

Biostratigraphy of Ochigbo–1 Well, Offshore Niger Delta; Evidence from Foraminifera, Spores and Pollen

ABSTRACT:

This study involved the palynological and micropalaeontological studies of Ochigbo – 1 well, offshore Niger Delta. A total of Sixty-two (62) ditch cutting samples were composited at intervals of 100ft covering a total depth of 7,235ft (3,405-10,640ft). The samples were subjected to standard procedure for palynological and micropalaeontological studies. The recovered palynomorph and the foraminiferal assemblages were rich over the intervals and were generally good to moderate, both diverse and well preserved. The recovered palynomorphs were used in establishing four palynological zones. These are: *Crassoretitritiles vanraadshooveni*/P700 Zone characterized by the quantitative base occurrence of *Crassoretitritiles vanraadshooveni* and co-occurrence of *Belskipollis elegans*, *Crassoretitritiles vanraadshooveni*, *Echiperiporites estalae*, and *Verrutricolporites rotundiporus*; dated Middle Miocene; *Magnastriatites howardii*/P600 Zone characterized by quantitative base occurrence of *Peregrinipollis nigericus* and co-occurrence of *Praedapollis flexibilis*, *Magnastriatites howardii* and *Monoporites annulatus*; dated Early Miocene – Late Oligocene; *Retibrevitricolporite obodoensis/protudens*/P500 Zone characterized by the co-occurrence of *Arecipites exilimuratus*, *Retibrevitricolporite obodoensis/protudens*, *Verrucatosporites usmensis* and *Gemmamonoporites sp* dated Late – Early Oligocene and *Racemonocolpites hians*/P400 Zone characterized by the base occurrence of *Racemonocolpites hians*. The recovered foraminiferal assemblages revealed the well to have penetrated through the N16-N15 (*Uvigerina subperegriana*) Zone (Late – Middle Miocene), N15-N14 (*Spirosigmolina oligocaenica*) Zone; dated Middle Miocene; N13-N11(*Uvigerina sparsicostata*) Zone; dated Middle Miocene; N5-N4 (*Megastomella africana*) Zone: dated Early Miocene; N2 (*Spiroplectammina wrightii*) Zone; dated Late Oligocene;P18-P15 (*Hopkinsinna bononiensis*) Zone; dated Early Oligocene; P14-P12 (*Uvigerina hourqi*) Zone; dated Late Eocene; P12 (*Uvigerina havanensis*) Zone; dated Late – Middle Eocene; P5-P6/P7 (*Lenticullina pseudomamillegarus*) Zone; dated Early Eocene – Late Palaeocene and ?M18 (*Bolivina afra*) Zone; dated Maastrichtian – Late Campanian. The palaeoclimatic investigation from the recovered palynomorph and foraminifera assemblages revealed dominantly wet climatic environment which ranges from brackish to

33 deep marine environments subjected to transgressive – regressive alternating environment
34 covering Inner Neritic to Upper Bathyal settings.

35 **Key words:** Foraminifera, Palynomorph, Stratigraphy, Niger Delta, Micropalaeontology,
36 Palynology

37 1. INTRODUCTION

38 One of the earliest foraminiferal studies in the Niger Delta region was carried out by [1]. He
39 identified species such as *Miliolina*, *Tuncatilina*, *Textularia*, *Bolivina*, *Globigerina*,
40 *Lenticulina* and *Buliminina*. He also proposed a shallow water environment for them. The
41 most comprehensive palynological research work was carried out by [2] on some Tertiary
42 sediment from the world's tropical areas. It is largely a comparative study of palynomorphs
43 of Tertiary sediment from tropical South America, Asia and West Africa. Maximum
44 abundance as well as diversity of foraminifera and mangrove palynomorphs coupled with
45 maximum diversity of coastal plant pollen grains enhances the recognition of maximum
46 flooding surfaces and their condensed section, such analysis facilitates better understanding
47 of different facies relationship within sequences [3] in the Niger Delta. The use of integrated
48 data involving the use of palynological and foraminiferal study is applied for this study so as
49 to provide high resolution information on the biostratigraphy and palaeoenvironments.
50 The Niger Delta, an epicontinental marginal sag basin and petroliferous province is located in
51 the southernmost part of Nigeria. It comprises regressive wedge of clastic sediments which
52 reaches maximum thickness of about 12km and represents the most significant hydrocarbon
53 province in the West African continental margin. With proven reserve of thirty billion barrels
54 of oil and two hundred and sixty trillion cubic feet of natural gas, ranks the Niger Delta as
55 one of the world's major hydrocarbon provinces [4, 5] (Figs 1 and 2).

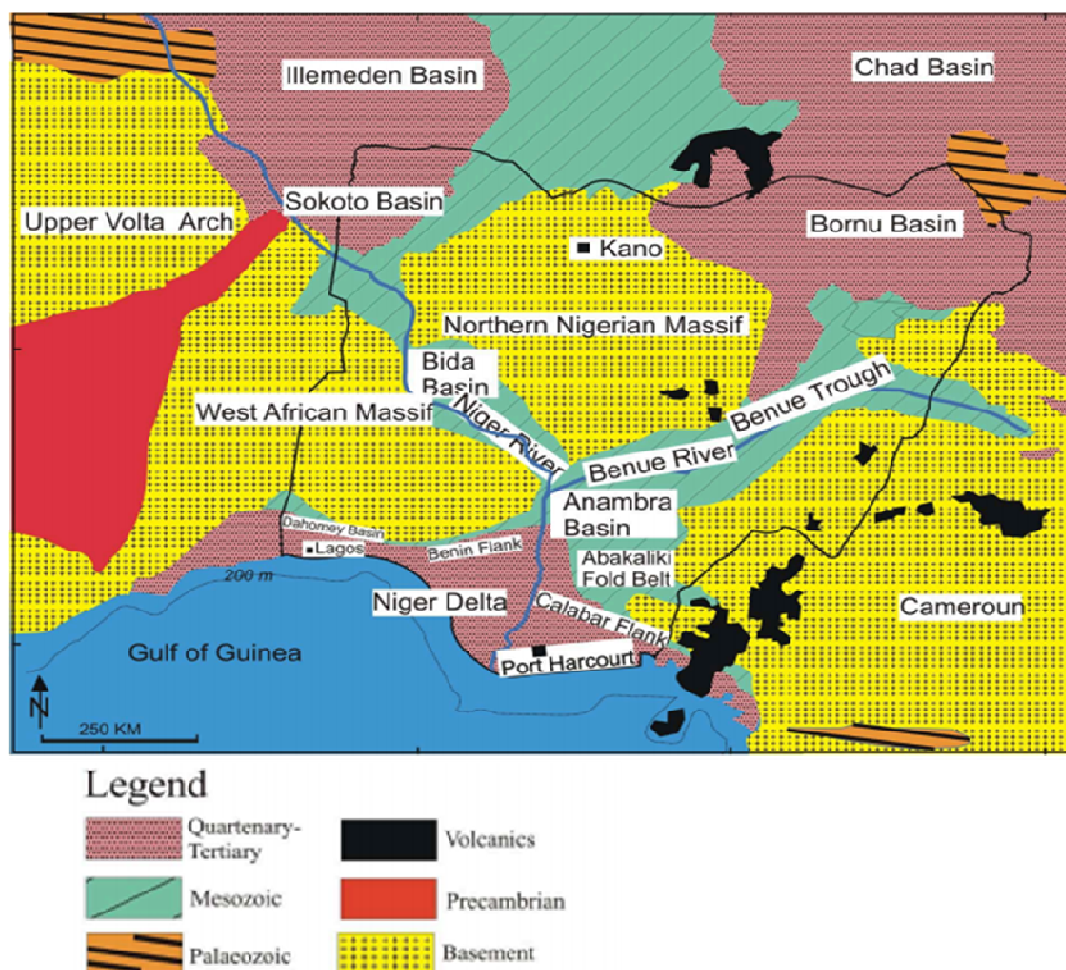


Fig. 1: Simplified geological map of Nigeria showing the location of the Niger Delta Basin and some other basins in Nigeria.[Modified after 6].

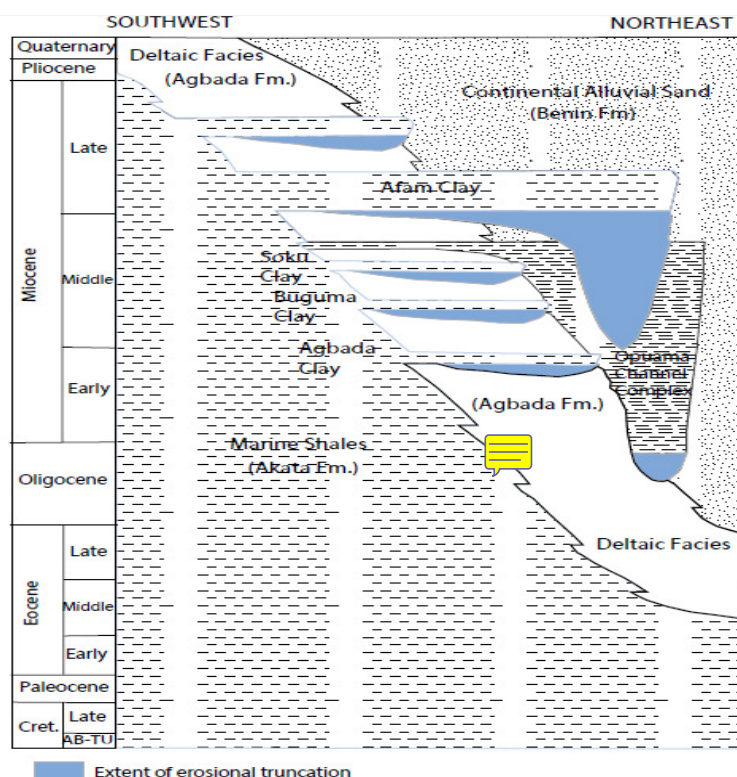


Fig. 2: Stratigraphic column showing three formation of the Niger Delta: Akata, Agbada and Benin Formations [7]

2. Material and Methods

Sixty-two ditch samples from Ochigbo-1 well, offshore Niger Delta. The samples were composited at intervals of 100ft at total depth of 7235ft (3405-10,640 Ft).

2.1 Lithologic Description

The lithology was described using the standard sedimentological approach from the ditch cuttings description. The total thickness of the analyzed interval is 7235 ft. The lithologic description involved the physical observation of the sample with a hand lense.

