Ceará to Potiguar: New Insights into an Underexplored Hydrocarbon Province

The Ceará and Potiguar Basins on the equatorial margin of Brazil are two deepwater underexplored basins. Both have geological exploration successes, indicating working petroleum systems and potential deepwater reservoirs.

PGS has undertaken an extensive series of broadband multi-sensor GeoStreamer 3D surveys to address exploration concerns and de-risk play elements in the Potiguar and Ceará Basins. In 2015, the company acquired the Ceará Fortaleza survey, followed by Potiguar Aquiraz in 2016 and Potiguar Aracati in 2017, covering over 18,000 km² in total. Potiguar Touros is currently being permitted and is scheduled for acquisition in 2019.

Several major E&P companies, including Petrobras, BP and Devon, have investigated the potential on the equatorial margin in recent years. Pecem and Pitu, discovered by Petrobras in the Ceará and Potiguar Basins respectively, are the two deepwater discoveries that have given life to the exploration programs of subsequent leaseholders like Total, Wintershall and Shell.

Figure 1: This Ceará Fortaleza dip seismic section demonstrates some of the significant surfaces in the area of the Pecem discovery well. Preston has a proposed location to the south-west of the Pecem well called the Pecem Crest. Rotated fault blocks in the rift section are overlain by Cretaceous syn-rift sediments. There is an interval of additional sedimentation prior to Tertiary erosion events, as well as volcanics intrusions.
Potential Reveals Exploration Potential

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Significant shallow water discoveries have been made in both the Ceará and Potiguar Basins, while the largest oil producing region in Equatorial Brazil is the southern portion of the Potiguar Basin, where production is from the syn-rift to transitional successions. However, with a few deepwater exploration wells have been drilled in the Equatorial Margin from the Amazonian Cone to the Potiguar Basin.

The offshore plays are structural and stratigraphic traps in the Upper Cretaceous reservoir sections. Tectonic events of these reservoirs along the conjugate margin in West Africa have precipitated a move by explorers to examine the Equatorial Margin from Brazil to Guyana from a new perspective. Zaedyus in French Guiana was an early geologic success and large associated prospects in Guyana have become the poster child for economic success in these play fairways on the South America Equatorial Margin.

**Structural Setting and Significant Wells**

The prolific oil field in the Bacia (Figure 2) shows rotated fault blocks in the rift section, overlain by Cretaceous rift sediments, which is in turn transition to post-rift turbidite facies. There is an internal of additional subsalinity prior to Tertiary events as well as volcanic intrusion. In the strike direction (Figure 1), there is a highly faulted and folded area associated with the Remoca Fracture Zone to the north-west. Spectral decomposition is a useful tool for characterizing the geology and reservoir architecture.

**PGS GeoStreamer 3D datasets are positioned to give explorers in Ceará and Potiguar the best opportunity to de-risk these play farways and prospects.**

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The fourth source system consists of Tertiary source rocks deposited in dolomite environments in the Paulista-Maranhão Basins and in five ultra-deepwater discoveries in the West African salt basins. Source systems are related to Late Cretaceous global Oceanic Anoxic Events, which could cause seal failure for younger stratigraphic intervals.

PGS GeoStreamer 3D data improves attribute computations and reduces risk with more precise reservoir estimates than conventional streamer data. An arbitrary well line (Figure 4) shows the Amontada, Ceará Quebrada and Pecem wells. The Alaptian source system is related to the fracture zone systems penetrated by the wells and illustrated on the full scale and Vp/Vs seismograms.

**Great Potential with Four Source Intervals**

The Equatorial Margin of Brazil has four potential source rock intervals for exploration prospects and play fairways.

- The ancient Aptian-Burdigalian of the Amazonian Cone is characterized by highly compacted, very low permeability rocks and carbonates sourced by a subaerial to alkaline, carbonaceous black shale deposited in a transitional environment to shelf marine environments. This petroleum system sources the majority of current production offshore Brazil.
- The second source system is characterized by transitional environment, found in the Ceará and Potiguar Basins, with the Late Aptian source rocks in the east to peak oil window and the Late Alaptian source rock in the west. The restricted depositional environment. Geochemical data from the wells analyzed from oil fields in the Ceará and Potiguar Basins in northern Brazil indicate the presence of a similar source rock system. The origin of the marine source consists of Alaptian/ Cretaceous source rocks deposited in restricted deltaic environments in the Pará-Maranhão Basins and in five ultra-deepwater discoveries in the West African salt basins. Similar source rocks have also been recovered in the Amazonian Cone and Paulista-Maranhão Basins and in five ultra-deepwater discoveries in the Sergipe Basin.
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- The fourth source system consists of Tertiary source rocks deposited in dolomite environments in the Paulista-Maranhão Basins. The 1-PAS-9 and 1-PAS-11 sub-commercial prospects should lead to continued successes for the oil and gas industry in Brazil.

**Exploration Potential Revealed**

The current play farways, demonstrated by recent drilling and stratigraphic studies conducted by PGS, have been positioned to give explorers in Ceará and Potiguar Basins the best opportunity to de-risk these play farways with a few deepwater exploration wells have been drilled in the Equatorial Margin from the Amazonian Cone to the Potiguar Basin.

**Figure 3:** Frequency decomposition cube looking south-west towards the coast. **Figure 4:** 3D display of the reservoir facies in the lower image highlights turbidite fan/channel deposition. The Vp/Vs display of the reservoir facies in the lower image highlights turbidite fan/channel deposition. The Vp/Vs display of the reservoir facies in the lower image highlights turbidite fan/channel deposition. The Vp/Vs display of the reservoir facies in the lower image highlights turbidite fan/channel deposition.