PALYNOLOGY OF WELL-001 OF MEREN FIELD, NIGER DELTA: IMPLICATIONS FOR AGE AND ENVIRONMENT OF DEPOSITION

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ABSTRACT

Palynology formed the basis for the characterization of Well-001 in the Meren field, Western Niger Delta. Twenty (20) ditch cutting samples were used for Palynofacie analysis by non-acid method. All samples were collected from same Well-001. The palynofacie analysis investigated samples from depth 3660 ft to 11400 ft which permitted the resolution of age and depositional environment. From the result, recognized palynomorphs include: *Striatotricolporites sp., Psilatricoporites sp., Monoporites annulatus, Perchydermites diederexi, Fusformisporites pseudorabbi, Laevigatosporites sp, Leiotriletes sp, Proxaperities operculatus, Zonocastic romanae, Arecipites exillmuratus, Ephedripites sp, Tricolpites sp, Echiperipoites sp, Numupollis neogenicus.* Five palynofacies were described. Palynofacies I depicts fluvio-deltaic and moderately distal oxic environment, palynofacies II: nearshore dysoxic-anoxic environment, palynofacies III: marginal marine under a proximal dyoxi-suboxic environment, palynofacies IV: non-marine or nearshore environment under oxic conditions, and palynofacies V: fluvio-deltaic/nearshore (proximal shelf) under oxic condition. Early to Late-Miocene age was assigned to the the sedimentary strata encountered in the well based on diagnostic palynomorphs such as *Monoporites annulatus, Perchydermites diederixi, Striatricolpites sp, Laevigatosporites sp. and Leiotriletes sp., Zonocostites ramonae.*

INTRODUCTION

Niger Delta stands among the World's best studied Delta complexes because of its economic potentials petroliferous province (Ekweozor and Daukoru 1992; Ekweozor and Okoye 1980; Nyantakyi *et al*., 2013).

Niger Delta situates in the Gulf of Guinea on the West Coast of Central Africa (Obaje and Okosun 2013). Niger Delta is bounded in the North- East by Benue Trough while on the South by South Atlantic Ocean whereas on the West, Benin Flank and on the East, the Calabar Flank. (Ojo*et al.,* 2009; Nwachukwu and Chukwura, 1985).

Palynology is becoming increasingly an important tool in modern research for petroleum in resolving many age and facies correlation problems. They occur in abundance in both continental and marine deposits (Olajide, 2014).

The study area lies between latitude 4^0 and 6^0N and longitude 3^0 and 9^0E Southern Nigeria (Fig. 1). It is situated West of Benin river field, about 4 miles East South East of the Mefa field, about 5 miles West North West of the Gbokoda field. Meren field is situated almost entirely in the swamp region of OML-68 (Obaje and Okusun, 2013, Omoboriowo and Soronnadi-Ononiwu, 2011).

Nwachukwu and Chukwura (1985) in their organic survey of the Western Niger Delta, reported lack of dinoflagellates which suggest a predominance of terrestrially derived amorphous organic matter in the shales of Agbada Formation.

Similarly, Olajide (2014) stresses that mainly shaly sediments were deposited in a marginally marine environment under a terrestrial influence as indicated by presence of very rare dinocyst and significant amounts of cuticular material. They found the age of the sediments to range from late Oligocene-mid Miocene age based on the co-occurrence of pantropical stratigraphic markers such as Zonocostites ramonae (which first came into existence during the Late Oligocene), Retimonocolpites protrudens etc.

Based on the microfossil zones of *Cyclammina cf. minima, Globorotaliaacostaensis/Uvigerina sub peregina* zone, *Globorotalia merotumida/Plesio tumida/Ammobaculites agglutinans zone, and Globoquadrina dehiscens/Haplophragmoides narivaensis* zone. Boboye and Adeleye (2009) established the environments of deposition of the sequence of Early Pliocene – Late Miocene, Deep Offshore, Niger Delta, as marginal marine which are typified by hyposaline conditions.

Intensive biostratigraphic studies have been carried out in the onshore and shallow offshore Niger Delta while virtually all these studies were done on foraminifera and palynological aspects, only few of these were made available for publication. The present study therefore study the palynofacies in ditch samples from Well-001 of Meren Field, Niger Delta in order to characterize it based on age and environment of deposition.

