

PS The Salt Layer as Important Key to the Pernambuco Plateau Petroleum System, Northeast Brazil*

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Abstract

The Pernambuco Basin (PEB) represents a marginal basin with an area of approximately 20,800 km² located in the eastern portion of Northeast Brazil. This basin represents one of the most prominent exploration frontiers in the deep waters of the Brazilian margin. A piston core campaign performed in 2005 revealed the existence of an active petroleum system, with a few discoveries of oil exudations in the plateau region. These exudations can be related to structures associated with a regional evaporitic layer, which deformation created oil migration pathways. We performed a study of this salt layer that covers the Pernambuco Plateau. The lack of offshore wells prevents the confirmation of the nature and age of this salt basin. The study was based in the investigation of 132 2D time-migrated seismic sections that covers the offshore region of PEB, and 2D geophysical transects built with satellite-based gravimetric data and airborne magnetometric data.

The results allowed estimating the distribution, and the main characteristics of this salt layer (thickness and salt-related structures). PEB presents two rift stages – Barremian?-Aptian, and Lower-Middle Albian. Stratigraphic relations revealed that the salt layer was deposited in Late Aptian, which implies that it was affected by late rifting processes. Accordingly to that prospect, the salt layer was early deformed by active rift faulting (tilted and folded), which strongly influenced salt tectonics during the evolution of burial across the Late Cretaceous to the Present. Early deformation stages of the salt layer during the rift influenced the geometry of its post-rift deformation, when the salt formed salt sheets that intruded post-rift and drift successions (allochthonous salt sheets). Other structures like large salt diapirs and salt drops were formed mainly over the depocenters. Salt deformation patterns in regional scale show good correlation with the depocenters borders, and with location of oil exudation, which are of critical importance to modeling of the PEB Petroleum System.

THE SALT LAYER AS IMPORTANT KEY TO THE PERNAMBUCO PLATEAU PETROLEUM SYSTEM, NE BRAZIL

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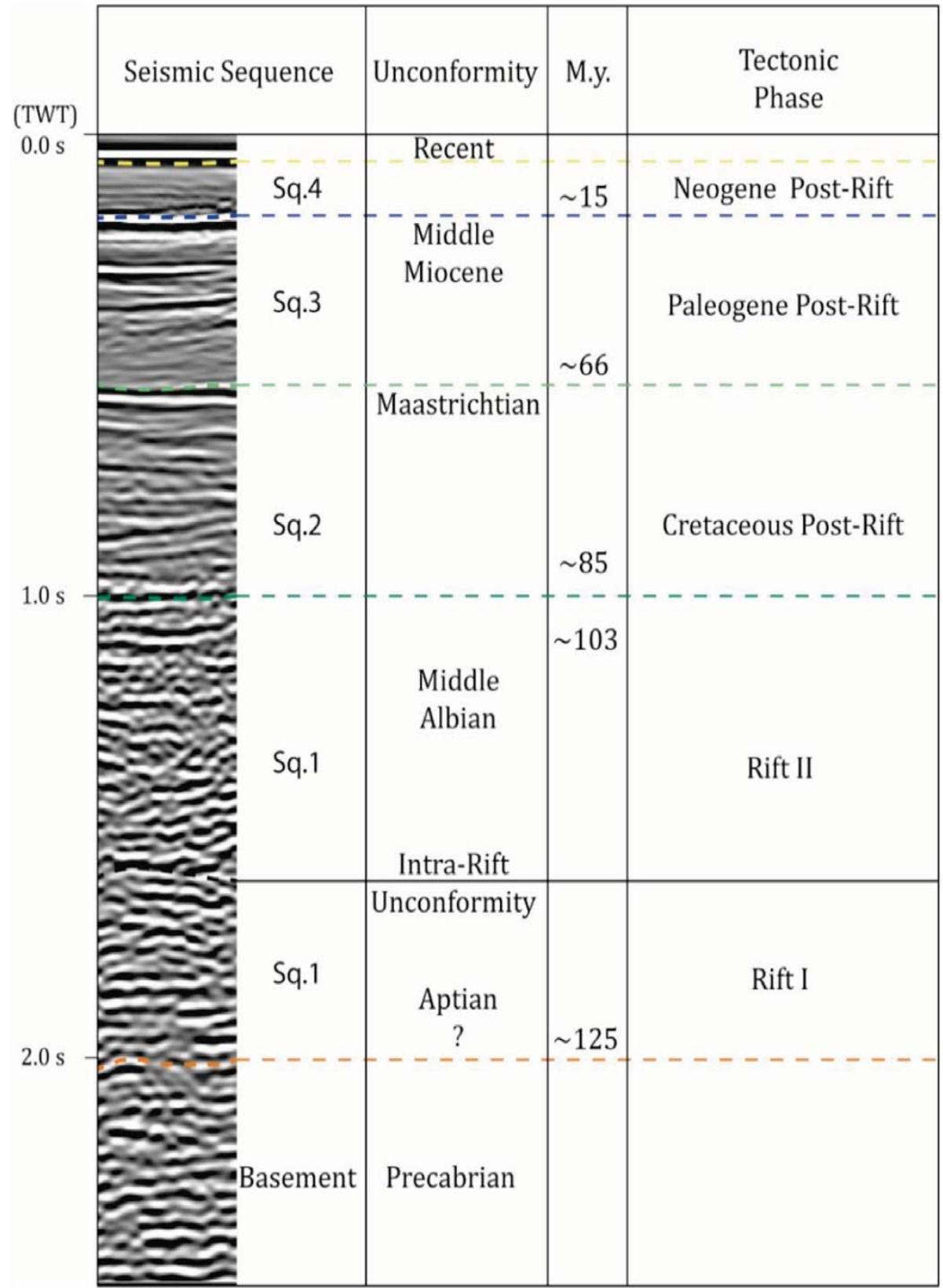


