ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 5, May 2023

Palynological characterization of Ben-98 well, OML 38 Greater Ughelli Depobelt onshore Niger Delta

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ABSTRACT: Since the discovery of petroleum in the Tertiary Niger Delta Basin, many researches have been carried out in the basin because of this high economic resource, but there is still paucity of palynological information due to restriction of research findings by oil companies, hence this study aims at contributing to the Niger delta enhanced palynological scheme. Palynofloral investigation was carried out on BEN-98 located at OML 38 Greater Ughelli Depobelt onshore Niger Delta with a view to characterize the age and environment of deposition of the sediments penetrated by the well interval. A total number of 60 ditch cutting samples composited at 60ft interval between 5200ft to 8710ft were analyzed for their palynofloral contents using the standard palynological method. The palynomorphs recovered in the well were very abundant and fairly diverse especially within the upper part (5,200-7,120ft.) but were few and scarce in the lower part of the well (7120-8710ft.). From the analysis it showed that samples were the Heterolithic Agbada Formation. From the distribution of the palynomorphs, sixteen (16) biozones were erected. They are *Psilamonocolpites marginatus zone, Cinctiperiporites mulleri zone, Verrutricolporites sp zone, Botrycoccus braunii zone, Polyadapollenites laevigatus zone, Proteacidites cooksoni zone, Retitricolporites irregularis zone, Racemonocolpites hians zone, Stephanoporites sp zone, Arecipites exilimuratus zone, Praedapollis flexibillis zone, Striatricolporites catatumbus zone, Gemmamonoporites sp zone, Retibrevitricolporites obodoensis/protrudens zone, Canthiumidites sp zone, and Peregrinipollis nigericus zone*. These zones were correlated with P560, P540, P520, P480 and P470 of the [1] scheme to assign Late Eocene to Early Oligocene age for the well interval studied. Shallow water (brackish) environment with incursion of marine influence is also inferred as the environment of deposition with a predominantly a wet climate was also inferred due to the abundance of *Zonocostites ramonae, Acrostichum aureum* and paucity of *Monoporites annulatus and Proteacidites cooksoni.*

KEYWORDS: Palynology, age, Oligocene, environment, Eocene, Niger Delta.

I. INTRODUCTION:

Petroleum was discovered in the Tertiary Niger Delta Basin in 1958 at Oloibiri. Since then, many researches have been carried out in the basin because of the high economic resources found in the basin. As exploration progressed, it became more difficult to discover petroleum, necessitating the use of a variety of technologies and processes, including petrophysical methods. Significant efforts have been made in the exploration of petroleum since the discovery of oil in the basin and over 5000 wells have been sunk and developed. The development of biostratigraphy and palynology has been a relief, making exploration easier than it was previously. Palynological investigation was carried out on Ben-98 Well, an NPDC well located at OML 38 Greater Ughelli Depobelt onshore Niger Delta. The goal of this study was to use Pollen and spores to determine the age of the rock succession, as well as to reconstruct the paleo depositional environment, while the objectives were to Prepare and analyze samples to create a Bio-zonation model for the wells based on the distribution of palynomorphs, and to use ecological models to reconstruct their paleo-depositional settings.

II. LITERATURE REVIEW

Palynological investigations in Nigeria are primarily restricted to the Tertiary Niger Delta, Since the discovery of crude oil at Oloibiri in the Niger delta in 1956, numerous studies on the region have been carried out by numerous authors, but many of the specifics remain secret by oil companies prospecting for crude oil within the Niger delta basin [2] and [3], however many important palynological reviews of the basin have been made. Evamy, et. al., 1978, established an informal palynological zonation for the Niger delta based on numerical criteria. The Niger delta Miocene palynostratigraphy was defined by [4] using the following palynomorphs: *Praedapollis africanus, Praedapollis*

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International Journal of Advanced Research in Science, Engineering and Technology
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flexibilis, Areciptes exilimuratus,Belskipollis elegans, and Verrutricolporites rotundiporus. [5], discovered diverse assemblages of tropical pollen and spores in association with sporadic abundances of freshwater algae and some dinoflaggelate cysts in some of Nigeria's deep offshore strata. [6], used sixty-seven biostratigraphically significant dinoflagellate cysts to erect a dinoflagellate cyst framework for the Maastrichtian-Lutenian succession of the Benin-1 well from the Western Anambra Basin flank of Southern Nigeria. [7], conducted research on integrated foraminifera and palynological analyses of the NEP -1 well, located off the coast of the eastern Niger Delta. They defined four benthic foraminiferal biozones, two planktonic biozones, and three palynological biozones and used it to delineate late Miocene to the early Pliocene. Numerous investigations using specific distinctive palynomorph indicators include [8] [9], [10], [11], as well as many others.

III. GEOLOGY OF THE NIGER DELTA.

The Tertiary Niger Delta is located at the intersection of the South Atlantic Ocean and the Benue Trough, where a triple junction formed during the late Jurassic separation of South America and Africa [12], [13], [14]. The Niger Delta basin is situated on the West African continental border, along Nigeria's coast, in the Gulf of Guinea. The Niger Delta Basin is encompassed by numerous other basins formed by similar processes [15] and is one of Africa's largest subaerial basins. According to [16] the Niger Delta has an area of around 75,000 square kilometers and is made up of a regressive clastic succession with a maximum thickness of 12,000 meters. The Tertiary Agbada-Akata petroleum system is regarded as one of the world's most productive hydrocarbon provinces [17]. The Akata, Agbada, and Benin Formations are three major lithostratigraphy units in the Niger Delta that reflect a complex mixture of marine, fluvio-marine, littoral, and deltaic plain environments. The ratio of sand to shale distinguishes these formations from one another.

The Akata Formation overlies the precambrian basement complex. It is composed of dark grey over-pressured marine shales, channel fills, and sandy turbidites which are potential reservoirs in deep-water environments. It dates from the Paleocene epoch. Furthermore, [18], stated that the Akata formation has a thickness of approximately 6500m.

The Agbada formation is overlies the Akata formation and contains the exploitable, economic hydrocarbon in the basin. Agbada formation is a sequence of alternating shales and sandstone that is divided into two subunits: the upper subunit, which is composed of the thicker part of the sandstone and contains 60-40 percent sand, the middle subunit, which contains 50-30 percent sand, and the lower subunit, which contains 20 percent sand interbedded with under compacted shale [19].

The Benin formation overlies the Agbada formation. With ages ranging from the Oligocene to the recent, it is the youngest formation in the Niger delta basin. It is composed of over 90% sandstones with shale intercalations and extends from the west across the entire Niger delta area and southward beyond the current coastline. The Benin formation is an upper coastal and alluvial plain deposit with a thickness of up to 2000m as reviewed by [16] (figure 2).

