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

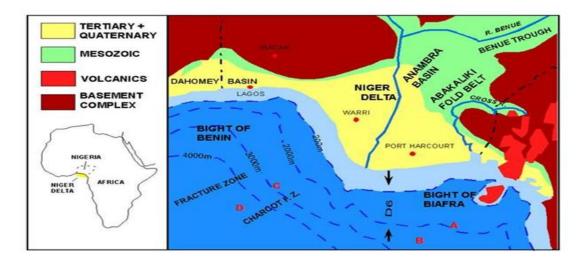
Abstract

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 \mathbf{A} – Well A \mathbf{B} – Well B \mathbf{C} – Well C \mathbf{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.

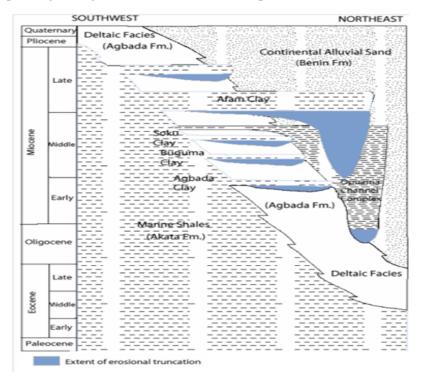


Figure 2: Stratigraphic Column Showing the Three Formations of the Niger Delta (modified after Doust & Omatsola, 1990

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° C 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).

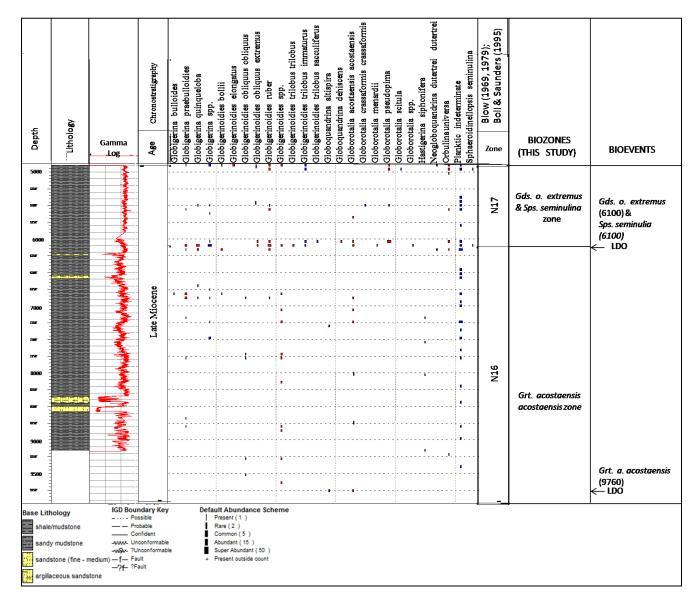


Figure 3: Planktic Foraminiferal Distribution Chart for Well A

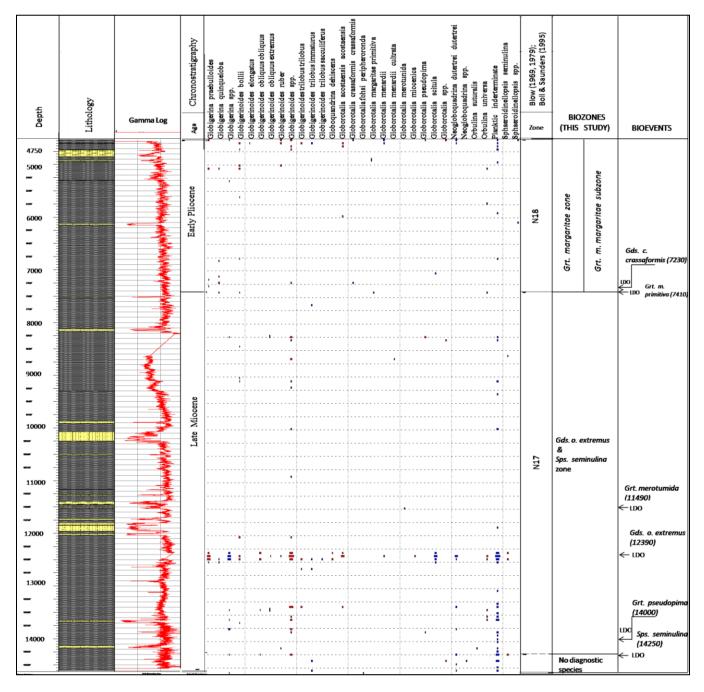


Figure 4: Planktic Foraminiferal Distribution Chart for Well B. Legend as in fig. 3

