Sao Francisco Basin

Andrei Dignart
Location
Infrastructure
Exploration Overview
Tectonostratigraphic Evolution
Petroleum Systems
Plays
Proterozoic Basins E&P
Area on Offer
Final Remarks
Agenda

Location

Infrastructure

Exploration Overview

Tectonostratigraphic Evolution

Petroleum Systems

Plays

Proterozoic Basins E&P

Area on Offer

Final Remarks
Location

São Francisco Basin
Proterozoic
Area: ~370,000 km²

Sector on offer: SF-N
Blocks on offer: 36
Area on offer: ~26,000 km²
Location

Legend

- Sedimentary basins
- Round 12 blocks
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Exploration Overview

Number of wells

Year

Exploration Overview

59 Exploration wells

~25,000 km of 2D seismic
Exploration Overview

ANP investment
R$ 108 millions

2,000 surface geochemistry sampling points

1,500 km 2D seismic survey

Gravity and magnetics aero surveys

Stratigraphic well drilling
2-ANP-003-BA
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Tectonostratigraphic evolution

- Foreland basin
- Subduction sequence
- Magmatic arc
- Passive margin
- Rift sequence
- Reverse fault
- Normal fault
- Inverted normal fault
- Oceanic crust
- Arai and Espinhaco sediments
- Basement

Martins-Neto & Alkmim, 2001
Tectonostratigraphic evolution

- Brasilia Fold Belt
- Sao Francisco Craton
- Aracuai Fold Belt

ca. 800 - 650 Ma

ca. 650 - 500 Ma

Foreland basin
Subduction sequence
Magmatic arc
Passive margin
Rift sequence

Reverse fault
Normal fault
Inverted normal fault
Oceanic crust
Arai and Espinhaco sediments
Basement

Martins-Neto & Alkmim, 2001
Tectonostratigraphic evolution

Zalán & Silva, 2007
Tectonostratigraphic evolution

Paleo-Mesoproterozoic

Rift Sequence

Zalán & Silva, 2007
Tectonostratigraphic evolution

Synclise

Neoproterozoic
Syneclise
Neoproterozoic

Tectonostratigraphic evolution

Zalán & Silva, 2007
Tectonostratigraphic evolution
Tectonostratigraphic evolution

Zalán & Silva, 2007
Tectonostratigraphic evolution

Bambui Top
Bambui I
Paranoa Top
Espinhaco Top
Basement

0284-0103

0284_2D_ANP_BACIA_DO_SAO_FRANCISCO
Location
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Possible cryogenian source rocks:

Lagoa do Jacare Fm. And Sete Lagoas Fm. carbonates and black shales (Bambui Gr.)

TOC up to 15%

Paranoa Group black shales
Petroleum Systems

Gas Seeps Along Paracatu River

Meister et al., 2007
Possible cryogenian reservoirs:

- Bambui Group carbonates
- Bambui Group fractured shales - Porosity up to 8% (Toledo et al., 1998)
- Paranoa Group carbonates
- Paranoa Group sandstones
## Hydrocarbon signs in wells

<table>
<thead>
<tr>
<th>Well</th>
<th>Hydrocarbon presence</th>
<th>Lithology</th>
<th>Unit</th>
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<tbody>
<tr>
<td>1-RC-1-GO</td>
<td>Gas show</td>
<td>Carbonates and shales</td>
<td>Bambui Gr.</td>
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<tr>
<td>1-RF-1-MG</td>
<td>Recovered gas (FT)</td>
<td>Carbonates and shales</td>
<td>Bambui Gr.</td>
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<tr>
<td>1-MA-1-MG</td>
<td>Recovered gas (FT)</td>
<td>Carbonates</td>
<td>Bambui Gr.</td>
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<tr>
<td>1-FLU-1-BA</td>
<td>Recovered gas (FT)</td>
<td>Carbonates</td>
<td>Bambui Gr.</td>
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<tr>
<td>Test</td>
<td>Unity</td>
<td>Result</td>
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<tr>
<td>FT 2</td>
<td>Siltstone/Sandstone Sete Lagoas Formation Neoproterozoic</td>
<td>Recovered gas</td>
<td></td>
</tr>
<tr>
<td>FT 3A</td>
<td>Siltstone/Sandstone Sete Lagoas Formation Neoproterozoic</td>
<td>Recovered gas</td>
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<tr>
<td>FT 4</td>
<td>Sandstone/Carbonate Canastra Group/Paranoa Group Neoproterozoic</td>
<td>Recovered gas</td>
<td></td>
</tr>
<tr>
<td>FT 5</td>
<td>Sandstone/Conglomerate Canastra Group/Paranoa Group Neoproterozoic</td>
<td>Recovered gas</td>
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</tbody>
</table>
Seals
Migration and Traps

