Seismostratigraphic analysis in the Inhambu Field, Espírito Santo Basin, Brazil

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This paper was prepared for presentation during the 15th International Congress of the Brazilian Geophysical Society held in Rio de Janeiro, Brazil, 31 July to 3 August, 2017.

Abstract

The onshore portion of the Espírito Santo Basin has few seismostratigraphic studies, even though it is an important basin in the exploratory context of hydrocarbons in Brazil. This work aims to interpret the internal seismic architecture and seismic facies and to construct a chronostratigraphic chart of events from the eastern part of the Inhambu Field of the Espírito Santo Basin. The division of seismic sequences was based on the study of the main unconformities, in which five depositional sequences were identified (from the basement to Upper Pre-Eocene unconformity). This study has allowed us to better understand the depositional sequences and the chronostratigraphic events reducing exploratory risks in the eastern area of the Inhambu Field.

Introduction

In recent years, numerous studies have emphasized the seismic interpretation and tectono-stratigraphic evolution of the Brazilian offshore basins, due to their great importance in the world context with the discoveries of giant reserves in the pre-salt. However, there are few studies in onshore basins, mainly regarding the seismostratigraphic interpretation which allows the establishment of criteria for the recognition of different stages during the basin evolution.

The recognition of the unconformities and their related conformities are fundamental to the identification of depositional sequences and to the construction of the chronostratigraphic framework, in order to document the infilling history of a sedimentary basin (Ribeiro, 2011).

In this work the definition of depositional sequences follows the works of Vail and Mitchum. (1977), and Mitchum *et al.* (1977), who define a depositional sequence as a stratigraphic unit composed of a relatively conformable sequence of genetically related strata and limited by unconformity or their correlative conformities.

The main objective of this work was to map the depositional sequences interpreted from the Necomian to the Neogene, in the eastern portion of the Inhambu Field of the Espírito Santo Basin. With the integration of seismic data and well logs, it was possible to identify the key surfaces that limit the depositional sequences, which finally indicate the stages of tectono-stratigraphic development of the Espírito Santo Basin

Espírito Santo Basin

The Espirito Santo Basin is located on the eastern Brazilian margin and is limited to the south by the Vitória High, to the north by the Mucuri paleocanyon, to the west by the crystalline basement and to the east by the volcanic complex of Abrolhos. Its area covers approximately 41,500 km², of which 3,000 km² onland, where 4 geological provinces are recognized: (I) São Mateus Platform; (II) Regência Platform; (III) Fazenda Cedro Paleo-canyon and (IV) Regência Paleo-canyon (Figure 1).

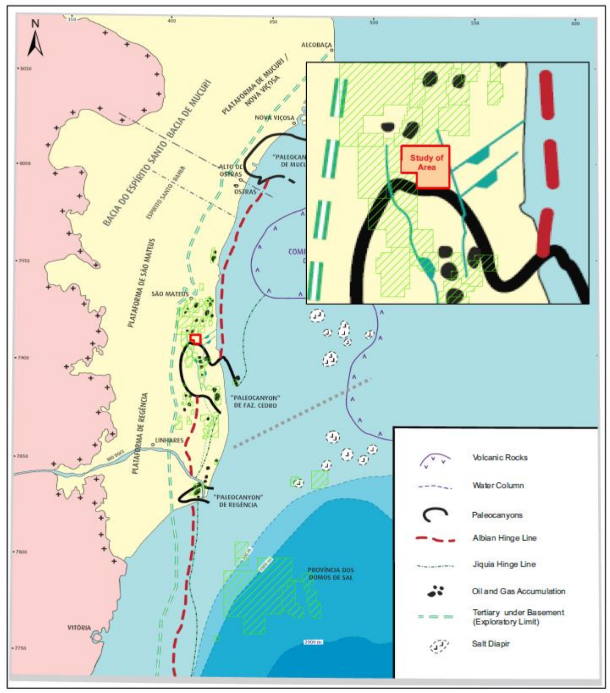

Figure 1: Location map of the study area showing the main provinces of the onshore Espírito Santo Basin.

