Planktic Foraminiferal Biostratigraphy of A, B, C, D Wells, Offshore Niger Delta, Nigeria

Ajayi, Eunice Omozusi
Bio-Metrics Geo Consult Ltd
Plot 68
Cascurina Close
Gaduwa Estate
Abuja, Nigeria

Okosun, Edward Agboneni
Dept of Geology
Federal University of Technology
Minna, Nigeria

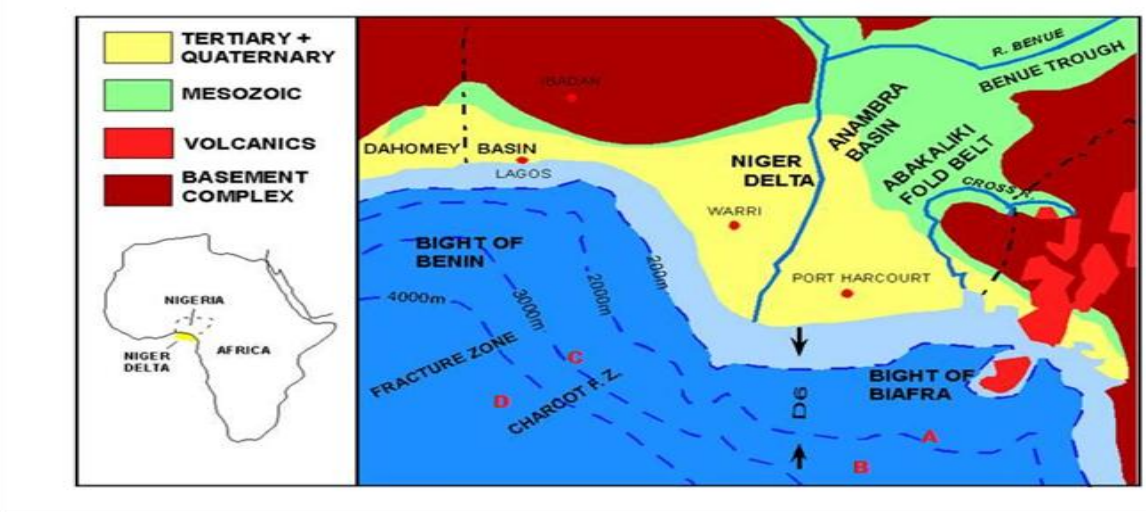
Abstract

Planktic Foraminiferal biostratigraphy was carried out in four wells drilled in the deep offshore area of the Niger Delta. Four hundred and fifty three ditch cutting samples from A,B,C,D wells were processed and analysed, in order to establish the age, biozones and correlation of the studied sections. Fourty-two planktic foraminiferal species were recovered from the four wells. Three planktic foraminifera zones were identified: Globorotalia margaritae margaritae subzone (N18), Globigerinoides obliquus extremus - Sphaeroidinellopsis seminulina zone (N17), and Globorotalia acostaensis acostaensis zone (N16), following the zonation schemes by Blow (1969, 1979) and Bolli and Saunders (1985) based on foraminiferal marker species whose stratigraphic ranges are well established globally and in the Niger Delta Neogene. The studied wells penetrated a sedimentary succession of Late Miocene to Early Pliocene age. The analyzed sections of the wells are composed of deepwater sediments deposited in the upper to lower bathyal environments.

Introduction

The Niger delta lies in the Gulf of Guinea between latitudes 4^0 and 6^0 N and longitudes 3^0 and 9^0 E on the west coast of Central Africa. Hydrocarbon exploration and production activities in the Niger delta which dates back to over five decades were mainly in the Eocene - Miocene onshore and shallow offshore sequences of the delta. But with the maturation of the onshore fields and availability of new technologies in the last decade, exploration and production of hydrocarbons have shifted to the deep offshore of the delta.

Planktic foraminifera play a significant role in age determination of sedimentary rocks, sequence stratigraphy, intra-basinal and global correlation. The purpose of this work is to identify the planktic foraminiferal bioevents and biozones, determine the age and correlate wells A,B,C and D in the offshore, Niger Delta of Nigeria (Fig. 1)



KEY
A – Well A
B – Well B
C – Well C
D – Well D

Figure 1: Simplified Geological Map of the Study Area in the Niger Delta

Geological Setting

The Niger Delta is subdivided into three diachronous lithostratigraphic units. These are the Benin Formation, (mostly continental sands), the Agbada Formation and the Akata Formation (Fig. 2). The Akata Formation is the basal unit which comprises mainly of marine shales believed to be the main source rock within the basin. The Agbada Formation is made up of alternating sandstone, and shale sequences that constitute the petroleum reservoirs of the basin. The Agbada Formation was penetrated in the late Miocene to early Pliocene sequences of the four wells studied, piercing through the mobile shale, mud diapir and channelized turbidites.

