BIOSTRATIGRAPHY AND PALEOENVIRONMENT OF SECTIONS FROM WELL XY-1 AND WELL XY-2, CENTRAL SWAMP DEPOBELT, NIGER DELTA BASIN, NIGERIA

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ABSTRACT

Micropaleontological analysis was carried out on eighty-nine (89) ditch cutting samples recovered from well XY-1 and well XY-2 within the depth interval of 1960 -2470 m and 2000 -2380 m with the aim of determining their lithologies, paleoenvironment of deposition and age range. The lithologic description of the samples shows that the lithologies consist of black shale, grey shale, sandy shale, shaly sand and sandstone. The acid maceration method was used to recover the palynomorphs. The ditch cutting samples yielded one-hundred and eighty-three (183) palynomorphs. Five Palynological zones were established for well sections in this study which includes *Magnastriatites howardi*, *Retibrevitricolporites obodoensis, Crassoretitriletes vanraadshooveni, Arecipites exilimuratus* and *Racemonocolpites hians Zones.* Early Oligocene to Middle Miocene age was assigned to the studied sections from the palynological analysis with environment of deposition ranging from middle to inner-neritic to marine.

Keywords: Biostratigraphy, Paleoenvironmental reconstruction, age range, palynomorphs, Niger Delta Basin.

INTRODUCTION

The Cenozoic Niger Delta Basin overlies an area that is over 256,000 km^2 (Kulke, 1995). It is the youngest of the three large sedimentary bodies that filled the aulacogen formed after the separation of the African and South American Plates. It was initially built out over a transgressive Paleocene prodelta as river-dominated lobes which later coalesced and became high-energy, wave-dominated, and tide-influenced depobelts (Short and Stauble 1967). The Niger Delta Basin is subdivided into depobelts based on the recognition of major regional down-to-the-basin faults. It is subdivided into five depobelts (Knox and Omatsola, 1987), Tuttle *et a*l. 1999, Saugy and Eyer 2003, Reijers 2011). namely; Northern Delta, Greater Ughelli, Central swamp, Coastal swamp and off-shore depobelts. This study falls within the Central swamp of the Niger Delta depobelt.

The Niger Delta Basin has been studied in recent times by both researchers and oil companies because of its hydrocarbons potentials and economic importance (Tuttle *et al*. 1999). It is a diachronous sedimentary basin having diverse characteristics such as ages, and depositional environments from one location to another (Doust and Omatsola, 1990.It is therefore important to establish the ages and paleoenvironment of the different oil wells in the Niger Delta Basin. The aim of this study is to carry out a biostratigraphic study on the shale sections, using palynomorphs to provide a biostratigraphic zonation for the sections penetrated by the two wells (XY-wells) as well as the age and the paleoenvironment of deposition of the wells. The integration of the dinoflagellates, spores and pollens have aided in zoning the sections penetrated by the studied wells.

Biostratigraphy is an essential tool for dating rocks and identifying the biotic record through time and is necessary for establishing temporal correlation, reconstructing paleogeography, paleoenvironmental reconstruction as well as recognition of oil and gas deposits and intervals. Several palynological studies have been conducted by different workers on the biostratigraphy of the Niger Delta Basin with aim of providing information on their age and paleoenvironment of deposition. Ozumba and Amajor (1999) carried out a high-resolution foraminiferal biostratigraphy of four wells located in the coastal and central swamp in the western Niger Delta Basin. Boboye and Fowora (2007) carried out calcareous nannofossil biostratigraphic studies on sequence within well XH-1 located in the Deep Offshore are of Niger Delta Basin. Oloto (2014) recognized four dinocysts and two pollen and spores' zones respectively in the palynological studies of Igbomotoru-1 well, Niger Delta Basin. The pollen and spores zonations consisted of Verrucatosporites usmensis and Magnastriatites howardi zones. The application of pollen and spores in understanding of paleo-vegetational trends in the Niger Delta Basin was carried out by Ige (2009). Ola et al. (2013) studied the palynomorphs from FB-1 well in the Niger Delta Basin and identified four informal biozones A, B, C and D based on the occurrence of fossil species: Retitricolporities crassus, Racemonocolpites hians, Retibrevitricolporites obodoensis and Retribrevitricolprites protrudens. The interval studied was deposited between Late Miocene and Early. Ajaegwu *et al*., (2012) carried out palynostratigraphic and paleoenvironmental studies of eastern Niger Delta Basin. Osokpor *et al*., (2019); high-resolution sequence stratigraphy The study area is located within the Central Swamp Depobelt of the Niger Delta Basin. The studied wells are located between latitude 5°35´ 3.710 N of the equator and longitude 6°32´ 45.152 E and latitude 5°32´ 3.65 N and longitude 6°33´ 45.149 E respectively as shown in (figure1).

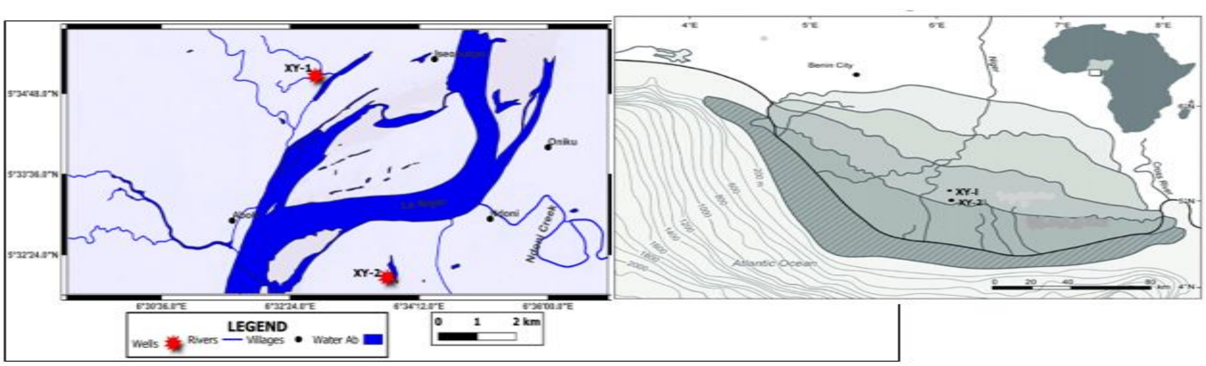


Figure 1: Map of the study area showing the well locations (modified after, Okosun and Chukwuma-Orji, 2016

REGIONAL GEOLOGY OF THE NIGER DELTA BASIN

The tripartite stratigraphy of the subsurface Niger Delta Basin consists of the Akata, the Agbada, and the Benin Formations (Short and Stauble, 1967). Some authors, however, opined that the Lithostratigraphy of the Niger Delta is underlain by Cretaceous strata (Tuttle *et al* 1999).