The accumulations of hydrocarbons in the Espírito Santo Basin can be classified according to the ages of the reservoir rocks: (i) Alagoas sandstones located mainly on structural traps at the São Mateus platform (Ii) Aptian calco-siliciclastic reservoirs located on structural traps at the Regência Platform and (iii) Cretaceous / Tertiary turbidite reservoirs that are located within the paleocanyons mainly in stratigraphic traps (Wolff et al., 1986). Most of the sandstone reservoirs of this basin are found in uplifted and/or tilted blocks affected by the rift tectonics. In the paleo-canyons, truncation features predominate against walls of canyons forming stratigraphic traps (Figure 2). However, recent studies after drilling new exploratory wells in the Inhambu Field (Neves et al., 2016), shows that the Urucutuca Formation can be very thin and in some areas non-existent, while hydrocarbon indications are present at the fluvial sandstones of the São Mateus and Mariricu Formations.

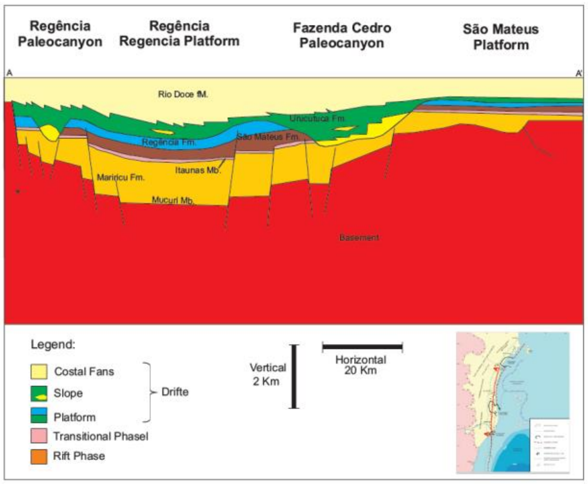

Figure 2: Geological section of the Espírito Santo Basin, showing the main compartments of the Basin.

Methodology

After a literature review, the study was developed in the following steps: seismic interpretation and definition of sequence boundaries limited by the main unconformities and correlative conformities, analysis of seismic facies and characterization of the internal and external configurations of major seismic units, integration of well logs with the seismic data and construction of a chronostratigraphic chart of events. The seismic analysis was performed in a seismic volume of approximately 100Km^2. The depositional sequences were interpreted from the basement to the Neogene, being identified 5 main horizons: Basement (Pre-Cambrian), Post-Rift top unconformity, base of salt (anhydrite), Pre-Urucutuca unconformity and Upper Pre-Eocene unconformity. Within the Pre-Urucutuca and Pre-Eocene unconformity, the Cretaceous canyons were also mapped.

The interpretation of seismic reflection terminations, onlap, downlap, toplap and erosive truncations, are the main criteria for the recognition of stratigraphic units (Mitchum, 1977).

The analysis of seismic facies was based on the configuration of reflections, continuity, relation of limits, terminations and lateral changes and the geometry of the seismic units. These characteristics allow us to interpret the possible changes in the relative sea level and, consequently, the potential of sediment accommodation and facies distribution within the system (Haq et al., 1987).

A chronostratigraphic chart of events was created, after defining the sequence boundaries and the architectural arrangement of the depositional systems during the infilling of the basin (Kuchle & Scherer, 2010).

Results and Discussions

Five seismic sequences were recognized above the basement, which basically correspond to the depositional sequences related to the evolutionary stages established in the stratigraphic chart of França et. al. (2007). These seismic sequences correspond to the post-rift (Mucuri and Itaunas Members) and drift (São Mateus, Urucutuca and Rio Doce Formations) sequences and are shown in Figure 3.

The basement is characterized by chaotic reflections, disrupted by normal faults, oriented in the N-S and NE-SW directions, cutting the entire post-rift section and locally the drift section (seismic facies A).