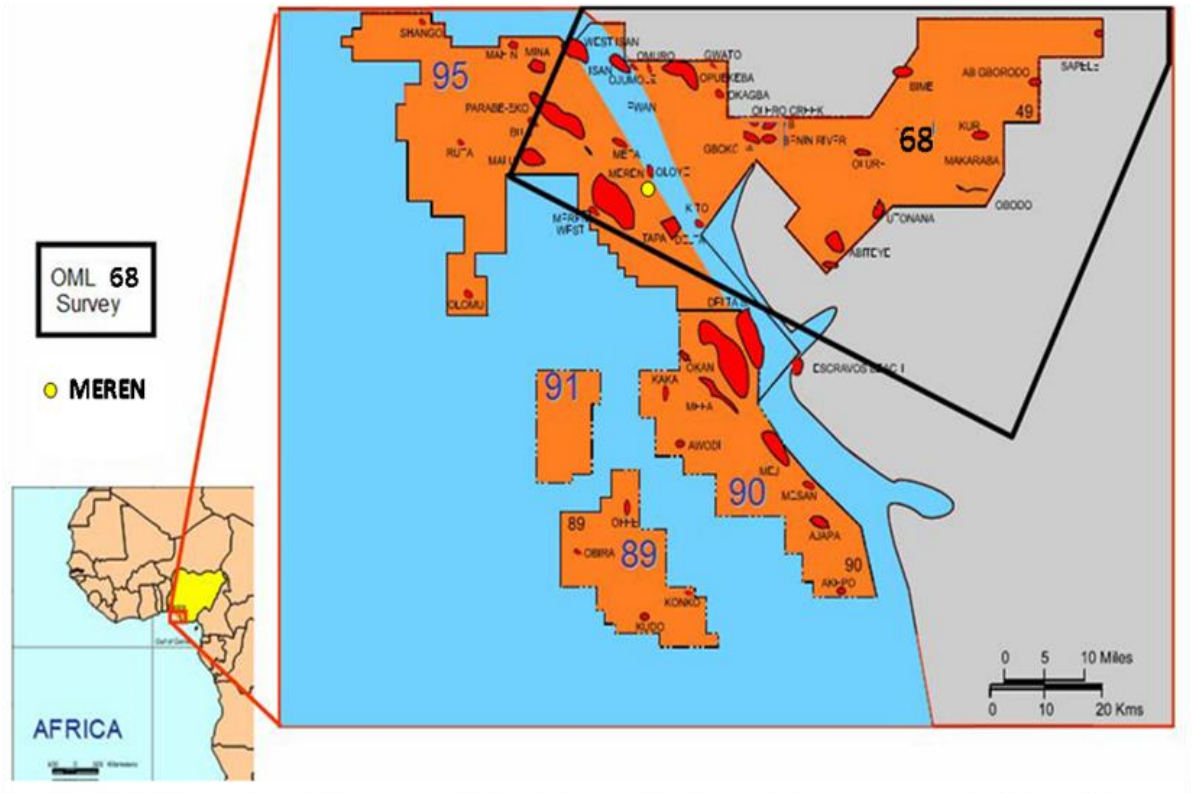


Fig 1. Location of Meren Field and adjacent fields in Western Niger Delta mining lease

GEOLOGY OF THE STUDY AREA

The Niger Delta is bounded to the North by the Anambra Basin and the Abakaliki high; to the West by the Dahomey basin and the Benin flank; and to the East by the Calabar Flank, the Equatorial Guinea Basin, and the Cameroonian volcanic line 9 (Doust and Omatsola, 1990).

It is situated in the Gulf of Guinea and estimated at about 116,000 m^2 (3000, 000 km^2) in area and about 6 mi (10 km) in depocentre thickness. Niger Basin is the largest basin in the continental margin of the Gulf of Guinea (Kulke, 1994).

The basin occupies the ocean ward part of a larger and older tectonic feature, the Benue Trough. The stratigraphic history of the Niger Delta basin in terms of tectonic event revealed that the basin represents the third cycle in the evolution of the Southern Nigerian sedimentary basin thus, a) Benue-Abakaliki phase (Aptian-Santonian), b) Anambra–Basin phase (Santonian–Early Eocene) and c) Niger Delta phase (Late Eocene-Recent).

Niger Delta is characterized of three lithostratigraphic units namely; Akata, Agbada and Benin Formation in ascending order with sediments fill of about 12,000 m. The three formations exist in the subsurface of the onshore and offshore of Niger Delta (Frankl and Cordry, 1967; Weber Daukoru, 1975; Knox and Omatsola, 1989; Obaje and Okosun, 2013; Short and Stauble, 1967).

Table 1 Stratigraphic Units of the Niger Delta (After Poston, *et al., 1983)*

Outcropping units	Subsurface units	Lithology	Depositional environ	facie
Coastal plain sands	Benin Formation	Medium-coarse grained sands, clay and silt	Continental environment	Deltaic plain facie
Ogwashi-Asaba/Ammeki	Agbada	Intercalation of sand, silt, and clay	Transitional environment	Deltaic plain facie
Imo Shale	Akata	Clay and Shale	Marine environment	Deltaic front

METHODOLOGY

Palynofacie Analysis

The analysis identified the palynofacies and their abundance in 20 ditch cutting samples retrieved from the strata penetrated by well-001 in the Meren field offshore, Western Niger Delta.