2.2 Palynological Analysis.

This analysis followed standard procedure for the palynological analysis. The samples were weighed to about 10gm, soaked overnight in Hydrofluoric acid (HF), and stirred intermittently for effective digestion. To completely remove the fluoro-silicate compounds that usually form from the reaction with HF, the content was again treated with warm 10% HCl and finally completely neutralized with distilled water. This is followed by sieving process with 5µm mesh in order to remove clay particles present, enhance collection of the debris and to achieve clean slide making. The retrieved debris of the samples was mildly oxidized, followed by heavy mineral liquid separation of the macerals using Zinc bromide

(ZnBr₂) at 2.1g/cc. The collected residue was mounted on glass slides with DPX. The preparation method was in accordance with standard methods. Photomicrographs of diagnostic species were taken with Nikon Koolpix P6000 digital camera; abundance of pollen, spores, dinoflagellates, fungal spores, and other stratigraphically significant forms present were determined for each sample.

Foraminifera Analysis

Standard weights of each sample were disaggregated and were soaked in liquid soap overnight to allow for further disaggregation. The disaggregated samples were then washed under a shower of water over a 63 microns sieve. The washed residue were then dried over a hot plate and sieved into three fractions prior to the picking of the foraminiferal contents. The foraminiferal contents and other microfauna were picked using a picking brush under an Olympus binocular microscope. Foraminiferal and other microfauna were picked, counted, placed in foraminiferal slides and covered with cover slide for safety and future reference. The slides were properly labeled using both the sample name and interval depths. Micropalaeontological analysis was carried out by identifying the foraminiferal species under light binocular microscope with the help of relevant manuals. The micropalaeontological and statistical data were plotted using the Stratabug software and photomicrographs of the identified foraminiferal species were made.

Quantitative analysis were made and provided on the charts as follows;

- Total foraminifera abundance per sample expressed in absolute number of individuals
- Total foraminifera diversity expressed in absolute number of species
- Total abundance and diversity of both planktic and benthic foraminifera

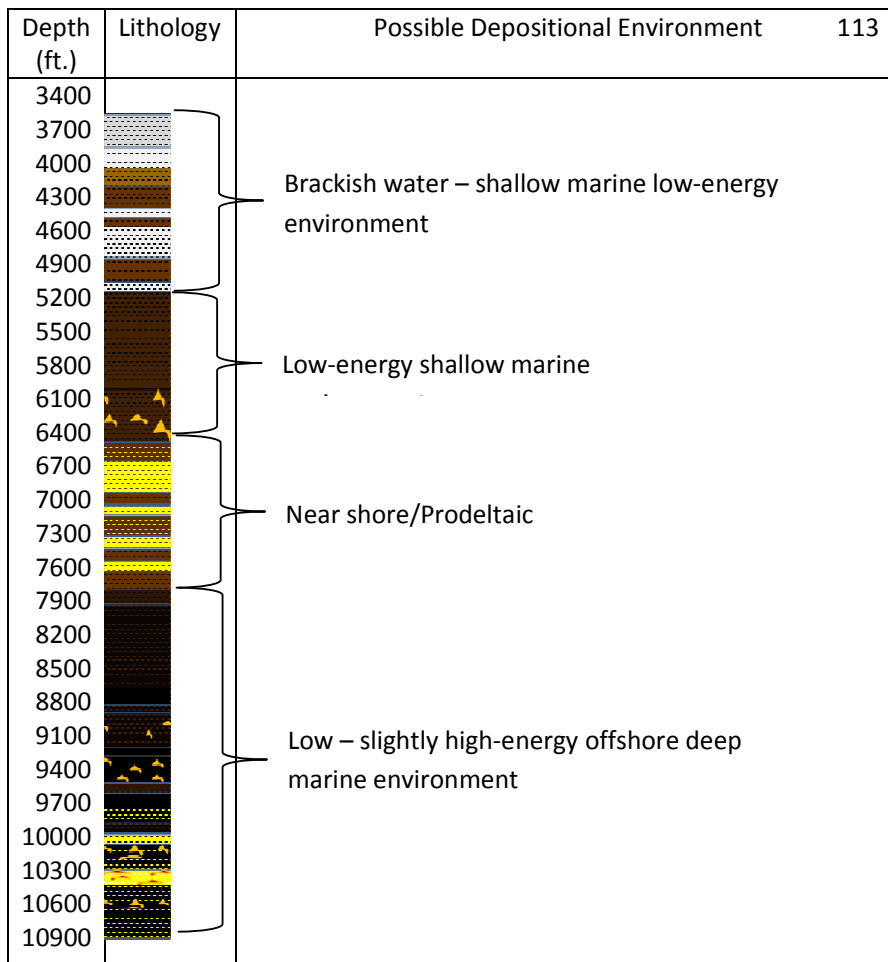
3. RESULT AND DISCUSSION

3.1 Lithologic Description

The samples are mainly shale, fissile and intercalations of whitish sandstone unit.

The observation revealed that the studied well is largely made up of a sequence of fine-grained shale alternating with fine to medium grained sandy shale in the lower part (Fig. 3).

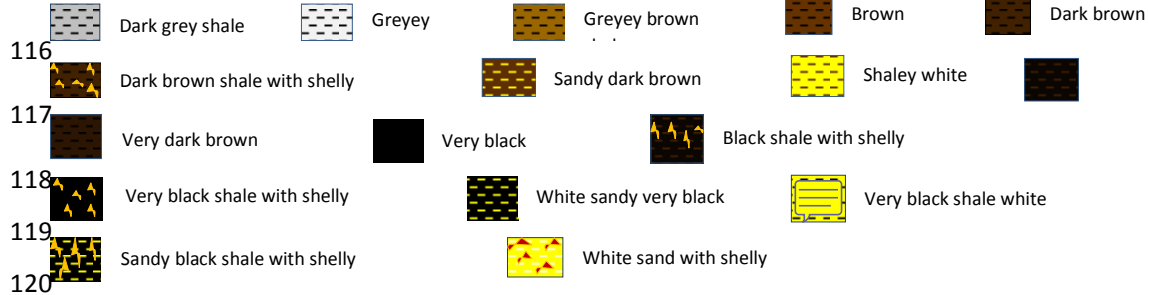
The observed colour in the shale is grey to black while the sandy is white.



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123 Fig. 3: Lithostratigraphy of Ochigbo – 1 well

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126 3.2 Palynostratigraphy

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Palynological zonation of the well is based on the palynofloral assemblages of significant species as well as their stratigraphic distribution with reference to the zonation schemes of Evamy et al. [8]. The section of the well analyzed has been broadly assigned to the *Crassoretitritiles Vanraadshooveni* /P700 Zone, *Magnastriates Howardii* / P600 Zone, *Retribrevitricolporites Obedensis/Protundens* / P500 Zone and *Racemonocolpites Hians* / P400 Zone. The zones are further subdivided into the P740, P720, P680- P670, P650, P630, P620- P580, P560, P540, P520 and P420 subzones. The well section under study is assigned late Eocene to middle Miocene based on the evidence of the palynological study (Fig. 4 and Table 1). Descriptions of the identified palynological zones are provided below (Fig. 10);

***Crassoretitritiles vanraadshooveni*/P700 Zone**

Subzone: P740 (3,460 –5,080ft) **Assigned Age:** Middle Miocene

Definition: The subzonal top is probably shallower than the first sample analysed at 3,460ft and the base is defined by the rich occurrence of *Belskipollis elegans* at 5,080ft.

Characteristic Features: The occurrence of *Belskipollis elegans* occurs in higher quantities and also regular within the subzone while *Echiperiporites estalae* exhibits higher percentage than underlying subzone and *Verrutricolporites rotundiporus* shows top regular, quantitative and/or top rich occurrence and is found throughout the subzone.

Subzone: P720 (5,080 – 5,320ft), **Assigned Age:** Middle Miocene

Definition: Top marked by the quantitative base rich occurrence of *Belskipollis elegans* at 5,080ft while its base is defined by the base occurrence of *Crassoretitritiles vanraadshooveni* at 5,320ft.

Characteristic Feature: *Belskipollis elegans* occurs in low frequencies.

***Magnastriatites howardii*/P600**

Subzone: P680 - P670 (5,320– 5,800ft) **Assigned Age:** Early - Middle Miocene.

Definition: The top of the composited subzone is defined by the base occurrence of *Crassoretitritiles vanraadshooveni* at 5,320ft and its base marked by the quantitative base occurrence of *Magnastriatites howardi* at 5,800ft.

Characteristic Features: *Magnastriatites howardi* occurs in high percentages while *Racemonocolpites hians* shows an increase compared with the overlying subzone and *Monoporites annulatus* has a base rich occurrence in this subzone.

159 **Subzone: P650** (5,800 –5,920ft), **Assigned Age:** Middle Miocene.

160 **Definition:** The Top is defined by the quantitative base occurrence of *Magnastriatites*
161 *howardi* at 5,800ft while its base is defined by increase occurrence of *Praedapollis flexibilis*
162 at 5,920ft.

163 **Characteristic Features-** The presence of *Verrucatosporites usmensis* and *Arecipites*
164 *crassimuratus* exhibit low percentages in this subzone while *Spirosyncolpites brauni* has a
165 quantitative top within this interval.

166 **Subzone: P630** (5,920 –6,280ft), **Assigned Age:** Early Miocene.

167 **Definition:** The top is defined by increase *Praedapollis flexibilis* at 5,920ft and the base is
168 marked by top occurrence of *Praedapollis africanus* at 6,280ft.

169 **Characteristic Features:** It is characterized by the occurrence of *Verrucatosporites usmensis*
170 and *Arecipites exilimuratus* show a top regular occurrence while *Praedapollis flexibilis* and
171 *Peregrinipollis nigericus* exhibit high frequencies than the overlying subzone P650, also the
172 presence of *Zonocostites* and *Psilatricolporites crassus* and the absence of *Praedapollis*
173 *africanus*.

174 **Subzone: P620 – P580** (6,280 –6,780ft), **Assigned Age:** Late Oligocene.

175 **Definition:** The top of the composited subzone is marked by the top occurrence of
176 *Praedapollis africanus* at 6,280ft and the subzonal base is defined by the quantitative base of
177 *Peregrinipollis nigericus* at 6,780ft.

178 **Characteristic Features:** *Retibrevitricolporites obodoensis* occurs as frequent as in the
179 underlying subzone P560 while *Praedapollis flexibilis* and *Striatricolporites catatumbus* are
180 present in abundant and *Peregrinipollis nigericus* occurs in moderate quantities. The presence
181 of *Praedapollis africanus* in single specimen only at the upper part characterized the subzone
182 boundary.

183 ***Retibrevitricolporite obodoensis/protudens/P500***

184 **Subzone: P560** (6,780 – 6,910ft), **Assigned Age:** Late Oligocene

185 **Definition:** The top is defined by the quantitative base *Peregrinipollis nigericus* at 6,780ft
186 while the base is marked by the increase in *Retibrevitricolporites obodoensis/protrudens* at
187 6,910ft.

188 **Characteristic Feature:** *Cinctiperiporites mulleri* and *Retimonocolpites asabaensis* have a
189 quantitative top occurrence within the interval.

