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

Shazana Gazalie[1], Christopher Lakhan[1], and Curtis Archie[1]

Search and Discovery Article #10894 (2016)**
Posted December 5, 2016

*Adapted from oral presentation given at AAPG 2016 International Convention and Exhibition, Cancun, Mexico, September 6-9, 2016

[1]The Petroleum Company of Trinidad and Tobago Limited, Pointe-a-Pierre, Trinidad and Tobago (shazana.gazalie@petrotrin.com)

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, palynogical 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

Carr-Brown, B., and J. Frampton, 1979, An outline of the stratigraphy of Trinidad: 4th Latin Amer. Geol. Congr., Field Guide, p. 7-19.

Díaz de Gamero, M.L., 1995, The changing course of the Orinoco River during the Neogene: A review: Palaeogeography Palaeoclimatology Palaeoecology, v. 123/1-4, p. 385-402.

Erlich, R.N., and S.F. Barrett, 1992, Petroleum geology of the eastern Venezuela foreland basin: in Macqueen, R.W., and Leckie, D.A., eds., Foreland basins and fold belts: AAPG Memoir 55, p. 341-362.

Germeraad, J.H., C.A. Hopping, and J. Muller, 1968, Palynology of Tertiary sediments from tropical areas: Review of Palaeobotany and Palynology, v. 6, p. 189-348.

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

Hardenbol, J., J. Thierry, M.B. Farley, T. Jacquin, P.C. de Graciansky, and P. Vail, 1998, Mesozoic and Cenozoic sequence chronostratigraphic framework of European basins: in P.C. Graciansky, et al. (eds) Mesozoic and Cenozoic Sequence Stratigraphy of European Basins: SEPM Special Publication 60, p. 3-13, charts 1-8.

Kugler, H.G., 1957, Contribution to the geology of the islands Margarita and Cubagua, Venezuela: Geological Society of American Bulletin, v. 68, p. 555-566.

Kugler, H.G., 2001, Treatise on the Geology of Trinidad, Part 4, Paleocene to Holocene Formations: in Bolli, H.M., and Knappertsbusch, eds., Museum of Natural History Basel, p. 309.

Rull, V., 1997, Oligo-Miocene palynology of the Rio Chama Sequence (Western Venezuela), with comments on fossil assemblages as paleoenvironmental indicators: Palynology, v. 21, p. 213–229.

Saunders, J.B., 1974, Trinidad: in A.M. Spencer (ed), Mesozoic-Cenozoic orogenic Belts: Data for Orgenic Studies, Geological Society of London Special Publication No. 4, p. 671-682.

Van Andel, T.H., 1967, The Orinoco Delta: Journal of Sedimentary Research, v. 37/2, p. 297-310.

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

Shazana Gazalie, Christopher Lakhan & Curtis Archie

Petroleum Company of Trinidad and Tobago Limited

Petrotrin

Exploring Frontiers in a Competitive Environment

Table of Contents

Introduction

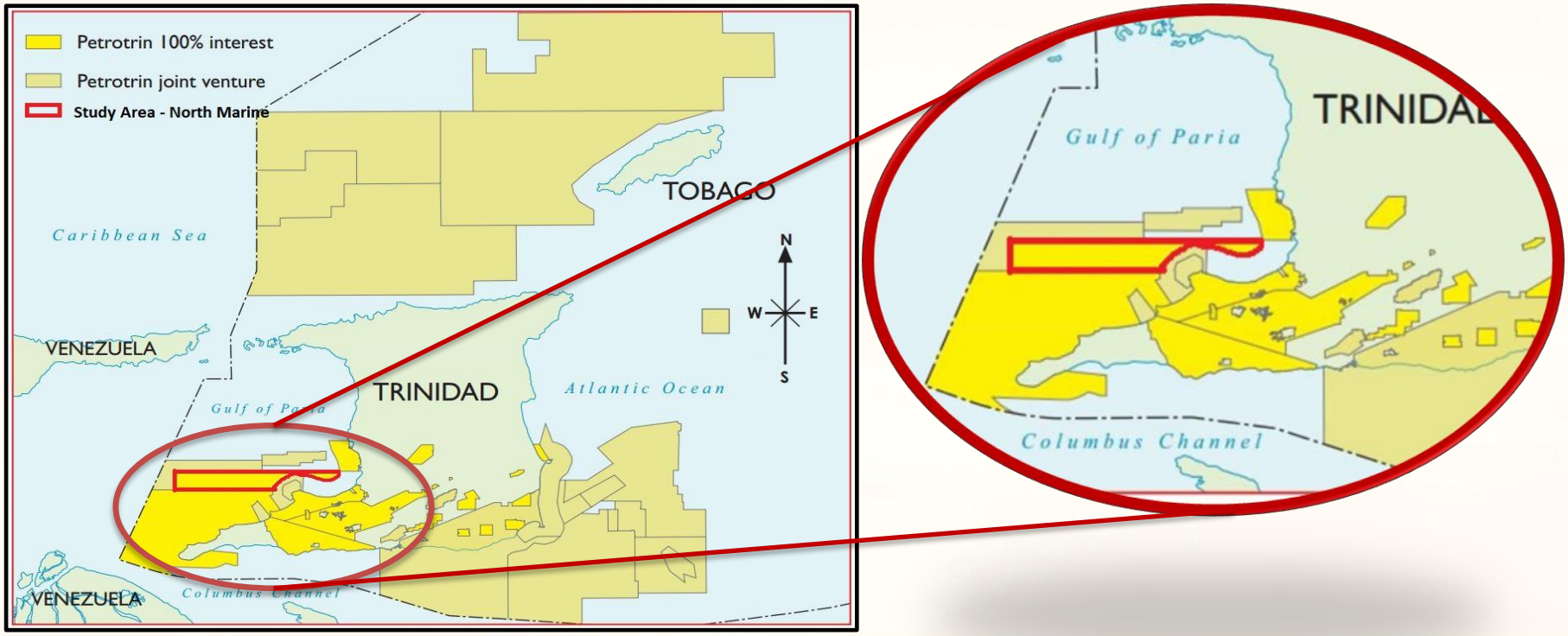
- This project presents the results and interpretations of an integrated overview of 18 wells from the North Marine Area, Trinidad & Tobago.

- 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.

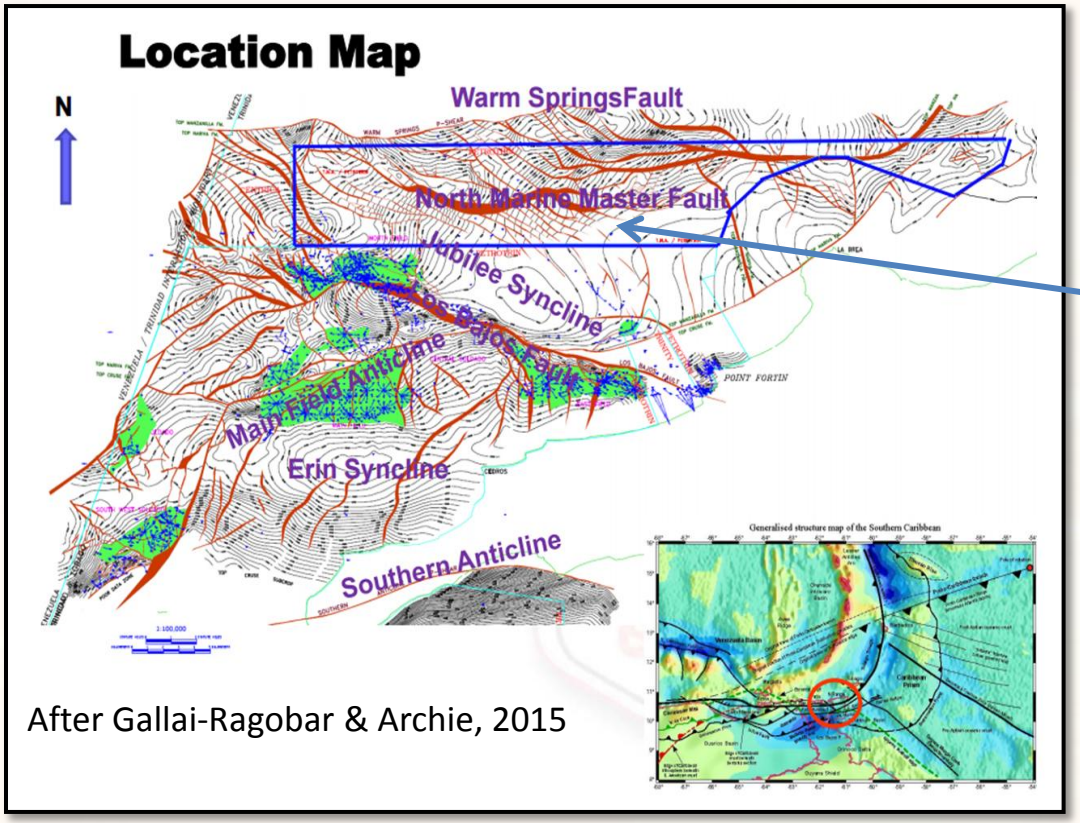
Study Area

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.

