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

Bruno Varela Buarque[1], José Antônio Barbosa[2], Jefferson Tavares Cruz Oliveira[2], Osvaldo Correia Filho[2], José Ricardo Gonçalves Magalhães[2]

Search and Discovery Article #10854 (2016)**
Posted August 8, 2016

*Adapted from oral presentation given at AAPG 2016 Annual Convention and Exhibition, Calgary, Alberta, Canada, June 19-22, 2016

[1]Laboratory of Seismic Stratigraphy, Department of Geology, University of Pernambuco, Recife, Pernambuco, Brazil (bv.buarque@gmail.com)
[2]Laboratory of Seismic Stratigraphy, Department of Geology, University of Pernambuco, Recife, Pernambuco, Brazil

Abstract

The Pernambuco Basin (PEB) is a 20,800-km^2 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

Barbosa, J.A., M.F. Maia, M.L. Filho, J.R. Magalhães, and O. Correia, 2014, Seismic Stratigraphy of the Onshore Portion of Pernambuco Basin: Evidence of Break-Up during Middle Albian for the South Atlantic Rift in Northeast Brazil: AAPG 2014 Annual Convention and Exhibition, Houston, Texas, April 6-9, 2014, Search and Discovery Article #30324 (2014), http://www.searchanddiscovery.com/documents/2014/30324barbosa/ndx_barbosa.pdf, Web accessed July 2016.

Buarque, B.V., J.A. Barbosa, J.R.G. Magalhães, J.T.C. Oliveira, and O.J.C. Filho, 2016, Post-Rift Volcanic Structures of the Pernambuco Plateau, Northeastern Brazil: Journal of South American Earth Sciences, 47 pp. doi: 10.1016/j.jsames.2016.05.014

Magalhães, J.R.G., J.T.C. Oliveira, J.A. Barbosa, and M.L. Filho, 2013, Continental Oceanic Crustal Transition in the Paraíba Basin Platform, Northeast Brazil Transição Da Crosta Continental-Oceânica Na Plataforma Da Bacia Da Paraíba, Ne Do Brazil: Estudos Geológicos, v. 23/2, p. 125-139.

Maia, M.F.B., 2012. Revisão Estratigráfica do intervalo Aptiano-Albiano da Bacia de Pernambuco Nordeste do Brasil: Master Thesis, Post-Graduation Program in Geosciences, Department of Geology, Federal University of Pernambuco, Recife – Brazil, 226 pp.

Maia, M.F.B., J.A. Barbosa, M. Lima Filho, H.P. Mort, and F.R. Santana, 2012, Características petrográficas e geoquímicas das formações siliciclásticas (Aptiano-Albiano) da Bacia de Pernambuco, NE do BRasil: Estudos Geológicos, v. 22/1, p. 55-75.

Skolotnev, S.G., A.A. Peyve, E.V. Ivanova, I.O. Murdmaa, O.V. Levchenko, and M.E. Bylinskaya, 2012, New Data on Composition and Structure of the Pernambuco Seamounts, Brazil Basin, South Atlantic Region: Doklady Akademii Nauk, v. 443/3, p. 330–336.

UNIVERSIDADE FEDERAL DE PERNAMBUCO

Carbonate buildups in the post-rift sequences of the Pernambuco Basin, NE Brazil: oil play implications

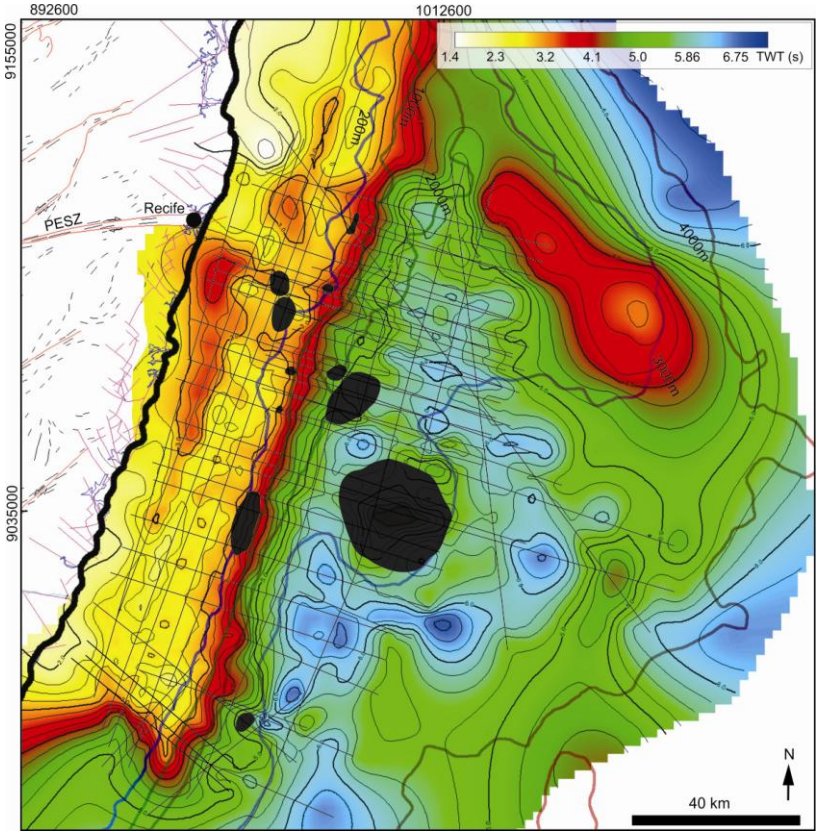
Bruno Varela Buarque, José Antônio Barbosa , Jefferson Tavares Cruz Oliveira, Osvaldo Correia Filho, José Ricardo Gonçalves Magalhães

Laboratory of seismic stratigraphy, Dept. of Geology, University of Pernambuco, Recife, Pernambuco, Brazil

Corresponding Author: ***bv.buarque@gmail.com***

June 2016

DATA SET AND OBJECTIVES



Basement countour map, location of the 59 2D selected seismic sections, and interpreted carbonate structures

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

WHY IS IMPORTANT TO STUDY CARBONATE PLATFORMS IN THE PERNAMBUCO BASIN???

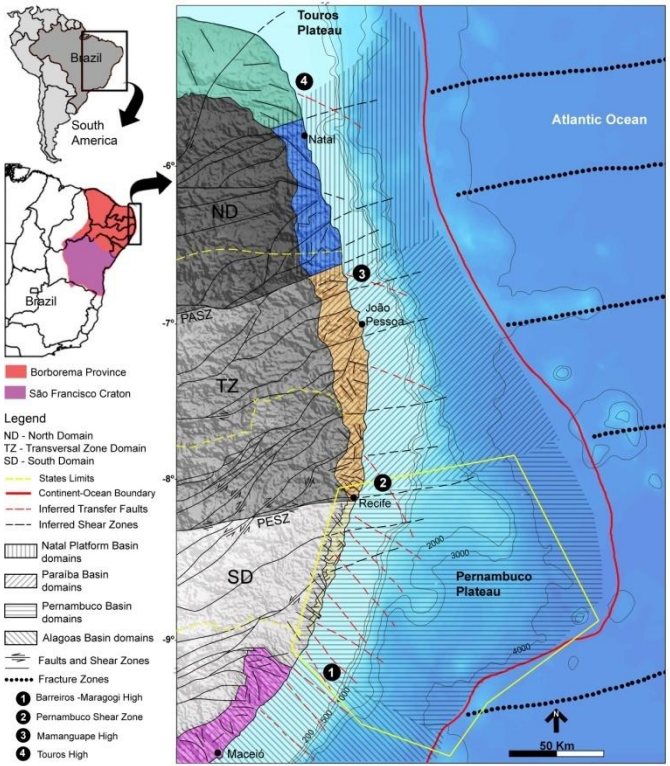
Help to understand the depositional systems succession in this basin, for which the knowledge is still limited...

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

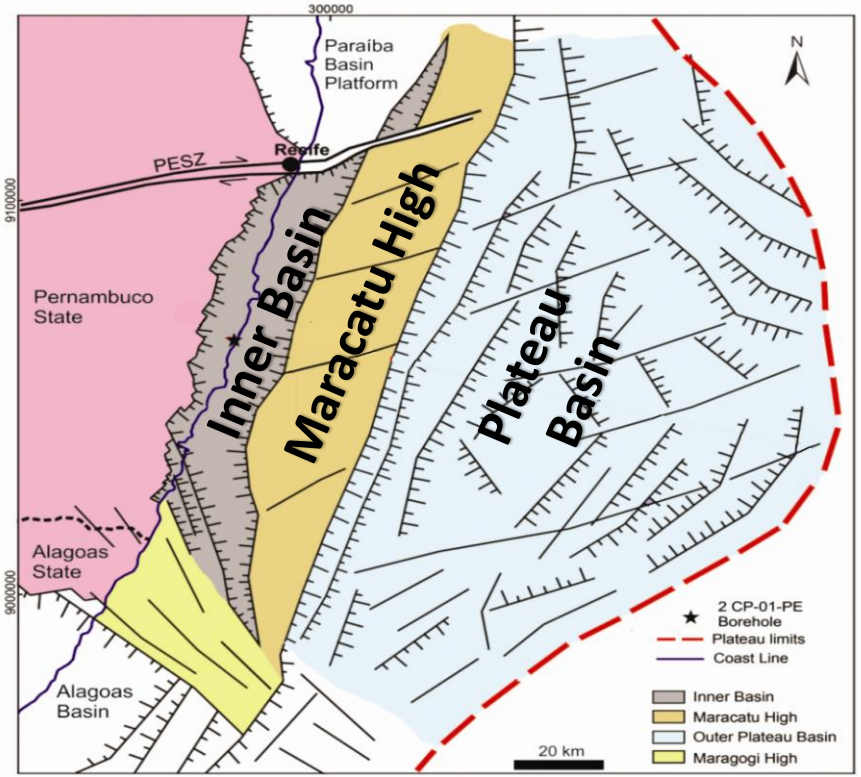
To establish Its role as oil and gas plays in this basin...

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

INTRODUCTION

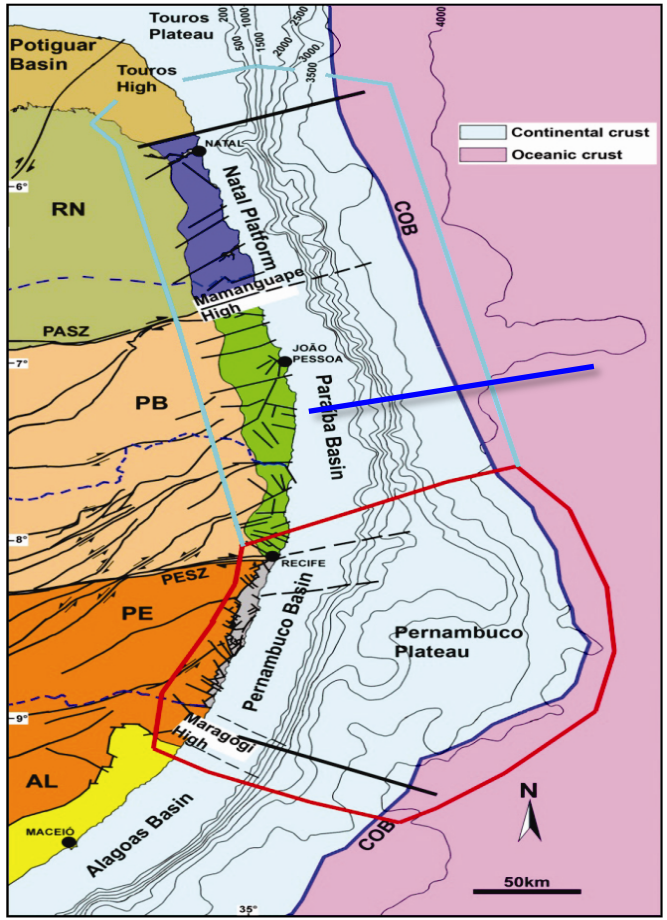


Location of the Borborema Province and the basins on the eastern border of Northeast Brazil



