Pará-Maranhão Basin

Geologist Rosemarí Fabianovicz, D.Sc.
Superintendency of Block Delimitation
• Location
• Infrastructure and Operational Conditions
• Exploration Overview
• Tectonostratigraphic Evolution
• Petroleum Systems
• Plays
• Analogous Exploration Successes
• Area on Offer
• Contractual Aspects
• Final Remarks
• Location
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Equatorial Margin
Cretaceous Basin
Total area (3,000 m): 92,890 km²

Limits:
NW - Foz do Amazonas Basin
SE - Barreirinhas Basin
S - Ilha de Santana Platform
N - São Paulo Fracture Zone
Blocks on offer: 6
LDA 100 to 3,000 m
Average area: 769 km²
Total Area: 4,615 km²
Distance from the coast: 150 to 200 km
USA (18.8 million bbl/d) *

Europe and Eurasia (18.9 million bbl/d) *

* Oil consumption in 2011
Source: BP statistical review of world energy, 2012
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Ports

Legend
- Round 11
- Round 9
- Round 6
- Round 3

Infrastructure and Operational Conditions
Infrastructure and Operational Conditions

Airports

Legend
- Round 11
- Round 9
- Round 6
- Round 3

Belém International Airport
São Luis International Airport
Fonte
River Terminals

Legend
- Round 11
- Round 9
- Round 6
- Round 3

Infrastructure and Operational Conditions
Infrastructure and Operational Conditions

Highways
Refineries

- **PLANNED REFINERY**
- **REFINERY ON OPERATION**

**Oil Pipelines**

**Gas Pipelines**

<table>
<thead>
<tr>
<th>Refining capacity (barrel/day)</th>
<th>Lubnor</th>
<th>RPCC</th>
<th>Premium I</th>
<th>Premium II</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Source: Petrobras, 2008.</em></td>
<td>8,177*</td>
<td>35,224*</td>
<td>600,000**</td>
<td>300,000**</td>
</tr>
</tbody>
</table>

*Source: Anuário Estatístico ANP, 2012
**Source: Petrobras, 2008. "Investimentos da Petrobras no Maranhão"
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70's: beginning of the exploration in the basin.

1978: Drilling of the 1st well (1MAS 0005 MA) - sub-commercial oil production well.

1980 to 1985 - Phase of greater exploratory investment of the basin. Drilling of well 1PAS 0011 PA, discovery well.

End of the 80s and 90s - stage of less investment in the basin.

In 1993 drilling of the first well in deep waters (1PAS 0025 PA).
Petroleum Law - ANP Created. Blocks offered in 6 rounds.

Return of exploration investments.

2011 - Drilling of the 1st well after the creation of ANP (1BRSA 903 PAS - block BM-PAMA3), classified as "well with oil shows".
11 Exploration Blocks
Granted area: 4,000 km²

 Granted Area
Existing Data

Seismic

- 2D public Seismic Post-stack: 51,106.15 km
- 2D confidential Seismic Post-stack: 11,843.71 km
- 3D confidential Seismic Post-stack: 6,041.16 km²
**Existing Data**

**Exploration wells**
Total: 30

- Sub-commercial oil production well
- Sub-commercial natural gas production well
- Sub-commercial natural gas and condensate production well
- Discovery well
- Well with oil shows
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164 Million of years ago

152 Million of years ago

122 Million of years ago

108 Million of years ago

79 Million of years ago

49 Million of years ago

Current configuration of the continents

Source: Scotese - SINBPA/Petrobras
Tectonic Framework

- São Paulo Fault Fracture Zone
- Romanche Fault Fracture Zone
Stratigraphic Evolution

Precambrian Basement

Soares et al., 2007
Stratigraphic Evolution

Intracratonic Supersequence

Precambrian Basement

Soares et al., 2007
Precambrian Basement

Intracratonic Supersequence

Rift II (continental syn-rift sediments)

Pre-Rift III (sag basin – Codó Formation)

Rift III (lowstand fans)
Drift Supersequence
Cenomanian – Holocene
Siliciclastic Sequence
Humberto de Campos Group

Late Albian – Cenomanian
Caju Group Carbonates

Rift Superseq.
- Rift III (lowstand fans)
- Pre-Rift III (sag basin – Codó Formation)
- Rift II (continental syn-rift sediments)

Intracratonic Supersequence
Pre cambrian Basement
Legend

- **Normal faults** (Rift Sequence)
- **Gravity faults** (Extension Zone)
- **Thrust faults** (Compression Zone)
Stratigraphic Evolution

Source: NUPETRO-UFOP 2003
Stratigraphic Evolution

R11 Blocks Area

Source: NUPETRO-UFOP 2003
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Source Rocks

Late Aptian
Codó Formation
TOC – 1 to 5%
Type I and II organic matter

Late Albian to Cenomanian
Caju Group
TOC - 1 to 2% (up to 5%)
Type II organic matter

Turonian
Travosas Formation
TOC – 0.5 to 1.7%
Type II and III organic matter
Soares et al., 2007

Paleogene
Turbidite sandstone (distal)
Late Cretaceous
Turbidite sandstone (proximal)
Travosas Formation
$\Phi \sim 20\%$ (analogy with Campos Basin)

Paleogene
Fractured limestone and carbonate turbidites
(Ilha de Santana Formation)
$\Phi = 5$ to $12\%$