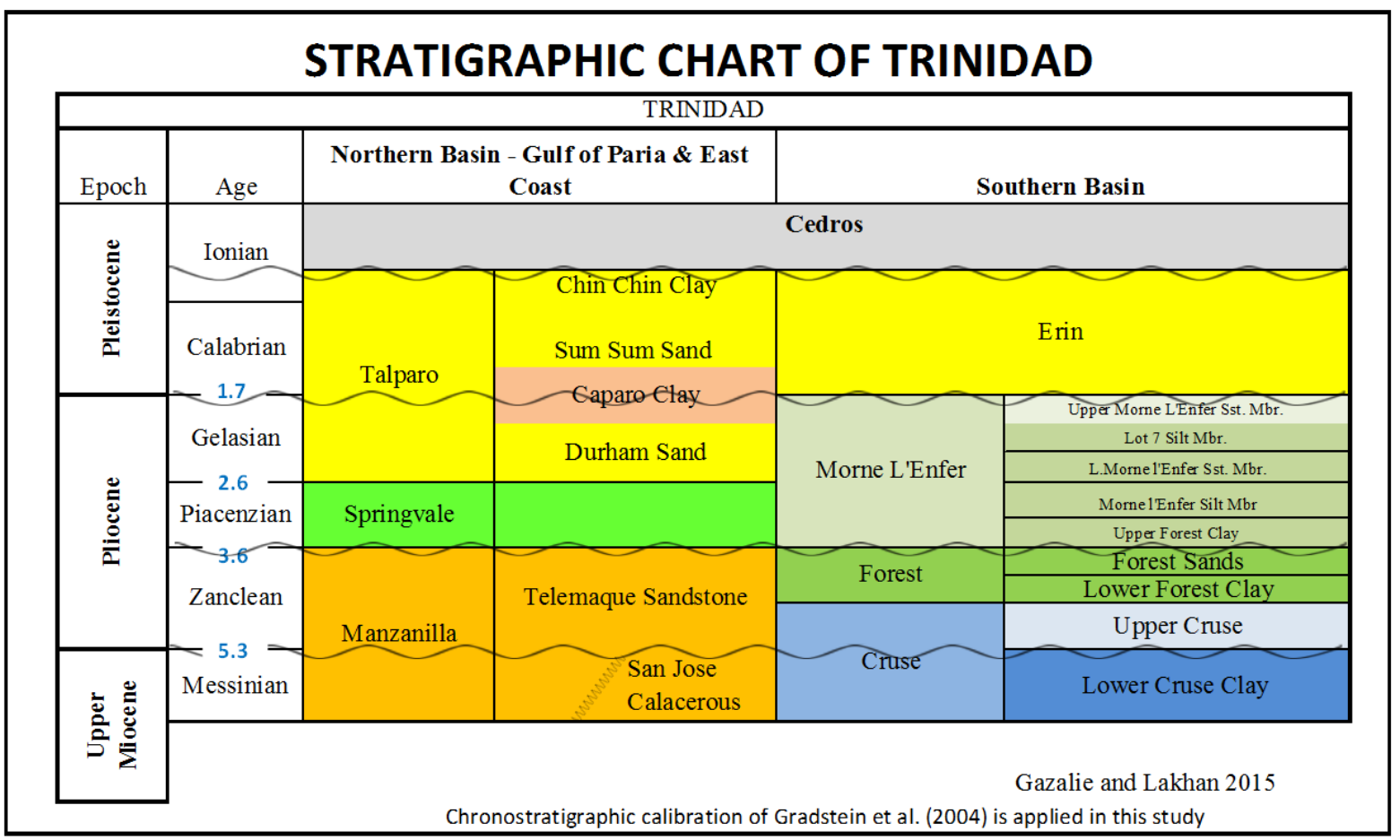


After Gallai-Ragobar & Archie, 2015

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.

Regional Stratigraphy



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

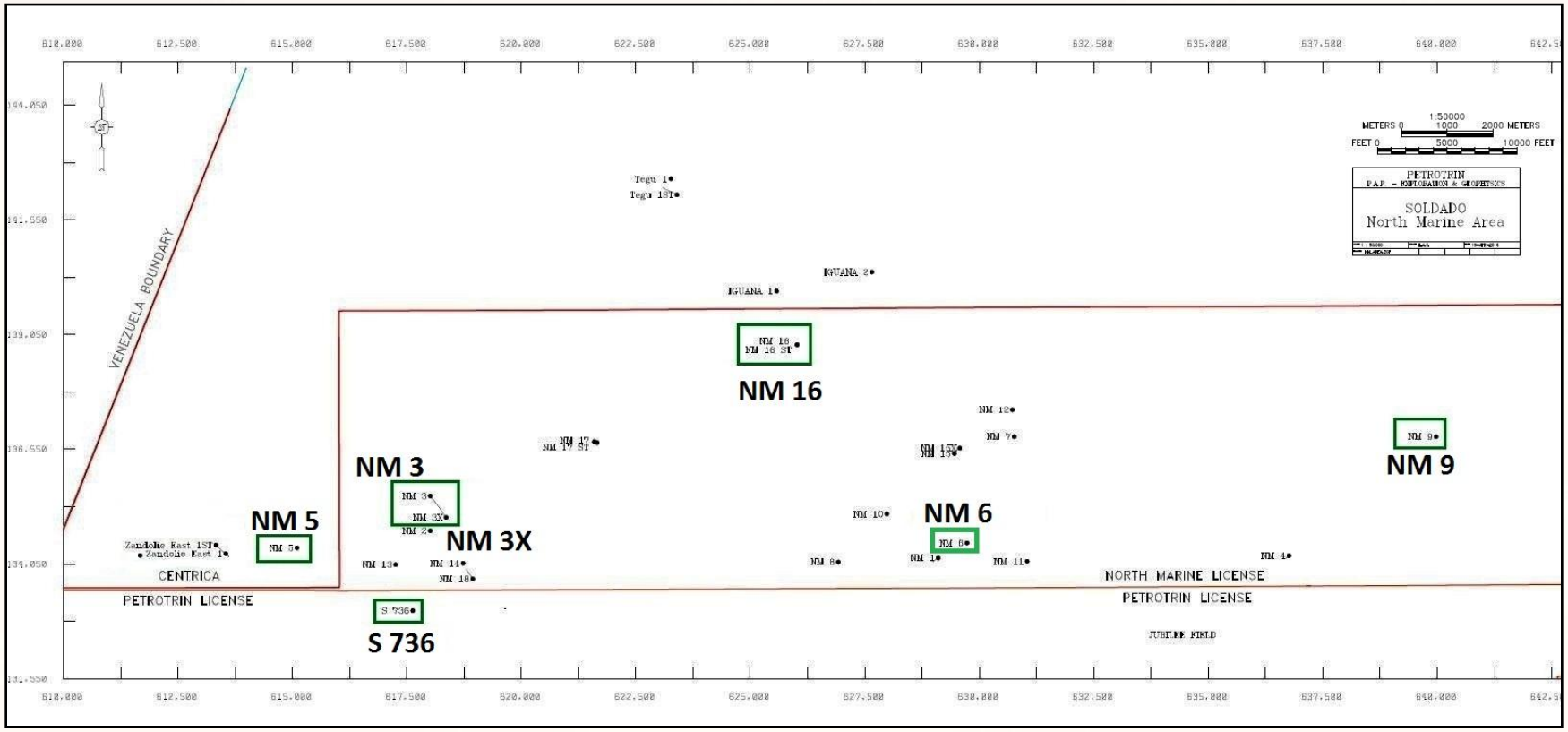
Outline

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

Map showing well locations

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.