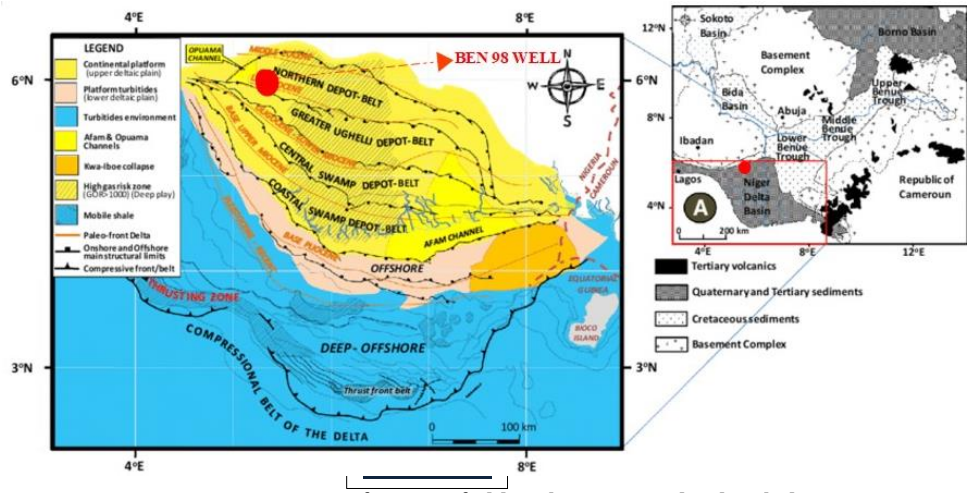

Figure 1: Location of Ben 98 field in the Niger Delta depobelt Map

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IV. METHODOLOGY:

Sampling is a key procedure in biostratigraphic investigations since biostratigraphic interpretation is heavily reliant on the quality of the samples. Sample administration is the process of sifting out samples delivered serially based on depth. During the analysis, sixty (60) samples were composited at sixty (60) feet interval. The well depth ranged from 5200ft to 8710ft.

Chemical treatments was applied to the ditch cuttings in order to extract the palynomorphs from the rock matrix in accordance with the standard palynological sample preparation method. Because the quality of interpretation is dependent on the precision of sample preparation, the degree of contamination was kept to the barest minimum by thorougly washing the apparatus during the processes. During the preparation of the palynological slides, the following procedures were observed.

A : LABELLING AND WEIGHING OF SAMPLES: clean plastic cups, test tubes, 100 ml beakers and glass slide were labelled with the name of the well, sample depth interval and sample number. Weigh ten (10) grams of the sample and dish into the labelled plastic cups with corresponding depth interval.

B: CARBONATE DIGESTION/DECARBONIZATION: the samples were taken to the fume cupboard for acid treatment. 10mls of dilute hydrochloric acid (5%hcl) was added to the samples and allowed to stand in the fume cupboard for 30 minutes

$2HCL + RC0_3$ ----- $RCL_2 + C0_2 + H_2O$

C: REMOVAL OF SILICATES: 60% hydrofluoric acid (60%hf) was added to the samples, stirred very well and allowed to stand in the fume cupboard for 30 minutes. The plastic cups were topped with water and allowed to stand in the fume cupboard overnight. Then the plastic cups were removed from the fume cupboard and decanted three times at 60 minutes interval. The residue was transferred to the 100ml glass beakers. Two drop of soap solution were pipetted into the glass beakers labelled with the sample interval and then taken back to the fume cupboard for treatment.

D: DISSOLUTION OF SILICOFLUORIDE GELS: silicofluoride gels are gelatinous substances covering the palynomorphs. The gels are formed by the reaction of Hydrofluoric acid with silicates. About 10-20mls of 10% Hydrochloric acid (HCL) was added and the samples were stirred thoroughly with a glass rod. The beakers were heated on a hot plate at a temperature between 70^0 c- 80^0 c for twenty minutes. The beakers were removed from the fume cupboard filled with water and decanted three times at 20 minutes interval.

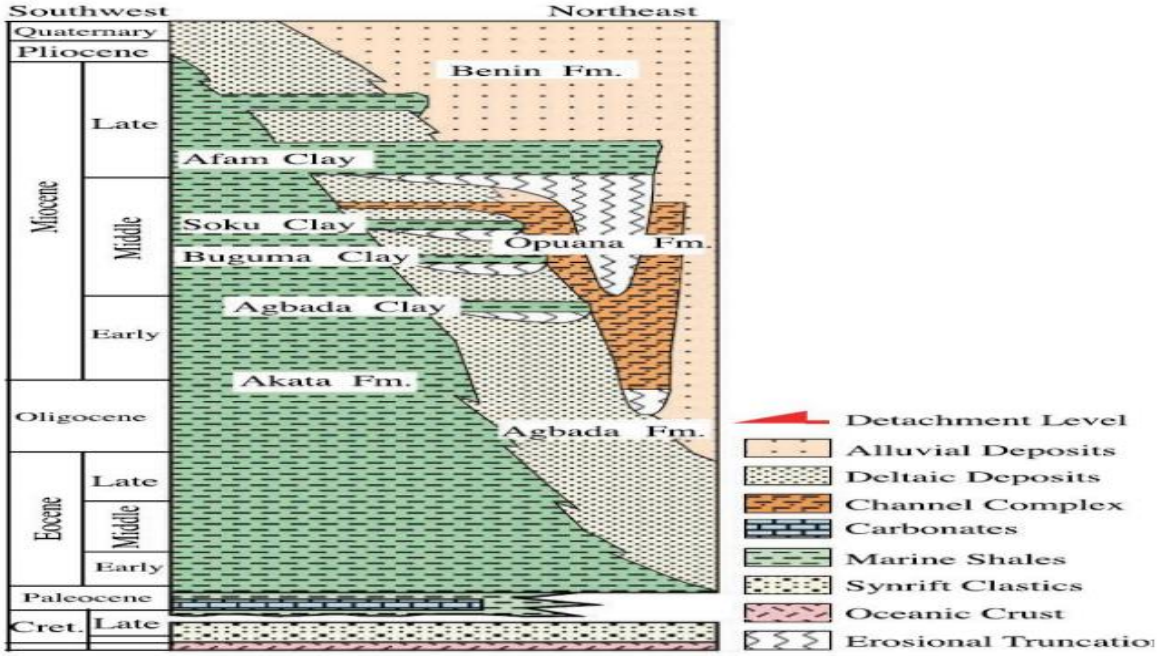

Figure 2: Niger Delta Regional Stratigraphy [19].

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International Journal of Advanced Research in Science, Engineering and Technology
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E: SIEVING: this process was done to wash out dirts, clay, mud and other dissolved materials within the residue. The residue was poured into the 5 micron sieve and washed until neutral was then transferred into the beakers. Residues were poured in residue bottles (test tubes)

F: CENTRIFUGING TO CONCENTRATE PALYNOMORPHS: the residue bottles (test tubes) were transferred to the centrifuge machine and centrifuged for five minutes.

G: ADDITION OF NITRIC ACID TO SEPARATE THE PALYNOMORPHS FROM INORGANIC SUBSTANCE: Nitric acid was added to the samples in the residue and it was allowed to settle for about seven minutes. After which the Palynomorhs was decanted from the inorganic matter and pipetted into the cover slips
.

H: SPOTTING AND STAINING: three drops of soffranin stain were added to the residue and swirled to ensure even distribution. The residue was pipetted into numbered cover slips, laid on top of a hot plate, and evaporated to dryness. The uniform spotting type was utilized to ensure that Palynomorphs were distributed evenly.

