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Palynostratigraphic Evaluation of Depositional Environment in Well E001 Niger Delta

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Abstract

Palynological investigation was carried out on E001 well to interpret the lithofacies and biostratigraphy with the aim of establishing the palynological zones and the consequent age, environment of deposition and paleoclimatic conditions of the rock sediments in the well, using visual microscopic observations to determine their lithological character and palynologic content of the sedimentary succession. E001 well is located on latitude 4° 31′ 16.58″N and longitude 8° 18′ 24.96″E onshore Niger Delta. The analysis of this study was carried out on 50 ditch cutting samples composite at 60ft interval ranging from a depth of 3480 to 6420ft. From the well logs, three lithofacies were delineated and stratified from shale to sandstone. The shale is fissile and dark brown, followed by the siltstone which are poorly sorted, and the sandstones are poorly to well sorted, rounded to well-rounded and fine to coarse grained, the presence of this lithofacies unit indicates that the well section penetrated the Agbada Formation. The Palynologic content recovered were fairly diverse as six (6) zones were erected from base to top which are *Acrostichum aureum (*Zone I*), Zonocostites ramonae (*Zone II*), Pachydermites diederixi (*Zone III*), Granulatisporites spp. (*Zone IV*), Verrucatosporites alienus (*Zone V*), and Psilatricolporites crassus* (Zone VI). These Miospore zones was compared with P820 palynological zones of Evamy et al. 1978 to assign a late Miocene age for the sediments. The paleoenvironmental conditions fluctuates between mangrove setting to freshwater conditions, based on the presence of continental-derived miospores such as *Zonocostites ramonae, Psilatricolporites crassus, Acrostichum aureum, Retibrevitricolporites obodoensis, Pachydermites diedirixi, ctenolophonidities costatus.* Analysis of the paleoclimatic conditions show that 60% of the total miospores are freshwater, 30% are mangrove, 1% Brackish water and 5% Marine environment. The Palynomorph Marine Index (PMI) also validates the depositional environment which transits from brackish water environment at the upper unit of the well to Fresh water and mangrove environment from the middle to the lower part of the well.

Keywords: Palynology; Biostratigraphy; Agbada Formation; Paleoenvironment; Age; Late Miocene

1. Introduction

Shell-BP discovered petroleum in the Niger Delta in 1956 at Oloibiri. As a result, the Niger Delta Basin has become extremely important economically due to its petroleum resources, which have allowed the region to transit from an agro-based to an oil-dependent economy. Today, it is estimated that oil and gas sales account for around 85 percent of the country's foreign exchange profits.

As exploration progressed, it became more difficult to discover petroleum, necessitating the use of a variety of technologies and processes, including petrophysical methods. In his research, (Reijers T.J.A, 2011) stated that significant efforts have been made in the exploration of petroleum since the discovery of oil inside the basin. Over 5000 wells have been sunk and developed as a result. The development of biostratigraphy and palynology has been a relief, making exploration easier than it was previously.

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Biostratigraphy is the study of layered rock using their fossil content (Bryce and Levin 2020). It is also the differentiation of rock facies due to their fossil content. Biostratigraphy is a branch of stratigraphy that uses fossils to determine the age of rocks (relative dating) and to correlate rocks in succession within and between basins. Palynology is the study of living and fossil plant pollen, spores, and certain microscopic plankton organisms (together known as palynomorphs). Palynology, to put it another way, is the study of palynomorphs, mostly spores and pollen grains. Also, Palynology is the branch of science that studies pollen, spores, and other palynomorphs, both living and fossilized. Pollen and spores are used in a variety of ways, including in the oil business during exploration. Williams and Hyde coined the term Palynology in 1944. Palynomorphs are microscopic plant and animal structures made of sporopollenin, chitin, and/or related compounds that are highly resistant to most forms of decay except oxidation. Palynomorphs are abundant in most sediments and sedimentary rocks, and they are resistant to common pollen extraction methods such as strong acids, bases, acetolysis, and density separation. The majority of palynomorphs range in size from 5 to 500μm. Other microfossils are classified as palynomorphs in a broader sense, despite the fact that they do not survive routine pollen-extraction procedures

2. Literature Review and Palynological Review in Nigeria

A lot of the geologic studies on both regional and global scale have been consulted on the course of this study.

