Following the Pre-Salt Play to its Outermost Extent in the Campos and Santos Basins, Brazil - An Analog for Gulf of Mexico Presalt?*

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Abstract

This presentation reviews the major elements of the Brazilian pre-salt play in the Campos and Santos Basin: source, reservoir, trap and seal and how the evolution of these elements through the different depositional and structural domains can be seen on well and seismic (2D and 3D) data. The presentation then looks at well and seismic data onshore and offshore Mexico to see if these same successful play elements can be seen in the Mexican Gulf of Mexico and answer the question: is there a pre-salt play in Mexico? A major problem with considering the viability of pre-salt play(s) in Mexico was the lack of a proven pre-salt source rock. Stabler (2020) has proven the existence of such a Middle Jurassic lacustrine source rock in the Huehueteppec-3 well onshore Tampico-Misantla province. All other elements (reservoir, trap, seal) for a pre-salt play can be shown to exist at a variety of depths throughout the Mexican Gulf of Mexico. We show seismic examples of possible such plays and conclude that the best location for testing such a play is in the shallow water Campeche Salt Basin. See the attached slide set presentation for the complete presentation.

Reference Cited

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Agenda

• Introduction
• Regional pre-salt geology (Brazil) – what makes the pre-salt play work in Brazil
• Examples of the success factors
• Do these factors obtain in the GOM: Regional pre-salt geology (MGOM)
• Examples where they exist
• Map: Where might the pre-salt play be viable
• Concluding remarks
Introduction – south Brazil salt basins

- Offshore oil production began 1968
- Production mostly from turbidite sands
- 2006 - Santos: Discovery of Tupi / Lula
- 2008 – Campos: Pre-salt carbonates under Jubarte Field
- Production from the Lula and Sapinhoa fields in the Santos Basin began in 2013, and other fields (e.g. Carioca / Lapa {2016} and Franco / Buzios {2018}) have followed.
- Half daily production from pre-salt
- Top 20 Brazilian wells in pre-salt; 19 in Santos
- TGS has new (in processing) 3D surveys over awarded & upcoming blocks
The viability of the pre-salt play drives exploration interest

• 2017: Round 14: 13 blocks awarded (XOM 8 blocks as partner with Petrobras or operator).  
  Total R14 signature bonus $1.2 billion.
• 2018: Round 15: 3 of the 6 Santos blocks sold; all 9 of the Campos blocks were awarded.  
  Total R15 signature bonus $2.4 billion.
• 2019: 13 blocks offered in Campos Basin:  
  10 sold for combined signature bonus of over $2 billion – range from $2.3 MM – $976.6 MM  
  11 blocks offered in Santos Basin: 2 blocks sold for $13 MM and $73 MM  
  Total R16 signature bonus $2.2 billion.

3 years: $5.8 billion!
What makes the Brazil pre-salt play work?

Source
Reservoir
Trap
Seal
Regional pre-salt geology – Campos Basin

- Albiano
- Aptiano
- Barremiano
- Hauteriviano
- Valanginiano

- Retiro salt (K50)
- Macabu FM (K46-48)
- Coqueiros FM (K38)
- Atafona FM (K36)
- Cabiunas (K20-34)
Regional pre-salt geology – Campos Basin

Petroleum system elements

Seal: K50 salt

Trap: Structural 4WDCs at base of salt

Reservoir: Mainly high poro-perm K46-48 carbonates. K38b coquinas locally important.

Source: K36 shales
Regional pre-salt geology (Brazil)

Internal Kitchen

Thin salt (salt welds)

Extension, salt pillows, rollovers

Contraction, salt walls

Outer High

Basement

BoS

K36

ToS

K38
Regional pre-salt geology – Campos Basin

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Regional pre-salt geology (Brazil)

The salt isopach shows the major risk is salt thickness.

Fields in the post-salt reservoirs occur in areas where salt is less than 100m thick (or not much greater).

Location of salt welds is of critical importance to lead generation in deeper water blocks.
Regional pre-salt geology – Campos Basin

- Albiano
- Aptiano
- Barremiano
- Hauteriviano
- Valanginiano

Retiro salt (K50)
Macabu FM (K46-48)
Coqueiros FM (K38)
Atafona FM (K36)
Cabiunas (K20-34)

The play is a little bit different in Santos…
Regional pre-salt geology – Santos Basin

- Ariri salt (K50)
- Barra Velha FM (K46-48)
- Barra Velha FM (K44)
- Itapema FM (K38)
- Picarras FM (K36)
- Camboriu (K20-34)
Regional pre-salt geology – Santos Basin

Petroleum system elements

Seal: K50 salt

Trap: Structural 4WDCs at base of salt

Reservoir: Mainly high poro-perm K46-48 carbonates. K38b coquinas locally important.

