Are Deepwater Plays Still Attractive?
Ceará Basin Brazil: a Case Study
CE-M-717, CE-M-661 and CE-M-665
1. Are Deepwater Plays Still Attractive?

2. Is the Ceará Basin a Deepwater Sweet Spot?
   - Regional geology and petroleum systems
   - The Source Rock Story – Explore where oil has been found already
   - Reservoir Targets – Exceptional Rocks at Unexceptional Depths
   - Prospectivity and Scale
   - Creative development solutions adding value

3. Conclusions
Current Deepwater Exploration Activity

• ~$1bn year on year reduction in exploration deepwater spend 2013 – present.
• Refocussing portfolios towards low breakeven plays.
• Cost focus driver to simpler wells
• Frontier and deepwater wells have seen severe declines – African deepwater frontier exploration fell from 23 wells in 2014 to just 2 in 2016.
• Exploration transformation to a smaller more efficient business.
Exploration Success Rates at an 8 Year High

- Success rates have improved to the highest levels since at least 2008 on the reduced well count.
- Exploration drilling down 70% on 2014 (51% on 2015 levels)
- 2015 commercial success rates were kept low by overhanging high risk commitment wells.
- Overall commercial success rate (CSR) improved to 44% - a 9 year high
- Hydrocarbons discovered per well increased to 77 mmboe back to 2012 levels

W40 Gross Volumes Discovered

W40 Gross Finding Costs

Copyright: Westwood Global Energy
Deepwater discoveries have accounted for 77% of discovered volumes in the 2012 – 2017 period. The average deepwater discovery size is c.400mmboe but the oil content has been significantly lower than shallow water discoveries. However, shallow water has had a noticeably worse CSR and finding costs than deepwater and onshore since 2012. An average deepwater well is twice the cost of a shallow well but typically targets twice the resource.
Narrowing Focus to Deepwater Sweetspots

• The key to deepwater sweet spots are exceptional reservoirs at unexceptional depths.
Is the Ceará Basin a Deepwater Sweetspot?
Exploration: PMO Brazil

• Largest acreage holder in the Ceará Basin
• Licences extended for all 3 blocks to July 2019
• Final depth migrated broadband seismic data received in April 2017, merged with shelf survey repro in June 2017
• Multiple play and independent prospects to target
• Play risk removed by Pecem and 1-CES-160 wells
• Drilling operations planned for H1 2019

Excellent imaging on new broadband seismic of Upper Cretaceous turbidite channel sands
Discoveries on Equatorial Atlantic Margins

- Zaedyus
- Pecem
- Tango
- Pitu
- Jubilee, TEN

Ceará BASIN
San Paul FZ
Romanche FZ
Chain FZ
Tectono Stratigraphy

Rift Phase (125Ma)

Post/late-rift, Transition (110Ma)

Onset of Drift Phase (100Ma)
Ceará CE-M-717 Play Diagram

- Continental succession
  - Rifting during Aptian

- Transitional mega-sequence
  - Trairi source rock

- Drift Mega-sequence
  - High TOC shale
  - Deep-water canyons

- Tert. Regressive Cycle
  - Carbonates
  - Magmatism

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Data Proprietary to PGS Investigacao Petrolifera Limitada
Source Rocks
Source Rocks

1. **Turonian** – Marine source – Oil prone
2. **Albo-Cenomanian** – Marine source – Variable quality, mixed oil and gas
3. **Upper Paracuru Formation, including Trairi Member** – Marginal marine shale, carbonate, evaporite, lacustrine
4. **Lower Paracuru and Mundaú Formations** – Lacustrine

**L. Cretaceous onset HC generation – earlier as you move northwards**

**Charge History Berimbau (717)**

**Well 1-CES-042a**

**Top Albian**

**Top Trairi**
Primary structures receiving majority of charge are Pecem, Ganza and Maraca and off block to the open area in southeast.

Berimbau canyon (red polygon) overlies Ganza and Maraca and downdip Pecem which act as conduits to focus charge into shallower levels.

Repinique (blue polygon) has limited underlying structuration to focus charge.
Deepwater Oil Discoveries

- 1-CES-160 rec. oil from basal conglomerate of Cenomanian canyon
- 1-CES-158 DST’d oil from thin Aptian marine sands (transitional MS)
- Sands characterised by bright peak-trough pairs (high P-imp)
- Siltstones and shales by low amplitude, parallel reflectors
Reservoirs
Albo-Cenomanian Canyon Fill

- Stacked channel complexes and narrow proximal internal levees, separated by slump, overbank, hemipelagics.
- Confined system. Well-defined external levees, seismic-scale active channel set
- Canyon width: 7-11km; Height: 270m
Canyon Evolution: Albo-Cenomanian

- Linear canyon, linear channels, basal lag, N-S depositional axis
- Bank-to-bank meandering terrace. High N:G. Semi-confined down-dip
- System rotates clockwise. Highly-confined, with well-developed levees
Albian / Early Cenomanian (~break-up U/C)
Mid Cenomanian
Top Cenomanian
Turonian
Upper Cretaceous Reservoir Quality: 1-CES-160