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

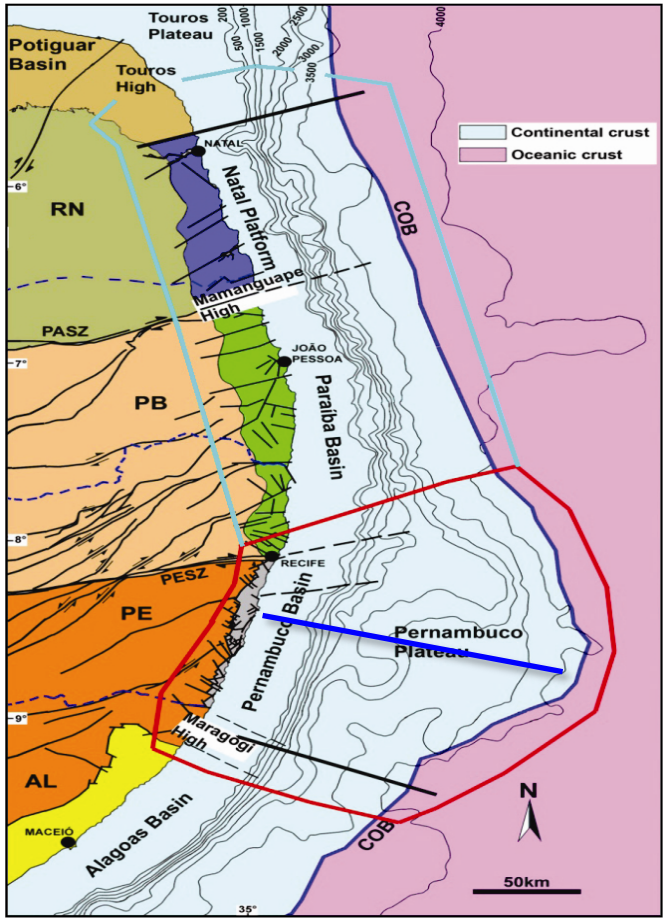
INTRODUCTION



CHARACTERISTICS OF THE PARAIBA BASIN

LOWER POTENTIAL FOR GENERATION AND ACCUMULATION OF OIL

INTRODUCTION

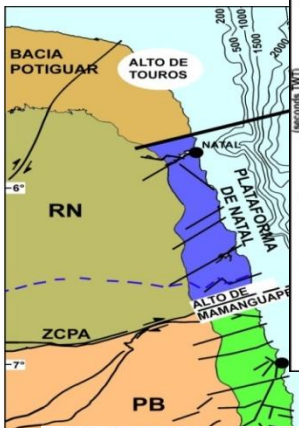


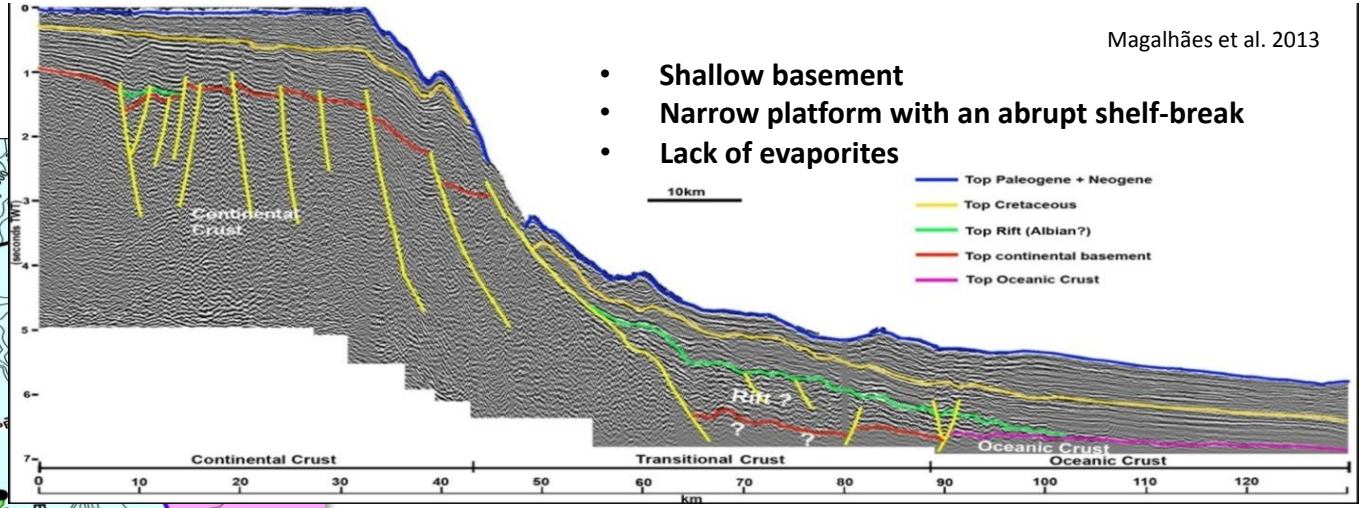
CHARACTERISTICS OF THE PERNAMBUCO BASIN

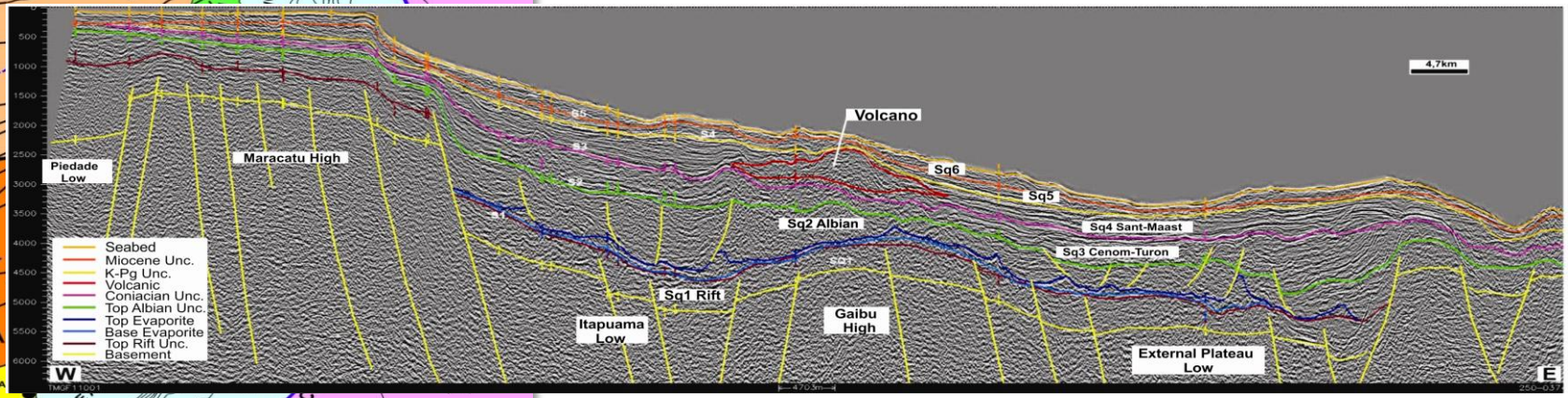
HIGHER POTENTIAL FOR GENERATION AND ACCUMULATION OF OIL

Magalhães et al. 2013

- **Shallow basement**
- **Narrow platform with an abrupt shelf-break**
- **Lack of evaporites**

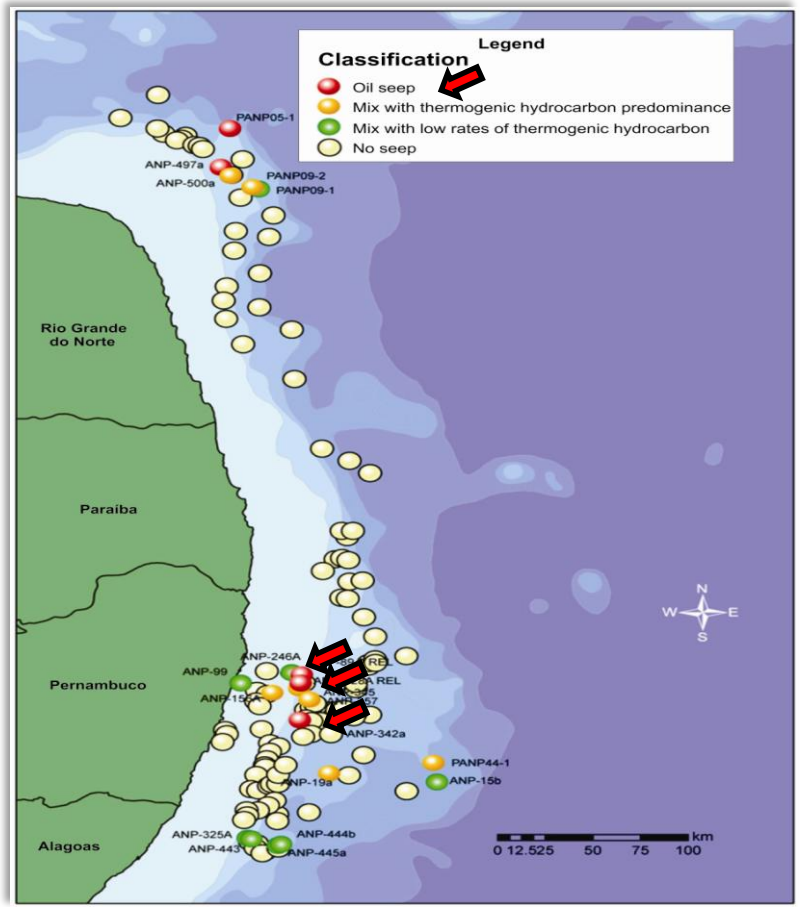






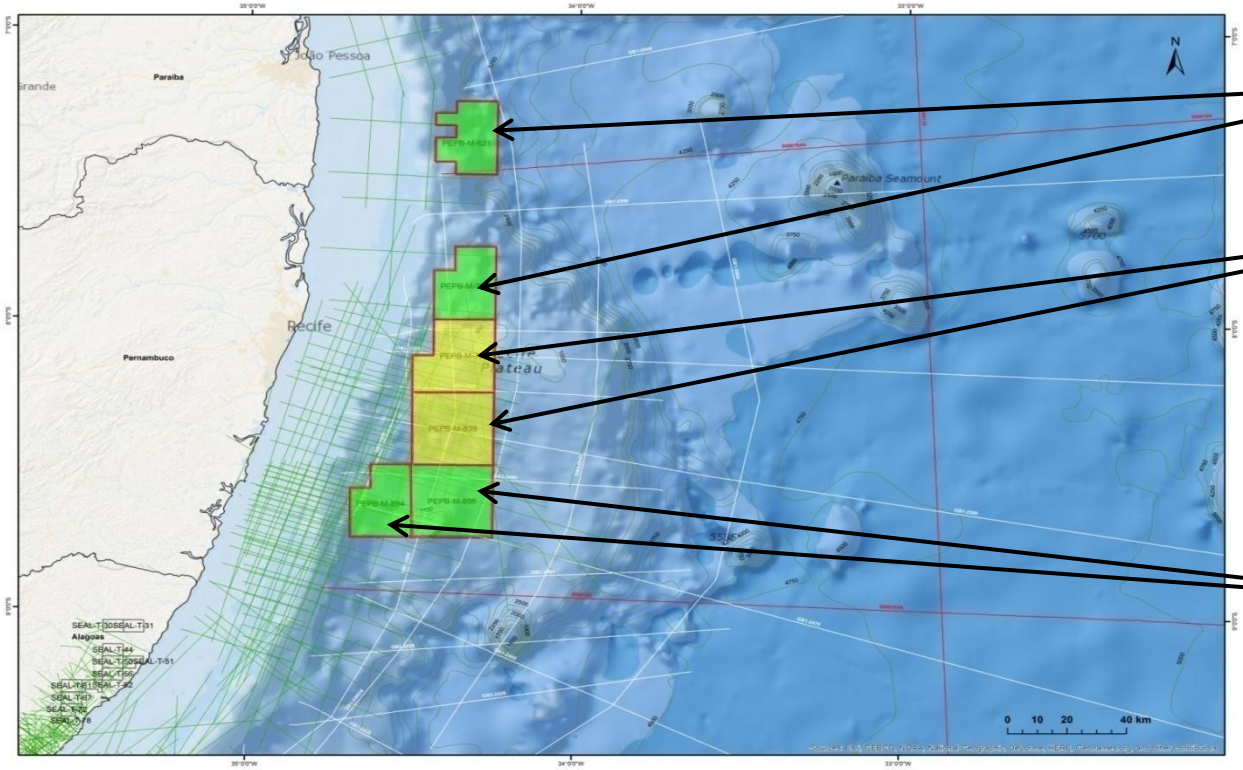
Modified from LAGESE, 2007

INTRODUCTION



Map of piston core sampling showing oil seeps in the Pernambuco Plateau. Modified from ANP, 2005

CURRENT SITUATION – EXPLORATORY PROCESS



NIKO RESOURCES LTD 30%(OP)

petra energia 70%

BR PETROBRAS 80%(OP)

