Recent Advances in the Understanding of Northern Basin Stratigraphy, Gulf of Paria: Integrating Biostratigraphic and Palynological Analysis*

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Abstract

The North Marine area is located in the East Central part of the Gulf of Paria, on the western coast of Trinidad. It is situated within the Eastern Venezuelan Basin, more specifically within the Maturin Sub Basin. The North Marine block is the result of the interaction of right lateral motion of the Warm Springs and Los Bajos Faults. Eighteen wells were drilled in the North Marine area and sub-commercial amounts of oil were produced from various wells. The lack of significant discoveries resulted in the acreage remaining idle for > 35 years. These existing wells contain a suite of geological analyses that were used for the re-evaluation of the area. The re-interpretation incorporates new analyses of High-resolution biostratigraphy including paleobathymetries, well log motifs, palynological zonation, lithological and seismic correlations. The study is focused on the North Marine area, which will develop a stratigraphic framework for Petrotrin’s Marine acreage on the west coast of Trinidad. This stratigraphic framework will aid in building a relationship to define the Formations to the north and south of the Los Bajos Fault in the Gulf of Paria. The Northern Basin lithostratigraphic units range in age from the Early Miocene Manzanilla Formation to the Pleistocene Talparo Formation. Traditionally, it was noted that the Manzanilla Formation deposited in the Pliocene underlies the more argillaceous Springvale Formation and the top of which is bounded by the Pliocene-Pleistocene boundary. The Talparo Formation lies unconformably on the Springvale Formation and the sediments represent a gradual transgressive sequence.

The current re-evaluation illustrated some discrepancies; the Pliocene-Pleistocene boundary now lies within the Talparo Formation. The top and base of the Manzanilla Formation was reviewed and noted to range from Zanclean to Messinian
respectively. The chronostratigraphic results were determined primarily by palynological events correlating within the Trinidad region, which are prevalent within the Pleistocene-Pliocene and the Miocene intervals. The top of the Zanclean is a correlative 3.6Ma flooding surface event on the relative change of coastal onlap from Haq et al. (1987). The ultimate goal of this study is to focus on a stratigraphic revision and use these integrated results to assist in building a relationship with the Northern and Southern Basin stratigraphy.

Selected References


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Petroleum Company of Trinidad and Tobago Limited
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This project presents the results and interpretations of an integrated overview of 18 wells from the North Marine Area, Trinidad & Tobago.

The stratigraphic intervals under investigation encompass the Early Pleistocene to the Late Miocene.

The purpose of this study is to review the available biostratigraphic data from the western offshore Trinidad & Tobago with the intent of building an integrated stratigraphic framework for correlating wells in the North Marine Area.
North Marine Area is located in the western coast of Trinidad, in the East Central part of the Gulf of Paria. It is situated within the Eastern Venezuelan Basin, more specifically within the Maturin Sub Basin (After Gallai-Ragobar & Archie, 2015).
Regional Geology

The faulting pattern within the North Marine block is the result of the interaction of the right lateral motion of the Warm Springs and Los Bajos Faults. This has set up a transtensional stress field which has resulted the faults all being extensional, with downthrow to the east.

Location Map

North Marine Master Fault was developed from normal faults merged from east to west. This fault has significant downthrow to the north. These normal faults usually detach near the 11.4Ma (10.5Ma) unconformity or within the upper part of the Miocene.

After Gallai-Ragobar & Archie, 2015
Regional Stratigraphy

The geologic Formations and their Members on the revised Stratigraphic Chart were characterised based on lithological and biostratigraphic fauna.

Gazalie and Lakhan 2015

Chronostratigraphic calibration of Gradstein et al. (2004) is applied in this study
Outline

The primary objectives of this integrated review were:

- Provide a fully integrated biostratigraphical framework of the Early Pleistocene to Late Miocene, with particular interest in the Pliocene.
- Develop biostratigraphic correlations between the wells from North Marine, and North Soldado Field (South of North Marine).
- Provide a palaeoenvironmental interpretation of each well to develop an understanding of both vertical and lateral variations in facies distribution.
- Evaluate the quality of historical biostratigraphic data for North Marine.
The outlined wells in green were utilized in this project (NM 16, NM 9, NM 3, NM 3X, NM 6, NM 9 & S 736) for further re-interpretation.
Project Data

- **Bibliography Study**
  - Study of previous work to improve database. Age control of seismic sequences

- **High Resolution Biostratigraphy**
  - Biostratigraphic analysis conducted on ninety-six (96) samples through the interval 2500′ to 11,890′ (TD).