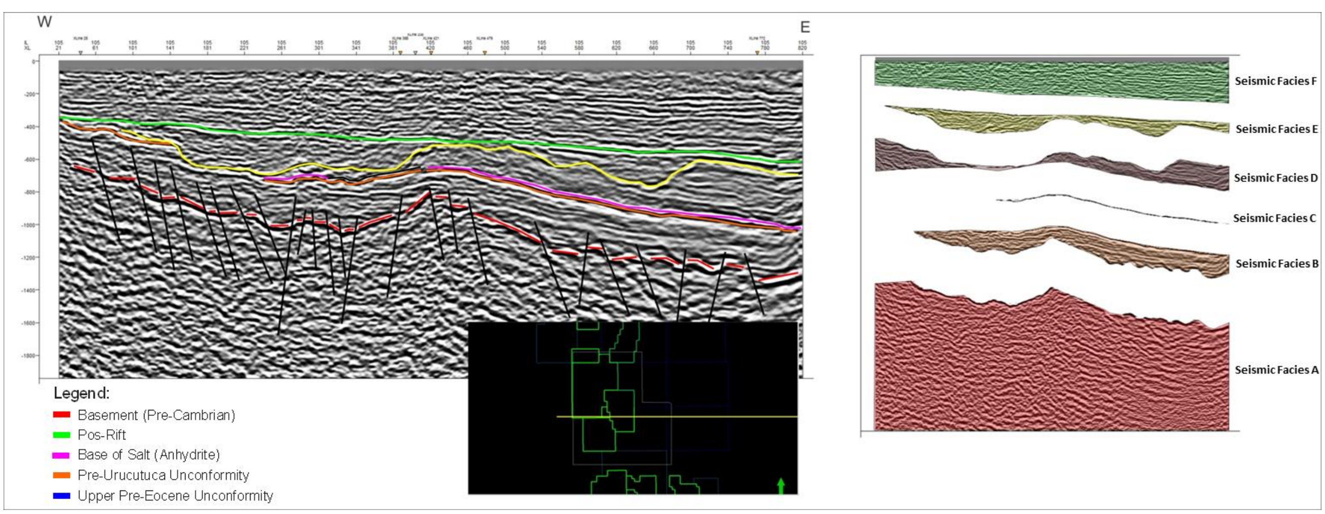

Figure 3: (A) Inline 105 showing the main mapped horizons; (B) Main seismic facies and their internal and external configurations.

The post-rift sequence is characterized by onlap terminations against basement highs and presents divergent, parallel, hummocky and sometimes chaotic reflections with external wedge-like geometry. Regionally this sequence thickens towards the east, and locally is incised by Eo-Cretaceous canyons (seismic facies B).

Above the post-rift section, seismic facies C presents high-amplitude reflectors with high frequency and greater continuity locally incised by Eo-Cretaceous canyons.

This seismic facies indicates a gradual deepening of the basin characterized by the top of the Mucuri Mb. followed by the evaporites (Itaunas Mb. anhydrites), indicating the passage from a typically continental environment to an evaporitic environment on the course of seawater invasion during the subsidence of the margin.

The Seismic facies D is limited at the base by the post-rift unconformity and is characterized by subparallel, divergent, oblique tangential and hummocky reflectors, with varying frequencies from medium to high and low to high amplitudes.

This section represents the initial drift phase, being composed basically by sandstones of the São Mateus Formation and it is also eroded by the Eo-Cretaceous canyons.

The seismic facies E is limited at the base by the Pre-Urucutuca unconformity and have an overall channel geometry, filled by onlap, complex and onlap montiform reflectors. This unconformity was responsible for the paleocanyons of Fazenda Cedro and Regência. The canyon filling preserves shales of the Urucutuca Formation deposited in low energy environments alternated with turbiditic sandstones related to the main transgressive phase of the basin (Stanley, 1969).

The seismic facies F covers the entire area and is characterized by parallel to continuous sheet like geometry, with medium to high amplitude reflectors, above the Upper Pre-Eocene unconformities.

The chronostratigraphic chart of events was created after the seismic interpretation of inline 191. In this section 40 seismostratigraphic units were identified and 4 unconformities: intra-Alagoas (?), Post-Rift, Pre-Urucutuca and Upper Pre-Eocene (Figure 4).