Sample Preparation

The unwashed ditch-cutting samples were initially rinsed to remove drilling mud and then dried samples at room temperature for 24 hours to avoid agglomeration or clumps of the samples at some point in crushing. The ditch cutting samples are crushed to the size of 250 um and the aim of the reduced particles is to expose more samples material to chemical processing as well as totally separate all organic constituents. The size of 250um particle broken makes it easy to be observing in palynofacies slides.

Procedure

Palynofacies were extracted using sodium hexametaphosphate six salt [$(NaPO_3)_6$] as disaggregating and deflocculating agent. Phosphates in solution have a high ionic charge and, even at low concentrations, affect suspensions of colloidal particles. The phosphates generally are known as deflocculating, dispersing and peptizing reagents. They reduce the coherent nature of the clay because phosphate ions are strongly adsorbed onto the clay particles, which break up because of the high ionic charges. The surface charges prevent any reflocculation of the clay.

This analysis adopted the prototype work of Blandon *et al*. (2007). For Palynomorph recovery using the above named salt {$(NaPO_3)_6$}, the following steps were taken:

1. Indurated samples were crushed to pea size
2. Twenty grams of each sample were weighed and soaked with distilled water in a container.

3. Two spoons of sodium hexametaphosphate six [$(NaPO_3)_6$] salt was measured into each soaked sample. They were stirred for twenty minutes and left over night.
4. These samples were washed clean through 10 µ sieve and the residue poured into an EDTA (ethylenediaminetetracetic acid) bottle.
5. The residues were pipette and dropped on rectangular cover slips which were later placed on hot plate for onward drying.
6. Thereafter, dried cover slips were glued to biological slides using Norland adhesive and allowed to dry under the sun.
7. These slides were viewed with an Olympus CHB binocular microscope and photomicrograph of observed form were taken and documented.

RESULTS

Palynomorphs of Well-001

The recovered palynological assemblage consists of pollen, spore, some cuticle materials, (well preserved structured leaf cuticles) and amorphous organic matter. They include *Zonocostites ramonae, Monoporites annulatus, Striatricolporites sp., Auriculopollenites simplex, Perchydermites diderexi, Laevigastoporites sp, Ephedripites sp, Fusformisporites pseudorabbi, Echiperipoites sp, Numupollis neogenicus, Psilatricoporites sp., Leiotriletes sp, Proxaperities operculatus, Arecipites exillmuratus* sp. as shown in plates 1-3.