FIRST WELL IS GOING TO BE DRILLED UNTIL 2017

galp energia 20%

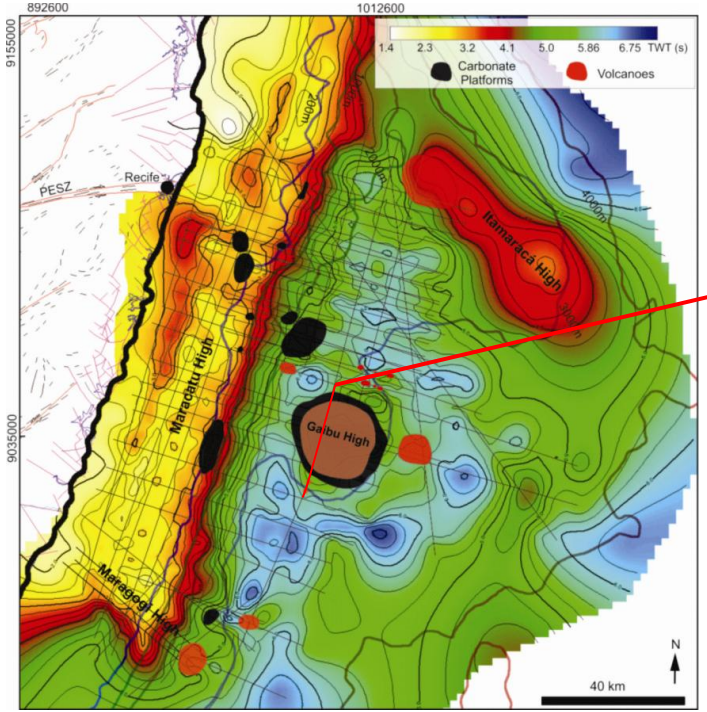
queiroz galvão ÓLEO E GÁS 30%(OP)

petra energia 70%

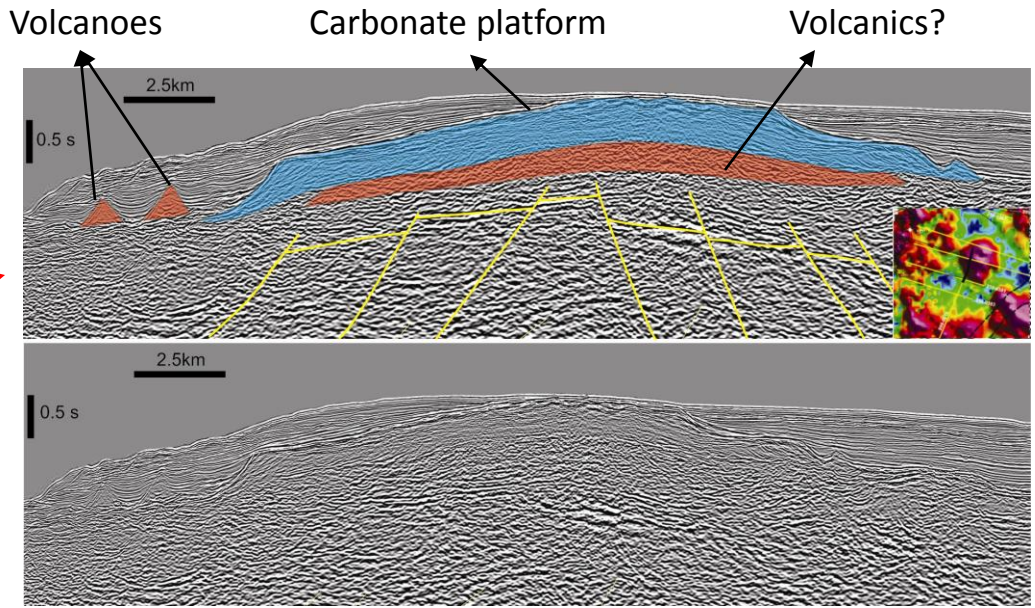
SISMOS (2014)

Main Results

Carbonate structures x volcanoes

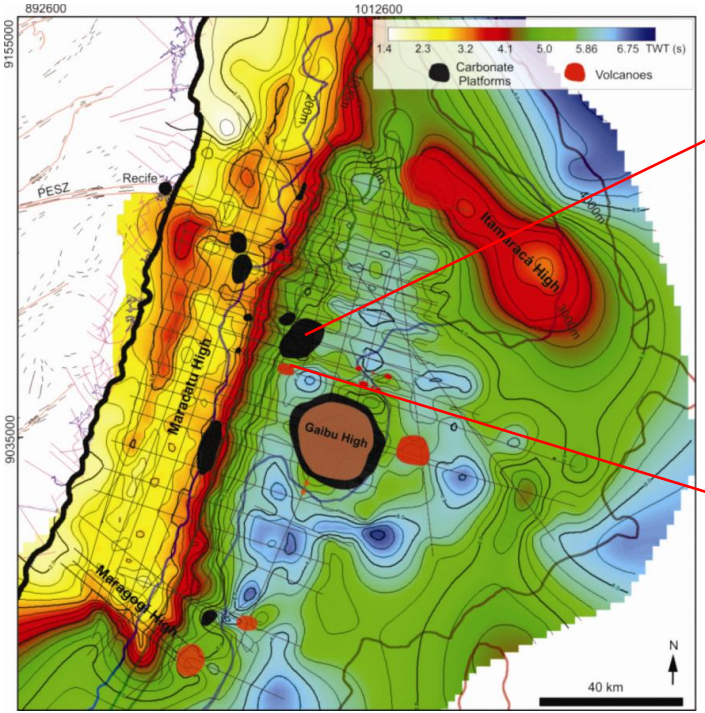


Localization of the main carbonate platforms and volcanoes discussed in this work

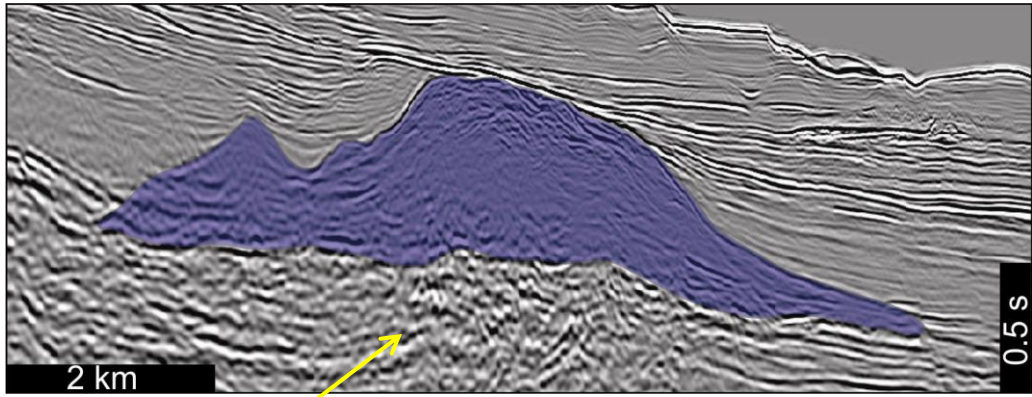


Seismic section showing a large carbonate platform over the Gaiubu High

CARBONATE STRUCTURES X VOLCANOES

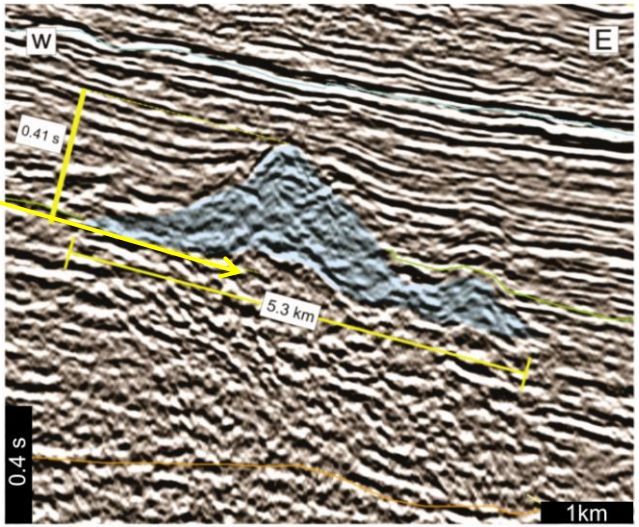


Basement countour map



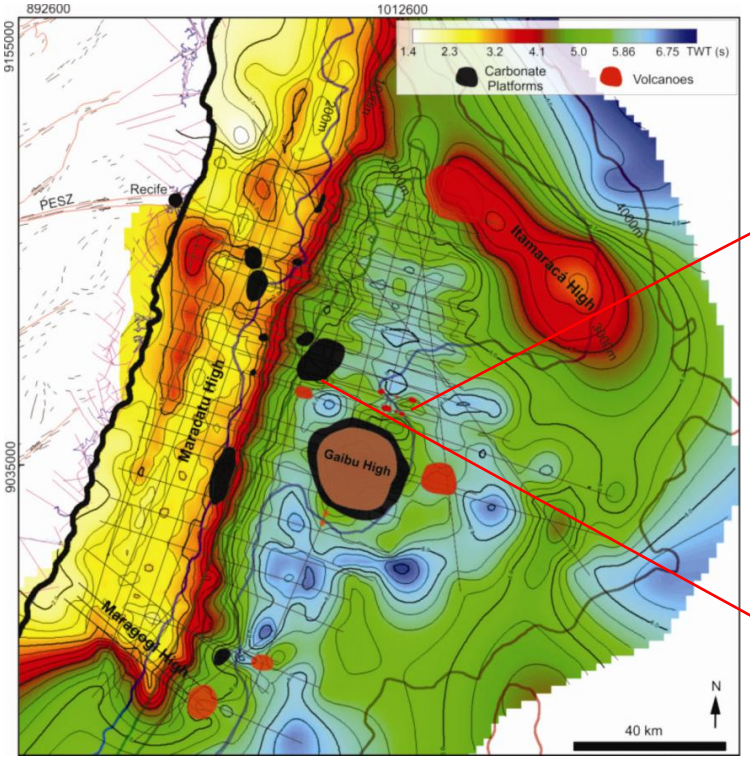
Carbonate platform

Localised
"pull –ups"