190 **Subzone: P540** (6,910 – 7,150ft), **Assigned Age:** Early Oligocene

191 **Definition:** The top is defined by the increase in *Retibrevitricolporites*
 192 *obodoensis/protrudens* at 6,910ft while its base is marked by the base continuous occurrence
 193 of *Arecipites exilimuratus* at 7,150ft.

194 **Characteristic Features:** *Peregrinipollis nigericus* and *Arecipites crassimuratus* have a base
 195 occurrence at or near the base of subzone.

196 **Subzone: P520** (7,150 – 8,100ft), **Assigned Age:** Early Oligocene

197 **Definition:** Top of the subzone is defined by the base continuous occurrence of *Arecipites*
 198 *exilimuratus* at 7,150ft while its base is marked by base occurrence of *Racemonocolpites*
 199 *hians* at 8,100ft.

200 **Characteristic Features:** *Verrucatosporites usmensis* define the very rich top occurrence
 201 while the percentage of *Gemmamonoporites sp* is high as compared with the overlying and
 202 underlying subzones. The *Praedapollis flexibilis* is present in high quantity throughout and
 203 has a base rich occurrence while *Retimonocolpites hians* shows a quantitative base in this
 204 subzone.

205 ***Racemonocolpites hians*/P400 Zone**

206 **Subzone: P480 & Older** (8,100 – 10,640ft), **Assigned Age:** Late Eocene

207 **Definition:** The top of the subzone is defined by the base occurrence of *Racemonocolpites*
 208 *hians* at 8,100ft while its base is tentatively placed at 10,640ft.

209 **Characteristic Feature:** The paucity of palynomorphs especially pollens and spores within
 210 this interval limits the well to late Eocene. Some of the Dinoflagellates have a very long age
 211 range, therefore it would be difficult to further establish subzones because they are not
 212 markers. Examples are *Senegalinium bioavatum*, *Lingulodinium machaerophorum*,
 213 *Dapsilidinium stelacum*, *Lejeunecysta sp*, and others.

Table 1 PALYNOSTRATIGRAPHY ZONATION OF OCHIGBO-1 WELL
(Done based on the work of 11)

DEPTH	CHRONOSTRATIGRAPHY SERIES	SUBSERIES	PALYNOLOGICAL ZONE EVAMITZ (1978) ZONES	SUBZONES	IMPORTANT PALYNOLOGICAL EVENT
3045					
		MIDDLE MIocene	P700	P740	
5080				P720	Base rich <i>Beliskipollis elegans</i>
5920				P580-P670	Base occurrence <i>Crassoretotriletes vanraadshooveni</i>
5800		EARLY-MIDDLE MIocene	P600	P650	Quantitative base <i>Magnastriolites howardi</i>
5920				P630	Increase <i>Prædopollis flexibilis</i>
6280				P620-P580	Top occurrence <i>Prædopollis africanus</i>
6780	OLIGOCENE - MIocene	LATE OLIGOCENE - EARLY MIocene		P580	Quantitative base <i>Penehnipollis nigericus</i>
6910				P540	Increase <i>Retibrevitricolporites abdicensis/protudens</i>
7150	OLIGOCENE	EARLY OLIGOCENE		P520	Base continuous <i>Araclites extimuratus</i>
8110					Base occurrence <i>Racemonocolpites hians</i>
	OLDER & Eocene	OLDER & Eocene	P400	P480 & OLDER	
10540					TD

Paleoenvironmental Study and Subdivisions

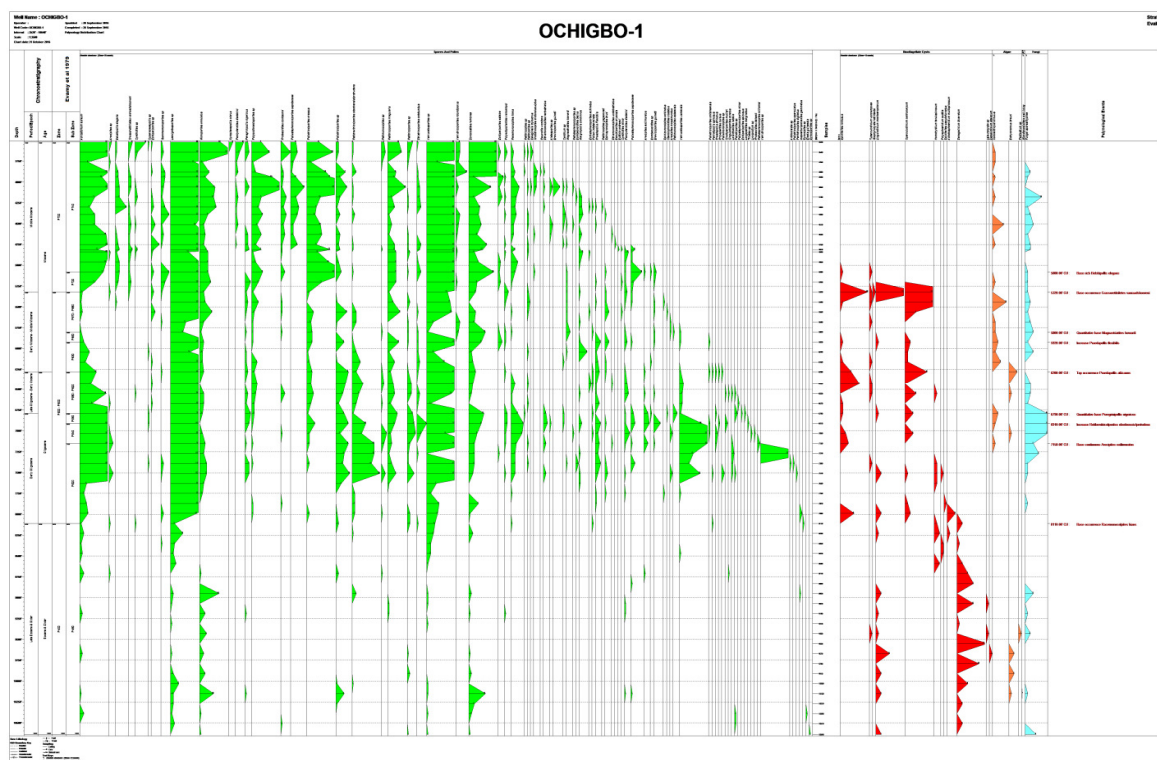
The Upper Paralic Unit (3,405 – 5,200 Feet)

The predominance of mangrove swamp species such as *Zonocostites ramonae*, *Acrostichum aureum*, *Psilatricolporites crassus* *Botryococcus brauni* and pteridophytes spores represented largely by species of *Leavigatosporites* sp., *Verrucatosporites* sp. and *Polypodiaceoisporites* sp. Characterized this interval. Estuarine dinoflagellate cysts such as *Spiniferites ramosus* and *Tuberculodinium vancampoe*, while the spot occurrence of algae such as *Concentricyst circulus* and *Fungi spore* were also recorded. This assemblage is indicative of an estuarine or brackish-water environment.

The Marine-Paralic Unit (5,200 – 6,430 Feet)

The brackish-water swamp species such as *Acrostichum aureum* and *Botryococcus brauni* and fern spores recorded moderate recoveries. Dinoflagellate cysts increased in abundance and diversity than in the overlying interval. The palynofloral

229 assemblage within this interval suggests deposition in environments fluctuating between
230 marine and nearshore.



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232 Fig. 4: Distribution and Abundance chart of Important Palynomorphs in Ochigbo – 1 well

233 **The Lower Paralic Unit (6,430 – 7,510feet)**

234 The proportion of brackish-water swamp species such as *Acrostichum aureum* and *Botryococcus*
235 *brauni* and fern spores are higher than overlying interval (5,200-6,430). Dinoflagellate cysts become
236 increased in abundance and diversity. The palynofloral assemblage within this interval suggests
237 deposition in environments fluctuating between marine and nearshore.

238 **The Marine Unit (7,510 – 10,640 Feet)**

239 The interval between 7,510 and 10,640ft is totally dominated by marine dinoflagellate cysts such as
240 *Tuberculodinium vancampoe*, *Lejeunecysta* sp, *Dapsilodinium stelacum*
241 *Senegalinium bioavatum*, *Polysphaeridium subtile*, *Homotrybulium tenuispinosus*, *Lingulodinium*
242 *machaerophorum* among others. The occurrence of microforaminiferal wall linings and spot
243 occurrence of brackish water species such as *Acrostichum aureum*, *Botryococcus brauni* and
244 pteridophytes spores indicate a deep deposition marine environment.

245 **Palaeoclimatic Study and Subdivisions**

Palynology is now a strong tool used in determining paleoclimatic conditions. The climate of an area is reflected by its vegetation type [9]. The effect of this variation on floral communities depends on whether such a climate change favours or prejudices against the plant community or individual plant in question [10]. These changes in plant community or variation in their composition or abundance of an assemblage or individual species are usually a direct consequence of variation in climate and / or environment of deposition [11]. The method adopted here is widely practiced and advocated by [12], [13] and [14]. [14] articulated the use of palynomorph abundance and diversity in evaluating sea level changes, palaeoenvironment and palaeoclimatic conditions for Cretaceous sediments in Anambra Basin, Nigeria and its utilization for Recent sediments. For this work, three palynomorph variables represented by *Acrostichum aureum* and *Zonocostites ramonae* for mangrove species depicting wet climate against *Monoporites annulatus* representing Savanna species and dry climate are compared on the bases of their abundance (Fig. 5).

Monoporites annulatus

Monoporites annulatus is also the morphogeneric name given to all the pollen species of Poaceae [15, 16], they are known to be very homogenous [17] and widely distributed, which makes it easier for recognition. Increase in *M. annulatus* abundance is often used as indicator of large degree of landscape openness [18, 19], and increased aridity [20, 21].

Acrostichum aureum

The genus, *Acrostichumsporites* morphologically similar to the spores of *Acrostichum aureum* which has been identified as a principal fern presently growing within mangrove vegetation [22, 23, 24, 25] hence, its adaptation in coastal areas associated with mangrove vegetation, areas inundated with saline waters, open salt marshes, coastal swamps and areas along estuarine rivers [25] thus, its use as indicator of wet climatic condition [14].

Zonocostites ramonae

The pollen *Zonocostites ramonae* botanically belongs to the *Rhizophoraceae* [26] therefore increase in the abundance of *Zonocostites ramonae* has been used as an indicator for mangrove vegetation and hence wet climatic condition [27]. As a result of the above, the study well was broken down to four intervals as done above and the paleoclimatic condition of well is done the abundance of *Zonocostites ramonae* (*Z. ramonae*) against *Monoporites annulatus*(*M.annulatus*) and that of *Acrostichum aureum* (*A. aureum*) against *Monoporites annulatus* in each case (Figs 5, 6, 7, 8 and 9).