Figure 4 - Regional seismic sequences mapped on the survey of Pernambuco Basin.

RESULTS

The results allowed estimating the distribution, and the main characteristics of this salt layer (thickness and salt-related structures). PEB presents two rift stages – Barremian?-Aptian, and Lower-Middle Albian. Stratigraphic relations revealed that the salt layer was deposited in Late Aptian (figure 4), which implies that it was affected by late rifting processes. Accordingly to that prospect (figure 5 and 6), the salt layer was early deformed by active rift faulting (tilted and folded), which strongly influenced salt tectonics during the evolution of burial across Late Cretaceous to the Present. Early deformation stages of the salt layer during the rift influenced the geometry of its post rift deformation, when the salt formed salt sheets that intruded post-rift and drift successions (allochthonous salt sheets). Other structures like large salt diapirs and salt drops were formed mainly over the depocenters (figure 7). Salt deformation patterns in regional scale show good correlation with the depocenters borders, and with location of oil exudation (Da Silva, 2019), which are of critical importance to modeling of the PEB Petroleum System.

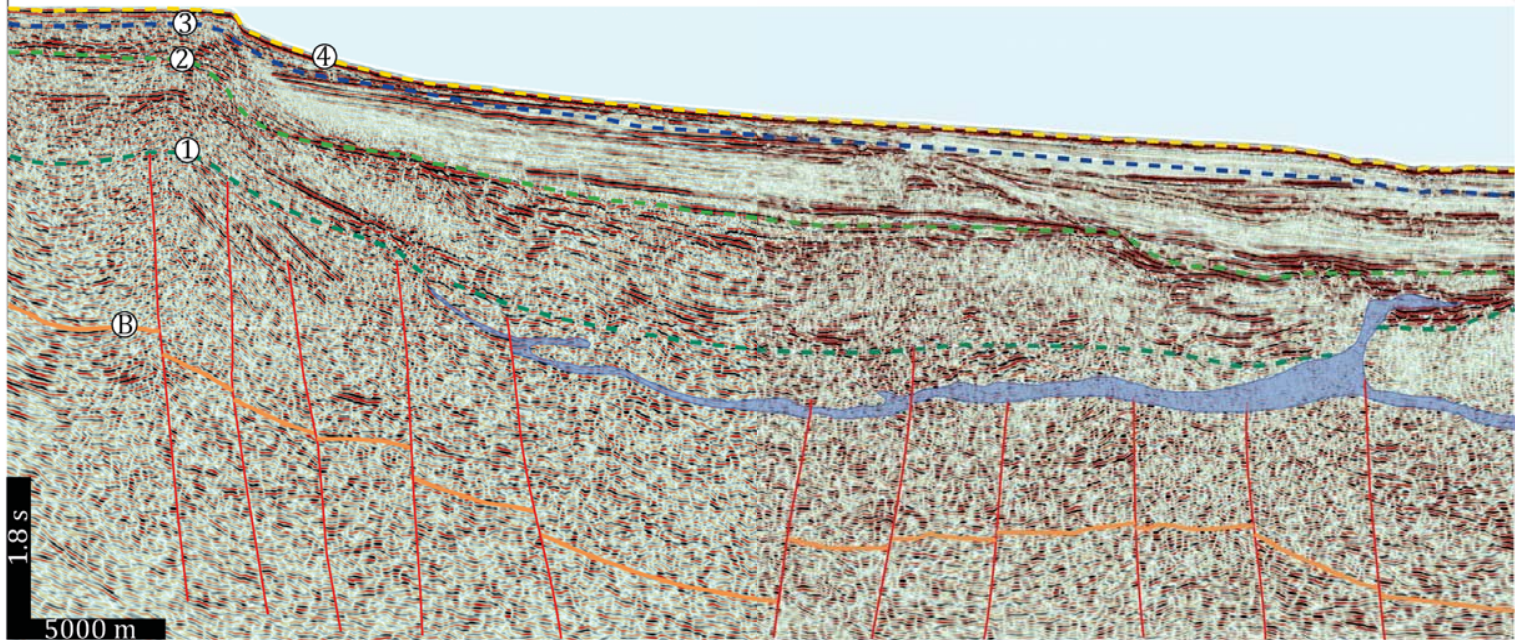


Figure 5 - Seismic section migrated in time (TWT).