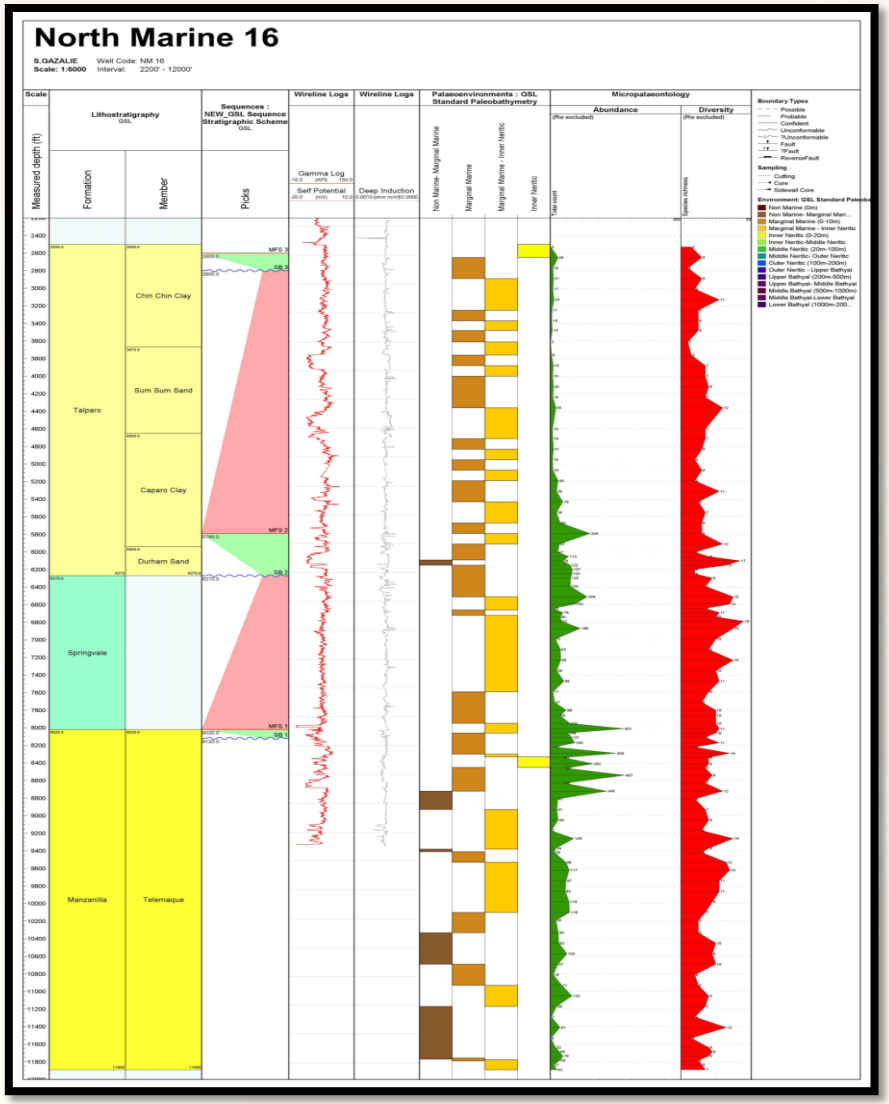


Project Data

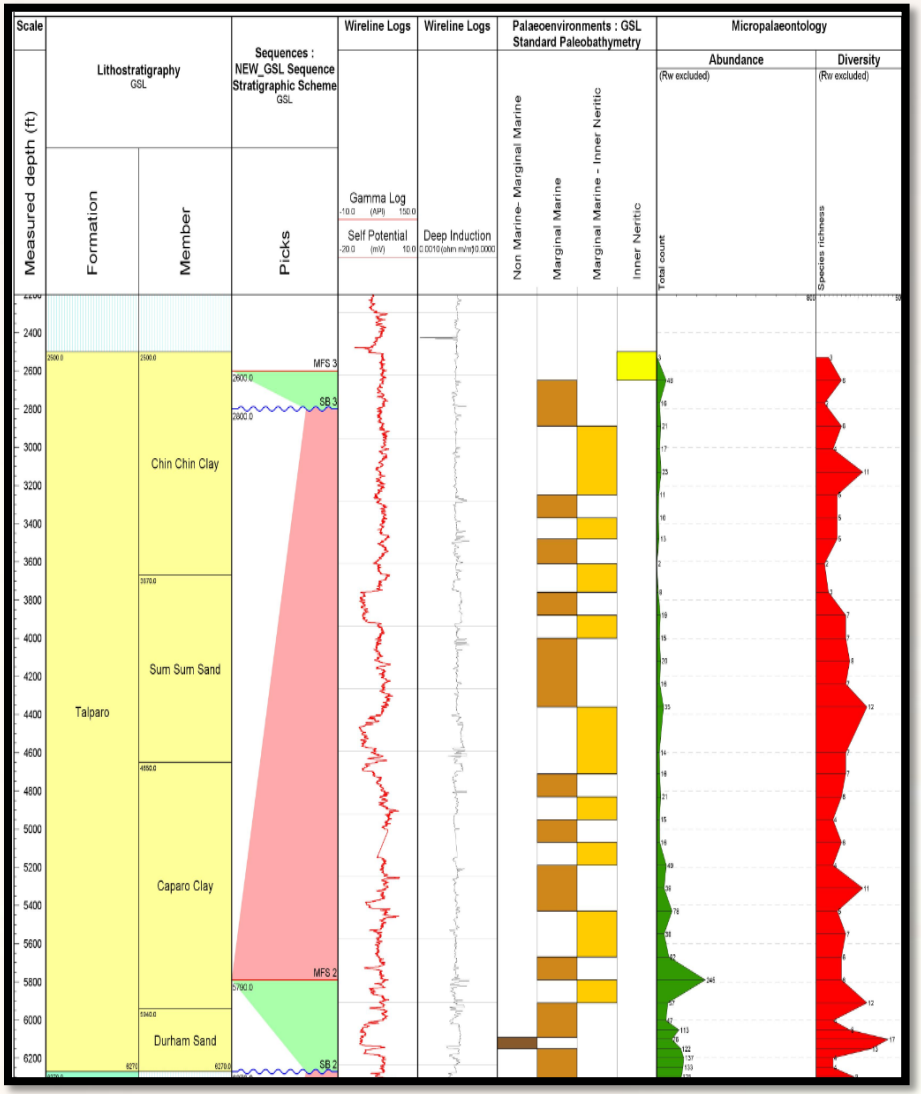
Bibliography Study	• Study of previous work to improve database. Age control of seismic sequences
High Resolution Biostratigraphy	• Biostratigraphic analysis conducted on ninety-six (96) samples through the interval 2500′ to 11,890′ (TD).
Sequence Stratigraphy	• Seismic interpretation using P. Vail's (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

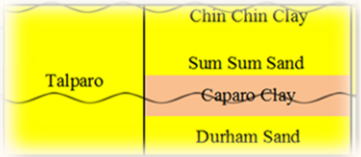
- NM 16 has the thickness interval of Telemaque Member, Manzanilla Formation (4000ft) in the North Marine Area.
- First high resolution study to be completed in the North Marine area by GSL , Petrotrin.
- 3RD Order Cycles identified.



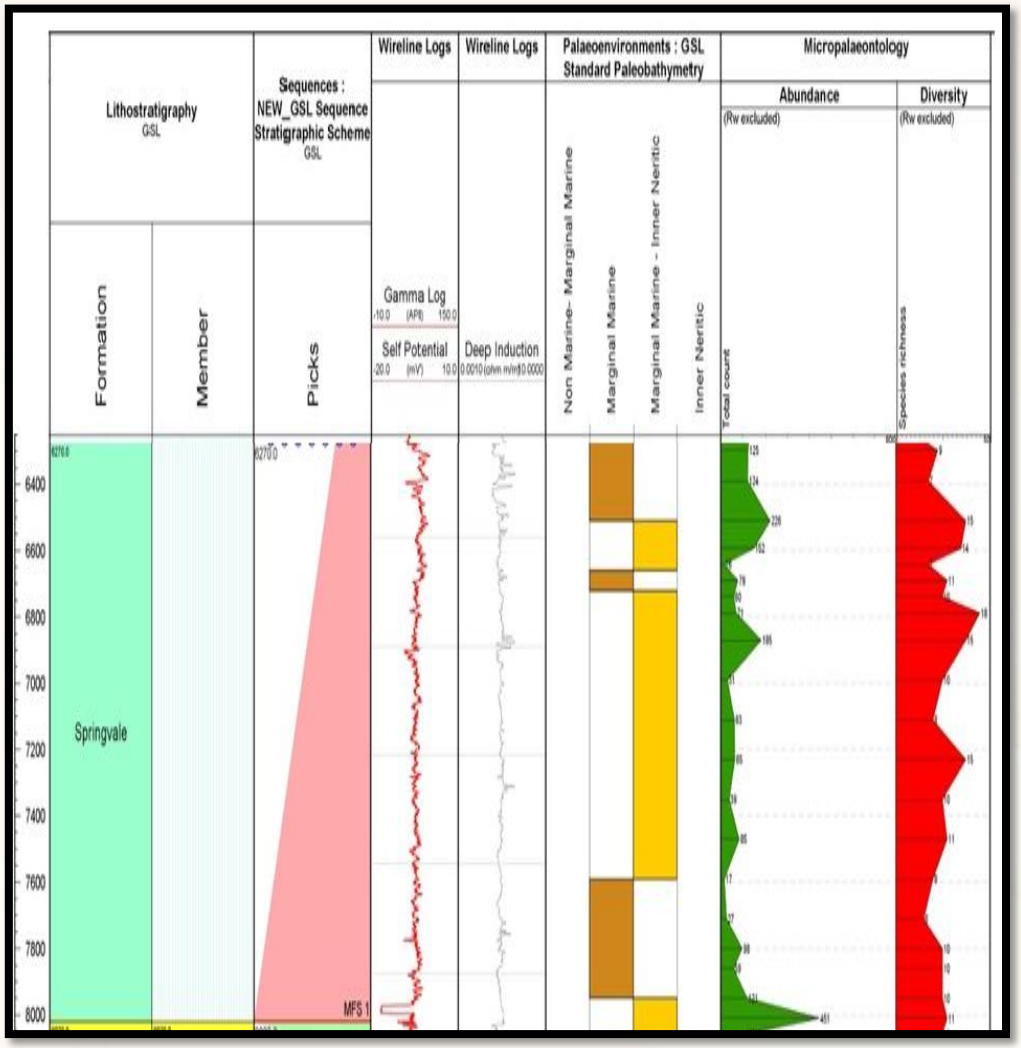
Talparo Formation



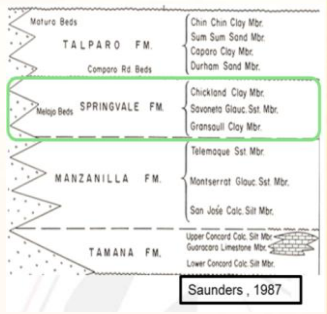
- Well logs and seismic correlation were utilized since these areas contain age diagnostic fauna.
- Fauna assemblage found are *Rotalia stellata* , *Elphidium sp.* , *Uvigerina isidroensis* and *Quinqueloculina sp.* (Marginal Marine – Inner neritic setting)



