Brazilian Carbonate Oil Fields: A Perspective

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1. Sumary

2. Current Brazilian Exploration Cenarium

3. Brazilian Carbonate Fields

4. Brazilian Carbonate Plays Exploration Perspectives

5. Final Remarks
1. Summary

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More than Half of the World's Conventional Petroleum Reserves in Carbonate Reservoirs

Source: Schlumberger.com
VoIP proved reserves worldwide

1.655,56 Bilion bbl

> 60% world’s Oil
> 40% world’s Gas

Source: Schlumberger.com
The Middle East: one of the major provinces of oil production

70% of oil and 90% of gas reserves held within carbonate reservoir

Source: Schlumberger.com
Carbonates Characteristics

exploration and production in carbonates
Complex Processes

Main challenge:
Rock Heterogeneity at all scales

Properties Variations
(porosity, permeability and flow mechanisms)
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~ 2% of sedimentary areas: Production Sharing 1st Pre-Salt Bidding Round

Remaining areas: Concession Regime

Exploration blocks area under concession ~ 300,000 km²
Proven Reserves

Oil – 16.2 billion barrels
Gas – 471 billion m³

Near Future: x2

* Considering only discoveries already made, especially in the pre-salt area.
Brazilian Oil Production: 2008–2015

Oil Production
1. Sumary
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Brazil’s Oil and/or Natural Gas Fields

433 Fields
360 Producing Fields
73 in development phase

Updated in 28/04/2015
Brazil’s Oil and Gas Fields

78 Fields with at least one carbonate reservoir

62 Producing Fields with at least one carbonate reservoir

Updated in 28/04/2015
Brazilian Carbonate Fields

- **78** Campos
- **62** produtores

- **85%** At least one carbonate reservoir
- **15%** Non-carbonate Fields

Brazil's Oil and Gas Fields

- **At least one carbonate reservoir**
- **Non-carbonate Fields**
10 MAJOR PRODUCING FIELDS IN BRAZIL

Available in: www.anp.gov.br - Updated in May 2015
Brazilian Carbonate Fields

9 HAVE AT LEAST ONE CARBONATE RESERVOIR

Available in: www.anp.gov.br - Updated in may 2015
2 MAINLY CARBONATE RESERVOIRS

Available in: www.anp.gov.br - Updated in May 2015
Ceara Basin Carbonate Fields

Producing Fields in Brazil

at least one carbonate reservoir
Producing Fields in Brazil at least one carbonate reservoir

Ceara Basin
Ceara Basin
Carbonate Fields

Aptian Carbonates
Play

Atum Xareu

Fields with at least one Carbonate Reservoir
Fields
Schematic Geological Section

Source: Petrobras
Ceara Basin Carbonate Plays

Schematic Geological Section

Aptian Carbonates
Post-Rift
Paracuru Fm
Lacustrine

Source: Petrobras
Producing Fields in Brazil at least one carbonate reservoir

Potiguar Basin
Potiguar Basin
Carbonate Fields

Aptian Carbonates
Play
(5 fields)

Boa vista
Morrinho
Pintassilgo
Ponta do mel
Serra do mel

Albian Carbonates
Play

Siri

Fields with at least one Carbonate Reservoir
Fields
Potiguar Basin Carbonate Plays

Schematic Geological Section

[Diagram showing stratigraphic sections with labels such as 'Tibau', 'Jandaira', 'Guamaré', 'Açu 2', 'Açu 3/4 - Quebradas', 'Ubarana', 'ALTO DE MACAU', 'Pendência', 'Embasamento', 'Exagero Vertical = 2x']
Schematic Geological Section

Aptian Carbonates
Post-Rift
Alagamar Fm.
Lacustrine

Schematic Geologic Section: Petrobras
Schematic Geological Section

Ponta do Mel Fm.
Albian Carbonates
Drift
Shallow Marine
Produce Fields in Brazil at least one carbonate reservoir

Sergipe-Alagoas Basin
Sergipe-Alagoas Basin Carbonate Fields

Aptian Carbonates
Rift Play
Camorim
Harpia*

Aptian Carbonates
Post-Rift Play
Angelim
Aruari
Atalaia Sul
Camorim
Carmópolis
Castanhal
Dó-re-mi
Guará*
Rabo Branco

Albian Carbonates
Play
Carmopolis
Tigre

* Mainly Carbonates

Fields with at least one Carbonate Reservoir
Fields
Schematic Geological Section
Schematic Geological Section

Aptian Carbonates
Rift
Morro do Chaves Fm.
Lacustrine

Source: CPRM
Schematic Geological Section

Aptian Carbonates
Post-Rift
Muribeca Fm.
Micobrialite and Calcilutite

Source: CPRM
Schematic Geological Section

Albian Carbonates
Drift
Riachuelo Fm.
Oolitic and Oncolitic
Producing Fields in Brazil

at least one carbonate reservoir

Espírito Santo Basin
Espírito Santo Basin Carbonate Fields

Albian Carbonates
Regência Fm.