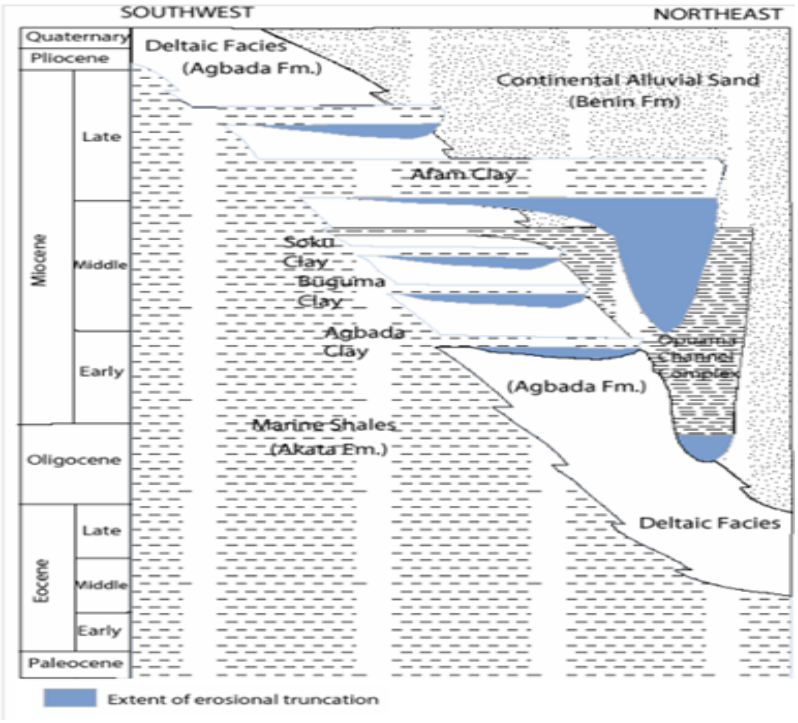


Figure 2: Stratigraphic Column Showing the Three Formations of the Niger Delta (modified after Doust & Omatsola, 1990

Method of Study

A total of 453 ditch cuttings were analysed for the wells A, B, C and D. Eighty-five and 164 ditch cutting samples from interval of 4900 – 9920 ft. and 4530 – 14600 ft. of wells A and well B respectively, while 92 and 112 samples from interval of 5760 – 11400 ft. and 6000 – 12750 ft. were analysed in wells C and D respectively. These samples were processed and analysed at 60 ft. interval for planktic foraminifera using the standard micropaleontological sample preparation procedures.

Samples were first laid out sequentially according to their depths. Labels were prepared for each sample. Clean sample plates are laid out.

About 25g of samples were placed (for ditch cutting samples) into the sample plates. The samples were dried on a hot plate at about 800^0C for 2-3 hours. The sample plates were allowed to cool and weighed. Samples were soaked in kerosene and left overnight to disintegrate. The samples were decanted, topped with water and left overnight.

The samples were washed with liquid soap and water through four sieve mesh sizes of 500, 250, 150 and 63 microns and dried. Samples were transferred into four different bags/phials and labelled accordingly. Foraminifera were picked from the packaged samples and studied with the aid of a reflected light binnocular Zeis microscope. All the planktic foraminifera recovered were analysed. Generic and species identification were based on Bolli and Saunders (1985) and other relevant Neogene planktic foraminiferal publications.

Results and Discussion

Forty-two planktic foraminiferal species were identified from the four wells in this study (Figs. 3-6). Three planktic foraminiferal biozones were recognised based on their stratigraphic distribution (Figs. 3-6). The zones were based on the planktic foraminiferal zonation schemes of Blow (1969, 1979) and Bolli and Saunders (1985). First and last downhole occurrences (FDO and LDO) of chronostratigraphically significant planktic foraminiferal species formed the basis of the biozonation in this study. The identified planktic foraminiferal zones are beginning from the oldest: *Globorotalia acostaensis acostaensis* zone (N16), *Globigerinoides obliquus extremus - Sphaeroidinellopsis seminulina zone* (N17) and *Globorotalia margaritae margaritae* subzone (N18). The zones range in age from late Miocene to the early Pliocene. Some interval of wells C and D could not be zoned because they contained no diagnostic planktic foraminiferal species (Figs. 3-6).

