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Miospore Biozonation and age characterization of Upper Miocene - Pliocene sediments in well X, deep offshore Niger delta.

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Abstract**:** *Miospore biozonation carried out on ditch cutting rock samples has been used to delineate the Upper Miocene/Pliocene sediments in well X, deep offshore, Niger delta. The rock succession is characterized by the alternation of sand and shale of variable thicknesses with lateral gradation in grain size. The base of the studied interval is made of Black shales intercalating with medium to coarse grained, sub rounded to rounded sandstone and siltstone at intervals representing the paralic Agbada formation while the top is made of Sub angular - sub rounded quartz pebble conglomerate, pebbly sandstone, medium - coarse grained, sub- rounded to well-rounded sandstone, intercalating with very thin lenses of grey shales typically of the coastal plain sand of the Benin Formation. The palynological characterization of the well yielded a well preserved and diverse biostratigraphic important Miospores among which sixty-one miospores (fifty-one pollen and ten spores) were identified and used to erect ten miospore zones. The biozonation is premised on the recognition of the first and last downhole occurrences of these Palynological events. The zones are defined from the base to top as follows: Magnastiatites howardi, Inerperturopollenites sp, Caryapollenites veripites, Striatricolpites catatumbus, Verrutricolporites rotundiporis, Echitriporites spinosus, Canthimidites sp, Pordocarpus milanjanus and Verrutriculporites rotundiporis. Correlation with the existing pantropical zones yielded Upper Miocene to Pliocene age. Results from textural and lithological analysis show that the rock succession penetrated the Agbada and Benin Formations.*

Keywords*: Age, Biozonation, Formation, Miospore, Miocene, Pliocene*

I. Introduction

An excellent biostratigraphic framework is crucial for understanding the stratigraphy and age characterization of sedimentary rocks. This research was aimed at the use of high resolution biostratigraphy as a tool for the age characterization of the rock succession in one EXXONMOBIL hydrocarbon exploratory (X), offshore Niger delta, Nigeria (figure 1). The main objectives of the research were to study the lithologic characteristics of the sediments in order to determine the lithostratigraphic units penetrated by the well and also to erect the biozonation model of the well for the purpose of age characterization.

1.1: Previous palynological investigations:

Pollen and spores have been well studied in Niger delta and has proven a useful biostratigraphic tool in Cretaceous to Recent sediments in the Niger delta and other adjoining sedimentary basins in Nigeria**.** However, a number of papers have been reviewed for the purpose of re-validation of this method. [1], discussed the aspects of geology of Nigeria. He studied the biostratigraphy and tectonic setting of the Cretaceous and Cenozoic sediments in Nigeria and gave detailed paleontological account of both mega and microfossils such as foraminifera, ostracods, gastropods, pelecepods, pollen and spores.He used them to characterise the age and environment of deposition of the sediments. He also gave some illustrations (photomicrographs) and contributed much to the nomenclature of the forms recovered in these sediments. [2], discussed the palynology of the Tertiary sediments from tropical areas including South America, West Africa (Nigeria) and Asia. They described and illustrated forty-nine biostratigraphically important 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 *Echitriporites spinosus* zone of [2]. [3], 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. [4], 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 [2]. [5], erected the pollen zones of the Niger delta published in the Niger delta chronostratigraphic chart. [6], Ige, 2011, studied the Vegetation and Climatic History of the Late Tertiary Niger delta, based on Pollen [7], 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*.