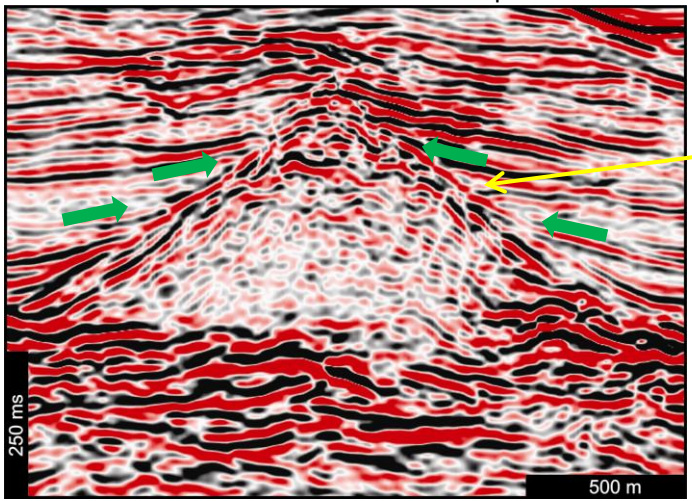
Small shield volcano

CARBONATE STRUCTURES X VOLCANOES

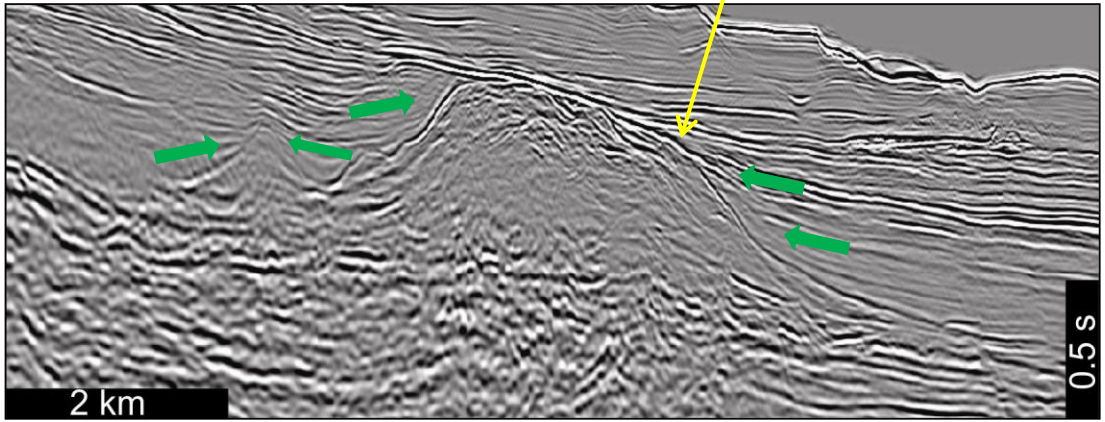


Basement countour map

Cone-shaped Volcano

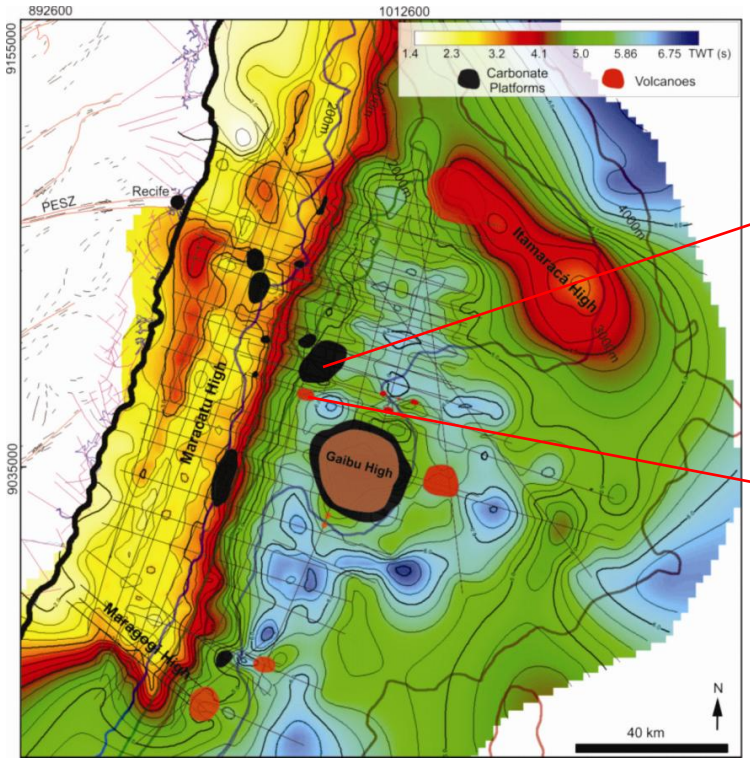


Continuous High-Amplitude Capping Reflection

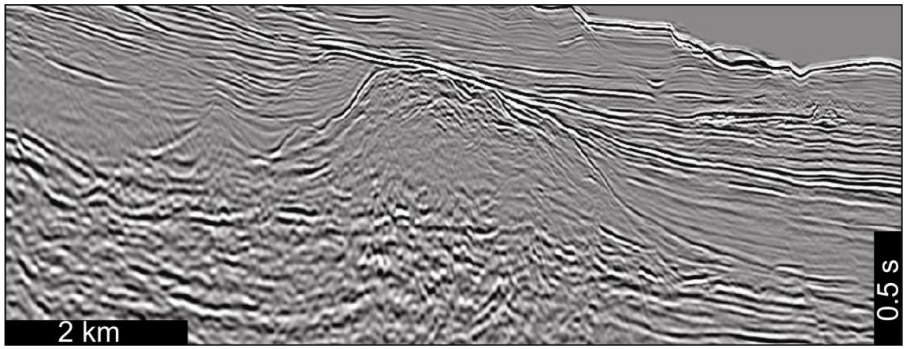


Carbonate platform

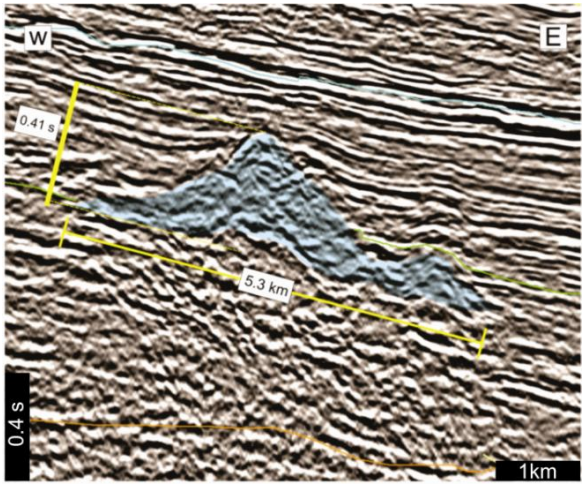
CARBONATE STRUCTURES X VOLCANOES



Basement countour map

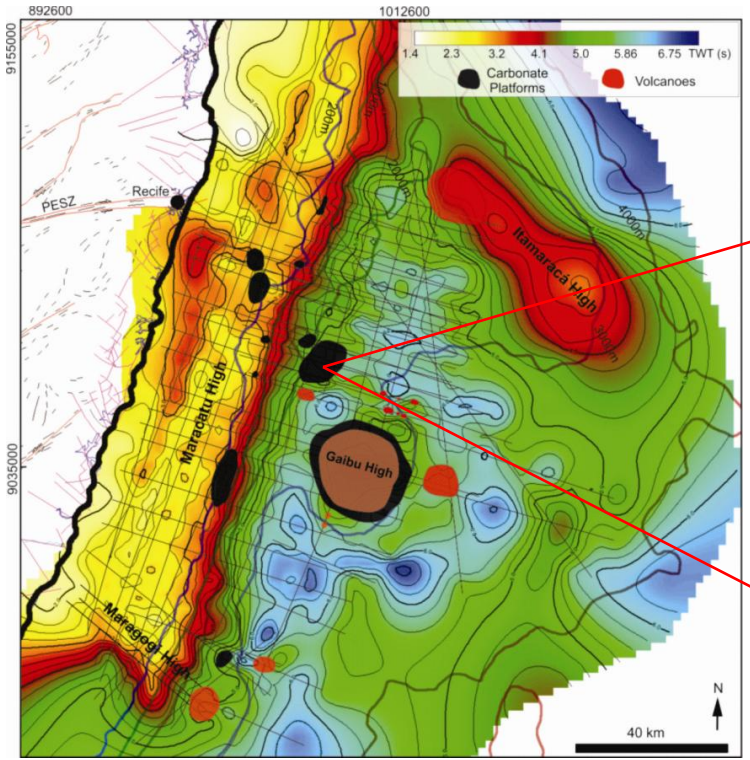


Carbonate platform

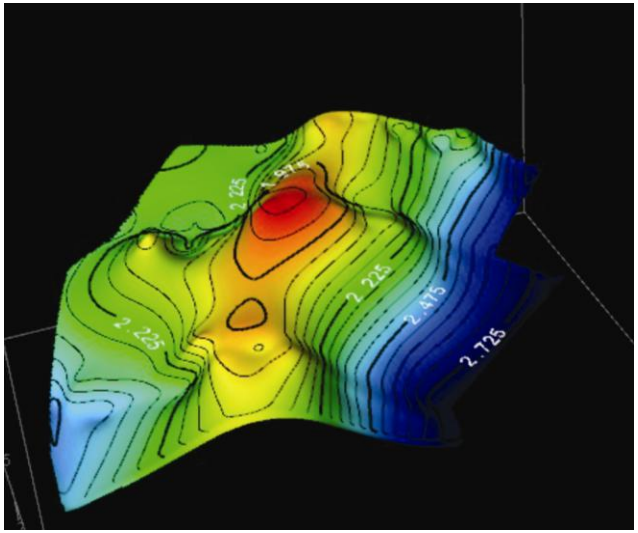


Small shield volcano

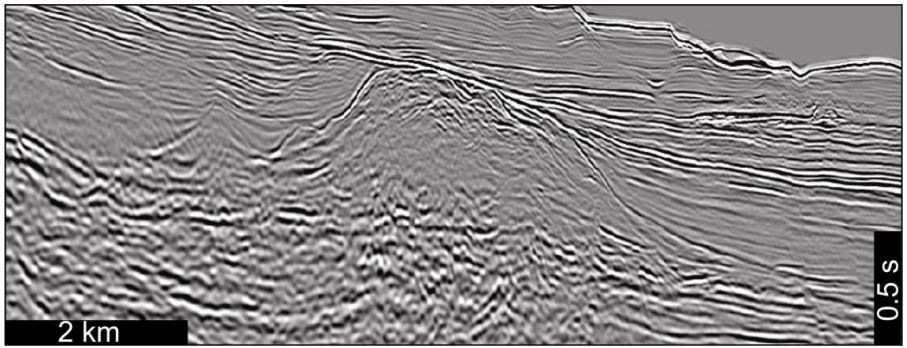
CARBONATE STRUCTURES X VOLCANOES



Basement countour map

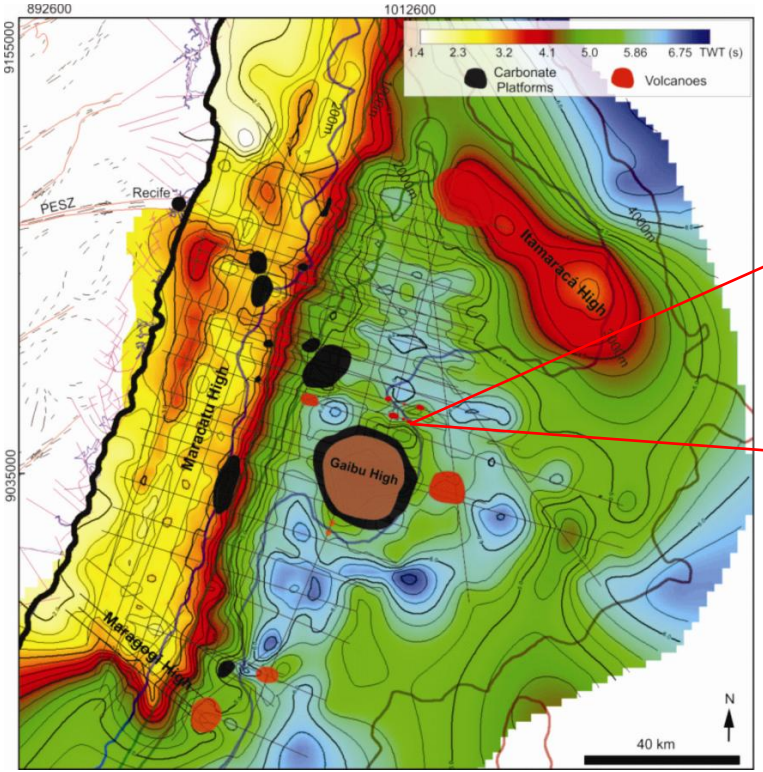


Surface of top Carbonate platform

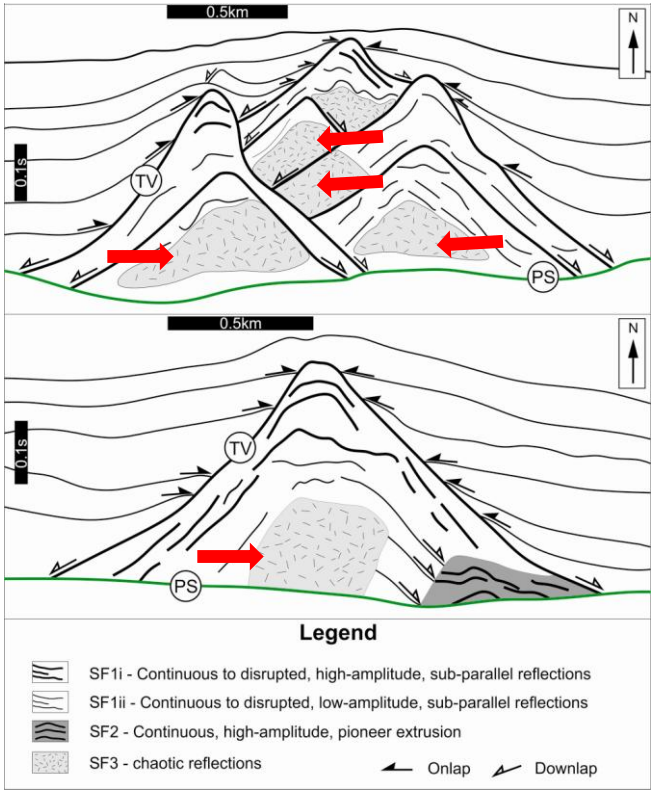


Carbonate platform

CARBONATE STRUCTURES X VOLCANOES



Basement countour map

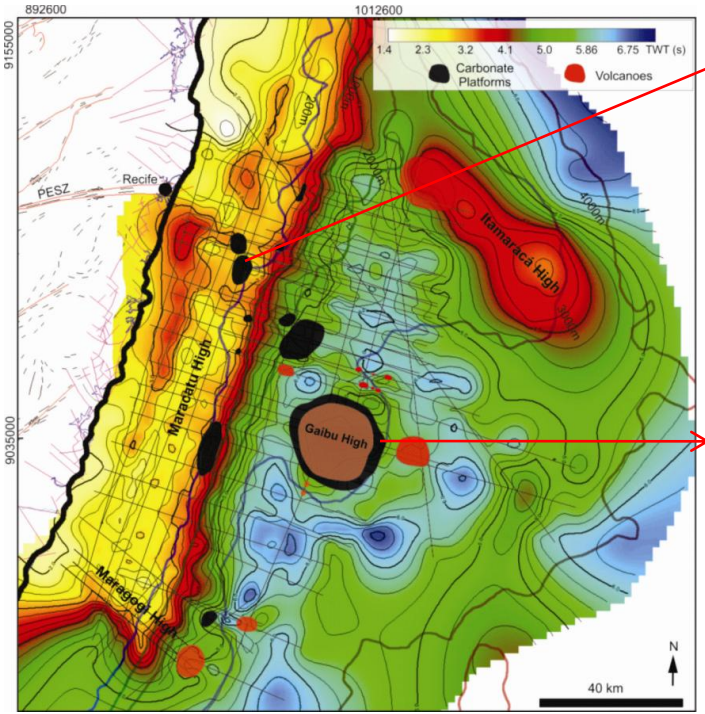


From Buarque et al. 2016

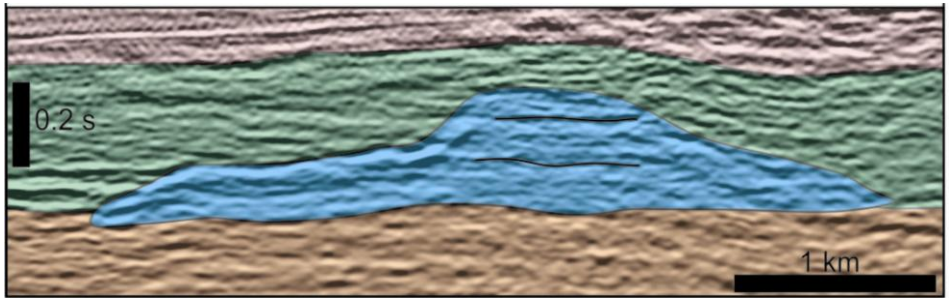
- magmatic intrusions interconnected in a dense network
- homogenized acoustic impedance due to hydrothermal activity