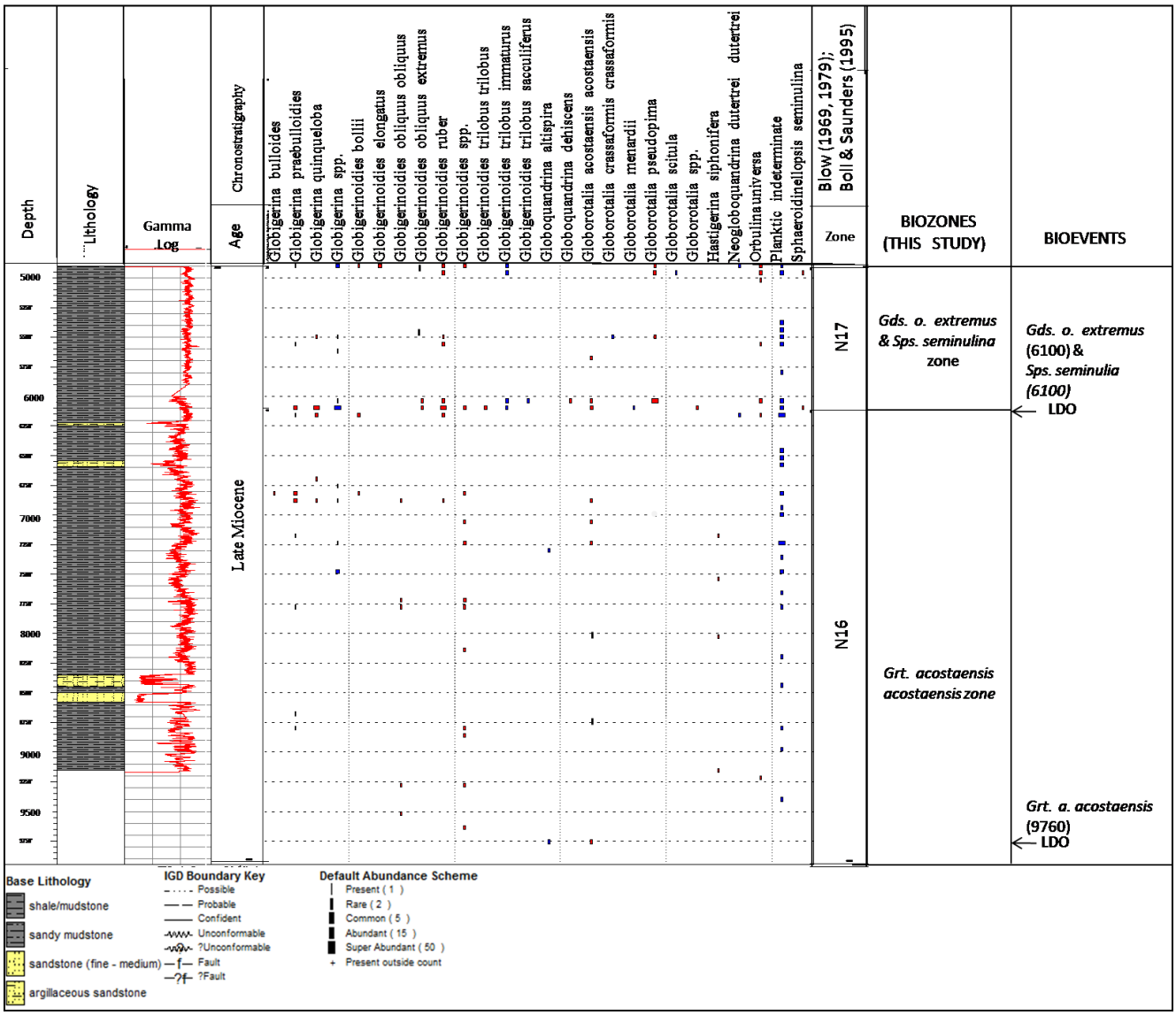


Figure 3: Planktic Foraminiferal Distribution Chart for Well A

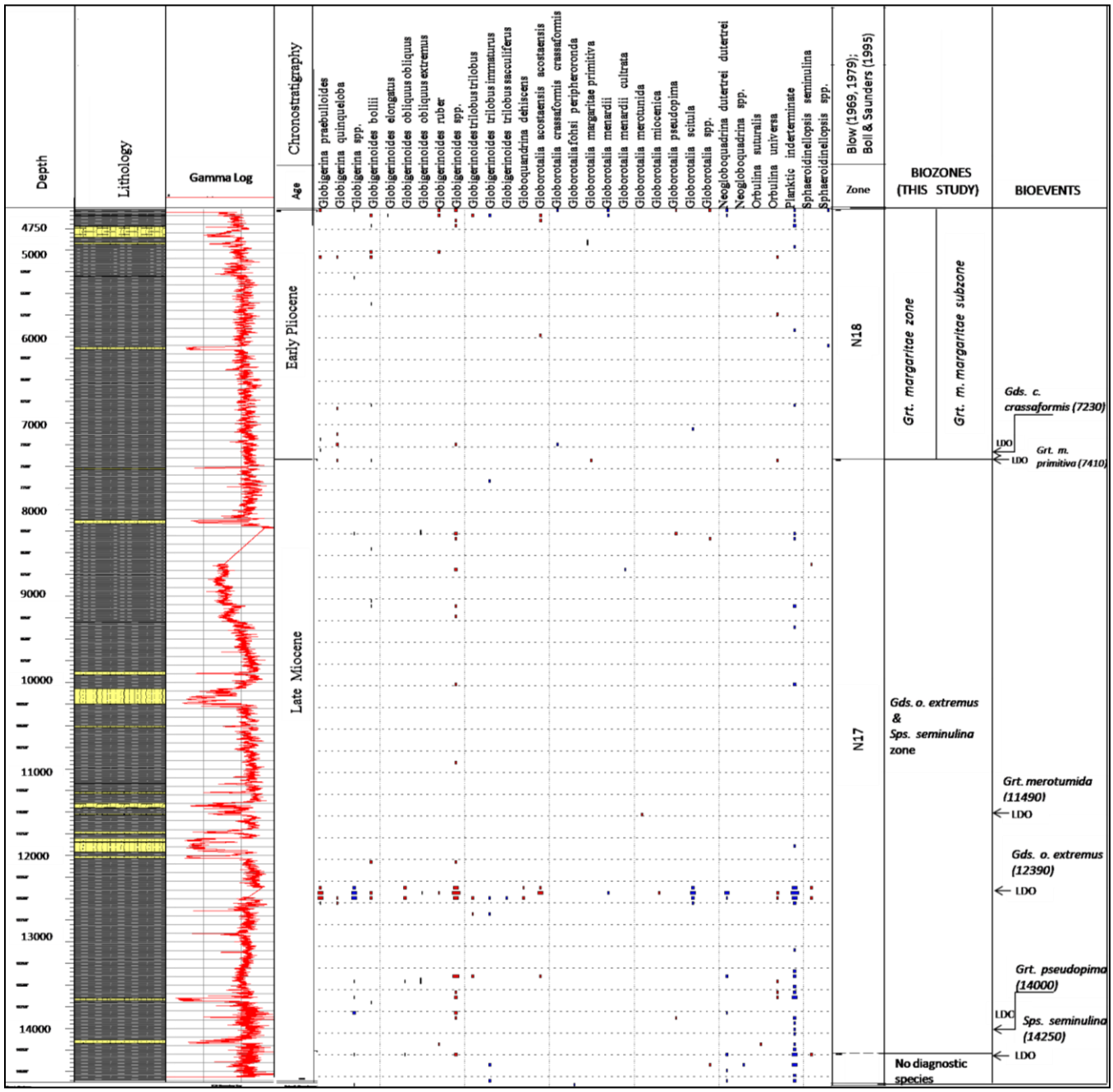


Figure 4: Planktic Foraminiferal Distribution Chart for Well B. Legend as in fig. 3

