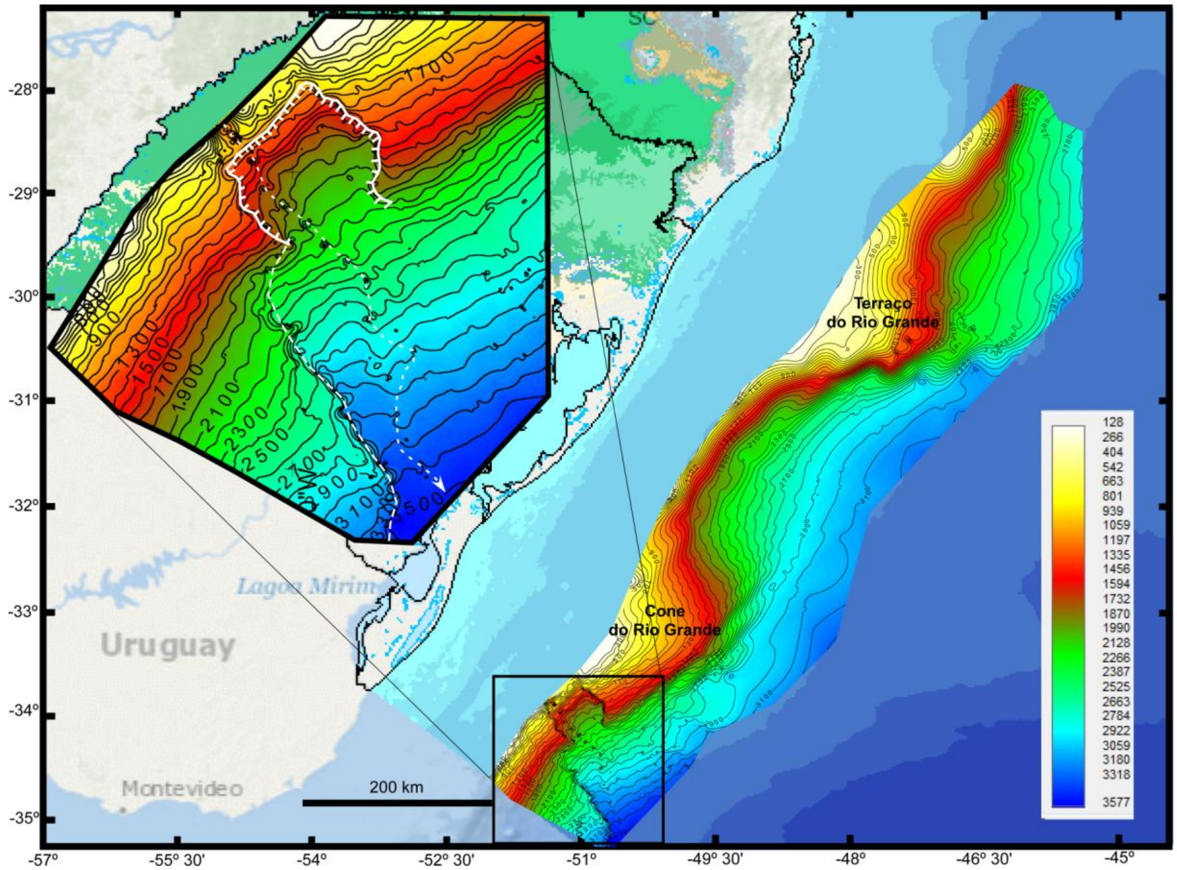

Figure 1 - Bathymetric map of the southern continental margin derived from the seabed picking on the 2D multichannel seismic data. The inset shows the location of the Chuí Megaslide headwall scar and intermediate meandering channel (segmented line with arrow). Depths in meters.

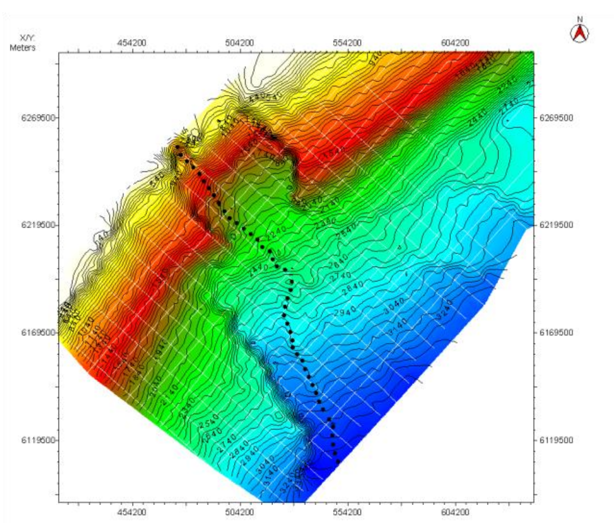

Figure 2 - 2D multichannel seismic coverage(white lines) on the Chuí Megaslide area.

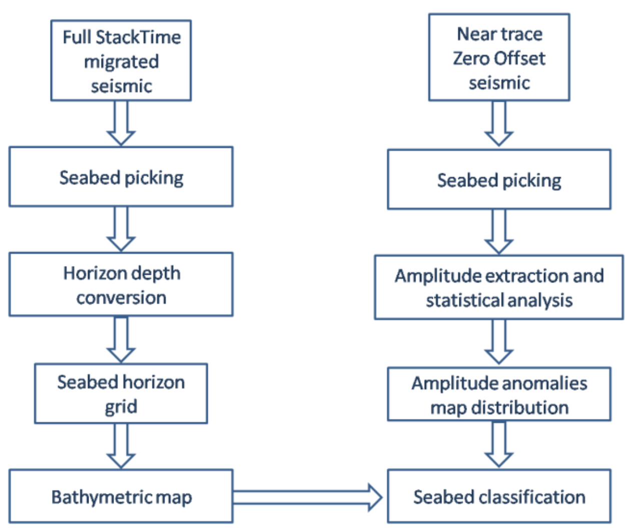

Figure 3 - Process flow chart adopted for seabed seismic amplitude anomalies analysis.