- lava flows or/and slumps

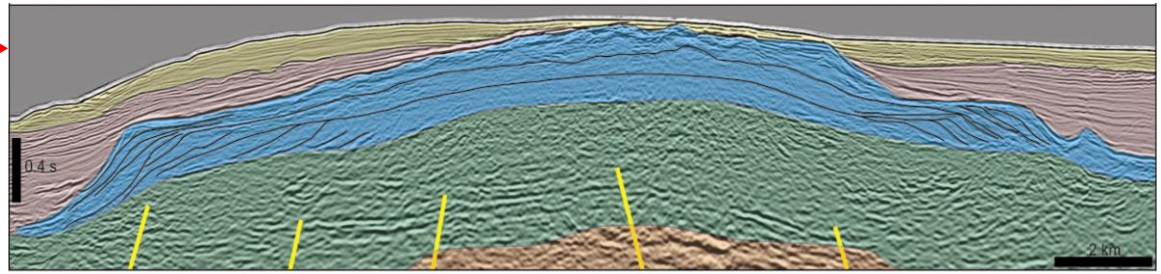
CARBONATE STRUCTURES X VOLCANOES



Basement countour map

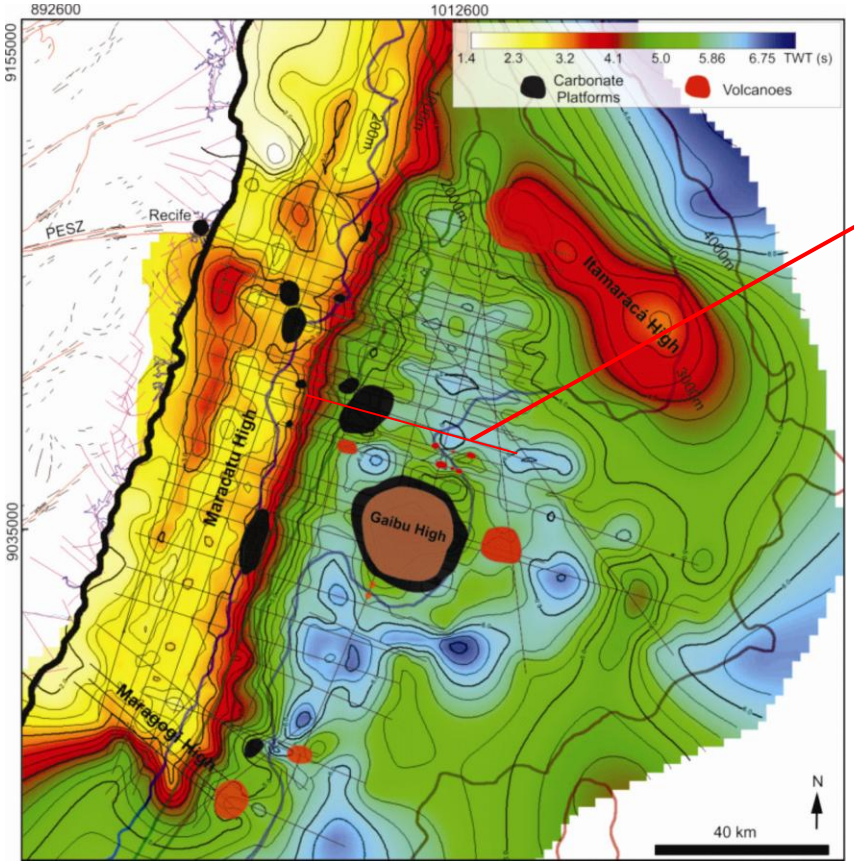


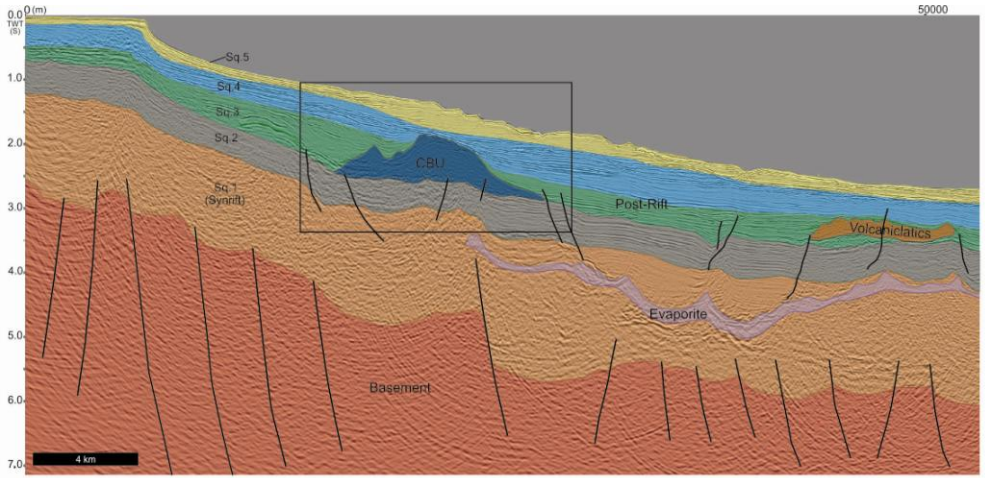
Carbonate platform



Carbonate platform

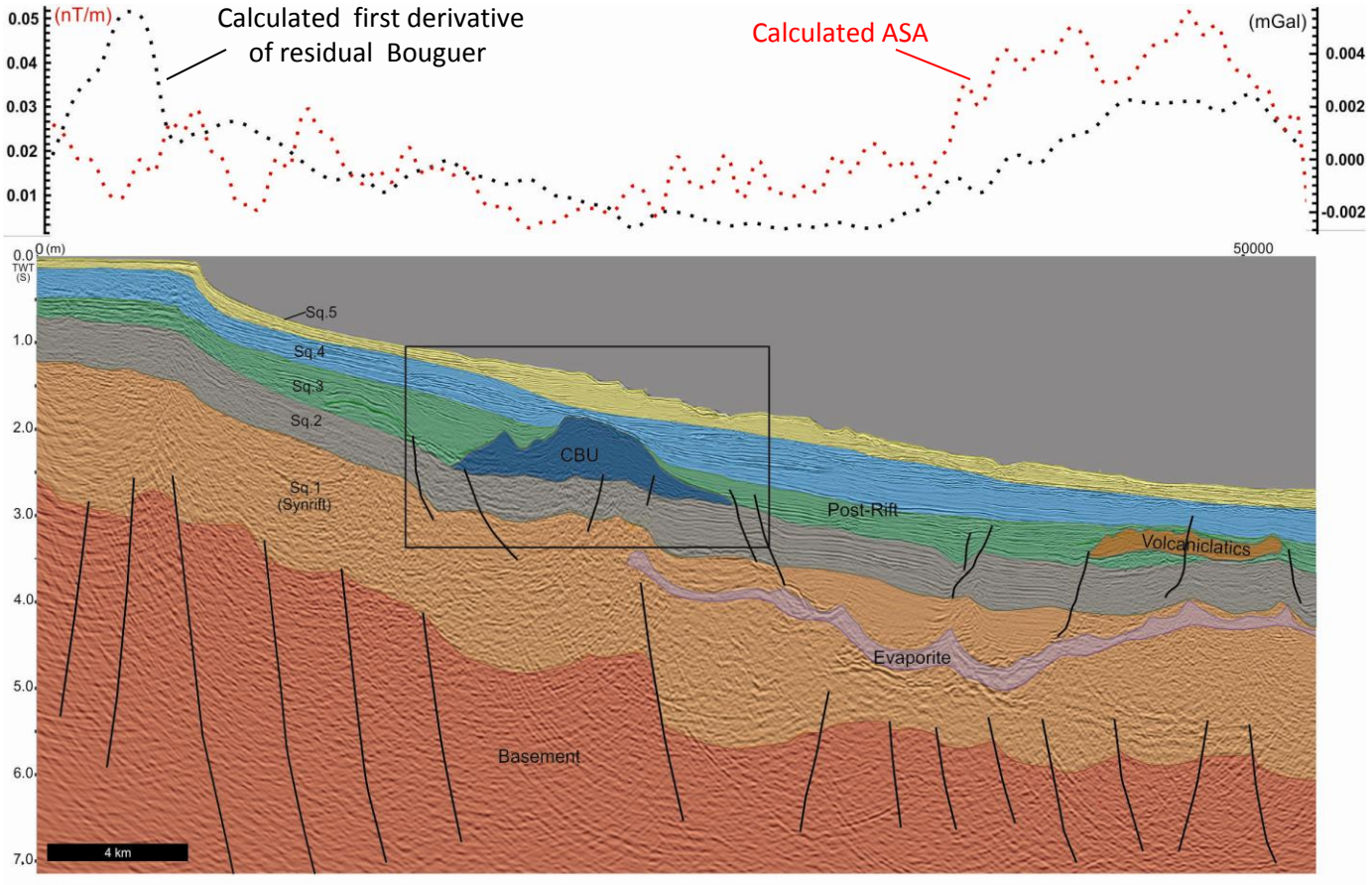
CARBONATE STRUCTURES X VOLCANOES



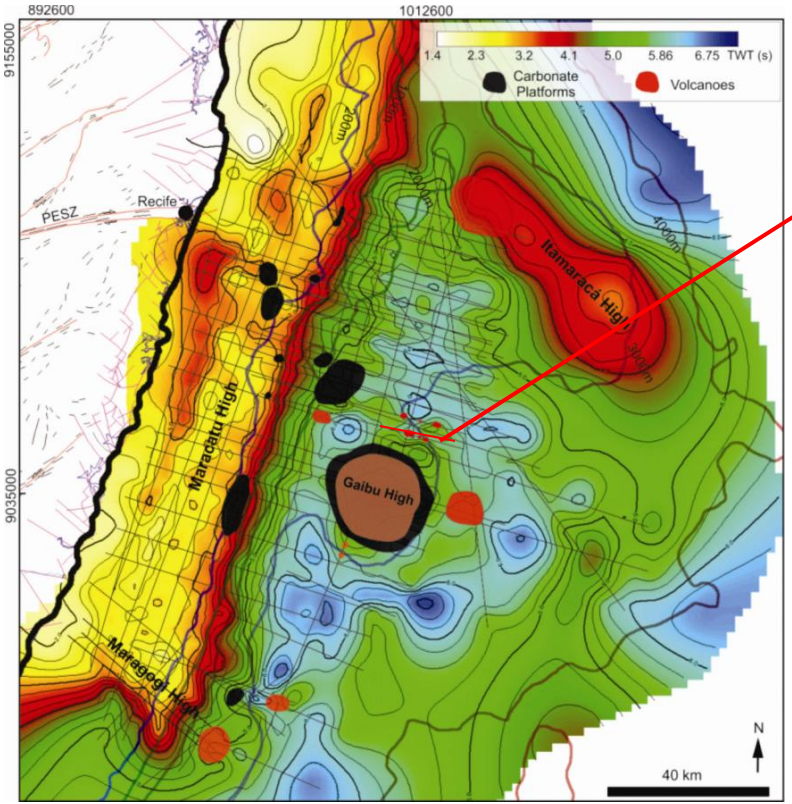


Basement countour map