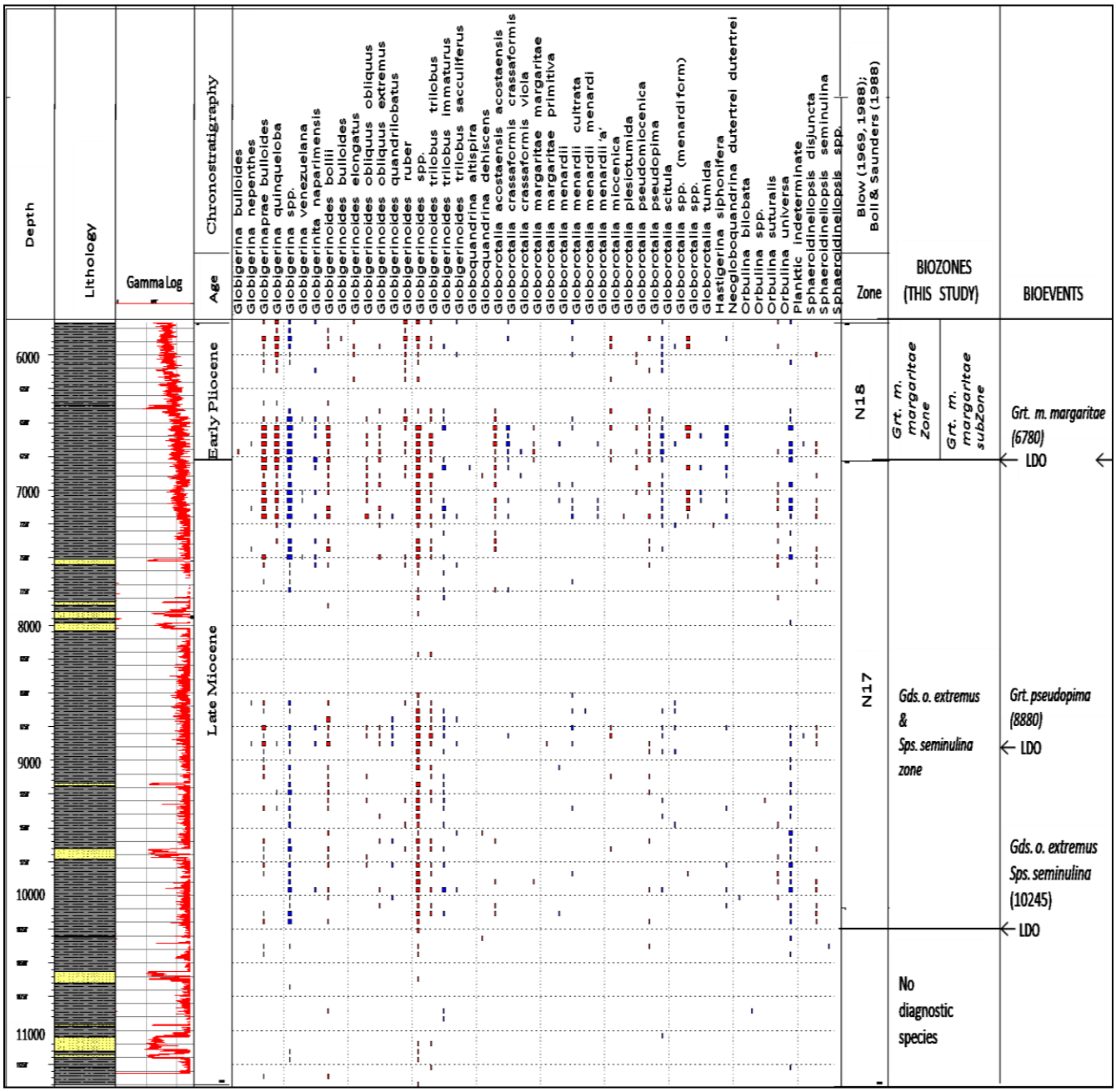


Figure 5: Planktic Foraminiferal Distribution Chart for Well C. Legend as in fig. 3

