SHALLOW GAS ACCUMULATION IN SEDIMENTS OF THE RIA DE AVEIRO, PORTUGAL

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Abstract

Numerous studies show that the coastal ecosystems are an important source of natural gas. The purpose of this study is to identify natural gas occurrences using a Chirp Sonar (0,5-12kHz) Edgetech 512-I in the sediments of North Terminal, located in the Ria de Aveiro coastal lagoon (Portugal). Geophysical data were collected and then used to identify indicators of natural gas in the sub-bottom sediments. Seismic profiles and gas field maps were produced. Chirp sonar has proved to be a most effective tool for identifying shallow gas occurrences trapped in the sediments.

Introduction

The importance of studying shallow gas accumulation in sediments has increased over recent decades. A set of reasons exist to study these natural gas occurrences. It is an important energy source often used in human societies, especially methane, which is an important contributor to climate change, and it can be a problem for the geotechnical stability of underwater operations. Methane is an atmospheric greenhouse gas, being the most abundant hydrocarbon in the atmosphere (Zhou et al., 2009).

Therefore, the knowledge of marine geological environments in which shallow gas accumulates is becoming increasingly important in global studies. Within this context, coastal environments, such as bays, estuaries, incised valleys, and rías, represent important geological environments where the shallow gas is being generated, accumulated and released to the atmosphere.

Gas accumulations in shallow shelf and coastal sediments are a common phenomenon worldwide (e.g. Park et al., 1991; Karisiddaiah et al., 1992; Papatheodorou et al., 1993; Garcia-Garcia et al., 1999, 2007; Okyar and Ediger, 1999; Fleischer et al., 2001; Missiaen et al., 2002; Garcia-Gil, 2003; Duarte et al., 2007; Terra et al., 2013).

The presence of gas in sediments is well detected by high resolution seismic surveying due to the change of acoustic impedance between media with and without gas. Seismic sections with gas structures display anomalous acoustic reflection patterns. These anomalous responses observed in these sections are related to the amount of gas trapped in the sediments.

The study area presented here is characterized by a grid of 24 seismic lines acquired in the North Terminal of the Ria de Aveiro (Figure 1), a very recent barrier-lagoon system, located along the Northwest Portuguese Coast (Portugal, 40°38'N, 08°45'W).

The Ria de Aveiro barrier-lagoon system covers an area of approximately 530 km² and is located at the mouth of a drainage basin of 3 635 km² (Vouga River and its tributaries). It is characterized by very shallow waters with depths usually around 1-2 meters, locally reaching 20 meters in the navigable channels. The tidal regime is semi-diurnal with an average amplitude of 1.90 meters and a maximum around 2.57 meters during spring tides (Duarte et al., 2007).

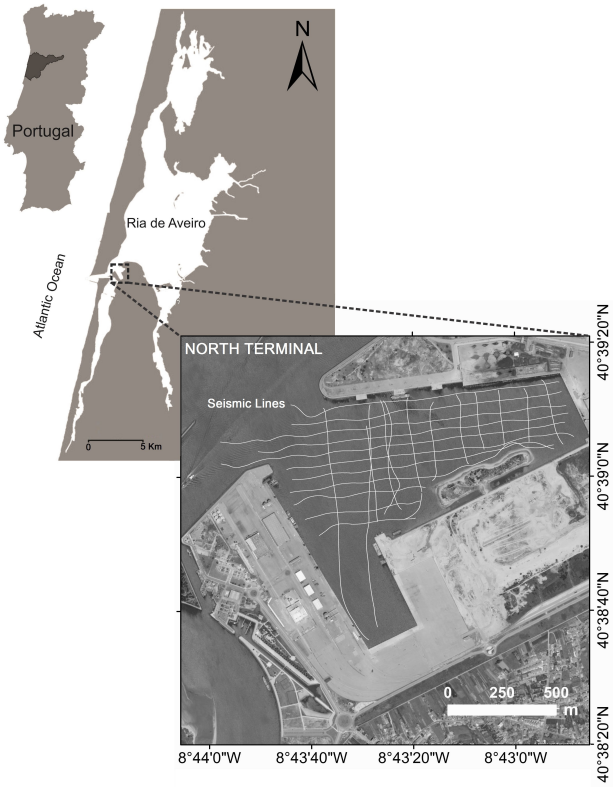

Figure 1 – Location of Ria de Aveiro coastal lagoon and the North Terminal, with the location of the seismic lines.

The shallow seismic survey undertaken in sediments from the Ria de Aveiro revealed acoustic anomalies that were

related to gas occurrences. The purpose of this study is to characterize these anomalies in the study area and to understand the process of gas formation within the context of the geological evolution of this area.

Method

The geophysics campaign was carried out on October 2, 2013 and 55 km of high-resolution seismic lines were acquired using a Chirp Sonar (0,5-12kHz) Edgetech 512-I are presented.
The data were collected by EdgeTech Discover acquisition software and the position was given by a DGPS system. After their acquisition the seismic data were processed with the software RaDex Pro and interpreted by using the software Kingdom Suite 2016.1. The offset was corrected and a Bandpass filter was applied to minimize the noise and to improve the visibility of data. In the software Kingdom Suite, the tide effects were corrected for general interpretation of the seismic profiles.

Results

The high-resolution seismic reflection profiles show sedimentary layers that cover the whole area but in some places the seismic reflectors from the Aveiro Clay Unit (late Cretaceous clays and marls) are not visible from the sub-bottom data due to acoustic turbidity anomaly.
Regions with acoustic turbidity presence were observed in almost all of the survey lines in the study area (Figure 2). The changes in acoustic character provide evidence of gas trapped in the sediments (García-Gil et al., 2002).