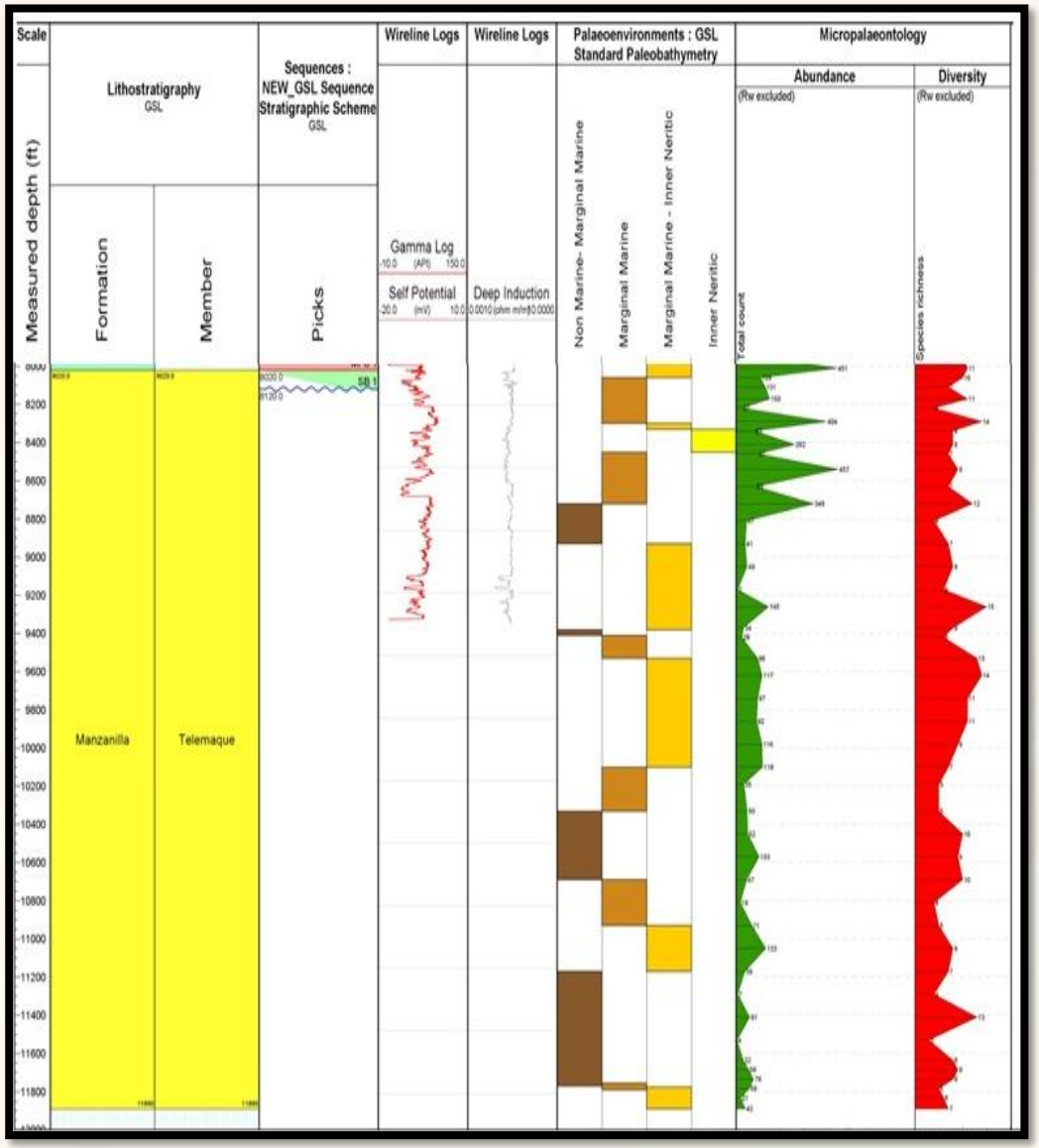
Springvale Formation



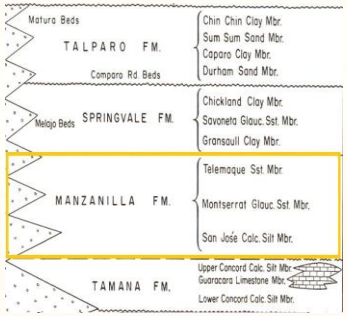
- Faunal assemblage includes *Elphidium 15* and *Ammobaculites sp.*
- Formation is occasionally absent presumably due to either non-deposition or to deposition and subsequent erosion.
- Members are not traceable in the Gulf of Paria

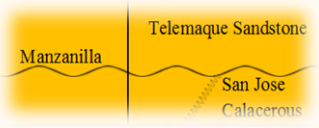


Manzanilla Formation



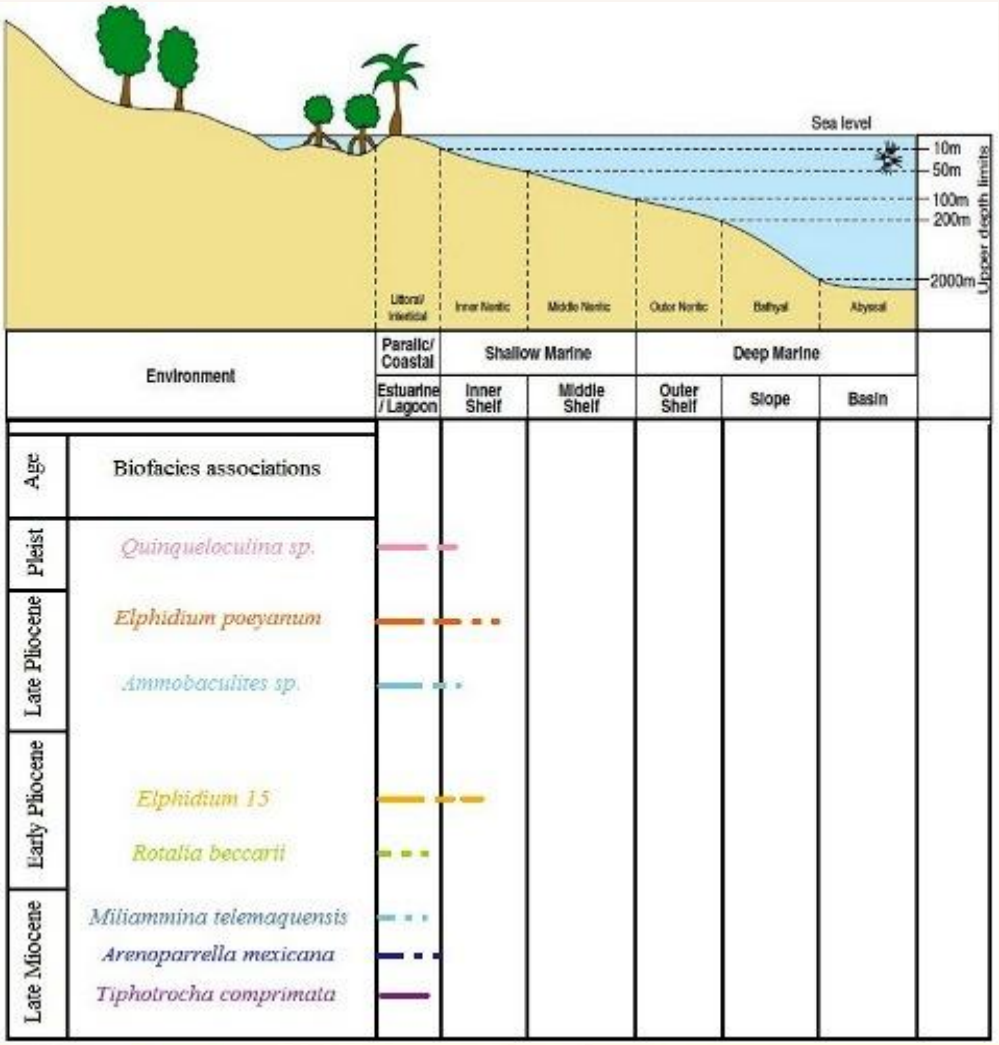
- It is suggested that these members extend westwards across the island from a maximum thickness on the east coast.
- Montserrat Glauconitic Sandstone and San Jose Calacerous member in the Gulf of Paria is being investigated.