Anticline structures
Migration through associated faults

Trapping in structural highs limited by faults
Migration along the faults

Stratigraphic traps
Medium to long distances direct migration
Migration and Traps

Klett & Charpentier, 2003
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<table>
<thead>
<tr>
<th>Play</th>
<th>Exploration target</th>
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</thead>
<tbody>
<tr>
<td>Neoproterozoic (Bambui Group)</td>
<td>Carbonates</td>
</tr>
<tr>
<td>Neoproterozoic (Paranoa Group)</td>
<td>Carbonates</td>
</tr>
<tr>
<td>Neoproterozoic (Paranoa Group)</td>
<td>Sandstones</td>
</tr>
</tbody>
</table>
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Hydrocarbons discoveries reported in several basins

- Russia
- Oman
- China
- Australia
Lena-Tunguska Petroleum Province
Russia

- More than 20 discoveries
- Bigger volumes on the proterozoic section
- Structural and stratigraphic traps
- Mainly gas

Meyerhoff, 1980
Sichuan Basin - China

Source rocks: proterozoic carbonates

Reservoir rock: Proterozoic fractured dolomite
Porosity: 3.5-4.5%
Permeability: 0.1-2.0 mD
Proterozoic Basins

Sichuan Basin
China

Weiyan Gas Field

Anticline
800 m of thickness
895 km² of area

Guoqi Wei et al., 2008
Proterozoic Basins

Amadeus Basin Australia

1 Magee well – 2,342 m (63.1 Mscfd)

Unidentified source rock on the well – migration from deeper areas of the basin

Heine, 2008

Wakelin-King, 1994
Amadeus Basin Australia

Proterozoic Basins

Young & Ambrose, 2007
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Area on Offer

Sao Francisco Basin
Sector on Offer: SF-N
Blocks on Offer: 36
Area on Offer: ~26,000 km²
Area on Offer

Legend
- Leads
- Round 12 blocks
- Sedimentary basins

Leads total area:
~2,800 km²
Leads

0284-0104

0284_2D_ANP_BACIA_DO_SAO_FRANCISCO

Bambui Top
Espinhaco Top
Bambui I
Basement
Paranoa Top
Leads

Bambui
Paranoa
7.5 km
7.5 km

Brasil
12th Round
Oil & Gas Bidding Rounds

National Agency of Petroleum,
Natural Gas and Biofuels
Leads

Bambui Top
Bambui I
Paranoa Top
Espinhaco Top
Basement
Leads

0284-0105

0284_2D_ANP_BACIA_DO_SAOFRANCISCO
Leads

Bambui Top
Bambui I
Paranoa Top
Espinhaco Top
Basement
Leads

0284-0106
Leads

- Bambui Top
- Espinhaco Top
- Bambui I
- Basement
- Paranoa Top
- Leads
Leads

Bambui Top
Espirhaco Top
Bambui I
Basement
Paranoa Top
Leads

0284-0101

0284_2D_ANP_BACIA_DO_SAO_FRANCISCO
Leads

Bambui Top
Bambui I
Paranoa Top
Espinhaco Top
Basement
Leads

0284-0101

0284_2D_ANP_BACIA_DO_SAO_FRANCISCO
Leads

Bambui Top
Bambui I
Paranoa Top
Espinhaco Top
Basement
Leads

15 km

1500 ms
3000 ms
Area on Offer

In place gas volume – Upper Paranoa leads:

~1.5 – 4.5 TCF
Data Package

Legend
- Seismic lines
- Well
- Round 12 blocks
- Sedimentary basins
- Basement

3 Wells
1,500 km
2D seismic
Potential methods data
## Contractual Aspects

<table>
<thead>
<tr>
<th>Sector</th>
<th>SF-N</th>
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<tbody>
<tr>
<td>Exploration Model</td>
<td>Frontier Basin</td>
</tr>
<tr>
<td>Number of Blocks</td>
<td>36</td>
</tr>
<tr>
<td>Area on Offer</td>
<td>~26,059 km²</td>
</tr>
<tr>
<td>Exploration Phase</td>
<td>6 years</td>
</tr>
<tr>
<td>Exploration Period</td>
<td>4 + 2 years</td>
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<tr>
<td>Technical Qualification of the Operator</td>
<td>C</td>
</tr>
<tr>
<td>Minimum Bonus</td>
<td>R$ 98,757.92 – R$ 512,863.69</td>
</tr>
<tr>
<td>Exploration Objective</td>
<td>Paranoa Group (Neoproterozoic)</td>
</tr>
<tr>
<td>Stratigraphic Objective</td>
<td>Paranoa Group (Neoproterozoic)</td>
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- Proterozoic basin
- Frontier basin
- Several signs of natural gas presence
- Identified opportunities in place volume: 1.5 to 4.5 TCF
National Agency of Petroleum, Natural Gas and Biofuels

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www.anp.gov.br