Akata Formation

The Akata Formation is the major time transgressive lithological unit of the Niger Delta. It is marine mud facies with turbiditic sands and continental slope channel fills. This formation underlies the whole of the Niger Delta complex south of the Imo Shale outcrop area. The Akata Formation consists of dark gray shales, especially in its upper part while its lower part is sandy and it grades into the Agbada Formation (Tuttle *et al*. 1999). The top of the formation is not clearly defined. It is taken arbitrarily as the deepest development of deltaic sandstones assignable to the Agbada Formation (Short and Stauble, 1967). Its base has been reached only in some wells Akata 1(Short and Stauble, 1967). The Akata Formation is about 3–4 km thick (Doust 1989, Haack et al. 2000). A major regional sequence boundary between the Akata and Agbada Formations marks an abrupt change in the depositional environment (Morgan 2003). The age of the Akata Formation ranges from Paleocene in the proximal parts of the delta to Recent in the distal offshore (Reijers,1996) and (Ige (2010).

Agbada Formation

The formation is a paralic sequence of alternating sandstones and shales; with sandstone dominant in the upper unit and thick shales in the lower unit. It is very rich in micro fauna at the base decreasing upwards suggesting an increase in the rate of deposition at the delta front. The sandstone is coarse and poorly sorted indicating a fluviatile origin and marine origin for the shale. The Agbada Formation covers the entire subsurface of the delta and may be continuous with the Ogwashi-Asaba and Ameki Formations of Eocene to Oligocene age which is generally marine (Ozumba,1994) The formation is over 3,048m thick and is the major hydrocarbon bearing unit in the Niger Delta Basin (Reijers, 2011). It is strongly diachronous, ranging in age from Eocene to present day (Short and Stauble,1967).

Benin Formation

This unit consists predominantly of continental fluvial sands that underlie an extensive area of southern Nigeria typified by the sands around Benin City where it is estimated to be 3,050 m thick. (Short and Stauble, 1967). The unit is generally friable and consists of white, fine to coarse and pebbly, poorly sorted sands. Lignite occurs as thin streaks or as finely dispersed fragments. The Benin formation also comprises thin grayish brown shale bands containing plant fragments. It is reconstructed as the upper and lower flood (delta) plain setting. Some marine shale breaks have been identified within the formation, the bulk of the sediments were deposited in the upper delta plain as freshwater, backswamp, and meander belt facies (Allen, 1965a; Dessauvagie, 1972). The age is Oligocene to Recent (Short and Stauble, 1967; Whiteman, 1982).

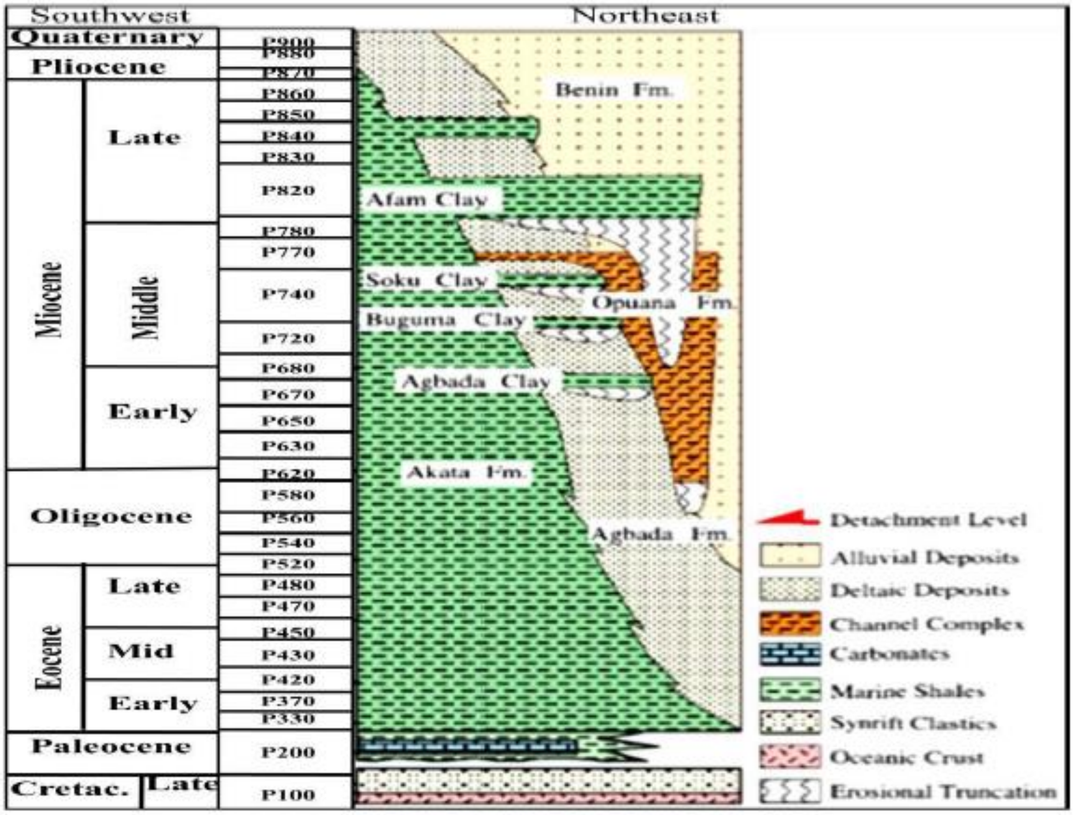


Fig: 2 Schematic representation of Stratigraphic column showing formations of the Niger Delta Basin with Palynological zones (Doust and Omatsola, 1990).