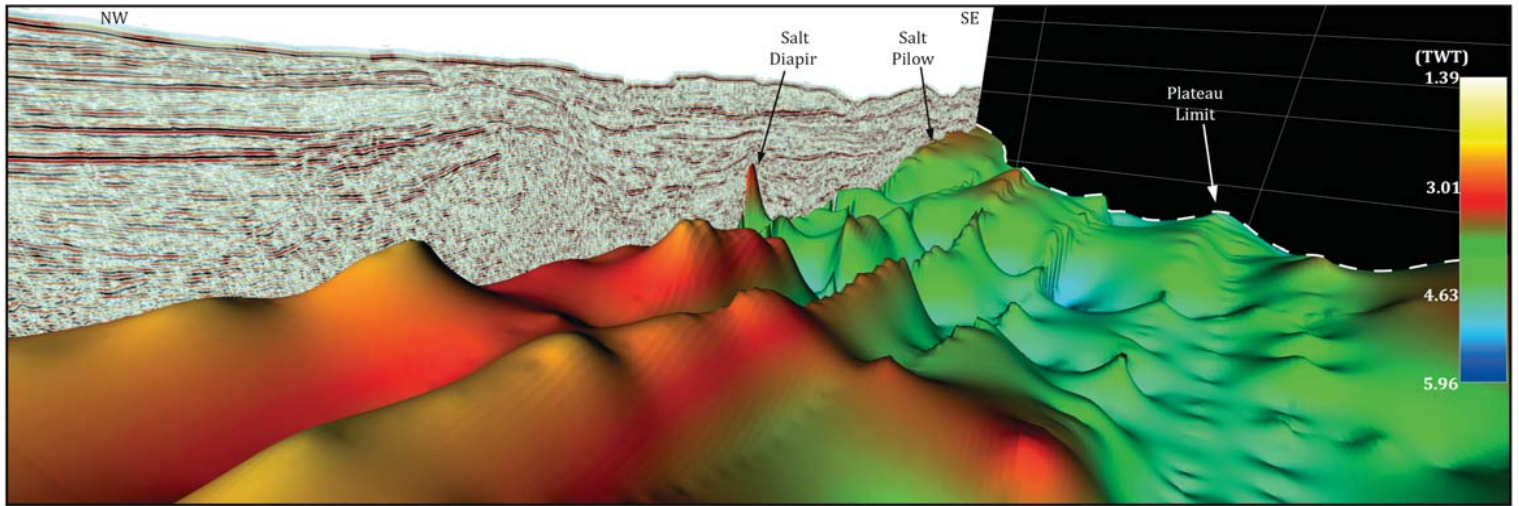


Figure 6 - Surface of the top of the salt layer, mapped in the seismic lines of the north region of the Pernambuco Plateau.