- **Sequence Stratigraphy**
  - Seismic interpretation using P. Vail’s (1990) approach.
  - Structural interpretation.
  - Chronostratigraphic chart.

- **Sequence Stratigraphy Framework**
  - Identification of stratigraphic indicators of sea level fluctuations. Progradational reflectors, onlap, toplap, truncations and erosional channels. Log pattern recognition and environments from biostratigraphy.

- **Revised Stratigraphic Chart**
  - Compilation and discussion of stratigraphic evolution of the northern basin offshore.
Biostratigraphy

• NM 16 has the thickness interval of Telemaque Member, Manzanilla Formation (4000ft) in the North Marine Area.

• First high resolution study to be completed in the North Marine area by GSL, Petrotrin.

• 3\textsuperscript{RD} Order Cycles identified.
Talparo Formation

- Well logs and seismic correlation were utilized since these areas contain age diagnostic fauna.

- Fauna assemblage found are *Rotalia stellata*, *Elphidium sp.*, *Uvigerina isidroensis* and *Quinqueloculina sp.* (Marginal Marine – Inner neritic setting)
Springvale Formation

- Faunal assemblage includes *Elphidium 15* and *Ammobaculites sp.*
- Formation is occasionally absent presumably due to either non-deposition or to deposition and subsequent erosion.
- Members are not traceable in the Gulf of Paria
It is suggested that these members extend westwards across the island from a maximum thickness on the east coast.

Montserrat Glauconitic Sandstone and San Jose Calacerous member in the Gulf of Paria is being investigated.
Paleoenvironment

Distribution of Modern Bathymetric environments shown at present-day highstand of sea-level.

Common organisms with preservable paths recognizing bathymetric environments within the geologic record in the North Marine Area.
Palynomorphs

- The age calibration done entirely using palynological markers.
- The palynomorphs ecological interpretations were similar to microforaminifera paleobathymetry.

Grimsdalea magnaclavata - swampy (Germeraad et al, 1968; Rull 1997)

Echitricolporites mcneillyi – Mangrove – open vegetation; aquatic (Germeraad et al, 1968; Rull 1997)
Biostratigraphic Indicators

This diagram illustrates the key indicators used for the Northern Basin stratigraphy (offshore).

<table>
<thead>
<tr>
<th>Age (Ma)</th>
<th>Formation</th>
<th>Members</th>
<th>Microforaminifera</th>
<th>Palynomorphs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7</td>
<td>Pleistocene</td>
<td>Talparo</td>
<td>Chin Chin Clay</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Sum Sum Sand</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Caparo Clay</td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td>Pliocene</td>
<td></td>
<td>Durham Sand</td>
<td>Grimsdalea magnaclavata</td>
</tr>
<tr>
<td>3.6</td>
<td></td>
<td>Springvale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>Miocene</td>
<td>Manzanilla</td>
<td>Telemaque Sandstone</td>
<td>Miliammina telemaqueensis</td>
</tr>
</tbody>
</table>

Legend

<table>
<thead>
<tr>
<th>FAD</th>
<th>LAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Appearance Datum</td>
<td>Last Appearance Datum</td>
</tr>
</tbody>
</table>

Legend:
- Polynomorph datum
- Microforaminifera datum
- Datum with multiple disciplinary datums
Sequence Stratigraphy

• The sequence chronostratigraphic framework of Hardenbol et al (1998) was integrated with biostratigraphic and log criteria for identifying the sequence stratigraphic surfaces.

• The Late Miocene-Pleistocene deposited in a marginal marine setting.

• These stress environment provided very little planktonic species for age calibration.
Correlation in North Marine

In NM-9 the Springvale rests unconformably on the Nariva Formation, while in NM-16 and S-736 it is underlain by the Manzanilla Formation.

<table>
<thead>
<tr>
<th>Soldado 736</th>
<th>North Marine 16</th>
<th>North Marine 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Springvale</td>
<td>Top Springvale</td>
<td>Top Springvale</td>
</tr>
<tr>
<td>Top Manzanilla</td>
<td>Top Manzanilla</td>
<td>Top Manzanilla</td>
</tr>
</tbody>
</table>
Seismic Stratigraphy

Seismic line illustrating the correlation between NM 16 to NM 6, highlighting the picks for Top Springvale and Top Manzanilla.
Seismic Stratigraphy

Seismic line illustrating the correlation between NM3 and NM16. Middle Miocene unconformity mapped.
Revised Stratigraphic Chart

Pliocene-Pleistocene boundary within the Caparo Clay, Talparo Formation and the Miocene-Pliocene boundary at the Top of Manzanilla Formation.

