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Palynostratigraphy and Palynoclimate of Ochigbo – 1 well Offshore Niger Delta-Basin, Nigeria

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ABSTRACT

This work entails a palynostratigraphy and palynoclimatic study of Ochigbo – 1 well, offshore Niger Delta. A total of Sixty-two (62) ditch samples were composited at intervals of 100ft. The well covered a total depth range of 3,405-10,640ft. These samples were subjected to standard procedure for palynological study. Recovered palynomorph were rich, diverse and well preserved. The recovered palynomorphs were used for identifying four main palynological zones. These are: *Crassoretitriletes vanraadshooveni*/P700 Zone characterized by the quantitative base occurrence of *Crassoretitriletes vanraadshooveni* and co-occurrence of *Belskipollis elegans*, *Crassoretitriletes 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 *Arecipitesexili muratus*, *Retibrevitricolporite obodoensis/protudens*, *Verrucatosporite susmensis and Gemmamonoporite ssp* dated Late – Early Oligocene and *Racemonocolpite shians/*P400 Zone characterized by the base occurrence of *Racemonocolpite shians.* The palaeoclimatic investigation showed that the sediments were deposited predominantly under wet climate in a mangrove setting and the palaeoenvironment ranges from brackish to deep marine environments.

Introduction

The Niger Delta petroliferous province located in the southernmost part of Nigeria represents the most significant hydrocarbon province in the West African continental margin. With proven reserve of thirty billion barrels of oil and two hundred and sixty trillion cubic feet of natural gas, ranks the Niger Delta as one of the world's major hydrocarbon provinces [1].

The pursuit of petroleum resources has driven exploration and production from onshore terrains into offshore environments, which are geographically and geologically complex [2]. Deep-water exploration and production is a high-risk venture [3]. These include harsh offshore environments such as severe weather, ice and storms that pose engineering challenges to offshore drilling equipment, and risk due to incidents that may represent challenges for emergency preparedness. In addition, there are risks due to major hazards, occupational injury and illness [4]. Therefore, sufficient knowledge of the palaeoenvironment of the petroleum system, such as source, reservoir, and cap or seal rocks of the deep offshore area, is essential to guarantee the safety of the rig personnel and marine life in particular, and to reduce the overall cost of deep offshore exploration and production [5][6]. In order to achieve this goal, it is vital to have a better understanding of the environment under which the lithologies of this petroleum system were deposited.

Pollen grains and spores of vascular plants are some of the biotic proxies that provide evidence of the past occurrences, past populations, past communities, past ecosystems and landscapes, and past environments [7][8]. Palynofloral data can be used to establish local and even worldwide datum of chronologic importance [9].

Palaeoecological record is a natural laboratory to explore biotic responses under a range of past conditions. This record can be used to improve our ability to predict ecological responses to environmental changes using detailed biostratigraphical data of palynoecological groups of interest [9].

Geologic Setting and Stratigraphy

The Niger Delta is an epicontinental marginal sag basin of the deltaic gravity tectonics type. It occupies an area of about 100,000 sq. km extending for more than 300km offshore and onshore. It comprises regressive wedge of clastic sediments which reaches maximum thickness of about 12km [10].

It is situated in the Gulf of Guinea and extends throughout the Niger Delta Province as defined by [11]. From the Eocene to the present, the delta has prograded southwestward, forming depobelts that represent the most active portion of the delta at each stage of its development [12].

The samples are mainly dark gray to black fissile shale and white sandstone. These were packed in small polythene bags which bear the name of the well and sampling depths.

The other materials used for the palynological analysis apart from Sixty-Two standard weighed samples are mortar and pestle, weighing balance, sample plastic cups, pipettes, 5 micron sieves, centrifuge, fume cupboard, Branson sonifer

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250, distilled water, test tubes, glass slide and cover slip, hydrochloric acid (HCl), hydrofluoric acid (HF), filter paper, glycerine (C3H8O3), 250 ml polypropylene beakers, Nitric acid (HNO3), Zinc Bromide (ZnBr2), TPX (a mounting medium), Potassium hydroxide (KOH) and personal protective wears such as safety gloves, glasses and coverall. 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.

Result and Discussion

Lithostratigraphic Description

The lithostratigraphic section of the study well was produced from ditch sample description. The total thickness of the analyzed sample is 7235 Feet (i.e. between 3405-10,640 Feet intervals). The lithologic description involved the physical observation of the sample with a hand lense. 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 (Figure 3). The observed colour in the shale is grey to black while the sandy is white.

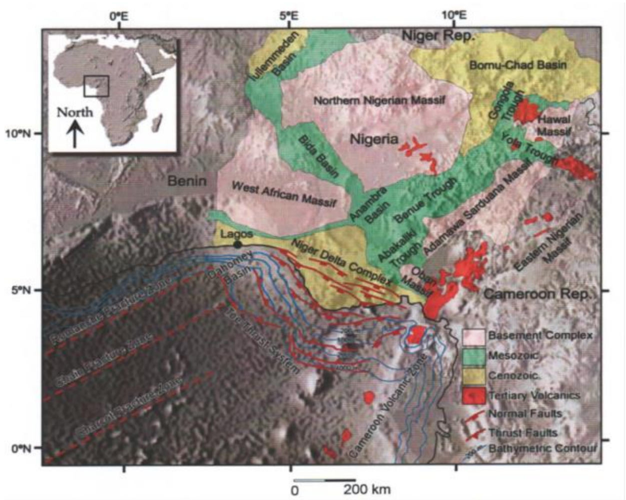

Figure 1: Geologic map of the Niger Delta region [13].