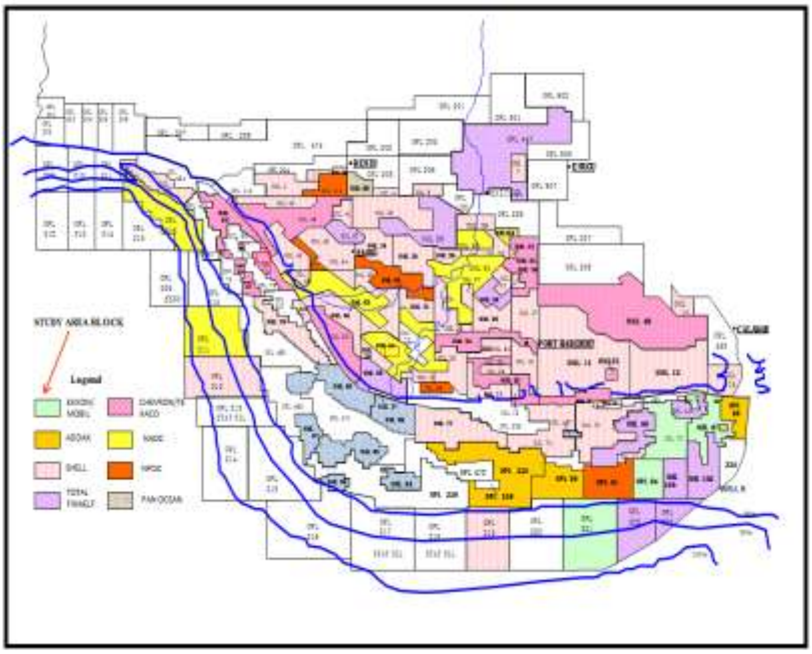


Figure 1: Niger delta oil mining lease (OML) map showing location of the study area.

1.2: Niger delta Geology:

The Tertiary Niger delta is one of the largest regressive deltas in the world with an area extent of about 300,000 km^2 [8], a sediment volume of 500,000 km [9], and a sediment thickness of over 10km in the basin depocenter [10]. The geology of the Niger delta has been extensively discussed by several authors as [11],[12], [5], [13],[13], [14],[14] [15],[16] and [17]. The Niger delta basin is situated on the continental margin of the Gulf of Guinea in Equatorial West Africa. The Tertiary Niger delta complex is divided into three diachronous formations, representing prograding depositional facies that are distinguished mostly on the basis of sand-shale ratios. They are the Akata, Agbada and Benin Formations. The Akata Formation is the basal unit of the Tertiary delta complex. This 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 [18], 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 is the principal reservoir of Niger Delta oil therefore has been well studied. The works of [18] and [19] 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 paralicclastics 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).

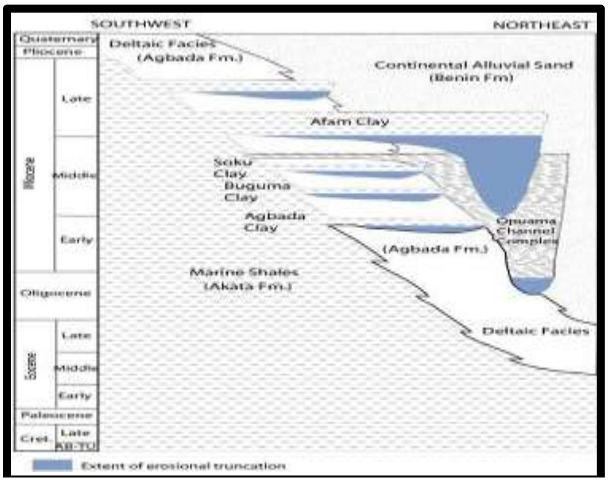
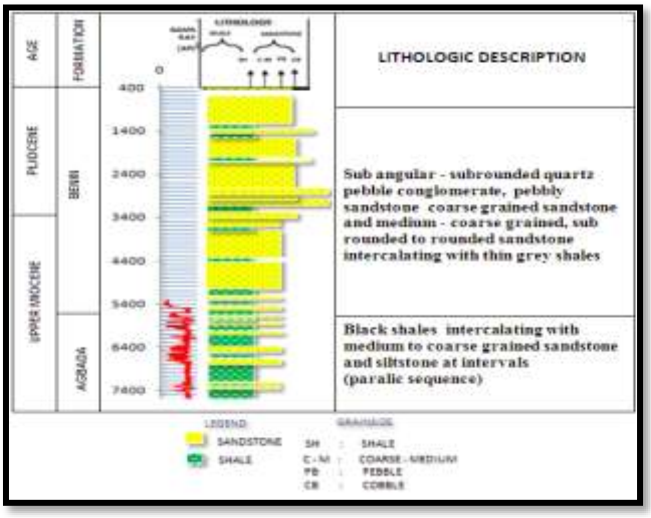


Figure 2: Stratigraphic column showing formations of the Niger delta (modified from [14] and [20].

II. 2: Method Of Study

The methods used were the sedimentological analysis and Palynostratigrphy of the ditch cutting rock samples. A total of one hundred and forty (140) ditch cutting rock samples from this well 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 ninety-eight (98) 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.