Traditionally, the Talparo, Springvale and Manzanilla Formation lies within the Pliocene boundary.

**STRATIGRAPHIC CHART OF TRINIDAD**

<table>
<thead>
<tr>
<th>Epoch</th>
<th>Age</th>
<th>Northern Basin - Gulf of Paria &amp; East Coast</th>
<th>Southern Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pliocene</td>
<td>1.7</td>
<td>Talparo</td>
<td>Sum Sum Sand</td>
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<tr>
<td></td>
<td></td>
<td>Calabrian</td>
<td>Caparo Clay</td>
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<td></td>
<td></td>
<td>Gelasian</td>
<td>Durham Sand</td>
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<td></td>
<td></td>
<td>Pliocene</td>
<td>Manzanilla</td>
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<td></td>
<td></td>
<td>Zanclean</td>
<td>Telemagne Sandstone</td>
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<tr>
<td></td>
<td></td>
<td>Messinian</td>
<td>San Jose Calcareous</td>
</tr>
</tbody>
</table>

Garnache and Lakhani 2015

Chronostratigraphic calibration of Gradstein et al. (2004) is applied in this study

After Carr-Brown & Frampton 1979
Comparison Chart
Chronostratigraphy from different authors (Gulf of Paria)

<table>
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<tbody>
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<tr>
<td>Late</td>
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<td>Middle</td>
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<tr>
<td>Early</td>
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<tr>
<td><strong>MIOCENE</strong></td>
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<tr>
<td>Late</td>
<td>MGSM SJCSM</td>
<td></td>
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<td>TSM</td>
<td>SJCSM</td>
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</tr>
<tr>
<td>Middle</td>
<td>TSM</td>
<td>TSM</td>
<td>MGSM</td>
<td>MGSM</td>
<td>SJCSM</td>
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<tr>
<td>Early</td>
<td>TSM</td>
<td>MGSM SJCSM</td>
<td></td>
<td>TSM</td>
<td>SJCSM</td>
<td></td>
</tr>
</tbody>
</table>

Telemaque Sandstone Member - TSM
Montserrat Glauconitic Sandstone Member - MGSM
San Jose Calcareous Silt Member - SJCSM
Discussions

• The Late Miocene sedimentary record of the Orinoco River delta appears east of the Maturin, in the Eastern Venezuela Basin, and Pliocene and Pleistocene deltaic sediments are especially evident in Trinidad.

• The Manzanilla to Talparo Formations in the North Marine Area shallows to an overall marginal marine environment.

• According to Van Andel (1967), most of the sediment load of the Orinoco River is fine grained and the sediments are carried by strong longshore currents to the northwest and deposited in the Gulf of Paria.

(Diaz de Gamero, 1995)
At 6myr, the Lower Cruse sediments of the Southern Basin was being deposited in a deeper setting whereas the lower Telemaque Sandstone of the Manzanilla Formation was being deposited in a shallower setting.
At 4myr, the equivalent of the upper Telemaque Sandstone the Forest Formation were being deposited in an equivalent shallow setting.
Summary

• Pleistocene-Pliocene boundary is now found to be within the Caparo Clay Member in the North Marine Area.

• Manzanilla Formation top is now at the top of the Zanclean.

• The Telemaque Member of the Manzanilla Formation is interpreted to extend to Late Miocene as evident from palynological data.
Conclusions

- Manzanilla, Springvale and Talparo Formations were divided into three 3rd order sequences.

- Biostratigraphic and Chronostratigraphic studies helped to firm up the stratigraphic framework.

- The revised Stratigraphy will constrain the future Geostatistical model for realistic mapping of reservoir units.
Acknowledgements

• Nancy Gallai-Ragoobar, Petrotrin
• Avita Chang, Petrotrin
• Geological Services Laboratory Team, Petrotrin
• Nazima Khan, Petrotrin
References


Haq, B.L., Hardenbol, J., & Vail, P.R., 1987. The New Chronostratigraphic Basis of Cenozoic and Mesozoic Sea Level Cycles. Figure 1. Cushman Foundation for Foraminiferal Research, Special Publication No. 24.

Shallow Horizon Project (Petrotrin Internal Report) 1996

Thank You

Questions?