The Niger Delta stratigraphic sequence comprises an upward-coarsening regressive association of Tertiary clastics up to 12 km thick. It is informally divided into three gross lithofacies: (i) marine claystones and shales of unknown thickness, at the base; (ii) alternation of sandstones, siltstones and claystones, in which the sand percentage increases upwards; (iii) alluvial sands, at the top [12], these represents the three lithostratigraphic units that have been recognized in the subsurface of the Niger Delta by Short and [14]; and [15]. These are from the oldest to the youngest, the Akata, Agbada and Benin Formation.

The Agbada Formation is the hydrocarbon - prospective sequence, a paralicclastic sequence which lies below the Benin Formation (continental sand) in the Niger delta. The shallowest part of this sequence is composed almost entirely of non-marine sand [12]. The Agbada Formation consists of predominantly sandy units with minor shale intercalations and thick shale units at the base (which is an alternation of paralic sandstone, shale and clay). This sequence is over 4,000 m thick, but thicker at the central part showing that the depocentre is located in the central Niger delta [16].

The alternation of fine and coarse clastics sediments or clastic particles provides multiple reservoirs-seal couplets, the paralic sequence is present in all depobelts, and the age ranges from Eocene to Pleistocene.

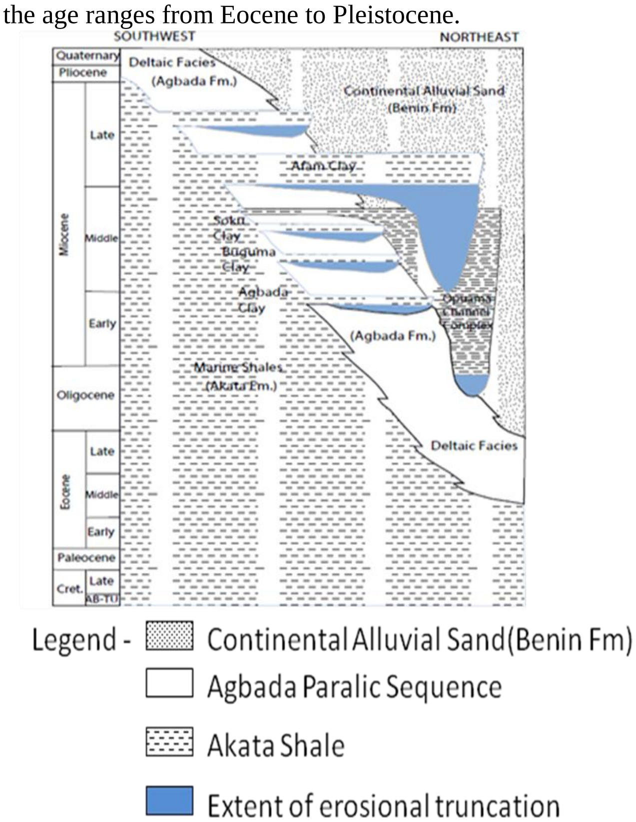

Fig. 2: Stratigraphic column showing three formation of the Niger Delta: Akata, Agbada and Benin Formations [modified after 12]

Materials and Methods

Ditch samples of sedimentary rocks from Ochigbo-1 well were analyzed forpalynomorph constituents from the offshore Niger Delta, Nigeria. The name and location of this well is confidential for proprietary reasons. Therefore, this well has been code-named Ochigbo-1 well. Sixty-two samples were composited at intervals at an average of 100ft.within intervals of 3405-10,640 Feet and analyzed.

The samples are mainly dark gray to black fissile shale and white sandstone. These were packed in small polythene bags which bear the name of the well and sampling depths.

The other materials used for the palynological analysis apart from Sixty-Two standard weighed samples are mortar and pestle, weighing balance, sample plastic cups, pipettes, 5 micron sieves, centrifuge, fume cupboard, Branson sonifer 250, distilled water, test tubes, glass slide and cover slip, hydrochloric acid (HCl), hydrofluoric acid (HF), filter paper, glycerine (C3H8O3), 250 ml polypropylene beakers, Nitric acid (HNO3), Zinc Bromide (ZnBr2), TPX (a mounting medium), Potassium hydroxide (KOH) and personal protective wears such as safety gloves, glasses and coverall. 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.

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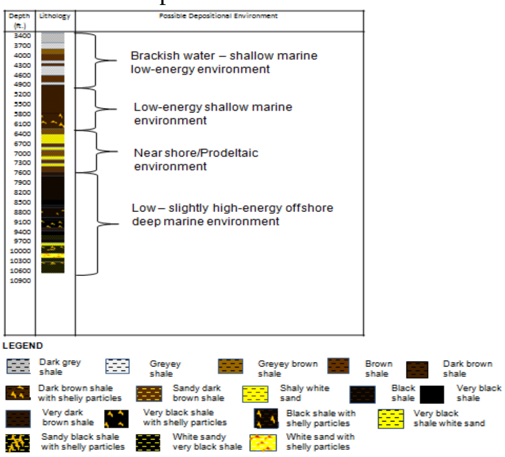


Figure 3: Lithostratigraphy of Ochigbo – 1 well.

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.