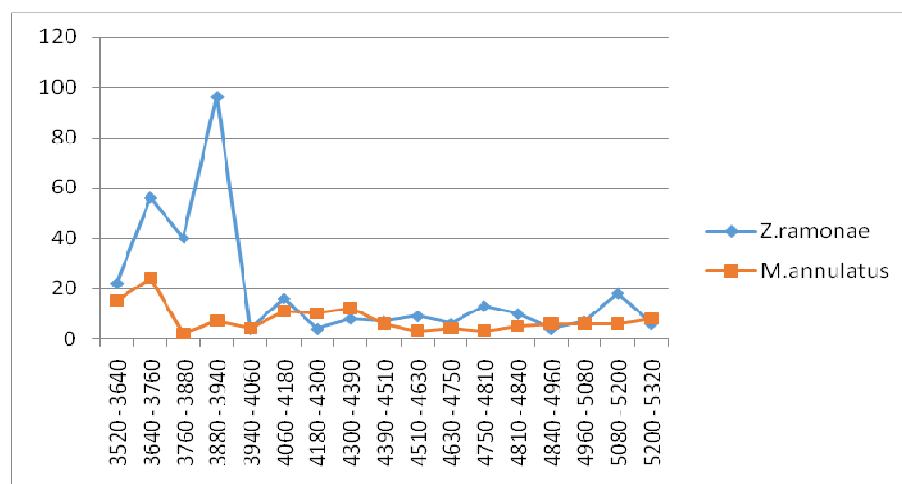


Fig. 5a: Plot of *Zonocostites ramonae* (*Z. ramonae*) against *Monoporites annulatus* (*M. annulatus*) (3,520ft – 5,320ft)

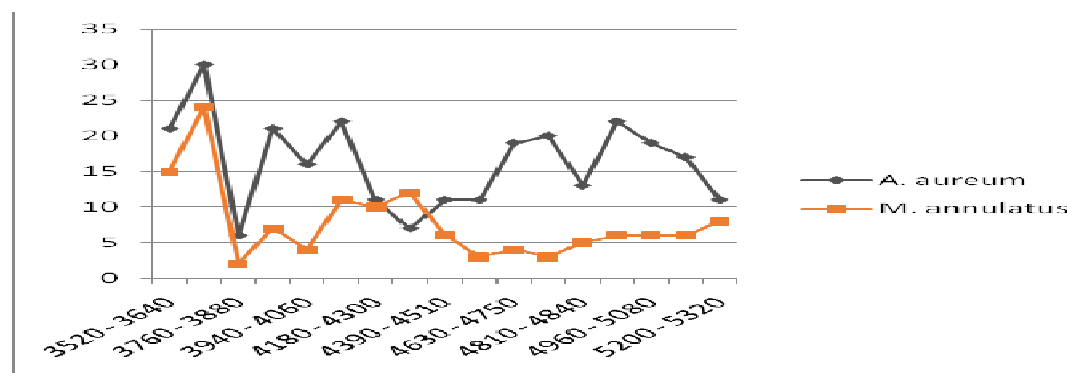


Fig. 5b: Plot of *Acrostichum aureum* (*A. aureum*) against *Monoporites annulatus* (*M. annulatus*) (3,520ft – 5,320ft)

From Figs 5a and 5b above, the dominance in abundance of *Zonocostites ramonae* and *Acrostichum aureum* over the relative abundance of *Monoporites annulatus* established wet climatic conditions for interval 3,520ft to 5,320ft. while the sediments were believed to have been deposited in a mangrove setting.

From figs 6a and 6b, *Zonocostites ramonae* and *Acrostichum aureum* show alternating and relative abundance over one another and thus the the interval revealed and alternating wet and dry climatic condition between 5,320ft to 6,550ft

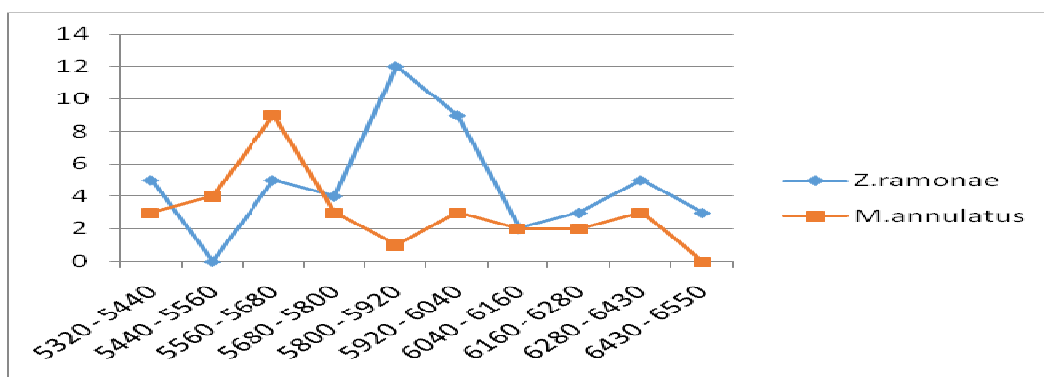


Fig. 6a: Plot of *Zonocostites ramonae* (*Z. ramonae*) against *Monoporites annulatus* (*M. annulatus*) (5,320ft – 6,550ft)

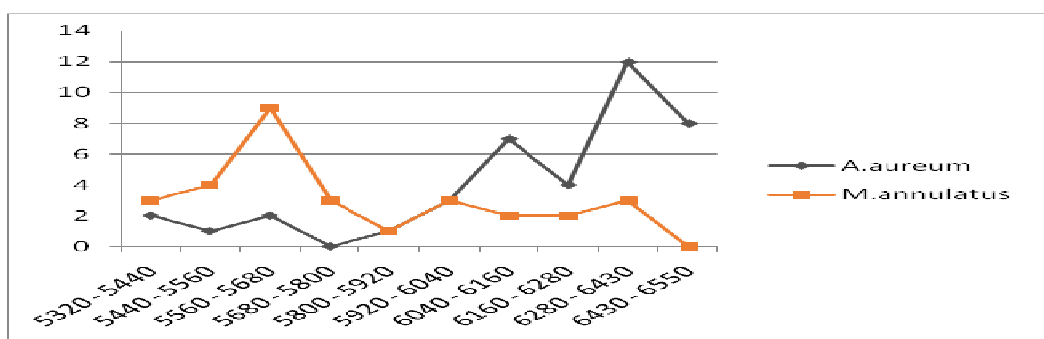


Fig. 6b: Plot of *Acrostichum aureum* (*A. aureum*) against *Monoporites annulatus* (*M. Annulatus*) (5,320ft – 6,550ft)

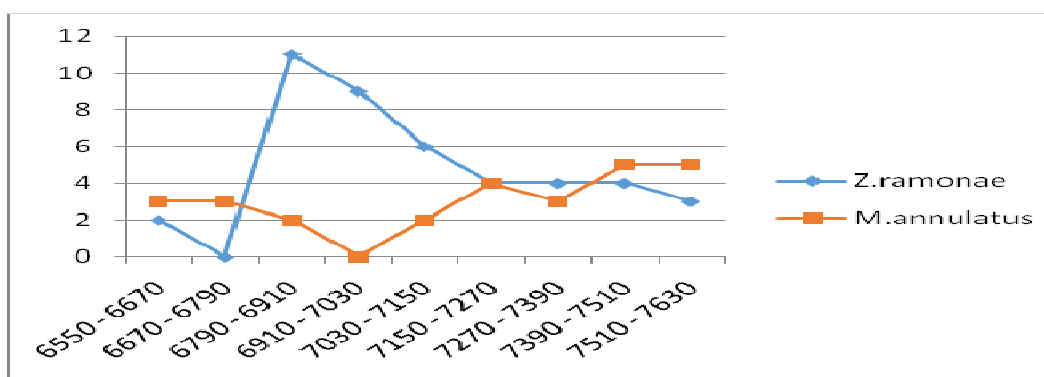


Fig. 7a Plot of *Zonocostites ramonae* (*Z. ramonae*) against *Monoporites annulatus* (*M. annulatus*) (6,550ft – 7,630ft)

In figs 8a and 8b, the abundance of *Monoporites annulatus* rose relatively higher than those of *Zonocostites ramonae* and *Acrostichum aureum* within the interval 9,610ft to 10,640ft favouring a prevailing dry climatic condition.

The summary of the paleoclimatic and paleoenvironmental condition is shown below (Fig. 9)

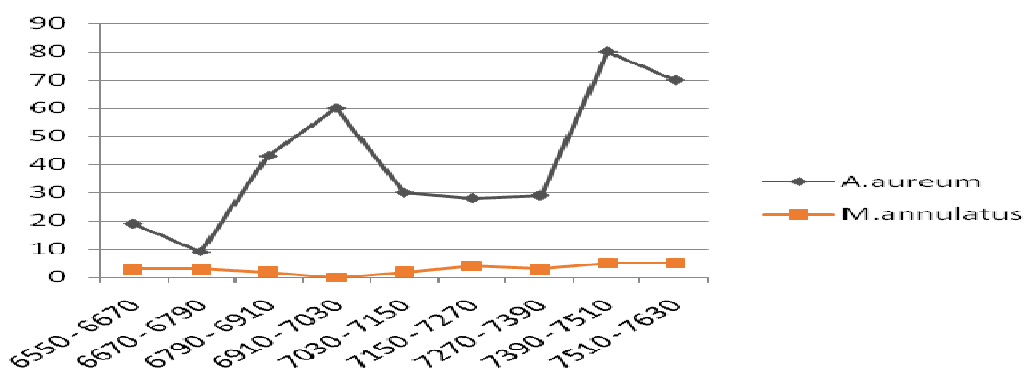


Fig. 7b Plot of *Acrostichum aureum* (A. aureum) against *Monoporites annulatus* (M. Annulatus) (6,550ft – 7,630ft)

The figs 7a and 7b also followed similar trend of wet climatic condition.