Shell D'Arcy (now Shell Petroleum Company of Nigeria) carried out geological exploration in search of oil in southern Nigeria from 1938-1957. In 1957, they found oil in the Niger Delta at Oloibiri. Reyment (1965) discussed the aspects of geology of Nigeria. He studied the stratigraphy and tectonic setting of the Cretaceous and Cenozoic sediments in Nigeria and gave a detailed paleontological account of both mega and microfossils such as Foraminifera, Ostracods, Gastropods, Pelecepods, Pollen and Spores. He used them to characterize the age and environment of deposition of sediments. He also gave some illustrations (photomicrographs) of some of these forms recovered from these sediments and contributed much to nomenclature.

According to (Asadu and Onifade 2020), the Akata, Agbada, and Benin Formations are three major lithostratigraphy units in the Niger Delta that reflect a complex mixture of fluvio-marine, marine, deltaic plain and littoral environments. The distinguishing factor in this basin is the ratio of sand to shale. The ratio of sand to shale distinguishes these formations from one another.

According to (Asadu and Odumoso 2020), 43 pollen, seven (7) spores, and one dinoflagellate cyst were recovered, and four subzones were established based on the palynofloral assemblage of marker species. The zones from the first downhole to the last downhole are as follows: Racemonocolpiteshians, Stereisporites sp., Retibrevitricolporites obodoensis and Verrutricolporites rotundiporus zones. The age of these palynomorphs indicated late Miocene to middle Miocene.

According to (Asadu A.N. and Oghotuoma O.B, 2023) who worked on Ben 98 offshore Niger Delta, the palynomorphs recovered were very abundant and fairly diverse especially within the upper part (5,200-7,120ft.) of the analyzed interval. However, a drop in miospore proportion characterized the lower part (7,120-8,710ft.) of the Well. The palynomorphs recorded were dominated by land derived lowland pollens such as Psilatricolporites crassus and Psilastephanocolporites sapotaceae and other important palynomorphs such as, Retibrevitricolporites obodoensis/protrudens, Retibrevitricolporites ibadanensis, Striatricolpites catatumbus, Pachydermites diederixi, Polypodiaceoisporites sp and Retitricolporites irregularis.

3. Geology of the Niger Delta

(Obaje, 2009) postulated that the Tertiary Niger Delta is located or found at the intersection of the South Atlantic Ocean and the Benue Trough, where a triple junction formed during the late Jurassic separation of South American and African plate which was earlier stated by (Whiteman, 1982). The Niger Delta Basin is surrounded by so many basins formed from the same processes. (Michele, L.W., Ronald R.C., and Michael E.B., 1999) stated that the Niger delta basin is one of the largest subaerial basins in the African continent. The Niger Delta Basin attains an area of about 8000 square kilometers and comprises of regressive clastic succession with a maximum thickness depth of about 12 kilometers (Orife, J.M and Avbovbo, A.A, 1982). The Niger Delta basin is known to be one of the best productive hydrocarbon provinces in the world (Corredor, F., Shaw, J.H., and Bilotti, F., 2005).

The petroleum system found in the Niger delta basin is the Tertiary Akata-Agbada petroleum system. The Niger Delta Basin is comprised of three Formations which are: the older Basal Akata Formation which overlies the precambrian basement complex, the Agbada Formation and the younger Benin Formation. The Akata Formation is comprised mainly of Marine shales and turbidites sands in deeper marine. İt is Paleocene in age. İt is about 5000 meter thick. The Agbada Formation is comprised of an intercalation of shale and sand. İt is both heterolithic and paralic in nature. İt is Eocene in age. İt is 3000 meter thick. The Benin Formation comprises of continental and alluvial flood plain sand. İt is the fresh water bearing layer in the basin. İt is Oligocene in age. İt is about 2000 meter thick.

