A BRIEF ACCOUNT OF FEATURES TYPICAL OF THE OFFSHORE GUYANA & TAKUTU BASINS

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Introduction

- Guyana has two main petroleum provinces:
  - **Guyana Basin** – situated in Guyana’s Maritime Area and is ~120,000 sq.km
    - can be divided into two parts: coastal onshore basin fringe and offshore basin.
    - Most of the basin lies offshore Guyana
  - **Takutu Basin** – situated in south central Guyana.
    - Is shared with neighbouring Brazil measuring ~280 km (174 miles) long from Boa Vista, Brazil to the Essequibo River of Guyana: ~40 km (25 miles) wide and ~6km (4miles) deep. (Crawford et. al, 1983)
    - Has an area of ~9800 sq. km in Guyana.
During the break-up commencing in the Jurassic and progressing through the Cretaceous, Africa and South America drifted along transform fault boundaries resulting in the evolution of the Guyana-Suriname basin.

Initially, there was a thick deposition of Jurassic to early Cretaceous sediments.

Subsequently, a thick succession of Jurassic to Recent sedimentary section in depositional environments ranging from proximal near coastal to distal deep-marine in which were intervals of carbonates.

It is generally referred to as a passive margin basin.
The Guyana Basin is part of the Guyana-Suriname Basin which is a Cretaceous sedimentary basin geographically situated along the north-east coast of South America extending across the Maritime Areas of Guyana, Suriname and French Guiana.

The basin is bounded to the south by the Demerara Plateau high and to the north by the Pomeroon Arch. (Staatsolie Suriname, n.d.)

Notably, most of the Guyana-Suriname Basin lies offshore where thicker sedimentary accumulations were preserved in deeper waters.

The understanding of any sedimentary basin is progressive and is a function of exploration work.

Most of the interpretations derived are from seismic and lithology from wells.

Schematic of Basin Structure and Morphology

- **Sediment Sources**
  - Canyon features off major rivers
  - Slumped deposits off the shelf edge
  - Shelf deposits sourced by rivers and influenced by long shore currents
  - Shelf carbonates

Schematic of a Passive Margin Basin.
Source: [http://geography.unt.edu/~williams/GEOG_3350/examreviews/tectonics.htm](http://geography.unt.edu/~williams/GEOG_3350/examreviews/tectonics.htm)

Figure 5: Slope Mini-Basin & Mud Rich Fine-Grained Submarine Fan.
The basement is represented by igneous Formations associated with the Atlantic Unconformity and ranges from Precambrian to Jurassic time.

Stabroek Fm - consists of early Cretaceous basal clastics mostly sands, overlain by fluvial and deltaic sediments which grade upward into shallow marine sands and silts with continued transgression.

Potoco Fm - consists of Albian shelf carbonates that are massive shallow water limestones.

Canje Fm - contains the regional Cenomanian-Turonian anoxic shale source rocks for the basin.

Berbice unconformity - the maximum incision of this sequence boundary forms the Berbice Canyon being more than 1000 m deep.

New Amsterdam Fm - dominantly sand bearing on the shelf (as observed in the Horseshoe #1 well drilled by CGX) and interbedded sand clays and modest carbonates (as was encountered in the Arapaima #1 well), marking the locus of the shelf margin.

Overlying the Cretaceous Period section are a series of carbonate rich members of the Tertiary Period Georgetown and Pomeroon Fms. Shelfwards these formations are dominated by sand as carbonates diminish. Late Tertiary (mid Mio & Plio) and later, sands and silty intervals of the Corentyne Fm prevail.
Schematics of Structure and Morphology

Offshore Guyana, structure is modest.

- Fault blocks and half graben geometry
- Listric faulting during late Cretaceous
- Anticlinal features such as the Pomeroon Arch which could be indicative of wrenching.