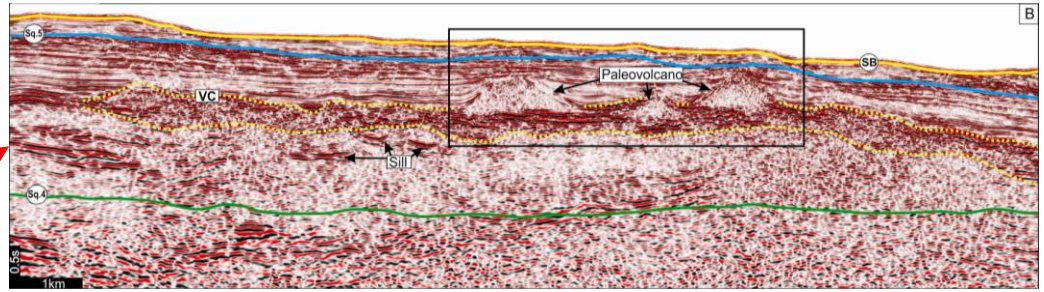
CARBONATE STRUCTURES X VOLCANOES



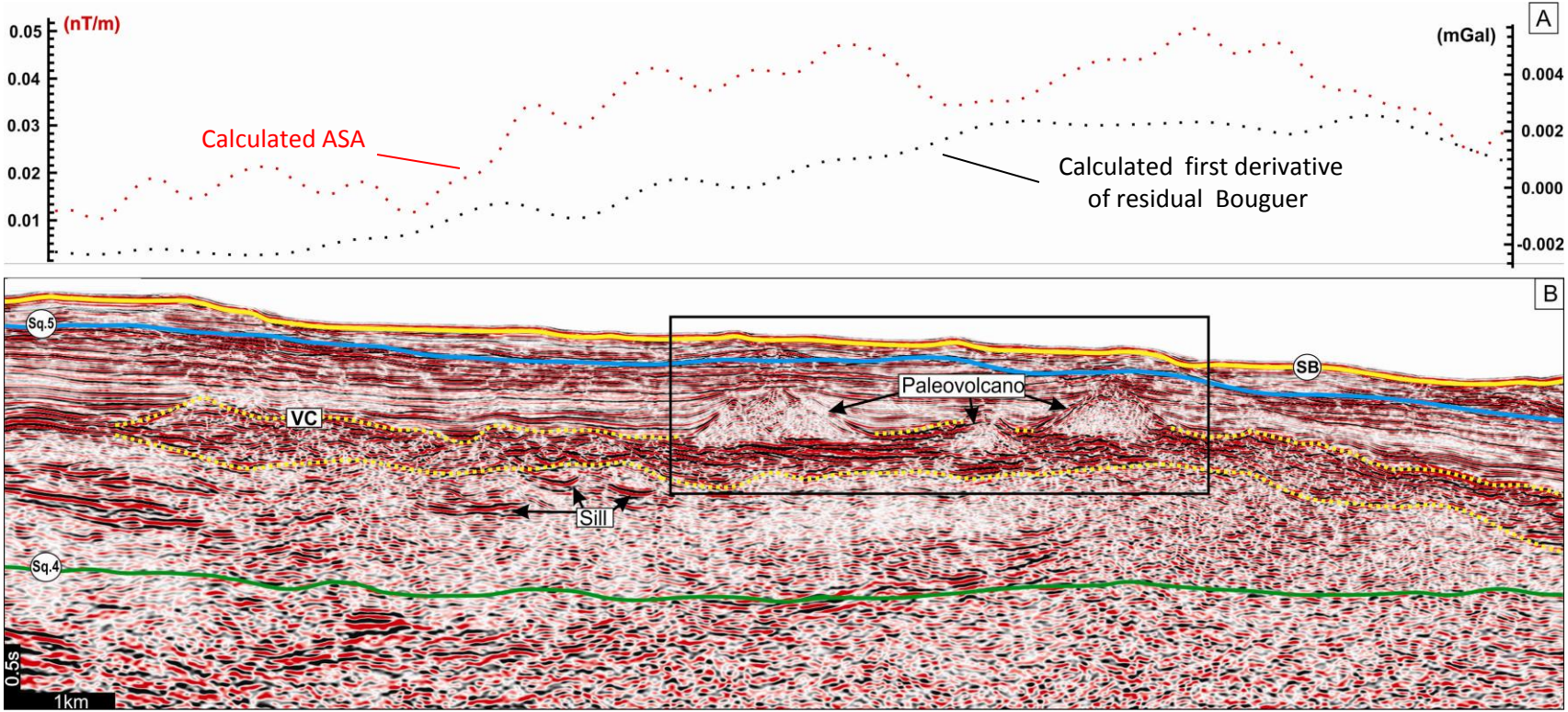
CARBONATE STRUCTURES X VOLCANOES



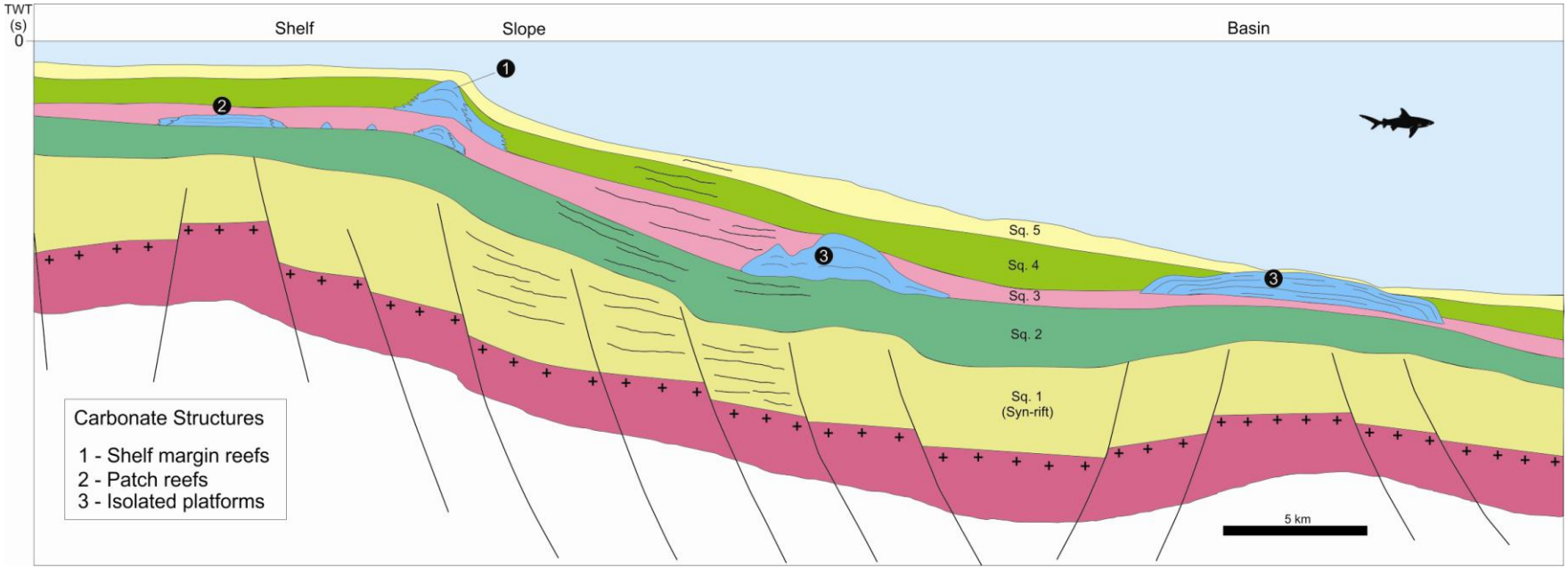
Basement countour map



CARBONATE STRUCTURES X VOLCANOES

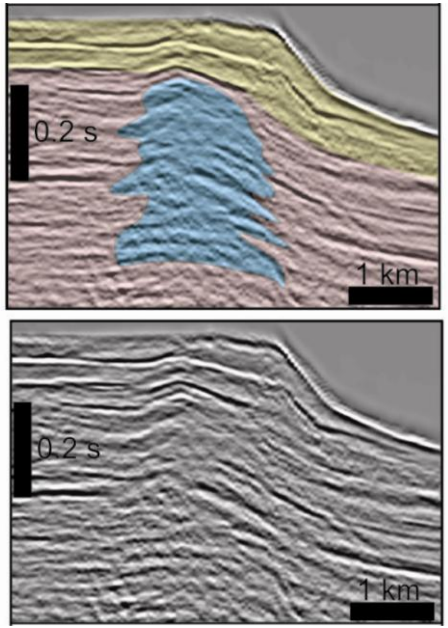


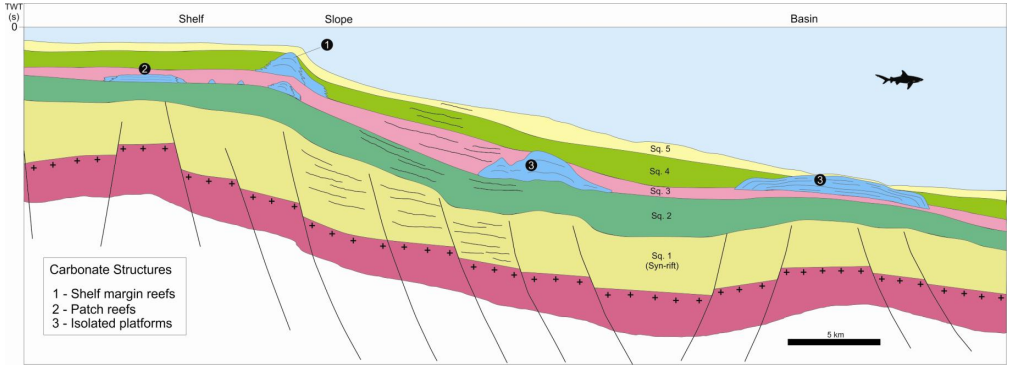
Types and distribution of carbonate structures