Palynological Zonation

Palynological zonation of the well is based on the palynofloral assemblage of significant species as well as their stratigraphic distribution with reference to the zonation schemes of [16]. The section of the well analyzed has been broadly assigned to the P700, P600, P500 and P400 palynological zones of [16]. 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 (Table 1). Descriptions of the palynological zones recognized are provided below:

Crassoretitriletesvanraadshooveni/P700 Zone

Subzone: P740

Interval: 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 base rich occurrence of *Belskipolliselegans*at 5,080ft.

Characteristic Features:

• *Belskipolliselegans*occurs in higher quantities and also regular within the subzone.

• *Echiperiporitesestalae*exhibits higher percentage than underlying subzone.

• *Verrutricolporitesrotundiporus*shows top regular, quantitative top and/or top rich occurrence and is present throughout the subzone.

Subzone: P720

Interval: 5,080 – 5,320ft

Assigned Age: Middle Miocene

Definition: Top marked by the quantitative base rich occurrence of *Belskipolliselegans*at 5,080ft while its base is defined by the base occurrence of *Crassoretitriletesvanraadshooveni*at 5,320ft.

Characteristic Feature:

• *Belskipolliselegans*occurs in low frequencies.

***Magnastriatiteshowardii*/P600**

Subzone: P680 - P670

Interval: 5,320– 5,800ft

Assigned Age: Early - Middle Miocene

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

Characteristic Features:

•*Magnastriatiteshowardi*occurs in high percentages.

• *Racemonocolpiteshians*shows an increase compared with the overlying subzone.

•Monoporitesannulatus has a base rich occurrence in this subzone.

Subzone: P650

Interval: 5,800 –5,920ft

Assigned Age: Middle Miocene

Definition: Top: Defined by the quantitative base occurrence of *Magnastriatiteshowardi*at 5,800ft while its base is defined by increase *Praedapollisflexibilis*at 5,920ft.

Characteristic Features:

•Verrucatosporitesusmensis ndArecipitescrassimuratusexhibit low percentages in this subzone.

• Spirosyncolpitesbrunihas a quantitative top within this interval.

Subzone: P630

Interval: 5,920 –6,280ft

Assigned Age: Early Miocene

Definition: The top is defined by increase *Praedapollisflexibilis*at 5,920ft and the base is marked by top occurrence of *Praedapollisafricanus*at 6,280ft.

Characteristic Features

• VerrucatosporitesusmensisandArecipitesexilimuratusshow a top regular occurrence.

•Praedapollisflexibilis and Peregrinipollisnigericus exhibit a high frequencies than overlying subzone P650.

•Praedapollisafricanusis absent.

•Zonocostites and Psilatricolporitescrassus are present.

Subzone: P620 – P580

Interval: 6,280 –6,780ft

Assigned Age: Late Oligocene

Definition: The top of the composited subzone is marked by the top occurrence of *Praedapollisafricanus*at 6,280ft and the subzonal base is defined by the quantitative base of *Peregrinipollisnigericus*at 6,780ft.

Characteristic Features:

• Retibrevitricolporites obodoensisoccurs as frequent as in the underlying subzone P560.

• Praedapollis flexibilis and Striatricolporites catatumbus are present in abundant or very rich occurrence.

• Peregrinipollis nigericus occurs in moderate quantities.

• The presence of Praedapollis africanus in single specimen only at the upper part characterized the subzone boundary.

***Retibrevitricolporite obodoensis/protudens*/P500Subzone: P560**

Interval: 6,780 – 6,910ft

Assigned Age: Late Oligocene

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

Characteristic Feature:

• *Cinctiperiporites mulleri and Retimonocolpites asabaensis* have a top or quantitative top occurrence within the interval.

Subzone: P540

Interval: 6,910 – 7,150ft

Assigned Age: Early Oligocene

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

Characteristic Feature:

• Peregrinipollis nigericus and Arecipites crassimuratus have a base occurrence at or near the base of subzone.

Subzone: P520

Interval: 7,150 – 8,100ft

Assigned Age: Early Oligocene

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

Characteristic Features:

• Verrucatosporites usmensis shows a top very rich occurrence.

• The percentage of Gemmamonoporites spare high as compared with the overlying and underlying subzones.

• Praedapollis flexibilisis present in high quantity throughout and has a base rich occurrence.

•Retimonocolpites shows a quantitative base in this subzone.

