International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Palynostratigraphy of Upper Miocene - Pliocene Sediments in Well Z, offshore Niger Delta

Asadu, A.N[1], Ugwu J.U.[2]

[1] Department of Earth Sciences, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria

[2]Department of Geology, Michael Okpara University of Agriculture Umudike

Abstract: ***Palynological analysis of ditch cutting rock samples from upper Miocene - Pliocene succession of well Z, Offshore Niger Delta, was carried out for their biostratigraphic significance. The analysis yielded a well preserved and diverse biostratigraphic important Miospores among which fifty six Miospores (forty five pollen and eleven spores) were identified. Ten miospore biozones were erected on the basis of their first and last downhole occurrences. The zones are from base to top as follows: Multiaerolites formosus, Psilatriculporites Crassus, Retritricolporites irregularis, Archornea obovata, Pachydermites diederixi, Striatriculpites catatumbus, Caryadopollenites veripites, Monoporites annulatus, Pordocarpus milanjanus, and Verrutricolporites rotundiporis. These miospore zones were compared with the standard miospore biozonation schemes existing in the area and used to delineate the Upper Miocene/Pliocene boundary. From the sedimentological result, the rock succession studied are the fossilferous grey sandy shale with shells and shell fragments intercalating with medium - coarse grained, sub rounded to rounded sandstone with scattered mica flakes possibly the top of the paralic Agbada Formation and thickly bedded medium - coarse grained, sub rounded to rounded sandstone with mica flakes intercalating with very thin lenses of shaly sand with mica flakes, capped with sub angular - sub rounded quartz pebble conglomerate and pebbly sandstone representing the water bearing coastal plain sands of the Benin Formation.***

Keywords: Biostratigraphy, Age, Miospores, Agbada, Zones, Formation, Miocene, Niger Delta

1. Introduction

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 (B), 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.

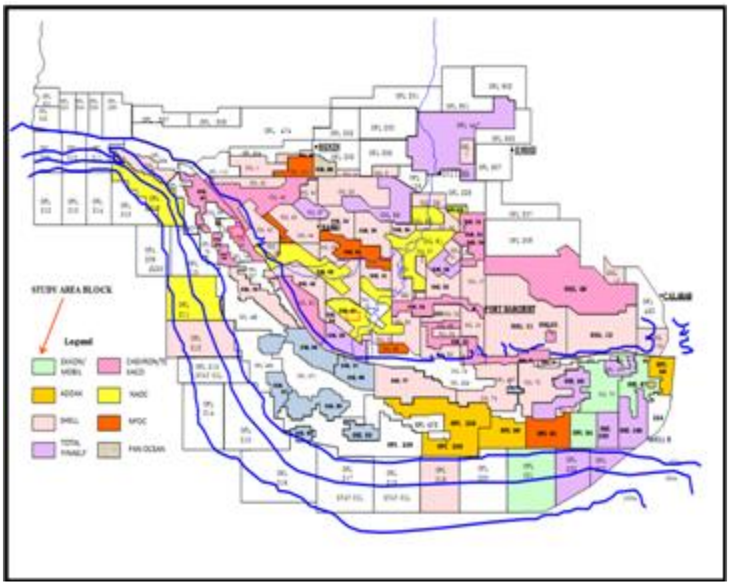


Figure 1: Niger delta oil mining lease (OML) map showing locations of major oil company blocks

1.1 Previous Palynological Studies

Pollen and spores has been well studied in Niger delta and has proven a useful biostratigraphic tool in Cretaceous and Tertiary sediments**.** [1], 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 [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 originally described. [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 of the Niger delta published in the Niger delta chronostratigraphic chart. [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 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 type sections of these formations have been reviewed as described in [6] and summarized in a variety of papers ([7], [8], [9]). 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[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 [12] are however, quite classic. The Agbada Formation is represented by an alternation of sands, 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).

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 five (105) 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-five (85) 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.