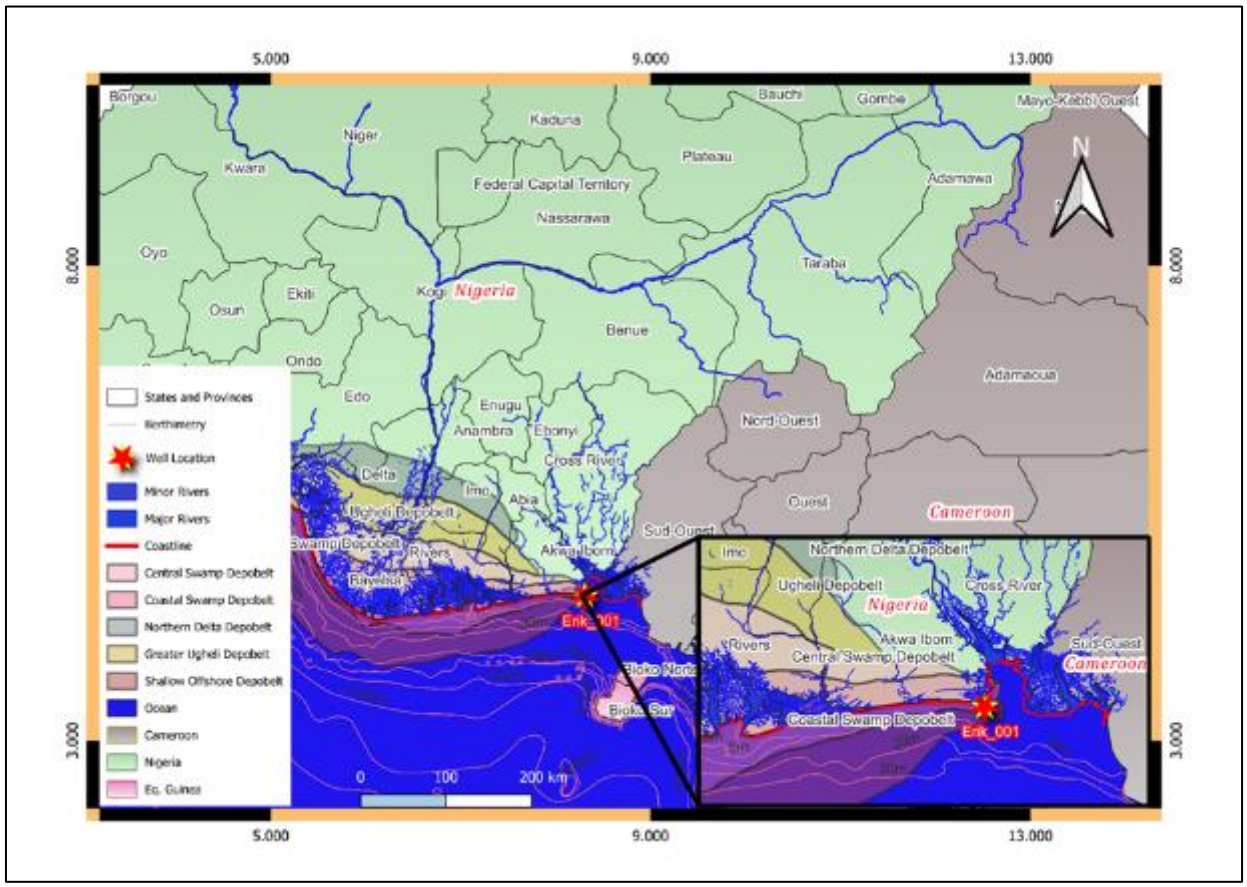


Figure 1 The Map of the Study Area (Well E001)