Depth	Litholo g y	Gamma Log	re Chronostratigraphy	Giobigerina bulloides Giobigerina nepenthes Giobigerinaprae bulloides	bigerina suurduerooa bigerina spp.	bigerina venezuelana bigerinta naparimensis		Globigerinoides obliquus obliquus Globigerinoides obliquus extremus	quandrilo		trilobus		orotalia	orotalia ci	borotalia margaritae margaritae borotalia margaritae primitiva	orotalia m m m m m m m m m m m m m m m m m m m	orotalia	orotalia	borotalia pseudopima	borotalia spp. (menardiform) borotalia spp.	borotana spp. borotalia tumida tigerina siphonifera	ogloboquandrina dutertrei dutertrei ulina blobata	ulina spp. ulina suturalis	ulina universa Nicic indeterminate	sphaeroidineilopsis disjuncta Sphaeroidineilopsis seminulina I Sphaeroidineilopsis spp.	Blow (1969, 1988); Boll & Saunders (1988)	1	ZONES		
	Ľ		Age				100		100	1010	000	000									1 O D D	S G	ā ā ō ō	Plan	r das das s das	Zone	(THIS	STUDY)	BIOEVENTS	
6000 er er		A CONTRACTOR OF A CONTRACTOR A CONTRACT	Early Pliocene				•									· · · · · ·					1			•		N18	Grt. m. margaritae Zone	Grt. m. margaritae subZone	Grt. m. margaritae (6780)	
												•		•						-	· ·								<u>←</u> LD0 ←	
er er 197 9000 227			Late Miocene	Late Mioce					•							1	· · · · · · · · · · · · · · · · · · ·				1					•	N17	Gds. o. extremus & Sps. seminulina zone		Grt.pseudopima (8880) ← LDO
597 - 10000								, 	l. 1 1 1		1 1 1 1		1 1		1	1			1 1.1			r	·····			7			Gds. o. extremus Sps. seminulina (10245) ← LDO	
827 8537 111000 1027					-						1								1 				1	· ·	· · · · · · · · · · · · · · · · · · ·		No diagno: species			

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

Depth	GammaLog	Lithology	Age Chronostratigraphy	"Cassigerinella spp Globigerina praebulloides Globigerina spp.	Gobigerina variational Gobigerinita haepamaensis Gobigerinoides bolli Giobigerinoides bulloides Giobigerinoides obliquus extremus	Giobigerinoides trilobus immaturus Giobigerinoides obliquus obliquus Giobigerinoides quadrilobatus Giobigerinoides ruber Giobigerinoides rubeus saccuilferus	dionigerinoudes spp. Globigerinoides trilobus trilobus Globiquadrina altispira Globiquadrina dehiscens Globorotalia acostaensis acostaensis Globorotalia humerosa humerosa	Globorotalla margaritae margaritae Globorotalla merotumida/plesiotumida Globorotalla merotumida/plesiotumida Globorotalla pseudopima Globorotalla setula Globorotalla spt. Globorotalla spt. Hastigerina spp.	Neogloboquadirina dutertrei dutertrei Orbulina universa Planktonic indeterminate Sphaeroidinelopsis seminulina Turborotalia fohsi peripheroacuta Turborotalia spo. Sovis Blow (1965, 1979); ZONES Blow (1965, 1979);	BIOZONES (THIS STUDY)	BIOEVENTS
6500 6750 ⁻	M. Howard									No diagnostic species	
7000°	An and the second second second	3. 0	Early Pliocene						1	Grt. margaritae zone Grt. m. margaritae subzone	Grt. m. margaritae (7620)
7789 - 8000 - 8389 - 8500 8789 - 9500 9500 9500 9789 - 10000 -	al series of the se									ତି ହ Gds. o. extremus & Sps. seminulina zone	← 100 ←
102207 - 10500 107567 - 110067 - 112207 - 122007 - 122207 - 12200	MM AND		Late Milocene							Grt. a. acostaensis zone	Grt. a. acostaensis (12400) ← LDO

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 *Globorotalia 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 Sphaeroidinellopsis 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*, *Globigerinoides obliquus obliquus*, *Globorotalia pseudopima*, *Neogloboquadrina dutertrei*, *Sphaeroidinellopsis 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 *Sphaeroidinellopsis seminulina* were used as nominate species for the subzone. *Globigerinoides obliquus extremus* and *Sphaeroidinellopsis 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*, *G.bolli*, *G.immaturus*, *Globigerina praebulloides* and *Globorotalia 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).