Albian
Fluvio-deltaic sandstone
(Canárias Group)
**Traps and Migration**

**Seals:**
- Intra-formational shales, marl and lime mudstone

**Traps:**
- Structural
- Stratigraphic
- Mixed

**Migration:**
- Listric Faults
- Rift Faults
- Discordant Surfaces

Source: NUPETRO-UFOP 2003
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<table>
<thead>
<tr>
<th>Plays</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluvial-deltaic sandstones Late Aptian to Early Albian</td>
<td></td>
</tr>
<tr>
<td>Turbidite Sandstones Upper and Lower Cretaceous</td>
<td></td>
</tr>
<tr>
<td>Fractured calcarenite and dolomites Paleogene</td>
<td></td>
</tr>
<tr>
<td>Turbidite Sandstones Oligocene</td>
<td></td>
</tr>
</tbody>
</table>
Plays

- Calcarenite of Ilha de Santana Formation associated with listric faults
- Paleogene turbidite sandstones of Travosas Formation
- Fluvial-deltaic sandstone of Rift Sequence

Source: Petrobras

Brandão et al., 1989 *apud* Mello, 2003
Event Chart

Source: DPC & ASSOC., 2000. Petroleum systems of Brazil
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Analogous Exploration Successes
Analogous Exploration Successes

Oils Correlation

- Marine A
- Marine B
- Albian/Aptian
- Aptian
- Marine/Lacustrine Mix
- Lacustrine/Marine Mix
- Transitional Marine
- Paleogene Deltaic
- Lacustrine A
- Lacustrine B
- Lacustrine C

Schiefelbein et al., 2000
Analogous Exploration Successes

Ghana

Pará-Maranhão

Brandão et al., 1989

Source: Interoil, 2009
Discoveries in Africa: Jubilee
Reservoir: Upper Cretaceous Sandstone
LDA 1,000 to 1,700 m
Light oil: 37.6° API
Recoverable Resources: Up to 800 MM bbl *
Discovery: June 2007
1st oil 2010
Production: 83,000 bbl/d (Aug/2012) *

Source: Anadarko Petroleum Corp., 2009

Analogous Exploration Successes

Analogous in South America: French Guiana

Zaedyus discovery

Available at: http://ghanaoilwatch.org/images/jubilee_field/capital_markets_event.pdf
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Area on Offer

SPAMA-AP1 Sector: 5 Blocks
Total Area: 3,846.36 km²
Area per block: 769 km²

SPAMA-AP2 Sector: 1 Block
Area of the block: 769 km²
Seismic Line 0022-0831

Legend
- Oligocene
- Top Cretaceous
- Detachment Surface
- Faults

Objective:
Structured turbidite sandstones

BM-PAMA-263
Seismic Line 0022-0837

Exploration Opportunities
Objective:
Structured turbidite sandstones

Legend
- Oligocene
- Top Cretaceous
- Detachment Surface
- Faults

BM-PAMA-265

Seismic Line 0022-0837
Objective:
Structured turbidite sandstones

Legend
- Oligocene
- Top Cretaceous
- Detachment Surface
- Faults

Seismic Line 0239-0143

BM-PAMA-410
Exploration Opportunities

Seismic Line 0270-3016
**Objective:**
Structured turbidite sandstones

**Legend**
- Oligocene
- Top Cretaceous
- Detachment Surface
- Faults

**Seismic Line**
0270-3016

**BM-PAMA-410**
BM-PAMA-190

Seismic Line 0222-0647
Seismic Line 0222-0647

Legend
- Oligocene
- Top Cretaceous
- Detachment Surface
- Faults

BM-PAMA-190

Exploration Opportunities
Data Package

• Exploration wells (29)

Public 2D Seismic (Post-Stack): 12,230 km
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<th>Sector</th>
<th>SPAMA-AP1</th>
<th>SPAMA-AP2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration Model</td>
<td>Frontier Basin</td>
<td>Frontier Basin</td>
</tr>
<tr>
<td>Number of Blocks</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Area per block</td>
<td>769.3 km²</td>
<td>769.3 km²</td>
</tr>
<tr>
<td>Area on Offer</td>
<td>3,846.36 km²</td>
<td>769.3 km²</td>
</tr>
<tr>
<td>Exploration Phase</td>
<td>8 years</td>
<td>8 years</td>
</tr>
<tr>
<td>Exploration Period</td>
<td>5+3</td>
<td>5+3</td>
</tr>
<tr>
<td>Technical Qualification of the Operator</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Minimum Bonus (R$)</td>
<td>4.8 to 5.2 million</td>
<td>5.7 million</td>
</tr>
<tr>
<td>Minimum Depth</td>
<td>Eocene (Travosas Fm.)</td>
<td>Eocene (Travosas Fm.)</td>
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• Area on offer still poorly explored (deep water);
• Basin with several shows on the platform - proven petroleum system;
• Oil of excellent quality - API around 40°.
• The success at the African equatorial margin encourages the search of the deep marine turbidites play in South American equatorial margin;
Final Remarks

• Seismic data show evidence of Paleogene turbidite reservoirs - main play in the area on offer;
• Various other exploration opportunities may occur in different stratigraphic horizons;
• High-resolution seismic (3D) → essential for the identification of stratigraphic traps.
National Agency of Petroleum, Natural Gas and Biofuels

Rosemari Fabianovicz
rfabianovicz@anp.gov.br
www.anp.gov.br