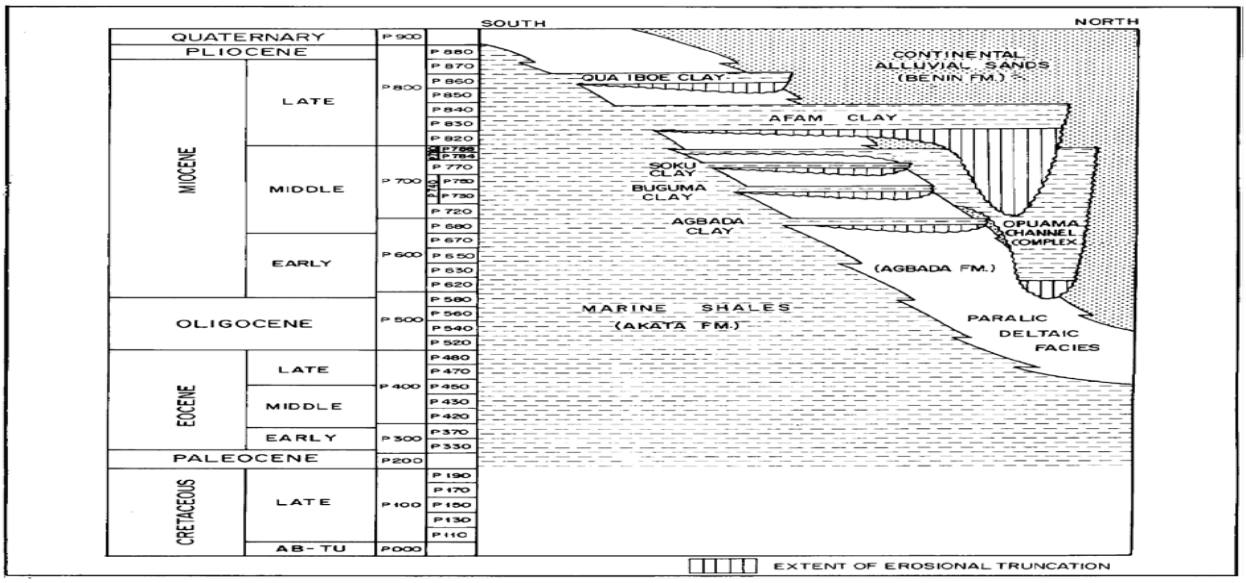


Figure 2 Depicting the Niger Delta Regional Stratigraphy (Lawrence, S. R., Munday, S., and Bray, R., 2002)

4. Methodology

The result of Palynological analysis carried out on fifty (50) ditch cutting samples from Well E 001 (intervals 3480 – 7720ft) is presented in this report. The samples were processed for their palynomorph content and analyzed. These samples were subjected to standard palynological processing procedures Ditch cutting samples was composited at 60ft from one well (E 001 well) and underwent standard palynological sample preparation method involving intense acid treatments. The procedures are as follows:

- Weighing and labelling of samples
- Heat the samples in the beaker for about 5 minutes
- Add distilled water to the samples in the beaker
- Soak with soap and allow to stay over night
- Decant the sample add distilled water, thereafter decant again
- Transfer to the centrifuge and spin for about 5 minutes at 200rpm
- Decant from the centrifuge and add your heavy liquid (a mixture of zinc bromide and HCl)
- Transfer to the centrifuge and spin for about 5 minutes at 200 rpm
- Pipette the liquid containing the palynomorph at the top of the centrifuge and transfer to a 5micron sieve and wash. Then transfer the washed samples to EDTA bottles
- Pipette from EDTA bottles to the cover slip and place on hot plate for about 5 minutes
- Mount the glass slides on cover slip using optimal glue (Norland optical glue)
- Place under sunlight for about 7 minutes then the slides are ready for microscopic examination under the binocular light transmitted microscope

Also, the Environment of deposition were deciphered using combination of results from the abundance plots of ecological groups of palynomorphs, lithostratigraphy and results of lithofacies which unveils the lithofacies boundary of adjacent facies units.