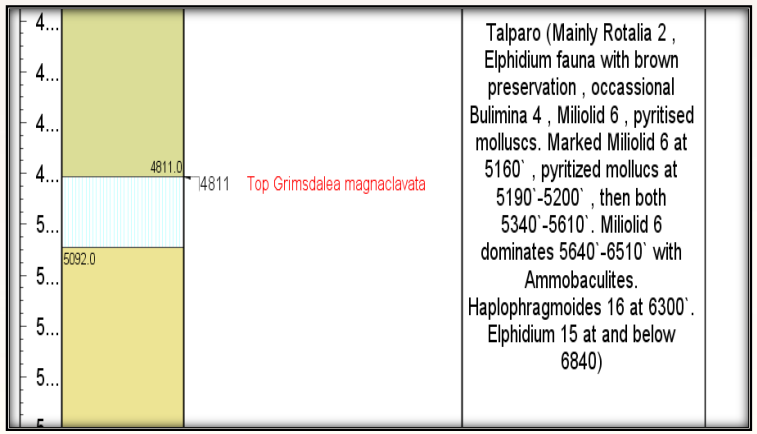
Paleoenvironment

Paleobathymetry Chart for the North Marine Area

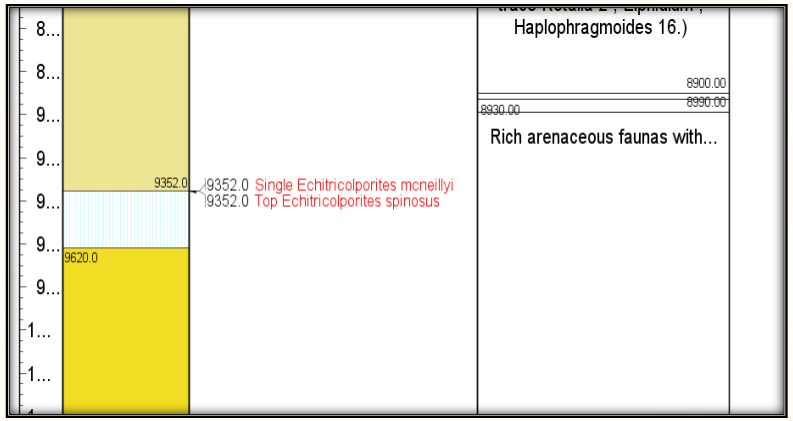


- Distribution of Modern Bathymetric environments shown at present-day highstand of sea-level.
- Common organisms with preservable paths recognizing bathymetric environments within the geologic record in the North Marine Area.

Palynomorphs



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

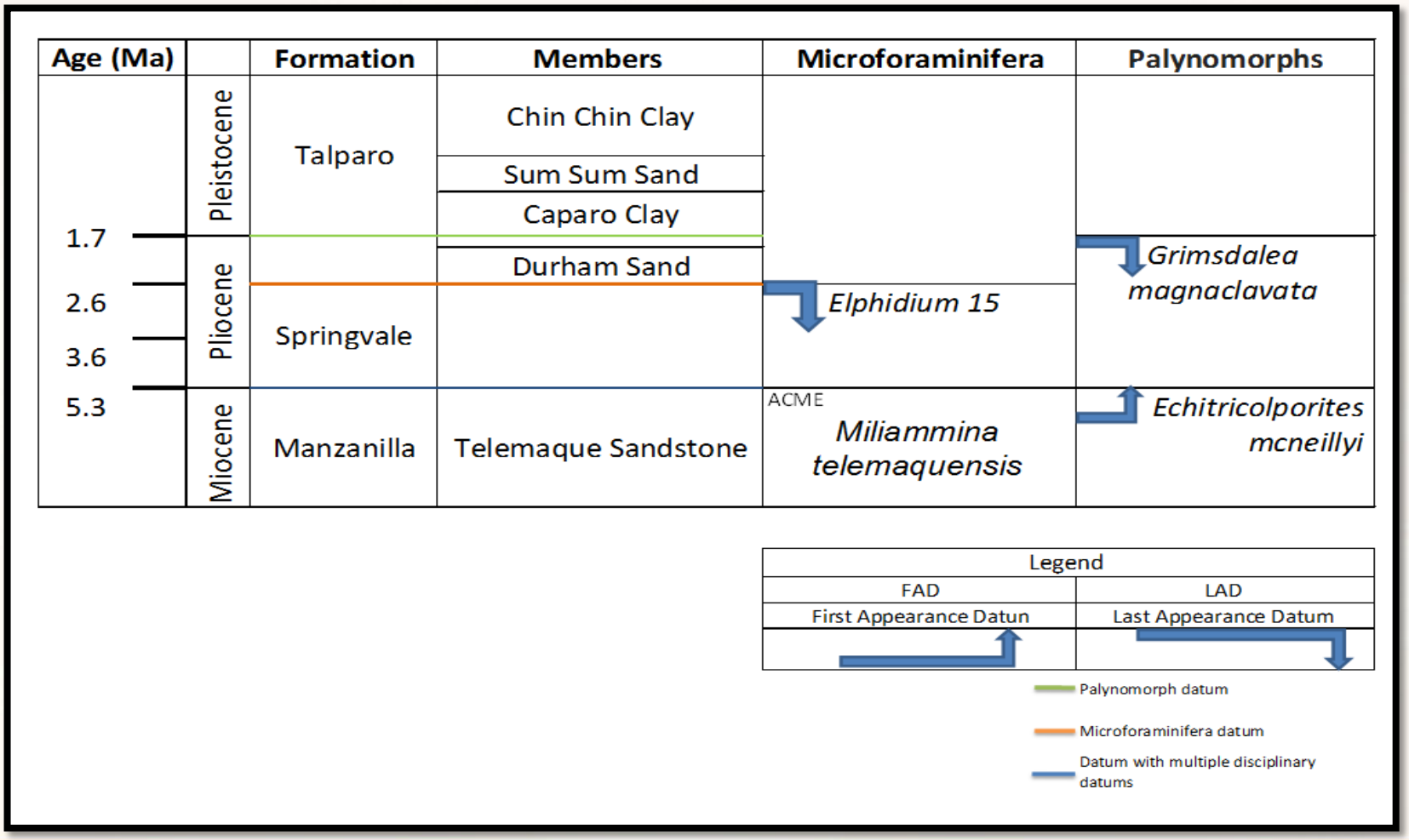


Echitricolporites mcneillyi – Mangrove – open vegetation; aquatic (Germeraad et al, 1968; Rull 1997)