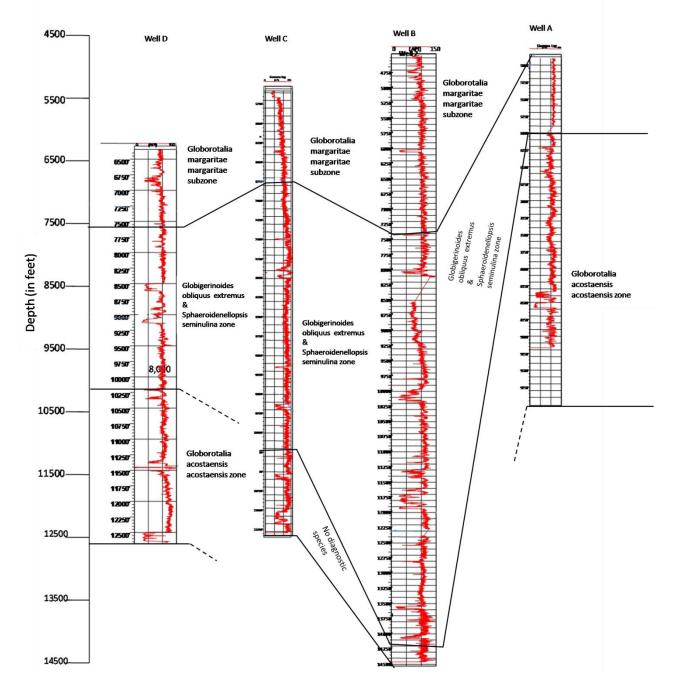
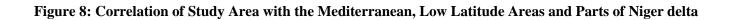


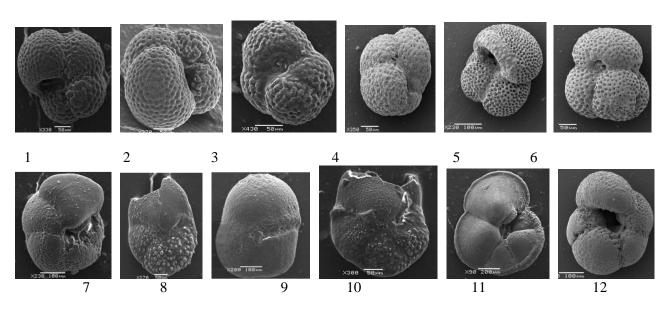
Figure 7: Correlation of Planktic Foraminiferal Zones in the Studied Wells