I: MOUNTING: few drops of norland glue (mounting medium) were put on dully labelled glass slides and mounted on cover slips. The slides were dried in the sun for five (5) minutes after which they were ready for microscopic examination. A total of sixty (60) slides were made from the sixty (60) samples and analyzed with transmitted light type binocular microscope.

V. RESULTS AND DISCUSSIONS

Sedimentological criteria including gamma ray log responses and sand/shale ratios supported by paleobathymetric data indicate that the BEN-98 well encountered the Heterolithic Agbada Formation within the studied interval. The sedimentological attributes of the well section further enabled the delineation of Transitional lithofacies units. Lithologic characteristics including well log signatures, sand/shale ratios, textural attributes of sands and accessory mineral compositions of samples were used to define the depositional environments recorded over the studied section (5,200 – 8,710ft) of BEN-98 well.
The sands are generally thicker than the shales. The sands are milky white, fine- to coarse-grained, occasionally very coarse-grained and granular, poorly to moderately sorted, sub-angular to sub-rounded. The shales are dark grey to grey in colour, platy to flaggy and moderately hard. The index mineral accessories recorded over this unit include rare ferruginous materials and carbonaceous detritus. The sands of this unit exhibit cylindrical and bell-shaped Gamma Ray signatures, which indicates a coarsening upward sequence typical of the Agbada formation. At the upper part of the well from interval 5200 to 5350ft, the lithology is majorly shaly sand, from 5350 to 6940ft the lithology is sand, While from 6940-8710ft, there is an intercalation of both sand and shaly sand (figure 3).

VI: PALYNOFLORAL ZONATION:

A total number of sixty (60) ditch cutting samples of BEN-98 well composited at 60ft interval were provided for palynological analysis between interval 5,200ft and 8,710ft and analyzed for their palynofloral contents. The data was used for the biozonation, depositional environment and paleoenvironmental reconstruction of the Well sequence. The palynomorphs recovered were very abundant and fairly diverse especially within the upper part (5,200-7,120ft.) of the analyzed interval. However, a drop in miospore proportion characterized the lower part (7,120-8,710ft.) of the Well.

The palynomorphs recorded were dominated by land derived lowland pollens such as *Psilatricolporites crassus* and *Psilastephanocolporites sapotaceae* and other important palynomorphs such as *Cicatricosisporites dorogensis, Racemonocolpites hians, Doualaidites laevigatus, Arecipites exilimuratus, Cinctiperiporites mulleri, Praedapollis africanus, Spirosyncolpites braunii, Praedapollis flexibilis, Magnastriatites howardi, Peregrinipollis nigericus, Retibrevitricolporites obodoensis/protrudens, Retibrevitricolporites ibadanensis, Striamonocolpites rectostriatus, Striatricolpites catatumbus, Pachydermites diederixi, Polypodiaceoisporites sp* and*Retitricolporites irregularis.* Other palynomorphs recorded in high proportion include brackish water species- *Acrostichum aureum* and pteridophyte spores like *Laevigatosporites sp,* and *Verrucatosporites spp.* A significant number of *Botryococcus braunii, mangrove pollen Zonocostites ramonae* and *fungal spores,* moderate number *of Foraminifera wall lining* and spot occurrence of *Dinoflagellate cysts* were also recorded in the Well. The palynological zonation of BEN-98 well is mostly based on the

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palynofloral assemblage of significant species as well as their stratigraphic distribution. The interval 5,200ft and 8,710ft section of the Well analyzed has been broadly assigned to sixteen (16) zones which are *Psilamonocolpites marginatus, Cinctiperiporites mulleri, Verrutricolporites* sp, *Botrycoccus braunii, Polyadapollenites laevigatus, Proteacidites cooksoni, Retitricolporites irregularis, Racemonocolpites hians, Stephanoporites* sp, *Arecipites exilimuratus, Praedapollis flexibillis, Striatricolporites catatumbus Gemmamonoporites* sp, *Retibrevitricolporites obodoensis/protrudens, Canthiumidites* sp, and *Peregrinipollis nigericus* informal zones and defined as follows:

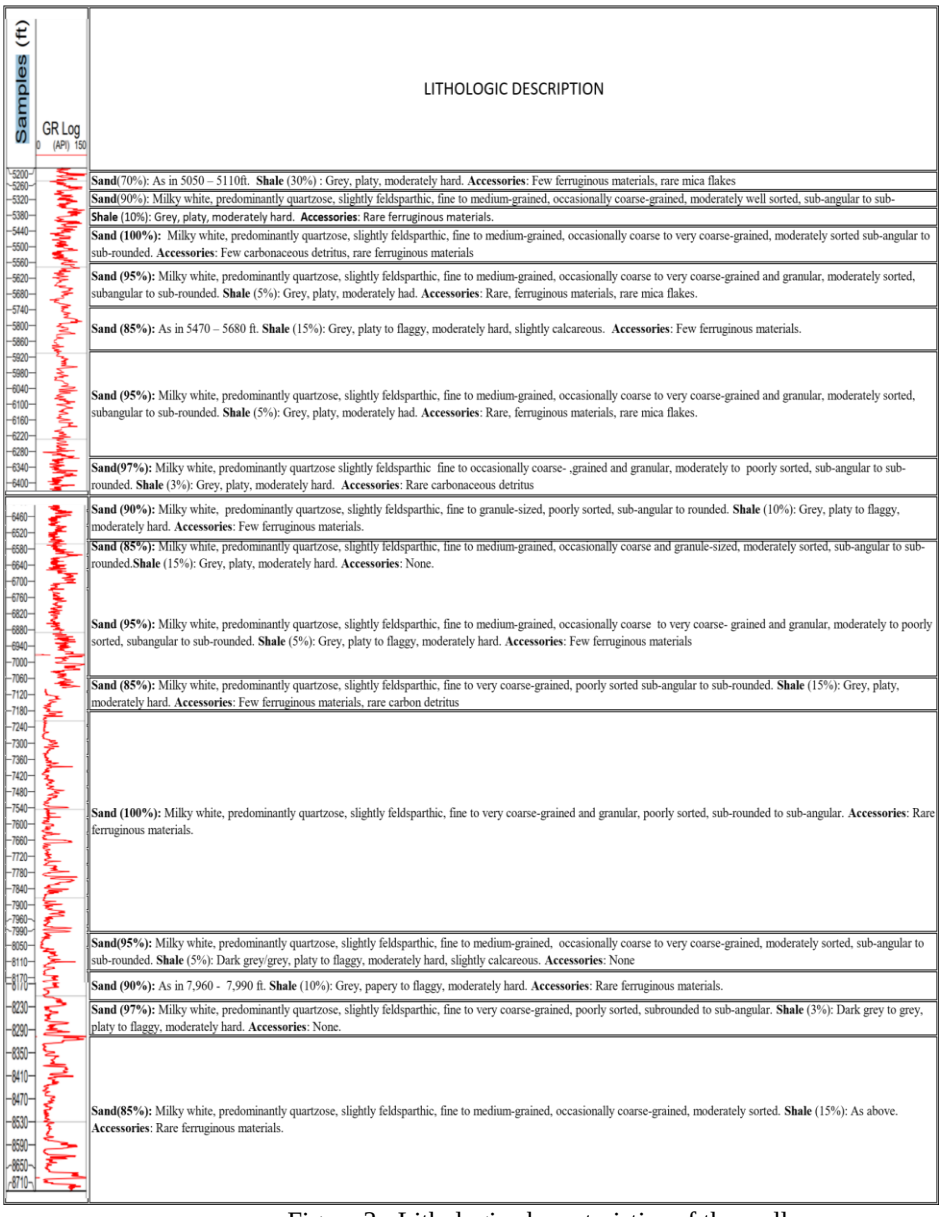

Figure 3: Lithologic characteristics of the well

Zone (i) Psilamonocolpites marginatus zone –Eocene: The palynological event that defines this zone are the last downhole occurrence of *Psilamonocolpites marginatus, Praedapollis flexibillis, Retibrevitricolporites ibadanesis, Verrucatosporites usmensis, Polypodiaceoisporites sp* and the first downhole occurrence of *Doulaidites laevigatus*.

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The first downhole occurrence of Doulaidites laevigatus is at 8470ft and it very close to the terminal depth which is 8710ft.

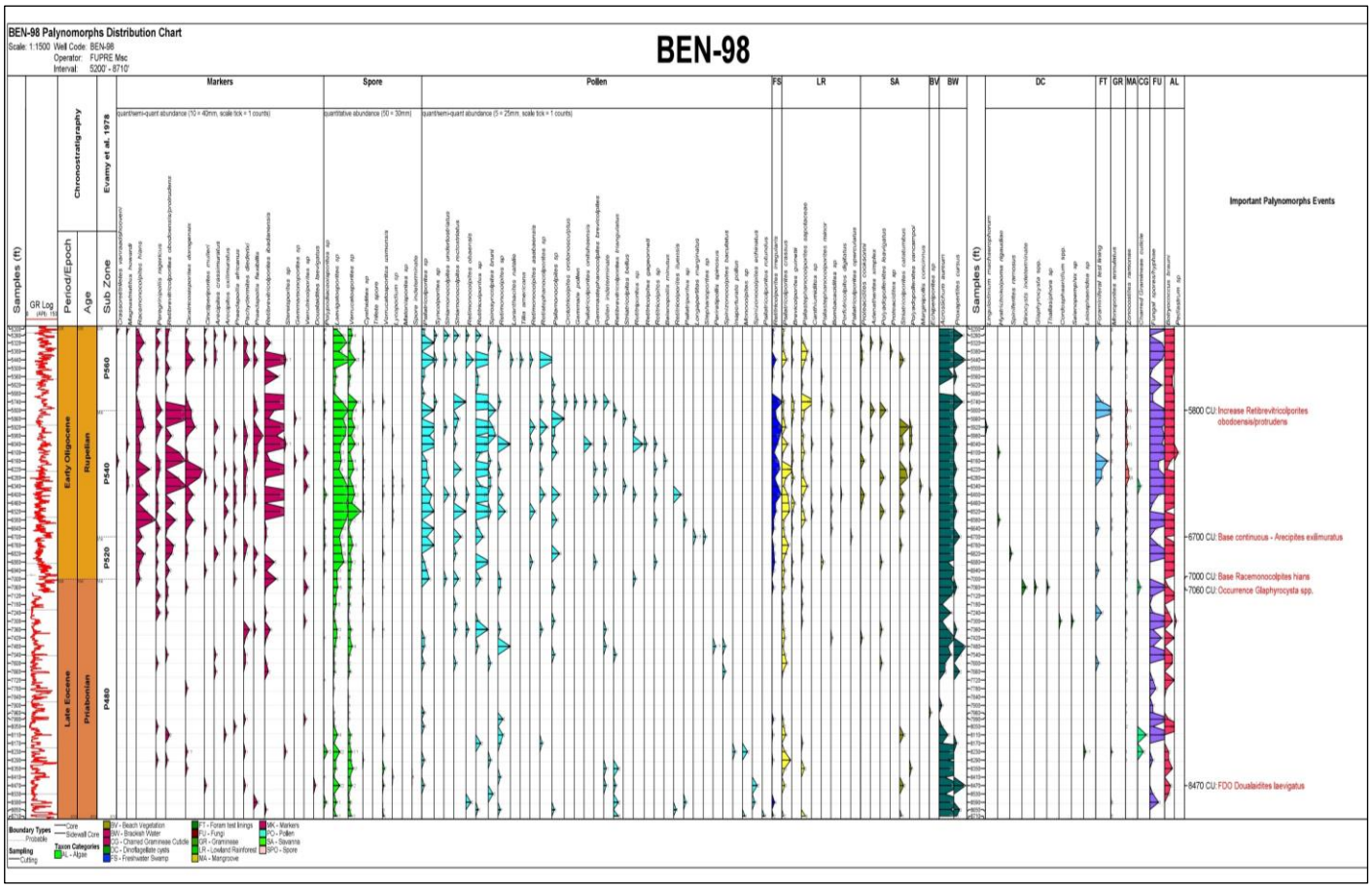

Figure 4: palynomorph distribution chart of BEN 1 WELL.

Zone (ii) Cinctiperiporites mulleri zone-Eocene: The base is defined by the top of zone (i) while the top is at 8470ft. The palynological event that defines this zone are the last downhole occurrence of *Cinctiperiporites mulleri, Leiosphaeridea sp, Polyadopollenites vancampoi, Stereisporites, Monocolpites sp. and Inaperturate pollen*. Cinctiperiporites mulleri has a first downhole occurrence of 5200ft and last downhole occurrence of 8410ft.

Zone (iii) Verrutricolporites sp zone-Eocene: The base is defined by the top of zone (ii) while the top is at 8200ft. The palynological event that defines this zone are the last downhole occurrence of *Verrutricolporites sp, Monoporites annulatus, Zonocostites ramonae, Retistephanocolpiteas sp* and the first downhole occurrence of *Leiosphaeridea sp. Verrutricolporites* sp has a first downhole occurrence of 5200ft and last downhole occurrence of 8710ft.

Zone (IV) Botrycoccus braunii zone-Eocene: The base is defined by the top of zone (iii) while the top is at 8000ft. The palynological event that defines this zone are the last downhole
occurrence of *Botrycoccus braunii, Verrutricolporites sp and Echiperiporites sp. Botrycoccus braunii* has a first downhole occurrence of 5200ft and a last downhole occurrence of 8530ft.

Zone (V) Polyadopollenites leavigatus zone-Eocene: The base is defined by the top of zone (iv) while the top is at 7700ft. The palynological event that defines this zone are the last downhole occurrence of, *Polyadapollenites laevigatus, Striamonocolpites rectostriatus, and Spinizonocolpites baculatus.* Polyadopollenites leavigatus has a first downhole occurrence of 5320ft and last downhole occurrence of 7600ft.