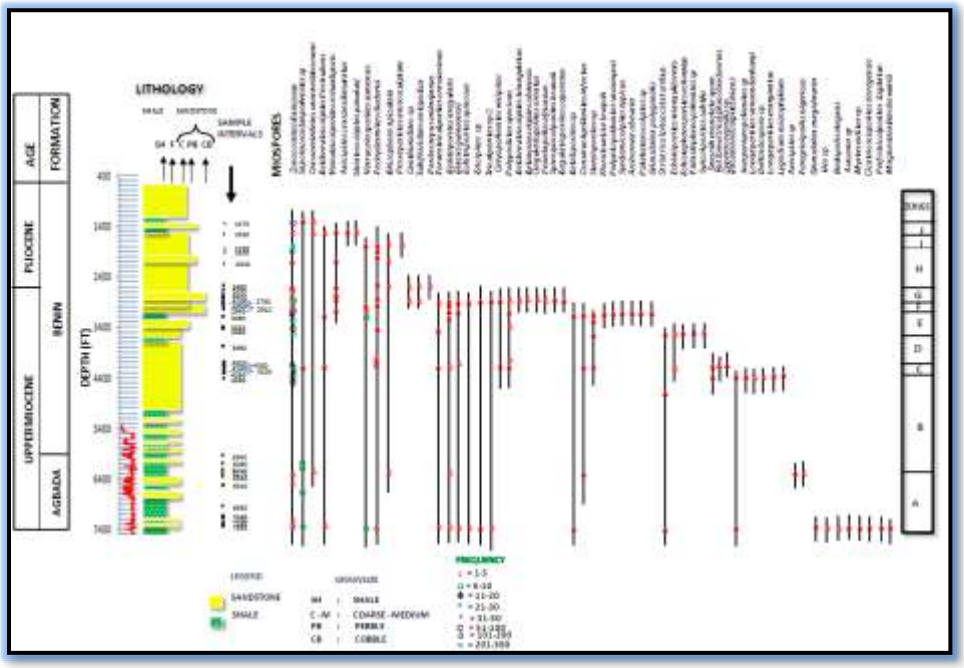


Figure, 3: Litholog of well X

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 of sand and shale of variable thicknesses with lateral gradation In particle size resulting in typical coarsening upward sequence of a prograding delta. Both the sedimentological results and petrophysical information from Gamma Ray log were integrated for the delineation and characterization of the lithofacies units. The base of the studied interval which ranged from 7500 Feet to 4500 Feet is made of Black shales intercalating with medium to coarse grained, sub rounded to rounded sandstone and siltstone at intervals representing the paralic Agbada formation while the top is ranging from 4500 Feet to the top of the well is made of Sub angular - sub rounded quartz pebble conglomerate, pebbly sandstone, medium - coarse grained, sub-rounded to well-rounded sandstone, intercalating with very thin lenses of grey shales representing the coastal plain sand of the Benin Formation (Figure, 3).

3:2: Biozonation and Age: Although there was general paucity of palynomorphs due to the sandy nature of the samples, analysis yielded well preserved and diverse biostratigraphic important miospores among which sixty-one miospores (fifty-one pollen and ten spores) were identified. Some of the photomicrographs of these events are illustrated in plates (1-2). On the basis of the first downhole (FDO) and last downhole (LDO) occurrences of these Palynological events, ten miospores biozones were erected and used to characterize the age of the sediments from Upper Miocene to Pliocene (Figure, 4). The zones are defined from the base to top as follows:



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

Zone A: *Magnastiatites howardi* zone: Upper Miocene. The base is at 7350 feet (ft) and the base of the studied interval of the well. It is characterized by the last downhole occurrences of *Forveotriculporites crassiexinus, Zonocostites ramonae, Verrucatosporites usmensis, Pachydermites diederixi, Striatriculpites catatumbus*, *Sapotaceoidopollenites* sp, *Rretidiporites* sp, *Elaesis guineansis, Echitriporites spinosus, Ericipites sp, Triculpites* sp 2, *Retitricolporites irregularis, Retibrevitriculpites protrudens, Racemonocolpites hians* and the first down hole occurrences of *Avicenia* sp, *Beskipolis elegans, Magnastiatites howardi, Perfotriculporites digitatus, Grimsdalea magiclavata*, *Cicatricocisporites dorogensis*, *Ilex* sp and *Myrtaceidites* sp. The top of this zone is at 6210 ft and is characterized by the last downhole occurrences *Crassoretitriletes vanraadshoeveni, Constructipollenites infectus, Rhizophora apiculata* and by the first downhole occurrences of *Peregrinipollis nigericus* and *Arecipites* sp.