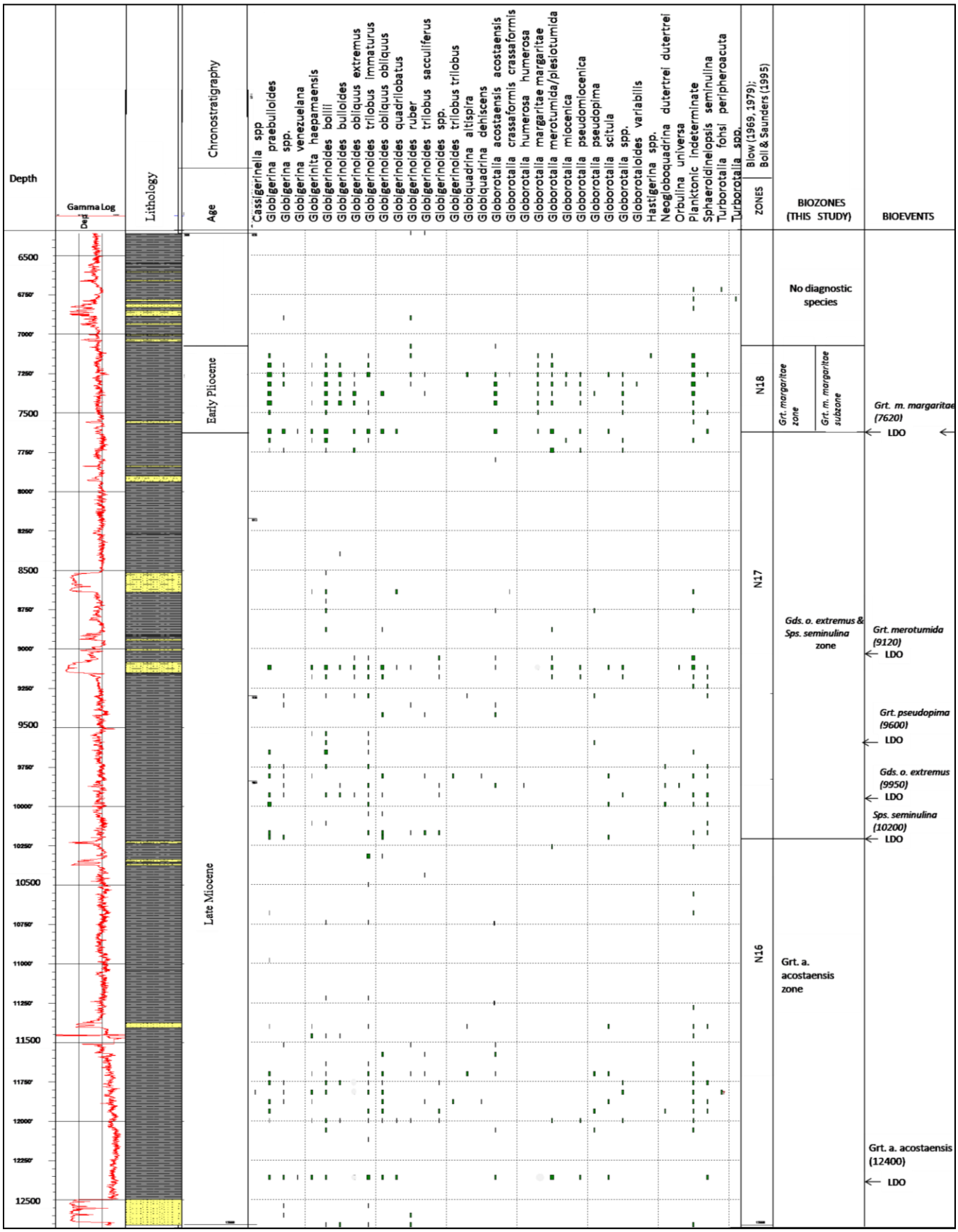


Figure 6: Planktic Foraminiferal Distribution Chart for Well D. Legend as in fig. 3

(a) Globorotalia margaritae Zone

Category: Taxon range Zone

Age: Early Pliocene (N18)
Authors: Bolli and Bermudez (1965)

Definition: the *Globorotalia margaritae* zone is usually identified by the last and first occurrence datums (LDO and FDO) of the nominate species (Bolli, 1969,1970). The zone however was subdivided into a lower *Globorotalia margaritae margaritae* subzone and an upper *Globorotalia margaritae evoluta* subzone by Cita (1973). Only the lower of the two (2) zones was observed in wells B,C and D.

b) *Globorotalia margaritae margaritae* Subzone

Category: lineage zone
Age: Early Pliocene (N18)

Author: Cita (1975). Subzone was redefined by Bolli & Premoli Silva (1973).

Stratigraphic intervals: well B 7410 - 4530 feet (2259- 1381 m), well C 6450 - 6780 feet (1966 – 2067 m), well D 7620 -7100 feet (2323 – 2164 m)

Definition: interval with the first occurrence of *Globorotalia margaritae margaritae* and or *Globorotalia margaritae primitiva* to the first occurrence of *Globorotalia evoluta.*

Characteristic subzonal species: the nominate subzonal species are associated with *Globorotalia crassaformis crassaformis, Globoquadrina dehiscens, Globigerinoides ruber, Globorotalia merotumida, Globigerinoides bolli* and *Globigerina praebulloides*. (Figs.3-6).

Remarks: *Globorotalia margaritae margaritae* and *Globorotalia margaritae primtiva* were used as the nominate species for the subzone. *Globorotalia margaritae primitiva* occurred in well B while *Globorotalia margaritae margaritae and Globorotalia margaritae primitiva* occurred together in well C. *Globorotalia margaritae margaritae* occurred in well D. Thus the two species were used singly and jointly as the nominate subzonal species for the subzone. This is in agreement with the concept of the subzonal definition as expressed by Bolli & Saunders (1985).

The top of the subzone was tentatively placed at 4530 ft (1380 m) in well B and at 7280 ft (2119 m) in well D. The top of the subzone has been placed at 6780 ft (2067 m) in well C. The base of the subzone was defined by the last downhole occurrence (LDO) of *Globorotalia margaritae primitiva* at 7410 ft (2259 m) in well B and 7620 ft (2323 m) in well D. The base was placed at 6450 ft (1966 m) in well C. The last downhole occurrence (LDO) of G*loborotalia crassaformis crassaformis* at 7230 ft (2204 m) in well B is another important N18 bioevent (Bolli and Saunders, 1985).