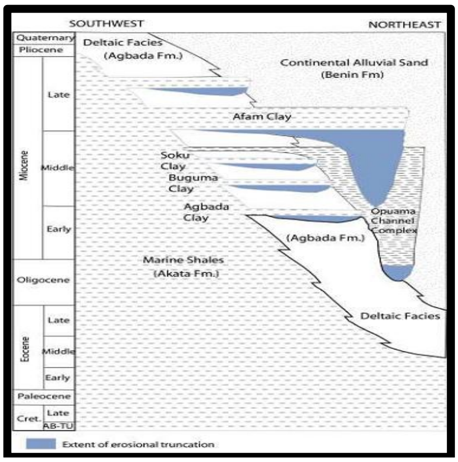


Figure 2: Stratigraphic column showing formations of the Niger delta (modified from [8] and [13]).

International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

3. Results and Discussions

3.1Lithostratigraphy

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 characterisation of the lithofacies units. The lithologic units present are the fossilferous grey sandy shale with shells and shell fragments intercalating with medium - coarse grained, sub rounded to rounded sandstone with scattered mica flakes possibly top of the paralic Agbada Formation, overlain by the thickly bedded medium - coarse grained, sub rounded to rounded sandstone with mica flakes intercalating with very thin lenses of shaly sand with mica flakes, capped with sub angular - sub rounded quartz pebble conglomerate and pebbly sandstone representing the water bearing coastal plain sands of the Benin Formation. The paralic Agbada formation ranged from 4800 ft to 3400 ft while the Benin Formation ranged from 3400 ft to the top of the well (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 relevant miospores among which fifty six miospores were identified. On the basis of first and last downhole occurrences of these Palynological events, ten miospores biozones were erected for well interval studied. These biozones were used to characterize the age of the sediments from Upper Miocene to Pliocene (Figure). The zones are defined from the base to top as follows:

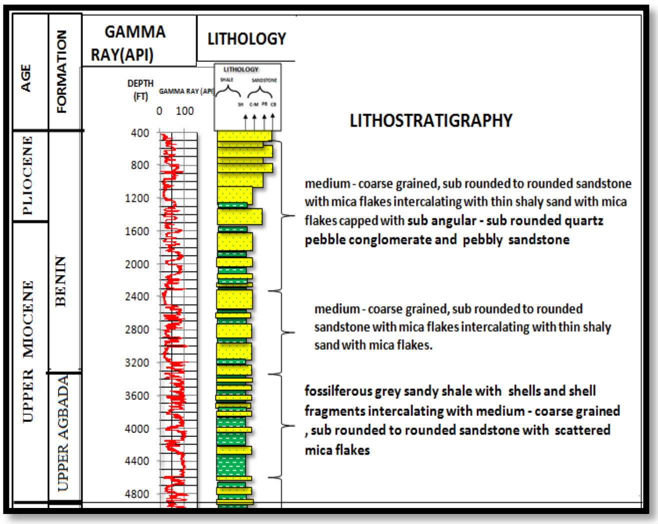


Figure 3: Litholog of well A.

3.2.1 Miospores biozonation of well B

Zone (i): *Multiaerolites formosus* zone–Upper Miocene. The base of this zone which is the same as the base of the studied interval is at 4590 ft and defined by the last downhole occurrences of *Zonocostites ramonae, Verrutriculporites rotundiporis, Pisonia grandis, Syncolporites incomptus, Sapotaceoidaepollenits* sp, *Gemmamonoporites* sp, *Cyperaceapollis* sp, *Multiaerolites formosus, Deltoidospora sp, Caryadopollenites veripites, Monoporites annulatus, Polygonium* sp, *Echitriporites Spinosus, Avicenia* sp, *Elaesis guineansis, Striatriculpites catatumbus Pachydermites diederixi, Crassoretitriletes vanraadshoeveni, Archornea Obovata, Ilex* sp, *Verrucatosporites usmensis, Retitriculporites irregularis, Triculpites retibacculatus, Psilatriclporites crassus, Retitriculporites* sp, *Tubifloridites antipodica;* the first downhole occurrences of *Praedapollis spiralis, Beskipollis elegans, Perfotriculporites digitatus, Racemonocolpites hians, Monocolpollenites trianguilus, Myrtaceidites* sp *Psilaheterocolporites* sp, *Polypodiaceisporites spedia* and *Bombax ceiba,* while the top recognised at 3840 ft is defined by the last downhole occurrence of *Striatriculpites pimulus* and the first downhole occurrences of *Retitriculporites* sp, *Tubifloridites antipodica, Praedapollis* sp and *Inaperturopollenites versus.*