5. Results and Discussion

The sedimentology of the well described with the incorporation of gamma ray logs indicates the Well E 001 penetrated the Agbada Formation throughout the entire depth ranging from 3480ft to 6840ft. There is an intercalation of sand and shale throughout the well. The uppermost part of the well from 3500ft to 4050ft is majorly fissile shale which then translate to medium to fine grained sand from 4050ft to 4350ft. This particular layer indicates a boxcar shaped signature as deduced from the gamma ray log response. The middle part of the well is characterized by shale with very little interaction of shale from a depth of 4350ft to 5200ft. A bell-shaped gamma ray response is implied at this interval. Then finally from this layer at 5200ft to 68400ft the well protrudes into majorly shale which is indicative of a bell-shaped

gamma ray log response. The gamma ray signature of Boxcar to bell-shaped gamma ray response is indicative of coarsening upward sequence which is a common feature of the Agbada Formation.

6. Palynofloral Zonation/Age

The result of Palynological analysis carried out on fifty (50) ditch cutting samples from Well E001 (intervals 3480 – 7720ft) is presented in this report. The data gotten from this report was used to infer the environment of deposition and age characterization of well. The analyzed section of the well (3480 – 6420ft) penetrated P800; P820 palynological zone (Evamy et al. 1978) of Late Miocene age. Palynomorph preservation was relatively fair while the recovery was moderately rich. E 001 well is subdivided into six (6) zones from a depth interval of 3480ft to 6420ft which are Psilatricolporites crassus zone at the base of the well (6420ft), Granulatisporites spp., zone, Verrucatosporites alienus zone, Psilatricolporites crassus zone, Acrostichum aureum zone, Zonocostites ramonae zone and finally Pachydermites diederixi zone at the top of the well (3480ft).

7. Definition of Zones

7.1. Zones 1 Granulatisporites spp. Zone Late Miocene

The palynological event that defines this zone are the last downhole occurrence of Psilatricolporites crassus, LDO Zonocostites ramonae, LDO Retitricolporites irregularis, LDO Smooth monolete spores, LDO smooth trilete spores, LDO Laevigatosporites harditii, LDO Echitrilete spp., LDO Callimothalus pertusus, LDO Botryococcus braunii and LDO Alternaria spp. at a top of 6000ft. The Granulatisporites spp. Zone has a First downhole occurrence of Stereisporites spp. FDO Podocarpites spp., FDO Ipomaea digitate and FDO Echiperiporites estelae. The Granulatisporites spp., zone has a base depth of 6420ft which is the terminal depth. The analysed section of the well penetrated P800; P820 palynological zone (Evamy et al. 1978) of Late Miocene age.

7.2. Zone 2 Verrucatosporites alienus Zone Late Miocene

The base is defined by the top of Zone 1 while the top is at 5550ft. The palynological event that defines this zone are the occurrence of Echiperiporites estelae, Echistephanocolpites echinatus, Acrostichum aureum, Pachydermites diederixi, Zonocostites ramonae, Psilatricolporites crassus, Granulatisporites spp., Verrucatosporites farvus, Fungal hyphae, Fungal spore, Dinocysts indeterminate, (Peridinoid) and Concentricystes circulus. The Verrucatosporites alienus zone has a base depth of 6000ft. The analyzed section of the well penetrated P800; P820 palynological zone (Evamy et al. 1978) of Late Miocene age.

7.3. Zone 3 Psilatricolporites crassus Zone Late Miocene

The base is defined by the top of Zone 2 while the top is at 5000ft. The palynological event that defines this zone are the occurrence of Granulatisporites spp., Verrucatosporites alienus, Zonocostites ramonae, Verrucatosporites farvus, Pachydermites diederixi, Smooth trilete spores, Smooth monolete spores, Fungal spore Fungal hyphae, Aletesporites and Callimothalus pertusus. The Psilatricolporites crassus zone has a base depth of 5550ft. The analysed section of the well penetrated P800; P820 palynological zone (Evamy et al. 1978) of Late Miocene age.