Age and correlation: the subzone correlates to N18 zone of Blow (1969, 1979) and is dated Early Pliocene.

c) *Globigerinoides obliquus extremus* and S*phaeroidinellopsis seminulina* Zone.

Category: interval zone.
Age: late Miocene (N17).

Definition: interval with zonal markers from first occurrence of both or one species to the first occurrence of both *Globorotalia margaritae margaritae* and *Globorotalia margaritae primitiva* or either of the two species.
Stratigraphic intervals:

Well A: 6100 – 4900 ft (1859 – 1493 m), well B: 14250 -7410 ft (4343 – 2259 m), well C: 10245 – 6780 ft (3123- 2067 m), well D: 10,200 – 7620 ft (3109 – 2323 m).

Zonal characteristics: the zonal intervals in the four wells are characterized by fairly abundant and diverse planktic foraminifera. The stratigraphically important ones are *Globigerinoides obliquus extremus, Globigerinodes obliquus obliquus, Globorotalia pseudopima, Neogloboquadrina dutertrei,* S*phaeroidinellopsis seminulina, Globorotalia acostaensis acostaensis, Globorotalia merotumida, Globorotalia plesiotumida*. The zonal intervals of the four wells were delineated based on the key foraminiferal bioevents of Neogene species (Figs. 3 - 6).

Remarks: *Globigerinoides obliquus extremus* and S*phaeroidinellopsis seminulina* were used as nominate species for the subzone. *Globigerinoides obliquus extremus* and S*phaeroidinellopsis seminulina* occurred in wells A, B, C and D. This zone is equivalent to the *Globorotalia humerosa* zone (N17) of Bolli and Bermudez (1965) *Globorotalia humerosa* was absent in three of the studied wells. The absence or scarcity of the nominate zonal species led to the adoption of *Globigerinoides obliquus extremus* and *Sphaeroidinellopsis seminulina* as proxies for the original index species. The selected proxies for the N17 zone have enabled adequate stratigraphic correlation of the studied four wells (Fig. 7).

d) *Globorotalia acostaensis acostaensis* Zone

Category: interval zone.
Age: late Miocene (N16).
Author: Bolli and Bermudez (1965).

Definition: interval with zonal marker from its first occurrence to the first occurrence of *Globorotalia humerosa* (Bolli and Saunders, 1985).

Stratigraphic intervals: well A: 9760 - 6100 ft (2975 – 1859 m), well D: 12360 -10200 ft (3767 - 3109 m).
Zonal characteristics: the zonal interval contains sparse and poorly diverse planktic foraminiferal species in well A. Well D interval is characterized by fairly abundant and diverse species which include *Globigerinoides obliquus obliquus, G.bolli, G.immaturus, Globigerina praebulloides* and G*loborotalia scitula*.

Remarks: *Globorotalia acostaensis acostaensis* was used as the nominate species for the subzone. *Globorotalia acostaensis acostaensis* occurred in wells A and D. Since *Globorotalia humerosa*, the original N17 zonal nominate species was absent in three wells but present only in well D, the interval with *Globorotalia acostaensis acostaensis* from its first occurrence to the first occurrence of both *Globigerinoides obliquus extremus* and *Sphaeroidinellopsis seminulina* (N17 proxies) or either of them defines the zone. This zone was recognized in two of the studied wells.

Correlation of Wells A, B, C, D

Based on the work of Blow (1969, 1979), Bolli and Saunders (1985) and Berggren *et al* (1995), the zones encountered in this study range from Late Miocene N16, M12; to Early Pliocene N18, PL1a. The faunal contents are very similar as the same biostratigraphic zones were established in the four wells. Three planktic foraminiferal zones namely, *Globorotalia margaritae margaritae* subzone, *Globigerinoides obliquus extremus* - *Sphaeroidinellopsis seminulina* zone and *Globorotalia acostaensis acostaensis* zone were identified. The 3 biozones show good correlation in the four wells (Fig. 7). In addition, the 3 biozones correlate well with parts of the Niger delta, the Mediterranean and some other low latitude areas (Fig. 8).

