Exploration Opportunities in the Pre-Salt Play, Deepwater Campos Basin, Brazil

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Abstract

Several conceptual exploration models are still to be tested and extensive pre-salt acreage within the Brazilian pre-salt hydrocarbon play remain unexplored or under-explored. The announced 2017 ANP license rounds will offer opportunities within pre-salt acreage studied in this work.

Based on seismic interpretation of 3D PSDM surveys in the deepwater Campos basin, we have identified several exploration trends and very large drilling opportunities in the sedimentary succession locate immediately beneath the salt. We interpreted that these potential accumulations are hosted by carbonate and siliceous microbialites and several reservoir facies can be encoutered.

Large outboard microbial platforms nucleated on top of volcanic complexes could potentially introduce a new, high-risk frontier play that can reveal very large hydrocarbon volumes just beneath the main evaporitic succession in distal segments of Campos basin. Besides reservoir presence/quality, exploratory risks for this trend would be related to hydrocarbon generation and migration. As for other microbial limestone accumulations, we could contemplate the possibility of a self-sourced system to mitigate the risk.

Introduction

The discovery of the Lula field by Petrobras and partners in 2006 opened a new E&P frontier in Brazil: the Barremian/Aptian pre-salt play in the offshore Santos and Campos basins. Several multi-billion-barrels discoveries have been made in carbonate reservoirs in pre-salt sequences of these two producing Brazilian basins and their African counterparts. These recent Santos and Campos discoveries, after appraisal, are expected to add at least 10 Bboe to the Brazilian proved reserves by 2022 (from ANP, 2014).

The Brazilian pre-salt play consists of rift/sag-sourced oils, accumulated in Aptian reservoirs (microbialites) in structural closures or paleo-topographic/depositional highs beneath the salt (figure 1). The overlying Aptian evaporites provide the sealing unit. In addition to the microbialites, deeper coquina reservoirs have become important exploration targets in the pre-salt succession of Campos and Santos basins as proven by successful well tests on Búzios (previous referred as Franco) and Libra pre-salt discoveries.

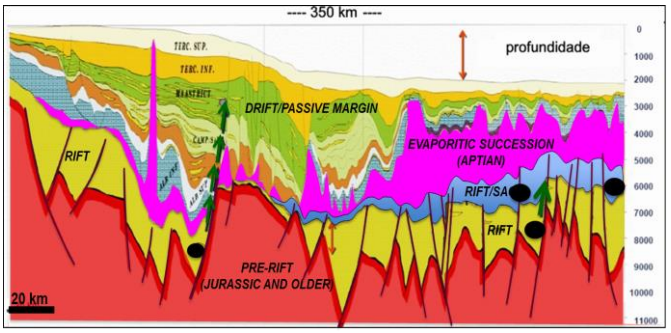


Figure 1: Pre-salt Play Summary: schematic cross-section, for Santos basin. From IBP internet site, session compiled by Marco Antonio Pinheiro Machado (Cainelli, pers.com.)

Based on available Santos well data, observed seismic responses as well as on published analytical studies of the major commercial and non-commercial pre-salt discoveries in Brazil (e.g. Fontes and Zalan, 2014 and Petersohn et. al., 2013), two main reservoir targets are recognized the for the pre-salt within the study areas:
a. late rift coquinas: lacustrine facies deposited at the Late Barremian to Early Aptian and,
b.the younger rift/sag microbial limestones or microbialites: mostly lacustrine units deposited during Aptian just before the establishment of the major evaporitic sag basin between South America and Africa, during the late phases of rifting/sag of the continental break-up. Microbial limestones are currently the major producing reservoir units.

The microbialites that occur just beneath the base salt can be interpreted as “organosedimentary deposits that have accreted as a result of a benthic microbial community trapping and binding detrital sediment and/or forming the locus of mineral precipitation” (Burne and Moore, 1987, pp. 241–242). Microbialites formed in large, mostly lacustrine, settings due to the activity of extremophilic microorganisms surviving in potential hypersaline and hydrothermal conditions during the

Aptian thermal sag phase that followed the syn-rift deposition.