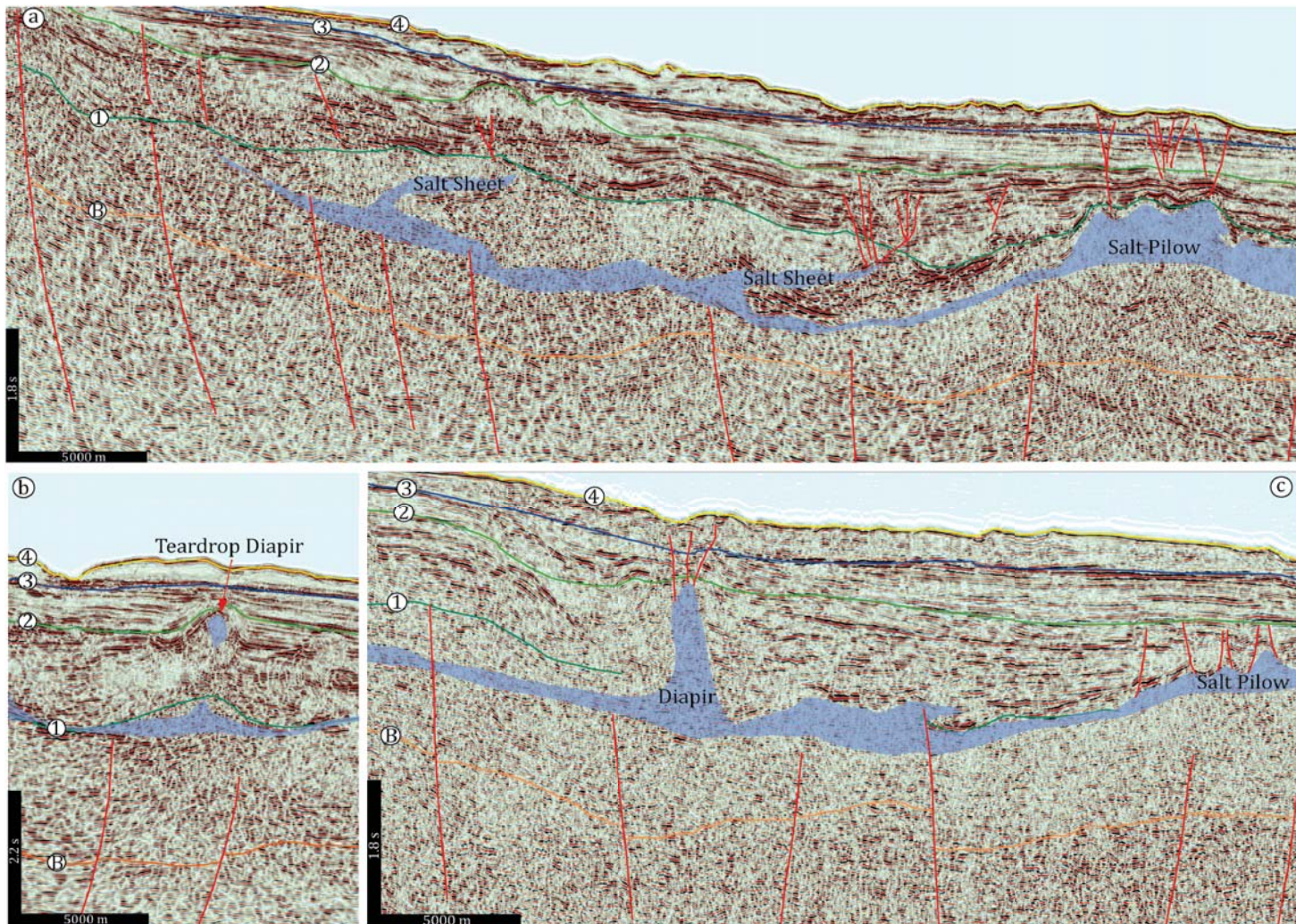


Figure 7 - Aspects observed in the seismic lines located in the Pernambuco Plateau region related to salt tectonics.

DISCUSSION

Although there is no direct evidence from well data, the data presented by present study, suggests the existence of an expressive salt layer in the Pernambuco Plateau region, expanding the influence of evaporite deposition during the South Atlantic transitional phase. Probably this salt layer was deposited in Upper-Aptian-Lower-Albian in the Pernambuco Basin and represents an extension of the evaporitic layers of the Alagoas Basin to the north (Mohriak et al., 1998; Rabêlo Cruz, 2008).

The evidence of salt layers in the Pernambuco Basin suggests that the topographic barrier north of the salt deposition was in the Pernambuco Basin. It is possible that the northern region of the Pernambuco Basin, affected by the Pernambuco Shear Zone (PESZ) (Fig. 8), was the region that works like the topographic barrier for deposition of the evaporitic layers in the transitional phase of the South Atlantic.

In relation to the deformation associated to salt, in the Pernambuco Basin, the layer presents a very peculiar deformation, being the fruit of reactive processes, at least in the initial process of deformation of the salt layer (Hudec and Jackson, 2007).

The rift faults still remain active after the salt deposition, causing intense tilting of the salt layers, together with a tectonic deformation associated with the rift extension. Due to the complexity of the movement of salt layers, the present study proposes an a model for salt deformation in the Pernambuco Plateau region being composed of 4 phases shown in figure 9.

INTRODUCTION

The Pernambuco Basin (PB) represents a marginal basin with an area of approximately 20,800 km² and is located in the northeast portion of the Brazilian continental shelf (Figure 1). This basin is considered an exploratory frontier of oil over the last few years. The Pernambuco plateau shows a high potential in exploratory terms. Volcanic structures and carbonate constructions were mapped in this region (Buarque et. al., 2016, 2017), currently considered important exploratory plays in the oil industry. The present study aims to show the existence of an evaporite basin in the Pernambuco Plateau region. Were used a survey of seismic reflection. The existence of an evaporite layer north of the Alagoas Basin, expands the influence of evaporite deposition within the Gulf of the South Atlantic. This may represent significant changes in Pre-Salt occurrence, however, the lack of exploratory wells in the BP offshore region, prevents the confirmation of the nature and age of this evaporite layer. The evaporitic layers were mapped in the central region of the pernambuco plateau, and strutures were identified, such as pillows and diaphoretic saline bodies. Also, are observed alchoctone salt bodies, interpreted as detached salt sheet and teardrop diapir (Jackson and Talbot, 1991; Hudec and Jackson, 2007). The salt layers are disconnected, and tilted with the rift faults. As the salt layer is tilted, folded and segmented by rift faults, probably the age of this salt layer could be associated with the upper-Aptian.