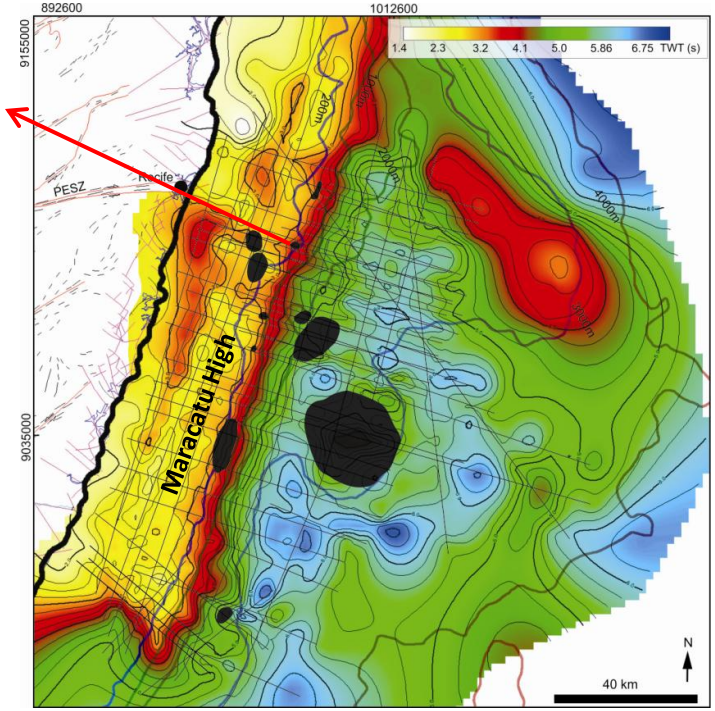


SHELF MARGIN REEFS

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



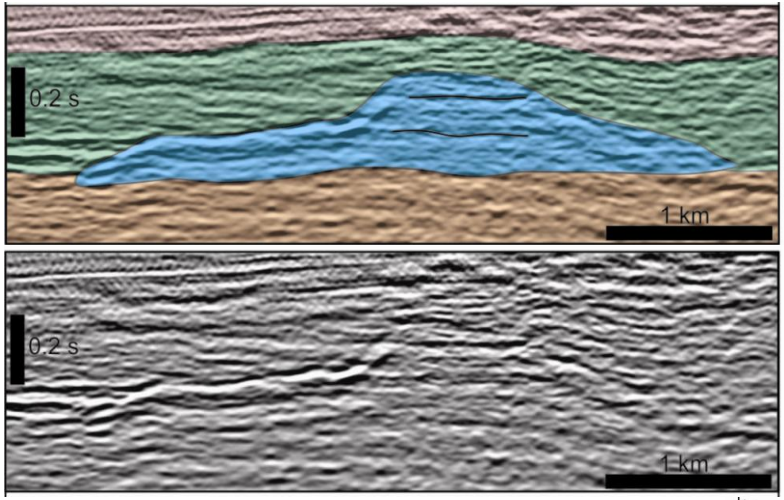


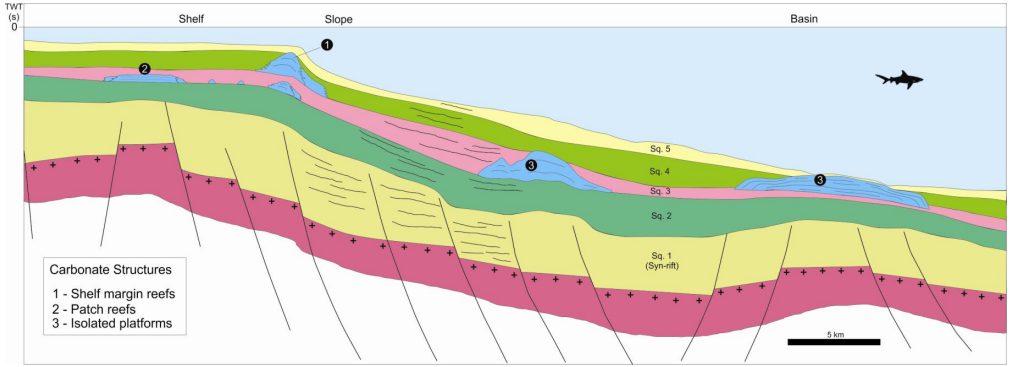


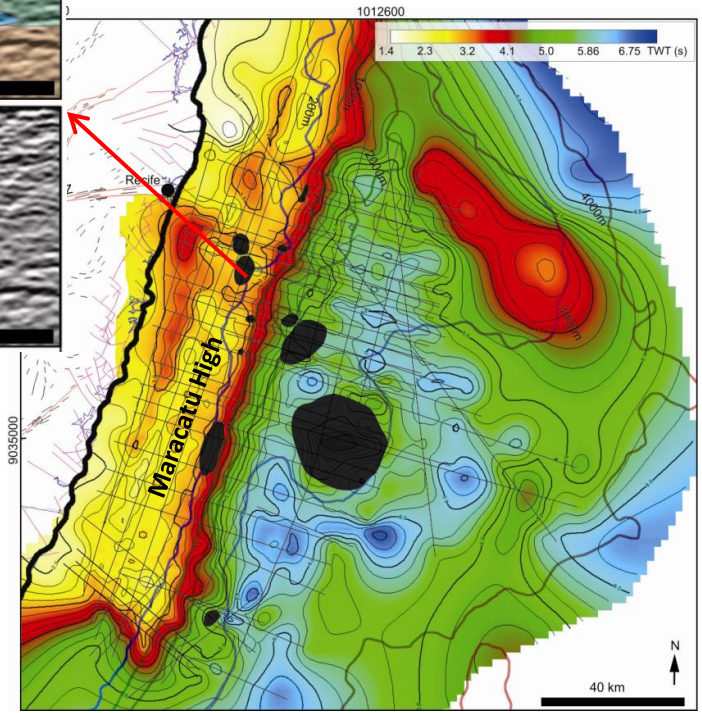
Basement countour map

PATCH REEFS

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

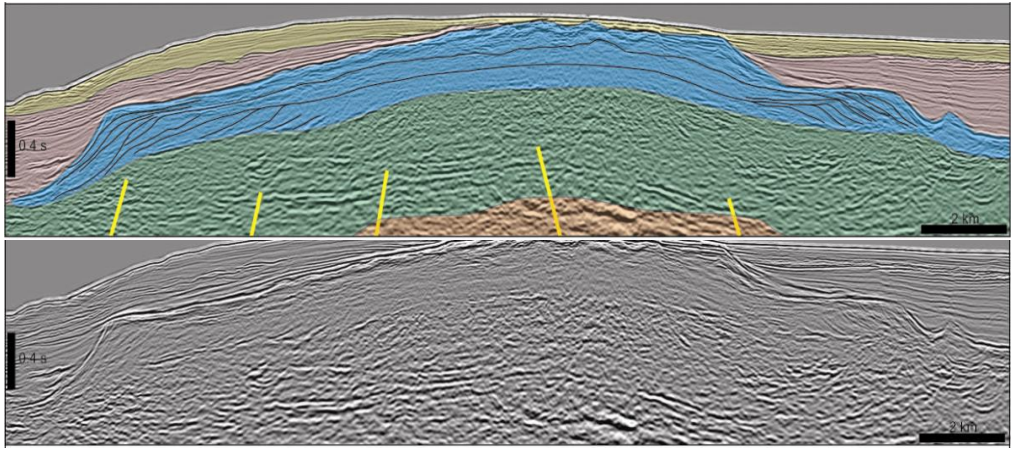




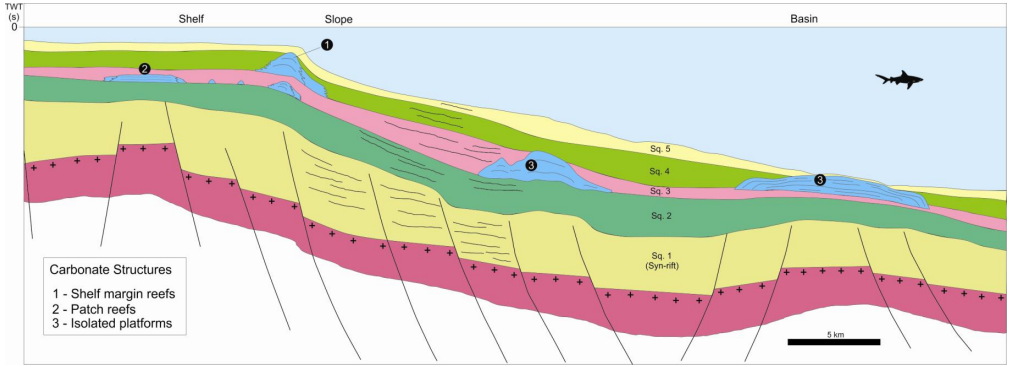


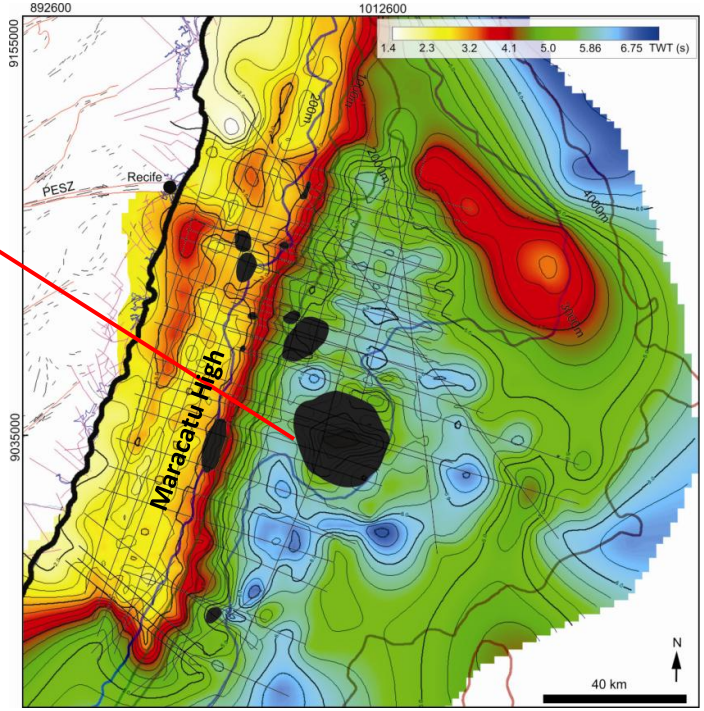
Basement countour map

ISOLATED PLATFORMS

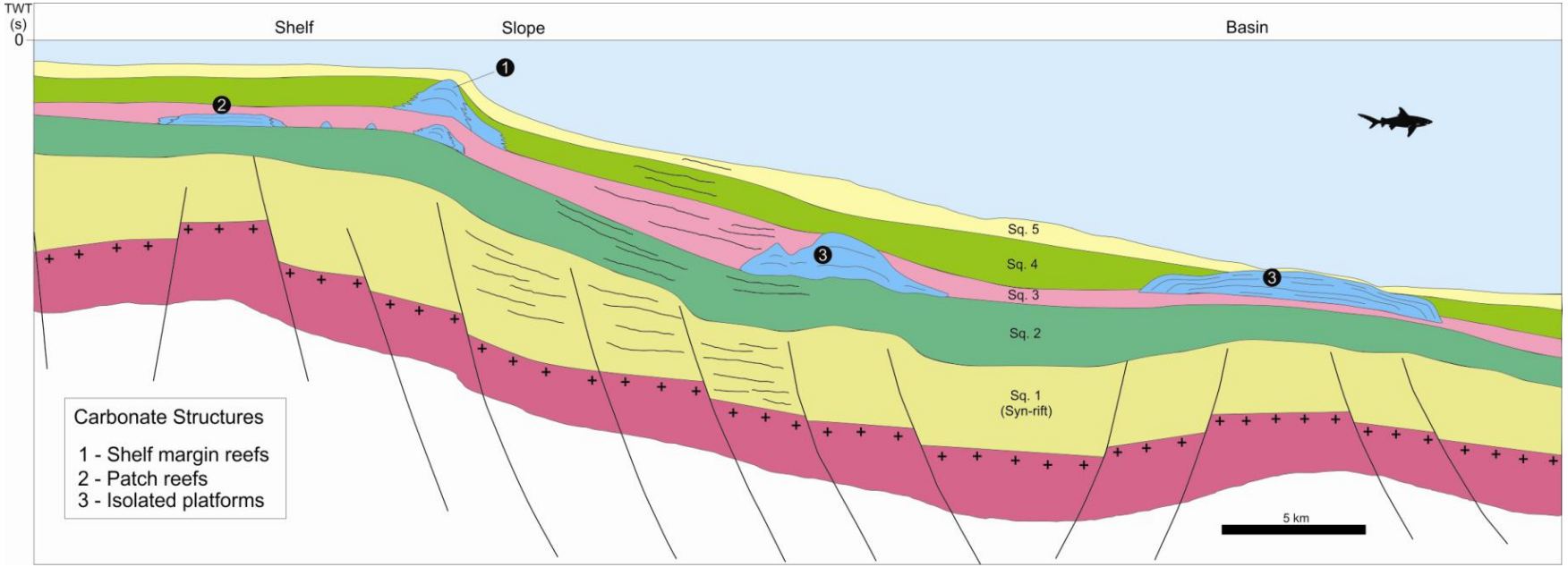


- Length : 4 - 29 km
- Height: 0.33 - 0.54 s



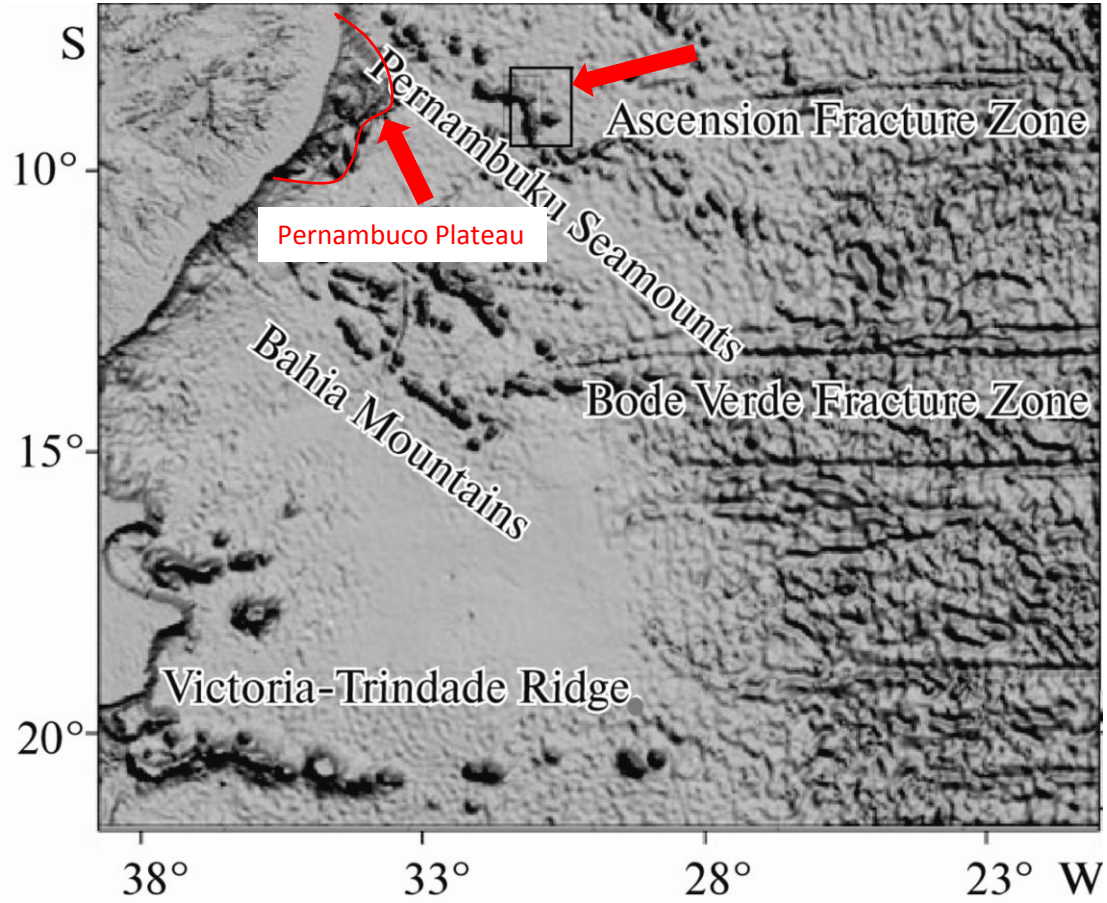


Stratigrafic position of the carbonate platforms



Sq.1: Barremian-middle Albian; **Sq.2**: middle Albian-Santonian; **Sq.3**: Santonian-Maastrichtian; **Sq.4**: Maastrichtian-Middle Miocene; **Sq.5**: Middle Miocene-recent