Dataset and Method

PGS 3D PSDM multi-client surveys constitute the main database for this study (figure 01; total PSDM 3D area – ca. 46,000 sq. km; 34,000 sq. km in Santos and 12,000 sq. km in Campos).

In the Santos basin, we mapped the pre-salt succession and evaluated the exploration opportunities within the PGS BMS-50/52 and BS-1_South 3D PSDM seismic surveys, on the trend of Carcará and Sagitário discoveries, and the PGS Santos Phase I: merged/reprocessed, 3D PSDM survey covering partially Gato-do-Mato, Florim and Búzios (Franco) discoveries. These multi-client surveys include both conventional and broad-band seismic data and have been tied to the main control wells and pre-salt discoveries and producing fields through ca. of 1,420 linear km of 2D regional PSDM broad-band seismic lines (figure 01).

Our seismic data in the Campos pre-salt succession consists of merged and reprocessed 3D PSDM survey from older conventionally-acquired datasets, covering a recent discovery in the block BM-C-33 and extending into deep waters (Campos Phase I, II, III and IV).

Figure 2 show the main EOD's (Environments of Deposition) for the pre-salt microbial succession in Campos and Santos basin based on our seismic interpretation, available well control and recent/outcrop analogues.

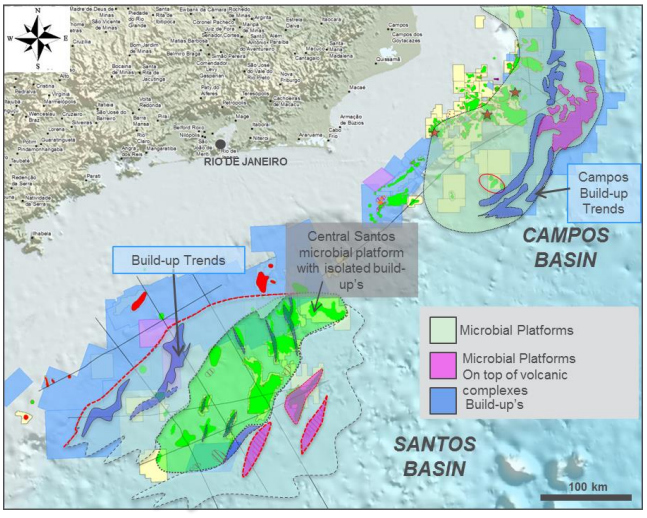


Figure 2: Pre-salt EOD (Environments of Deposition) for Santos and Campos Basins

Microbial Succession in the Deepwater Settings of the Campos Basin

In what relates to the pre-salt play, this survey area can be considered frontier. No pre-salt penetration in the area was available to calibrate our interpretation. The presented considerations are based on analogies with the Santos and the Kwanza basin discoveries. 3D seismic interpretation of the pre-salt section at the southern sector of the deep water Campos Basin has allowed the delineation of several pre-salt exploration segments.

3D seismic interpretation of the pre-salt section at the southern sector of the deepwater Campos Basin (figure 05) has allowed the delineation of several pre-salt plays:

i) Structural Play in coquinas and microbialites (Late Rift to Sag);
ii) Stratigraphic/Combination Play in coquinas (Late Rift to Sag);
iii) Microbial Build-up Play on rift shoulders (Sag microbialites) and;
iv) Microbial Platform nucleated on top of and around large volcanic complexes (Figure 3).