7.4. Zone 4 Acrostichum aureum. Zone Late Miocene

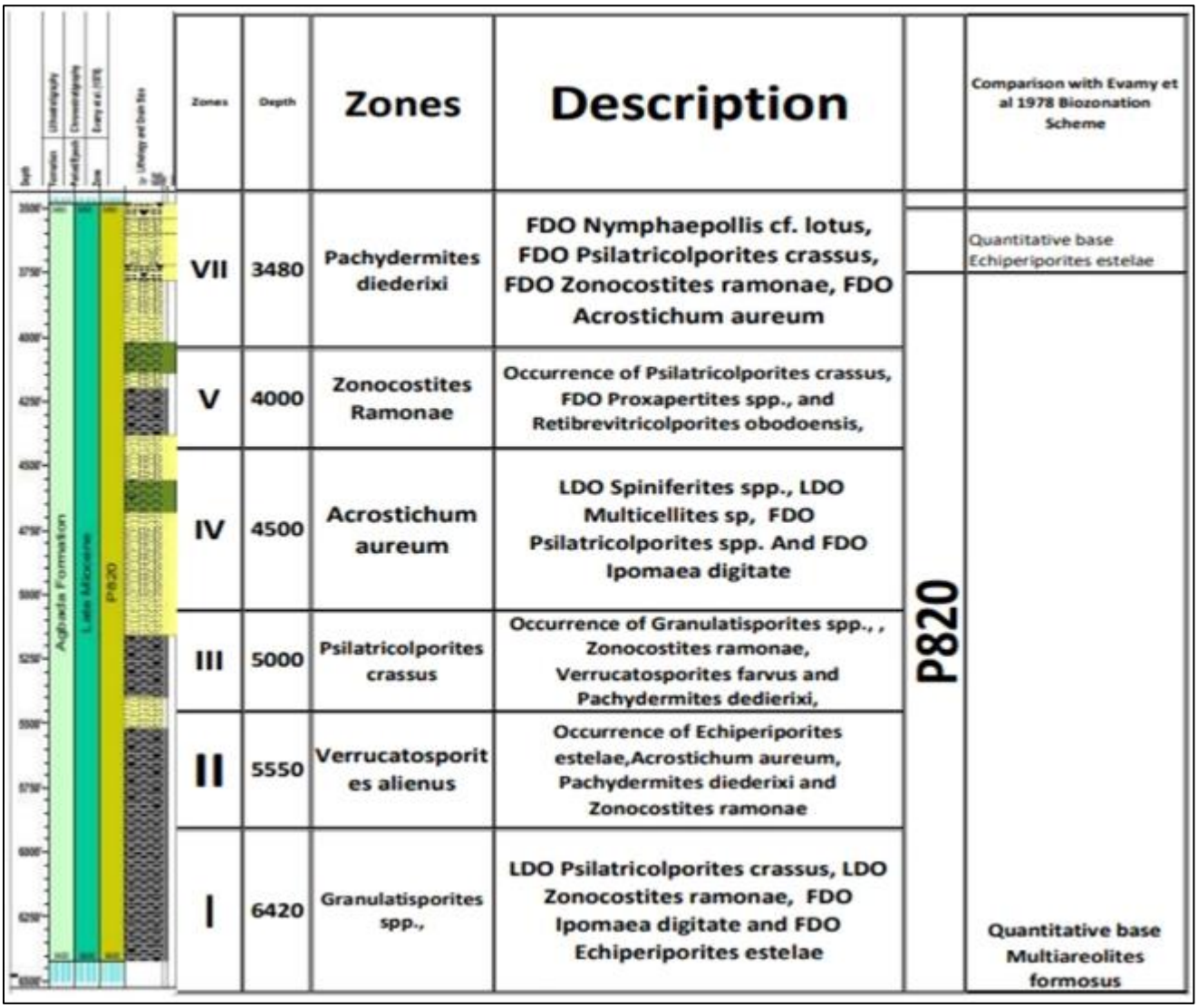
The base is defined by the top of Zone 3 while the top is at 4500ft. The palynological event that defines this zone are the last downhole occurrence of Concentricystes circulus, LDO Spiniferites spp., LDO Pluricellaesporites sp., LDO Multicellites spp., and LDO Fungal hyphae. There is also a palynological occurrence of FDO Psilatricolporites spp., and FDO Ipomaea digitate. The Acrostichum aureum zone has a base depth of 5000ft. The analyzed section of the well penetrated P800; P820 palynological zone (Evamy et al. 1978) of Late Miocene age.

