IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 5, Issue 3 Ver. I (May. - June. 2017), PP 14-20
www.iosrjournals.org

Palynological Investigation of Oligocene - Lower Miocene Sediments in Well Z, offshore Niger Delta, Nigeria.

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Abstract: *Palynological investigation of the ditch cutting rock samples from well Z, offshore Niger Delta has been carried out. The rock succession is characterised by the alternation of fossilferous grey sandy shale with shells and shell fragments intercalating with medium - coarse grained, sub rounded to rounded sandstone with scattered mica flakes with appreciable thickness at the base and more paralic at the top, characteristically of the paralic Agbada Formation. Palynological analysis yielded a well preserved and well distributed biostratigraphic relevant Miospores among which fifty nine Miospores were identified. On the basis of the first and last downhole occurrences of these Palynological events, nine miospore biozones were erected. The zones are Zonocostites ramonae, Monoporites annulatus, Dualidites laevigatus, Pachydermites diederixi, Canthium sp, Gemmamonoporites sp, Retibrevitricolpites protrudens, Inaperturopollenites hiatus and Perfotricolporites digitatus.These zones were compared with the pre existing standard palynological zones in Niger delta and other adjoining basins in Nigeria and used to delineate the Oligocene (Chatian) / Lower Miocene intervals in the well.*
Keywords: *Agbada, Age, Miocene, Miospore, Oligocene, Zones.*

I. Introduction:

High resolution biostratigraphic framework is fundamental in the design of an effective exploration strategy to reduce the complexities and enhance the degree of reliability and precision in the stratigraphic mapping of the siliciclastic sequences of the Niger delta basin. The area under study is located in the South eastern part of the offshore Niger delta within ExxonMobil block in the Niger delta oil mining lease (OML) map (Figure, 1)

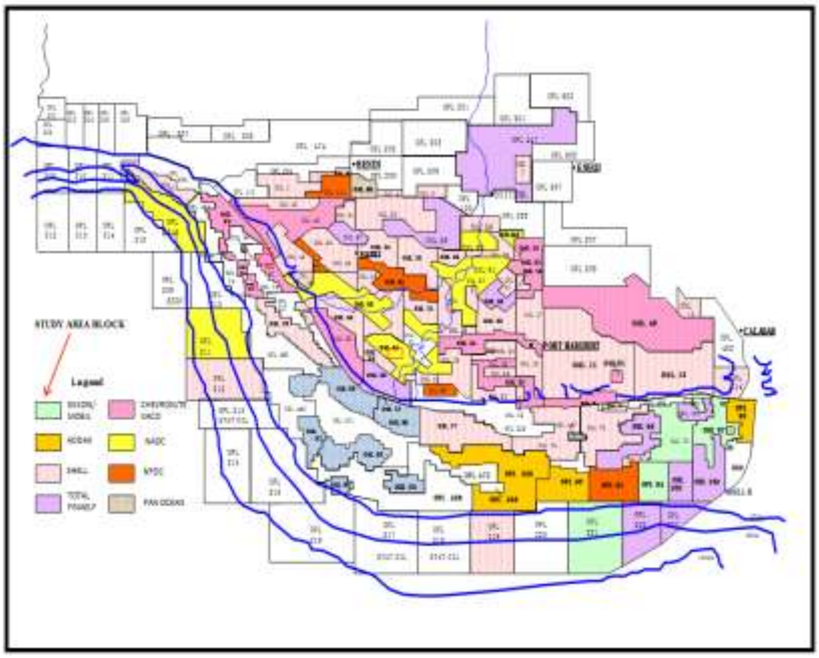


Figure 1: Niger delta oil mining lease (OML) map showing locations of major oil company blocks.

The aim of the research was to use high resolution biostratigraphy as a tool for the age characterization of the rock succession in one EXXONMOBIL hydrocarbon exploratory well (Z), offshore Niger delta, Nigeria (figure 1). The main objectives of the research were to study the lithologic characteristics of the rocks in order to determine the lithostratigraphic units penetrated by the well and to erect the biozonation model of the well using pollen and spores as tools and use it to characterize the age of the sediments.