***Racemonocolpites hians/*P400 Zone**

Subzone: P480 & Older

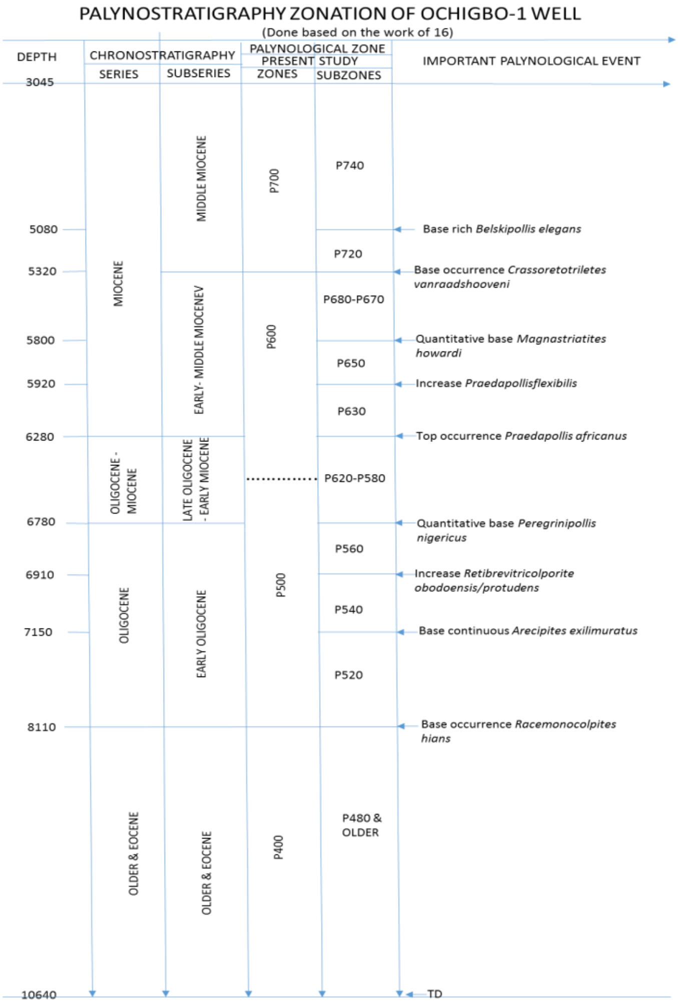
Interval: 8,100 – 10,640ft

Assigned Age: Late Eocene

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

Characteristic Feature:

• The paucity of palynomorphs especially pollens and spores within this interval limits the well to late Eocene. Some of the Dinoflagellates have a very long age range, therefore it would be difficult to further establish subzones because they are not markers. Examples are Senegaliniumbioavatum, Lingulodiniummachaerophorum, Dapsilidiniumstelacum, Lejeunecystasp, and others.



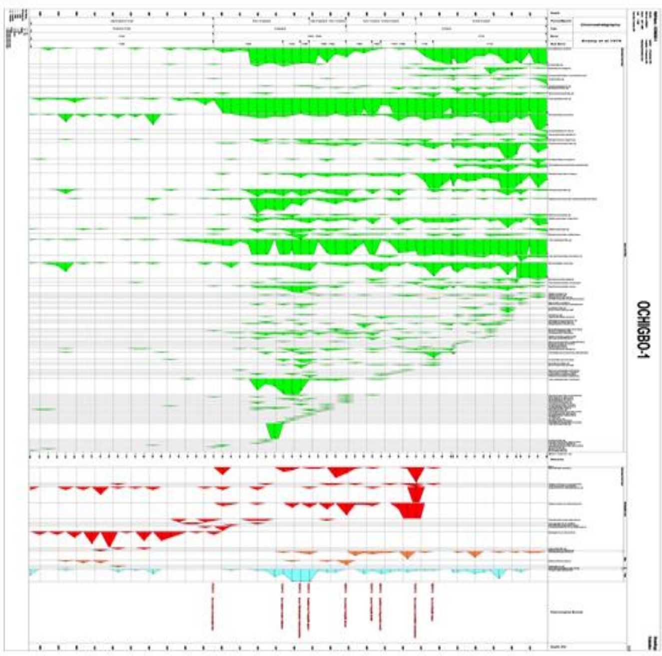


Figure 4. Distribution and Abundance chart of Important Palynomorphs in Ochigbo – 1 well.

Paleoenvironmental Study and Subdivisions of Ochigbo-1 well

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

The predominance of mangrove swamp species such as Zonocostitesramonae,Acrostichumaureum,Psilatricolporitescr assusand Botryococcusbrauni; pteridophytes spores represented largely by species of Leavigatosporites sp., Verrucatosporites sp. and Polypodiaceoisporites sp.characterized this interval. Estuarine dinoflagellate cysts such as Spiniferitesramosus and Tuberculodiniumvancampoe, while the spot occurrence of algae such as Concentricystcirculus and Fungi spore were also recorded. This assemblage is indicative of deposition in an estuarine or brackish-water environment.

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

The brackish-water swamp species such as Acrostichumaureumand Botryococcusbrauniand fern spores recorded moderate recoveries. Dinoflagellate cysts become increased in abundance and diversity than in the overlying interval. The palynofloral assemblage within this interval suggests deposition in environments fluctuating between marine and nearshore.

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

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

The Marine Unit (7,510 – 10,640 Feet)

The interval between 7,510 and 10,640ft is totally dominated by marine dinoflagellate cysts such as Tuberculodiniumvancampoe,Lejeunecystasp,Dapsilidiniumstelacum Senegalinium bioavatum, Polysphaeridiumsubtile, Homotrybuliumtenuispinosus,Lingulodiniummachaerophorum among others. Theoccurance of microforaminiferal wall linings and spot occurrence of brackish water species such as Acrostichumaureum, Botryococcusbrauniand pteridophytes spores indicate a deep deposition marine environment.

Palaeoclimatic Study and Subdivisions

One of the strong tools used in biostratigraphy to determine paleoclimatic conditions is Palynology. The climate of an area is reflected by its vegetation type [17].

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[18]. 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[19].

The method adopted here in is widely practiced and advocated by [20], [21] and [22]. [22] 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 how it could be utilized for Recent sediments.

In this study three palynomorph variables represented by Acrostichumaureum and Zonocostites ramonaeforMangrove species depicting wet climate against Monoporiteannulatusrepresenting Savanna species and dry climate are compared on the bases of their abundance.

Monoporites annulatus

Monoporites annulatusis also the morphogeneric name given to all the pollen species of Poaceae, a grass family. This is because all the pollen grains of Poaceae possess a pore surrounded by annulus, though with varying pore diameter, annulus shape and size [23], [14]; they are well known to be very homogenous [24] which makes it easy to recognise them. Poaceae is one of the most widely distributed and abundant groups of plants on Earth. Grasses are found in every continent and are absent only from central Greenland and much of Antarctica [25]. The persistence of grassland depends on the exclusion of competing woody species that would supplant the grass, hence all major habitats of grass are open and largely devoid of trees [26]. Increase in M. annulatus abundance is often used as indicator of large degree of landscape openness [27][28] and increased aridity [29], [30].