Zone (ii): *Psilatriculporites Crassus* zone – Upper Miocene. The base of this zone is the same with the top of zone (i), while the top is recognised at 3240 ft interval and defined by the first downhole occurrences of *Tubifloridites antipodica, Psilatriclporites crassus, Proxapertites cursus, combrentum* sp, *Gemmamonoporites* sp, and *Regulatisporites caperatus.*

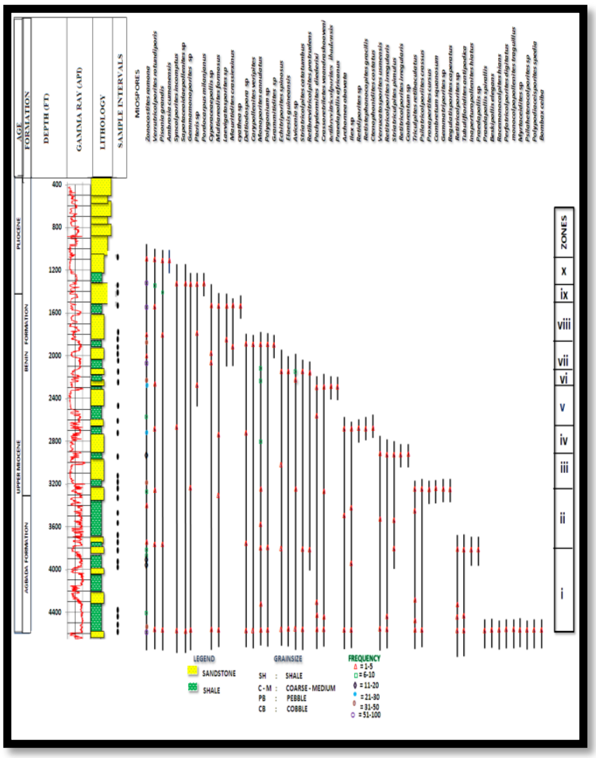


Figure 4: Miospore range chart and biozonation of well X

Zone (iii): *Retritricolporites irregularis* zone - Upper Miocene. The base is the same as the top of zone (ii). The top is recognised at 2940ft and defined by the first downhole occurrences of *verrucatosporites usmensis, Striatricolporites pimulus* (394), *Retritricolporites irregularis,* and *Combrentum* sp. **Zone (iv): *Archornea obovata* sp zone –Upper Miocene.** The base is the same as the top of zone (xiii). The top is recognised at 2760ft and marked by the first downhole occurrences of *Archornea obovata*, *Ilex* sp, *Retidiporites* sp, *Retistephanocolpites gracilis* and *Ctenophonidites costatus.*

Zone (v): *Pachydermites diederixi* zone –Upper Miocene. The base is the same as the top of zone (xiv). The top is recognised at 2280 ft and defined by the first downhole occurrences of *Brevicolpites guinetti*, *Pachydermites diederixi*, *Crassoretitriletes vanraadshoeveni*, *Praedapollis africanus;* and the last downhole occurrences of *Pteris* sp.

Zone (vi): *Striatriculpites catatumbus* – Upper Miocene. The base is the same as the top of zone (v). The top is recognised at 2160 f t and defined by the first downhole occurrences of *Echitriporites spinosus*, *Elaesis guineansis*, *Avicenia* sp, *Striatriculpites catatumbus* and *Ritibrevitricolpites protrudens.*

Zone (vii): *Caryadopollenites veripites* zone –Upper Miocene. The base is the same as the top of zone (vi). The top is recognised at1920 ft and characterised by the first downhole occurrences of *Grammidites* sp, *Polygonium* sp, *Monoporites annulatus*, *Deltoidospora sp*, and *Caryadopollenites veripites* and the last downhole occurrences of *Mauritidites crassibaculatus* and *Laevigatosporites* sp.