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Zone (VI) Proteacidites cooksoni zone-Eocene: The base is defined by the top of zone (v) while the top is at 7450ft. The palynological event that defines this zone are the last downhole occurrence of *Adenatherites simplex, Selenopemphix sp., Leiosphaeridea sp., Proteacidites cooksoni, Bombacacidites sp., Periretipollis spinosus* and the first downhole occurrence of*Cordosphaeridium sp. Proteacidites cooksoni* has a first downhole occurrence of 5260ft and last downhole occurrence of 7420ft.

Zone (vii) Retitricolporites irregularis zone-Eocene: The base is defined by the top of zone (vi) while the top is at 7200ftft. The palynological event that defines this zone are the last downhole occurrence of *Retitricolporites irregularis,Glaphyrocysta sp, Thallasiphora sp and Dinocyst indeterminate. Retitricolporites irregularis* has a first downhole occurrence of 5200ft and last downhole occurrence of 8710ft.

Zone (viii) Racemonocolpites hians zone-Oligocene: The base is defined by the top of zone (vii) while the top is at 7000ft. The palynological event that defines this zone are the last downhole occurrence of *Racemonocolpites hians, Gemmastephanocolpites brevicolpites, Retitriporites sp, Retimonocolpites asabaensis, Psilastephanocolporites minor and. Racemonocolpites hians* has a first downhole occurrence of 5200ft and a last downhole occurrence of 7000ft.

Zone (ix)Stephanoporites sp zone-Oligocene: The base is defined by the top of zone (vii) while the top is at 6800ft. The palynological event that defines this zone are the first downhole occurrence of *Stephanoporites sp, Spiniferites ramosus, Longapertites marginatus and Psilatricolporites operculatus. Stephanoporites sp* has a first downhole occurrence 6700ft
Zone (x) Arecipites exilimuratus zone-Oligocene**:** the base is defined by the top of zone (ix) while the top is at 6700ft. The palynological event that defines this zone are the last downhole occurrence of *Arecipites exilimuratus, Hystrichokolpoma rigaudiae, Striatricolpites bellus and first downhole occurrence of Perfortricolpites digitatus. Arecipites exilimuratus* has a first downhole occurrence of 5260ft and last downhole of 8110ft.

Zone (xi) Praedapollis flexibillis zone-Oligocene: the base is defined by the top of zone (x) while the top is at 6400ft. The palynological event that defines this zone are the first downhole occurrence of *Praedapollis flexibillis, Echiperiporites sp, Marginipollis concinnus and Belanopollis minutus. Praedapollis flexibillis* has a first downhole occurrence of 5320ft and last downhole occurrence of 8590ft.

Zone (xii) Striatricolporites catatumbus zone-Oligocene: the base is defined by the top of zone (xi) while the top is at 6100ft. The palynological event that defines this zone are the first downhole occurrence of *Striatricolporites catatumbus, Lingulodinium machaerophorum, Retitricolpites gageonneti Hystrichokolpoma rigaudiae, Polyadopollenites vancampoi, Belanopollis minutus and Retitriporites sp. Striatricolporites catatumbus* has a first downhole occurrence of 5440ft and last downhole occurrence of 8710ft.

Zone (xiii) Gemmamonoporites spzone-Oligocene: the base is defined by the top of zone (xii) while the top is at 5900ft. The palynological event that defines this zone is defined by the first downhole occurrence of *Gemmamonoporites sp,Bombacacidites sp, and Retibrevitricolporites triangulatus. Gemmamonoporites sp*has a first downhole occurrence of 5800ft and last downhole occurrence of 7420ft.

Zone (xiv) Retibrevitricolporites obodoensis/protrudens zone-Oligocene: the base is defined by the top of zone (xiii) while the top is at 5800ft. The palynological event that defines this zone is defined by the first downhole occurrence of *Psilatricolporites onitshaensis, Retibrevitricolporites triangulatus, Gemmastephanocolpites brevicolpites, Stephanocolporites minor and Crototricolpites crotonosculptus.*The first downhole occurrence of *Retibrevitricolporites obodoensis/protrudens* is 5200ft and the last downhole occurrence is 8290ft.

Zone (xv) Canthiumidites sp zone -Oligocene: the base is defined by the top of zone (xiv) while the top is at 5400ft. The palynological event that defines this zone is defined by the first downhole occurrence of *Striatricolporites catatumbus, Tilia americana, Loranthacites natalia Canthiumidites sp, Retimonocolpites asabaensis and Retistephanocolporites sp. Canthiumidites sp* zone has a first downhole occurrence of 5400ft and last downhole occurrence of 6520ft.

Zone (xvi) Peregrinipollis nigericus zone: Oligocene: the base is defined by the top of zone (xv). The palynological event that defines this zone is defined by the first downhole occurrence of *Peregrinipollis nigericus, Proteacidites cooksoni, Retitricolporites irregularis, Crassoretitriletes varaadshooveni, Retimonocolpites obaensis, Psilatricolporites sp,*

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Arecipites crassimuratus and Magnastriatites howardi. Peregrinipollis nigericus has a first downhole occurrence of 5200ft and last downhole occurrence of 8290ft.

VII. AGE CHARACTERIZATION:

The erected miospore zones were compared with the [1] and was used to delineate the Late Eocene to Early Oligocene.

Stratigraphic interval : 7,000 – 8710ft.
Zone :P400
Subzone :P480 and P470
Age :Late Eocene

This interval is delineated by miospore zones (i-viii) corresponding to P470 and P480 zones of the Evamy 1978 scheme. It is characterized by low frequency of miospore population which is as a result of the sandy nature of the sample intervals within this zone. The presence of *Cinctiperiporites mulleri* at 8,470ft indicates the penetration of late Eocene in this interval. Due to the presence of the spore *Verrucatosporites sp and Laevigatosporites sp*, this indicates that the well is not younger than Miocene. This zone when compared to the [1] zone