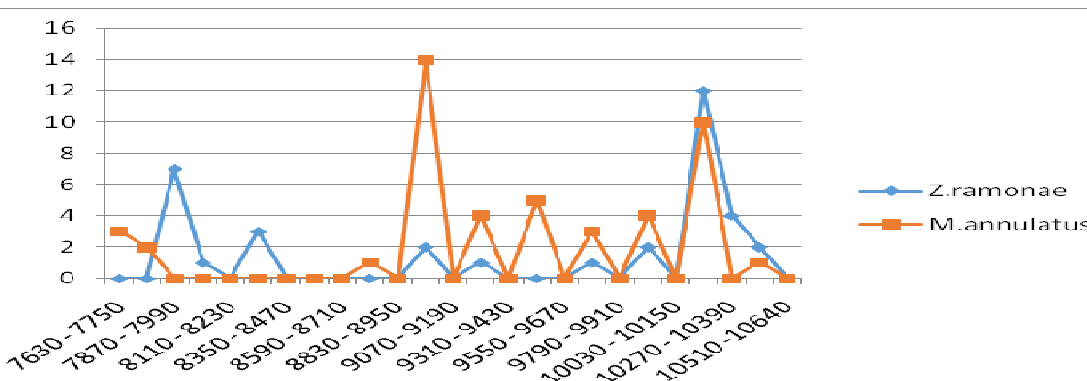


Fig. 8a Plot of *Zonocostites ramonae* (Z. ramonae) against *Monoporites annulatus* (M.annulatus) (7,630-10,640)

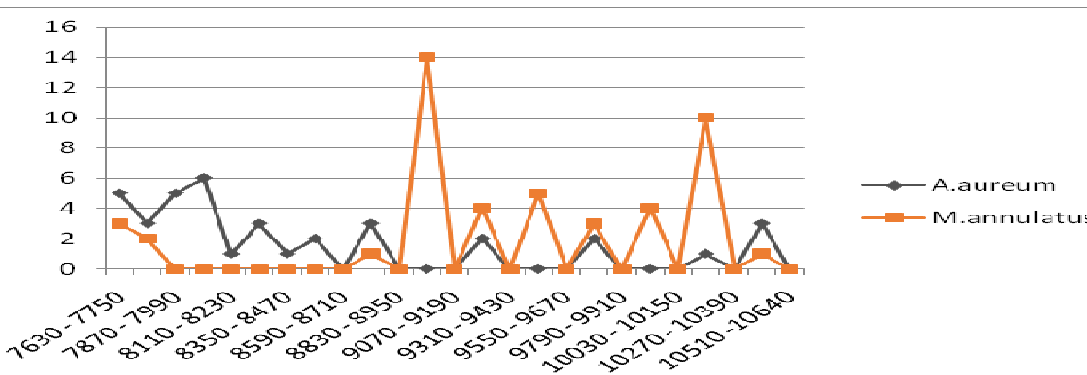
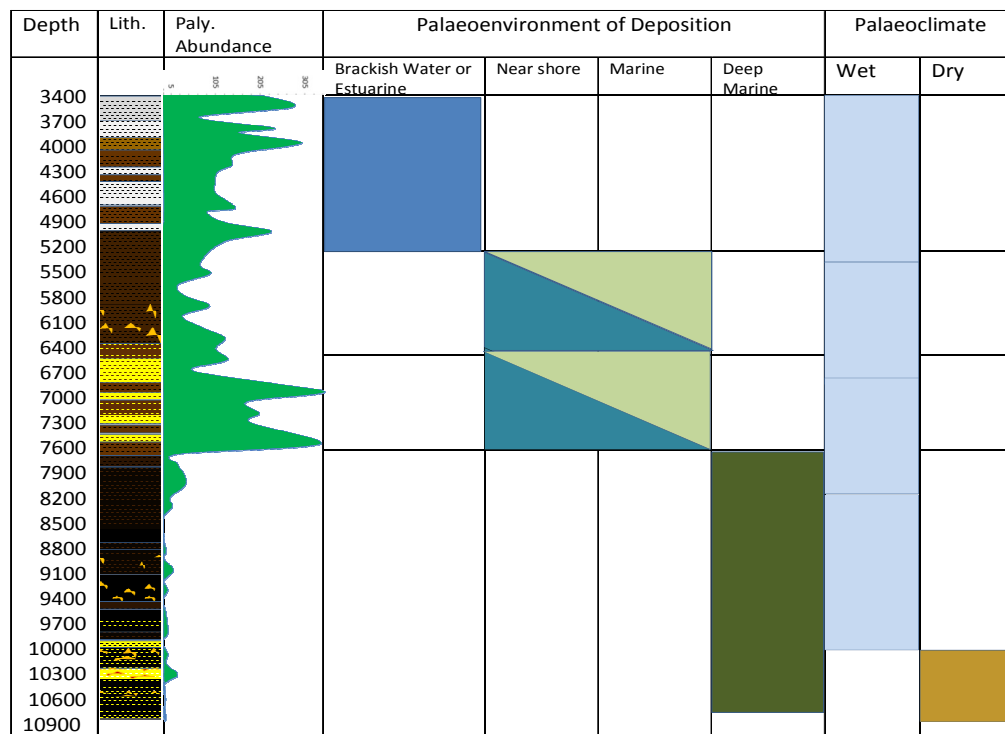


Fig. 8b Plot of *Acrostichum aureum* (A. aureum) against *Monoporites annulatus* (M. annulatus) (7,630-10,640)



LEGEND



Fig.9: Palynomorph abundance palaeodepositional environment and palaeoclimatic settings

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- 364 **Interval:** 3,405 – 3,760ft
- 365 **Planktic zone:** N16 – N15 (*Uvigerina subperegrina*) Zone
- 366 **Age:** late? – middle Miocene
- 367 **Definition:** The top of this zonal interval is placed at 3,405ft (Top of well) while the base is marked at
- 368 3,760ft by the FDO of *Spirosigmoilina oligocaenica*.
- 369 **Features:** The zone /interval are characterized by the co-occurrences of the following foraminiferal
- 370 species viz: *Brizalina mandoroveensis*, *Amphistegina lessonii*, *Uvigerina subperegrina*,
- 371 *Spirosigmoilina oligocaenica*, *Hanzawaia stratonii*, *Florilus ex. gr. costiferum*, and
- 372 *Lenticulina inornata*. This foraminiferal association suggest a middle Miocene age. The FDO
- 373 of *Spirosigmoilina oligocaenica* at 3,760ft also confirmed a middle Miocene age. This zone
- 374 N16 and N15 planktic zone of [28, 29] further correlates with *Florilus costiferum*/
- 375 *Globorotalia acostaensis* and *Uvigerina subpergrina*/ *Globorotalia menardii* zone in the
- 376 Niger Delta.
- 377 **Interval:** 3,760 – 4,810ft
- 378 **Planktic zone:** N15 – N14 (*Spirosigmolina oligocaenica*) Zone
- 379 **Age:** middle Miocene
- 380 **Definition:** The top of this zonal interval is marked by the FDO of *Spirosigmoilina oligocaenica* at
- 381 3,760ft.
- 382 The base is marked at 4,810ft by the FDO of *Globigerinoides subquadratus*.
- 383 **Features:** First Downhole Occurrence of *Globigerinoides subquadratus* at 4,810ft confirms the
- 384 middle Miocene age of this interval. This zonal interval is characterized by the co-
- 385 occurrences of *Amphistegina lessonii*, *Globigerinoides subquadratus*, *Orbulina universa*,
- 386 *Lenticulina inornata*, *Uvigerina subperegrina*, *Spirosigmoilina oligocaenica*, *Brizalina*
- 387 *mandoroveensis*, *Cibicorbis inflata*, and *Poritextularia panamensis*. This zone N15 and N14
- 388 planktic zone of correlates with *Spirosigmoilina oligocaenica*/ *Globorotalia mayeri* and
- 389 *Globorotalia robusta-lobata* zone in the Niger Delta [28, 29].
- 390 **Interval:** 4,810 – 5,560ft
- 391 **Planktic zone:** N13 – N11 (*Uvigerina sparsicostata*) Zone
- 392 **Age:** middle Miocene
- 393 **Definition:** The top of this zonal interval is marked by the FDO *Globigerinoides subquadratus* at
- 394 4,810ft. while the base is placed at 5,560ft., the terminal depth.
- 395 **Features:** It is characterized by the First Downhole Occurrence of *Globigerinoides subquadratus* at
- 396 4,810ft, FDO *Brizalina interjuncta* and *Uvigerina sparsicostata* at 4,960ft. The interval is
- 397 also characterized by the co-occurrences of *Orbulina universa*, *Globigerinoides*
- 398 *subquadratus*, *Brizalina interjuncta*, *Uvigerina sparsicostata*, *Amphistegina lessonii*,
- 399 *Brizalina mandoroveensis*, and *Lenticulina inornata*. This assemblage further confirmed the
- 400 middle Miocene age while the observed acme of *Amphistegina lessonii* recorded at interval

401 4,960 – 5200ft suggest a middle Miocene age. The zone N13 – N11 planktic zone of [28, 29]
 402 correlates with *Uvigerina sparsicostata*/ *Globorotalia robusta-lobata* and *Globorotalia fohsi*
 403 zone in the Niger Delta.

404 **Interval:** 5,560 – 5,920ft

405 **Planktic zone:** N13 – N11 (*Uvigerina sparsicostata*) Zone

406 **Age:** middle Miocene

407 **Definition:** The top of this zonal interval is placed at 5,560ft (Top of analyzed interval) and the base
 408 is marked at 5,920ft by the FDO *Globigerinoides primordius*.

409 **Features:** The interval is characterized by the co-occurrences of the following foraminiferal
 410 assemblage

411 *Amphistegina lessonii*, *Lenticulina inornata*, *Uvigerina sparsicostata*, *Heterostegina sp.*, and
 412 *Valvulineria sp.* The zone N13 and N11 planktic zone of [28, 29] correlates with *Uvigerina*
 413 *sparsicostata*/*Globorotalia robusta-lobata* and *Globorotalia fohsi* zone in the Niger Delta.

414 **Interval:** 5,920 – 6,430ft

415 **Planktic zone:** N5 – N4 (*Megastomella africana*) Zone

416 **Age:** early Miocene

417 **Definition:** The top of this zonal interval is marked by the FDO *Globigerinoides primordius* at
 418 5,920ft and the base is also marked at 6,430ft by the LDO *Globigerinoides primordius*.

419 **Features:** The FDO *Globigerinoides primordius* at 5,920ft and LDO of *Globigerinoides primordius*
 420 at 6,430ft suggests an early Miocene age at this depth. The acmes of *Uvigerina sparsicostata*
 421 and *Eponides eshira*/*Lenticulina grandis* at 5,920 – 6,430ft and 6,040 – 6,430ft respectively
 422 also led credence to the interval. This might possibly be a regional event. The interval was
 423 also characterized by the co-occurrences of *Eponides eshira*, *Lenticulina grandis*, *Uvigerina*
 424 *sparsicostata*, *Brizalina mandoroveensis*, *Uvigerina auberiana*, *Fursenkoina scalaris*,
 425 *Hanzawaia concentrica*, *Brizalina interjuncta*, *Altistoma tenuis*, *Brizalina imperatrix*,
 426 *Buliminella subfusiformis*, and *Nonion centrosulcatum*. These foraminifera associations are
 427 typical of early Miocene age. Planktic foraminifera assemblage that characterized this zonal
 428 interval include; *Globigerinoides primordius*, *Globorotalia mayeri*, *Globorotalia continuosa*,
 429 *Globorotalia obesa*, *Globoquadrina dehiscens*, *Globoquadrina altispira* and *Globigerinoides*
 430 *subquadratus*. This also gives credence to the assigned early Miocene age. The N5 and N4
 431 planktic zone of [28, 29] correlates with *Fursenkoina punctata* and *Megastomella*
 432 *africa*/*Globigerinoides primordius* and *Catapsydrax dissimilis* zone in the Niger Delta.