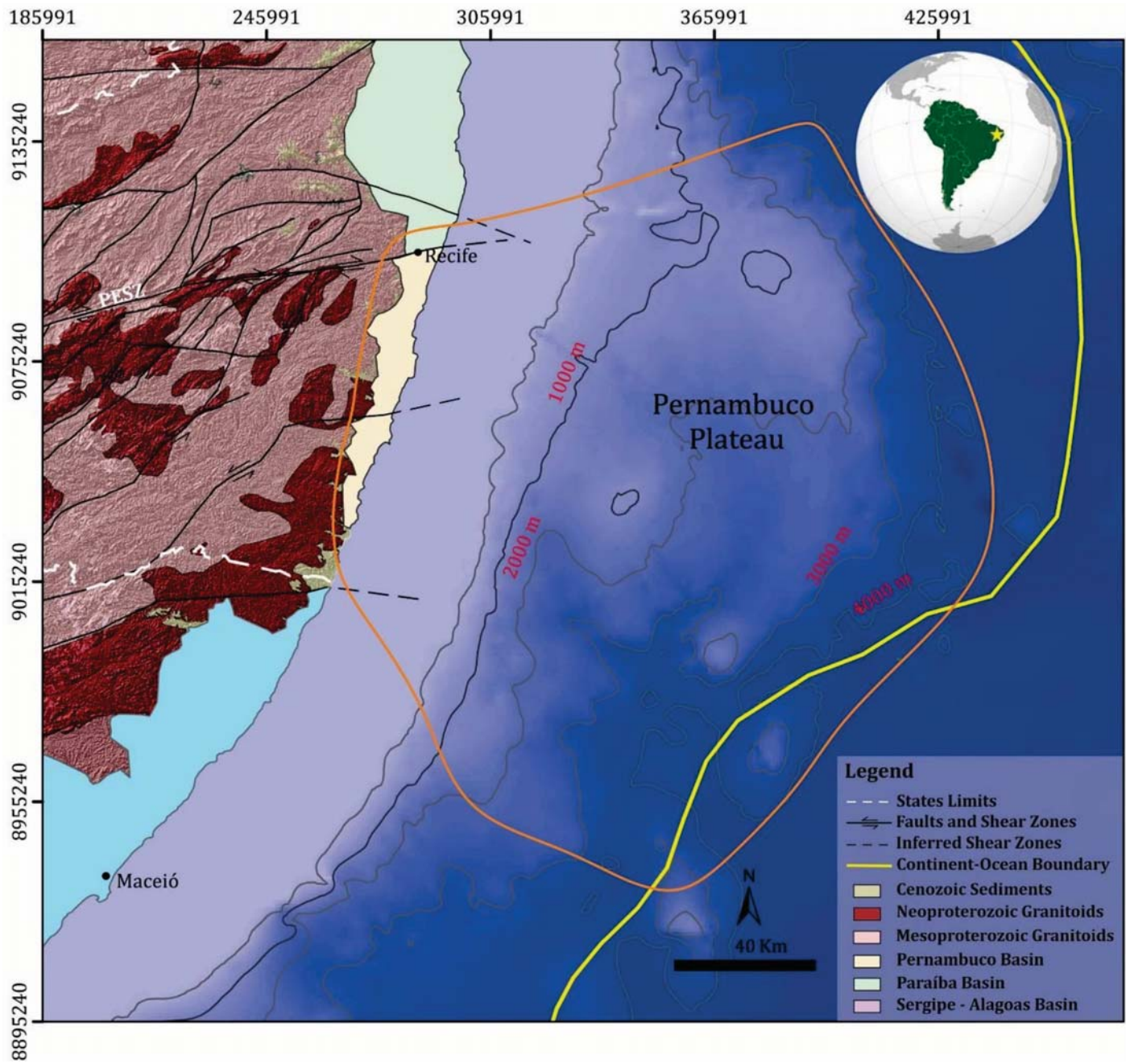


Figure 1 - Location map of the marginal basins of northeastern Brazil.

MATERIALS AND METHODS

SEISMIC DATA

Analysis of seismic data for 132 time-migrated 2D lines acquired from BDEP-ANP (figure 2), with the purpose of assisting in the regional mapping of the seismic subsurface contour and the main regional seismic sequences (Figure 3). The acquired seismic data allowed a detailed interpretation of the geographic distribution of the salt layers, as well as the saline body geometry and salt tectonics related fault systems.