1.1: Previous work:

Niger delta stratigraphy has been well studied using pollen and spore from Cretaceous to recent sediments in Niger delta and other adjoining sedimentary basins in Nigeria. Among the earlier authors who utilized pollen and spore for age characterization are [1], who discussed the palynology of the Tertiary sediments from tropical areas including South America, West Africa (Nigeria) and Asia. They described and illustrated forty-nine biostratigraphic relevant miospores from which seven pan - tropical zones were erected and used to delineate all geologic boundaries from Maastrichtian to Pleistocene. The zones are from base to top: *Proteacidites dehaani* zone delineating the Maastrichtian sediments; *Proxapertites operculatus* delineating the lower Paleocene to lower Eocene; *Monoporities annulatus* covering the mid Eocene; *Verrucatosporites usmensis* delineating the upper Eocene; *Magnasriatites howardi* of Oligocene to lower Miocene; *Crassoretitriletes vanraadshooveni* delineates the top of lower Miocene and the *Echitriporites spinosus* zone delineating the middle Miocene to Pleistocene intervals. They further subdivided these zones regionally and recognized *Retidiporites magdalenensis* and *Reitibrevitricolpites triangulates* subzones in *Proxapertites operculatus* zone and also recognized *Cicatricosisporites dorogensis* and *Verrucatosporites rotundiporis* subzones in *Magnasriatites howardi* zone. They also compared these zones in Nigeria, Borneo, Caribbean and other areas. The studied interval of the well fall within the *Magnastriatites howardi* zone of [1]. [2], studied some new Eocene pollen of Ogwashi- Asaba Formation in southeastern Nigeria. They systematically described and illustrated forty new Eocene pollen grains attributed to twenty- three genera among which three were originallydescribed. [3], summarized the dinocyst and miospore biozonation models for Maastrichtian-Pleistocene succession of Nigerian sedimentary basins. She erected nineteen informal dinocyst zones and seventeen miospore assemblage zones and compared the dinocyst zones with zonation schemes covering the type Maastrichtian -Pleistocene sections and compared the miospore zones with that of [1]. [4], erected the pollen zones published in Niger delta geological data table. [5], studied the Late Miocene to Early Pliocene palynostratigrphy and Paleoenvironment of ANE-1 Well, Eastern Niger delta and placed the Miocene/Pliocene with the First Appearance Datum (FAD) of *Nymphaeapollis clarus* and increase in *Monoporites annulatus*.

1.2: Niger Delta Geology:

The Tertiary Niger delta complex is made of three diachronous formations, representing prograding depositional facies. These formations are mostly distinguished on the basis of sand-shale ratios. They are the Akata, Agbada and Benin Formations. The type sections of these formations have been well studied and reviewed by several authors as Short and [6], [7], [8], and [9], among others. The Akata Formation is the basal unit of the Tertiary delta complex. The lithofacies is composed of shales, clays, and silts at the base of the known delta sequence. They contain a few streaks of sand, possibly of turbiditic origin [10], and were deposited in holomarine (delta-front to deeper marine) environments. This formation is characteristically over pressured and range in age from the Paleocene to Recent. The Agbada Formation overlies the Akata Formation and forms the second of the three strongly diachronous Niger Delta Complex formations. This forms the hydrocarbon-prospective sequence in the Niger Delta. As the principal reservoir of Niger Delta oil, the formation has been studied in some detail. The works of [11] and Weber and [12] are however, quite classic. The Agbada Formation is represented by an alternation of sands (fluviatile, coastal, and fluviomarine), silts, clays, and marine shales (shale percentage increasing with depth) in various proportion and thicknesses, representing cyclic sequences of offlap units. These paralic clastics are the truly deltaic portion of the sequence and were deposited in a number of delta-front, delta-topset, and fluvio-deltaic environments. The upper part of the Agbada Formation often has sand percentages ranging from 50 – 75%, becoming increasingly sandy towards the overlying Benin Formation. The low part has less than 40% sand and the shaliness increases downwards and laterally into the Akata Formation. Agbada Formation is overlain by the third formation, the Benin Formation, a continental latest Eocene to Recent deposit of alluvial and upper coastal plain sands that are up to 2000 m thick. This is the freshwater bearing formation in the Niger Delta (figure 2).