Zone (B) : *Inerperturopollenites* sp - Upper Miocene. The base is the same as the top of zone (A) while the top is at 4260 ft. It is defined by the first downhole occurrences of *lygodium Microphyllum, Racemonocopites hians, Deltoidospora* sp, *Inerperturopollenites* sp, *Longerpertites Marginatus* and *longapertites Vaneendeburg.*

Zone (C) : *Caryapollenites veripites* - Upper Miocene.

The base is the same as the top of zone (B) while the top is at 4140 ft. It is characterized by the first downhole occurrences of *Caryapollenites veripites, Polypodiites specious, Stereisporites* sp, and the first downhole occurrences of *Retibrievitricolpites obodoensis, Cyperacaepollis* sp and smooth monolith spore.

Zone (D):*Striatricolpites Catatumbus* zone- Upper Miocene.

The base is the same as the top of zone (C) while the top is at 3360 ft. It is characterized by the first downhole occurrences of *Echistephanoporites echinatus, Striatriculpites catatumbus, Echitriporites trianguliformis, Psilastephanocolpollenites* sp and *Syncolporites subtilis.*

Zone (E): *Verrutricolporites rotundiporis* zone- Upper Miocene. The base is the same as the top of zone (D) while the top is at 2940 ft and defined by the first downhole occurrences of S*yncolporites typicus, Psilastephanocopollenites* sp, *Polyadopollenites vacampori, Constructipollenites infectus, Stereisporites* sp, *Retidiporites* sp, *Florschuezia levipoli, Archornea obovata* and *Grimsdalea polygonalis,* and the last downhole occurrence of *Verrutricolporites rotundiporis.*

Zone (F) *Echitriporites spinosus* zone- Upper Miocene. The base is the same as the top of zone (F) while the top is at 2790 ft and defined by the first downhole occurrences of *Echitriporites spinosus, Elaesis guineansis, Forveotricolporites crassiexinus, Cingulatisporites ornatus, Spirosyncolporites brunni, Regulatisprites caparatus, Retibrievitricolpites triangulatus, Triculpites* sp 2, *Caryapollenites veripites, Ericipites* sp, *Retibrievitricolpites obodoensis, Polypodiites specious, Praedapollis africanus* and *Retitricolporites irregularis and the last downhole occurrence of Canthium* sp and *Tubifloridites antipodica.*

Zone (G): *Canthimidites* sp zone-Upper Miocene. The base is the same as the top of zone (F) while the top is at 2310 ft and defined by the first downhole occurrences of *Canthimidites* sp, *Tubifloridites antipodica* and *Pordocarpus milanjanus.*

Zone (H): *Pordocarpus milanjanus.*– Pliocene-: The base is the same as the top of zone (G) while the top is at1740 ft and marked by the first downhole occurrences of *Proxapertites annisosculpture, Verrucatosporites usmensis, Pachydermites diederixi*and *Rhizophora apiculata.*

Zone (I): *Verrutriculporites rotundiporis* zone- Pliocene. The base is the same as the top of zone H, while the top is at1320 ft and defined by the first downhole occurrences of *Verrutriculporites rotundiporis, Striatricolpites pimulus, Arecipites exilimuratus* and *Retibrevitricolpites protrudens.*

Zone (J): *Zonocostites ramonae* zone- Pliocene. The base is the same as the top of zone (I) while the top is at1170 ft and defined by the first downhole occurrences of *Crassoretitriletes vanraadshoveni, Sapotaceoidopollenites* sp, and *Zonocostites ramonae.* The top of this zone is the top of the studied interval. Some of the microphotographs of these events are illustrated in plates (1-2).

Age Characterization:

The erected miospore zones were compared with pantropical zones of Germeraad *et al.*, 1968 and Evamy *et al*., 1978 and used to delineate the Upper Miocene/Pliocene boundary (Figure, 5).

The Upper Miocene interval: this is defined by miospore zones (A-H). The *multiaerolites formosus* (P780) and *Stereisporites* sp (P820) of [5] are recognised by the first downhole occurrences of significant events *as Magnastiatites howardi, Stereisporites* sp, *Retibrevitricoporites obodoensis, Racemonocolpites hians, Peregrinipollis nigericus Pachydermites diederixi, Striatriculpites catatumbus, Sapotaceoidopollenites* sp, *Echitriporites spinosus, Retitricolporites irregularis, Retibrevitriculpites protrudens, Racemonocolpites hians Avicenia* sp, *Beskipolis elegans, , Perfotriculporites digitatus, Grimsdalea magiclavata,* etc. This interval also correlates with *Echitriporites spinosus* of [2]. The top is recognised at 3360 ft.