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

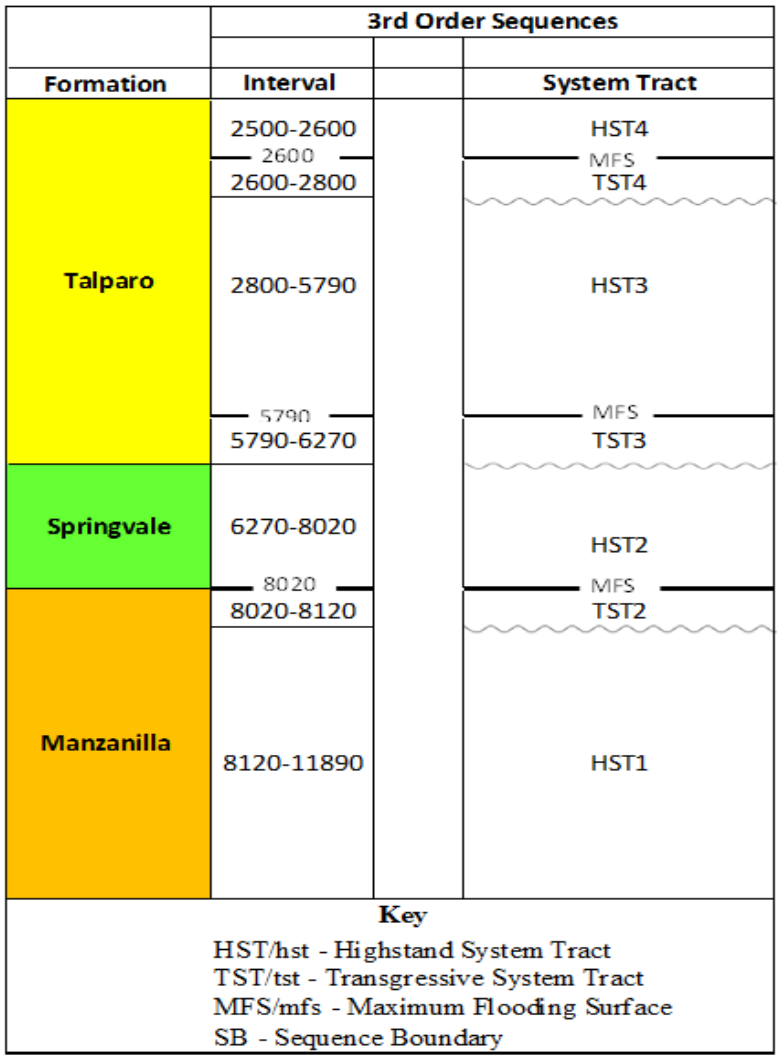
Biostratigraphic Indicators

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



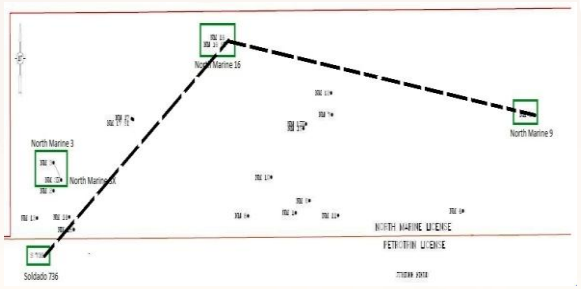
Sequence Stratigraphy

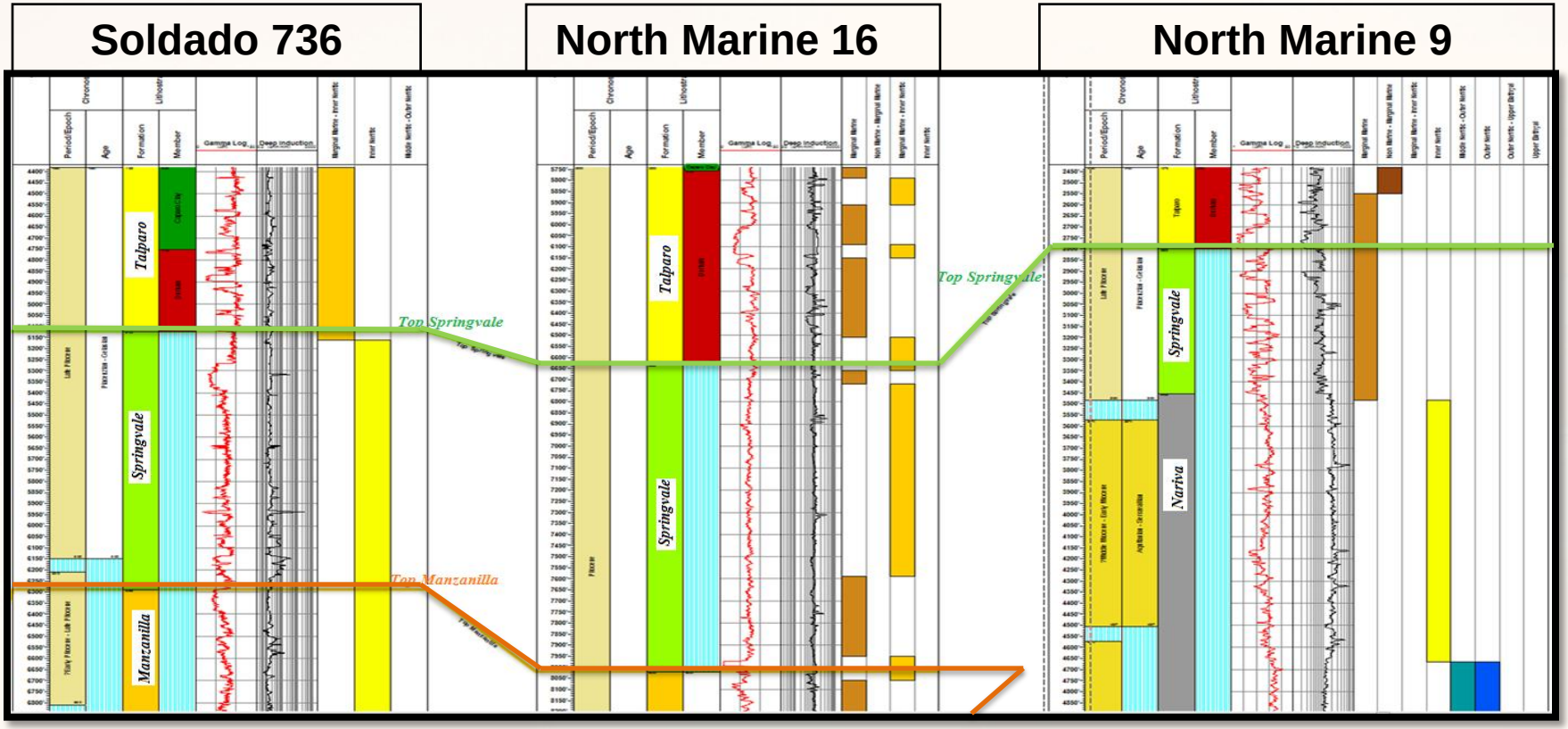
- The sequence chronostratigraphic framework of Hardenbol et al (1998) was integrated with biostratigraphic and log criteria for identifying the sequence stratigraphic surfaces.
- The Late Miocene-Pleistocene deposited in a marginal marine setting.
- These stress environment provided very little planktonic species for age calibration.



Correlation in North Marine

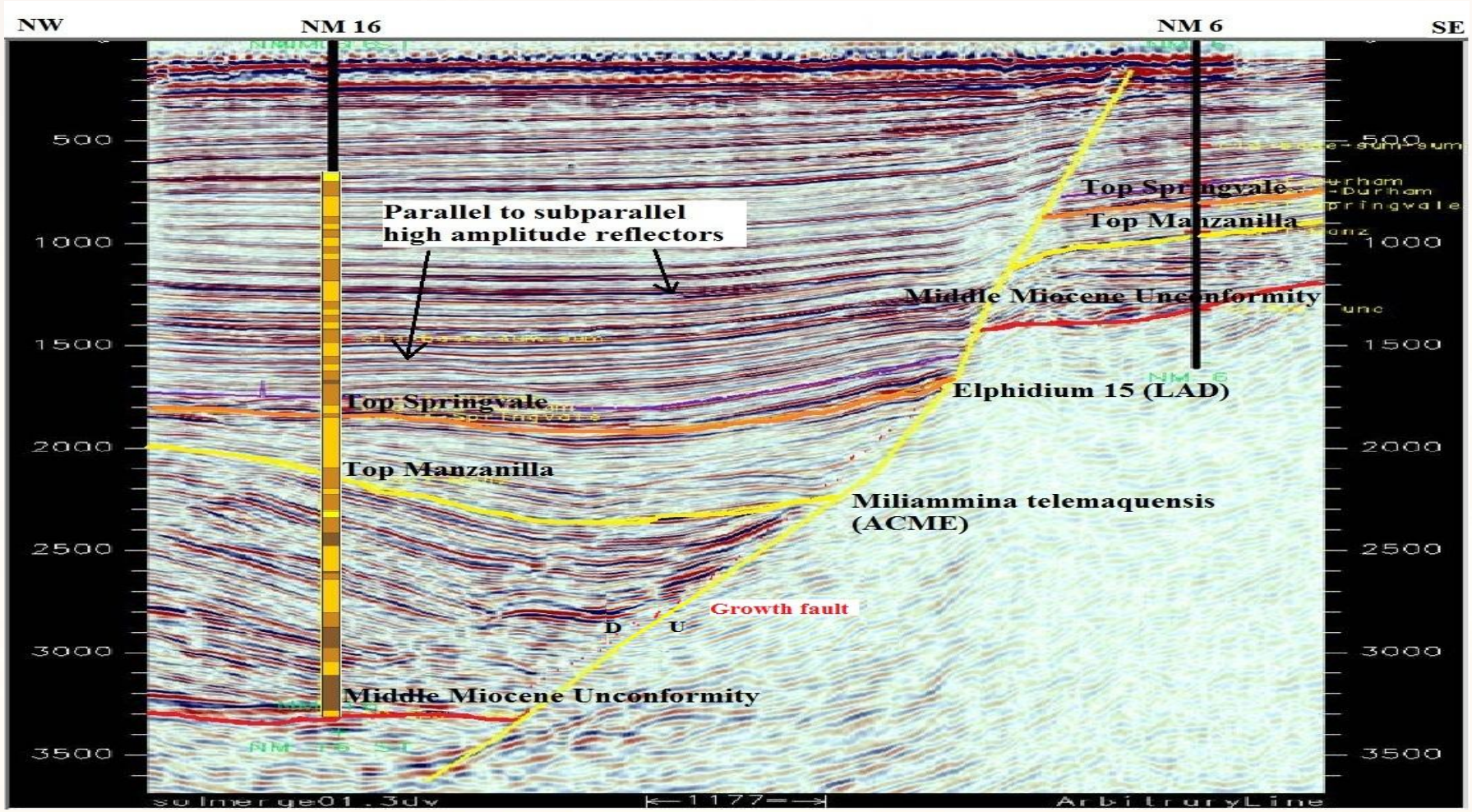
In NM-9 the Springvale rests unconformably on the Nariva Formation, while in NM-16 and S-736 it is underlain by the Manzanilla Formation.