Zone (viii): *Monoporites annulatus* zone – Upper Miocene. The base is the same as the top of zone (vii). The top is recognised at1530 ft and defined by the first downhole occurrences of *Laevigatosporites* sp, *Multiaerolites formosus*, *Cyathea* sp, *Mauritidites crassibaculatus* and *Cyperaceaecopollis* sp.

Zone (ix): *Pordocarpus milanjanus* zone – Pliocene. The base is the same as the top of zone (viii). The top is recognised at1380 ft and defined by the first downhole occurrences of *Pteris* sp, *Pordcanpus milanjanus*, *Gemmamonoporites* sp, *Sapotacaeoidopollentes* sp and *Syncolporites incomptus.*

Zone (x): *Verrutricolporites rotrudiporis Zone*- Pliocene. The base is the same as the top of zone (ix). The top is recognised at 1080 ft and defined by the first downhole occurrences of *zonocostites ramona*, *Verrutricolporites rotrudiporis*, *pisonia grandis* and *Ambroisa cumanensis.* Some of the recovered Miospore microphotographs are presented in plates (1 to 2).

3.2.2 Age characterization

The erected miospore zones were compared with pantropical zones of [1] and [4], for the purpose of delineating the Oligocene/Lower Miocene boundary (Figure, 5). **The Upper Miocene interval:** this is defined by miospore zones (i-viii). Most of the miospores events recorded in this interval are mainly the long ranging forms from as low as the Eocene through Oligocene to lower Miocene age which recorded their last occurrences here. They include *Syncolporites incomptus*, *Multiaerolites formosus*, *Deltoidospora sp*, *Caryadopollenites veripites*, *Monoporites annulatus*, *Echitriporites Spinosus*, *Striatriculpites catatumbus Pachydermites diederixi*, *Archornea Obovata*, *Verrucatosporites usmensis*, *Retitriculporites irregularis*, *Triculpites retibacculatus*, *Psilatriclporites crassus*, *Retitriculporites* sp, the first downhole occurrences of *Praedapollis spiralis*, *Beskipollis elegans*, *Perfotriculporites digitatus*, *Racemonocolpites hians*, *Sapotaceoidaepollenites* sp, *Gemmamonoporites* sp, *Polypodiaceisporites spedia* and *Bombax ceiba.* The *multiaerolites formosus* [4] is also recognised by the LDO of *Multiaerolites formosus* and FDO of *Beskipolis elegans*, *Perfotriculporites digitatus* , *Racemonocolpites hians*, *Caryadopollenites veripites*, *Myrtaceidites* sp and *Bombax ceiba*. Another significant miospores event delineating the Upper Miocene – Pliocene boundary is the incoming of *Podocarpus milanjianus* at the top of zone (viii). The last downhole occurrence of *Podocarpus milanjianus* has not been recognized in pre Pliocene sediments therefore used as a boundary marker to define the boundary between Upper Miocene and Pliocene intervals.

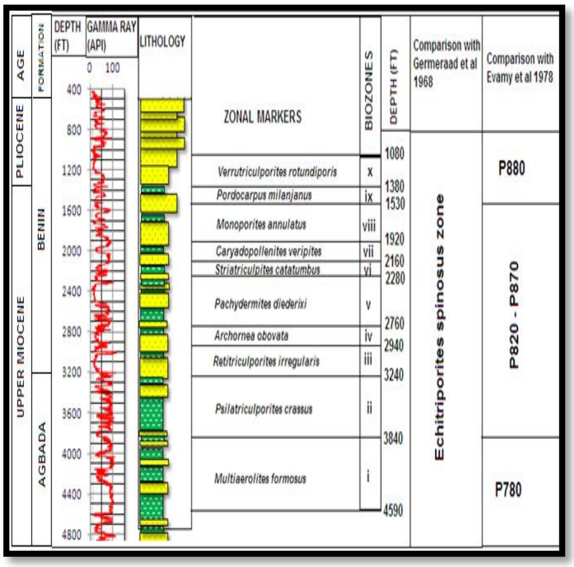


Figure 5: Miospore biozones of well A, in comparison with [1], and [4] zonation models.