MATERIALS AND METHODS

The ditch cuttings were examined for their lithologies, colour, mineralogical composition and textural characteristics (grain size). This was done to obtain information on the grain size distribution. Eighty- nine (89) ditch cuttings samples were provided by Sterling Global Oil Limited from two (2) wells, well XY- 1 and well XY- 2 within the central swamp Niger Delta Basin. Fifty-one (51) ditch cutting samples were collected at well XY- 1 between 1960 and 2470 m, while thirty-eight (38) ditch cuttings samples were obtained from 2000 to 2380 m at well XY-2. The samples were collected at a regular interval of 10 m from both wells. Thirty-six (36) ditch cuttings samples, (twenty-one (21) and fifteen (15) ditch cuttings samples) were selected from well XY-1 and well XY-2 respectively for palynological analysis at the Sedimentology and Paleontological Laboratory, Delta State University Abraka. The conventional acid maceration method recommended by Traverse (1988) were adopted for the sample analysis. These involve the cleaning and removal of field contaminants such muds.10g of each sample was weighed and disaggregated into smaller pieces of 1-3 mm fractions by crushing with agate mortar and pestle.10% of the sample was treated with dilute hydrochloric acid (HCl) to remove carbonates that may be present in the sample. Thereafter the samples were treated with 45% HF to remove silicate materials. The residue was again treated with 10% HCl to remove any Fluorosilicate that may have formed during reaction with HF. The palynomorphs were separated from the residue using zinc chloride, $ZnCl_2$ (specific gravity 1.98) and centrifuged at 2000 rev/min for 5 minutes. This process helped to separate the palynoflora which was decanted and rinsed thrice with distilled water. Density separation was followed by acetolysis to dissolve cellulose for easy identification of palynomorphs. Two drops of the residue containing sporomorphs were spotted onto cover slip measuring 32 by 22 mm and placed on slide warmer (low-temperature hot plate) to dry. The cover slip was sealed permanently onto a glass slide by means of petropoxyl resin.

RESULTS AND DISCUSSIONS

The examination of the lithologies from the grain size distribution using microscope provided information on the lithofacies of the studied wells. Five lithofacies comprising sandstone (medium-coarsed grained, smoky white to orange colour), grey shale (grey in colour and fissile), black shale (black in colour and fissile) well XY-1 and sandstone (medium-coarsed, smoky white to grey colour) and alternation of shale (grey- black, fissile), shaly sand and sandy shale well XY-2.as shown in (figure 3and 4).