The Pliocene interval: biozones (I-J) were recognised in this interval. *Podocarpus milanjianus* subzone (P880) of Evamy et al., (1978) was recognised by the LDO of *Podocarpus milanjianus* at 2310 ft. Also the FDO of *Verrutricolporites rotundiporis, Ambroisa cumanensis* and *Zonocostites ramonae* are also diagnostic of this interval. The Pliocene interval is also placed in the *Echirtiporites spinosus* zone of Germeraad *et al.*, 1968.

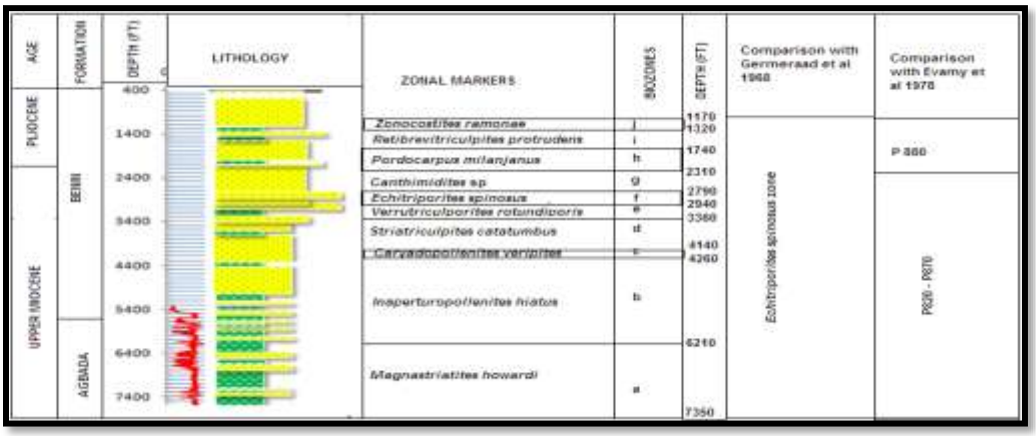


Figure 5: Miospore biozones of well X, in comparison with Germeraad et al 1968, and Evamy et al, 1978 zonation models.

IV. Summary / Conclusion:

Palynological characterization of the well yielded a well preserved and diverse biostratigraphic important Miospores among which sixty-one miospores (fifty-one pollen and ten spores) were identified. The biozonation of the well is premised on the recognition of the first and last downhole occurrences of these Palynological events, consequently, ten miospores biozones were erected and used to characterize the age of the sediments from Upper Miocene to Pliocene. The zones are from the base to top as follows: *Magnastiatites howardi, Inerperturopollenites* sp, *Caryapollenites veripites, Striatricolpites catatumbus, Verrutricolporites rotundiporis, Echitriporites spinosus, Canthimidites* sp, *Pordocarpus milanjanus and Verrutriculporites rotundiporis.* Correlation with the pantropical zones of [2] and [5] yielded Upper Miocene to Pliocene age. The biozones corresponds with pollen zones P780 to P880 of [5] and *Echitriporites spinosus* of [2]. Results from textural and lithological analysis show that the rock succession penetrated the Agbada Formation which range from 7500 - 4500 ft and Benin Formation ranging from 4500 ft to the top of the well.

