Characterization of gas chimneys in Almada Basin

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Abstract

The occurrence of gas chimneys in Almada basin is indicative of an active petroleum system, with migration of fluids between the source rock and reservoirs or between reservoirs and the sea bed.

Gas chimneys are recognized as low amplitude seismic facies. To map and improve the identification of the gas chimneys in Almada basin, we applied a attribute based on coherence and amplitude.

Structures commonly related to the escape of fluids, e.g., pockmarks, mud volcanoes or crusts of authigenic carbonates are found in the northern part of Almada basin.

Introduction

The Almada basin is located in the southern portion of the coast of Bahia state, northeastern region of Brazil. It is bounded to the north by the Camamu Basin and to the south by the Jequitinhonha Basin.

The origin of the Almada Basin is associated with the rifting that resulted in the break-up of South America and Africa and the development of the Brazilian eastern marginal basins. The tectono-sedimentary evolution of the basin, as well as other eastern Brazilian margin basins, can be summarized as sucession of three main stages: prerift, rift and postrift (Ponte and Asmus, 1978; Ojeda, 1982; Gonçalves et al, 2000).

According to modeling studies of petroleum systems described in Santos, 2011, the source rocks of the pre-salt, with lacustrine origin (e.g. Fm Morro do Barro and Fm Rio de Contas), are in a gas generation phase

The identification of gas chimney may be useful to the analysis of hydrocarbons conductive faults and to investigate the integrity of the seal rocks. Furthermore, it might indicate that the petroleum system is active and it can lower the risks for the drilling phase and for the production facilities.

The seismic facies of the gas chimney tends to be chaotic with low amplitude. The seismic attributes, based on coherence and amplitude, has proven to be an useful tool to highlight such features.

Pockmarks, mud volcanoes or authigenic carbonate crusts of cold water, which are commonly associated with the escape of fluids, were identified in the northern part of the basin. Several oil provinces worldwide show these fluid leakage features, e.g., Santos Basin (Carlotto & Vasconcelos, 2011), Gulf of Cadiz (Baraza & Ercilla, 1995) and Troll field (Norway) (Hovland et al, 2005).

In this paper, we test the seismic attribute Dip (measuring the dip of the structures) to highlight features of these mounds (mud volcanoes or coral) and pockmarks on the seabed. The software Geoteric was used for extracting the seismic attributes.

Methodology

Mapping the gas chimneys in seismic data, sometimes, becomes difficult due to low amplitudes of their seismic facies. The application of the seismic attribute called Diapir, improved the identification of gas chimney and facilitated its mapping. This attribute highlights the chaotic and low amplitude facies, commonly associated with the presence of salt diapir or gas chimney.

It is worth noting that beneath submarine canyon regions, the seismic data tend to lose amplitudes. In this scenario, thick shale layers present similar seismic facies to the gas chimney ones. Therefore, around these regions are created seismic artifacts.

Figure 1 shows a conventional amplitude seismic section and Figure 2 shows the same section combined with the seismic attribute called Diapir, where gas chimneys are easily identified.

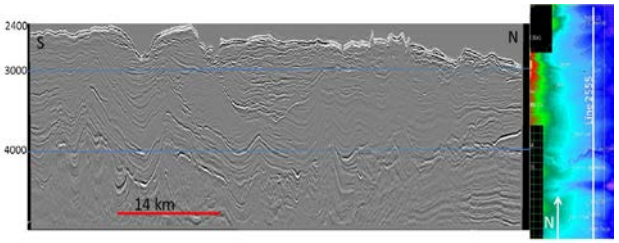

Figure 1: Line south-north. Conventional amplitude seismic data. In the right, the localization of the line over the bathymetry.

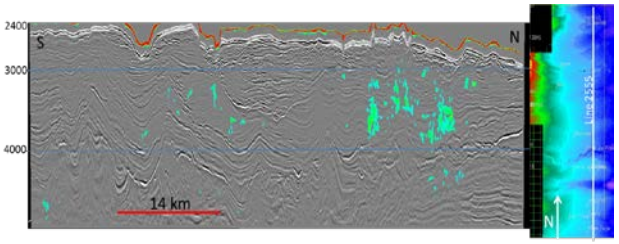

Figure 2: The same section as the Figure 1 combined with the seismic attribute called Diapir.

Features associated with gas leakage

Pockmarks, mud volcanoes or crusts of authigenic carbonates are features commonly associated with the escape of fluid. The methane gas emission in the marine environment provides formation of microbial mats and profusion of fauna connected to the escape of the gas, such as mussels, worms and deep sea corals.

Pockmarks are depressions in the seabed. Two generation processes are proposed (Hovland & Judd, 1988): catastrophic eruptions of gas and continuous discharge of fluids.