433 **Interval:** 6,430 – 6,910ft

434 **Planktic zone:** N2 (*Spiroplectammina wrightii*) Zone

435 **Age:** late Oligocene

436 **Definition:** The top of this zonal interval is marked by the LDO *Globigerinoides primordius* at
 437 6,430ft. and the base is marked at 6,910ft by the LDO *Pseudohastigerina sp*

438 Features: The top of the interval correspond to the LDO *Globigerinoides primordius* at 6,430ft and
 439 the base correspond to LDO of *Spiroplectammina wrightii* and *Pseudohastigerina sp* at
 440 6,910ft and the bioevents suggests Oligocene age. The interval is also characterized by the
 441 co-occurrences of *Hanzawaia concentrica*, *Eponides eshira*, *Lenticulina grandis*, *Bolivina*
 442 *dertonensis*, *Poritextularia panamensis*, *Spiroplectammina wrightii*, *Nonion centrosulcatum*,
 443 *Uvigerina sparsicostata*, and *Brizalina interjuncta*. This assemblage also confirms a late
 444 Oligocene age. The zone N2 planktic zone of [28, 29] correlates with *Bolivina*
 445 *interjuncta*/*Globorotalia opima* and *Spiroplectammina wrightii*/*Globorotalia opima* zone in
 446 the Niger Delta.

447 Interval: **6,910 – 7,270ft**
 448 **Planktic zone:** **P18 – P15 (*Hopkinsinna bononiensis*) Zone**
 449 **Age:** **early Oligocene**
 450 **Definition:** The top of this interval is marked by the LDO *Pseudohastigerina sp.* at 6,910ft. The base
 451 is marked at 7,270ft by the FDO *Uvigerina hourqi*.
 452 **Features:** The LDO of *Spiroplectammina wrightii* at 6,910ft suggests an early Oligocene age while
 453 FDO of *Uvigerina hourqi* at 7,270ft. The interval is also characterized by the co-occurrences
 454 of *Hopkinsinna bononiensis*, *Eponides eshira*, *Lenticulina grandis*, *Brizalina imperatrix*,
 455 *Buliminella subfusiformis*, and *Hanzawaia concentrica*, this assemblage conforms to the early
 456 Oligocene age. The planktic zone P18-P15 of [28, 29] correlates with *Hopkinsinna*
 457 *bononiensis*/*Globigerina ampliapertura*, *Uvigerina gallowayi*/*Cassigerinella chipollensis*,
 458 *Nonion oya*/*Globorotalia cerroazullensis* and *Bolivina ihuoensis*/*Globorotalia*
 459 *cerroazullensis* zones in the Niger Delta.

460 Interval: **7,270 – 7,510ft**
 461 **Planktic zone:** **P14 – P12 (*Uvigerina hourqi*) Zone**
 462 **Age:** **late Eocene**
 463 **Definition:** The top of this zonal interval is marked by the FDO *Uvigerina hourqi* at 7,270ft and the
 464 base is marked at 7,510ft by the FDO *Uvigerina gallowayi*.
 465 **Features:** The interval is marked by FDO *Uvigerina hourqi* at 7,270ft and the base is FDO of
 466 *Uvigerina gallowayi* at 7,510ft which suggests late Eocene age. The acme of *Uvigerina*
 467 *hourqi* recorded at 7,270ft to 7,630ft is a regional event in the Niger Delta and it also
 468 corroborated the late Eocene age. The interval also characterized by the co-occurrences of,
 469 *Hopkinsinna bononiensis*, *Altistoma scalaris*, *Eponides eshira*, *Lenticulina grandis*, *Brizalina*
 470 *imperatrix*, *Buliminella subfusiformis*, and *Hanzawaia concentrica*, which also confirms late
 471 Eocene age. The zone P14 - P12 planktic zone of [28, 29] correlates with *Uvigerina*
 472 *hourqi*/*Turborotalia rohri*, *Eponides africana*/*Turborotalia rohri* and *Hopkinsina*
 473 *danvillensis*/*Truncorotaloides pomeroli* zones in the Niger Delta.

474 Interval: **7,510 – 7,870ft**

475 **Planktic zone:** **P12 (*Uvigerina havanensis*) Zone**
 476 **Age:** **late – middle Eocene**
 477 **Definition:** The top of this zonal interval is marked by the FDO *Uvigerina gallowayi* at 7,510ft.
 478 The base is marked at 7,870ft by the occurrences of *Globigerina triculinoidea*.
 479 **Features:** marked by FDO *Uvigerina gallowayi* at 7,510ft and characterized by the co-occurrences of,
 480 *Uvigerina hourqi*, *Hopkinsina bononiensis*, *Eponides eshira*, *Lenticulina grandis*,
 481 *Hanzawaia concentrica*, *Uvigerina sparsicostata*, *Brizalina imperatrix* and *Buliminella*
 482 *subfusiformis*, This assemblage confirms late/middle Eocene age. The zone P12 planktic zone
 483 of [28, 29] correlates with *Altistoma tenuis*/*Uvigerina havanensis*/ *Chiloguembelina cubensis*
 484 zones in the Niger Delta.

485 **Interval:** **7,870 – 7,990ft**
 486 **Planktic zone:** **P5-P6/P7 (*Lenticulina pseudomamillegarus*) Zone**
 487 **Age:** **early Eocene – late Paleocene**
 488 **Definition:** The top of this zonal interval is marked by the occurrence of *Globigerina triculinoidea* at
 489 7,870ft and the base is placed at 7,990ft.
 490 **Features:** The occurrences of *Globigerina triculinoidea* and *Morozovella quetra* at 7,870ft.suggest a
 491 late Paleocene age. The interval is characterized by the co-occurrences of *Uvigerina hourqi*,
 492 *Hopkinsina bononiensis*, *Eponides eshira*, *Lenticulina grandis*, *Hanzawaia concentrica*,
 493 *Uvigerina sparsicostata*, *Cassigerinella chipollensis* and *Brazilina ihuensis*, This
 494 assemblage confirms a late Paleocene age. The occurrences of *Globigerina triculinoidea* and
 495 *Morozovella quetra* at the last sample analyzed (7,870 – 7,990ft) confirmed late Paleocene
 496 age of this interval. The planktic zone P5-P6/P7 of [28, 29] correlates with *Eponides*
 497 *pseudoelavatus*/*Morozovella subbotinae* and *Lenticulina pseudomamillegarus*/*Morozovella*
 498 *velascoensis* zone in the Niger Delta.

499 However, it should be noted that the admixtures of zonal markers and missing of some zones e.g N8
 500 to N3 and P19, P11 to P8 in the course of the study suggest possible erosional activities,
 501 faulting/unconformity.

502 **Interval:** **8,590 – 10,640ft**
 503 **Planktic zone:** **M18 – (*Bolivina afra*)? Zone**
 504 **Age:** **Maastrichtian - late Campanian**
 505 **Definition:** The top of this zonal interval is marked by the FDO *Bolivina afra* at 8,590ft and the base
 506 is placed at 10, 640ft, the Terminal Depth of the analyzed well.
 507 **Features:** The interval is characterized by FDO *Bolivina afra* *Hedbergella holmdellensis*
 508 (Maastrichtian age) at 8,590ft. Also, FDO *Praebulimina* genus (*P.fang*, *P. proluxa*, *laddi*) at
 509 8,710ft and *Globotruncana aegyptiaca* (Maastrichtian age) at 9,550ft. The interval 8710ft to
 510 9550ft is characterized by acme of foraminiferal species dominated by the species of *Bolivina*
 511 *afra* and genus *Praebulimina* (*P. fang*, *P. proluxa*, *P. laddi*, *P. longa*) which could be a
 512 regional transgressive event. Also the interval also characterized by the co-occurrences of,

Praebulimina fang, *Praebulimina lata*, *Praebulimina laddi*, *Praebulimina proluxa*, *Praebulimina longa*, *Gavelinella guineana*, *Gavelinella intermedia*, *Orthokaestenia clavata*, and *Lenticulina stephensoni*. The planktic assemblage is characterized by *Hedbergella monmouthensis*, *Hedbergella holmdellensis*, *Hedbergella planispira*, *Heterohelis reussi*, *Heterohelix globulosa*, and *Globotruncana aegyptiaca* suggesting late Campanian to Maastrichtian age. The planktic zone M18? of [28, 29] correlates with *Bolivina afra*/*Praebulimina* and *Hedbergella holmdellensis* zone in the late Campanian to Maastrichtian age in the Niger Delta (Fig. 12)

However, the admixtures of zonal markers and absence of P4 to P1 zones within this interval may probably be due to erosional activities, faulting/unconformity.

Table 2: Foraminiferal Biostratigraphic summary of Ochigbo-1 well

(Guided by the works of 28,29 and 30)

DEPTH (FT)	AGE	PLANKTIC ZONE	BENTHIC ZONE	IMPORTANT BIOEVENTS
3405	LATE MIOCENE - MIDDLE MIOCENE	N16 - N15	TRILORUS COSTIFERUS - UVIGERINA SUBPREGRATA	
3760				← FDO Spirosigmoilina oligocaenica (12.26 Ma)
4810	MIDDLE MIOCENE	N15 - N14	SPIROSIGMOILINA OLIGOCAENICA	← FDO Globigerinoides subquadratus (13.12 Ma)
4960		N11 - N13	UVIGERINA SPARSICOSTATA	← FDO Brizalina interjuncta → FDO Uvigerina sparsicostata (13.12 Ma)
5920			TURNERELLA PUNCTATA	← FDO Globigerinoides primordius
6430	EARLY MIOCENE	N4 - N3	MEGASTOMELLA AFRICANA - BOLIVINA INTERJUNCTA	← LDO Globigerinoides primordius ← LDO Bolivina dertonensis
6910	LATE OLILOCENE	P12 - P13	SPIROPLECTAMMINA WRIGHTII - HOPKINSINA BONGENENSIS	← LDO Spiroplectammina wrightii → LDO Pseudohastigerina sp
7270	EARLY OLILOCENE	P12 - P14	BOLIVINA HOURQUI - HOPKINSINA BONGENENSIS	← FDO Uvigerina hourqi (38.0Ma) → ACME OF Uvigerina hourqi
7510	LATE EOCENE	P12 - P14	HOPKINSINA BONGENENSIS - ALDIBONIA TENNIS	← FDO Uvigerina gallowayi (43.2Ma)
7870	MIDDLE EOCENE - LATE EOCENE	P12	UVIGERINA HANANENSIS	← Occurrence of Globigerina Triculinoidea and Morozovella quetra
7990	EARLY EOCENE - LATE EOCENE	P4/P6 - P7	EPONIDES PSEUDOLIVATUS - LENTICULINA PSEUDOMAMILEGERUS	← FDO Lenticulina pseudomamilegerus (55.9Ma)
8590				← FDO Bolivina afra (64.6 Ma) → FDO Hedbergella holmdellensis
8710	LATE CAMPANIAN - MAASTRICHTIAN	M18 - 7	BOLIVINA AFRA - PRAEBULIMINA	← FDO Praebulimina genus (P.fang, P. proluxa, Pladdi etc) → ACME of Bolivina afra & Praebulimina genus
9550				← FDO Globotruncana aegyptiaca
10640				