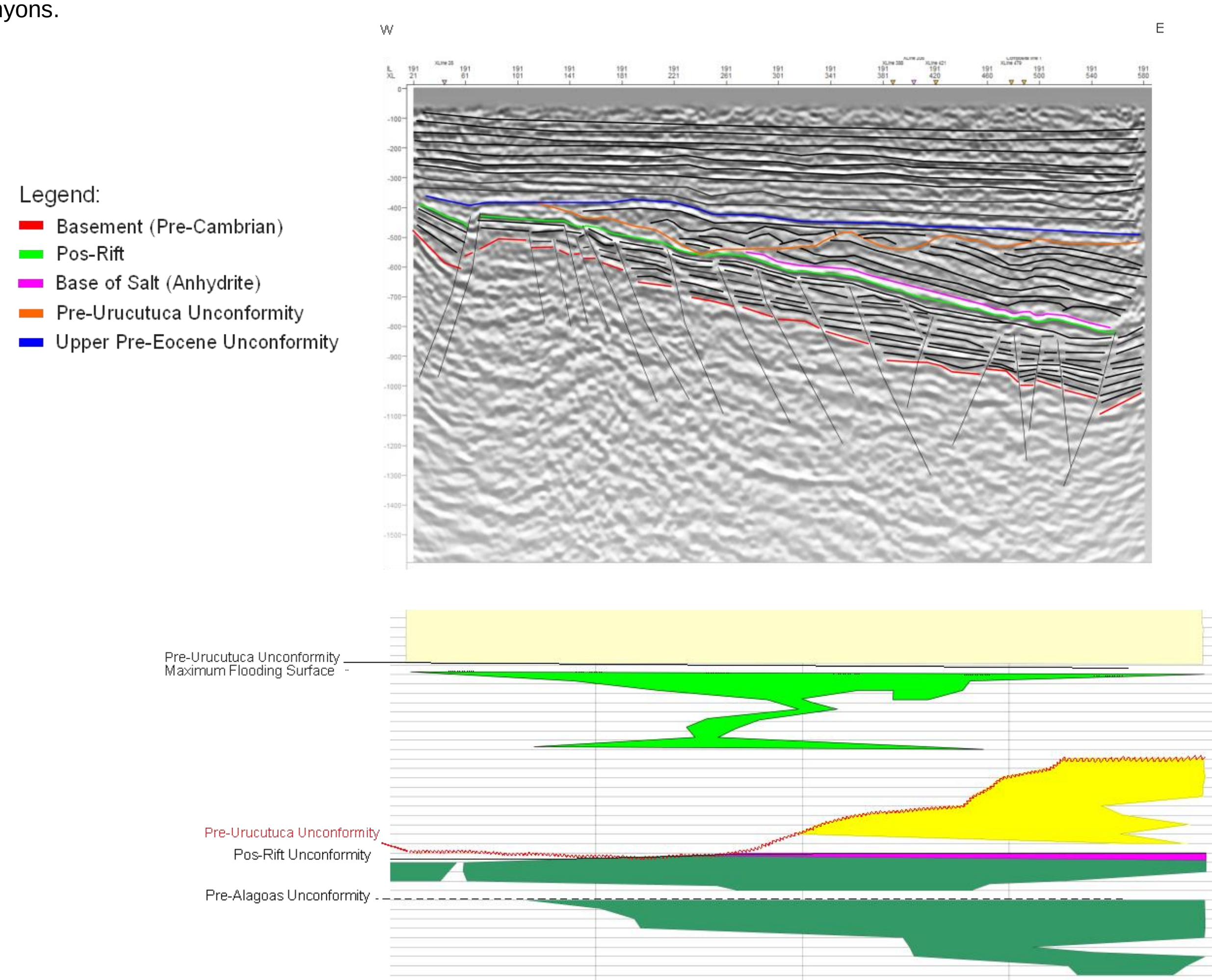

Figure 4: (a) Seismic line in time (inline 191) showing the main mapped horizons and internal seismic units; (b) Chronostratigraphic chart of events showing the main unconformity.

The initial basal sedimentation of the Mariricu Formation (Mucuri Member), deposited during the Eo/Meso Aptian, reaches its maximum expansion at the seismostratigraphic unit 9. This unit is eroded by the intra-alagoas unconformity (Vieira et. al., 1994; Dias, 2005), culminating in the deposition of the anhydrite in an evaporitic environment (Eo Aptian). After the evaporitic phase, in the São Mateus Platform there is a predominance of siliciclastics (sandstones and shales) of the São Mateus Formation and the Urucutuca Formation.

Conclusion

In this study, six seismic facies (A-F) were mapped and interpreted according to their seismic patterns in conjunction with information from well logs. The seismostratigraphic interpretation allowed the definition of five depositional sequences and 40 seismic units throughout the section, providing the understanding of the sedimentary infilling of the basin. This study helped to correct possible flaws in the construction of geological models and contributed reducing exploratory uncertainties in the drilling of new wells.

Acknowledgment

The authors thank the ANP for providing the data for publication of this article, to colleagues who supported the decision to publish and to all who contributed directly and indirectly to the present study.

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