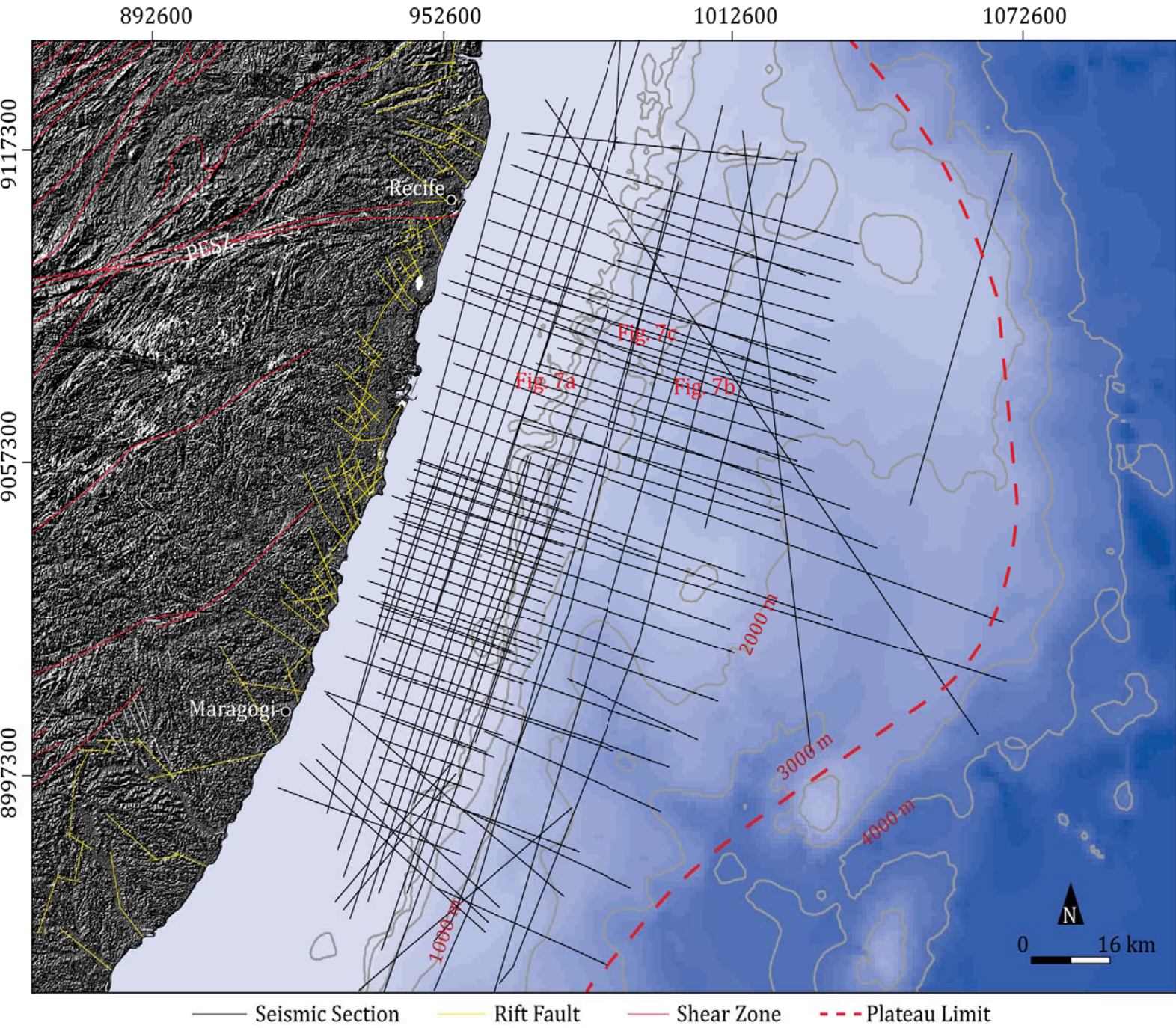


Figure 2 - Location of the seismic sections interpreted in the Pernambuco Basin.