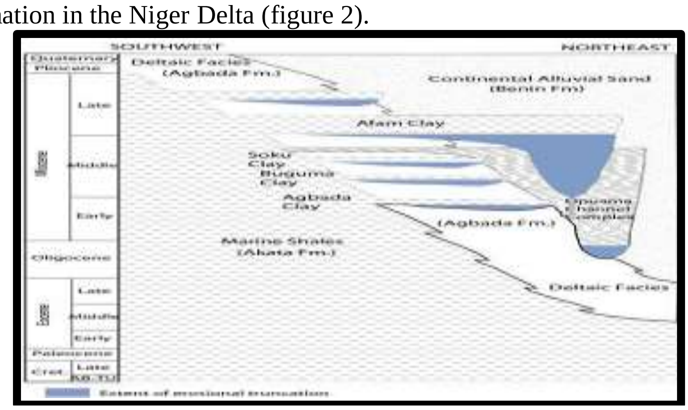


Figure 2: Stratigraphic column showing formations of the Niger delta (modified from [8], and [13].

II. Method Of Study

The methods used were the sedimentological analysis and Palynostratigrphy of the ditch cutting rock samples. A total of one hundred and ten (110) ditch cutting rock samples made available for this study were analyzed texturally and lithologically. The Lithological analysis was done with the aid of the gamma ray log. Variations in the gamma ray log signatures were used in differentiating the lithologic units with high gamma ray log values depicting shale while low gamma ray values corresponds with sandy units. The textural analysis was made by viewing these samples under the microscope with a grain size comparator in order to identify the different rock types penetrated by the well and its variability within succession. The sedimentary structures and associated accessory mineral content of the sediments were also considered within the limit of the available data. In order to recover the palynomorphs from the rock matrix, the ditch cutting rock samples were composited at 30-60 Feet intervals and subjected to standard Palynological sample preparation method involving various acid treatments for the removal of carbonates, silicates, oxidation, washing, concentration of palynomorphs, staining and mounting into microscope slides with subsequent analysis for pollen and spores. A total of eighty-eight (88) slides were made from the well and analyzed for pollen and spores with transmitted light binocular microscope. The analysis involved the identification of the palynomorphs from genus to species level using albums and catalogues of Niger delta palynomorphs and other available useful journals of both local and global importance; recognition and proper counting and study of general distribution of the palynomorphs in the sediments in order to characterize the age of the sediments. The (x40) objective lens and a digital camera were used for the analysis.

III. Results And Discussions

3.1: Lithostratigraphy:

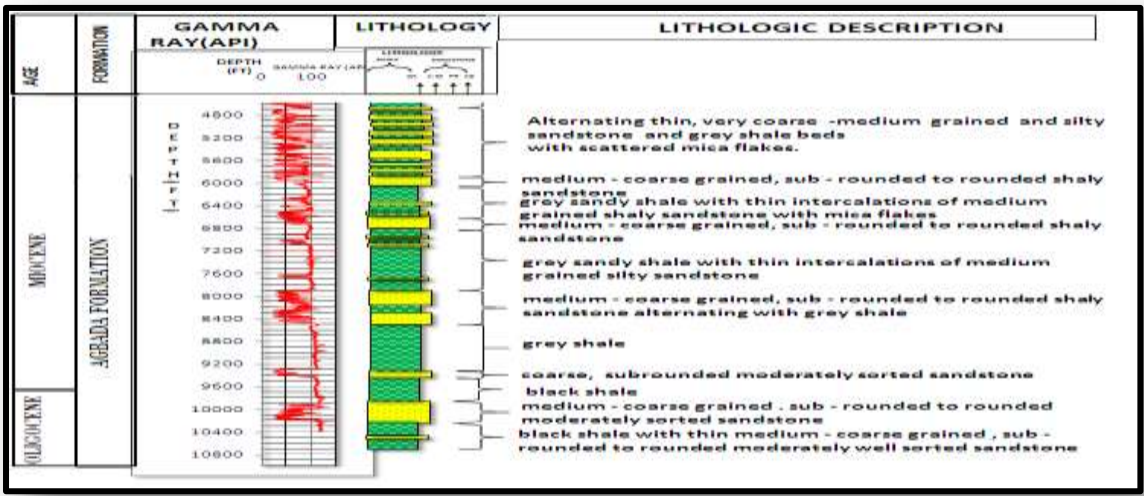
The Litholog of the well is presented in Figure (3). The rock succession is characterised by the alternation fossilferous grey sandy shale with shells and shell fragments intercalating with medium - coarse grained, sub rounded to rounded sandstone with scattered mica flakes with appreciable thickness at the base and more paralic at the top characteristically of the paralic Agbada Formation (figure 3).

