The Petroleum Geology of Offshore Honduras

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CaribX (UK) Limited
Contents

• Location: History of exploration
• Basins, stratigraphic column & cross section
• Source rock evidence:
  • Eocene Jamaica-Honduras
  • Cretaceous & the proto-Caribbean Seaway
• The oils – shows, seeps & slicks
• Onshore & offshore Mosquitia
• What does it all mean,
• Application to the Patuca basin

Disclaimer
Some or all of what I am about to say may be true
Exploration History

- **1920**: First exploration well drilled in the Maracaibo Basin region.
- **1956**: UNOCAL begins exploration in the Andean region.
- **1963**: UNOCAL exploration reaches Colombia.
- **1969**: Exploration activities expand to Peru.
- **1971**: Exploration efforts conclude in Ecuador.
- **1972**: Exploration activities cease in Venezuela.
- **1973**: Exploration activities resume in Venezuela.
- **1975**: Exploration activities conclude in Peru.
- **1980**: Exploration activities conclude in Colombia.

**Political Unrest**

- **1980’s-90’s**: Little to no exploration due to political unrest.

**2000**: Increase in exploration activities as political stability returns.

**Present Day**: Exploration activities continue with various companies active in the region.

Legend:
- Well: Discovery/hydrocarbon indications
- Well: Dry
- Application: Caribx Activity

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>First exploration well drilled in Maracaibo Basin region.</td>
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</tr>
</tbody>
</table>
**Eastern Honduras—general stratigraphy & basins**

<table>
<thead>
<tr>
<th>AGE</th>
<th>HONDURAS AOI</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td>QUATERNARY</td>
<td>Sand &amp; Gravel</td>
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<tr>
<td>PLEISTOCENE</td>
<td>Gracias Fm.</td>
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<tr>
<td>JURASSIC</td>
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<tr>
<td>PERMIAN CARBONIAN</td>
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<tr>
<td>PALEOZOIC METAM.</td>
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</table>

Valle de Angelles is made up of sand, gravel, extensive red beds with limestone beds at the base of the group.

Tertiary outcrops are common. Very strong petroleum colour on fresh break.

Atima Fm. is gray limestone, locally very fossiliferous, very porous. Locally altered to dolomite, kerogen, glieonite, oil stains.

Cacantarranas Fm. consists of black petroilferous limestones, chalcedon and porous sandstone. Good reservoir rocks in this formation.

El Plan - 3000 feet of alternating petroilferous sandstone, chalcedon and silstone.

The onshore geology
Strike-slip extensional tectonics

Adapted from Mann, Sanchez & Emmet 2015
Source and product oils of the Upper Nicaraguan Rise

We know that oil has been generated in north-eastern Honduras as it has reached the surface in:

- Main Cape #1 ~100bbls+ to the surface – two pulses
- La Pure oil seep onshore, lake Cococaratasca
- Mosquitia #1 & Lempira #1 oil shows

Oil shows in several offshore wells (traces of bitumen which can be identified under florescent light) in the Cretaceous sections of several wells, ie not the younger Eocene derived oil

Suitable source rocks have also been encountered: ~ 770m of very rich source rock in the nearby Coca Marina #1 of Eocene age. This organic rich interval is encountered in many wells in adjacent Nicaragua and as far away as Jamaica – where it is called the Chapleton-Litchfield formation, ie it is regionally significant and robust

Cretaceous source rock e.g. the Guare fish beds, onshore NE Honduras. The shales have bituminous odour and are laminated

Elevated TOC & WLL responses at Upper Cretaceous levels in some wells

There are at least two regional Cretaceous source system due to periods of global anoxia

- The Turonian is the source (Upper Cretaceous) for the oil in Maracaibo and southern Petén basin and elsewhere.
- & Apto-Albian age Lower Cretaceous, northern Petén and elsewhere in the region

There are references to older source rocks, these references and occurrences have yet to be examined, but are not thought relevant to the Pataua and Mosquitia basins

The Pataua basin has not been drilled – The analysis and comparison of the recent satellite and seabed coring data, acquired by BG demonstrate that two oil families are present – the following set of slides & notes attempt to do the same
Eocene: Punta Gorda, Coco Marina #1 well, Mosquitia basin

- Punta Gorda. Honduras 5-10+%TOC, marly limestone
- ~770m of super rich source
- Ref SERNAM data base, original Brown & Ruth, (now GeoMark Research), presented by JGI in Houston 2008 AAPG

- 770m of enhanced TOC, S2, HI, minor sulphur
- A prolific source seen in multiple wells in offshore Honduras and Nicaragua with a time equivalent in Jamaica – 650m of Eocene source (Litchfield-Chapleton member)
- Whilst the Eocene appears to be less well developed on the flanks of the Patuca basin, based on CaribX seismic interpretation there are several hundred metres of presumed Tertiary section above the Cretaceous unconformity and below the Miocene reservoir interval that possesses a similar seismic character to the Eocene source section in the Mosquitia basin (also a Cretaceous source)
Jamaica to East coast Honduras