AGE OF CARBONATES OVER THE PERNAMBUCO SEAMOUNTS



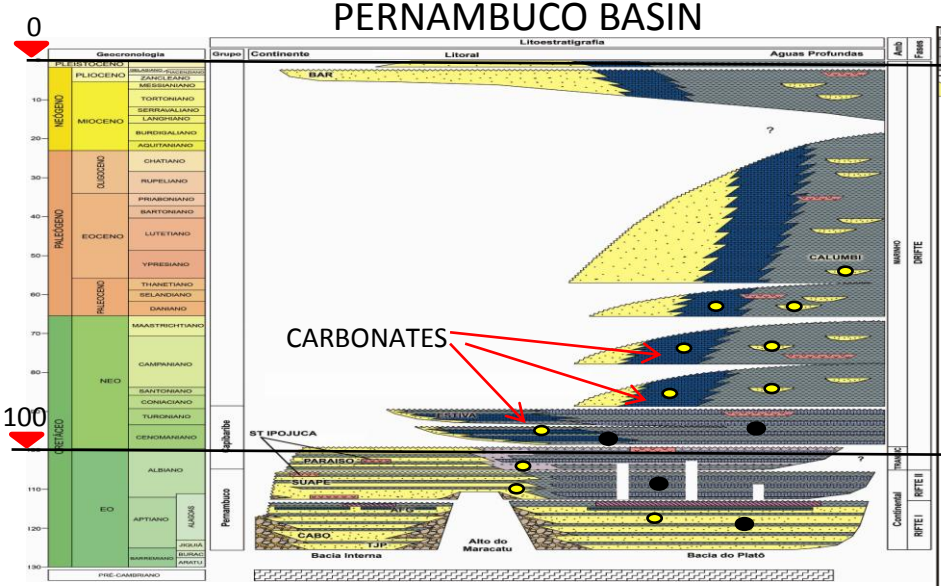
"Dredging operations made it possible to collect samples of **volcanic rocks and limestone**. Highly lithified limestone, recrystallized and occasionally phosphatized, contains an admixture of volcanic material and foraminifer chambers with the age estimated at the **Campanian - Maastrichtian** and the **Turonian - Santonian**"

From Skolotnev et al., 2012

OIL PLAYS IMPLICATIONS

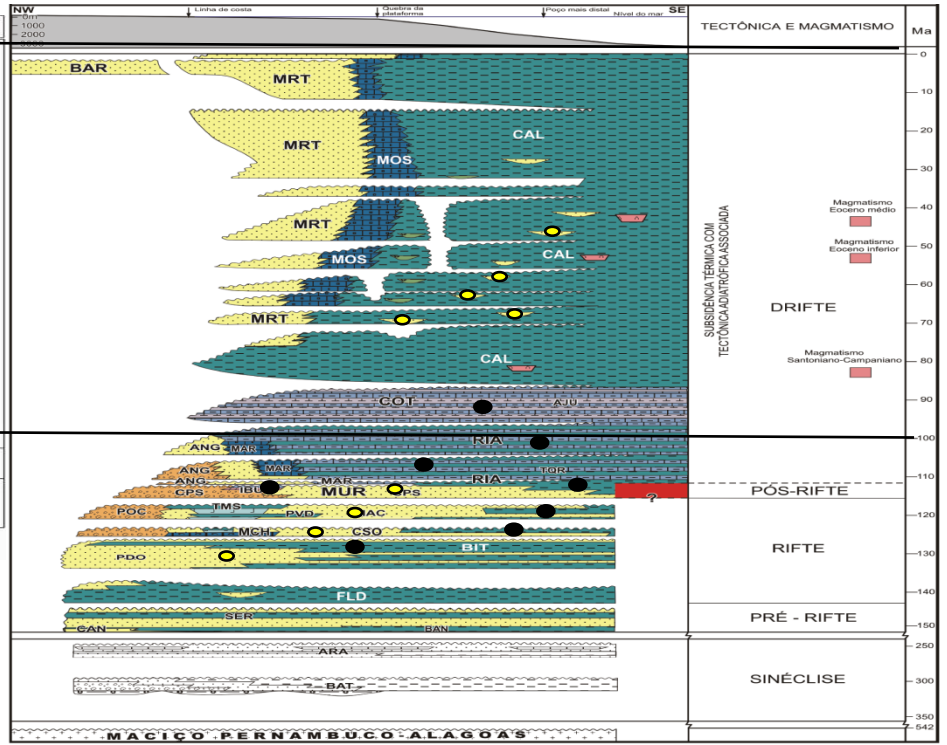
DISTRIBUTION OF RESERVOIRS IN THE ALAGOAS BASIN

PERNAMBUCO BASIN



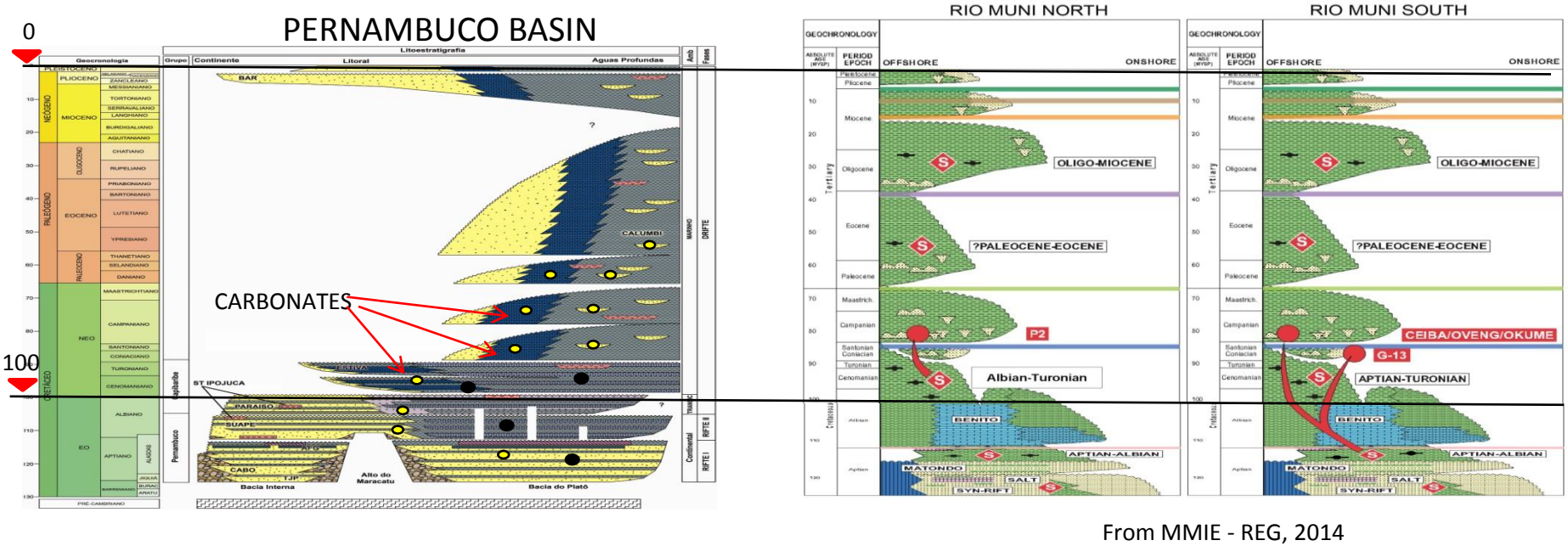
Modified from Maia, 2012

ALAGOAS BASIN



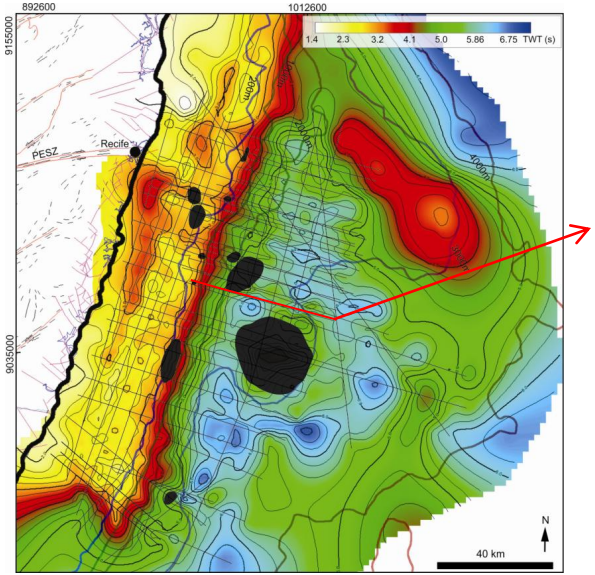
From PETROBRAS, 2007

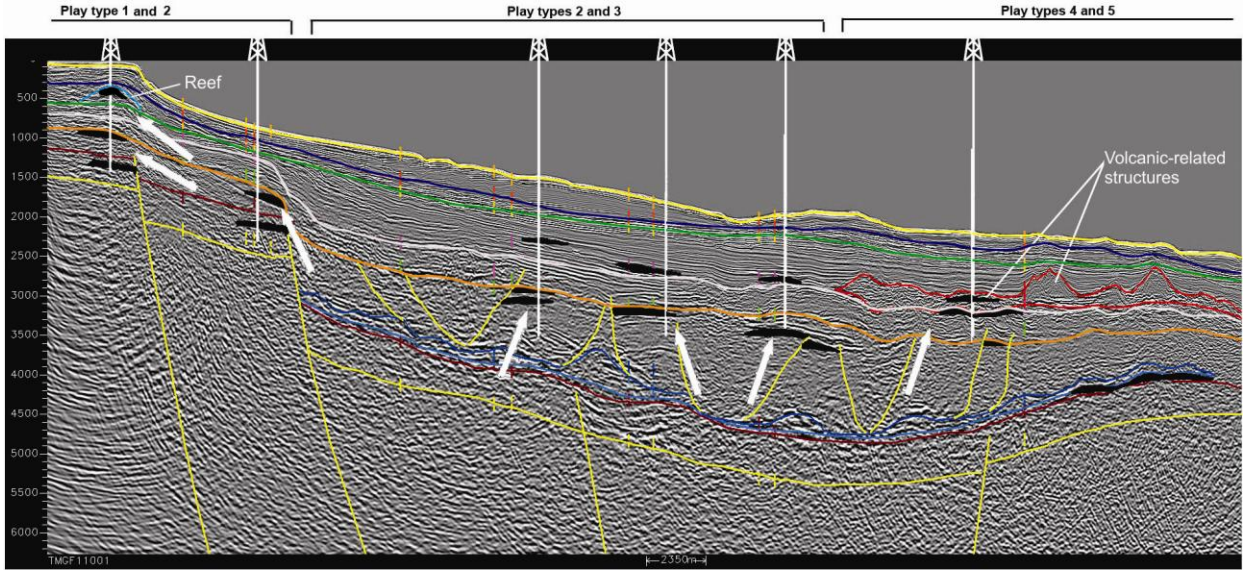
CARBONATE RESERVOIRS IN THE AFRICAN CONJUGATE MARGIN



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?

UFPE

LAGESE
LABORATÓRIO DE GEOLOGIA SEDIMENTAR E AMBIENTAL
DGEO - CTG - UFPE

SISMOS
Laboratório de Sismoestratigrafia
DGEO-UFPE

anp
Agência Nacional do Petróleo, Gás Natural e Biocombustíveis
COMPROMISSO COM INVESTIMENTO EM PESQUISA & DESENVOLVIMENTO

SINOCHEM PETRÓLEO BRASIL LIMITADA

PROJETO SEASOUND

IHS
IHS Kingdom

GEOSOFT

OpendTect

bv.buarque@gmail.com