3.2: Biozonation and Age: Palynological analysis yielded well preserved and diverse miospores useful for biostratigraphy among which fifty-nine Miospores (forty- seven pollen and twelve spores) were identified. On the basis of first and last downhole occurrences of these palynological events, nine miospore biozones were erected and used to characterize the age of the sediments from Oligocene to Lower Miocene (Figure, 4).

3:2:1: Miospores Biozonation : The miospore range chart and biozonation of well Z, is presented in (Figure, 4) The zones are defined from base to top as follows:

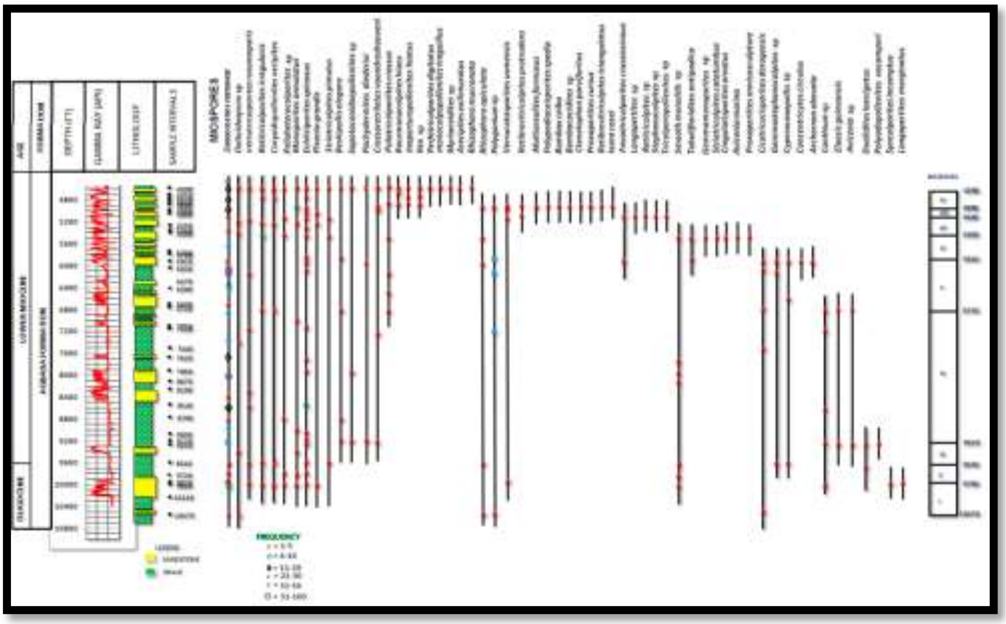
Zone (i): *Zonocostites ramonae*– Oligocene. The base of this zone which is the base of the well is at 10470 ft and defined by the first downhole occurrences of *Zonocostites ramonae, Rhizophora apiculata, Cicatricocisporites dorogensis, Polygonium* sp, and *Deltoidospora* sp. The top is recognised at 9870 ft and defined by the first downhole occurrence of *Longertites marginatus* and *Syncolporites incomptus;* The last downhole occurrences of *Verrucatosporites usmensis, Caryadopollenites veripites,* sp, *Monoporites annulatus,* , *Verrutriculporites rotundiporis, Retitriculporites irregularis, Pisonia grandis,* smooth monolith spore, *Canthium* sp, *Psilaheterocolpites* sp and *Echitriporites Spinosus.*

Zone (ii): *Monoporites annulatus* sp zone- Oligocene. The base is the same as the top of zone (i). The top is recognised at 9540 ft and defined by the last downhole occurrences of *striatriculpites pimulus, Dualidites laevigatus, Cyperaceapollis* sp, *and Gemmastephanocolpites* sp.