Fazenda Santa Luzia
Fazenda São Rafael
Lagoa Bonita
Lagoa Parda Norte
Lagoa Piabanha*
Mariricu
Rio Itaúnas
Rio Mariricu

Tertiary Carbonates
Caravelas Fm.

Rio Itaúnas

* Mainly Carbonates
Espírito Santo Basin Carbonate Plays

Schematic Geological Section

Source: Petrobras
Espírito Santo Basin Carbonate Plays

Schematic Geological Section

Albian Carbonates  Drift  Regência Fm.  Calcarenite and Calcilutite

Source: Petrobras
Tertiary Carbonates
Drift
Caravelas Fm.
Calcarenite

Source: Petrobras
Campos Basin Carbonate Fields

Producing Fields in Brazil at least one carbonate reservoir

Campos Basin
Aptian play: 21 fields
(Pre-Salt)

Fields with at least one Carbonate Reservoir

* *Mainly Carbonates on development phase

Albacora
Badejo
Bagre
Baleia azul
Baleia franca
Barracuda
Bicudo
Cachalote
Caratinga
Caxareu**
Congro

Espadarte
Jubarte
Linguado
Marlim
Marlim leste
Maromba
Pampo
Pirambu
Trilha
Voador
Aptian play: 21 fields
(Pre-Salt: Coquinas)

Albacora
Badejo
Bagre
Baleia azul
Baleia franca
Barracuda
Bicudo
Cachalote
Caratinga
Caxareu**
Congro
Espadarte
Jubarte
Linguado
Marlim
Marlim leste
Maromba
Pampo
Pirambu
Trilha
Voador

* *Mainly Carbonates on development phase

Fields with at least one Carbonate Reservoir
Fields
Fields with at least one Carbonate Reservoir

Albian play: 24 fields

Bagre
Bicudo
Bonito
Carapicu*
Caratinga
Catuá
Cherne
Congro
Enchova
Enchova oeste
Espadarte
Garoupa
Linguado
Malhado
Marlim leste
Marlim sul
Maromba
Namorado
Pampo
Polvo
Roncador
Tartaruga verde*
Tubarão azul*
Tubarão martelo*

* Mainly Carbonates
Monthly Production (bbl/day)
Oil and Condensate

Tartaruga verde: 11,965.69
Tubarão azul: 3,164.41
Tubarão martelo: 11,515.45

Albian Calcarenite

Available in: www.anp.gov.br - Updated on may/2015
Schematic Geological Section

Source: Petrobras
Campos Basin Carbonate Plays

Schematic Geological Section

Aptian Carbonates Coqueiros Fm.
Pre-Salt
Upper-Rift Phase Coquinas

Legend:
- Sequência Drift
- Sequência Transicional
- Sequência Rift
- Embasamento/Rochas Ígneas

Source: Petrobras

(Modified from Rangel et al., 1998)
Aptian Carbonates
Macabu Fm.
Pre-Salt
Upper-Rift/Sag Phase
Microbialites

Schematic Geological Section

 Campos Basin Carbonate Plays

Source: Petrobras
Campos Basin Carbonate Plays

Schematic Geological Section

Albian Carbonates Quissama Fm.
Drift Oolitic Calcarenite

Legenda
- Sequência Drift
- Sequência Transicional
- Sequência Rift
- Embasamento/Rochas Ígneas

Source: Petrobras
Producing Fields in Brazil at least one carbonate reservoir

Santos Basin
Santos Basin Carbonate Fields

Barremian/Aptian Pre-Salt Play
- Lula*
- Sapinhoa *
- Buzios *

Albian Play Drift
Fields on Development Phase
- Tubarão
- Coral
- Caravela
- Cavalo-Marinho

* Mainly Carbonates

Fields with at least one Carbonate Reservoir
- Lula
- Sapinhoa
- Buzios
- Tubarão
- Coral
- Caravela
- Cavalo-Marinho

* Mainly Carbonates
Santos Basin Carbonate Fields

Monthly Production (bbl/day) Oil and Condensate

Lula: 288,070.14
Sapinhoa: 153,214.98
Buzios: 9,449.74

Fields with at least one Carbonate Reservoir
Fields

Available in: www.anp.gov.br - Updated on May/2015
Schematic Geological Section

Barremian/Aptian Carbonates
Itapema and Barra Velha Fm.
Upper Rift-Sag
Coquinas and Microbialites
Schematic Geological Section

Santos Basin
Carbonate Plays
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38 Sedimentary Basins
29 Interest for Oil and Gas Exploration