7.5. Zone 5 Zonocostites ramonae Zone Late Miocene

The base is defined by the top of zone 4 while the top is at 4000ft. The palynological event that defines this zone are the occurrence of Psilatricolporites crassus, Peregrinipollis nigericus, FDO Echistephanocolpites echinatus, FDO Gemmamonoporites spp., FDO Proxapertites spp., Retibrevitricolporites obodoensis, Retitriporites heterobrochatii, Retistephanocolporites perforates, FDO Psilatricolporites spp., FDO Psilamonocolpites sp., Psilastephanocolporites laevigatus and Pachydermites diederixi. The Zonocostites ramonae zone has a base depth of 4500ft. The analyzed section of the well penetrated P800; P820 palynological zone (Evamy et al. 1978) of Late Miocene age.

7.6. Zone 6 Pachydermites diederixi Zone Late Miocene:

The base is defined by the top of zone 5 while the top is at 3480ft. The palynological event that defines this zone are the First downhole occurrence of Nymphaepollis cf. lotus, FDO Verrucatosporites microporus, FDO Psilatricolporites crassus, FDO Zonocostites ramonae, FDO Acrostichum aureum, FDO Psilastephanocolporites sp., FDO Echistephanocolporites spp. FDO Perfotricolpoites digitatus, FDO Verrucatosporites tenellis, FDO Acrostichum aureum, FDO Laevigatosporites harditii, FDO Pediastrum spp., and FDO Leiosphaerida spp. The Pachydermites diederixi zone has a base depth of 3480ft. The analyzed section of the well penetrated P800; P820 palynological zone (Evamy et al. 1978) of Late Miocene age.



Zones	Depth	Zones	Description		Comparison with Evamy et al 1978 Biozonation Scheme
VII	3480	Pachydermites diederixi	FDO Nymphaepollis cf. lotus, FDO Psilatricolporites crassus, FDO Zonocostites ramonae, FDO Acrostichum aureum		Quantitative base Echiperiporites estelae
V	4000	Zonocostites Ramonae	Occurrence of Psilatricolporites crassus, FDO Proxapertites spp., and Retibrevitricolporites obodoensis,		
IV	4500	Acrostichum aureum	LDO Spiniferites spp., LDO Multicellites sp, FDO Psilatricolporites spp. And FDO Ipomaea digitate	P820	
III	5000	Psilatricolporites crassus	Occurrence of Granulatisporites spp., , Zonocostites ramonae, Verrucatosporites farvus and Pachydermites dedierixi,		
II	5550	Verrucatosporites alienus	Occurrence of Echiperiporites estelae,Acrostichum aureum, Pachydermites diederixi and Zonocostites ramonae		
I	6420	Granulatisporites spp.,	LDO Psilatricolporites crassus, LDO Zonocostites ramonae, FDO Ipomaea digitate and FDO Echiperiporites estelae		Quantitative base Multiareolites formosus