The positive features of seafloor can be mud volcanoes or building corals. In Almada basin, these features can reach up to 150 m high and up to 1 km wide (Figure 3).

The sulphate-reducing bacteria react with methane exudate and precipitate calcium carbonate (CaCO3), creating a hard substrate. Corals grow on this substrate or on the edges of pockmarks (Carlotto & Vasconcelos, 2011). Therefore, these carbonated crusts correspond to the lithification of sediments by precipitation of authigenic calcite and dolomite. The microbial activity has an important role in the formation of carbonate minerals (Magalhães et al, 2002).

Mud volcanoes are the result of a penetrating structure created by a pressurized mud diapir that reaches the earth's surface or seabed. The seismic attribute called Dip (which highlights the dip of the structures) was applied on the seabed to enhance the visualization of these features associated with gas leakage (Figure 4). The gas chimneys are concentrated in the northern portion of the basin.

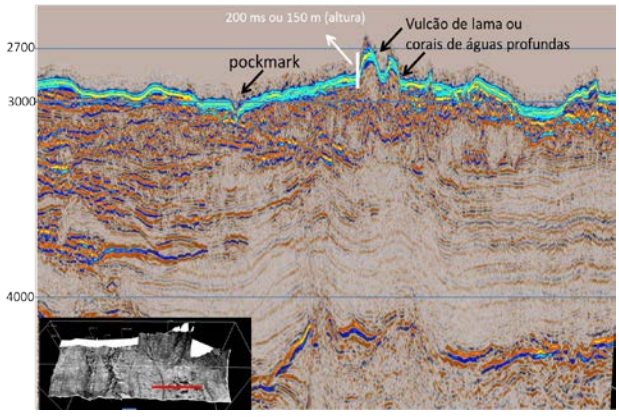

Figure 3: Seismic line showing the features associated with gas leakage.

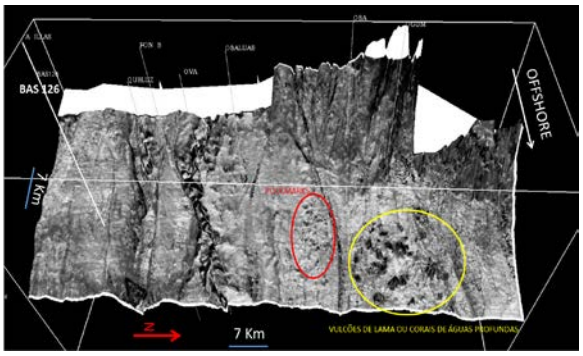

Figure 4: The seabed with seismic attribute called Dip. The structures with the biggest dip are indicated by darker colors. Observe the pockmarks (highlighted red) and positive features (highlighted yellow) that can be mud volcanoes or deep-water corals. Note the submarine canyons in the southern portion of the basin.

The Figure 5 shows an example of coral deep water and pockmarks over a gas field in Santos basin.

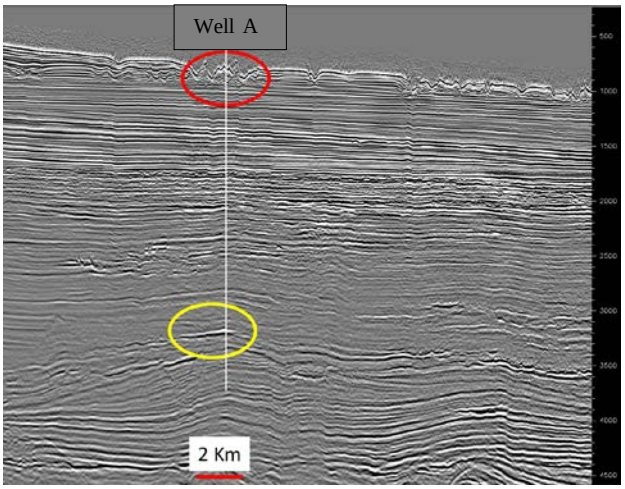

Figure 5: Analogy Santos basin. The accumulation of gas in santonian reservoirs is highlighted by yellow. The deep-water corals on the seafloor and pockmarks are colored by red, possibly indicating that there was a leak fluid. Modified from Carlotto & Vasconcelos, 2011.

Conclusions

The application of seismic attribute Diapir, which highlights the seismic facies chaotic and weak amplitude, facilitated the identification and spatial distribution of gas chimneys.

Pockmarks, mud volcanoes or authigenic carbonate crusts of cold water, which commonly are associated with the escape of fluids, were identified in the northern part of the basin, suggesting that the gas chimneys are concentrated in this portion of the basin. Whereas many petroleum fields exhibit these features on the seabed, then we suggest more attention when mapping this seismic reflector.

The recognition of the gas chimneys in Almada Basin indicates the presence of an active petroleum system, with migration of fluids between the source rock and reservoirs or between reservoirs and the seabed.

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