----- Unconformity

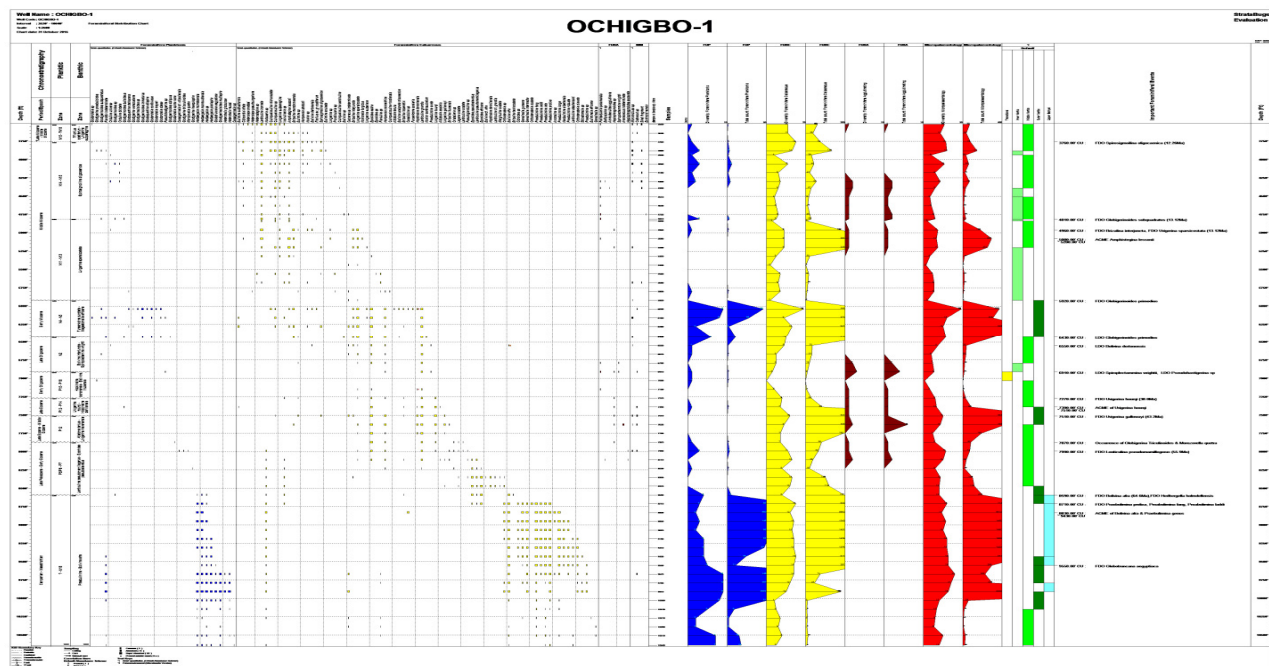


Fig. 11: Micropalaeontological Distribution and Abundance Chart for Ochigbo – 1 well

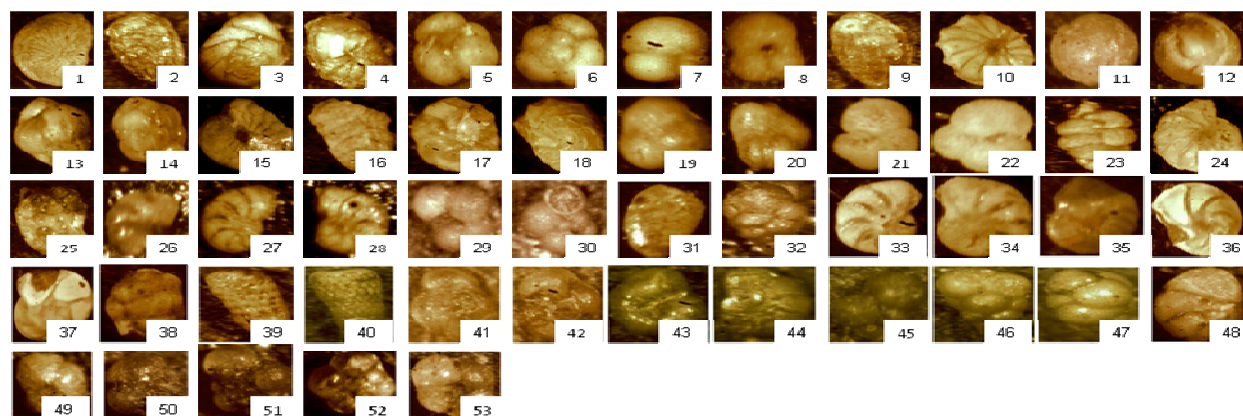


Fig. 12: Selected Foraminifera photomicrographs recovered from Ochigbo-1 well

Palaeoenvironmental Studies

Paleoenvironmental deductions of this study were based primarily on benthic foraminiferal assemblages and abundance and diversity of species. Presence or absence of planktic foraminifera also helped in deciphering open ocean environments. The following environments were deduced from the studied well and were outlined below; Inner neritic, middle neritic, outer neritic and Upper Bathyal.

Inner Neritic

The presence of foraminiferal assemblages such as *Amphistegina lessonii*, *Heterostegina* sp., *Poritextularia panamensis*, *Quinqueloculina microcostata*, *Valvulineria* sp., *Quinqueloculina* sp., *Lenticulina inornata*, *Planulina* sp, *Spiroplectammmina wrightii*, and *Haplophragmoides* were used in establishing this depositional environment. It is recorded over the following intervals; 3,880 – 3,940ft., 5,200 – 5,920ft and 6,790 – 6,910ft of Ochigbo-1 well (Fig. 13).

Middle Neritic

This paleoenvironmental setting is characterized by relatively high abundance and diversity of foraminiferal species. The abundance of Planktic foraminiferal species suggest open marine setting. Typical assemblages recorded are *Globigerinoides subquadratus*, *Globigerinoides immaturus*, *Globigerinoides primordius*, *Globorotalia mayeri*, *Globorotalia obesa*, *Globoquadrina dehiscens* and *Globoquadrina altispira* *Uvigerina sparsicostata*, *Uvigerina auberiana*, *Brizalina mandoroveensis*, *Altistoma tenuis*, *Lenticulina grandis*, *Brizalina interjuncta*, *Buliminella subfusiformis*, *Brizalina imperatrix*, *Uvigerina hourqi*, *Eponides eshira*, *Uvigerina gallowayi*, *Uvigerina subperegrina*, *Heterolepa crebbisi*, *Heterolepa pseudoungeriana*, *Spirosigmoilina oligocaenica*, *Lenticulina inornata*, *Amphistegina lessonii*, *Lenticulina pseudomamilligerus*, *Eponides pseudoelevatus*, *Hanzawaia concentrica*, *Haplophragmoides excavata*, *Eponides africana* *Hopkinsinna danvillensis*, *Marginulina costata*, and *Lagena costata*. Middle Neritic environment thrived over the following intervals: 3,405 – 3,880ft, 3,940 – 4,390ft, 4,840 – 5,200ft, 6,430 – 6,790ft., 7,030 - 7, 390ft, 7,630 – 7,990ft, 7,990 - 8,470ft and 10,150 – 10,640ft (Fig. 13).

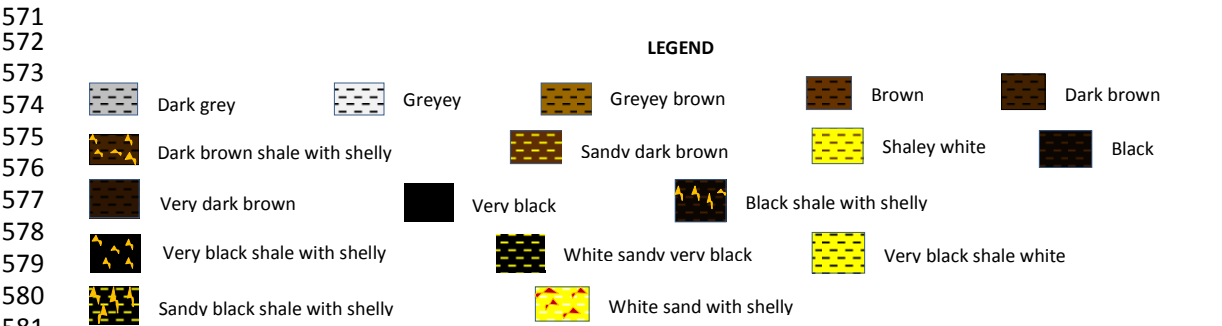
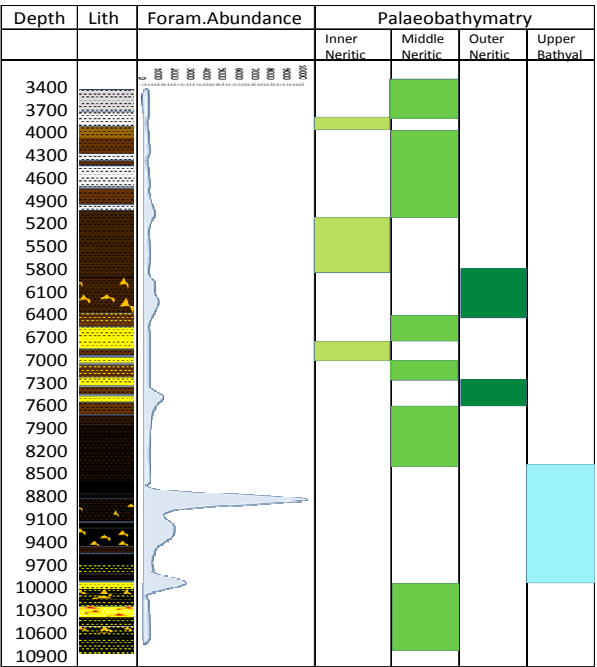
Outer Neritic

Most of the foraminiferal species recorded in the Middle Neritic also characterized the Outer Neritic environment. This environment is further characterized by high abundance and diversity of foraminiferal species dominated by the genus - *Uvigerina*, (*Uvigerina sparsicostata*, *Uvigerina hourqi*,) and *Eponides eshira* and *Lenticulina grandis*. This environment is recorded in 5,920 - 6,430ft, and 7,390 – 7,630ft (Fig. 13).