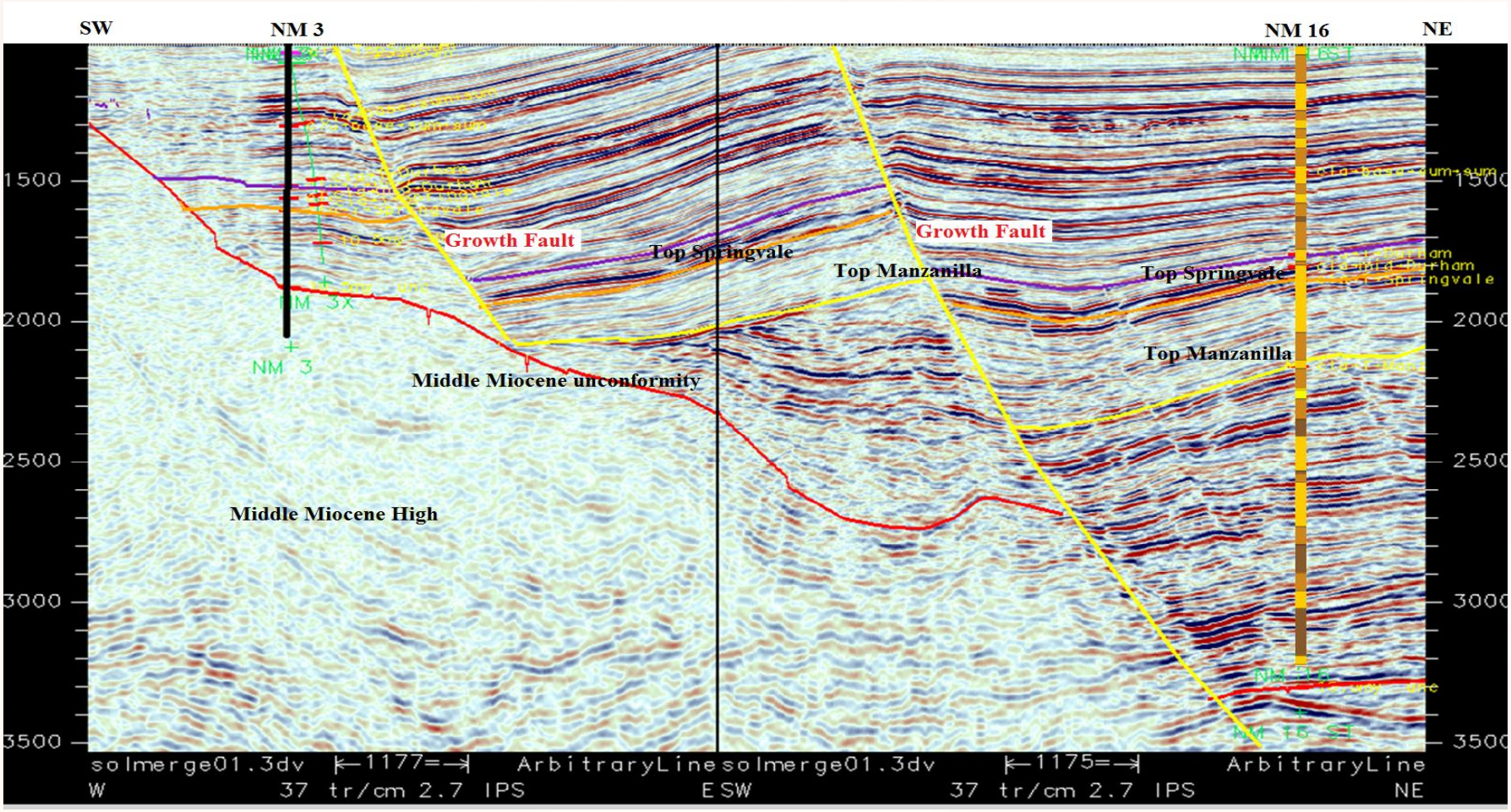
Seismic Stratigraphy

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



Seismic Stratigraphy

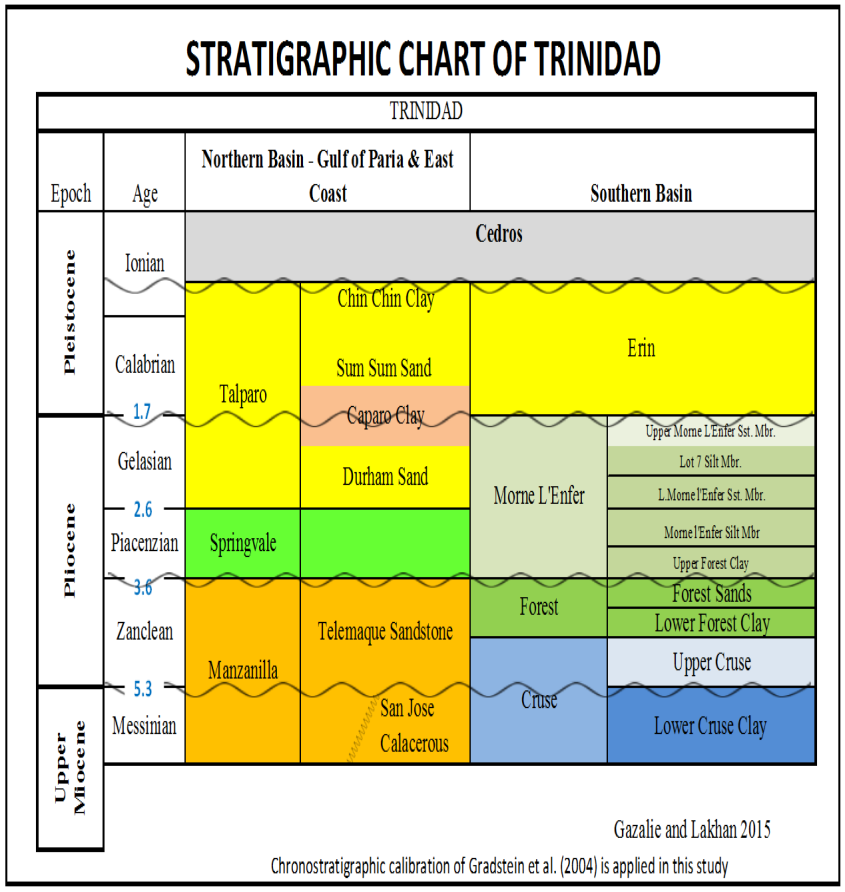
Seismic line illustrating the correlation between NM3 and NM16. Middle Miocene unconformity mapped.

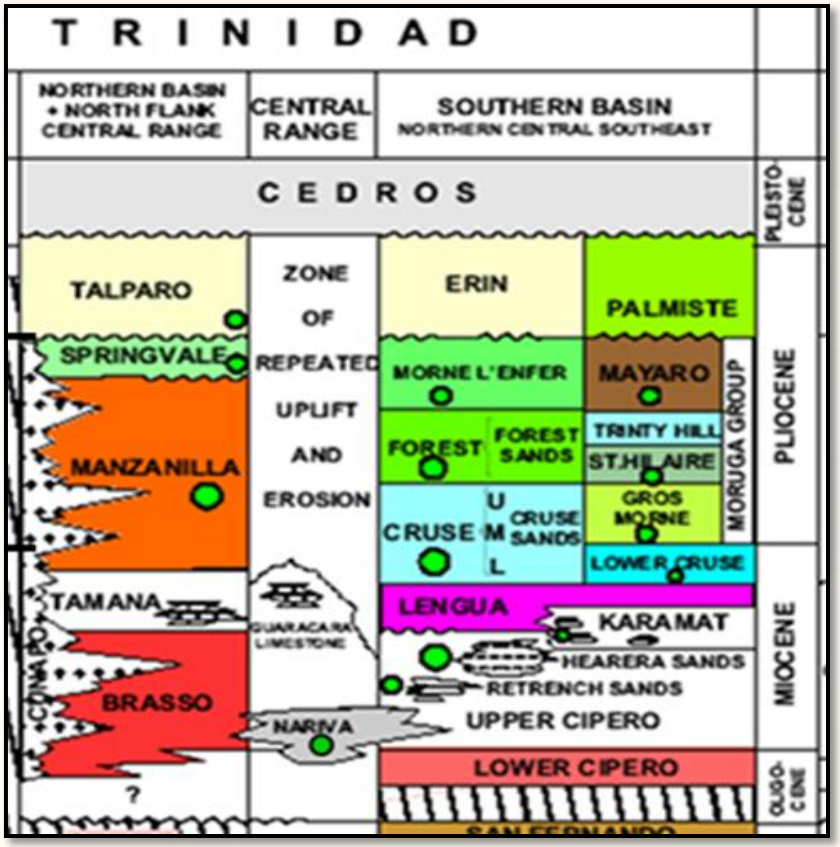


Revised Stratigraphic Chart

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.





After Carr-Brown & Frampton 1979

Comparison Chart

Chronostratigraphy from different authors (Gulf of Paria)

Comparison of Manzanilla Formation chronostratigraphy from different authors (Gulf of Paria)

		Lexicon (Kugler) 1957	Stratigraphic Chart (Saunders) 1974	Carr-Brown & Frampton 1979	Stratigraphic Chart (Saunders) 1987	Treatise (Kugler) 2001	GSL (Archie , Lakhan & Gazalie) 2015
PLIOCENE	Late						
	Middle			TSM MGSM SJCSM	TSM		
	Early		TSM		MGSM		TSM
MIOCENE	Late	TSM MGSM SJCSM	MGSM SJCSM		SJCSM	TSM MGSM SJCSM	SJCSM
	Middle						
	Early						