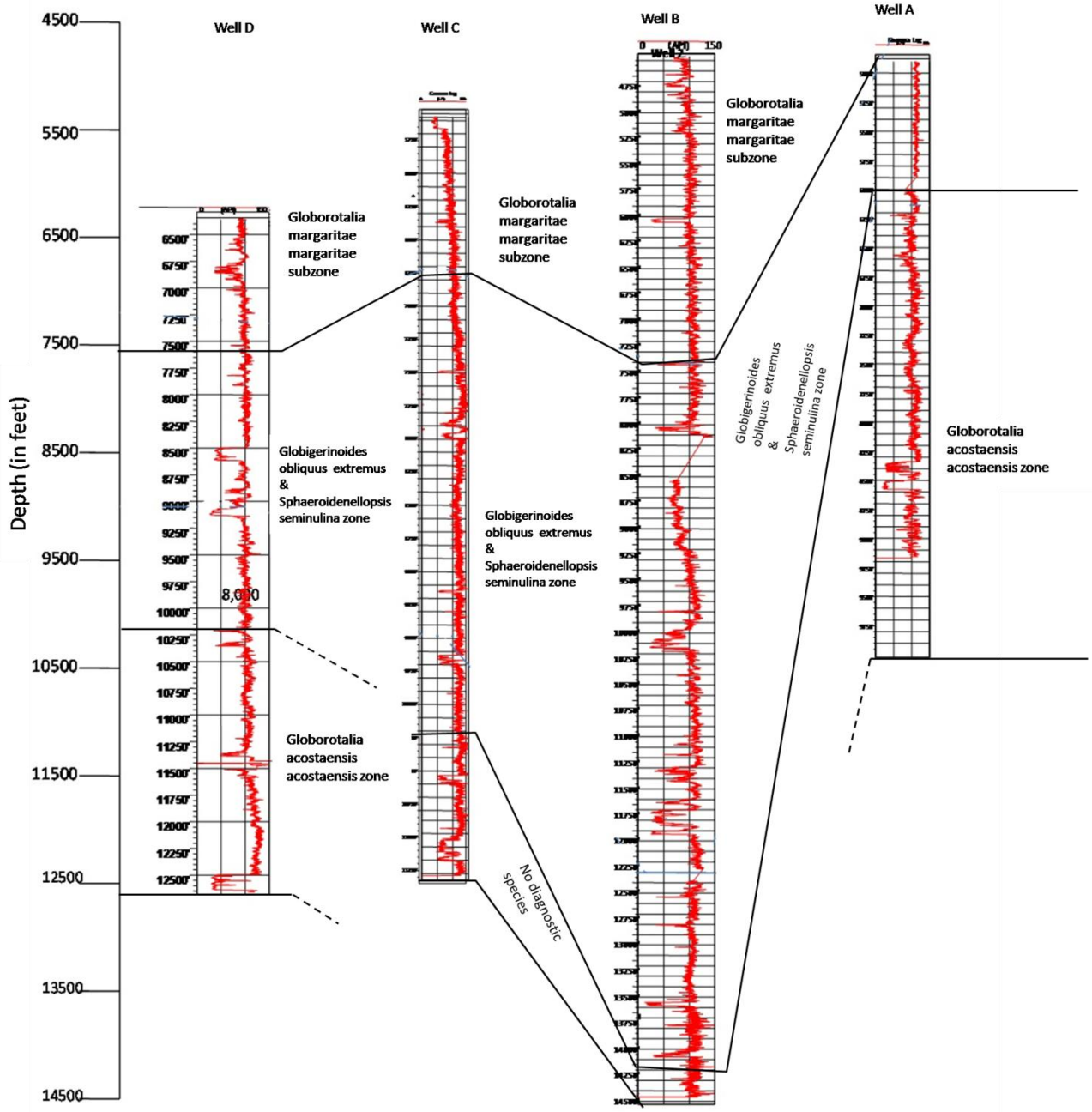


Figure 7: Correlation of Planktic Foraminiferal Zones in the Studied Wells

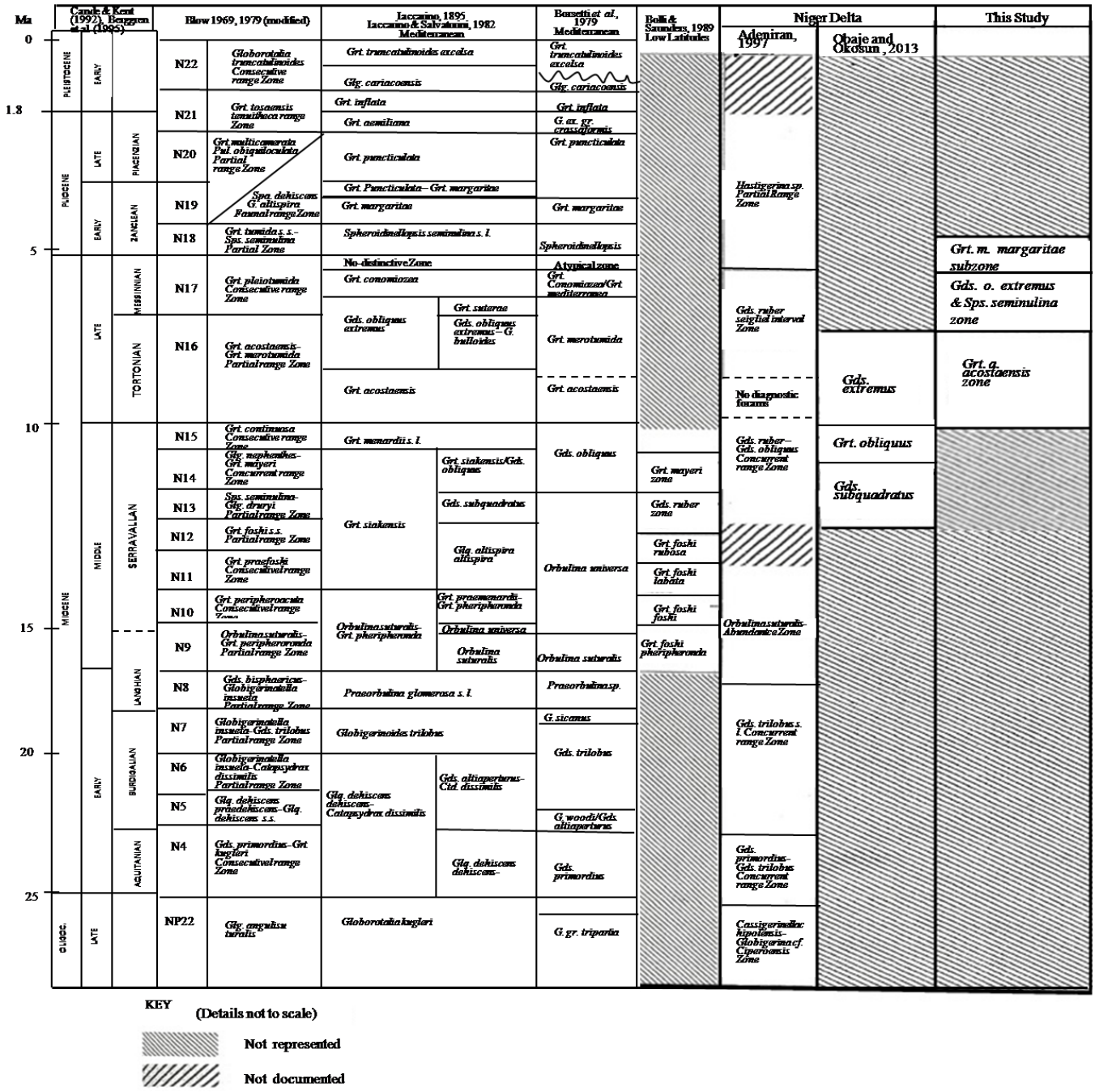
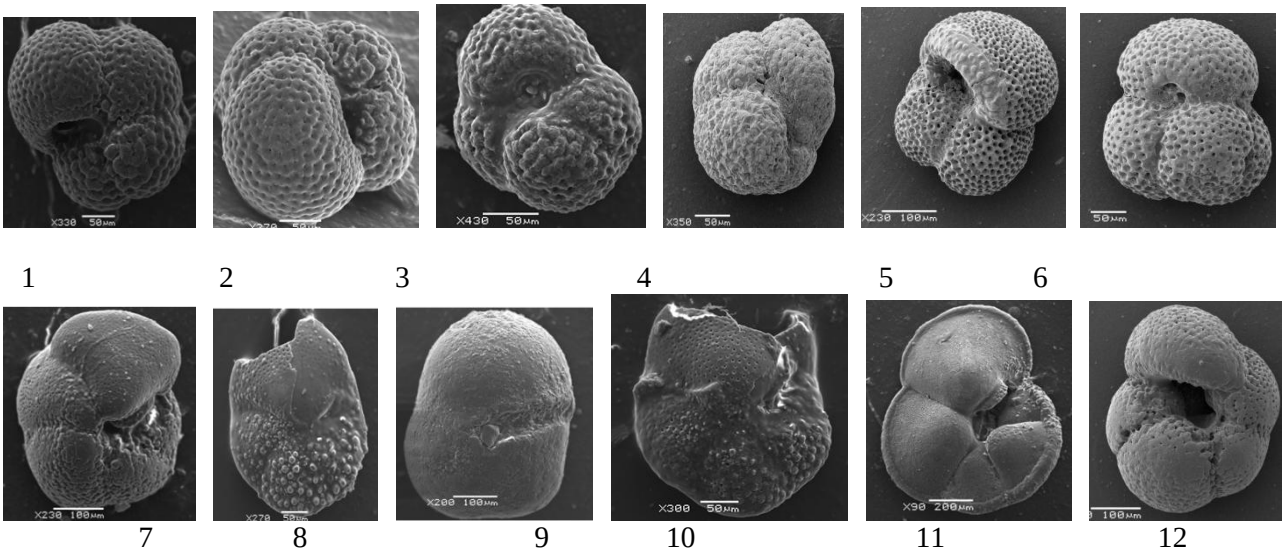


Figure 8: Correlation of Study Area with the Mediterranean, Low Latitude Areas and Parts of Niger delta

Micrographs of Diagnostic Species

The scanning electron microscope (SEM) micrographs of the zonal diagnostic planktic foraminiferal marker species encountered in this study are shown in figure 9.



1 *Globorotalia pseudopima* Bolli and Blow,

2 *Globorotalia acostaensis acostaensis* Blow

3 *Globigerinoides bolli* Bolli and Blow

4 *Globigerinoides obliquus extremus* Bolli and Bermudez

5 *Globigerinoides obliquus obliquus* Bolli

6 *Globigerinoides trilobus immaturus* LeRoy

7 *Globorotalia crassaformis crassaformis* Galloway and Wissler

8 *Globorotalia margaritae margaritae* Bolli and Bermudez

9 *Sphaeroidinellopsis seminulina* Schwager

10 *Globorotalia margaritae primitiva* Bolli and Bermudez

11 *Globorotalia menardi* Bolli and Bermudez

12 *Globorotalia humerosa* Takayanagi and Saito

Figure 9: Scanning Electron Microscope Images of Diagnostic Planktic Foraminiferal Species

Conclusion

The studied wells penetrated a sedimentary succession of Late Miocene to Early Pliocene. The Miocene/Pliocene boundary was recorded at 7410, 6780 and 7320 feet in wells B, C and D respectively. Well A penetrated only the Late Miocene succession; the other 3 wells penetrated the Late Miocene and Early Pliocene. The 3 planktic foraminifera zones encountered are, *Globorotalia margaritae margaritae* subzone (N18), *Globigerinoides obliquus extremus - Sphaeroidinellopsis seminulina* zone (N17) and *Globorotalia acostaensis acostaensis* zone (N16). The 3 biozones have good correlation value in the studied wells.

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