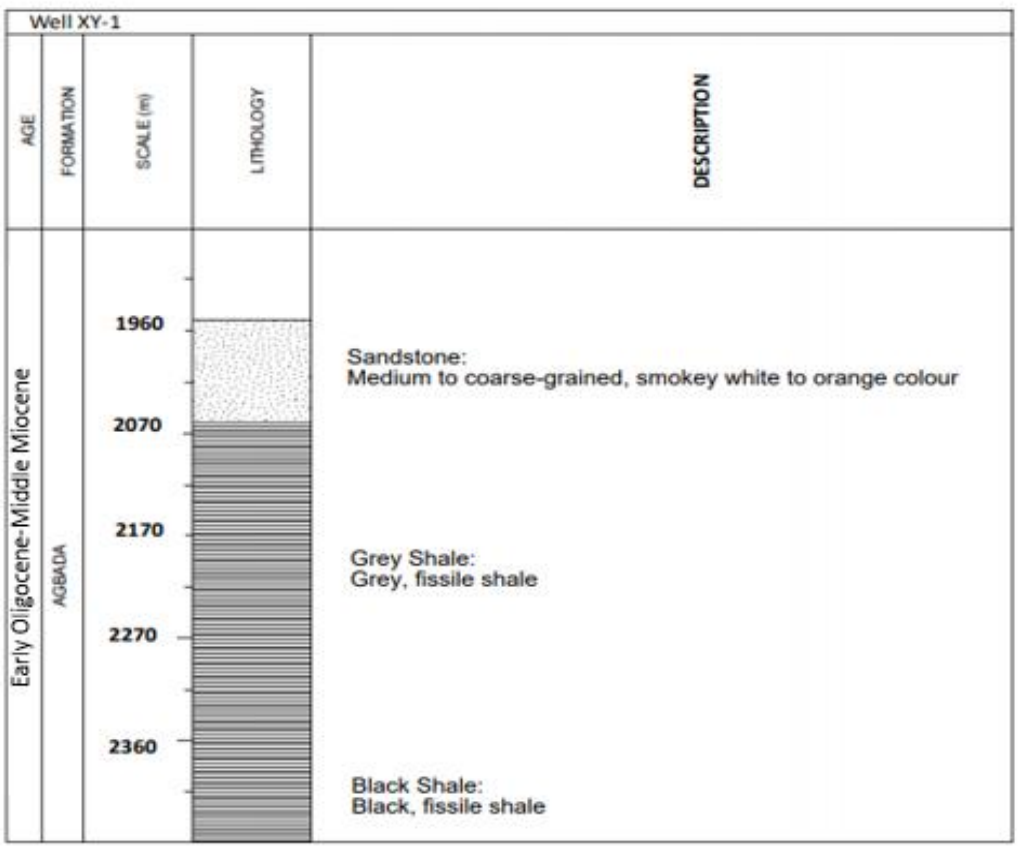


Fig 3: lithologic log of well XY-1

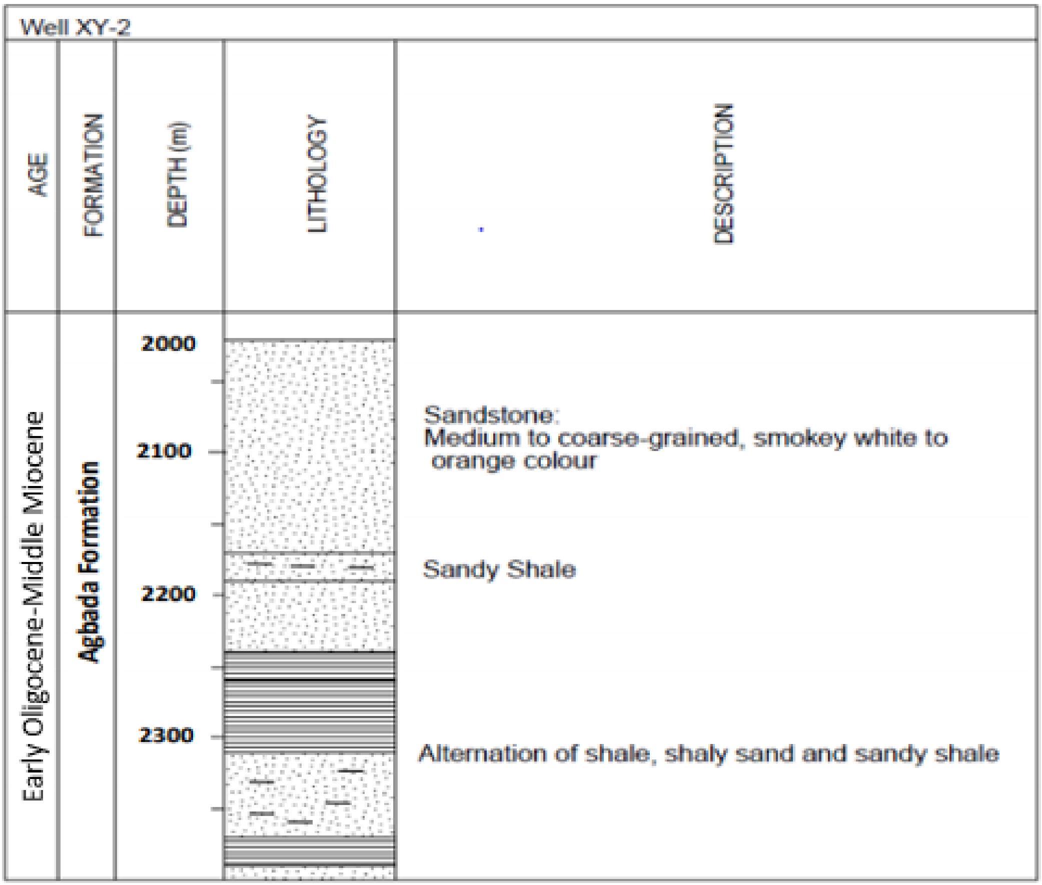


Fig 4: lithologic log of well XY-2

Palynomorphs

The Palynological analysis of XY-wells 1 and 2 yielded rich and divers palynomorphs of one-hundred and three (103) different species, comprising fifty-one (51) (pollen and spores) and fifty-two (52) dinoflagellate cysts for XY-well 1. A total of eighty (80) Palynomorphs were recovered from XY-well 2 comprising, thirty-seven (37) pollen and spores and forty-three (43) dinoflagellate cysts. Some of the recovered species include: *Proxapertites cursus*, *Crassoretitriletes vanraadshooveni*, *Verruticolporites irregularis*, *Laevigatosporites ovatus*, *Tricolpites hians*, *Retibrevitricolporites protrudens*, *monocolpites marginatus*, *Zonocostites ramonae*, *Verrucatosporites alienus*, *Perretipollis spinosus*, *Cyathidites minor*, *Monoporites annulatus*, *Arecipites crassimuratus*, *Echiperiporites minor*, *Striatopollis catatumbus*, *Verrucatosporites usmensis and Praedopolis africanus* among others. The following species: *Spiniferites ramosus*, *Distatodinium ellipticum*, *Tuberculodinium vancampoae*, *Membranophoridium aspinatum*, *Operculodinium erikianum*, *Operculodinium microtriainum*, *Selenopemphix quanta*, *Paleocystodinium sp*, *Filisphaera filifera*, *Spiniferites pachydermu*, *Areoligera semicirculata*,*Membranophoridinum perforatum*,*Polysphaeridium zoharyi* and *Eocladopyxis peniculata* among others represents the dinoflagellate cysts shown in

Table 1: Distribution chart of some palynomorphs recovered from wellXY-1

Sample Numbers Palynomorphs	2080-2090	2090-2100	2110-2120	2130-2140	2150-2160	2170-2180	2190-2200	2210-2220	2220-2230	2240-2250	2250-2260	2280-2290	2300-2310	2320-2330	2340-2350	2360-2370	2380-2390	2400-2410	2420-2430	2440-2450	2450-2460
Pollen and Spores																					
Proxapertites cursus	16	10	12	2	4	5	4	1	2	0	4	8	5	2	5	2	3	2	3	1	2
Retibrevitricolporites protrudens	7	8	5	0	2	6	3	0	2	0	1	5	1	6	1	2	0	2	4	1	2
Crassoretitriletes vanraadshooveni	4	9	8	1	0	2	1	1	0	0	1	7	3	1	3	0	0	0	1	1	0
Perretipollis spinosus	4	10	7	8	9	3	3	0	0	2	1	0	1	2	1	0	0	2	1	0	0
Peregrinipollis nigericus	7	12	10	8	7	5	6	2	2	0	2	10	2	6	2	0	1	1	2	0	2
Retibrevitricolpites triangulates	17	8	15	10	8	4	3	4	3	4	3	10	2	4	2	3	1	2	4	2	1
Verrutricolporites irregularis	15	14	20	8	7	1	3	1	0	1	2	9	1	3	1	4	2	5	3	2	2
Psilatricolporites crassus	10	16	12	1	8	4	10	2	3	0	2	8	2	1	2	0	2	3	4	4	2
Racemonocolpites hians	6	9	8	7	4	2	0	0	0	0	1	6	1	2	1	2	1	3	1	2	0
Alnipollenites verus	1	0	7	5	2	1	2	0	0	1	0	7	0	3	0	0	0	1	0	0	0
Tricolpites hians	3	6	9	8	3	1	0	0	1	1	0	9	0	0	0	4	3	4	4	3	3
Brevicolporites guinetii	1	0	5	0	0	0	1	0	0	0	1	5	1	3	1	3	2	3	2	2	0
Matonisporites rarus	6	0	7	2	4	1	0	0	0	1	0	7	1	4	1	0	0	1	0	0	0
Cyathidites minor	8	9	16	9	5	6	6	3	4	1	0	7	2	4	2	3	0	1	0	2	0
Polypodiaceoisporites turpitus	6	7	6	4	5	3	3	2	0	1	0	6	0	1	0	2	0	2	0	0	1
Verrucatosporites alienus	9	6	12	5	0	0	2	0	2	1	2	4	2	2	2	0	0	1	0	3	1
Monocolpites marginatus	15	16	10	9	4	2	3	3	2	2	1	6	1	3	1	4	5	3	2	3	2
Bacumorphomonocolpites tausae	6	8	3	0	2	0	3	0	0	0	0	3	0	2	0	3	2	3	3	0	0
Membranophoridium aspinatum	2	2	1	2	2	3	2	9	2	0	5	3	6	3	2	2	6	0	0	1	4
Batiacasphaera minuta	2	0	1	0	1	3	2	5	5	4	0	0	8	2	3	4	5	0	0	0	4
Cleistosphaeridium placacanthum	2	1	1	1	0	1	1	17	8	2	4	2	9	0	2	7	9	9	3	6	2
Adnatosphaeridium vittatum	0	2	1	3	4	1	2	4	0	1	4	3	15	5	1	6	8	12	7	5	7
Spiniferites pachydermus	2	5	3	4	3	2	3	10	0	0	4	2	6	2	2	8	7	10	5	6	5
Operculodinium erikianum	2	2	2	0	4	2	1	3	3	6	2	0	7	3	2	0	0	5	3	0	0
Operculodinium microtriainum	2	1	4	4	3	1	2	3	7	5	7	2	10	4	2	7	8	9	5	4	6
Glaphyrocysta retiintexta	2	2	3	1	4	2	5	13	5	6	5	1	0	3	5	3	7	7	8	7	4
Glaphyrocysta laciniiformis	0	1	3	3	2	1	6	12	3	0	0	2	3	1	4	0	0	1	1	0	0