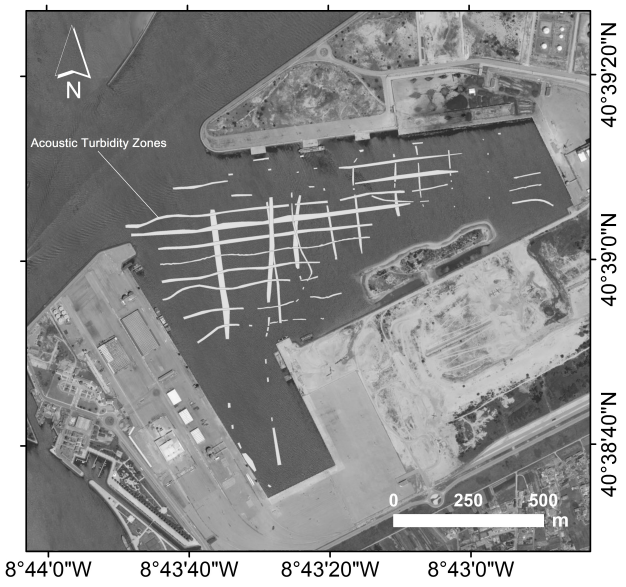

Figure 2 – Location of the profiles showing acoustic turbidity.

The evidence of the presence of shallow gas in the seismic data acquired in the North Terminal of the Ria de Aveiro can be characterized by anomalous windows that overlap the sedimentary structures interpreted as gas curtains (Figure 3).
The sub-bottom data are plotted in two-way-time (TWT), nevertheless, the conversion of TWT to depth can be made easily. To convert from time (s) to depth (m), the velocity of the material has to be known. In this case, a value of 1600 m/s was used for the marine sediments. Thus, the gas observed is approximately located between 4 to 14 meters depth.

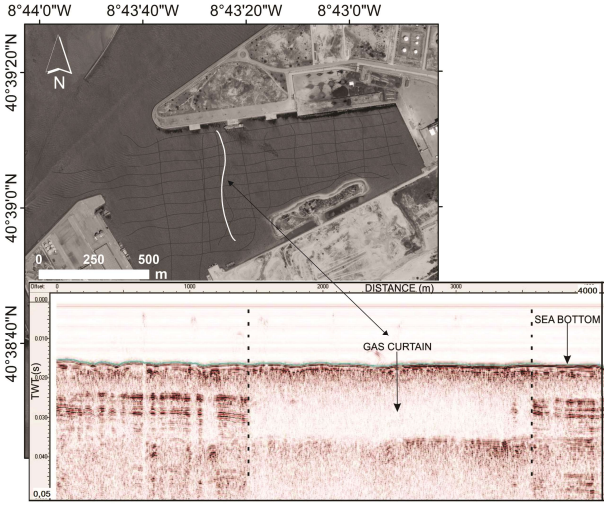

Figure 3 – Seismic profile of line TNC12 with evidence of gas accumulation.

From all the sub-bottom profiles acquired in the North Terminal, two main areas with gas trapped in the sediments were defined. They are represented in the map below (Figure 4).

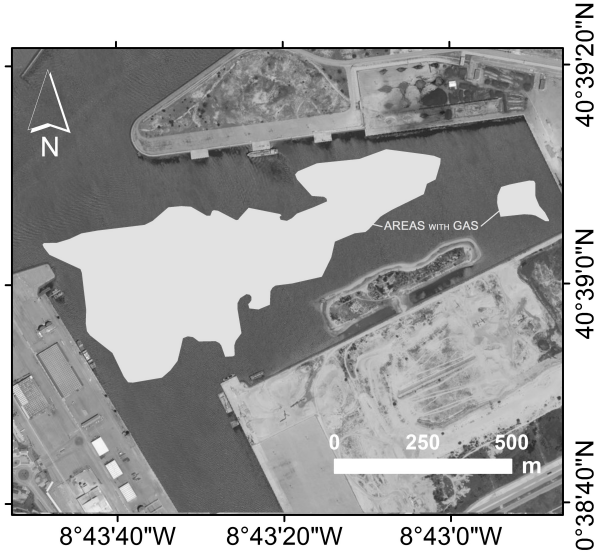

Figure 4 - Location of areas with acoustic evidences of gas in trapped the sediments.

Conclusions

Chirp seismic profiles are an excellent tool to highlight evidence of shallow gas accumulations. Gas trapped in the sediments causes a significant effect on the geoacoustic behavior, thus the gas accumulation can be clearly identified as anomalous or chaotic reflections and/or acoustic blanking. This methodology is widely used by geologists and geophysicists as an indicator of the presence of natural gas in estuarine and marine sediments.

The Ria de Aveiro is an environment favorable to the biogenic production of gas. The process consists of freshwater streams feeding the lagoon with sediments rich in organic matter, and these settle on the bottom of the lagoon due to its low hydrodynamic energy. These conditions promote the degradation of organic matter and the production of natural gas.

The grid of seismic data in this area enabled the detailed mapping of different types of seismic evidence of gas accumulation.

The results obtained with this high-resolution seismic study have confirmed that the Ria de Aveiro is an interesting natural laboratory to study the generation, migration, and escape of shallow gas in a typical barrier-lagoon system.

Acknowledgments

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