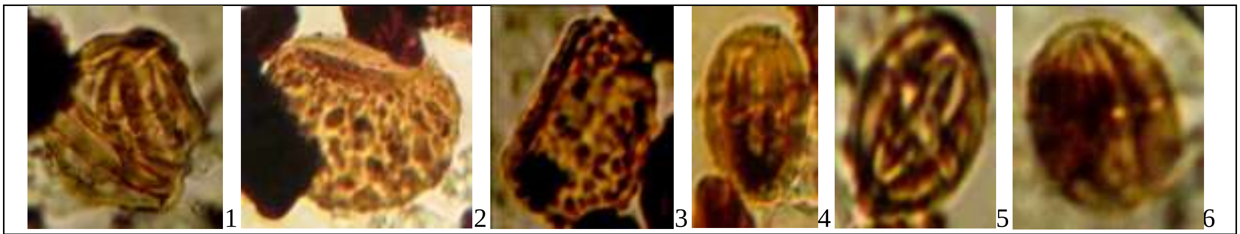
PLATE 1

1	*Magnastriatites howardi*
2	*Verucatosporites usmensis*
3	*Verucatosporites usmensis*
4	*Sapotaceoidaepollenites* sp
5	*Sapotaceoidaepollenites* sp
6	*Sapotaceoidaepollenites* sp
7	*Monoporites annulatus*
8	*Retidiporites* sp
9	*Retidiporites* sp
10	*Retibrevitricolporites protrudens*
11	*Retibrevitricolporites protrudens*
12	*Constructipollenites infectus*
13	*Stiatricolporites catatumbus*
14	*Stiatricolporites catatumbus*
15	*Elaesis guineansis*
16	*Anacolosidites luteoides*
17	*Caryadopollenites veripites*

PLATE 2

1	*Lygodium microphyllum*
2	*Pachydermites diederixi*
3	*Pachydermites diederixi*
4	*Pachydermites diederixi*
5	*Pachydermites diederixi*
6	*Elaesis guineansis*
7	*Margocolporites vanwijhei*
8	*Retiricolpories irregularis*
9	*Retiricolpories irregularis*
10	*Syncolporites subtilis*
11	*Retibrevitricolpites protrudens*
12	*Deltoidospora* sp
13	*Deltoidospora* sp
14	*Polypodiites specious*
15	*Praedapollis africanus*
16	*Striatricolporites pimulus*