Outer Neritic and Upper Bathyal

Outer Neritic and Upper Bathyal depositional environments are characterized by high abundance and diversity of foraminifera such as *Hedbergella*, *Heterohelix*, *Globotruncana*, *Globigerinelloides*

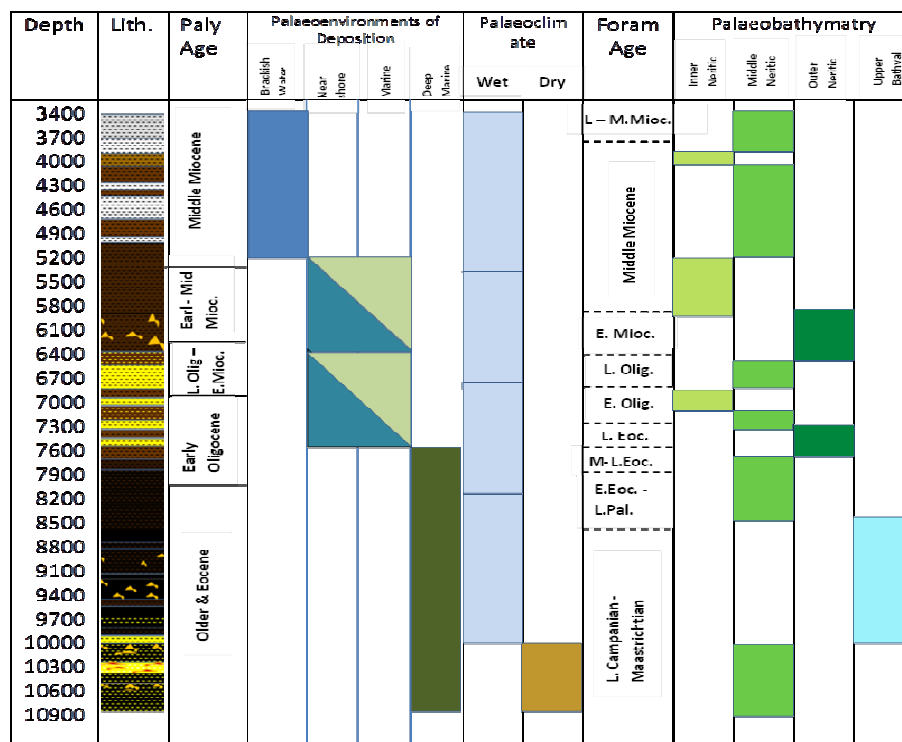
566 *Bolivina afra*, *Praebulimina fang*, *Praebulimina lata*, *Praebulimina laddi*, *Praebulimina proluxa*,
567 *Praebulimina longa*, *Orthokarstenia clavata*, *Gavelinella guineana*, *Gavelinella intermedia*,
568 *Neobulimina albertensis*, and *Lenticulina stephensoni*, suggesting a relatively deeper environment.
569 This paleoenvironment and the above foraminiferal associations are recorded over the interval: 8,470
570 – 10,150ft of the analyzed interval (Fig. 13).



583 **Fig. 13:** Foraminiferal abundance and palaeobathymetric depositional environment

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587 The palaeoenvironmental deposition of the Ochigbo – 1 well started at Middle Neritic (10,640ft –
588 10,150ft) followed by regression (sea level fall) during Upper Bathyal (10,150ft – 8,470ft). This
589 scenario is followed by transgression (Sea level rise) from Upper Bathyal to Middle Neritic (8470ft–
590 7630ft). The environment experienced regression again from Middle Neritic to Outer Neritic (7630ft–
591 7390ft). Another transgression occurred again from Outer Neritic to Middle Neritic (7390ft–7030ft)

and went further to Inner Neritic (7030ft–6790ft). There was an opposite movement of the transgression from Inner Neritic to Middle Neritic (6790ft– 5920ft) then to Outer Neritic (5920ft– 5200ft). There was a transitional ‘leap’ from Outer Neritic to Inner Neritic (5200ft– 4840ft) causing a land-ward transgressive movement after which there is a regression from Inner Neritic to Middle Neritic (4840ft - 3940ft). The final transgression was from Middle Neritic to Inner Neritic (3940– 3880) and then finally a regression to Middle Neritic (3880 – 3405ft).



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Fig. 14: Palaeoenvironmental chart from palynology and micropalaeontology
Palaeoenvironmental reconstruction of Ochigbo – 1 well

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The palynological and micropalaeontological forms recovered revealed the Ochigbo – 1 well to have penetrated Late Cretaceous (Late Campanian – Maastrichtian) to Middle Miocene. The reconstruction was done from Late Cretaceous to Early Oligocene using ages revealed by the micropalaeontological forms (foraminifera). While the remaining reconstruction (Late Oligocene to middle Miocene) was done using integrated results as revealed from the two disciplines of biostratigraphy employed in this work (micropalaeontology and palynology). This was because the palynological forms (pollen and spores) recovered were not able to date the sediments older than Eocene and the Dinoflagellates

recovered were long ranged and so not index forms. This situation presents the importance of using more than one branch or discipline of biostratigraphy for palaeoenvironmental reconstruction or other findings in biostratigraphy.

The sediments in the Ochigbo – 1 well were found deposited in Middle Neritic (10,640ft – 10,150ft) during the Late Cretaceous, after, there seems to be a major unconformity around Early to Middle Palaeocene. There was a record of deposition again in Upper Bathyal (10,150ft – 8,470ft), this transition is suggested to be as a result of a regression in Late Palaeocene. There was a transgression back to Middle Neritic (8,470ft – 7,630ft) around Late Palaeocene to Early Eocene. A regression is suggested to have taken place again around Middle Eocene to Late Eocene causing sediments to be deposited in Outer Neritic (7,630ft – 7,390ft). Around Late Eocene, a transgression started again to Middle Neritic (7,390ft – 7,030ft) from Outer Neritic and went further to Inner Neritic (7,030ft – 6,790ft) in Early Oligocene. The deposition of sediments from palynological results, took place in a wet climatic condition in an environment fluctuating between near-shore and marine. At about the ages between the end of Early Oligocene to Late Oligocene an unconformity is suggested to have taken place after which a regression happened allowing the recording of sediments in Middle Neritic (6,790ft – 5,920ft) in Late Oligocene. The regression went further to Outer Neritic (5,920ft – 5,200ft) from Middle Neritic in Early Miocene, still within a wet climatic condition in an environment fluctuating between near-shore and marine. About the end of Early Miocene there was a transgression from Outer Neritic to Inner Neritic (5,200ft – 4,840ft), still a wet climate fluctuating between near-shore and marine. During Middle Miocene, in a wet climate and brackish water environment, there was a regression from Inner Neritic to Middle Neritic (4,840ft – 3,940ft). Within this time and environmental setting, there was a transgression from Middle Neritic to Inner Neritic (3,740ft – 3,880) and a regression again to Middle Neritic (3,880ft – 3,405ft). See Figures 4.22 and 4.23 for the reconstruction chart and depositional environments and bathymetric ranges used for the palaeoenvironmental reconstruction (Fig. 14).

This alternating transgressive – regressive movement observed in Ochigbo – 1 well explained the possible paralic sequences found in Agbada Formation which coincided with the Ochigbo-1 well (3405ft–10,640ft) Figs 13 and 14).

CONCLUSIONS

Palynological and micropalaeontological analysis of sixty-two (62) samples of Ochigbo – 1 well within interval of 3405ft and 10640ft were processed, prepared and analysed. The lithostratigraphic unit, age, zonation, and environment of deposition of the studied well carried out. This revealed that the well penetrated a major sedimentary formation in the Niger Delta, comprising of shale, sandy shale and shaly sand, probably the paralic sequence of Agbada Formation.

A very rich recovery of palynomorphs, dominated by land-derived species of pollen and spores, abundant and diverse dinoflagellates cysts, brackish water spore and Fungal/spore/hyphae were recorded. The Palynological zonation of the well and their stratigraphic distribution based on the zonation schemes of [11] are broadly assigned to *Crassorettriletes Vanraadshooveni* /P700 Zone, *Magnastrates Howardii* / P600 Zone, *Retribrevitricolporites Obedensis/Protundens* / P500 Zone and *Racemonocolpites Hians* / P400 Zone which were further subdivided to the following subzones P740, P720, P680 - P670, P650, P630, P620-P580, P560, P540, and P420. The assigned age is late Eocene to Late Miocene maybe as a result of the paucity of palynomorphs towards the bottom of the studied well. The boundary between Miocene and Oligocene was at 6780ft with the Quantitative base occurrence of *Peregrinipollis nigericus* and that between Oligocene and Eocene is at 8110ft with the base occurrence of *Racemonocolpites hians*. The palynoflora identified suggests an environments ranging from estuarine/brackish water to deep marine whereas the palaeoclimatic setting is predominantly a wet climate.

One hundred and eighty one (181) foraminiferal species were identified. These include 170 species (93.92%) calcareous, while the remaining 11 species (6.08%) are arenaceous. Of the calcareous forms, benthics accounted for 118 species (69.41%) while the remaining 52 species (30.59%) are planktics. The results of the analysis indicated that the study interval (3,405 – 10,640ft) of the Ochigbo-1 well was deposited during the late Miocene? to Late Campanian/Maastrichtian epoch, straddling the N16 to M18 planktic zones of [35 and 37]. The boundary between Miocene and Oligocene was established at 6430ft based on the last downhole occurrence (LDO) of *Globigerinoides primordius* and *Bolivina dertonensis* while the boundary between Oligocene and Eocene was placed at 7270ft, based on first downhole occurrence (FDO) of *Uvigerina hourqi* (38.0Ma). The boundary between Early Eocene – Late Paleocene and Late Campanian – Maastrichtian was at 8590ft based on the FDO *Bolivina afra* (64.6 Ma) and *Hedbergella holmdellensis*. One condensed section in the Ochigbo – 1 well was identified at the intervals between 8,700ft and 9,310ft, this also house the Maximum Flooding Surface (MFS) at the depth of 8830ft, being its highest peak with a count of 9,910 [16, 15].

Palaeoenvironmental deductions from Micropaleontology were based primarily on benthic foraminiferal assemblage, abundance and diversity of species. Presence or absence of planktic foraminifera also helped in deciphering open ocean environments. From the identified microfauna, the palaeoenvironments of deposition alternates in a regressive – transgressive pattern cutting across Inner Neritic to Upper Bathyal.

Gathering from the integrated study of palynologyand micropalaeontology, lithology and palaeoenvironmental study, the studied interval (3,405ft – 10,640ft) is here by suggested to have

penetrated the Agbada Formation of the Niger Delta Basin, Nigeria. The alternation of shale and sandy shale within the sequence provides the combination of source, reservoir and cap rocks necessary for hydrocarbon generation, accumulation and trapping.

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