Figure, 3: Litholog of well Z

Zone (iii): zone: *Dualidites laevigatus* zone- Oligocene. The base is the same as the top of zone (ii). The top is recognised at 9210 ft and defined by the first downhole occurrences of *Polyadopollenites vacampori* and *Dualidites laevigatus;* the last downhole occurrences of *Pachydermites diederixi, Elaesis guineansis, Avicenia* sp, *Sapotaceoidaepollenits* sp, *Crassoretitriletes vanraadshoeveni* and *Beskipollis elegans.*
Zone (iv): *Pachydermites diederixi* zone- Lower Miocene. The base is the same as the top of zone (iii). The top is recognised at 6720 ft and defined by the first downhole occurrences of *Canthium* sp, *Avicenia* sp, *and Elaesis guineansis,* and the last downhole occurrence of *Psilatriclporites crassus.*
Zone (v): *Canthium* sp zone- Lower Miocene. The base is the same as the top of zone (iv). The top is recognised at 5910 ft and defined by the first downhole occurrences of *Concentricytes circulus, Gemmastephanocolpites* sp, *Cyperaceapollis* sp, *Archornea Obovata* and *Cicatricocisporites dorogensis* and last downhole occurrence of *Forveotricolporites crassiexinus,*



Figure, 4: Miospore range chart and biozonation of well Z

Zone (vi) *Gemmamonoporites* sp zone- Lower Miocene. The base is the same as the top of zone (v). The top is recognised at 5400 ft .The top of this zone is defined by the first downhole occurrences of *Tubifloridites antipodica,* smooth monolete spore, *Cingulatisporites ornatus, Avicenia marina, Gemmamonoporites* sp, *Striatriculpites catatumbus* and *Proxapertites annisoscpulture* and last downhole occurrence of *Retibrevitricolpites protrudens.*
Zone (vii): *Retibrevitricolpites protruden* szone- Lower Miocene. The base is the same as the top of zone (vi). The top is recognised at 5040ft and defined by the first downhole occurrences of *Forveotricolporites crassiexinus, Longapertites* sp, *Retitricolporites* sp, *Stephanocolporites* sp, and *Tricolporopollenites* sp
Zone (viii): *Inaperturopollenites hiatus* zone- Lower Miocene. The base is the same as the top of zone (vii). The top is recognised at 4890ft and defined by the first downhole occurrences of, *Rhizophora apialata, Retibrevitricolpites triangulatus, Bombax ceiba, Polygonium* sp, *Multiaerolites formosus, Ctenolonphonidites parviforlius, Verrucatosporites usmensis, Polypodiaceisporites spedia, Proxapertites cursus, Ixora casei* and *Retibrevitricolpites protruden;* and last downhole occurrences of *Racemonocolpites hians, Ilex* sp and *Inaperturopollenites hiatus.*
Zone (ix): *Perfotricolporites digitatus* zone - Lower Miocene The base is the same as the top of zone (viii). The top is recognised at 4770 ft and defined by the first downhole occurrences of *Zonocostites ramonae, Deltoidospora sp, Verrutriculporites rotundiporis, Caryadopollenites veripites, Psilaheterocolporites* sp, *Monoporites annulatus, Echitriporites Spinosus, Pisonia grandis, Striatriculpites pimulus, Beskipollis elegans, Sapotaceoidaepollenits* sp, *Pachydermites diederixi, Crassoretitriletes vanraadshoeveni, Psilatriclporites crassus, Racemonocolpites hians, Inaperturopollenites versus, Ilex* sp, *Perfotricolporites digitatus, Monocolpollenites trianguilus, Myrtaceidites* sp, *Arecipites exilimuratus, Rhizophora mucronata* and *Retitriculporites irregularis.* Some of the photomicrographs of these events are illustrated in plates (1-2).
3:2:3: Age Characterization: The erected miospore zones were compared with pantropical zones of [1] and used to delineate the Oligocene/Lower Miocene boundary (Figure, 5)

