Perspectives from Offshore Argentina & Uruguay

A Prospectivity Overview
Introduction

• Argentina Offshore License Round 1 – 14 blocks Argentina North, 24 Austral-Malvinas
• Offshore Round 2 – Argentina South
• Proven petroleum system in pre-rift and syn-rift along Atlantic margin
• 52,000 km of long offset 2D data acquired 2017-18, PSTM & PSDM
Tectonic Evolution – Pre-Rift (Permo-Triassic)

• Gondwanan orogeny – Paleozoic Cape Fold Belt – thrusts & box fold structures onshore
• Folded ‘Table Mountain Group’ – indurated quartzite with secondary porosity
Tectonic Evolution – Jurassic Rifting

Rio Salado & Colorado Basins part of Jurassic Karoo extensional basins trend
Tectonic Evolution – Early Cretaceous Rifting

• Early Cretaceous Atlantic rifting
• Argentina conjugate to Orange Basin

From Franke et al (2007)
Atlantic Margin Structure

- Shelf
- Slope / Ewing Terrace
- SDR Zone
- Deep Basin
- Jurassic Basins
- Outer High
- Transitional crust
- Continental crust
- Paleozoic thrusts & box folds
- Oceanic crust
- MOHO
Atlantic Margin Stratigraphy

Proven Sources:
- Permian
- Lower & Upper Syn-Rift (Early J to K; Early K) – marine

Probable Sources:
- Pedro Luro Fm (Paleocene) – Type II, high TOC
- Cenomanian-Turonian (OAE 2)
- Early Post-Rift (Aptian-Albian) (OAE 1a)

Loehering et al (2013)
Atlantic Margin Stratigraphy

Potential Reservoirs:

- Oligo-Miocene Barranca Final marine sandstones
- Paleocene Elvira Fm sandstones
- Upper K (Colorado Fm) sandstones
- Lower K (Fortin Fm)
- Lower K carbonate build-ups
- Upper & Lower Syn-Rift sandstones
- Permian sandstones

Loegering et al (2013)
Offshore Exploration

- First well 1956, first discovery 1970 – San Jorge Basin
## Atlantic Margin Offshore Exploration

- Proven sources on shelf – 8 wells with HC
- 1 deep water well (Raya-1) – TD: 6000m (3400m water)
- No wells in Argentina deep water, Aptian source proven in conjugate (HRT wells, Namibia)

<table>
<thead>
<tr>
<th>Well</th>
<th>Observations</th>
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<tbody>
<tr>
<td>1</td>
<td>Gaviotin 1</td>
</tr>
<tr>
<td>2</td>
<td>Lobo 1</td>
</tr>
<tr>
<td>3</td>
<td>Samborombon B</td>
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<tr>
<td>4</td>
<td>Samar 1</td>
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<tr>
<td>5</td>
<td>Pejerrey 1</td>
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<tr>
<td>6</td>
<td>Estrella 1</td>
</tr>
<tr>
<td>7</td>
<td>Corona Austral 1</td>
</tr>
<tr>
<td>8</td>
<td>Cruz del Sur 1</td>
</tr>
</tbody>
</table>
Aptian Source – Regional Correlation

Argentina Basin

Aptian source
From seismic character & correlation with conjugate

Orange Basin

Aptian source
Proven in wells in Namibia
Southern Pelotas Basin, Uruguay

Raya-1 only penetrated Cenozoic sediments
Excellent reservoir quality in Cenozoic sandstones, but no charge
Argentina Shelf – Structure

2 rift phases superimposed on compressional pre-rift:

- Jurassic Rifting – Rio Salado & Colorado Basins
- Early Cretaceous – W/E volcanic rifting, South Atlantic opening
- Both syn-rift intervals have proven source potential
Shelf – Rio Salado / Punta del Este Basin

Pre-rift sandstones in structural closures & Fractured Basement

Syn-rift channels & ponded sands in half grabens

Pre-rift truncations

Gas/fluid escape? Collapsing structure/
channel?

Pre-rift folds

Drapes & onlaps on basement highs

Thick syn-rift wedge

Fluid escape linked to syn-rift faults
Pre-rift truncations & Fractured Basement

Drapes over structural highs

Thrust faults & propagation folds

Pinch-outs & onlaps

TOP X

Ponded sandstones in half grabens

TOP PRE-RIFT

Pre-rift sandstones in structural closures

Pre-rift truncations & Fractured Basement

Shelf – Colorado Basin

Proven syn-rift and pre-rift source potential in wells
Post-rift faults may act as migration pathways charging shallow reservoirs.
Rio Colorado Fan was a key sediment source in Cretaceous in Argentina
Numerous confined channel complexes in Rio Colorado Fan sediment wedge
Argentina Basin – Play Example

- Coarse-grained channels and fine-grained contourite drifts formed by deep water processes
- Well-sorted, high N:G reservoirs predicted, sealed by fine-grained drift deposits
- Aptian sapropel source modelled in oil window, proven in conjugate
Source-reservoir migration via transform faults

Confined channel complexes – High amplitude anomalies, AVA supported
Argentina Basin – Play Example

- Sergipe 1900km² (3BBO)
  Argentina 5700km²
- AVA anomalies
- Overlie oil-mature Aptian source
- Sealed by fine-grained drift mounds
Summary Atlantic Margin

• Shelf and Ewing Terrace extend shallow water region
• Pre- and syn-rift sources proven oil-mature
• In deep water, early post-rift sources oil-mature, Aptian source identified from conjugate margin reconstruction
• Numerous play types with significant potential identified
Austral-Malvinas Basin

- Previous exploration success – 7 bboe recoverable discovered in Austral basin
- Relatively shallow water – up to 500m
- Proven petroleum system
- PSTM & PSDM 2D data available
Austral-Malvinas Regional Geology

- Late Jurassic/Early K separation from Antarctica
- Thrust belt & foreland basin development in Cenozoic
Austral-Malvinas Basin Architecture
Austral-Malvinas Stratigraphy

**Sources**

- Late Jurassic Tobifera Fm (syn-rift)
- Early K Margas Verdes and Lower Inoceramus Fm shales
- Potential in Albian, Coniacian & Eocene marine shales

**Reservoirs**

- Lower K / Upper J Springhill Fm – fluvial channels, estuarine bars, marine sandstones
- Upper K turbidites & shelf carbonates
- Cenozoic turbidites & foreland deposits

Vayssaire (2012)
Austral Malvinas – Offshore Exploration History

• 51 exploration wells in Austral Basin, 20 in Malvinas Basin
• Most success from Lower K/ Upper J Springhill Fm sandstones
• Fold and thrust belt unexplored
Austral Malvinas – Offshore Exploration History

- Darwin East condensate discovery (2012)
- 85m thick Aptian shallow marine sandstones in tilted fault block (Springhill equiv)
- Av $\phi$ 22%, av K 337mD
- Oil predicted updip of where source interval shallows

From Borders & Southern / RPS (2015)
Forebulge & Foreland Basin – Pseudo Relief

Anticlines

Folded sandstones in forebulge

Potential reservoir sands

Permian Source?

Toblera Source

Eocene source?

Fault-bound structures

3 km
Summary

• Offshore Licensing Round announced
• Underexplored basins with proven petroleum systems, shallow to moderate water depths
• 52,000 km of long offset 2D data acquired 2017-18, PSTM & PSDM processing
• First regional seismic grid using modern long streamer data