Cleistosphaeridium polypetellum	**1**	**0**	**1**	**3**	**2**	**1**	**2**	**4**	**5**	**4**	**6**	**3**	**15**	**2**	**4**	**0**	**6**	**0**	**0**	**3**	**3**

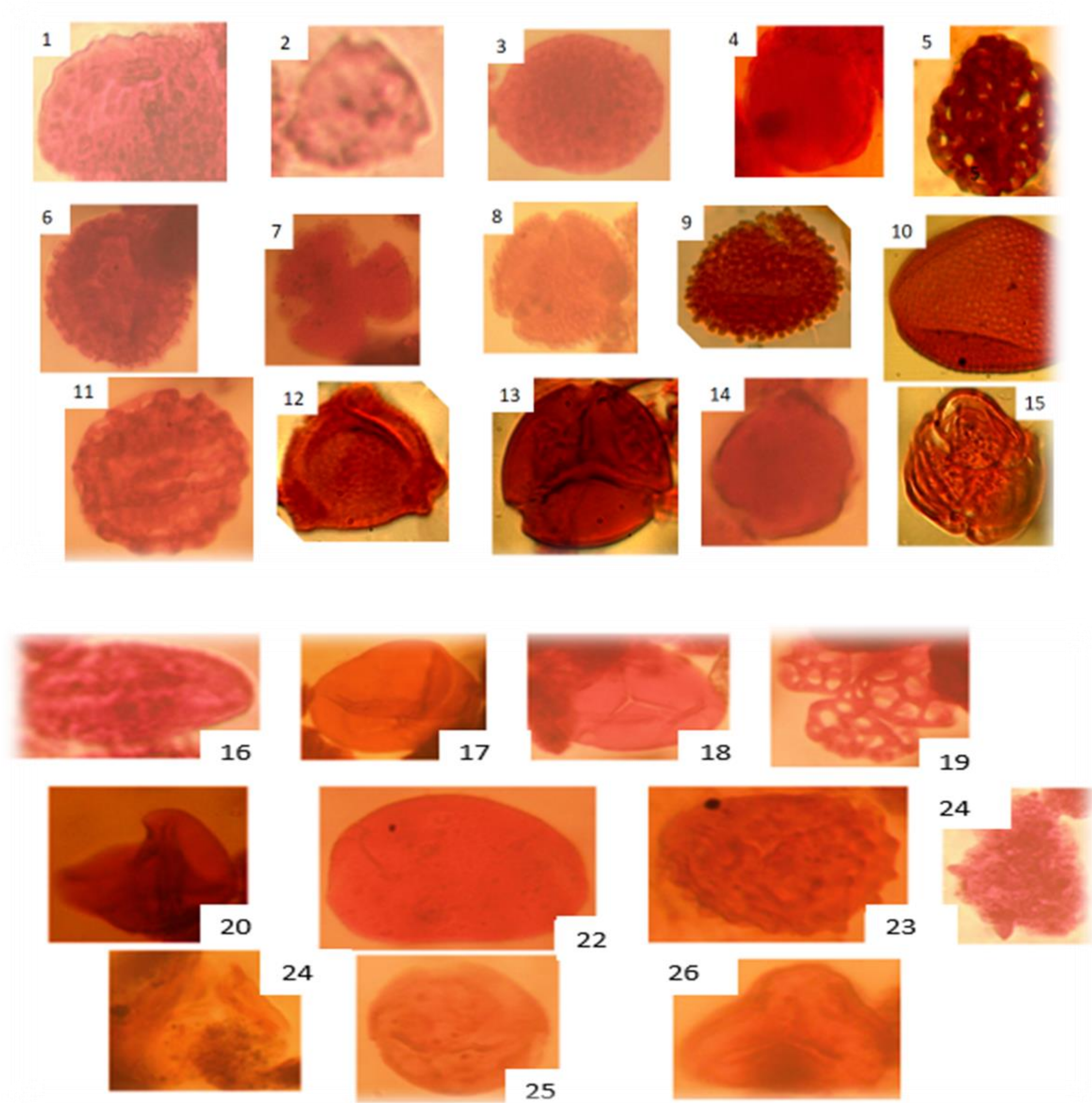


Fig 5: Photomicrographs of some Palynomorphs recovered from XY-well 1 and XY-well 2.

1.*Verrucatosporites usmensis (Van der Hammen) Gemeraad, Hopping and Muller,* 1968 2. *Retibrevitricolpites triangulates*. 3. *Proxapertites cursus* 4. *Alnipollenites verus.* 5. *Peregrinipollis nigericus* 6. *Perretipollis spinosus* 7. *Tricolpites hians Stanley*, 1965. 8. *Psilatricolporites crassus* 9. *Racemonocolpites hians*. 10. *Proxapertites cursus.* 11. *Crassoretitriletes vanraadshooveni Germeraad et al.*, 1968. 12. *Retibrevitricolporites protrudens Legoux,* 1971. 13.*Psilatricolporites crassus.* 14.*Verrutricolporites irregularis*. 15.*Perretipollis spinosus.* 16.*Monocolpites* *marginatus.* 17.*Leiotriletes adriennis Krutzsch,* 1962*. 18. Leiotriletes maxoides.* 19.*Praedopolis africanus* 20. *Matonisporites rarus.* 21.*Longapertites marginatus.* 22.*Verrucatosporites alienus.* 23. *Polypodiaceoisporites turpit* 24. *Brevicolporites guinetii Salard-Cheboldaeff,* 1978 26*. Bacumorphomonocolpites tausae.* 26*. Cyathidites minor Couper*, 1953.