Features in Guyana's Basin Sequence

- Rift basin development in Pomeroon area off Guyana
- Thick wedge of possibly sedimentary material, interpreted to the east offshore.
- The Berbice Canyon formed by maximum transgressive events that cut through the Canje shale to the Potoco carbonates and contains gravity flow deposits of terrestrial clastics encased in deep marine and prodelta shales.
- The Pomeroon Arch which is a structural high that separates the East Venezuela Basin from the Guyana Basin.
- The growth faulted structures developed off the flanks of the Pomeroon Arch in the east.
- Tertiary Turbidite Fans: These turbidite fans are present along the basin's entire shelf margin (McKenzie, 2008)
Petroleum System

Source Rocks

- World class source rocks: Canje (>300m) marine shale oil source rocks were deposited during marine transgression.

- The main source kitchen is the Canje-Saramacca Formation of Cenomanian to Turonian age.

- Hydrocarbons are believed to have migrated southwards from the source rock in an updip direction towards the onshore (where the Tambaredjo and Calcutta fields in Suriname are found) and in the distal environment of the Liza field, charge directly by the Canje into overlain porous clastics are thought to have occurred.

- The main risks in the Guyana Basin remains migration pathways, seals and timing.

CENOMANIAN PETROLEUM SYSTEM


(after McKenzie, 2008)
Petroleum System

Reservoir Rocks

- New Amsterdam
- Stabroek – consist of more than 50m of good quality reservoirs
- Georgetown sandstones
- Potoco carbonates – may offer more than 100m net reservoir quality limestones in some areas and less in others

Seal/Trap – Stratigraphic and structural

- Multiple stacked reservoirs where hydrocarbons can be trapped at different levels
- Pomeroon Formation consisting of its seasonal carbonates is a recognized seal
- Sealing of reservoirs sands when encased in deep marine shales as the sands flow under gravity along incisements

(Petroleum Division-GGMC, 2002)
Play Types

- **Sub-unconformity Play (Jurassic)**
  - This feature is situated about 110 km offshore between the Berbice and Demerara Rivers in about 30m of water.
  - Faulting was observed within the sequence.
  - Feature appears truncated by angular unconformity but the sediments also thin onto the Pomeroon Arch to the west.
  - Probable Jurassic reservoir could be realized through evident pinch out features.

- **Demerara Structure (Cretaceous)**
  - This structure is located 150km from the mouth of the Essequibo in about 90m of water.
  - Structure shows faulted four way closure. It could be wrench related anticline that lies within a slump area.
  - Encompasses both reservoir and source potential.
**Play Types**

- **Berbice Canyon (Cretaceous-Tertiary)**
  - A significant feature approximately 110km long and 15km wide where it cuts the Canje Formation.
  - Incision to the Potoco carbonates occurs in places as well.
  - Multiple erosional events observed.
  - Mounds interpreted as sand prone gravity flow deposits found within the Canyon.
  - No well control adds risk to the play but the Canyon cuts mature source, placing potential reservoir sand in direct contact with source.

- **Tertiary Turbidites**
  - Mounded sedimentary features lie on the Cretaceous-Tertiary sequence boundary.
  - Located on the pronounced shelf break at the toe of the Tertiary slope break, this trend of gravity flow deposits is parallel to the coast in less than 200m water depth.
  - Shell Abary well was interpreted to penetrate the edge of one such mound and oil 39 API was reported recovered from unknown depth.
In 1967, Conoco/Tenneco drilled GO #1 well which encountered gas shows. The second, GO #2, was a dry hole. Shelf sands target.

In 1971, Shell/Conoco drilled Berbice #1 which was abandoned due to drilling problems after a gas kick at 7,124 ft.

Berbice #2 was drilled, finding only minor gas shows and oil stains. In 1974, Shell drilled Mahaica #1 and #2 which were abandoned dry in 1974 and 1975 respectively. Turbidite sands and limestone targets.

In 1975 Abary #1 was drilled in the deepest part of Shell’s OPL in the offshore basin. It kicked violently at 13,091 ft. Turbidite target.

Deminex drilled Essequibo #1 which had several shows but their Essequibo #2 was drilled in 1977 with only minor methane shows. Turbidite sands and limestone targets.

The Takutu Basin is a Mesozoic, intracratonic, sedimentary basin bordered by the Pakaraima Mountains to the north, the Kanuku Mountains in the south, the Takutu River to the west and the Essequibo River to the east. (Crawford et. al, 1983)

The basin is considered to be very under-explored, having only six exploration wells with four on Guyana’s side.