Ma	Cande & Kent (1992), Benggien et al. (1995)		Kent Berggien	Blov	r 1969, 1979 (modified)	Laccarin Laccaring & Sal	e 1895 Instanta 1987	Barsetti et al., 1979 Mediteurnean	Bellick		er Delta	This Study	
0 -	+				(7-1	Medite Grt. trancabilinoide		Get trancabilinoides	Bolli & Saunders, 1989 Low Latitudes	Adeniran, 1997	Obaje and Okosun, 2013		
	PLEISTOCENE	EARLY		N22	Globorotalia truncatulinoides Consecutive range Zone		5 KIL 815/2	excelsa		11111			
	PLEIST	1				Glg. cariacoansis Grt. inflata		Gig. cariacoansis					
1.8 -	+ $+$ $+$ $+$			N21	Gri. tosaensis tennitheca range Zone	Grt. aemiliana		Gri. inflata G. er. gr. crassaformis	•	//////			
		Ĩ	PIACENZIAN	N20	Gri multicamerata Pul obiquiloculata Partial range Zone	Gri. practiculain		crassāformis Grt. puncticulata	•				
	PLICCENE					Grt. Puncticulata - C	int margaritae			Hastigerina sp. Partial Range			
	2	<u> </u>	ZANCLEAN	N19	Spa. dehiscons G. altispira Faunal range Ione	Grt. margaritae		Gri. margaritae		Zone			
5 -	Ł_	EARLY	ZANC	N18	Grt. tumidas. s.– Sps. seminulina Partial Zone	Spharoidinallegisis se	eminulina s. I.	Spheroidinellopsis				Grt. m. margaritae	
			×		Get nlajotunida	No-distinctiveZone Grt. conomiozaa		Atypical zone Grt. Conomiczeo/Grt				subzone	
			ESSINNIAN	N17	Grt. pleiotumida Conisecutive range Zone			ConomizeerGri mediterranea				Gds. o. extremus & Sps. seminulina	
		Ĩ	<u> </u>	N16	Grt. acostaensis- Grt. merotumida Partialrange Zone	Gds. oblignus actranus	Grt. suterne Gds. oblignus extremus—G. bulloides	Grt. merotumida		Gds. ruber seigliel interval Zone		zone	
			TORTONIAN			Grt acostaensis	1	Grt. acostaensis		No diagnostic foranti Gets. ruher-	Gds. extremus	Grt. q. acostaensis zone	
10 -	t			N15	Gri. continuosa Consecuive range	Grt. menardiis. I.					Grt. obliquus		
				N14	Zome Gig: nephenihes- Gri: miyeri Concurrent range Zone		Gri siakensisGek. oblignus	Gds. obliquus	Grt. mayeri zone	Gets. ruber– Gets. oblignus Concurrent range Zone	-		
			z	N13	Sps. seminulina- Glg. drurvi		Gds. subquadratus		Gds. ruber zone		Gds. subquadratus		
			SERRAVALLAN	N12	Partialrange Zone Gri. foshi s.s. Partialrange Zone	Grt sinkensis		ł	Grt foshi rubosa	(//////			
		MIDDLE	SERR	N11	Grt. praefoski Consecutivelrange Zone		Glą, altispira altispira	Orbulina universa	rubosa Grt. foshi labata	///////			
	MICCENE			N10	Grt. paripharoacula Conisecultvelrange Tama		Grt. praemenardii- Grt. pheripheronda		Grt foski foski	Orbulinasuturalis- Abundanire Zone			
15 -	- ₹				Orbulinasuturalis- Gri. peripheroronda Partialrange Zone	Orbulina suturalis Grt. pheripheronda	Orbulina universa		100 Television (100 met 2020)				
				N9			Orbulina suturnits	Orbulina suturalis	Grt. foshi pharipharonda				
			LANDHIAN	N8	Gds, bisphaericus- Globigerinatella insuela Partialranye Zone	Praeorbulina glome	rosa s. I.	Praeorbulina.sp.					
				N7	Globigerinatella insueta-Gds. trilobus Partialrange Zone	Globigerinoides trilob	*	<u>G. sicanus</u>		Gds. trilobus s. I. Concurrent range Zone			
20 -	Ť	2	BURDIGALIAN	N6	Globigerinatella insueta-Catapsydrax dissimilis Partialrange Zone		Gels, altiaperturns- Ctd. dissimilis	- Gds. trilobus					
		EARLY	Ē	N5	Glq. dehiscens	Glq. dehiscons dehiscons-	CIA ALSONIAS						
					deniscens s.s.	Catapsydran dissimilis		G.woodi/Gds. altiaperburns					
25 -			AQUITANIAN	N4	Gds.primordius-Get Ingleri Consecutivelrange Zone		Glq. dekiscens dekiscens-	Gds. primordius		Gels. primordius- Gels. trilobus Concurrent range Zone			
22	OLIACC.	LATE		NP22	Gig: angulisu turralis	Globoratalia kuglari		G.gr. trīpartia		Cassigerinellar hipotensis- Globigerinacf. Ciperoensis Zone			
	<u> </u>	1	K	īv	I			I					
				ı) ¹	Details not to scale)	ted							
			1	/////									



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
 - 11 Gioborolalla menaral Dolli alla Defilidaez
 - 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.