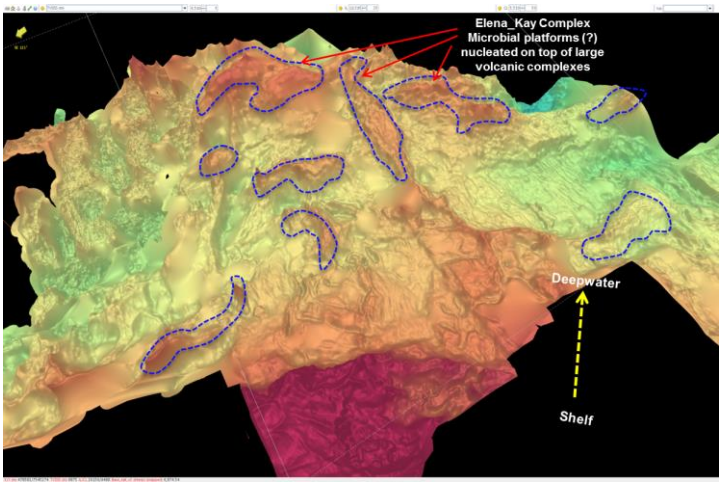


Figure 3: 3D perspective of the deepwater Campos pre-salt oportunities. Srutural map of the base salt horizon. View from Marlim Field in shallower water.

Coquinas targeted exploration should be focused in the western part of the surveyed area while microbial reservoirs with potentially good permo-porosity properties seems to be located towards the ultra-deep waters in the eastern part of the survey.

Exploration Opportunities

The announced 2017 ANP license rounds will offer opportunities within pre-salt acreage studied in this work.

A complex of large hydrocarbon opportunities (4-way closures related to paleo-topographic/depositional highs at the base salt, here named Elena_Kay Complex, Figures 3 and 4) constitutes interesting features offer for the one of the ANP (Agência Nacional do Petróleo) 2017 bid-rounds.

The interpreted depositional architecture indicates that the large microbial platforms were nucleated on top of volcanic complexes resulted from the relatively young rifting processes on largely extended continental crust as demonstrated by Figure 4. As per our well control and analogies, we can infer that the main reservoirs in these platforms are potentially carbonatic and/or siliceous microbialites.

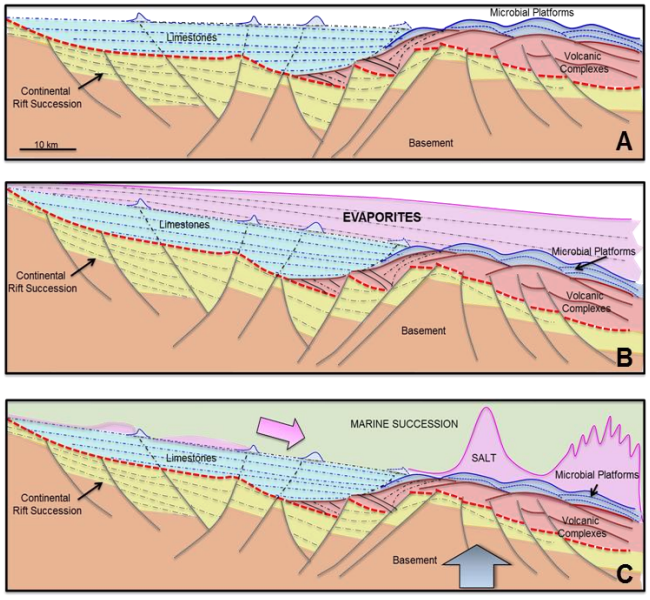
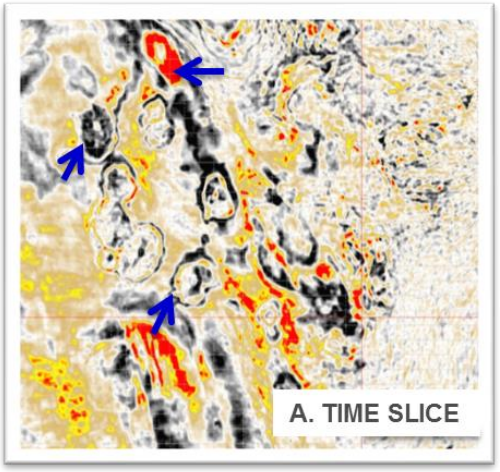


Figure 4: Elena Kay Complex Evolution

Orientation and external seismic geometries and the pre-existent fault-control suggested that their deposition were controlled by hydrothermal fluids (Figure 5). Significant hydrothermal structure found in Yellowstone Lake consists of hard, porous siliceous material protruding vertically from crater-like depressions as irregular, conically shaped “spires” discovered in Bridge Bay in 1997 and could be infered as a potential recent analogue to this pre-salt setting in the Campos basin as well as some potential hydrocarbon reservoir in the Kwanza basin (Casier *et.al*, 2014). The silicilythes in South Oman could also represent viable analogues to the proposed reservoir interpretation (Al-Siyabi, 2005)