The Pliocene interval: this interval is delineated by biozones (ix and x) *Podocarpus milanjianus* subzone (P880) of [4] was recognised here by the LDO of *Podocarpus milanjianus* at 1380 ft. Also the FDO of *Verrutricolporites rotundiporis*, *Pachydermites*, *diederixi*, *Psilatriclporites crassus*, *Multiaerolites formosus* and *Monoporites annulatus* are also diagnostic of this interval. The Pliocene interval is also placed in the *Echirtiporites spinosus* zone of [1].

4. Summary / Conclusion

The sedimentological results and petrophysical information from Gamma Ray log show that the lithologic units present are the fossilferous grey sandy shale with shells and shell fragments intercalating with medium - coarse grained, sub rounded to rounded sandstone with scattered mica flakes is possibly the top of the paralic Agbada Formation and ranged 4800 ft to 3400 ft, while the thickly bedded medium - coarse grained, sub rounded to rounded sandstone with mica flakes intercalating with very thin lenses of shaly sand with mica flakes, capped with sub angular - sub rounded quartz pebble conglomerate and pebbly sandstone represents the water bearing coastal plain sands of the Benin Formation and ranged from 3400 ft to the top of the well (figure 3). Palynological analysis of the studied well yielded a well preserved and diverse biostratigraphic relevant Miospores among which fifty six Miospores (forty five pollen and eleven spores) were identified. On the basis of the first and last downhole occurrences of these Palynological events, ten miospore biozones were erected and compared with the pantropical zones of [1] and [4], and used to delineate the Upper Miocene/Pliocene boundary. The biozones corresponds with pollen zones P780 to P880 of [4] and *Echitriporites spinosus* of [1].