Acrostichum aureum

The genus, Acrostichumsporitesis morphologically similar to the spores of Acrostichum aureum which has been identified as a principal fern presently growing within mangrove vegetation [31];[32]; [33] ;[34]. The above mentioned authors have indicated the adaptation of Acrostichum to coastal areas associated with mangrove vegetation, areas inundated with saline waters, open salt marshes, coastal swamps and areas along estuarine rivers [34]. This has been used to indicate wet climatic condtion [22].

Zonocostites ramonae

The pollen Zonocostites ramonae botanically belongs to the Rhizophoraceae[35];[36]. Rhizophora is an important member of mangrove community in southern America [37];[36];[38]; in the Gulf ofGuinea [36];[26]. Increase in the abundance of Zonocostites ramonaehas been used as an indicator for mangrove vegetation and hence wet climatic condition [12].

The studied well will be broken into four intervals as done above, where the paleoclimatic condition of deposition of each well will be analyse by comparing 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.

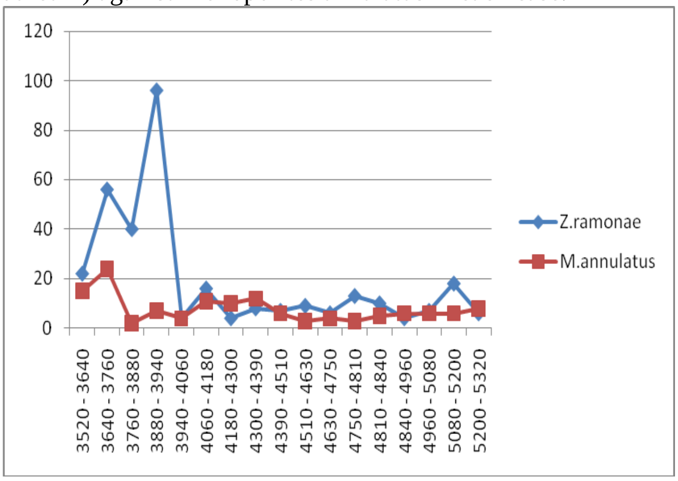


Fig 5a. Plot of Zonocostites ramonae (Z. ramonae)against Monoporites annulatus(M.annulatus) (3,520ft – 5,320ft).

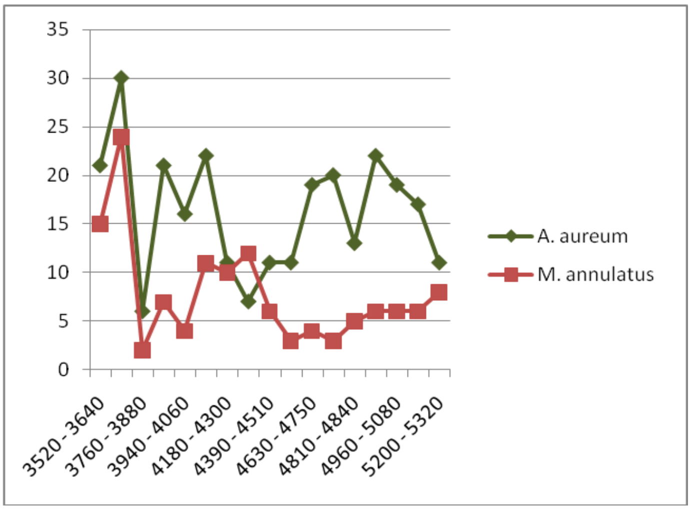


Fig 5b. Plot of Acrostichum aureum (A. aureum) against Monoporites annulatus (M.annulatus) (3,520ft – 5,320ft).

In this interval, the dominance in abundance of *Zonocostites ramonae* and *Acrostichum aureum* which are indicators of wet climatic conditions over the relative abundance of *Monoporites annulatus* which is for dry climate shows that the prevailed climatic condition at this interval (3,520ft to 5,320ft) is wet climate while the sediments were deposited in a mangrove setting.This agrees with the shale lithology in the lithostratigrphy of the well.

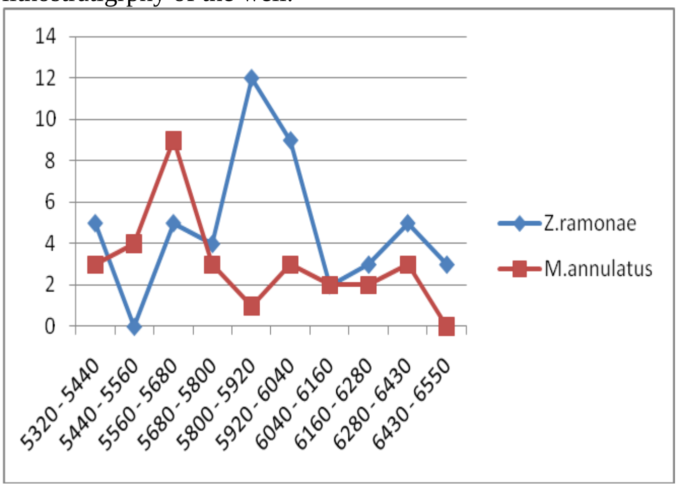
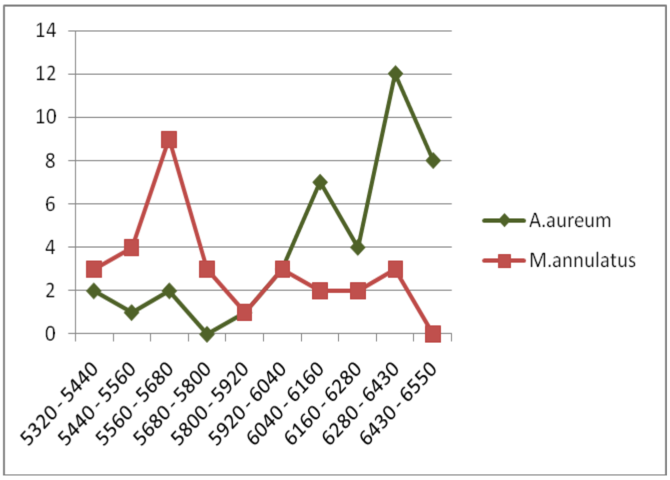