The Oligocene interval: This interval is characterised by Miospore zones, (i to iii). Some age diagnostic palynomorphs used to delineate this interval include: *Zonocostites ramonae, Beskipollis elegans, Verrucatosporites usmensis, Crassoretitriletes vanraadshoeveni, Triculpites retibaculatus, Canthimidites, Proxapertites annisosculpure, Verrutriculporites rotundiporis, Retitriculporites irregularis, Retibrevitricoporites protrudens, Retibrevitricoporites obodoensis, Pachydermites diederixi, Striatriculpites catatumbus, Perfotriculporites digitatus, Racemonocolpites hians, Polypodiaceisporites* sp, *Striatriculpites pimulus, Dualidites laevigatus* etc. The occurrence of *Zonocostites ramonae* at the base of the wells indicate an age not older than Oligocene. The Rhizophora pollen *Zonocostites ramonae* evolved in the western coast of Africa in Oligocene and has continued in coastal and marine sediments of the tropics to Recent [1]. There has not been any record of this marker pollen in Nigeria in pre Oligocene time. First regular increase in *Zonocostites ramonae* has been consistently found in the Miocene and has been used to recognize Miocene sediments. The pre Miocene recorded low frequency occurrence of this pollen as in the case of this interval in the studied well, therefore an Oligocene age is indicated for the sediments. Also the co occurrence of known Eocene to Miocene palynomorphs such as *Verrucatosporites usmensis, verrutricolporites rotundiporis, Beskipollis elegans* etc is an indication of an age not younger than Miocene. The top of this interval is constrained by the first downhole occurrence (FDO) of *Dualidites laevigatus* recorded in the *Dualidites laevigatus* zone. This pollen has not been recorded in sediments older than Oligocene. This judgement is also supported by the incoming of the Oligocene /Miocene transition miospores as *Gemmamonoporites* sp, *Perfotrocolorites digitatus, Caryadopollenites veripites, Sapotaceidopollenites* sp etc. The top of this interval is recognised at 9210 ft, and correlates well with *Verrucatosporites usmensis* zone of [1] and P620 of [4].

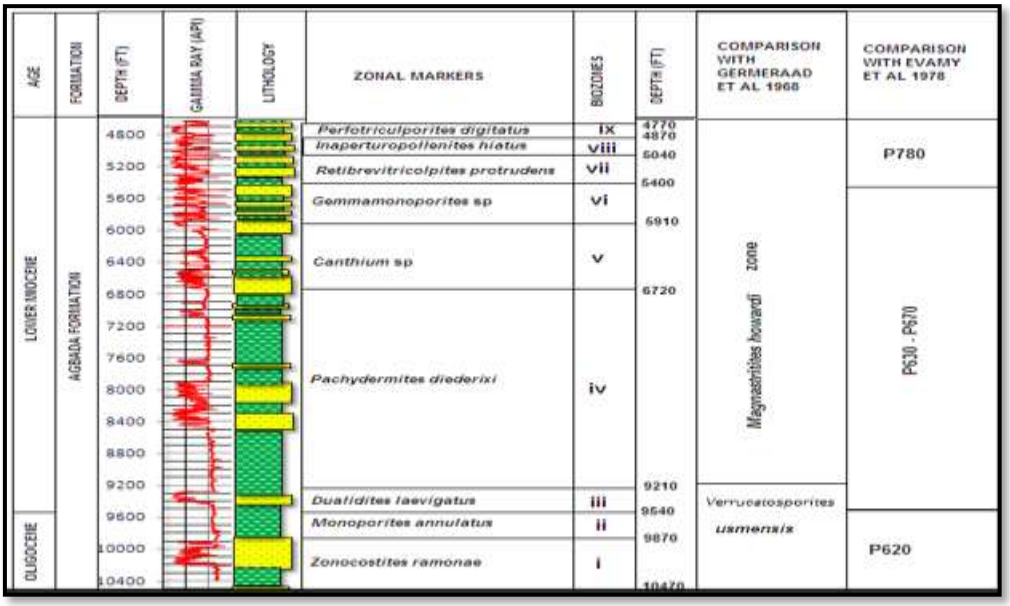


Figure 5: Miospore Biozones of well Z, in comparison with [1], and [4] zonation models.