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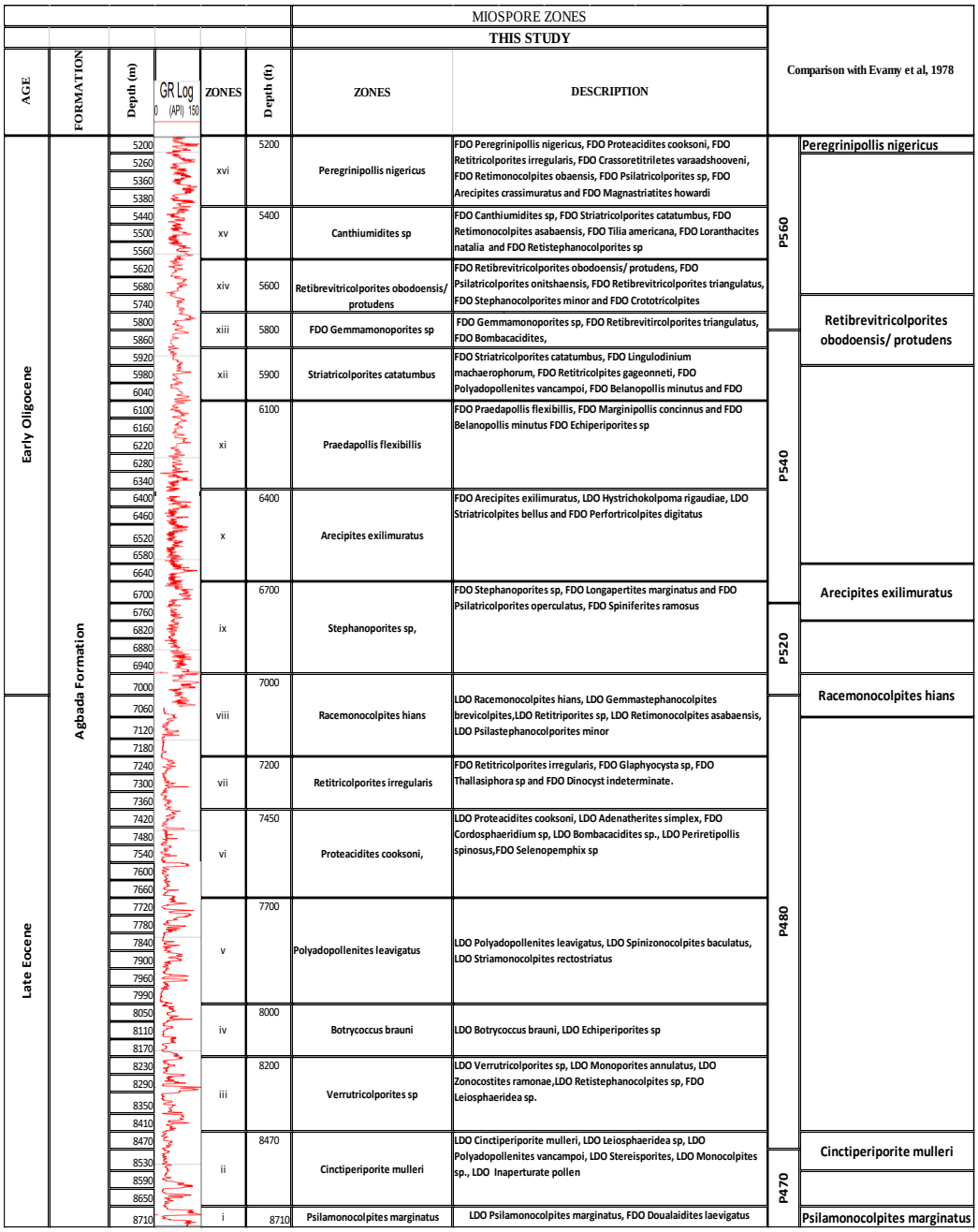

Figure 4: Biozonation of Ben-98 well in comparism with [1]

correlates to the P470 and P480 zones which is characterized by the quantitative top *Psilamonocolpites marginatus* and base *Cinctiperiporites mulleri* for the P470 zone and base *Racemonocolpites hians* and *Cinctiperiporites mulleri* for the P480 zone.

Stratigraphic interval : 5,200 – 7000ft.
Zone : P500
Subzone : P560, P540 and P520
Age : Early Oligocene

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This interval is delineated by miospore zones (ix-xvi) corresponding to P560, P540 and P520 zones of the [1] scheme**.** The occurrence of *Cicatricosisporites dorogensis* indicates that the well is not younger than Oligocene. Furthermore this zone when compared with the [1]zone corresponds to the P560, P540 and P520 zones. The diagnostic palynomorphs used to calibrate this zone are quantitative base *Peregrinipollis nigericus* and increase in *Retibrevitricolporites obodoensis/protrudens* for the P560 zone, *Retibrevitricolporites obodoensis/protrudens* and base continuous occurrence of *Arecipites exilimuratus* for the P540 zone and *Arecipites exilimuratus and Racemonocolpites* for the P520 zone.

VIII. PALEO-DEPOSITIONAL ENVIRONMENT

Integration of sedimentological, wireline log characters and palynological characteristics have enhanced the deductions of varying depositional environments over the analyzed interval (5,200 – 8,710ft) of BEN-98 well. The well recorded a bloom of *Acrostichum aureum* between interval 5200ft to 5560ft about 34% of the total palynomorph and reduces in abundance at 5680ft, from where it inceases in abundance again. This indicates a wet climate which is of brackish environment. Other palynomorphs such as the algae *Botryococcus braunii* which is about 19% is also abundant in the well and indicates a wet climate. It has a bloom from 5200ft to 7000ft and then decreases in abundance from 7000ft to 8710ft. Mangrove pollen *Zonocostites ramonae* is about 10%. Fungi spore hyphae is also found in large quantities indicating a wet climate. It is about 11% in the well. Savannah pollens such as *Proteacidites cooksoni and Striatricolpites catatumbus* is scanty in the well accounting for about 3% of the palynomorphs in the well. *Foraminifera wall linings* is about 1% in the well. Fresh water swamp *Retitricolporites irregularis* is about 8% in the well. Lowland rain forest palynomorphs such as *Psilatricolporites crassus and Psilastephanocolporites minor* is about 11% in the well. Dinocyst cyst such as *Lingulodinium machaerophorum, Spiniferites ramosus and Selenopemphix sp* are about 2% in the well. The Gramineae *Monoporites annulatus*is about 2% (figure 5).

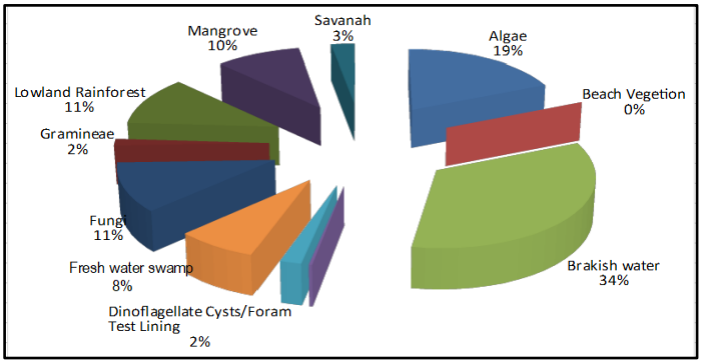

Figure 5: The percentage climatic distribution of Palynomorph in Ben -1, well

IX. SUMMARY/ CONCLUSION

Palynologically, this transitional lithofacies characterized by abundant pteridophyte spores such as *Laevigatosporites spp., Verrucatosporites spp., Zonocostites ramonae* and *Acrostichum aureum*, particularly at the upper part of the interval, dominate the assemblage. Dinoflagellate cysts such as species of *Selenopemphix sp., Lingulodinium machaerophorum* and *Spiniferites ramosus* as well as microforaminiferal wall lining also recorded represents the marine influence. Brackish water environment with marine incursion is inferred as the environment of deposition. The study was carried out on 60 ditch cutting rock samples composited at 60ft interval on a Nigerian Petroleum Development Company (NPDC) well located onshore Niger delta. The depth range of the well is between 5200-8710ft. The samples were analyzed using the standard palynological sample preparation methods. Data gotten from the palynomorphs identified were entered into the strata bug software and a distribution chart displaying the biozonationage and depositional environment of the well sequence was constructed. From the analysis of the samples, it showed that the palynomorphs were fairly diverse and abundant in the upper section of the well (5200-7120ft) and few and scarce in diversity in the lower part of the well (7120-8710ft).