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All: Medium-Coarse grained, moderately sorted.
Reservoir Quality: Porosity vs Depth mbml

Target Prospect Depth 717/661

Brazil Upper Cretaceous Deep Water Sands: Porosity vs Depth mbml

- Ceara
- Campos
- Sergipe
Reservoir Quality: Porosity vs Permeability
Prospectivity and Scale
Material Prospects and Independent Plays

- CE-M-661
- CE-M-665
- CE-M-717
- CE-M-112
- CE-M-151D
- CE-M-041

Discoveries:
- Curima (1978)
- Atum (1979)
- Xareu (1977)
- Berimbau
- Maraca
- Repinique
- Pecem
- Itarema
- Tatajuba
- Espada (1978)

Source: IHS

Shelf discoveries

Legend:
- Premier Oil Block
- Port of Pecem
- Gas Pipeline
- Fields: Oil
Stacked plays targeting 1.8 Bbbl STOIIP at two locations

- Berimbau Pinches out at Fault + significant fault throw
- Stacked targets - Maraca + Ganza underlie Berimbau

Potential well locations Targeting 1.8Bbbl STOIIP
Well A       Well B

Berimbau
Up dip Pinch out and Fault offset

Maraca syn-rift
Ganza syn-rift

Depth m

Data Proprietary to PGS Investigacao Petrolifera Limitada
Stacked Prospects: Berimbau & Maraca

- Turonian/Cenomanian regional seal - Good top seal for segments
- Berimbau upper sand evolved to Repinique
- Berimbau lower sand
- Maraca tilted fault block
- 5km
Block 661: Itarema & Tatajuba Prospects
(Seismic 90 degrees phase rotated)
Prospect Name: Tatajuba
Premier Equity: 30%
Partners: Total 45% (op), OGE 25%
Water Depth: 750-1250m
Top Reservoir Depth m: ~3600m TVDss, 2200mbml
Reservoir: Albian
Av Porosity: 19%, Permeability: 100smD

Gross Resource estimates:
P90: 28 / P50: 111 / P10: 250mmbbl: Mean: 127mmbbl
Risk Assessment – Ph: 42%
No Magic Bullet - Rock Physics

- Upper Cretaceous sands are generally harder than the shales
  - Best separation at EEI -70 for facies resolution
  - High-GR sands, and silty shales with variable properties, complicate the picture
- No DHIs: Sands are generally too stiff to be able to see fluids
- However frequency blending and pre stack inversion discriminate the sands from the silts and shales allowing accurate mapping of the internal channel architectures allowing identification of intra formational seals.
Creative Development Solutions Adding Value
Premier Assets Block 717, 665 and 661
Regional Reservoir Properties and Assumptions

Blocks 717, 665 and 661 (non op)
Development Assumptions
- No Wax
- No H2S
- Low CO2
- WI likely
- Wells Gas-lifted (optional subsea MPP)
- Normally Pressured (No HP/HT)
- Gas exported – Strong Regional Market
- Support Base Paracuru with Jetty
- Offshore 10 MW power cable

Case Data
- GOR 600 scf/bbl
- Reservoir 5000-6000 psi, Circa 200 Degf
- Water Depth 500-2000m
- Shelf Water depth circa 50m

Existing Gas export 16 inch to Fortaleza. Alternate route to Pecem possible
Shallow Water Developments for Deepwater Discoveries – Lubina, Mensa & Liwan

- Shallow water fixed jackets or MOPU’s with deepwater sub sea tiebacks.
- Facilitated by advances in multiphase pump technology advances.
- Significant cost and opex reductions possible compared to conventional FPSO developments.
- Higher recovery factors longer lived facilities.
- Benign fluid in Ceara Basin make these viable development solutions.

Cepsa - Spain

Husky - China

Shell - GoM

September 2014 | P35
Brazil Fiscal Regime

- Rd 11 Concession contract
- No government participation
- Government take composition
  - Royalty: 10%
  - Special Participation Tax: 0-40%
  - Licence rental
  - Corporation Income Tax: 34%
- SPT tax is only incurred at production rates > 30,000 bbls/day and remains below 10% up to 62,000 bbls/day
- For a ~200mmbbl field the government take is 53%. This compares favourably to a global average of 67%
- The Government take can be reduced to 36% by increasing local content and CIT relief mechanism

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Conclusions

• Focussed deepwater exploration can add significant resource volumes and commercial value to exploration portfolios.

• The best deepwater exploration targets exceptional reservoirs at unexceptional depths.

• Removal of play risk by exploring in basins where elements of the petroleum system are proven helps manage the prospect risk.

• The Ceara basin is a deepwater sweetspot with
  – Proven oil-prone source rocks
  – High quality reservoirs
  – Traps well-imaged on new high quality broadband seismic.
Acknowledgements

• Partners CEPSA for permission to show work done on behalf of the CE-M-717 and CE-M-665 Joint Ventures
• PGS for permission to show images of the Geostreamer seismic
• My fantastic Brazil Exploration G&G team who have done a huge amount of hard work and made these lovely images
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*Combination * = Mixture of fault and stratigraphic
**Combination** = Mixture of 4 way, nose and updip bounding fault