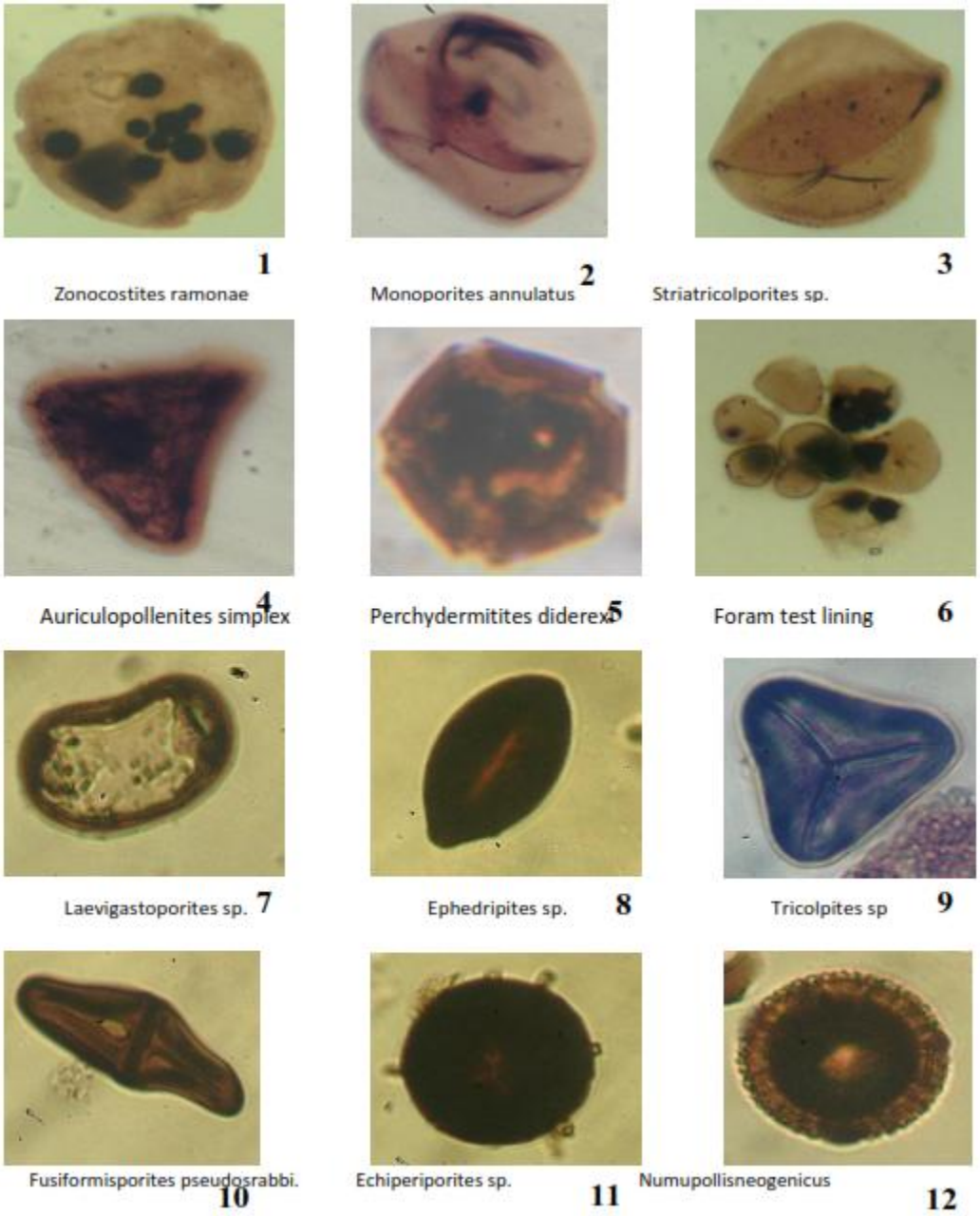
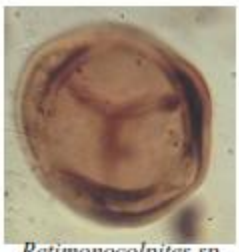
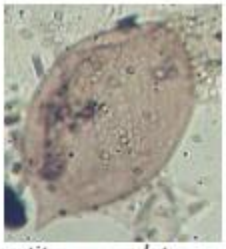


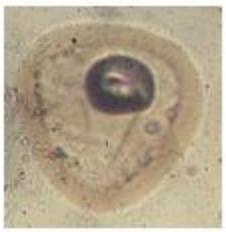
Plate 1a: Some recovered Palynofacies



Retimonocolpites sp. 13

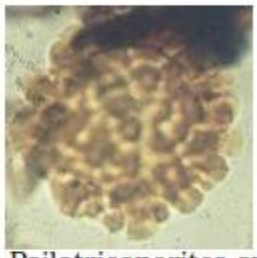


Proxapertites operculatus 14



Leiotriolites sp 15

Arecipites exillimuratus 16



Psilatricoporites sp. 17

EXPLANATION TO PLATE 1

Magnification x 100

1. *Zonocostites ramonae*
2. *Monoporites annulatus*
3. *Striatricolporites sp.*
4. *Auriculopollenites simplex*
5. *Perchydermitites diderexi*
6. *Foram test lining*
7. *Laevigastoporites sp.*
8. *Ephedripites sp.*
9. *Tricolpites sp.*
10. *Fusiformisporites pseudosrabbi*
11. *Echiperiporites sp.*
12. *Numupollisneogenicus*
13. *Retimonocolpites sp.*
14. *Proxapertites operculatus*
15. *Leiotriolites sp.*
16. *Arecipites exillimuratus*
17. *Psilatricoporites* sp.