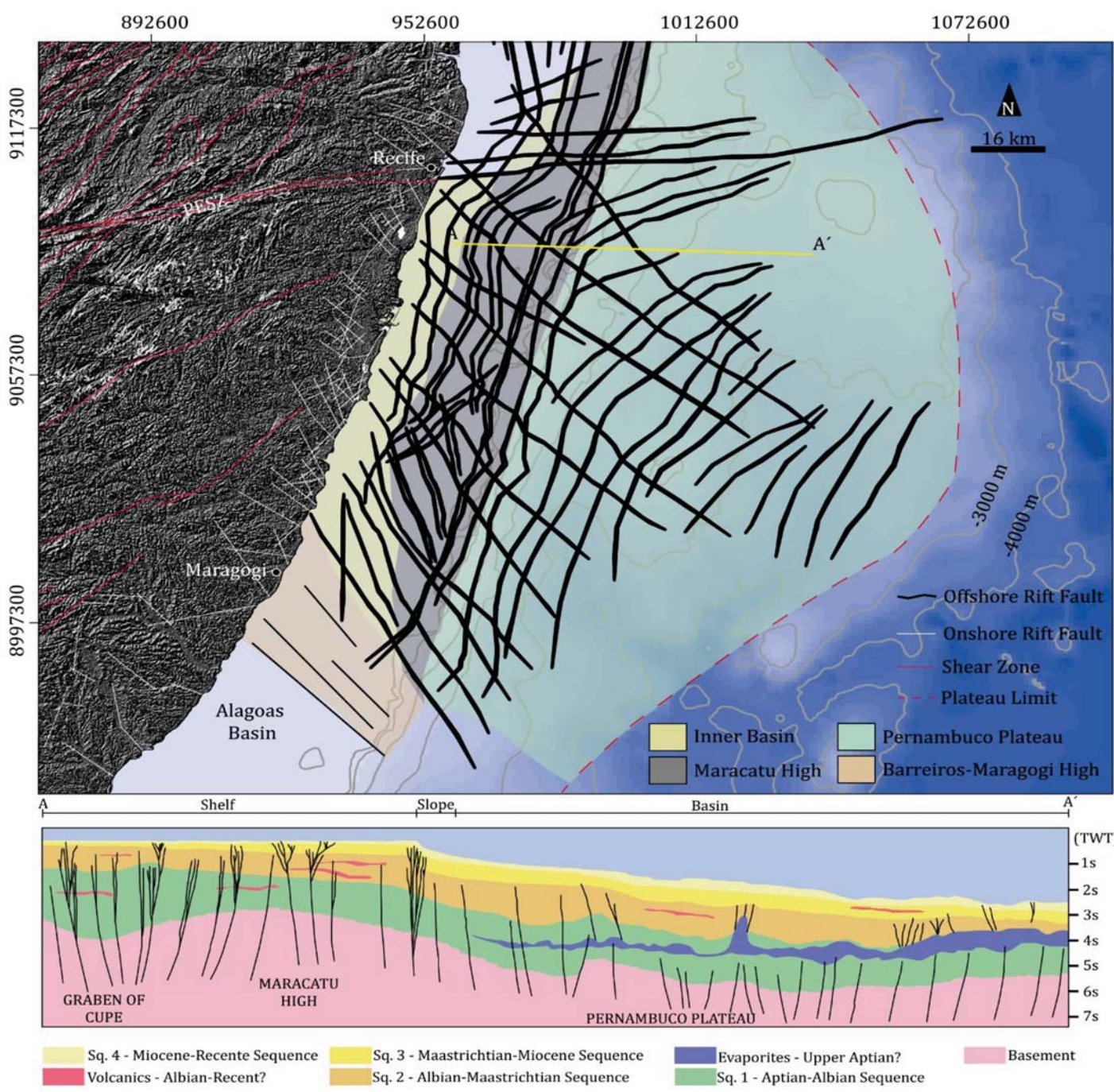


Figure 3 - Structural framework of the Pernambuco Basin.

CONCLUSIONS

The results presented by this research show evidence of an important salt layer, to the north of the Alagoas Basin, which expands the geographic influence of the (transitional) gulf phase in the process of opening of the South Atlantic Ocean. The northern topographic barrier, associated to the gulf phase, was represented by the structural high related to the Pernambuco Shear Zone, while to the south, the Rio Grande - Walvis Ridge High exerted this function. The layer of salt interpreted and mapped in the seismic data, is related to the main depocenters of the Pernambuco Plateau region. Accordingly to that prospect, the salt layer was early deformed by active rift faulting (tilted and folded), which strongly influenced salt tectonics during the evolution of burial across Late Cretaceous to the Present. Early deformation stages of the salt layer during the rift influenced the geometry of its post rift deformation, when the salt formed salt sheets that intruded post-rift and drift successions (allochthonous salt sheets). Other structures like large salt diapirs and salt drops were formed mainly over the depocenters. This possibility expands the economic area of the Pre-Salt to the Eastern Northeast, which substantially modifies the economic perspective of this region. Salt deformation patterns in regional scale show good correlation with location of oil exudation, which are of critical importance to modeling of the PEB Petroleum System.