References

- Adegoke, O. S., Dessauvavagie, T. F. J., & Kogbe, C. A. (1971). Planktonic foraminifera in Gulf of Guinea sediments. Micropaleontology Bulletin, 17 (2), 197 213.
- Adeniran, B.V. (1997). Quantitative Neogene Plankton Foraminiferal biostratigraphy of western Niger Delta, Nigerian Association of Petroleum Explorationists Bulletin, 12 (1), 54-69.
- AGIP, S.P.A. (1982). Foraminifera Padani (Terziario E Quaternario) Atlante Iconografico E Distbuzione Stratigraica. Seconda Edizione, 52 plates.
- Allen, J. R. L. (1964). Sedimentation in the modern delta of the River Niger, West Africa. Sedimentology, 1, 26-34.
- Armentrout, J.M. (1990). Patterns of Foraminiferal abundance and Diversity Implications for Sequence Stratigraphic Analysis. In Sequence stratigraphy as an Explorational Tool, Concepts and Practices in the Gulf Coast Section SPEM Foundation Eleventh Annual Research Conference Program and Abstracts, 21, pp. 53 – 58.
- Armentrout, J. M. (1991). Paleontological constratints on depositional modelling, examples of integration of biostratigraphy and seismic stratigraphy, Gulf of Mexico. In Weimer, P. & Link, M. H. (Eds.), Seismic Facies and Sedimentary Processes of Submarine Fans and Turbidite Systems, Springer- Verlag, Frontier in Sedimentary Geology series, 137 – 170.
- Avbovbo, A. A. (1978). Tertiary lithostratigraphy of Niger Delta. American Association of Petroleum Geologists Bulletin. U.S.A., 62, (2), 295 300.
- Berggren, W. A., Kent, D.V., Swisher, C.C., & Aubry M. (1995). A Revised Cenozoic Geochronology and Chronostratigraphy. In Geochronology Time Scales and Global Stratigraphic Correlation, SEPM Special Publication, 54, pp. 129 211.
- Blow, W. H. (1969). Late Middle Eocene to Recent planktonic foraminiferal biostratigraphy. In Bronnimann, P. & Renz, H. H. (eds.), Proceedings of the First International Conference on Planktonic Microfossils, Geneva, E. J. Brill, Leiden, 1., 199 422.
- Blow, W. H. (1979). The Cenozoic Globigerinida, E. J. Brill Leiden, I., 3, 1413.
- Bolli, H. M. (1957). Planktonic foraminifera from Oligocene to Miocene, Cipero and Lengua Formations of Trinidad, B. W. I., United States Natural History Museum Bulletins, 215, 97-127, 22 29.
- Bolli, H. M., & Saunders, J. B. (1985). Oligocene to Holocene low latitude planktic foraminifera. In Bolli, H. M., Saunders, J. B., & Perch-Nielsen, K. (Eds), Plankton Stratigraphy, Cambridge Earth Sciences Series, Cambridge University Press, pp.165-262.
- Borsetti, A. M., Cati, F., Colalongo, M. L. and Sartoni, S. 1979. Biostratigraphy and absolute ages of Italian Neogene. Ann. Geol. Hellen., 7th International Congress of Meditterrranean Neogene, Athens, 183-197.
- Doust, H. and Omatsola, E. 1990. Niger Delta. In Edwards, J. D and Santogrossi, P. A. (Eds.) Divergent/Passive Margin Basins, American Association of Petroleum Geologists Memoir 48, 201-239.
- Haq, B. U., Hardenbol, J., & Vail, P. R. (1987). Chronology of fluctuating sea levels since the Triassic. Science, 235, 1156 1167.
- Iaccarino, S. 1985. Meditterranean Miocene and Pliocene planktonic foraminifera, In: Bolli, H. M., Saunders, J. B. and Perch-Nielsen, K. (eds.), Planktonic Stratigraphy. Cambridge Press, 115-125.
- Iaccarino, S. and Salvatorini, G.1982. A framework of planktic foraminiferal biostratigraphy for Early Miocene to Late Pliocene Meditterranean area. Paleontology Stratigraphy Evolution, vol. 2, 115-125.
- Obaje, S. O. & Okosun, E. A. (2013). Planktic Foraminiferal Biozonation and Correlation of ZY-1 Field, Western Niger delta, Nigeria. International Journal of Science & Technology, vol. 3, (3), 160-166.