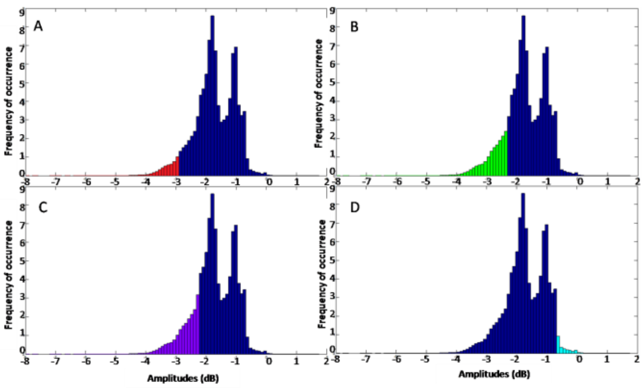

Figure 4 - Bimodal frequency distribution of seismic amplitude values. The categories A, B and C isolated the negative amplitude values and category D positive amplitude values.

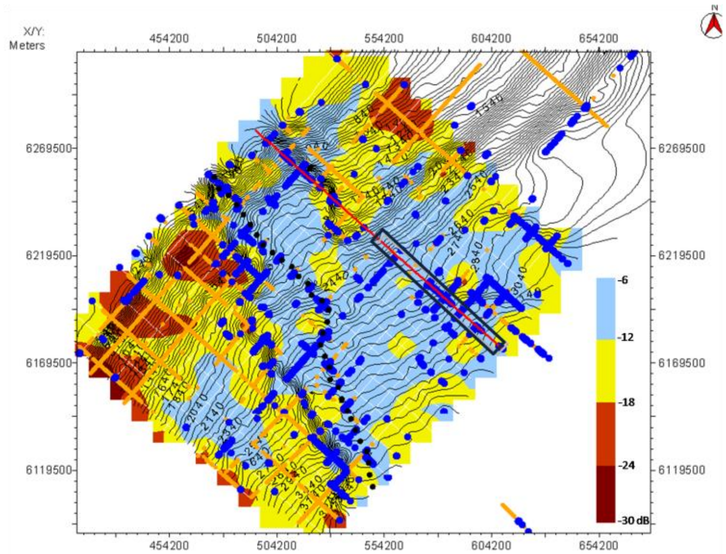

Figure 5 - Seabed seismic anomalies classification representing category 3 (dark blue) and 2 (orange). The irregular micro-morphology inside the Chuí Megaslide area is mostly represented by category 3 (amplitudes range from -6 to -12 dB. Smooth morphologies are mostly represented by category 2 (amplitudes smaller than -12 dB). The red line indicates the seismic section illustrated in figure 6.

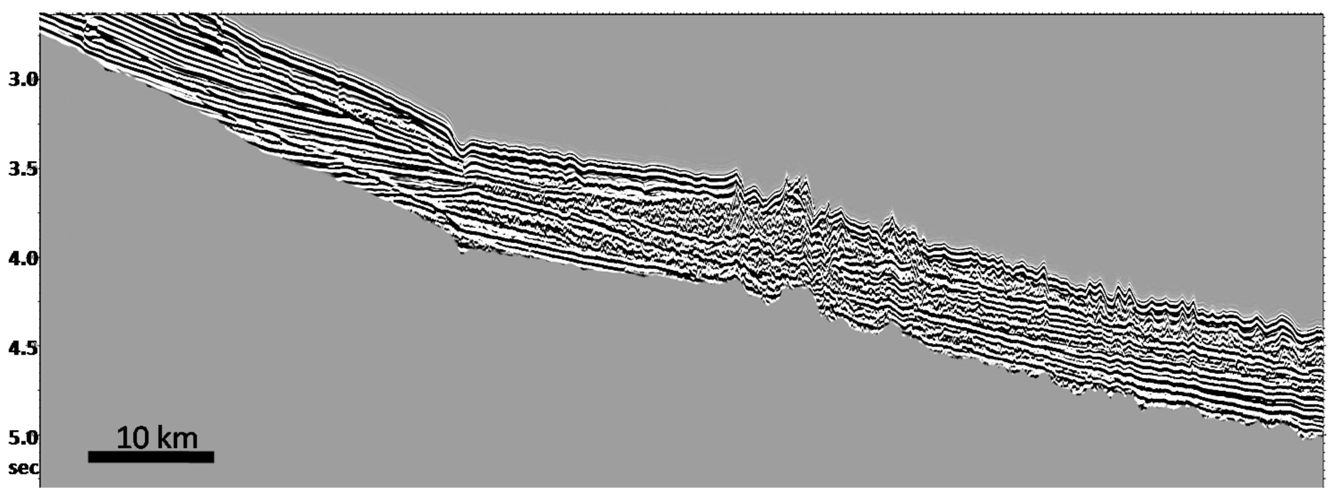

Figure 6 - Seismic section illustrating the irregular micro-morphology of the seabed associated with the Chuí Megaslide debris flow deposit. For location see figure 5 (black rectangle along red line).