Plate 1b: Some recovered Palynofacies

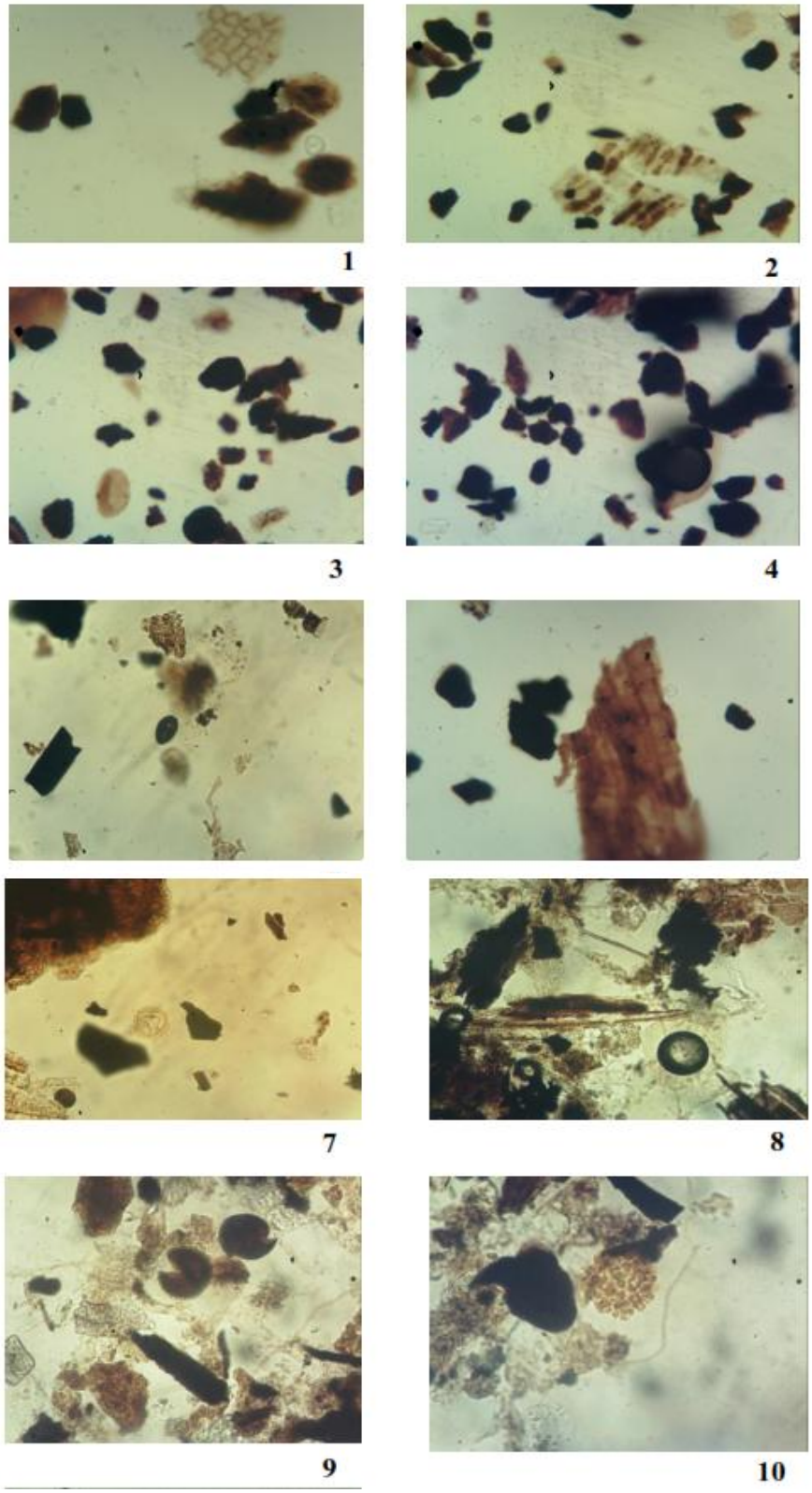


Plate 2: Brownish Amorphous organic matter with black phytoclasts.