From the gamma ray log responses and sand/shale ratios supported by paleobathymetric data, it indicates that BEN-98 encountered the Heterolithic Agbada Formation. The lithofacies of BEN-98 well was characterized by frequent

ISSN: 2350-0328
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sand/shale alternation, sand/shale ratio of approximately 85:15 and association of shallow water biofacies. Also the lithofacies were Parallic transitional lithofacies from a depth of 5200-7100ft and Transitional lithofacies from a depth of 7100-8710ft. The sandstone are generally thicker than the shale units.
From the palynomorph abundance and distribution, a total of (16) biozones were erected from base to top, the zones are *Psilamonocolpites marginatus zone, Cinctiperiporites mulleri zone, Verrutricolporites sp zone, Botrycoccus braunii zone, Polyadapollenites laevigatus zone, Proteacidites cooksoni zone, Retitricolporites irregularis zone,Racemonocolpites hians zone,Stephanoporites sp zone, Arecipites exilimuratus zone, Praedapollis flexibillis zone, Striatricolporites catatumbus zone, Gemmamonoporites sp zone, Retibrevitricolporites obodoensis/protrudens zone, Canthiumidites sp zone, and Peregrinipollis nigericus* zone.

These zones were correlated with the [1] scheme and two zones, five sub-zones with four bioevent were erected. The zones are P400 and P500 while the subzones were P560, P540, P520, P480 and P470. The significant bioevent as defined by [1] scheme are Quantitative base *Peregrinipollis nigericus* and an increase in *Retibrevitricolporites obodoensis/protrudens* at 5800ft, Base Continuous Occurrence of *Arecipites exilimuratus* at 6,700ft, Base *Racemonocolpites hians* at 7,000ft, Base *Cinctiperiporites mulleri* at 8470ft and FDO of *Doualaidites laevigatus* at 8710ft which is the terminal depth. The zones erected correlated well with the [1] scheme and was used to assign a late Eocene to early Oligocene for the sedimentary succession of Ben 98 well. Also a brackish water environment with marine incursion and a predominantly wet climate is inferred due to the abundance of *Zonocostites ramonae* (Mangrove pollen) and *Acrostichum aureum* and low abundance of savannah pollen *Monoporites annulatus* and *Proteacidites cooksoni* in the well.

PLATE 1

1	*Acostichum aureum*	7	*Brevicolporites guinetii*	13	*Echitriporites trianguliformis*	19
2	*Arecipites exilimuratus*	8	*Cyathidites sp*	14	*Gemmastephanocolpites brevicolpites*	20
3	*Bombacacidites sp*	9	*Canthium sp*	15	*Laevigatosporites sp*	21
c	*Botryococcus brauni*	10	*Ctenolophonidites costatus*	16	*Lycopodium sp*	22
5	*Cicatricosisporites dorogensis*	11	*Doualaidites laevigatus*	17	*Magnastriatites howardi*	
6	*Cinctiperiporites mulleri*	12	*Echistephanocolpites echinatus*	18	*Monoporites annulatus*	

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International Journal of Advanced Research in Science, Engineering and Technology
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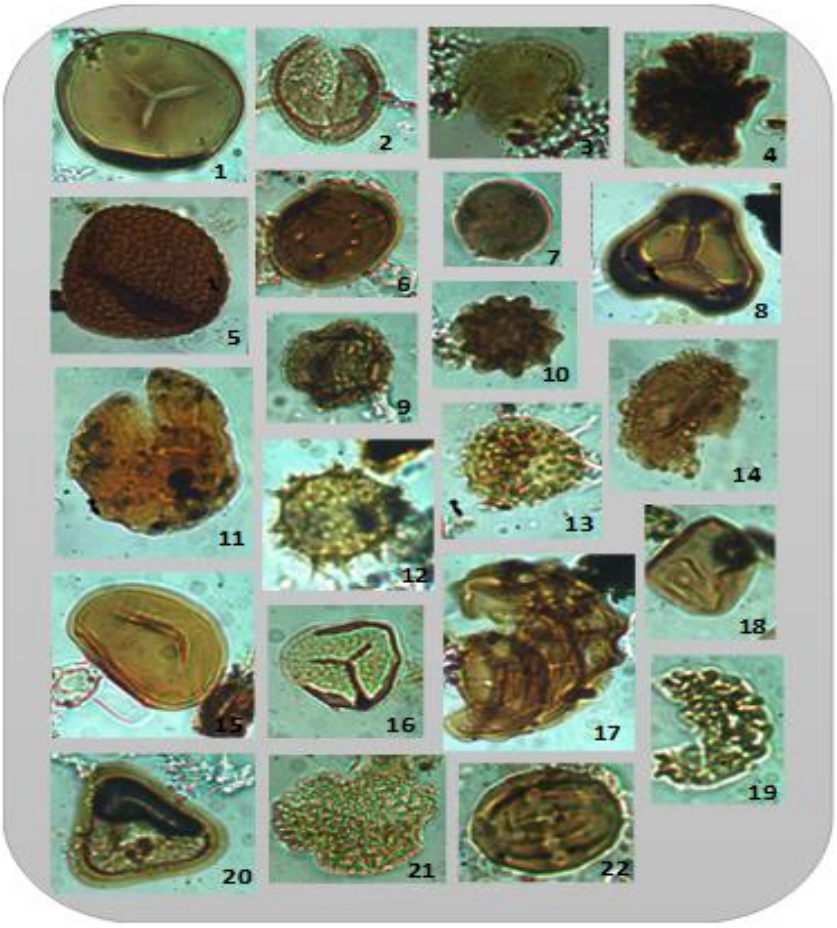

Plate 1: photomicrographs of palynomorphs

PLATE 2							
1	*Praedapollis africanus*	7	*Psilatricolporites onitshaensis*	13	*Retimonocolpites asabaensis*	19	
2	*Praedapollis flexibilis*	8	*Psilatricolporites crassus*	14	*Retistephanocolporites sp*	20	
3	*Proteacidites cooksonni*	9	*Retibrevitricolporites ibadanens*	15	*Retitricolpites ituensis*	21	
c	*Proxapertites cursus*	10	*Racemonocolpites hians,*	16	*Retitricolporites irregularis*	22	
5	*Psilastephanocolporites minor*	11	*Retibrevitricolporites obodoensi*	17	*Retitricolporites ituensis*		
6	*Psilatricolporites operculatus*	12	*Retibrevitricolporites triangulat*	18	*Striamonocolpites rectostriatus*		