7,5 million km²
5,0 million km² onshore
2,5 million km² offshore

~ 5,5% under concession
Pre-Salt Opportunities
Santos Basin

Pau-Brasil

Saturno
~750 km²

Peroba
~200 km²

Pau-Brasil
~135 km²
Cabo Frio High

New 3D seismic survey

Campos and Santos basins limit

About 130 kilometers from the coast

Location defined by ANP to G&G Multi Year Plan

Acquired by CGG
- Seismic survey aimed to investigate Cabo Frio High
- Pre-Salt seismic facies
Pre-Salt Opportunities
Campos Basin

Deep and Ultradeep Waters

New 2D and 3D seismic data

Few wells

Pre-Salt leads identified
Equatorial Margin Carbonate Plays Perspectives

- Area: ~ 570 thousand km²
- New Frontier basins;
- Transform Margin
- Margin basins formed during the breakup of Gondwana and opening of the Atlantic;
Equatorial Margin Carbonate Plays Perspectives

- 72 Exploration Blocks
- Rounds: 3, 4, 5, 6, 7, 9 and 11
- Area of ~35,000 km² on exploration
Tertiary Platform Carbonates well 1-PAS-11 on PAMA basin

Source: Bizzi et al., 2003
- Area: ~ 1.5 million km²
- High Potential and New Frontier basins;
- Margin basins formed during the breakup of Western Gondwana and opening of the South Atlantic;
- Extensional stresses dominated
122 Exploration Blocks

Rounds: 2, 3, 4, 5, 6, 7, 9, 11, 12

Area of more than 40,000 km$^2$ on exploration

Stratigraphic Charts Milani et al., 2007 and Bueno et al., 2007
Cenomanian/Turonian Ramp Carbonates

Stratigraphic Charts Milani et al., 2007 and Córdoba et al., 2007
Camamu-Almada
Jequitinhonha
Cumuruxatiba
Mucuri

Albian Carbonates
Lacustrine (Post-Rift)
Shallow Marine (Drift)

Stratigraphic Charts Milani et al., 2007 and Caixeta et al., 2007

East Margin Carbonate Plays Perspectives
East Margin Carbonate Plays Perspectives

Tertiary Calcarenites Marine (Drift)

Stratigraphic Charts Milani et al., 2007 and Caixeta et al., 2007
Albian
Shallow Platform Carbonates Drift

Stratigraphic Charts Milani et al., 2007 and Bueno et al., 2007
Onshore Paleozoic Basins

- Area: ~ 2.2 million km²
- New Frontier basins
- Synecclise basins
Onshore Paleozoic Basins

- 37 Exploration Blocks
- Rounds: 7, 9, 10, 11 and 12
- Area of ~ 85,000 km² on exploration
Onshore Paleozoic Basins

Paleozoic Onshore Basins
Carbonate Plays Perspectives

Stratigraphic Chart Milani et al., 2007
Paleozoic Onshore Basins
Carbonate Plays Perspectives

Onshore Paleozoic Basins

Permo-carboniferous Carbonates
Pedra de Fogo Fm.
Itaituba Fm.

Stratigraphic Chart Milani \textit{et al.}, 2007
Acre and Madre de Dios Basins

- Area: ~ 97,000 km²
- New Frontier basin
- Extensional and Compressional phases
Acre and Madre de Dios Basins

- 1 Exploration Block
- Round 12
- Area of ~ 1,630 km$^2$ on exploration
Acre and Madre de Dios Basins

Permian Carbonates
Cruzeiro do Sul Fm.
Onshore Precambrian Basins

- Parecis and São Francisco
- Neoproterozoic Reservoirs
- Tight Gas Carbonates
- Gas and Oil seeps
Onshore Precambrian Basins

- 34 Exploration Blocks
- Rounds: 7, and 10
- Area of ~ 100,000 km² on exploration
Parecis Basin

Pre-cambrian Onshore Basins
Carbonate Plays Perspectives

Stratigraphic Chart Haeser & Zalán, 2013
Parecis Basin

Neoproterozoic Carbonates
Araras Gr.
Sao Francisco Basin

Pre-cambrian Onshore Basins Carbonate Plays Perspectives

Stratigraphic Chart Zalán & Silva, 2007
Sao Francisco Basin

Neoproterozoic Platform Carbonates
Bambui and Paranoa Gr.
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- Carbonate reservoirs respond for more than half of the world's conventional petroleum reserves;

- In Brazil reserves contained in carbonate reservoirs are increasing exponentially especially due to the Pre-salt province;

- The main exploration model in Brazil has changed leading to the development of new technologies and knowledge evolution;

- Carbonate plays in Brazilian basins goes beyond the Pre-salt, presenting exploration opportunities for great, medium and small companies;

- Advances in knowledge and technology regarding carbonate reservoir exploration and production may increase even more the current resources held in Brazilian carbonate reservoirs.
Final Remarks

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