PLATE 1

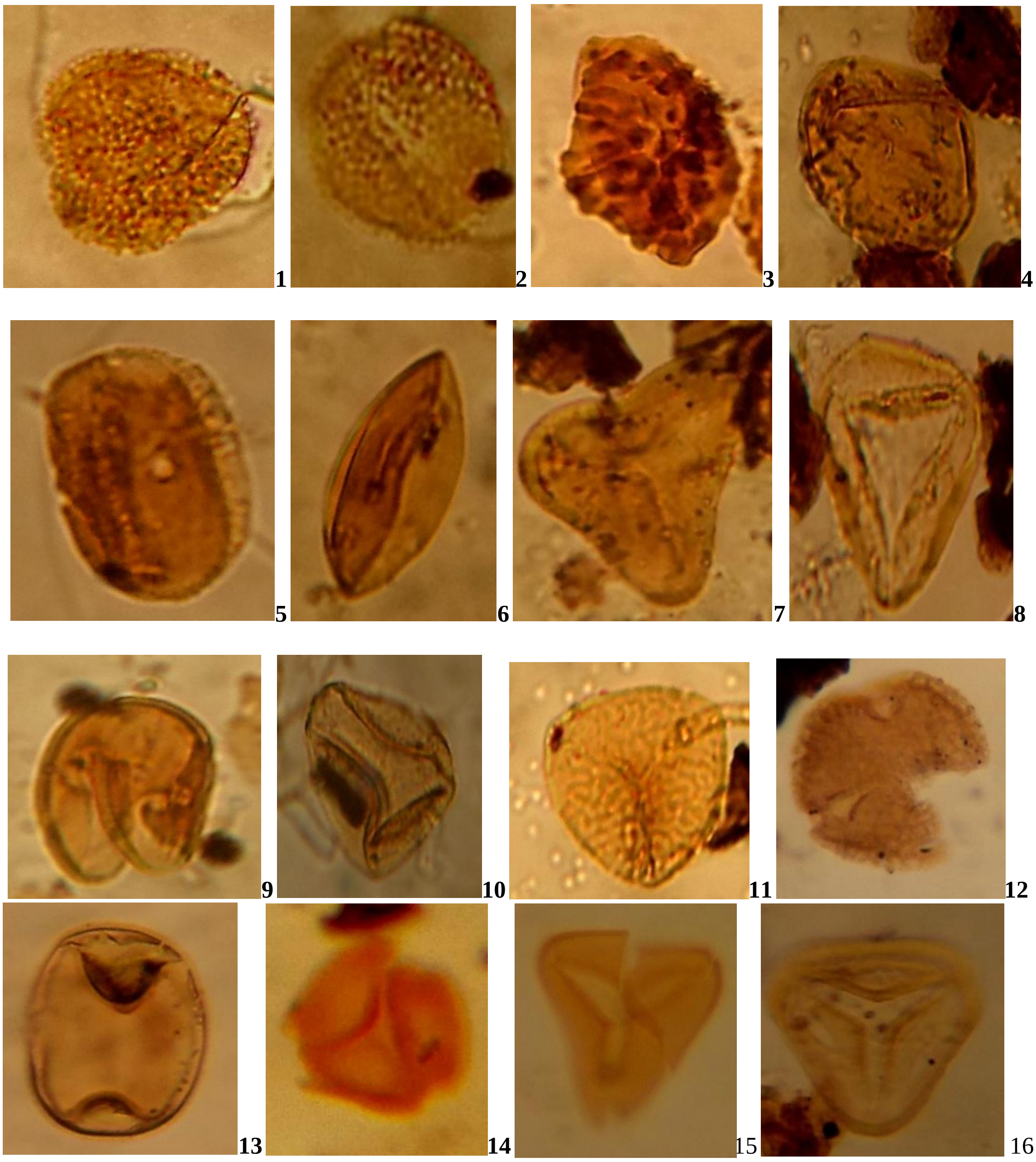


Plate 1

1	*Perfotricolporites digitatus*
2	*Racemonocolpites hians*
3	*Tubifloridites antipodica*
4	*Caryadopollenites veripites*
5	*Multiaerolites formosus*
6	*Monocolpollenites tranguilus*
7	*Deltoidospora sp*
8	*Deltoidospora sp*
9	*Inaperturopollenites hiatus*
10	*Combretum squanosum*
11	*Regulatisporites caperatus*
12	*Striatricolporites pimulus*
13	*Retidiporites sp*
14	*Syncolporites incomptus*
15	*Elaesi guineansis*
16	*Retibrevitricolporites ibadensis*