Plate 2: Photomicrographs of Palynomorphs

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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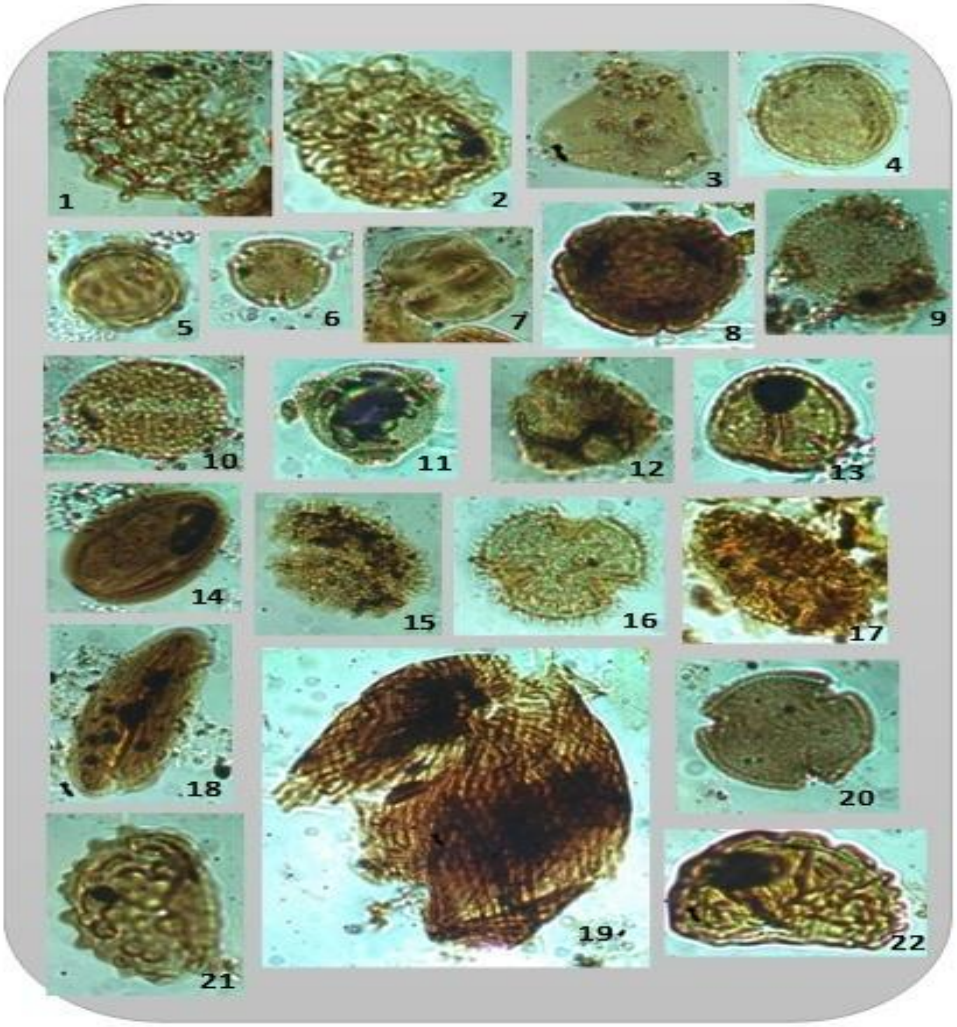

REFERENCES

[1] Evamy, B.D., Haremboure, J., Kamerling, P., Knaap, W.A., Molloy, F.A., Rowlands, P.H., (1978). Hydrocarbon habitat of Tertiary Niger Delta. American Association of Petroleum Geologist Bulletin 62, PP 1-39.
[2] Odumodu, C.F (2011). Geothermal Gradients and Burial History modeling in Parts of Eastern Niger Delta Nigeria. PP 1-195.
[3] Oboh, F.E., Salami, M.B., and Chapman, J.L., (1992). Palynological interpretations of the Paleoenvironments of Miocene strata of the Well Igbomotoru-1 Niger Delta. Journal of Micropaleontology 11, PP 1-6.
[4] Legoux, O., (1978). Quelques especes de pollen caracteristiques du Neogene du Nigeria. Bulletin des centres de recherches exploration-production Elf- Aquitaine 2(2). PP 265-317.
[5] Demchuk, T.D ., and Morley, R.J., (2004). General Palynofloral characteristics from Nigeria deepwater offshore: chronostratigraphy and calibration to sequence stratigraphy Palynology 28, PP 238.
[6] Asadu, A.N., and Lucas, F.A., (2006). A Dinoflagellate Cyst Biozonation Framework for Maastrichtian-Lutenian succession ofBenin-1 well, OPL 205, Western Anambra Basin Flank, Southern Nigeria. Nigerian association of Petroleum explorationists Bulletin 19(1) PP 1-14.
[7] Aturamu, A.O., and Ojo, A.O., (2015). Integrated Biostratigraphic analysis of the Agbada Formation (Nep-1) well Offshore Eastern Niger Delta Basin Nigeria. Australian Journal of Biology and Environmental research. PP 1-14.
[8] Asadu, A.N., and Ikporukpo, B.T., (2020). Foraminifera Biostratigraphy of Middle to Late Miocene sediments in Well X-1, OML 108 Offshore Niger Delta Nigeria. Journal of Scientific and Engineering research 7(5), PP 241-248.
[9] Ononeme, O.E, Lucas, F.A., and Fregene, T.J. Paleoenvironmental reconstruction of sediments in F field, greater ugheli depobelt, Niger delta basin. Journal of geosciences and geomathematics. Volume 9, N0 1, 2021, PP 24-27.
[10] Jacinta, N.C & Edward, A.O. (2019). Palynofacies analysis of Ida-4 well, Niger Delta Basin, Nigeria. Geology, Geophysics & Environmet, 45, 219-230.
[11] Fadiya, S. L., Ogunleye, S. O., Oyelami A. B. & Aroyewun, F. R. (2020). Palynostratigraphic and Palynofacies Analysis of X and Y Wells, Offshore Niger Delta, Nigeria. *Ife* Journal of Science, 22(3).

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International Journal of Advanced Research in Science, Engineering and Technology
Vol. 10, Issue 5, May 2023

[12] Short, K.C., and Stauble, A.J., (1967). Outline Geology of Nigeria. The American association of petroleum geology (AAPG) Bulletin 51. PP 761-791.
[13] Mamah, L.I., Okogbue, C.O., Onuoha, K.M., (2005). Inversion Tectonics of the Benue Trough. Global journal of geological sciences. 3(2). PP 163-167.
[14] Obaje, N.G., (2009). The Niger Delta Basin, In: Geology and Mineral Resources of Nigeria. Lecture Notes in Earth Sciences Volume 120, PP 109-113.
[15] Michele, L.W., Ronald, R.C., and Michael, E.B., (1999). The Niger Delta Petroleum: Niger Delta Province, Nigeria, Cameroon and Equitorial Guinea Africa. United States Geological Survey. PP 10-11.
[16] Odumodu, C.F., and Mode, A.W., (2014). Present day Geothermal regime in parts of Eastern Niger Delta Nigeria. Petroleum technology development journal: An international Journal 1, PP 7-26.
[17] Corredor, F., Shaw, J.H., and Bilotti, F., (2005) Structural styles in deepwater fold and thrust belt of Niger Delta. American Association of Petroleum Geology Bulletin 89, PP 753-780.
[18] Whiteman, A.J., (1982). Nigeria: its Petroleum geology, Resources and Potential. PP 394.
[19] Lawrence, S. R., Munday, S., & Bray, R. (2002). Regional geology and geophysics of the eastern Gulf of Guinea (Niger Delta to Rio Muni): The Leading Edge. *21*(11), 1112 – 1117.