Fig 6a. Plot of Zonocostites ramonae (Z. ramonae)against Monoporites annulatus(M.annulatus) (5,320ft – 6,550ft).



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

In this interval, *Zonocostites ramonae* and *Acrostichum aureum* which are indicators of wet climatic conditions shows dominance over the relative abundance of *Monoporites annulatus* which is for dry climate just like the interval above. Therefore, the prevailed climatic condition in the at interval 5,320ft to 6,550ft is wet climate condition, while the sediments were deposited in a mangrove setting also. This agrees with the shale lithology in the lithostratigrphy of the well.

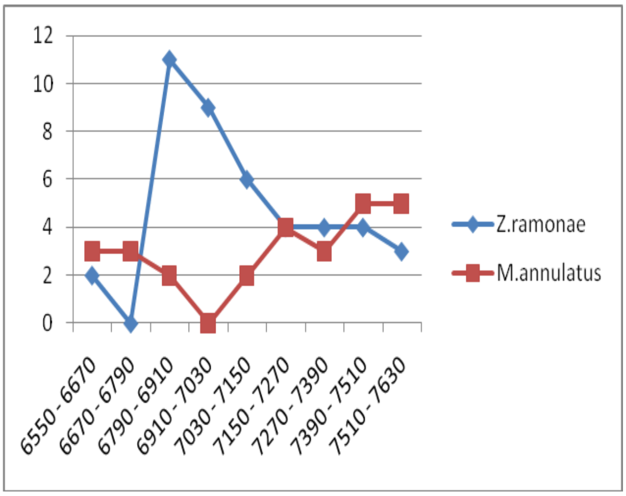


Fig 7a. Plot of *Zonocostites ramonae* (*Z. ramonae*)against *Monoporites annulatus*(*M.annulatus*) (6,550ft – 7,630ft).

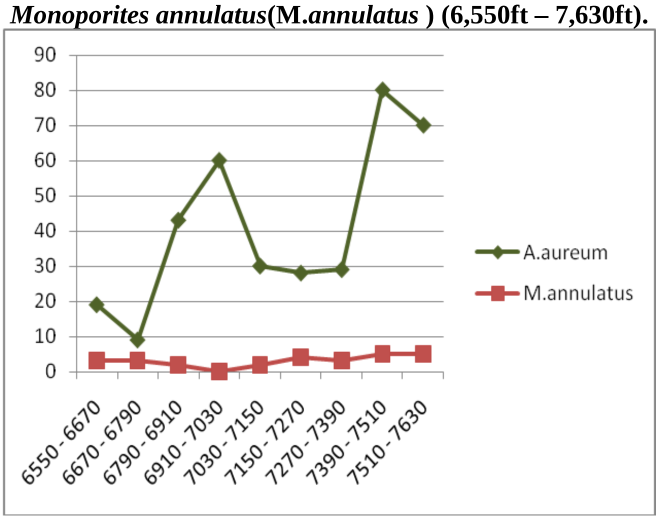


Fig 7b. Plot of *Acrostichum aureum* (A. *aureum*) against *Monoporites* annulatus (M. *Annulatus*) (6,550ft – 7,630ft).

The palaeoclamatic interpretation of this interval is also that of a wet climatic condition because of the dominance of the abundance of *Zonocostites ramonae* and *Acrostichum aureum*over the relative abundace of *Monoporites annulatus.* This also suggests that the sediments are deposited in a mangrove setting also.

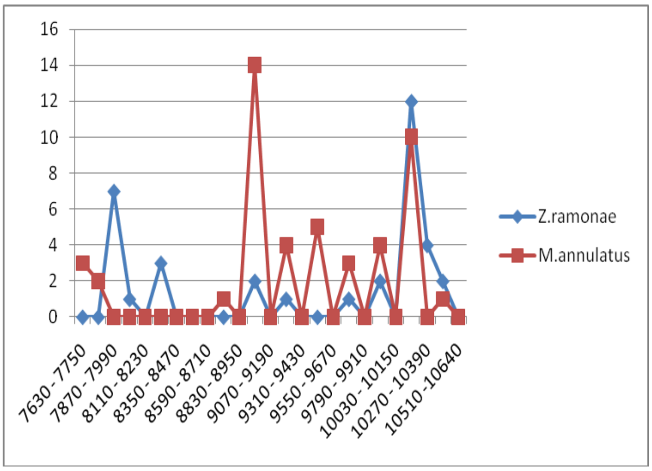


Fig 8a. Plot of Zonocostites ramonae (Z. ramonae)against Monoporites annulatus(M.annulatus) (7,630-10,640).