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

Discussions

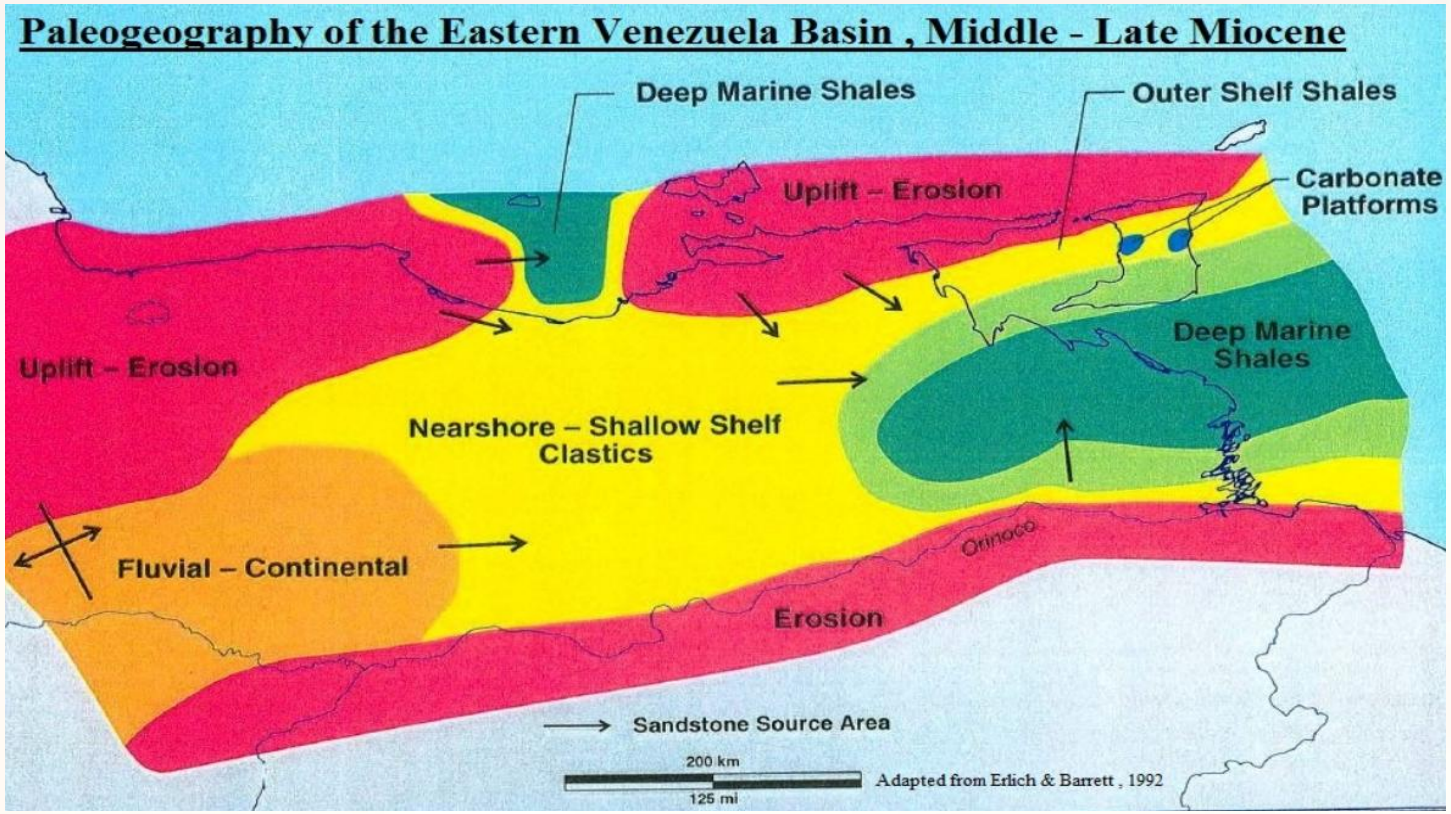
- The Late Miocene sedimentary record of the Orinoco River delta appears east of the Maturin, in the Eastern Venezuela Basin, and Pliocene and Pleistocene deltaic sediments are especially evident in Trinidad.

- 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.

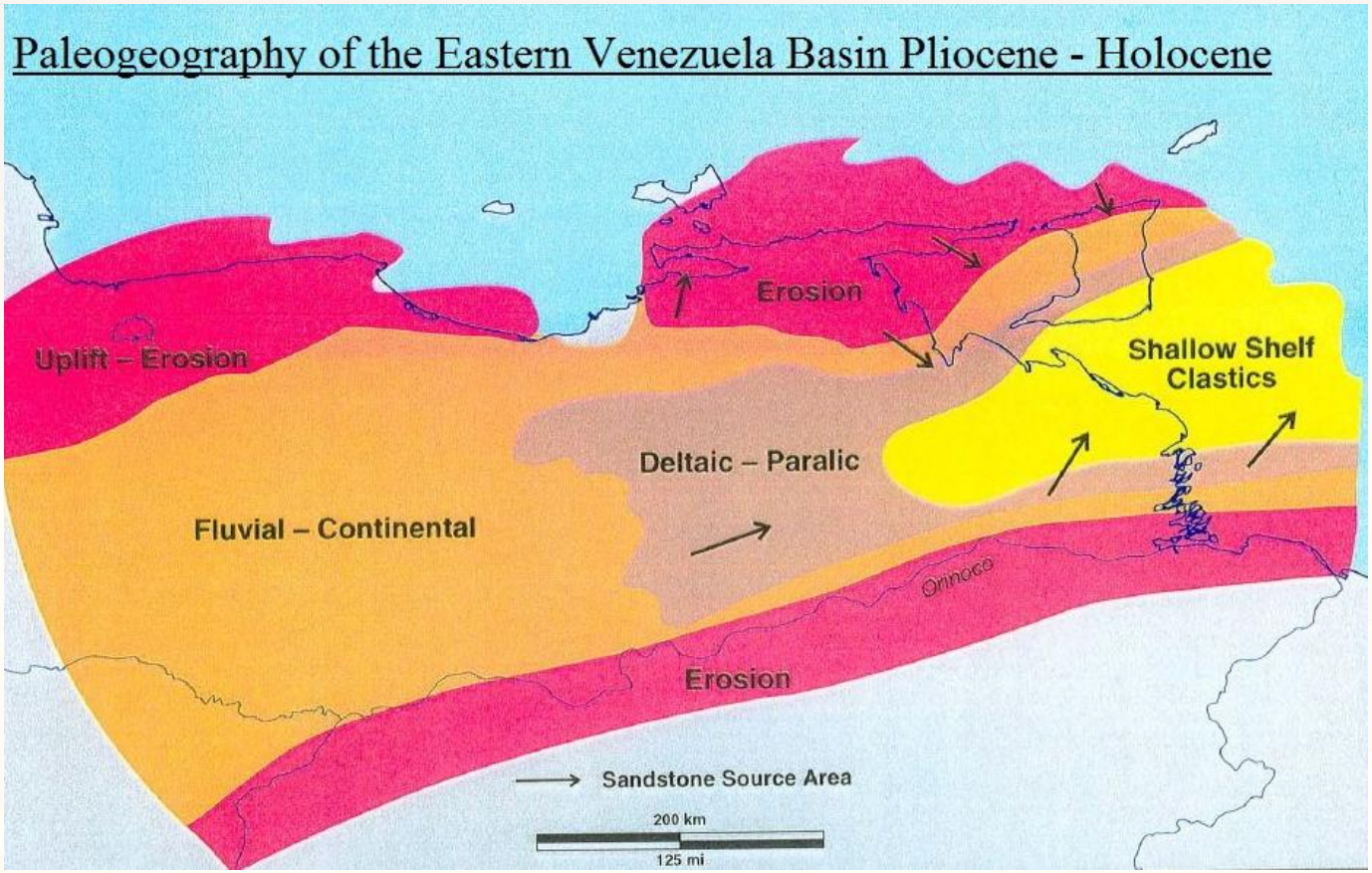
(Diaz de Gamero , 1995)

Tectonic Framework (6myr)



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.

Tectonic Framework (4myr)



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

Armentrout, J.M., Echols, R.J. & Lee, T.D., 1990. Patterns of Foraminiferal Abundance and Diversity: Implications for Sequence Stratigraphic Analysis. GCSSEPM Foundation Eleventh Annual Research Conference. pgs. 53-58.

Armentrout, J.M., 1996. Integrated Stratigraphic Analysis. SEPM Course No. 17.

Bolli, H.M., Beckmann, J.P., & Saunders, J.B. eds., 1985. Benthic Foraminiferal Biostratigraphy of the South Caribbean Region. Cambridge University Press.

Bolli, H.M., 1957a. Planktonic Foraminifera from the Oligo-Miocene Cipero and Lengua Formations of Trinidad, B.W.I., Bull. U.S. Nat. Mus. Vol. 215 pp. 97-123.

Bolli, H.M. and Saunders, J.B., 1985. Oligocene to Holocene low latitude planktic foraminifera. In: H.M. Bolli, J.B. Saunders and K. Perch Nielsen (Editors), Plankton Stratigraphy. Cambridge University Press, Cambridge, pp. 155-262.

Bolli, H.M., Saunders, J.B. & Perch-Nielsen, D. eds., 1985. Plankton Stratigraphy. Cambridge University Press, 1032 pp.

Diaz de Gamero, M.L.,1995. The changing course of the Orinoco River during the Neogene: a review. Palaeogeography, Palaeoclimatology, Palaeoecology 123 (1996) 385-402

Geological Review Team, 1967. Review of T.N.A. and T.P.D. Gulf of Paria Leases, Trinidad. Trinmar Limited, Guapo, Trinidad Geological Department.

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, Speical Publication No. 24.

Shallow Horizon Project (Petrotrin Internal Report) 1996

Van Wagoner, J.C., Mitchum, R.M., Campion, K.M. & Rahmanian, V.D., 1990. Siliciclastic Sequence Stratigraphy in Well Logs, Cores, and Outcrops. Concepts for High-Resolution Correlation of Time and Facies. AAPG Methods in Exploration Series, No. 7.

Thank You

Questions?