There are approximately 1270km of seismic lines in the Takutu Basin, Guyana.

Formation of the Takutu Basin

- Rifting due to divergent tectonic plate movements - Late Triassic to early Jurassic periods

- The geologic history of the Takutu Graben is characterized by one phase of volcanic activity and three non-marine depositional phases of sedimentary rocks.

- These were interrupted by at least two and possibly three periods of basement faulting.

(Crawford et. al, 1983)

Source: Webster, 2004
Stratigraphy of the Takutu Basin

- Apoteri Basalt – was extruded during rifting phase and is considered the base of the basin.

- Manari Formation – is a shaly lower Jurassic non marine clastic which overlaid the Apoteri Basalts.

- Pirara Formation – is a thick lower and middle Jurassic non-marine salt and gray shale which was deposited over the majority of the basin.

- Takutu Formation – is a middle and upper Jurassic non marine clastic.
Schematic of Structure and Morphology

Schematic geological cross-section of interpreted regional stratigraphy and structural styles across the Takutu graben.

Seismic Time Structure map, Takutu Basin.
Source
Petroleum System

Source Rocks
- There are several postulated source rocks for the Takutu Basins:
  - Pirara Formation
  - Takutu Formation

Reservoir Rocks
- Apoteri Volcanics (fractured)
- Pirara Fomation
- Takutu Formation

Seals
- Manari Formation – the shales are considered to have formed a seal over the fractured volcanic basement in Karanambo -1.
- Takutu Formation (interbedded shales)

(Crawford et. al, 1983)
Play Types

- Two trends of major normal faults: North and South Boundary Faults
- Cross-basin Savanna arch near the Rupununi River
- Goodhope graben – a wedge shaped graben in the center of the basin, bordered by fault “A” on the North and the Lethem fault to the south.
- Series of regional structural highs and lows segment the basin
- Salt structures – including non-piercement pillows, swells and ridges. The main salt movement occurred during the Cretaceous or Tertiary time

Undrilled Prospects

- Kanuku prospect – is a pre-salt Jurassic horst along the southern portion of the Savanna arch. The closure is 38 sq. km
- Jakaretinga prospect- is a 15 sq.km salt swell closure along the Lethem fault in the Goodhope graben
There were a total of five wells drilled between 1981 and 1993. (Wood Mackenzie, 2008)

Notably three were in Guyana, Lethem, Turantsink 1, Karanambo 1 and two in Brazil. (Wood Mackenzie, 2008)

All targeted the Apoteri Formation within basalt structures in what is known as the Rupununi Trough. (Wood Mackenzie, 2008)

All were dry holes, with the exception of Home Oil’s Karanambo-1 well drilled in 1982 which encountered oil shows.

Karanambo #1
  - Proven Light Oil
  - Tested at good rates – 411 BOPD
  - Potential for 800-1000 BOPD (Crawford et. al, 1983)
Exploration interest remains strong in Guyana. The country is still attracting the attention of all players: majors, juniors, independents and joint venture interests.

The present Petroleum Prospecting Licensees include ESSO (1999), ANADARKO (ultra-deep water, 2012), REPSOL (2013), CGX (2012, 2013), NABI Oil and Gas Inc. (2012), Mid-Atlantic Oil (deep water, 2015); JHI Associates; RATIO OIL (ultra-deep water, 2015); Eco-Atlantic and Tullow Oil. These allocations are depicted in map.
References


Source: http://geography.unt.edu/~williams/GEOG_3350/examreviews/tectonics.htm


http://www.searchanddiscovery.com/documents/2004/webster02/i
Thank You for your Attention!

Questions?
Map 3: Summary of present Offshore Petroleum Concession Licensees.
Structures

Figure: Schematic geological cross-section of interpreted regional stratigraphy and structural styles across the Takutu graben.

http://www.odec.ca/projects/2007/dunc7g2/pangea_history_text.htm


Source: http://geography.unt.edu/~williams/GEOG_3350/examreviews/tectonics.htm