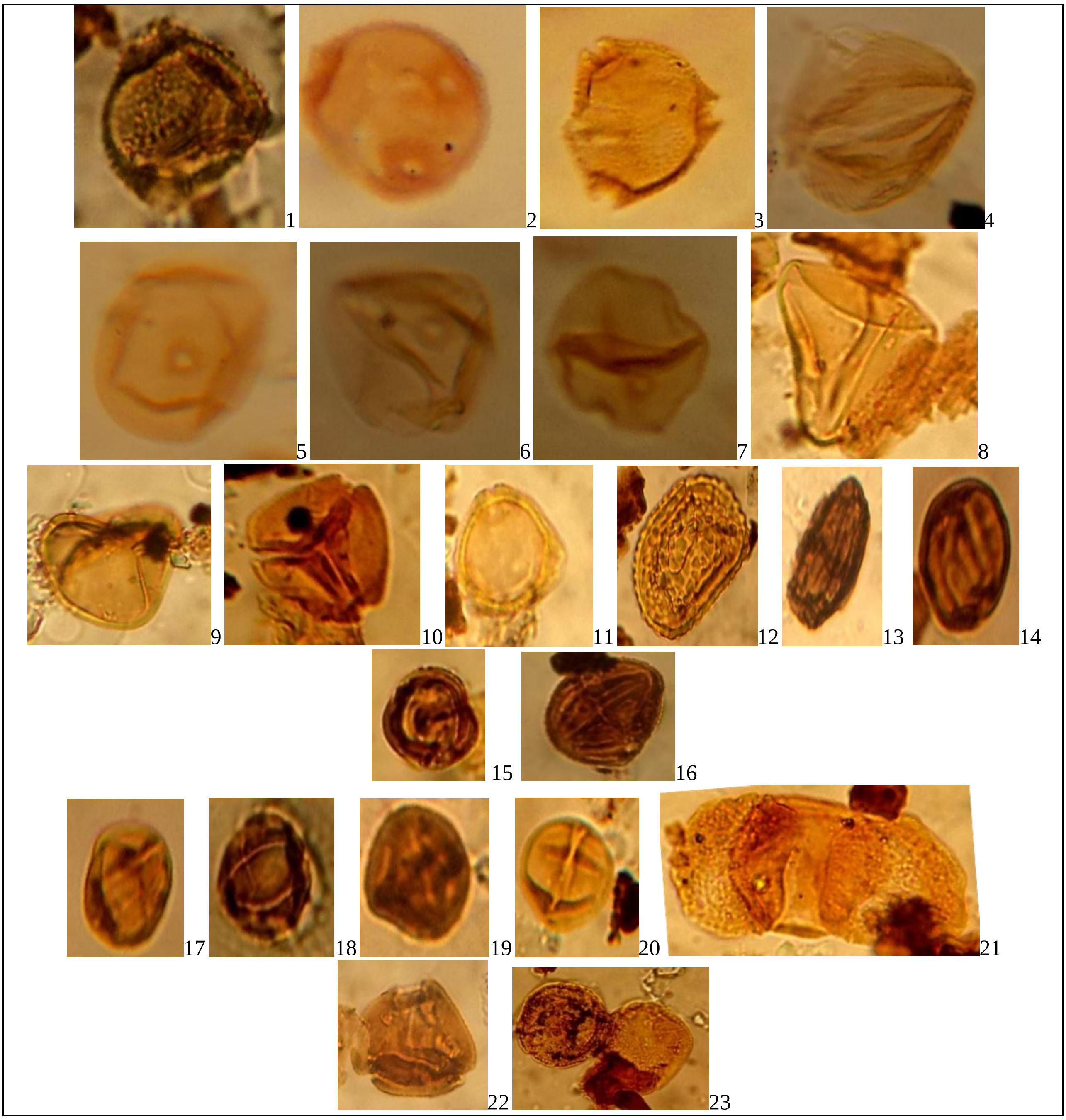
Plate 2

1	*Retibrevitricolporites protrudens*
2	*Retibrevitricolporites protrudens*
3	*Retibrevitricolporites protrudens*
4	*Striatriculpites catatumbus*
5	*Monoporites annulatus*

6	*Monoporites annulatus*
7	*Monoporites annulatus*
8	*Cyperaceaepollis sp*
9	*Cyperaceaepollis sp*
10	*Syncolporites incomptus*
11	*Ambrosia cumanensis*
12	*Beskipollis elegans*
13	*Verrucatosporites usmensis*
14	*Zonocostites ramonae*
15	*Zonocostites ramonae*

16	*Zonocostites ramonae*
17	*Zonocostites ramonae*
18	*Zonocostites ramonae*
19	*Zonocostites ramonae*
20	*Zonocostites ramonae*
21	*Pordocarpus milanjanus*
22	*Avicenia sp*
23	*Psilatricolporiites crassus*

PLATE 2



References

[1] Germeraad, J. B., Bopping, C. A..andMulIer, J., 1968. Palynology of Tertiary Sediments from Tropical areas. Rev. Paleobotan. Palynol., V. 6, P. 189 - 348.

[2] 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.

[3] 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.

[4] 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.

[5] 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.

[6] Short, K. C., and Stauble, A.J., 1967. Outline of geology of Niger Delta: American Association of PetroleumGeologists Bulletin, v. 51, p. 761-779.

[7] 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-

[8] Avbovbo, A. A., 1978. Tertiary lithostratigraphy of Niger Delta: American Association of Petroleum Geologists Bulletin, v. 62. p. 295-300.

[9] 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.

[10] 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.

[11] Doust, H. and E. Omatsola, (1989).Niger delta. AAPG Memoir 48 p. 201-238.

[12] Weber KJ (1971). Sedimentological aspect of oil fielding the Niger Delta. Geol. Minjbouw, 50: 559-576.

[13] 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.

[14] 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.