Punta Gorda, Eocene & Chapleton-Litchfield

Rock Eval plot - removed

Punta Gorda. Honduras 5-10+%TOC, marly limestone

~770m of super rich source

Ref SERNAM data base, original Brown & Ruth, (now GeoMark Research), presented by JGI in Houston 2008 AAPG

Eocene oil, Main Cape #1, discovery, UNCOCAL 1974. Unequivocally linked to the Eocene, Punta Gorda (oil family 1)

Ref Simon Mitchell, JEBCO & PCI, adapted by CBX
The Punta Gorda source rock appears to be best displayed within the Coco Marina #1 well, Mosquitia basin, there are several other significant penetrations in the Mosquitia basin and adjacent basins to the south.
Cretaceous source rocks/oils – onshore NE Honduras

- Guare fish beds, bituminous odour
- Onshore oil seeps noted by BG in Cretaceous geology
- Buena Vista Oil Company: spent Cretaceous source rocks
- Oils shows in offshore Cretaceous well sections
- Cretaceous source rocks onshore Jamaica
- Cretaceous oils onshore/offshore Jamaica
- Possible Cretaceous derived hydrocarbons in Paraiso #1
- High TOC values in Venezuelan DSPD core holes

High TOC %, WLL data & seismic indications for source on the Turonian – Turquesa & Gracias a Dios wells
NW American plate & Cretaceous source rocks/oils – proto Honduras

Upper Cretaceous, Turquesa #1 TOC’s up to 8.55% & barely in the oil window

Punta Patuca-1
Resistivity & GR - Source?
Mixed claystone, hard limestone, dense Dolomite, Upper Cretaceous – near TD
No source rock data
Shows and flows, on & offshore, Honduras

Oil to the surface and shows of oil and gas:

- Mosquita #1: Several sub-economic oil and gas shows drilled in 1963
- Lempira #1: flowed oil to the surface (anecdotal, drilled in 1956)
- Main Cape #1: DST #1 2808-2810 85bbls
- DST #2 2753-2757, 2761 160bbls
- DST #3 2711-2716 60bbls 38 API oil
- Berta #1: Calculated moveable hydrocarbons at 1391-1398 (log note)
- Caribe #1: Calculated moveable hydrocarbons at 1995-2010 (log note)
- Castilla #1: Bitumen coatings in lower Cretaceous Limestones (log note)
  - 1160-1240m Ethane (log note)
  - 3535-3560m dull yellow fluorescence, good streamcutting (log note), 11400ft to 11.700ft Dull fluorescence throughout
- Castana #1: 8850ft fluorescence
- Coca Marina #1: 1970-2025m Yellow-white fluorescence and cut (log note)
  - 2400-2520m C4, straw yellow cut, flash cut (log note). High trip gas 2480-2860m
- Diamante #1: 1510m & 1650-1690m pale straw yellow cut (log note)
  - 4950ft Pale straw yellow cut
  - 5400ft Straw yellow cut
  - 1985-2025m C3 (log note)
- Banca Gorda #1: 1050-1130m C4 and traces of dead oil (log note)
  - 1370m increased mud fluorescence (log note)
- ODP1000: 1322-1447m Enrichment of volatile hydrocarbons – believed to be migratory rather than in situ (log note)
- Gorda Bank: 3550m oil fluorescence, deep oil

Onshore

- Omoa #1, gas shows
- Ceibela #1 oil & gas shows
- Ceibela #2 & 3 oil shows

Juego de muestras de Main Cape 1

Three DSTs, two oil types
Satellite data, multi-beam sonar, seabed cores and seismic indicators of hydrocarbons, Patuca basin

- 198 stations, 201 piston cores, 3440 samples, 36 “quality” heat flow measurements, 1127 headspace, 214 Gore/AGI analysis, GC & GCMS analysis
- H₂S odour, gas expansion in 26 cores
- Both AGI (Gore) & CGG-Robertson-Geolabnor independently identified migrant/thermogenic hydrocarbons within and along the flanks of the Patuca basin
- Seep fauna/chemosynthetic communities recognised
- Butane present
- Oil, gas, condensate indicated in headspace gas data
- GC and GCMS data indicate oil

First class III AVO responses
Near & Fars comparisons indicate hydrocarbons
DHI
Satellite slicks
Multi-beam imagery – pock marks & gas plumes
Onshore NE Honduras – two oils

Cretaceous

Oil seep sampled ~14km to the SW of Puerto Lempira, BG

Tertiary (immature/exudite)

Oil film collected from adjacent to Lempira #1, CaribX - also examined by BP & Weatherford
Offshore North East Honduras oils (2)
Main Cape & Maracaibo compared