Source: K36 shales

Well = 1-RJS-628A Tupi (Lula)
Regional pre-salt geology – Santos Basin

Petroleum system elements

Seal: K50 salt

Trap: Structural 4WDCs at base of salt

Reservoir: Mainly high poro-perm K46-48 carbonates. K38b coquinas locally important.

Source: K36 shales

Well = 1-SPS-52A Bem Te Vi
So, that is the internal kitchen and the outer high: the kind of areas that may exist in the southern Salina del Istmo.

What about the external kitchen?
Regional pre-salt geology (Brazil)
Regional pre-salt geology (Brazil)

Salt isopach

Zalan et al., (2020)
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3 years: $5.8 billion!
R14 Block C-M-411: signature bonus = USD $375 million
R15 Block C-M-477: signature bonus = $490 million
R15 block C-M-661: signature bonus = $268 million
R16 Block S-M-1600: signature bonus = $74 million USD
Outboard of the Brazilian Exclusive Economic Zone (EEZ)
Can we see these same successful play elements in the MGOM?
Is there a pre-salt play in Mexico?
Regional pre-salt geology (MGOM)

Etapa distensiva Jurásica
Edad: Jurásico
Corresponde a la apertura del golfo de México.
Sistema de “horst y graben” poco conocido, relieves por capas Salinas del Cальловiano.
Estructuración débil de las unidades Salinas por draping y subsidencia diferencial. Creación de almohadillas de sal.
Regional pre-salt geology (MGOM)

A viable pre-salt play in the MGOM may not have all the factors that combine to make the Campos and Santos basins so successful, but some factors seem to be a necessary minimum:

- **SOURCE UNPROVEN**: A regionally extensive, large volume, high TOC source rock that expelled liquid hydrocarbons during the Late Jurassic to Paleogene
- **Reservoir presence probable**: Seismic facies evidence seems to indicate clastic reservoirs are more likely than carbonates? Quality (poro-perm, clay content, etc) unknown until drilling. Espirito Santo analogs?
- **Traps are probable**: Seismic evidence shows syn-rift grabens, half-grabens and horsts, as well as potential onlap traps against unconformities, horsts.
- **Seal is proven**: Salt. Intra-formational traps likely with interbedded sands and shales.

High TOC shales in Bejuco-6, Charolais-1 Lias, Triassic?
High TOC shales in Mantarraya-1, Sabalo-1 Lias, Triassic?
Tampico Misantla Reprocessed Seismic
Tampico Misantla Reprocessed Seismic-Gigante 2D Tie (Depth)

K-PSDM
787 km – Available Reprocessed PSTM and PSMD
Regional pre-salt geology (MGOM)

This slide shows a depth map (TVDSS) to the “Upper Jurassic” sequence.

As pre-salt play precluded where have oceanic crust, this area is excluded (purple polygon).

Arbitrary 9km cut-off point.

The map shows 3 general areas that may have feasible depths to drill to Pre-Salt sequences:
Perdido Foldbelt
Outboard of the Faja de Oro
Salina del Istmo - Yucatan platform
Regional pre-salt geology (MGOM)

This slide shows an isopach map for the “Upper Jurassic” to basement sequence.

The general area outboard of the Faja de Oro generally has too thin a pre-salt sequence to be a promising pre-salt play.

Pre-salt exploration may be feasible in parts of the Salina del Bravo and Perdido Fold Belt.

The obvious candidate is the Campeche salt province.
Pre-salt play in the Salina del Bravo & Perdido Foldbelt
Pre-salt play outboard of the Faja de Oro
Pre-salt play outboard of the Faja de Oro
Pre-salt play in the Salina del Istmo

BOK-1
Pre-salt play in the Salina del Istmo
Regional pre-salt geology (MGOM)

Hux-1 TDs in thin anhydrite and salt underneath sandy Oxfordian
Concluding comments

- Pre-salt (Middle Jurassic) lithologies occur throughout most of the Mexican GOM
- Best area for exploring the pre-salt play underlies the Campeche Salt basin
- Seismic facies appear to suggest interbedded clastics in the Campeche pre-salt

- Very little known of pre-salt play, lithologies, source rock potential in MGOM
- Few wells penetrate pre-salt Middle Jurassic or older rocks offshore Mexico
- Key uncertainty is source rock
- Middle Jurassic source rock proven onshore Tampico-Misantla province
- Seep analyses do not show pre-Oxfordian oils

- Better seismic imaging needed of the pre-salt sequence
- More wells!
Thank you