Hydrocarbon Potential of the Jurassic Source Rock in the Guiana Basin*

Clyde P. Griffith¹

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¹Petroleum Contracts, Staatsolie Maatschappij Suriname NV, Wanica, Suriname (clydegriffith@staatsolie.com)

Abstract

Mid- to upper-Jurassic age source rocks, and their related petroleum systems, have played a major role in generating some of the world’s largest oil and gas fields. Middle-Upper Jurassic source rocks are mainly found in the Middle East (Hanifa-Naokelkan-Sargelu-Dukhan formations), the Caspian region (various formation names), West Siberia (Bazhenov Formation), North Sea (Kimmeridgian Clay), and Gulf of Mexico (Haynesville Shale). These rocks are predominantly marine shale and marly limestone with kerogen types II and III and have charged Upper Jurassic to Cretaceous oil and gas reservoirs. The Guyana–Suriname basin displays the geologic elements described above. Mid to late Jurassic age graben structures, filled with syn-rift sediments, overlain by post rift, passive margin, prograding marine sediments from mid Cretaceous to present can be identified on seismic lines offshore Suriname. None of these graben structures have been penetrated by wells. The questions therefore are; ‘Is there mature source rock and related petroleum systems within the grabens of the Guiana–Suriname Basin like that of the North Sea graben and the Kimmeridgian Petroleum System?’ “How much hydrocarbons have been generated” “What are the implications for the Suriname part of the Guiana Basin” Analysis of crude oil in the Upper Cretaceous reservoirs onshore Suriname revealed the presence of a possible Mid Jurassic Source Rock. These oils were described as having been derived from an unknown source rock, probably strongly restricted lacustrine environment, of Jurassic or less likely Cretaceous age. All onshore Cretaceous oil impregnations and some Palaeocene oils analyzed, fall in this category. It is believed that this oil was generated by source rocks within the Jurassic grabens and is likely to be part of an intra-grabenal petroleum system that has not yet been drilled. The evidence presented indicate: The Jurassic source rock is mature for hydrocarbon generation. The Jurassic source rock has the generated tremendous amounts of hydrocarbons. The Jurassic source rock in the Suriname part of the Guiana basin can play an important role within the oil and gas industry for Suriname.
Hydrocarbon Potential of the Jurassic Source Rock in the Guiana Basin

Cape Town, 07 November 2018  Clyde Griffith MSc
Outline

✓ Geological Setting
✓ Tectonic Evolution
✓ Source Rock Potential
✓ Workflow
✓ Assumptions & Limitations
✓ Results
✓ Conclusions
✓ Recommendations
Geological Setting

[Map of the region showing countries such as Suriname, Brazil, Guyana, and others. The map is modified after USGS, 2012.]
Tectonic Evolution
Passive Margin

Yang, 2011
Source Rock Potential

After A.B. Ronov, Int. Geol. Rev., 1978, 24, 1365-1388
Source Rock Potential

- Basinal Area, Tertiary, immature, Type II/III?, Abary well
- Basinal Area, ACT, TOC, 0.70 - 16.00, Vre 0 - 0.85, Type II/III, immature – early mature, several wells
- Demerara Plateau, early mature, A2-1 well
- Demerara Plateau, Mid Jurassic, Type I?, TOC 1.5?, immature, A2-1 Well
- Takutu Graben, E-M Jurassic (Type I, VRe 0.2 - 3), immature – over mature, Robertson Research, 1981
Oil from Onshore Cretaceous: An unknown source rock, probably strongly restricted, lacustrine of Jurassic or less likely Cretaceous age.

I. All these severely biodegraded samples have carbon isotopes (whole oil) between -24.0 and -24.8 o/oo

II. Characteristic biomarkers (such as: low 3R/5R-hopane ratio, high 24/4R, high gammacerane, and a C29-sterane predominance).

In addition, offshore well A2-1, drilled on the Demerara Plateau, penetrated Syn Rift Middle Jurassic Source Rock with TOC 1-2%.

Similarly, the Takutu Graben of onshore Guyana, interpreted as a failed arm of the Early Jurassic North Atlantic rifting, has proven source rock with TOC <2.5%.