Main Cape & Maracaibo oils, Stable Isotope (aliphatics and aromatics) & sulphur abundance

Vnz  -26.84‰/-26.79‰, S 1.77
Hon  -27.90‰/-27.40‰, S 1.78

Ref The biomarker guide
Caribbean petroleum systems, Sofer plot

CaribX
Caribbean Oils data base

1. Main Cape
2. Main Cape
3. Lempira

NB no isotope data was recorded by BG for the onshore La Pure seep – an Upper Cretaceous domain is however indicated based on biomarker and geological considerations.
Based on average values for global petroleum systems built through the analysis of terpane biomarkers from several thousand oils, GEOMARK's OILS database (www.RFDbase.com) predictions regarding source rock lithology and depositional environment regardless of geologic age can be made. Oils collected from the region by CaribX have been analysed for the same biomarkers and data plotted against the global occurrences as described by GeoMark Research in various publications and data published by GeoMark for some of the classic oils/source rock end members in the region, namely the Upper Jurassic Smackover, Lower Cretaceous Sunniland and the Turonian La Luna and Eagleford oils.
Evidence for two source rocks units:
Upper Cretaceous and Eocene

Eocene, high terrestrial organic matter input marine-lacustrine

Cretaceous marine marl algal rich

The Cretaceous source being regional and the Eocene more discrete occupying the late Cenozoic basins and sub basins where it can be quite thick eg 770m in Cocoa Marina and ~560m in the Montpelier Trough, Jamaica

Differing maturities due the basin and horst geology
Patuca basin, seabed core data

CBX. Mature / condensate overprint on an otherwise typical immature GC profile

Higher hydrocarbons within the unresolved complex mixture (UCM)? – Requires GCMS analysis

Seabed cores and analysis by Fugro/CGG for BG
The detail

1) Methyl Phenanthrenes - soluble in water so an unreliable ratio

<table>
<thead>
<tr>
<th>Location</th>
<th>P</th>
<th>3</th>
<th>2</th>
<th>9</th>
<th>1</th>
<th>2&amp;3</th>
<th>MPI</th>
<th>Immature/Early</th>
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<tbody>
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<td>PC22-15</td>
<td>49061</td>
<td>2353</td>
<td>3719</td>
<td>2480</td>
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<td>11476.08</td>
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<td>4236</td>
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<td>PC204-10</td>
<td>44028</td>
<td>3596</td>
<td>4445</td>
<td>2913</td>
<td>2091</td>
<td>15197.49</td>
<td>50333.04</td>
<td>immature</td>
</tr>
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</table>

2) Sterane isomerisation - measuring just background immature sterane isomerisation/swamped?

<table>
<thead>
<tr>
<th>C29AAR</th>
<th>C29AAS</th>
<th>S/S+R</th>
<th>Immature/Early</th>
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<tr>
<td>PC22-15</td>
<td>232.9</td>
<td>31.7</td>
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<td>507.3</td>
<td>51</td>
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<td>2074.3</td>
<td>286.4</td>
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<td>20219.1</td>
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<td>2706.9</td>
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<td>PC204-10</td>
<td>5460.6</td>
<td>1206.7</td>
<td>immature</td>
</tr>
</tbody>
</table>

3) Triaromatic steroidal hydrocarbon ratio - An indication of type of oil reaching the surface. Both light oil condensate and black oil appear to be present

<table>
<thead>
<tr>
<th>C29AAR</th>
<th>C29AAS</th>
<th>S/S+R</th>
<th>Immature/Early</th>
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<tr>
<td>PC22-15</td>
<td>0.59</td>
<td>late</td>
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<td>0.63</td>
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<td>0.34</td>
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<td>0.52</td>
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<tr>
<td>PC204-10</td>
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101 whole extracts where examined by gas chromatography

5 samples were analysed by gas chromatography-mass spectrometry

GC, GCMS and headspace gas data indicates two hydrocarbon signatures
Two petroleum systems active within the Patuca basin

- Hydrocarbons generated / being generated – very late (additional) heating
- Eocene Type II/III marine source with a terrestrial input, mature in the deeper basins, best developed in the sub basins
- Upper Cretaceous Type II restricted marine, algal rich, carbonate-marl source, mature for oil and or condensate, regional
- Older sources such as earlier Cretaceous restricted marine and Jurassic sources are possible - but likely cooked
- Sufficient oil to charge prospects (∑15bbls STIOPP) in the Patuca basin
Geological setting - Middle to late Eocene

- Middle-Late Eocene (Punta Gorda)
- Inland Seas & Lakes

Key:
- Eocene/Punta Gorda
- Turonian
- Cenomanian & Younger
- Aptian-Albian
- Barremian & Older
- Basement
References and acknowledgements, some

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