Carbonate Buildups in the Post-Rift Sequence of the Pernambuco Basin, NE Brazil: Oil Play Implications*

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Abstract

The Pernambuco Basin (PEB) is a 20,800-km² area located in the eastern continental margin of Northeast Brazil. This basin represents one of the most prominent exploration frontiers in the deep waters of the Brazilian margin, with the best potential residing in the Pernambuco Plateau region. We performed a detailed study of carbonate buildups within the post-rift sequences of the PEB, which provides an important contribution to the Petroleum Potential of this marginal basin. This study is based on an analysis of 143 2D seismic surveys that cover almost the entire plateau region. The methodology included a detailed interpretation of 59 selected time-migrated seismic sections, application of post-processing filters to reduce the n/s ratio, and an additional integrated analysis of potential geophysical surveys to distinguish magmatic extrusive structures that also affect the post-rift sequences. Due to the lack of offshore wells, the age of the main interpreted seismic sequences were based on available data from the onshore region of the PEB and available data from the offshore region of the Alagoas Basin. Thus, four main seismic sections were defined: rift – (Barremian-Albian), Cretaceous post-rift (Albian-Maastrichtian), Lower Cenozoic post-rift (Maastrichtian-Middle Miocene), and Upper Cenozoic post-rift (Middle Miocene-Recent). Carbonate buildups represent structures extending up to 15 km long and up to 0.9 s (TWT) thick. They are abundant in the north and central portions of the Pernambuco Plateau, and were formed over outer structural highs, salt domes, and magmatic buildings. These structures formed from the Late Cretaceous (Santonian?-Maastrichtian) to the Neogene (Miocene). They consist of rimmed and isolated carbonate platforms exhibiting typical progradation wedges related to eustatic cycles, and this interpretation allows for a preliminary
sequence stratigraphy analysis for the Cenozoic interval of the PEB. Most of the carbonate buildups are capped by marine shales (seal rocks) and are connected with the deep zones of the depocentres by rift faults (possible migration paths) that were reactivated by post-rift events. Thus, the carbonate buildups of the PEB have important features that point to the potential of these structures as a promising oil play for oil and gas reservoirs, as observed in the southeast Brazilian margin basins.

**Selected References**


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DATA SET AND OBJECTIVES

- Criteria to differentiating carbonate structures from volcanic structures
- Classification of carbonate structures
- Stratigraphic position of the carbonate platforms
- Implications to the petroleum system

Basement contour map, location of the 59 2D selected seismic sections, and interpreted carbonate structures
Help to understand the depositional systems succession in this basin, for which the knowledge is still limited...

The close spatial relation between carbonate and volcanic structures can create pitfalls in the delineation of exploratory targets with the available geophysical coverage...

To establish its role as oil and gas plays in this basin...

We tried to do more, with the old data available!
INTRODUCTION

Location of the Borborema Province and the basins on the eastern border of Northeast Brazil

Pernambuco Basin main structural domains. Modified from Barbosa et al. 2014
INTRODUCTION

CHARACTERISTICS OF THE PARAIBA BASIN

LOWER POTENTIAL FOR GENERATION AND ACCUMULATION OF OIL
INTRODUCTION

CHARACTERISTICS OF THE PERNAMBUCO BASIN

HIGHER POTENTIAL FOR GENERATION AND ACCUMULATION OF OIL
• Shallow basement
• Narrow platform with an abrupt shelf-break
• Lack of evaporites
INTRODUCTION

Map of piston core sampling showing oil seeps in the Pernambuco Plateau. Modified from ANP, 2005
CURRENT SITUATION – EXPLORATORY PROCESS

FIRST WELL IS GOING TO BE DRILLED UNTIL 2017

SISMOS (2014)
Main Results
Carbonate structures x volcanoes

Localization of the main carbonate platforms and volcanoes discussed in this work

Seismic section showing a large carbonate platform over the Gaiubu High
Localised “pull-ups”

Carbonate platform

Basement countour map

Small shield volcano
CARBONATE STRUCTURES X VOLCANOES

Continuous Amplitude Reflection
High-Capping

Basement contour map

Cone-shaped Volcano

Carbonate platform
Carbonate Structures X Volcanoes

Basement contour map

Carbonate platform

Small shield volcano
CARBONATE STRUCTURES X VOLCANOES

Surface of top Carbonate platform

Basement countour map

Carbonate platform
• magmatic intrusions interconnected in a dense network
• homogenized acoustic impedance due to hydrothermal activity
• lava flows or/and slumps

From Buarque et al. 2016
Basement contour map
CARBONATE STRUCTURES X VOLCANOES

Calculated first derivative of residual Bouguer

Calculated ASA
CARBONATE STRUCTURES X VOLCANOES

Basement contour map
CARBONATE STRUCTURES X VOLCANOES

Calculated ASA

Calculated first derivative of residual Bouguer

Image A: Graph showing the magnetic field and the calculated ASA and first derivative of the residual Bouguer.

Image B: Geologic cross-section with labeled features such as paleovolcano and rock units.
Types and distribution of carbonate structures

- Shelf
- Patch margin reefs
- Isolated platforms
SHELF MARGIN REEFS

- Length: 1.3 - 4.7km
- Height: 0.2 - 0.39s
PATCH REEFS

• Mean Length: 5 km
• Height: 0.25 – 0.4s

Basement contour map
ISOLATED PLATFORMS

- Length: 4 - 29 km
- Height: 0.33 - 0.54 s
Stratigraphic position of the carbonate platforms

**Sq.1**: Barremian-middle Albian; **Sq.2**: middle Albian-Santonian; **Sq.3**: Santonian-Maastrichtian; **Sq.4**: Maastrichtian-Middle Miocene; **Sq.5**: Middle Miocene-recent
"Dredging operations made it possible to collect samples of volcanic rocks and limestone. Highly lithified limestone, recrystallized and occasionally phosphatized, contains an admixture of volcanic material and foraminifer chambers with the age estimated at the Campanian - Maastrichtian and the Turonian - Santonian."

From Skolotnev et al., 2012
OIL PLAYS IMPLICATIONS
DISTRIBUTION OF RESERVOIRS IN THE ALAGOAS BASIN

Modified from Maia, 2012

From PETROBRAS, 2007
CARBONATE RESERVOIRS IN THE AFRICAN CONJUGATE MARGIN

PERNAMBUCO BASIN

From MMIE - REG, 2014
PLAYS OF THE PERNAMBUCO BASIN

- **Play type 1**: carbonate Platforms
- **Play type 2**: sandstones from the rift sequence
- **Play type 3**: turbidite bodies
- **Play type 4**: volcanic rocks
- **Play type 5**: pre-salt accumulations
Final Considerations

• We have successfully applied a simple methodology, involving analysis of seismic and potential data together with the classical seismic stratigraphic interpretation in order to uncover carbonate structures in a region with limited knowledge and high petroleum potential.

• Our findings improved the knowledge of this area, and highlighted the potential of carbonate structures as a possible oil play.

• The abundance of carbonate structures indicates that the regional physiography of the Pernambuco Plateau helped the formation of carbonate platforms.
THANK YOU

ANY QUESTIONS?

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