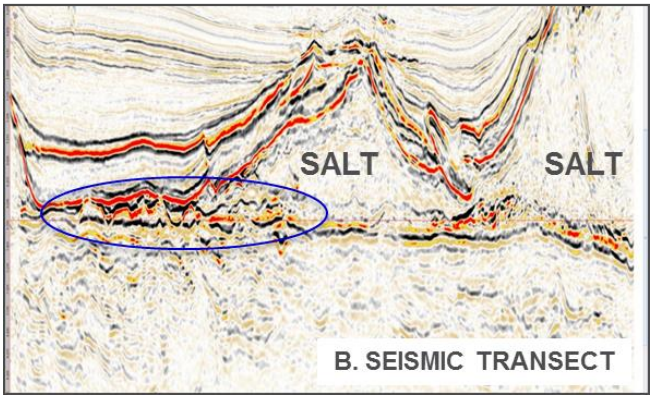


Figure 5: Seismic examples of potential hydrothermally-triggered microbial build-up’s

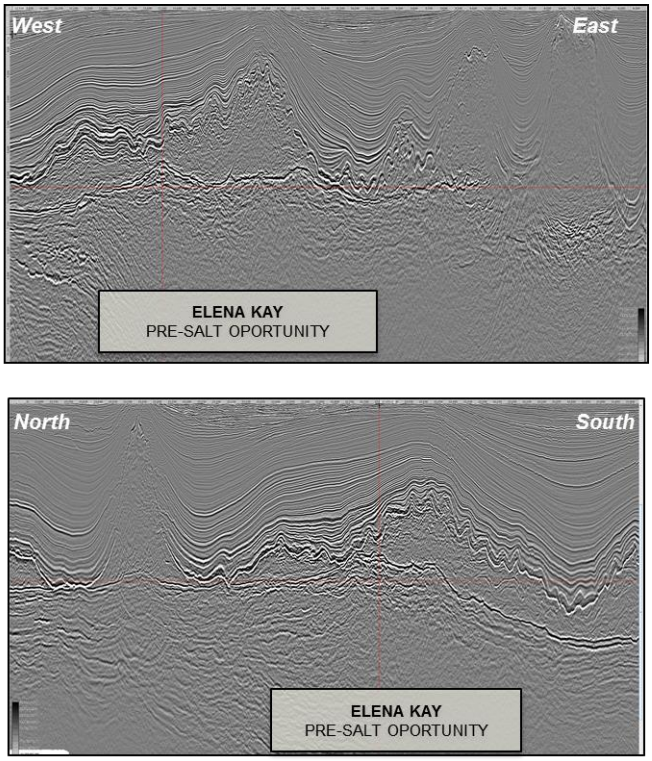


Figure 6: Seismic transects for one of the large hydrocarbon opportunity in the Campos deepwater settings.

Conclusions

Since 2006 Santos and Campos have been a success story for the pre-salt play exploration. Additional Campos and Santos pre-salt acreage is still available for future exploration efforts;

In the study area, we recognized several large exploration opportunities in the pre-salt succession. Some of them are in acreage that will be offered by ANP in 2017 bid-rounds;

The target reservoirs of the pre-salt succession are lacustrine carbonates, silicilythes (microbialites) and coquinas which can be recognized and mapped by their external geometries and internal seismic facies characteristics;

Large outboard microbial platforms nucleated on top of volcanic complexes could potentially introduce a new, high-risk frontier play that can reveal very large hydrocarbon volumes just beneath the main evaporitic succession in distal segments of Campos basin.

Besides reservoir presence/quality, exploratory risks for this trend would be related to hydrocarbon generation and migration.

As for other hydrocarbon accumulations in microbial limestone/silicilythes, we could contemplate the possibility of a self-sourced system to mitigate the source-rock presence risk.

Acknowledgments

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