Table 2: Distribution chart of some palynomorphs recovered from well XY-2

Palynomorphs	2060-2070	2150-2160	2160-2170	2180-2190	2200-2210	2220-2230	2230-2240	2250-2260	2260-2270	2280-2290	2290-2300	2310-2320	2330-2340	2350-2360	2370-2380
POLLEN AND SPORES															
Psilastephanocolporites minor	6	8	0	5	6	2	0	3	1	5	4	5	7	6	4
Leiotriletes maxoides	7	8	7	4	5	0	2	2	0	1	2	6	4	2	1
Arecipites crassimuratus	2	6	4	5	0	1	0	3	1	3	0	2	4	5	3
Monocolpites marginatus	12	10	4	10	7	8	2	0	0	6	9	3	7	6	2
Laevigatosporites ovatus	7	10	7	12	10	8	2	1	3	0	7	5	8	7	2
Proxapertites cursus	9	8	5	8	7	4	2	3	2	2	8	4	10	6	2
Praedopolis africanus	4	6	1	3	0	3	0	0	0	1	7	1	0	2	1
Polygalacidites sp.	3	3	3	0	2	1	1	0	0	2	8	4	0	0	0
Psilatriporites rotundus	6	9	0	2	4	4	1		0	1	4	2	6	2	1
Cyathidites minor	17	12	1	0	7	5	2	5	3	4	2	1	12	6	5
Psilatricolpites okeziei	3	6	3	0	0	0	0	0	0	0	3	1	3	4	0
Verrucatosporites alienus	6	3	1	0	5	3	1	1	0	1	0	0	0	0	1
Longapertites marginatus	10	7	6	2	7	2	2	2	0	3	4	1	9	6	5
Matonisporites rarus	0	2	0	4	3	0	0	0	1	2	5	6	0	1	0
Ctenophonidites costatus	6	7	0	2	3	0	0	0	2	0	5	3	2	1	0
Polypodiaceoisporites turpitus	1	2	5	3	6	0	2	1	0	2	0	0	4	3	2
Alnipollenites verus	2	3	0	0	1	1	0	0	3	1	4	2	2	3	1
Zonocostites ramonae	6	8	3	4	3	0	0	0	0	0	2	0	3	2	0
Retitricolporites irregularis	2	7	3	1	4	4	3	2	0	1	6	5	5	7	1

Crassoretitriletes vanraadshooveni	4	6	4	6	0	4	2	1	1	2	0	3	8	6	5
Echiperiporites minor	2	5	8	0	7	3	1	0	1	0	2	3	2	0	1
Inaperturopollenites hiatus	5	7	0	4	2	5	4	3	2	0	4	12	6	5	3
Psilatricolporites crassus	7	10	7	5	6	5	1	3	0	0	8	2	8	7	3
Retibrevitricolporites protrudens	5	6	0	2	0	2	1	0	0	1	4	5	2	1	2
Psilastephanocolporites perforates	2	0	3	4	2	0	1	1	0	1	2	6	4	0	2
Proxapertites operculatus	4	9	4	5	4	1	3	3	0	1	0	2	16	9	6
Psilastephanocolporites laevigatus	6	10	4	5	3	3	2	3	2	3	9	3	10	8	6
Retibrevitricolporites obodoensis	1	3	0	0	2	0	2	0	0	0	7	5	2	0	1
Verrucatosporites usmensis	9	3	9	3	5	5	0	0	1	1	6	4	17	10	7
Cicatricosisporites dorogenesis	3	0	0	1	0	4	0	0	0	0	0	1	2	0	1
Striatopollis catatumbus	2	0	5	6	0	1	1	0	1	2	3	4	3	5	1
Magnastriatites howardi	6	3	1	2	4	0	0	2	0	0	4	2	1	0	1
Mauritidites crassiexinus	1	0	1	0	2	5	1	1	0	1	2	1	2	1	2
Striamonocolpites undatostriatus	3	6	1	0	1	4	0	1	0	3	3	1	6	6	0
Racemonocolpites racematus	3	2	3	2	4	0	2	0	1	3	0	0	4	3	2
Psilatricolporites crassus	3	6	6	1	5	2	5	4	0	6	4	1	14	9	5
Verrutricolporites irregularis	4	7	4	3	2	4	2	1	0	3	5	3	5	3	2
DINOFLAGELLATE CYSTS															
Spiniferites pachydermu	0	1	0	2	3	2	1	0	0	2	2	3	2	4	2

Areoligera semicirculata	**2**	**0**	**3**	**4**	**2**	**0**	**3**	**5**	**1**	**3**	**1**	**3**	**3**	**4**	**1**
Phthanoperidinium comatum	**2**	**1**	**2**	**2**	**0**	**1**	**2**	**1**	**0**	**2**	**0**	**1**	**1**	**2**	**0**
Selenopemphix quanta	**0**	**2**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**
Ectosphaeropsis burdigalensis	**0**	**0**	**0**	**2**	**3**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**2**	**2**	**0**
Membranophoridium perforatum	2	0	2	4	3	2	1	3	2	2	1	2	2	3	0
Hystrichokolpoma pusillum	0	1	1	0	0	1	0	0	0	2	3	1	2	4	1
Diphyes ficusoides	0	2	3	0	2	1	4	2	0	5	0	2	2	5	1
Chiropteridium galea	0	1	0	2	1	1	2	0	0	4	2	1	1	4	0
Chiropteridium lobospinosum	1	0	1	0	3	2	3	0	1	4	2	1	2	4	0
Hystrichokolpoma reductum	1	2	1	0	0	0	2	0	0	3	0	1	1	3	0
Systematophora placacantha	2	1	1	0	2	0	5	1	0	0	3	2	3	6	2
Thalassiphora pelagic	0	2	0	2	1	2	1	2	0	2	2	1	2	5	1
Cordosphaeridium cantharellum	2	1	0	2	0	0	0	0	0	5	3	0	2	6	0
Distatodinium craterum	1	0	0	2	3	0	1	0	0	6	2	2	6	4	1
Lingulodinium machaerophorum	3	2	2	1	3	0	2	2	3	5	4	2	5	3	0
Eocladopyxis peniculata	1	2	0	0	1	1	0	3	0	0	2	2	1	2	0
Spiniferites ramosus	4	3	3	2	3	0	6	2	2	3	5	2	3	12	4
Homotryblium abbreviatum	2	0	0	1	0	0	0	0	0	6	0	0	2	1	0
Polysphaeridium zoharyi	2	2	2	3	3	0	5	2	1	8	5	2	8	4	0
Cordosphaeridium exilimurum	2	0	2	0	1	3	1	0	1	4	2	3	4	2	0
Cleistosphaeridium aciculare	2	1	0	2	2	1	4	2	1	3	2	2	3	6	2
Distatodinium ellipticum	0	1	0	0	1	0	0	1	0	1	0	2	1	2	0
Tuberculodinium vancampoae	0	1	0	2	0	2	1	0	0	2	2	2	2	3	1
Spiniferites pseudofurcatus	1	0	1	2	2	0	2	1	1	5	2	3	5	4	0
Operculodinium centrocarpum	3	4	0	0	0	1	3	2	0	6	1	1	6	5	1
Lejeunecysta spp.	1	0	2	2	1	1	2	2	2	5	0	2	5	3	3
Cleistosphaeridium diversispinosum	3	2	2	2	2	0	2	1	1	0	3	2	5	6	2