The lower Miocene interval: This interval is recognised by miospore zones (iv - ix) and the diagnostic miospore events used to characterise this interval include: the first downhole occurrences (FDO) of *Retibrevitricolpites protrudens, Bombax ceiba, Multiaerolites formosus, Perfotriculporites digitatus, Inaperturopollenites hiatus,* etc. These events correlate this interval with the *Magnastrites howardi* zone of [1], and P630 - P780 of [4] pollen zones (Figure, 5).

IV. Summary / Conclusion

Palynological analysis of the studied wells yielded a well preserved and diverse biostratigraphic relevant Miospores among which fifty nine Miospores were identified. On the basis of the first and last downhole occurrences of these Palynological events, nine miospore biozones were erected. The zones are *Zonocostites ramonae, Monoporites annulatus, Dualidites laevigatus, Pachydermites diederixi, Canthium* sp, *Gemmamonoporites* sp, *Retibrevitricolpites protrudens, Inaperturopollenites hiatus and Perfotricolporite digitatus. Zonocostites ramonae, Monoporites annulatus and Dualidites laevigatus* zones were compared with the *Verrucatosporites usmensis* zone and P620 of [1] and [4] respectively to delineate the Oligocene (Chatian) interval while the *Pachydermites diederixi, Canthium* sp, *Gemmamonoporites* sp, *Retibrevitricolpites protrudens, Inaperturopollenites hiatus and Perfotricolporites digitatus* zones were compared with the

Magnastriatites howardi zone and P630-P780 of [1] and [4] respectively to delineate the Lower Miocene. Inference from the sedimentology also shows that the studied section penetrated the Agbada Formation.