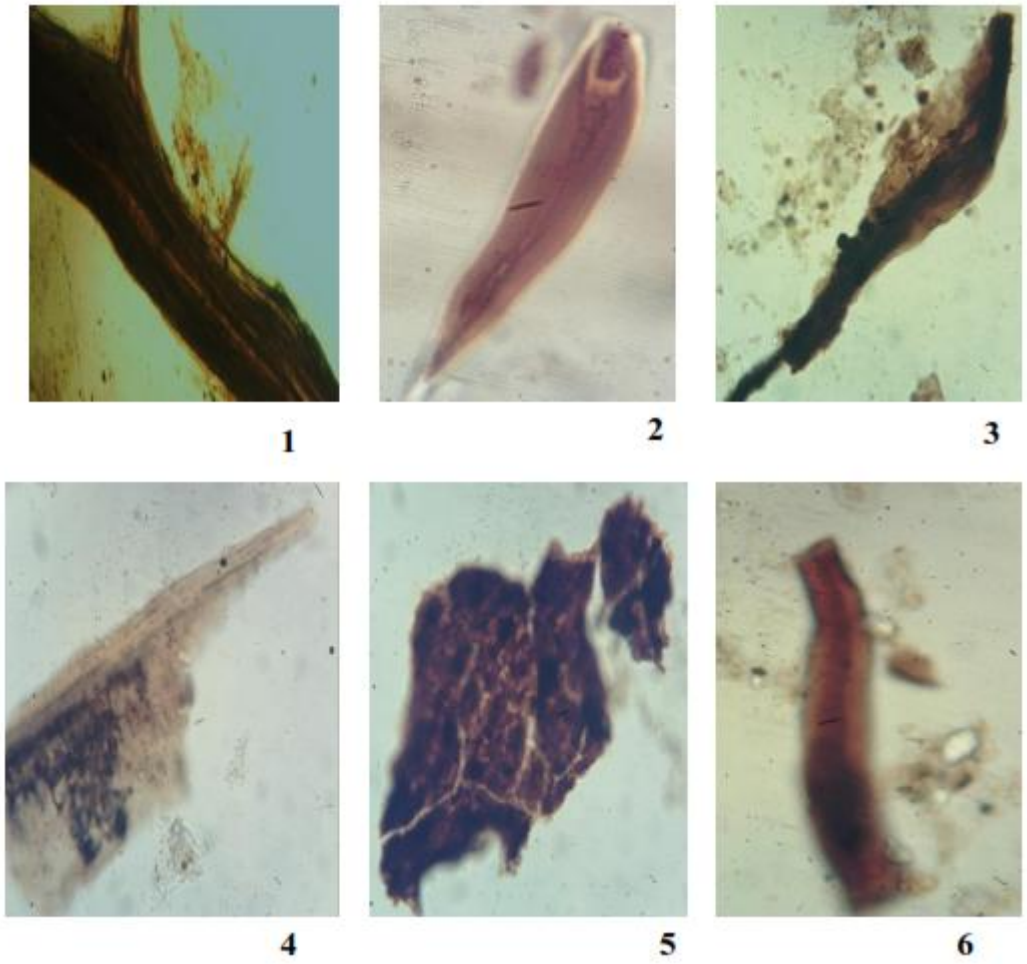


Plate 3: Structured phytoclast
2, 3: leaf cuticle structured with preserved cells. 1, 4, 5: Structured phytoclasts. 5: Fungal hyphae

Classification of the Recovered Palynofacies

The classification of the palynomorphs used here follows that of Tyson (1995)

Palynofacies I: Phytoclasts, **palynomorphs**, **opaque phytoclasts**

These palynodebris occur at depth 4380ft.; they are characterized by high percentage of (75% of the total particulate matter) well-preserved and poorly preserved plant fragments (mainly cuticular phytoclast and brown debris). It also contains opaque phytoclast (25% total particulate organic matter). Palynomorphs contribute 5% of total organic matter.

Palynofacies II: Amorphous organic matter and **palynomorphs**

These palynofacies occur at sample depths 4470 ft, 4560 ft, and 4740 ft and are characterized by high Amorphous Organic Matter (up to 50 % of the total particulate organic matter) composed mainly of yellow to brown amorphous organic matter and opaque phytoclasts (35 %). Palynomorphs are mostly pollen and spores (10 %). It also contains some little amount of well- and poorly- preserved phytoclasts (up to 5 %).

Palynofacies III: **Amorphous organic matter** and some **phytoclasts**

These palynofacies occur at sample depths 4830 ft, 5820 ft. It is characterized by high amount of amorphous organic matter (of up to 70 % total particulate organic matter), 18 % opaque debris and 7 % palynomorph.

Palynofacies IV: Opaque phytoclasts with few **palynomorphs**

These palynofacies occur at depths 4110 ft, 5460 ft, 5640 ft, 5730 ft, 5820 ft. This palynofacies contains high amount of opaque debris (of about 65 %) of total organic matter, 20 % of palynomorphs and 10% amorphous organic matter.

Palynofacies V: **Palynomorphs** with **Amorphous organic matter**

These palynofacies occur at depth 4740 ft, 5820 ft, 10830 ft, 11400 ft. This palynofacies has predominance of palynomorphs (65 % fungal spores) of total organic matter, 28 % Amorphous organic matter and lesser amount of phytoclasts (7 % of total organic matter).

DISCUSSION

Depositional Environment

Palynofacies I is reflective of continental shelf sediments characterized by phytoclasts, mostly well–preserved and poorly-preserved woody debris, cuticles and tracheids and a few phytoclasts that are infested. The low amounts of opaques suggest low salinity due to close proximity to active fluvio-deltaic sources. The presence of infested, poorly-preserved phytoclasts and black debris is an indication of decomposition in a warm well-oxygenated climatic condition within the depths at which this palynofacie type occur.

Palynofacies II is characterized by amorphous organic matter comprising resins, structured and non–structured amorphous organic matter deposited in low–energy environments. The high amount of AOM is as a result of a good preservation rate. The preservation of the amorphous organic matter is indicative of a dysoxic – anoxic condition within the sample depths (Tyson, 1993).

Palynofacies III comprised both amorphous organic matter and phytoclasts, with high amounts of AOM and few opaque phytoclasts (black debris), and palynomorphs. In oxygen deficient environments with high amounts of AOM preservation, allochthonous terrestrial material is dominant in the immediate vicinity of fluvio-deltaic sources or turbidites (Omoboriowo and Soronnadi-Ononiwu, 2011; Nwachukwu and Chukwura, 1985).