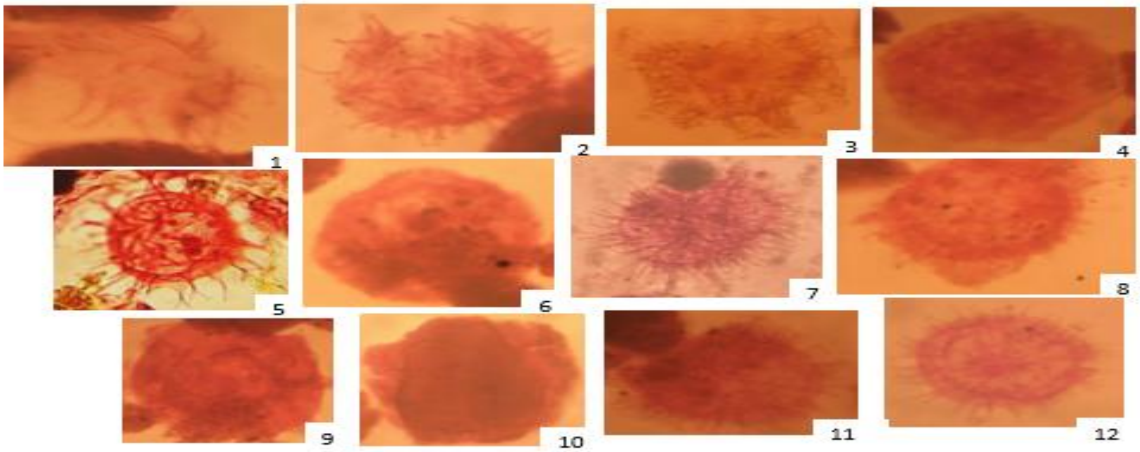


Fig6: Photomicrographs of some Dinoflagellates cysts recovered from XY-well 1 and 2

. 1. *Cordosphaeridium funiculatum*. 2. *Polysphaeridium zohary*i. 3. *Areoligera semicirculata*. 4.*Tuberculodinium vancampoae*. 5. *Spiniferites ramosus*. 6.*Thalassiphora fenestrate*. 7.*Eocladopyxis peniculata*. 8. *Diphyes ficusoides*.. 9. *Phthanoperidinium comatum.* 10. *Membranophoridium perforatum*. 11&12. *Cleistosphaeridium ancoriferum.*

PALYNOLOGICAL BIOZONATION

The Palynological zones proposed in this study were based on the work of Evamy et al, (1978)**.** Five (5) Palynological zones were erected based on the Stratigraphic distribution of some index fossils recovered from the study. Terrestrial palynomorph species were used in the delineation of the zones. The zones are:

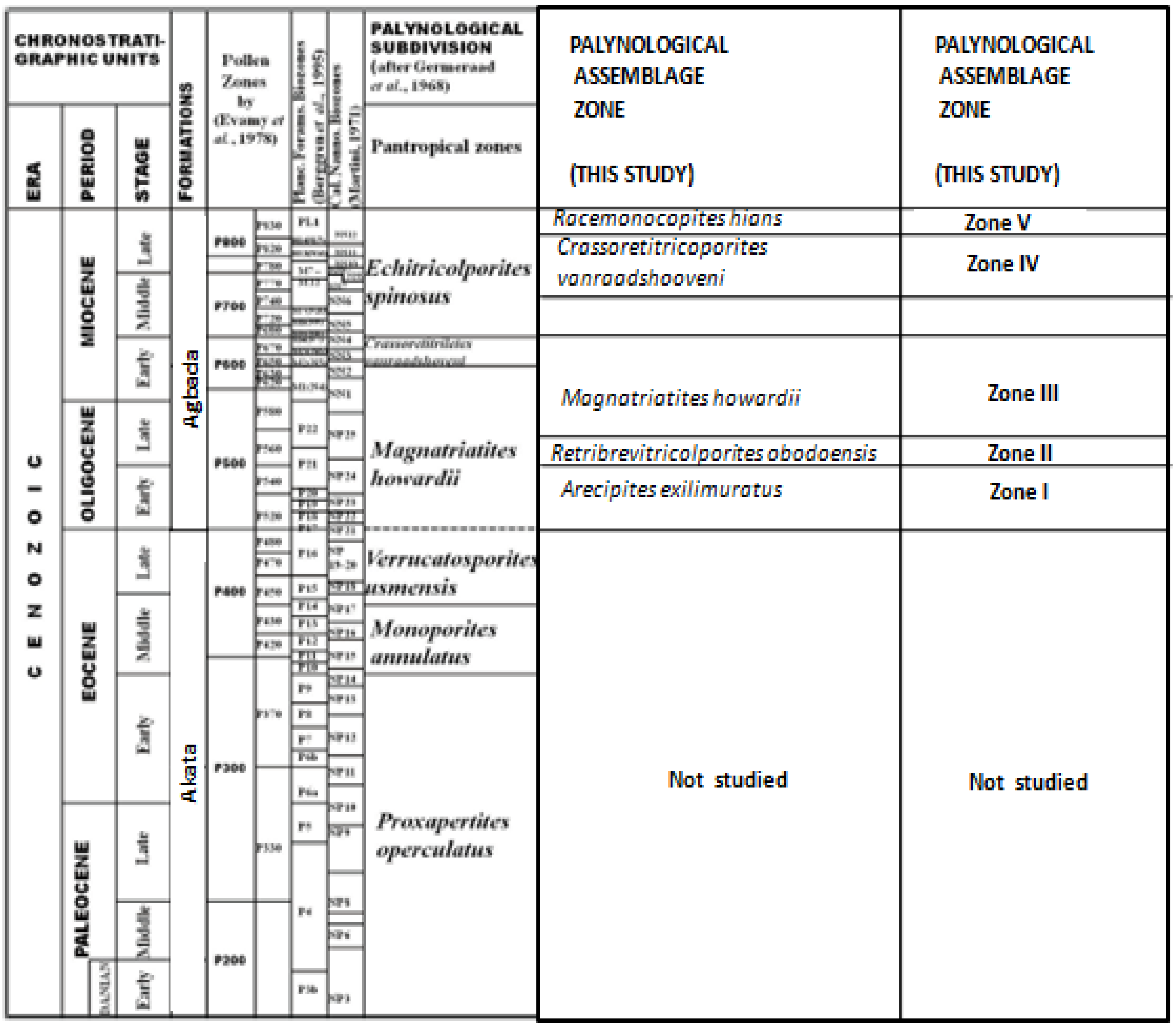
***Magnastriatites howardi* Zone**
Stratigraphic interval: 2280-2090 m