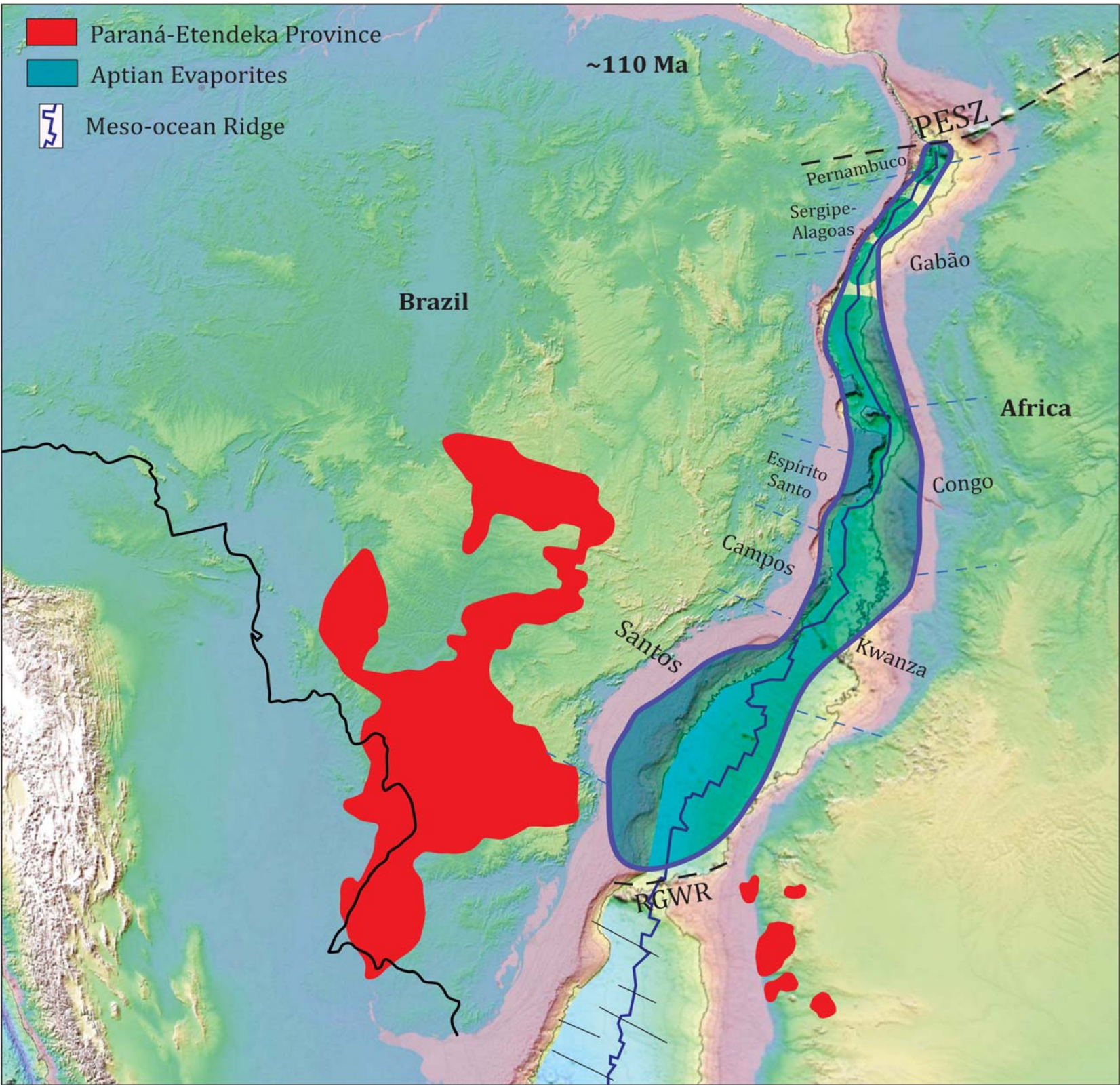


Figure 8 - Paleogeographic reconstruction involving South America and Africa.

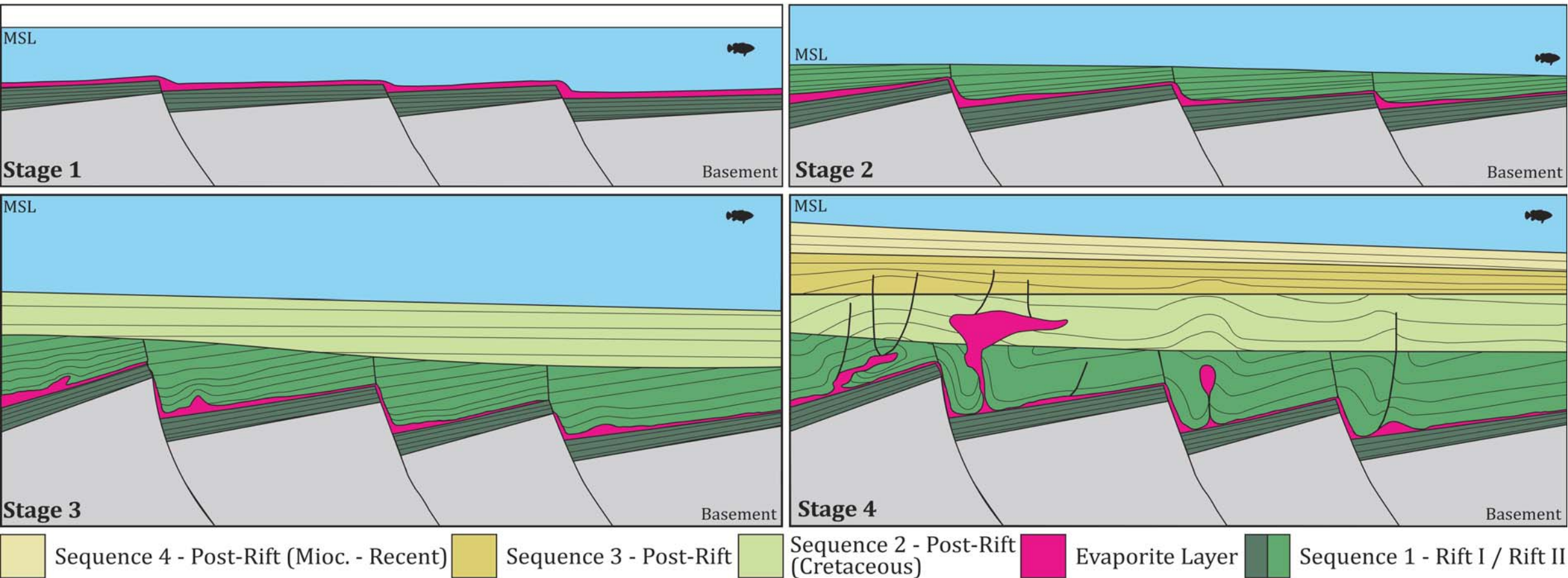


Figure 9 - Detail for the deposition and deformation of the salt layer in the Pernambuco Plateau region, in four stages: 1 - Deposition of the salt layer over the deposits of the first rift phase (Barremian? - Aptian); 2 - Beginning of the deposition of the sedimentary sequence related to the second phase rift (Aptian-Albian) over the evaporitic layer; 3 - Beginning of deformation of the salt layer caused by rift faults; 4 - Deformation of the salt layer by the effects of overload by the sedimentary column.

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