PLATE 1



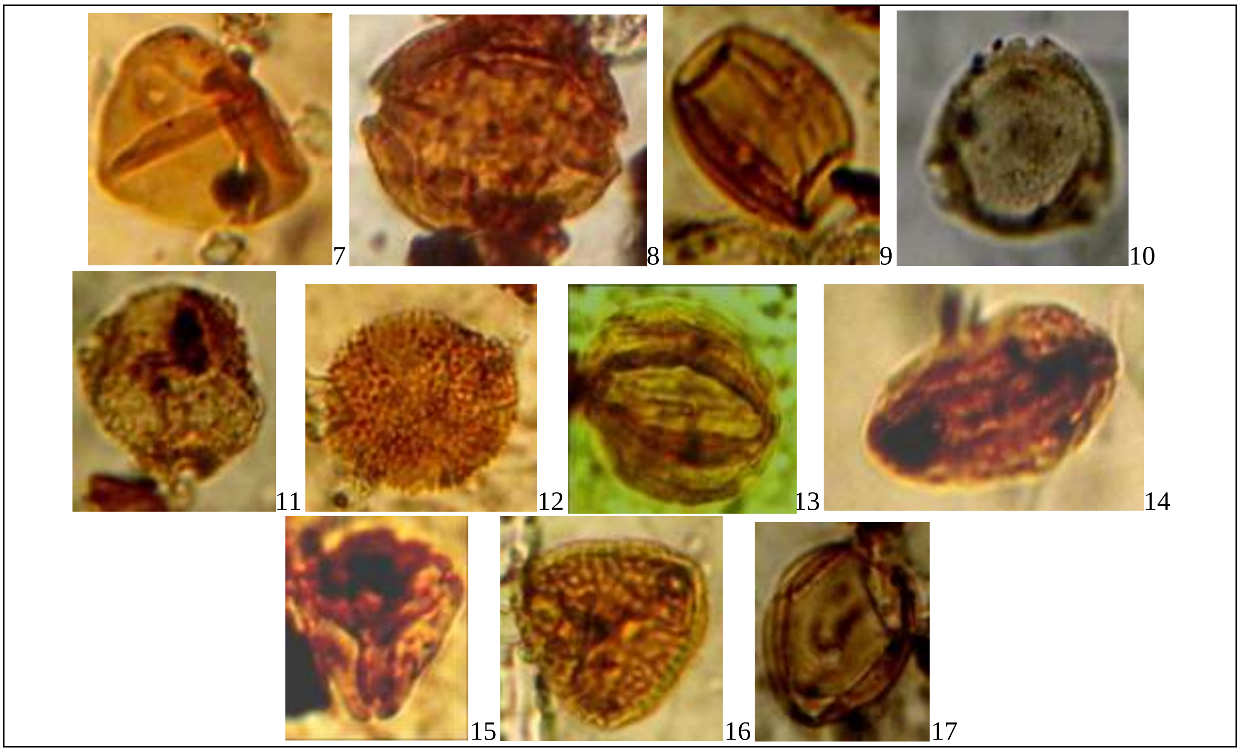
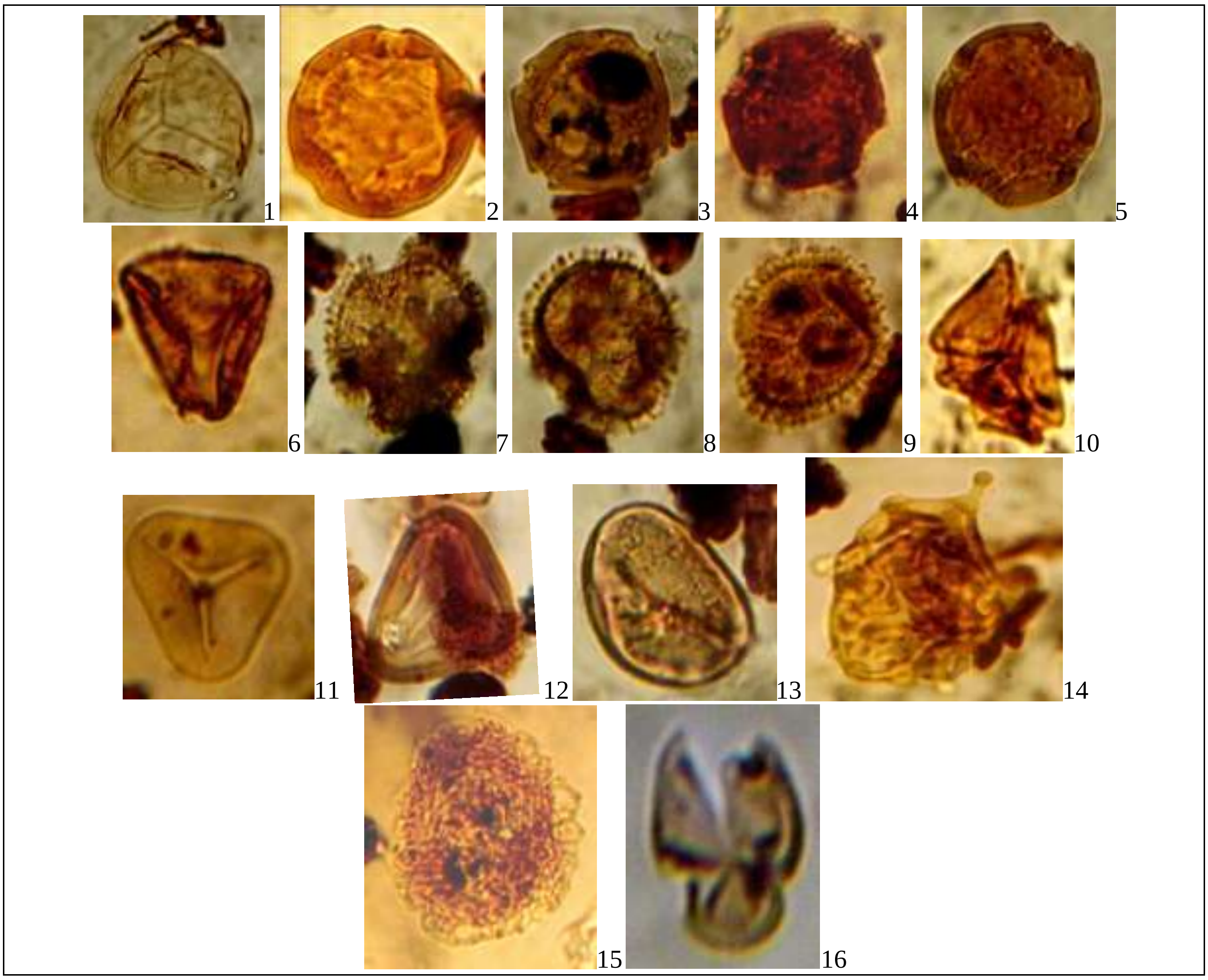


