

Are Deepwater Plays Still Attractive? Ceará Basin Brazil: a Case Study

CE-M-717, CE-M-661 and CE-M-665

Agenda

- **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.







Well Completions by Year, by Region and by Play Maturity

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Exploration Success Rates at an 8 Year High

\$/boe

- 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 Exploration Wells and Success Rates



W40 Gross Finding Costs



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What does Future Deepwater Exploration Look Like?

- 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.



W40 2012-2017 YTD Gross Exploration Wells and Success Rates

W40 2012-2017 YTD Gross Exploration Well Spend and Average Well Costs





W40 2012-2017 YTD Average Discovery Size

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Narrowing Focus to Deepwater Sweetspots



Chart includes exploration wells completed 2012-2014 in water

depths over 400 metres. Total 510 wells across 55 countries,

including 32 countries with five wells or fewer.

Focused deepwater exploration (2015-2017)

Mexico

Norway

Total 231 wells in 37 countries

Chart includes exploration wells completed January 2015 to August 2017 in water depths over 400 metres. Total 231 wells across 37 countries, including 28 countries with five wells or fewer.

Canada

Angola

The key to deepwater sweet spots are exceptional reservoirs at • unexceptional depths.

Wood Mackenzie: Sept 2017.

China

Australia





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





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Discoveries on Equatorial Atlantic Margins



Tectono Stratigraphy



Ceará CE-M-717 Play Diagram







Source Rocks

(scf/bbl) 400

..Cretac

L. Cretaceous onset HC generation –

earlier as you move northwards

1. Turonian – Marine source – Oil prone drift 2. Albo-Cenomanian – Marine source – Variable quality, mixed oil and gas transitiona 3. Upper Paracuru Formation, including Trairi Member – Marginal marine shale, carbonate, evaporite, lacustrine syn-rift 4. Lower Paracuru and Mundaú Formations Lacustrine Charge History Berimbau (717) Well 1-CES-042a Dil Charge (mmstb Gas Charge (bcf) (mg/g rock) (mg/gTOC) (%) (fraction) GOR (scf/bbl) 02 03 Source: Paracuru+Train area: 266.65 km2 g Dil expelled 3472.20 mmstb Gas expelled: 2758 43 hcf Turonian Cumulative GOR: 794.43 scf/bb (STP) Migration loss 2321 mmboe eq 59%. 10.00 mmboe/km2 Available charge ----Oil charge: 1521.63 mmstb Albo-Gas charge: 609.69 bcf Cen Paracuru

Trairi

Mundau



Top Albian





Block 717: Trairi/Lower Paracuru Source - Charge Focus



- 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.

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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





Albo-Cenomanian Canyon Fill

- Stacked channel complexes and narrow proximal internal levees, separated by slump, overbank, hemipelagics.
- Confined system. Well-defined external levees, seismicscale 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. Semiconfined down-dip

20km



System rotates clockwise. Highly-confined, with welldeveloped levees

Ν



Albian / Early Cenomanian (~break-up U/C)



Mid Cenomanian



Top Cenomanian



Turonian



Upper Cretaceous Reservoir Quality: 1-CES-160









All: Medium-Coarse grained, moderately sorted.



Reservoir Quality: Porosity vs Depth mbml



Reservoir Quality: Porosity vs Permeability





Material Prospects and Independent Plays



Stacked plays targeting 1.8 Bbbl STOIIP at two locations

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



Stacked Prospects: Berimbau & Maraca



Block 661: Itarema & Tatajuba Prospects

(Seismic 90 degrees phase rotated)



Brazil / Ceará 661 / Tatajuba: Summary

- Prospect Name: ٠
- Tatajuba 30%
- **Premier Equity:**
- *Total 45*% (op), *QGEP* 25% Partners: Water Depth: 750-1250m
- ~3600mTVDss, 2200mbml Top Reservoir Depth m: ٠
- **Reservoir:** •

٠

٠

٠

- Albian
- 19%, Permeability: 100smD Av Porosity: ٠
- Gross Resource estimates : ٠
- P90: 28 / P50: 111 / P10: 250mmbbl: Mean : 127mmbbl ٠
- 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

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

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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 ~200mmbl 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



SPT rates

Production	bbl/d	Year 1	Year 2	Year 3	Year 4
Less than	31,099	0%	0%	0%	0%
Less than	51,832	0%	0%	0%	10%
Less than	62,199	0%	0%	10%	10%
Less than	72,565	0%	0%	10%	20%
Less than	82,932	0%	10%	10%	20%
Less than	93,298	0%	10%	20%	20%
Less than	103,665	10%	10%	20%	30%
Less than	114,031	10%	20%	20%	30%
Less than	124,398	10%	20%	30%	30%
Less than	134,764	20%	20%	30%	35%
Less than	145,131	20%	30%	30%	35%
Less than	155,497	20%	30%	35%	35%
Less than	165,864	30%	30%	35%	40%
Less than	176,230	30%	35%	35%	40%
Less than	186,597	30%	35%	40%	40%
Less than	196,963	35%	35%	40%	40%
Less than	217,696	35%	40%	40%	40%
More than	217,696	40%	40%	40%	40%



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 quiality reservoirs
 - Traps well-imaged on new high quality broadband seismic.

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Diverse and robust portfolio across independent plays

Prospect/Segment	Block	Reservoir Target Age	Trap Type	STOIIP Mean MMbbl	POSg %
Berimbau Segment 40.3	CE-M-717	Upper Cretaceous – K8os	Combination *	51	11
Berimbau Segment 40.5	CE-M-717	Upper Cretaceous – K8os	Combination *	247	13
Berimbau Segment 40.7	CE-M-717	Upper Cretaceous – K8os	Combination *	206	15
Berimbau Segment 40.9	CE-M-717	Upper Cretaceous – K8os	Combination *	50	14
Berimbau Segment 41.1	CE-M-717	Upper Cretaceous – K8os	Combination *	696	19
Berimbau Segment 41.3	CE-M-717	Upper Cretaceous – K8os	Combination *	479	17
Repinique Segment 40.7	CE-M-717	Upper Cretaceous – K8os	Combination *	631	14
Repinique Segment 40.8	CE-M-717	Upper Cretaceous – K8os	Combination *	257	14
Ganza	CE-M-717	Aptian – K40	Fault – 3 way	60	42
Maraca	CE-M-717	Aptian – K40	Fault – 3 way	130	34
Pecem K50	CE-M-717	Aptian - K50	4 way	1434	N/A
Pecem K40	CE-M-717	Aptian – K40	4 way	375	42
Itarema	CE-M-661	Upper Cretaceous – K8os	Combination*	678	15
Itarema Deep Inbourd	CE-M-661	Upper Cretaceous – K8os	Combination*	431	13
Itarema Deep Outbourd	CE-M-661	Upper Cretaceous – K8os	Pinch Out	542	12
Rumpi	CE-M-661	Upper Cretaceous – K70/80s	Combination*	459	14
Bombo,bombo (Roll up)	CE-M-661	Cenomanian + Albian — K8o/7o/6o	Combination*	172	45
Cocho (Roll up)	CE-M-661	Albian — K70/60	Combination*	278	41
Cavaquinho	CE-M-665	Upper Cretaceous – K8os	Combination*	470	15
Cavaquinho Deep	CE-M-665	Upper Cretaceous – K8os	Combination*	429	10
Pandeiron (Binlauio)n * = Mixture of Gault 665 stratigraph Albian – K70/60			Combination*	351	17
Atabamehination * = Mixture of <u>reway</u> nose and updin hounding fault			Combination*	202	6