CURRENT ACTIVITIES
EXPLORATION & APPRAISAL

In October 2017, the Araku-1 exploration well in Suriname was drilled to a total depth of 2,685 metres and no significant reservoir quality rocks were encountered. The well has been plugged and abandoned. Logging and sampling proved the presence of gas condensate, which in combination with high quality 3D seismic data, has de-risked deeper plays which offer significant future exploration potential in the Group’s acreage. See full Araku Press Release.
Onshore Oil Correlation Suriname

Onshore: COM/ NIC/ COM:
Age: Early Cretaceous/Jurassic
Reservoirs: Paleocene/Cretaceous
SR Type: Type I??
Onshore Oil Correlation Guyana

geologically unlikely to be from Cen.-Turon. source rx (no "easy" down-section migration route)
PS Modeling

Horizon Mapping
TwT

Reservoir (Albian)

Seal (U Albian)

Well Analysis

SR Paleo Environment

T-D Conversion

Surfaces in Time

TOC, HI, VRe, Tmax

Surfaces in Depth

Source Rock Type

Lithology, Age

TOC, HI, VRe, Tmax

Lithology, Age

PS Modeling

Maturity Maps
Charge Models

Callovian

Lithology, Age
Well Analysis

1. Offshore: A2-1 well (SR):
   - Age: Callovian
   - TOC: 1.1 – 1.5%
   - VR: 0.6
   - Kerogen Type: III
   - Rock Type: Shallow Marine Clay
Outline Callovian Source Rock

- Jurassic Oceanic Crust
- Outline Callovian Source Rock
- Stretched Continental/Transitional Crust
- Failed Rift Nickerie Graben
- Tr-Ju Extended Continental Crust
- Failed Rift Commewijne Graben
- Structural High Granitic Basement?
Homogeneous distribution of source rock, reservoir and seal
Presence of Albian Sandstone reservoir (N/G = 60%, Sw = 20%)
Lateral Seal Shale Upper Albian
Maturity based on Vitrinite Reflectance Classification by Peters, 1994
Type II/III source rock modeled as Type III source rock in Neritic zone

- No faults taken into account for charge model
- Carrier beds in model defined as vertical up to reservoir-seal interval followed by lateral migration up structure
- Software used cannot model Type II/III source rock
- Software used does not permit ranges for input parameters (TOC, HI)
- Sea bed
- Near Top Miocene
- Intra Paleocene
- Top Cretaceous

- Mid Turonian
- Mid Albian
- Top Callovian SR
- Bottom Callovian SR
<table>
<thead>
<tr>
<th>Elements</th>
<th>Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography</td>
<td>Albian (Critical Moment)</td>
</tr>
<tr>
<td>Source rock</td>
<td>Callovian Type: III</td>
</tr>
<tr>
<td>- Kerogen</td>
<td></td>
</tr>
<tr>
<td>- TOC</td>
<td>2</td>
</tr>
<tr>
<td>- HI</td>
<td>450</td>
</tr>
<tr>
<td>- Thermal gradient</td>
<td>30°C/km</td>
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<tr>
<td>Reservoir</td>
<td>Albian/Aptian</td>
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<tr>
<td>Reservoir Lithology</td>
<td>Sandstone (Analog from FG-2 well)</td>
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<tr>
<td>Seal</td>
<td>Albian Regional Seal</td>
</tr>
<tr>
<td>Seal Lithology</td>
<td>Shale</td>
</tr>
</tbody>
</table>
Characteristics:
- Av. Thickness: 350m
- Area: 31MM km²
Albian Reservoir Porosity Distribution

\( \phi: 10-17\% \)
Seal Capacity
Albian
Regional Seal
Good Seal Potential
Charge Model for Albian Gen. Potential: ~90B bbls
Risks:
- Leaking Faults
- Breach of Regional Seal
- Preservation

Resources:
- Rec Resources: 1,500 MMBBLs
- Rec Resources: 900 MMBBLs
• Evidence indicates that there is a deeper Source Rock potential in the Guiana Basin, which is of Callovian age.
• The Guiana Basin has prolific Source Rock Potential for the Demerara Plateau
• Lower Cretaceous Plays have been upgraded
• **Maturity and Migration Model need improvement.**
  - Maturity Model needs to be updated with influences of Basin Evolution/ dynamics, Paleo Heatflow, Correction for erosion, various Facies Transitions
  - Migration Model needs to be updated with faults, Facies Transitions and Carrier Beds Analysis
Thank You For Your Attention

Questions