Palynofacies IV: These palynofacies have predominance of opaque phytoclasts (black debris) with a few spores and pollen grains. The high amount of the opaque debris indicates oxidizing condition and either proximity to terrestrial sources or redeposition of organic matter from fluvio-deltaic environment of deposition. The opaque phytoclasts are gotten from the oxidation of woody materials either during prolonged transport or post – depositional alteration.

Palynofacies V: According to Traverse (1992), Oboh-Ikuenobe et. al. (2005), the presence of fungal spores appears to correlate with abundances of land plants debris and, therefore, with both modern and ancient swamp, fluvial-lacustrine, lagoonal, delta-top and near-shore marine facies. The indication is that these facies were deposited in a fluvio-deltaic/ nearshore (proximal shelf) where there is a high level of oxidizing conditions and low preservation rates.

The palynofacie retrieved showed total of 22 % palynomorphs, 31 % amorphous organic matter, and 47 % phytoclasts. This means that the facie has predominance of terrestrial materials deposited in marginal marine environment under terrestrial influence.

The depositional environment can also be predicted by the lack of dinoflagellates which suggests a predominance of terrestrially derived amorphous organic matter. However, the abundance of terrestrial organic matters in deltaic sediments has been documented (Barker, 1974).

Palynological Age

The age of the recovered palynormphs was determined based on their occurrence and general ditribution within the studied well with reference to Niger Delta Palynomorphs atlas produced by Shell company. The palynomorphs within the studied interval include; *Striatotricolporites sp., Psilatricoporites sp., Monoporites annulatus, Perchydermites diederexi, Fusformisporites pseudorabbi, Laevigatosporites sp, Leiotriletes sp, Proxaperities operculatus, Zonocastic romanae, Arecipites exillmuratus, Ephedripites sp, Tricolpites sp, Echiperipoites sp, Numupollis neogenicus.*

Table 2: Palynomorphs/ Age of Evolution and Real Age (modified from Shell palynomorphs atlas)

Recovered Palynomorphs	**Age of Evolution**	**Age of Palynomorph**
Zonocastic ramonae	Oligocene-recent	Mid Miocene
Stritricolporites sp.	Late Oligocene-mid Miocene	Miocene
Psilatricolporites sp.	Late Oligocene to early Miocene	Early Miocene
Monoporites annulatus /perchydermites diederexi	Mid Miocene to recent	Miocene age
Arecipites exillimuratus. Echhiperiporotes sp. Laevigatosporites sp./Leiotriletes sp.	Tertiary specie	Early Miocene
Proxaporites operculatus, Auriculopollenites sp. Retimonocolporites sp.	Late Eocene to early Oligocene	Late Eocene Early Eocene Early Oligocene

Monoporites annulatus and Perchydermites diederixi which occurred in abundance evolved during the Middle Eocene to recent but commonly occur during the Miocene age.Striatricolpites sp. is a late Oligocene to middle Miocene specie but commonly occur in the Miocene assemblage while Psilatricolporites sp. is of Late Oligocene to Early Miocene age but frequently occur in the Early Miocene assemblage. Laevigatosporites sp. and Leiotriletes sp. are of the Miocene age (Oboh, 1992).

Zonocostites ramonae is a mangrove sp. which evolved in Nigeria in the Oligocene age till recent but frequently occurred in the Mid-Miocene assemblage. Echiperiporites sp. occurs commonly during the Miocene age. Laevigatosporites sp. and Leiotriletes sp. are Miocene species. Arecipites exillmurtus is an early-Miocene specie (Oboh-Ikuenobe et al, 2005).

Proxapertites operculatus, Retimonocolporites sp., and Auriculopollenites sp. which appeared very few throughout the well are of Late Eocene to early Oligocene ages but frequently occur during the Late Eocene, Oligocene and Early Eocene ages respectively and so cannot be used to determine the age of the studied samples.

Therefore, the samples within the studies interval based on ocuurence indicate Early to Late-Miocene age.

Fig. 2 shows diagnostic palynofacie and the depth at which they occur. Based on abundance, the palynomorphs found within the range of depth 3750 ft. to 11400 ft. were deposited during the Early Miocene to Late Miocene age.