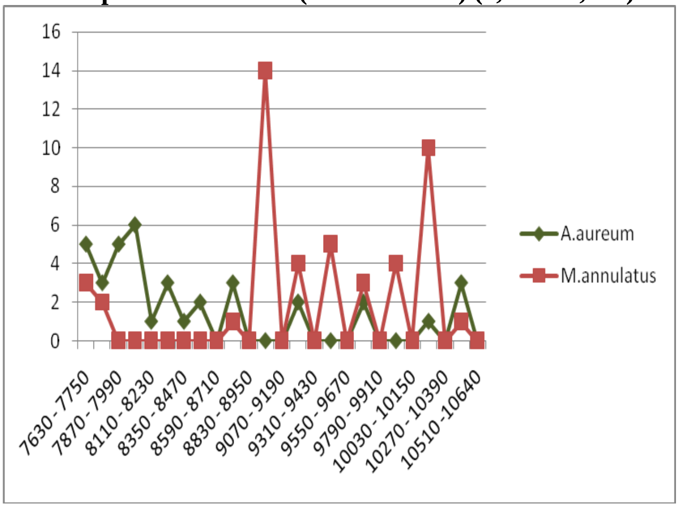
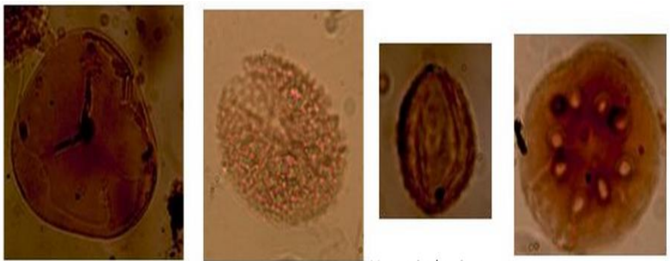


Fig. 8b. Plot of *Acrostichum aureum* (*A. aureum*) against *Monoporites annulatus* (*M. annulatus*) (7,630-10,640).

This is the last interval of the well. Here the abundance of *Monoporites annulatus* rose relatively higher than those of *Zonocostites ramonae* and *Acrostichum aureum* favouring a dry climatic condition of depostion. This also suggests that the sediments were deposited in an environment that is moving from mangrove to savanna setting or fluctuating between mangrove and savnna setting. This is also seen from the lithology of a mixture of sand and shale towards the end of the well (9,610ft to 10,640ft).

PLATE 1

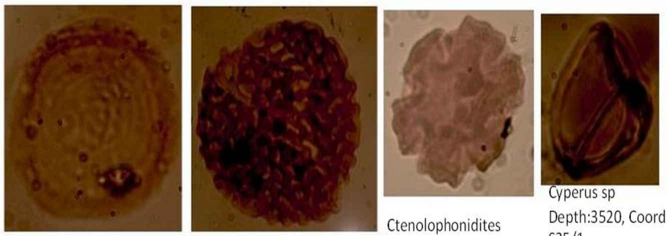


Acrostichum aureum Depth:3520, Coord:R37/1

Arecipites exilimuratus Depth:6550, Coord:X44

Verrutricolporites rotundiporus, Depth: 3520, Coord:S35/1

Cinctiperiporites mulleri Depth:6550, Coord:X35/2

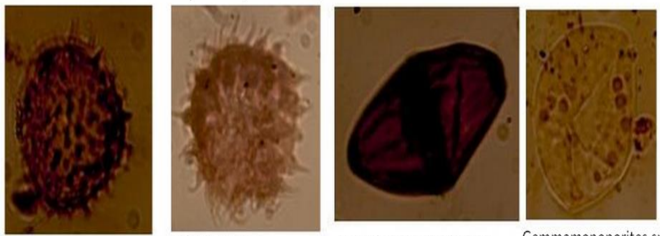


Concentricyst circulus, Depth:3640, Coord:S42/4

Crassoretitriletes vanraadshooveni, Depth:3940, Coord: T29/3

Ctenolophonidites Costatus, Depth:6790, Coord:P33/1

Cyperus sp Depth:3520, Coord S35/1

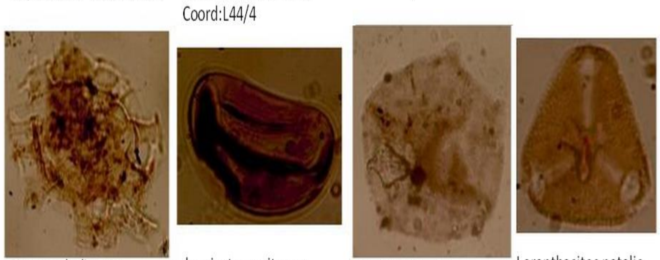


Echiperiporites estalae Depth:3520, Coord:S43/4

Echiperiporites spinosus Depth:6790, Coord:L44/4

Fungal spore Depth:3940, Coord:U46/4

Gemmamonoporites sp Coord:W27,1



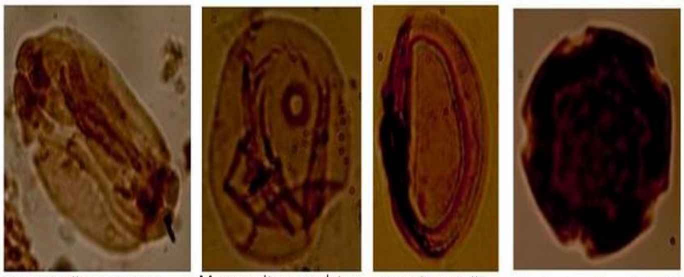
Homotrybulium sp Depth:8110, Coord:U30/3