PLATE 2



References

[1]. Reyment, R. A., 1965: Aspects of the Geology of Nigeria.Univ. Ibadan Press, Nigeria. 145pp.
[2]. Germeraad, J. B., Bopping, C. A..andMulIer, J., 1968. Palynology of Tertiary Sediments from Tropical areas. Rev. Paleobotan. Palynol., V. 6, P. 189 - 348.
[3]. Jan du Chene, R. E. Onyike, M. S. and Sowunmi, M. A., 1978C. Some new Eocene Pollen of the OgwashiAsaba Formation, Southern Nigeria. Revista Espanola De Micropaleontologia, V. X (2), P.285 – 322.
[4]. A Oloto, I. N., 1994**.** Nigerian Maastrichtian to Miocene dinoflagellate and MiosporeBiozonation - A summary. Journal of Mining and Geosciences.Society. (NMGS) V. 30(4), P. 61 - 73.
[5]. Evamy, B.D., Haremboure. J., Kamerling, P., Knaap, W.A., Molloy, F .A., and Rowlands, P .B., 1978. Hydrocarbon habitat of Tertiary Niger Delta.American Association of Petroleum Geologists Bulletin. v. 62, p.
[6]. Ige ,O E., 2011. Vegetation and Climatic History of the Late Tertiary Niger Delta, Nigeria, based on Pollen Record. Research Journal of Botany, 6: 21-30.
[7]. Ajaegwu, N.E., Odoh, B.I., Akpunonu, E.O., Obiadi I.I. and Anakwuba, E.K., 2012. Late Miocene to Early Pliocene Palynostratigraphy and Palaeoenvironments of ANE-1 Well, Eastern Niger Delta, Nigeria. Journal of Mining and Geology Vol. 48(1) 2012, pp. 31–43.
[8]. Kulke, H., 1995**.**Nigeria, *in*, Kulke.H., ed., Regional Petroleum Geology of the World. Part II: Africa, America, Australia and Antarctica: Berlin, Gebriider Borntraeger, P. 143172.
[9]. Hospers, J., 1965. Gravity field and structure of the Niger Delta, Nigeria, West Africa: Geological Society of American Bulletin. v. 76, p. 407-422.
[10]. Kaplan, A., Lusser, C.U., Norton. I.O.,1994**.** Tectonic map of the world, panel 10 Tulsa:American Association of Petroleum Geologists, seale 1:10,000,000.
[11]. Nwachukwu,J.I., and Chukwurah, P. I., 1986, Organic matter of Agbada Formation, Niger Delta, Nigeria. American Association of Petroleum Geologists Bulletin, v. 70, p. 48-55.
[12]. Short, K. C., and Stauble, A.J., 1967. Outline of geology of Niger Delta: American Association of PetroleumGeologists Bulletin, v. 51, p. 761-779.
[13]. Tuttle, M. L. W., Charpentier,R. R.and Brownfield, M. E.,1999. The Niger delta petroleum system: Niger delta province, Nigeria, Cameroon, and Equatorial Guinea, Africa: USGS Open-
[14]. Whiteman, A.J. (1982). Nigeria. Its Petroleum Geology, Resources and Potential. Graham and Trotman, London, 399p.
[15]. Williams, G.L. & Manum, S.B., 1999. Oligocene – Early Miocene dinocyst stratigraphy of hole
[16]. Doust, B., and Omatsola, E., 1990**.** Niger Delta, *in*, Edwards, J. D., and Santogrossi, P .A., eds., Divergent/passive Margin Basins., AAPG Memoir 48: Tulsa, American Association of Petroleum Geologists. p. 239-248.
[17]. Stacher, P.,1995. Present Understanding of the Niger Delta Hydrocarbon Habitat, In, Oti, M. N.and Postman Eds., Geology of Deltas: Rotterdam, A. A., Balkema, Pg. 257-267.
[18]. Avbovbo, A. A., 1978. Tertiary lithostratigraphy of Niger Delta: American Association of Petroleum Geologists Bulletin, v. 62. p. 295-300.
[19]. Tuttle, M. L. W., Charpentier,R. R.and Brownfield, M. E.,1999. The Niger delta petroleum system: Niger delta province, Nigeria, Cameroon, and Equatorial Guinea, Africa: USGS Open-file report 99-50-H.
[20]. Doust, H. and E. Omatsola, (1989).Niger delta. AAPG Memoir 48 p. 201-238.
[21]. Weber KJ (1971). Sedimentological aspect of oil fielding the Niger Delta. Geol. Minjbouw, 50: 559-576.
[22]. Weber, K. J., and Daukoru, E.M., 1975.Petroleum geology of the Niger Delta: Proceedings of the Ninth World Petroleum Congress, volume 2, Geology: London, Applied Science Publishers, Ltd., p. 210-221.