This zone is characterized by first down hole occurrence (FDO) of *Magnastriatiteshowardi* and *Verrucatosporites usmensis* at the base. This zone is equivalent to P670 (Evamy *et al,* 1978). The age of this zone is late Miocene due to the presence of *Pachydermites diederixi* and *Monoporites anulatus.* The dinoflagellate cysts present are, Hystrichokolpoma *cinctum, Spiniferites mirabilis* and *Paleocystodinium sp.*

***Retibrevitricolporites obodoensis* Zone**
Stratigraphic interval: 2460-2090 m

The *Retibrevitricolporites obodoensis* zone is defined by first downhole occurrence (FDO) of *R. obodoensis* and *Auricariacites autralis* at the bottom. This zone is equivalent to P550/P580 of Evamy, *et a*l. (1978). The age of this zone is Middle Oligocene due to the presence of *Retibrevitricolpites protrudes*, *Areciptes exilimuratus* and *pereginipollis nigericus.* Dinoflagellate taxa include *Phthanoperidinium comatum, Diphyes ficusoides* and *Tuberculodinium vancampoae*.

Table 3: Stratigraphic range chart of the studied sections (well XY-1 and well XY-2) Evamy *et al*., (1978)



***Crassoretitriletes vanraadshooveni* Zone**
Stratigraphic interval: 2350 -2090 m

The *C. vanraadshooveni* zone is characterized by the FDO of *Crassoretitriletes vanraadshooveni* and *Perrtipollis spinosus* at the base. This zone correlated to P720 of Evamy, *et al.* (1978). The age of this is Middle Miocene due the presence of *Pachydermites diedeerixi.* The dinoflagellate cysts present are *Cleistosphaeridium placacantum, Adnatosphaeridium vittatum* and *Operculodinium erikianum.*

***Arecipites exilimuratus* Zone**
Stratigraphic interval: 2410 -2090 m
This zone is defined by the (FDO) of *A. exilimuratus* with high occurrence of *laevigatosporites javanicus* at the bottom. This zone is equivalent to the P540 of Evamy,

et al. (1978). The age is Early Oligocene due to the presence of *Retibrevitricolporite obodoensis* and *Retrbrevitricolporites protrudens*. The dinoflagellate cysts present are; *Chiropteridium lobospinosum* and *Phelodinium pachyceras*.

***Racemonocolpites hians* Zone.**
Stratigraphic interval: 2290 -2090 m

This is characterized by the (FDO) of *Racemonocolpites hians* with low occurrence of *Alnipollenites versus* at the bottom. This is equivalent to the P788 Evamy, *et al*. (1978). The zone is characterized by the regular and abundance records of *Proxapatites cursus, Verrucatosporites usmensis* and *Proxapertites operculatus.* The age is Middle Miocene. Dinoflagellate taxa are; *Glaphyrocysta laciniiformis* and *Cleistophaeridium poypetellum.*

Paleoenvironment

The Palynomorphs and the dinoflagellate cyst were integrated in reconstructing the depositional environment. The occurrence of *Verrucatosprites usmensis* and *Cyathidites minor* suggests fresh water swamps and marshes. The presence of some dinoflagellate cysts like *Operculodinium centrocartupum* and *Cleistosphaeridium polypetellum* reflects near shore environment (Downie, *et al*. 1971). The *Spiniferites ramosus, Areoligera semicirculata* and *Areligera senonensis* denotes open marine (Li and Habib, 1996). *Proxapertites operculatus*, *Longapertites marginatus* and *Proxapertites cursus* suggest mangrove swamp environment. The inner neritic zone is represented by *Homotryblium plectilum* and *Phthanoperidinium comatum*. The middle to inner neritic components are represented by *Hystrichokopoma pusillum* and *Heterosphaeridium* sp.

Age determination

The distribution of stratigraphically important palynomorph form species such as *Retibrevitricolporites obodoensis, Racemonocolpites hians, Arecipites exilimuratus, Praedapollis africanus,* and *Crassoretitriletes vanraadshooveni,* etc. dated the studied section as Early Oligocene to Middle Miocene.

CONCLUSION

Micropaleontological analysis of ditch cuttings samples from well XY-1 and well XY- 2 within the depth interval of 1960-2470 m and 2000 -2380 m yielded pollens and spores and dinoflagellate cysts. Early Oligocene to Middle Miocene age was inferred for both well from the palynological analysis. Five palynological zones were established from this study following Evamy, *et al.* (1978) scheme of pollen Zonation. The biozones include *Magnastriatites howardi, Retibrevitricolporites obodoensis, Crassoretitriletes vanraadshooveni, Arecipites exilimuratus* and *Racemonocolpites hians Zone***.** The age erected in this study provided a vital tool in understanding the depositional cycle of the sediment profile within the Agbada Formation in the Niger Delta Basin.

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