laevigatosporites sp Depth:3640, Coord:R31/2

Lejeunecysta sp Depth:9070, Coord:Q46/1

Loranthacites natalie Depth:6550, Coord:S37/2

Plate 2



Marginipollis concinnus Depth:7510, Coord:J43/2

Monoporites annulatus, Depth:3640, Coord:Z30/2

Nymphaeapollis clarus

Pachydermites diederixi, Depth:3940, Coord:V42

Peregrinipollis nigericus Depth:6790, Coord:L43

Polypodiaceoisporites sp Depth:3520,Coord:P26/4

Polysphaeridium subtile Depth:8350, Coord:U27

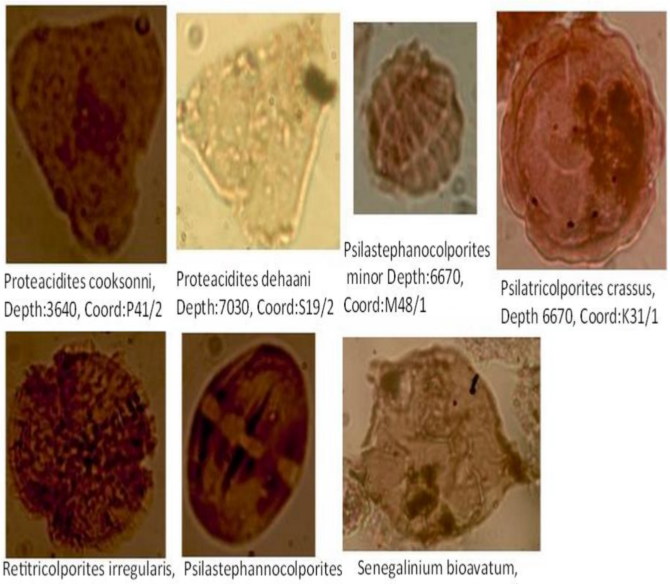
Praedapollis africanus Depth:6790, Coord:L4/,4

Psilatricolporites onitshaensis Depth:6910, Coord:U40/1

Psilatricolporites sp, Depth:3520, Coord:N46/1

Racemonocolpites hians, Depth:3940, Coord:F43

Retibrevitricolporites obodoensis, Depth:5680, Coord:S36/3



Proteacidites cooksonni, Depth:3640, Coord:P41/2

Proteacidites dehaani Depth:7030, Coord:S19/2

Psilastephanocolporites minor Depth:6670, Coord:M48/1

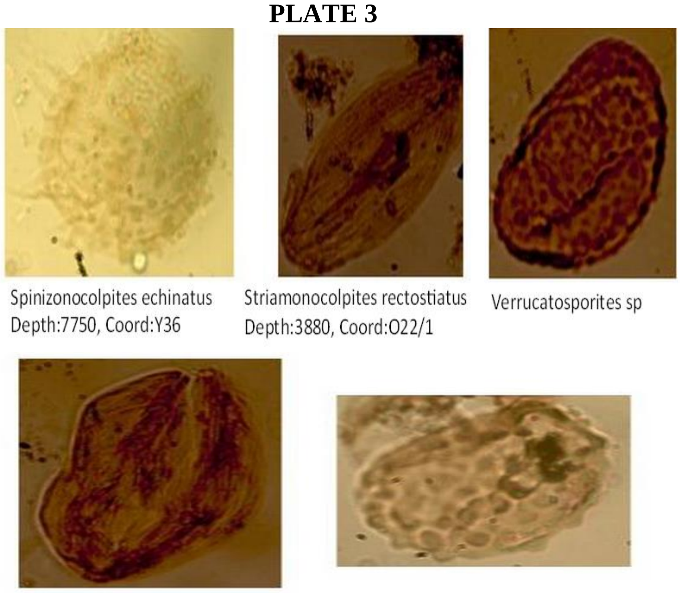
Psilatricolporites crassus, Depth 6670, Coord:K31/1

Retitricolporites irregularis, Depth:3520, Coord:N40/4

Psilastephannocolporites Sapotaceae, Depth:3640, Coord:N38/3

Senegalinium bioavatum, Depth:8110, Coord:M26/3

PLATE 3



Spinizonocolpites echinatus Depth:7750, Coord:Y36

Striamonocolpites rectostiatus Depth:3880, Coord:O22/1

Verrucatosporites sp

Striatricolporites catatumbus Depth:, Coord:Y23/2

Verrrucatosporites usmensis, Depth:6910, Coord:M20/4

Conclusion

Palynological study of the Ochigbo – 1 wells located in the offshore Niger Delta has delivered information on the biostratigraphy of the penetrated stratigraphic sections.The section of the well analysed has been broadly assigned to the P700, P600, P500 and P400 palynological zones of [11]. The zones are further subdivided into the P740, P720, P680- P670, P650, P630, P620- P580, P560, P540, P520 and P420 subzones.

The well section studied is assigned late Eocene to middle Miocene age based on the evidence of the palynological study. Thepalaeoclimatic investigation showed that the sediments in the well sections were deposited predominantly under wet climate in a mangrove setting and the palaeoenvironments ranges from brackish water to deep marine environment.

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