PLATE 1

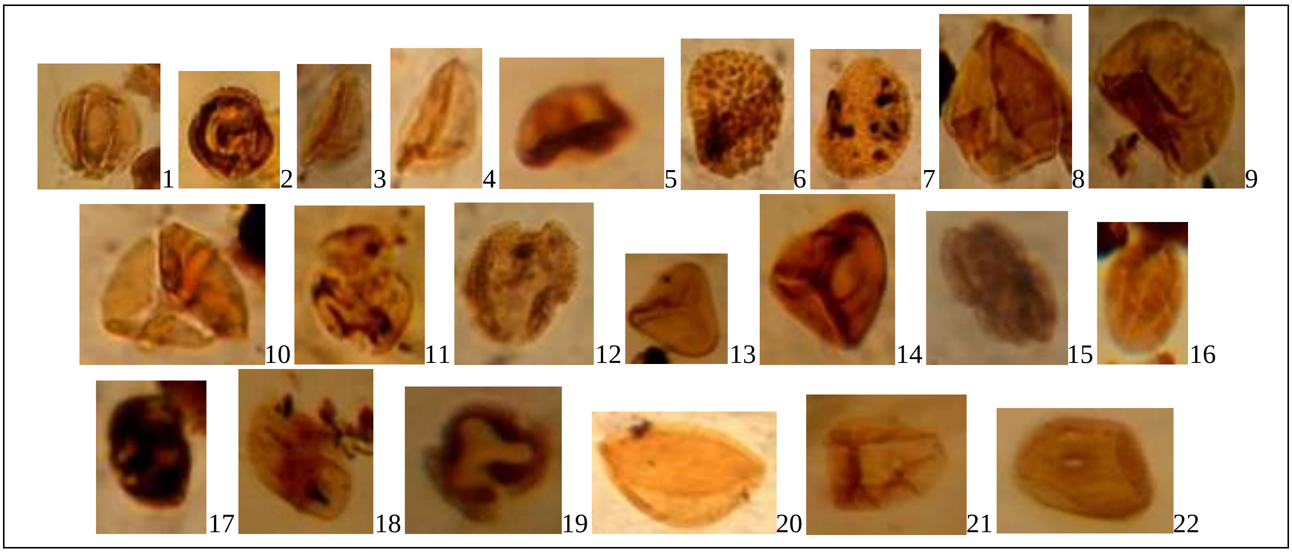


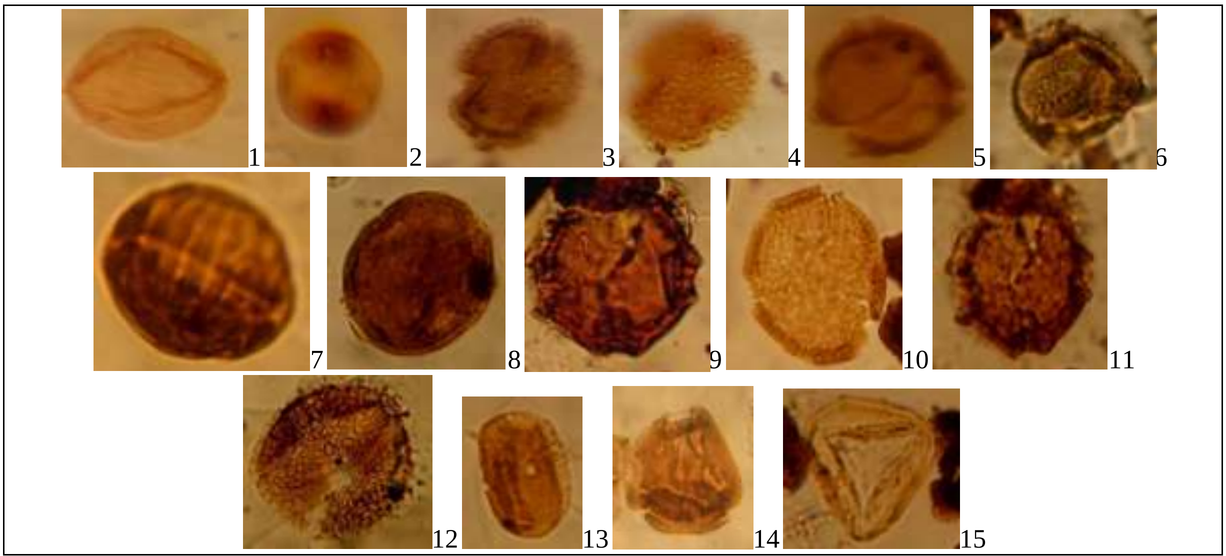
PLATE 1

1	*Zonocostites ramonae*
2	*Zonocostites ramonae*
3	*Verrutricolporites rotundiporis*
4	*Verrutricolporites rotundiporis*
5	*Verrutricolporites rotundiporis*
6	*Verrucatosporites usmensis*
7	*Verrucatosporites usmensis*
8	*Cyperaceaepollis* sp
9	*Cyperaceaepollis* sp
10	*Syncolporites incomptus*
11	*Striatriculpites pimulus*
12	*Canthium* sp
13	*Deltoidospora* sp
14	*Deltoidospora* sp
15	*Polyadopollenites vacampori*
16	*Sapotaceoidaepollenites* sp
17	*Dualaidites laevigatus*
18	*Beskipollis elegans*
19	*Archornea obovata*
20	*Longapertites marginatus*
21	*Monoporotes annulatus*
22	*Monoporotes annulatus*

PLATE 2

1	*Striatriculpites catatumbus*
2	*Tricolporopollenites* sp
3	*Retitricolporites irregularis*
4	*Retitricolporites irregularis*
5	*Retibrevitricolporites protrudens*
6	*Retibrevitricolporites protrudens*
7	*Stephanocolpites* sp
8	*Pachydermites diederixi*
9	*Pachydermites diederixi*
10	*Pachydermites diederixi*
11	*Pachydermites diederixi*
12	*Racemonocolpites hians*
13	*Multiaerolites formosus*
14	*Avicenia* sp
15	*Polypodiaceisporites spedia*

PLATE 2



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