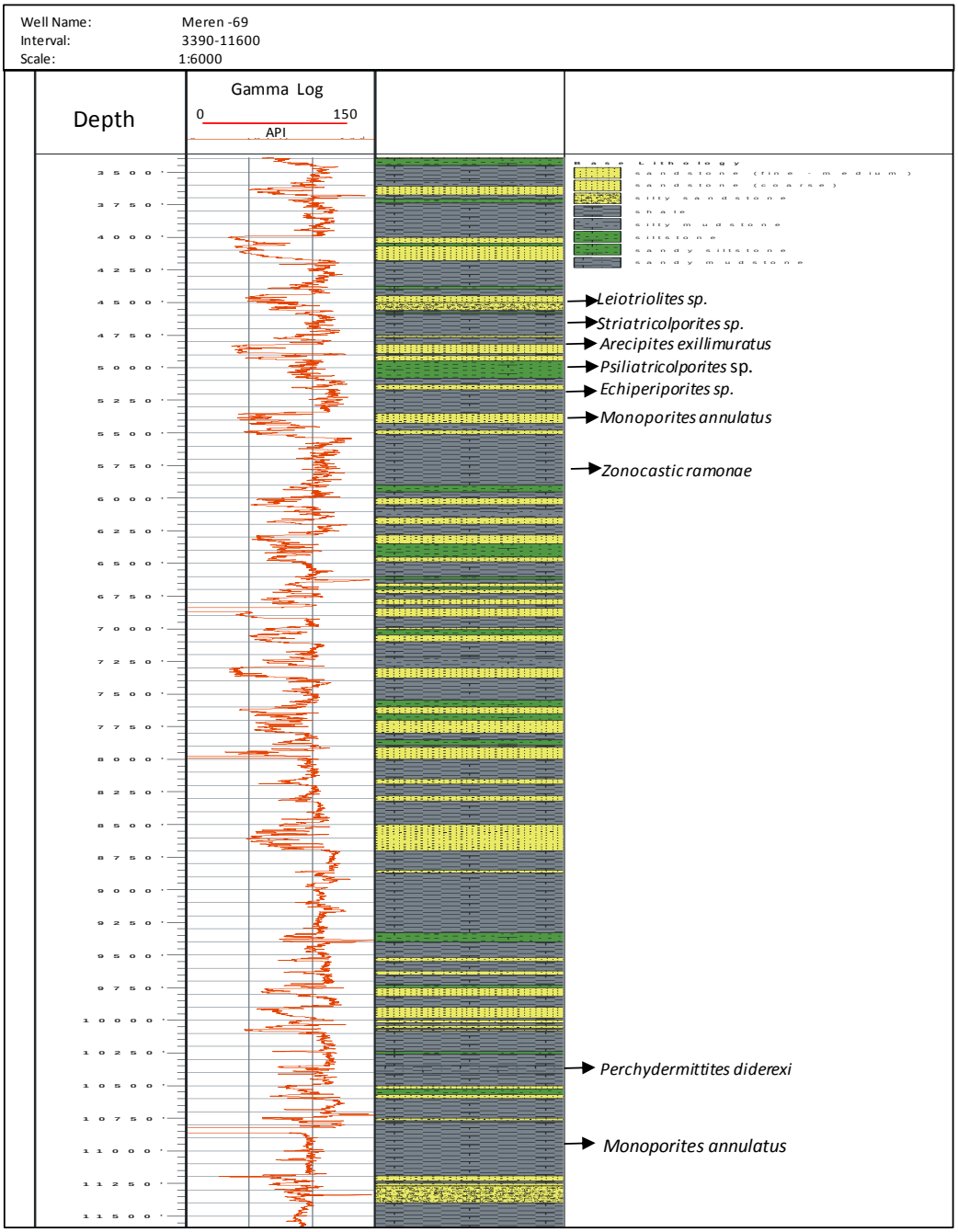


Fig. 2. Diagnostic palynofacie and the depth at which they occur

CONCLUSION

Five palynofacies were described; Palynofacies I depicts fluvio-deltaic and moderately distal oxic environment, Palynofacies II: nearshoredysoxic-anoxic environment, Palynofacies III: marginal marine under a proximal dyoxi-suboxic environment, Palynofacies IV: non-marine or nearshore environment under oxic conditions, and Palynofacies V: fluvio-deltaic/nearshore (proximal shelf) under oxiccondition .

The study has revealed a palynological assemblage dominated by structured cells, amorphous organic matter and pollen/spores consists of well preserved and diverse taxa, most of which are characteristic of dense lowland vegetation.

The sediments were deposited during the Early Miocene to Late-Miocene age based on the occurrence of *Zonocostites ramonae, Monoporites annulatus, Striatricolporites sp., Perchydermites diderexi, Psilatricolporites sp., Leiotriletes sp., Laevigastoporites sp, Ephedripites sp, Tricolpites sp, Fusformisporites pseudorabbi, Echiperipoites sp.*

The sediments were deposited in a marginal marine environment under terrestrial influence. This is supported by the absence of dinoflagellates which suggests a predominance of terrestrially derived organic matter.

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