Figure 3 Biozonation of Well E001 in comparism with Evamy et al scheme 1978

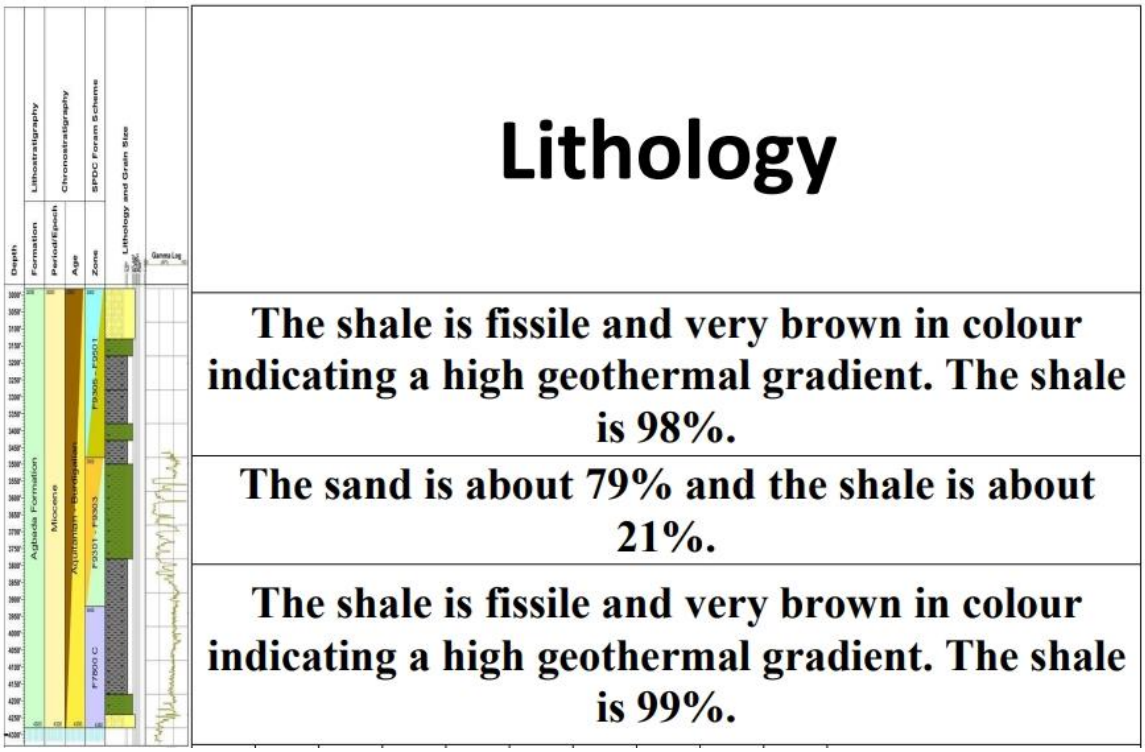


Figure 4 Lithologic description of Well E 001

8. Age Characterization

The result of Palynological analysis carried out on fifty (50) ditch cutting samples from Erica well (intervals 3480 – 7720ft) is presented in this report. The samples were processed for their palynomorph content and analyzed. These samples were subjected to standard palynological processing procedures shown in appendix 1, while the analyses of the samples are shown in appendix 2. Palynomorph preservation was relatively fair while the recovery was moderately rich.

The analyzed section of the well (3480 – 6420ft) penetrated P800; P820 palynological zone (Evamy et al. 1978) of Late Miocene age. The age interpretation was attempted based on the palynofloral assemblage observed in the studied samples as well as identified index marker species.

Detailed Interpretation:

- Interval: 3480 – 6420ft
- P-zone: P820
- Age: Late Miocene

Bio-events:

- Single occurrence of Steriesporites sp. at 6300ft.
- Acme of Echiperiporites estelae towards the base

The top of this P820 subzone which is usually defined by the quantitative base occurrence of Stereisporites sp. was not encountered except for a single occurrence The P820 subzone is inferred using the single occurrence of Steriesporites sp. at 6300ft. which has its base in this subzone. The base of this zone, which is commonly defined by the quantitative base occurrence of Multiareolites formosus could not be delineated because this event was not encountered, hence it is considered to be below the TD (terminal depth).

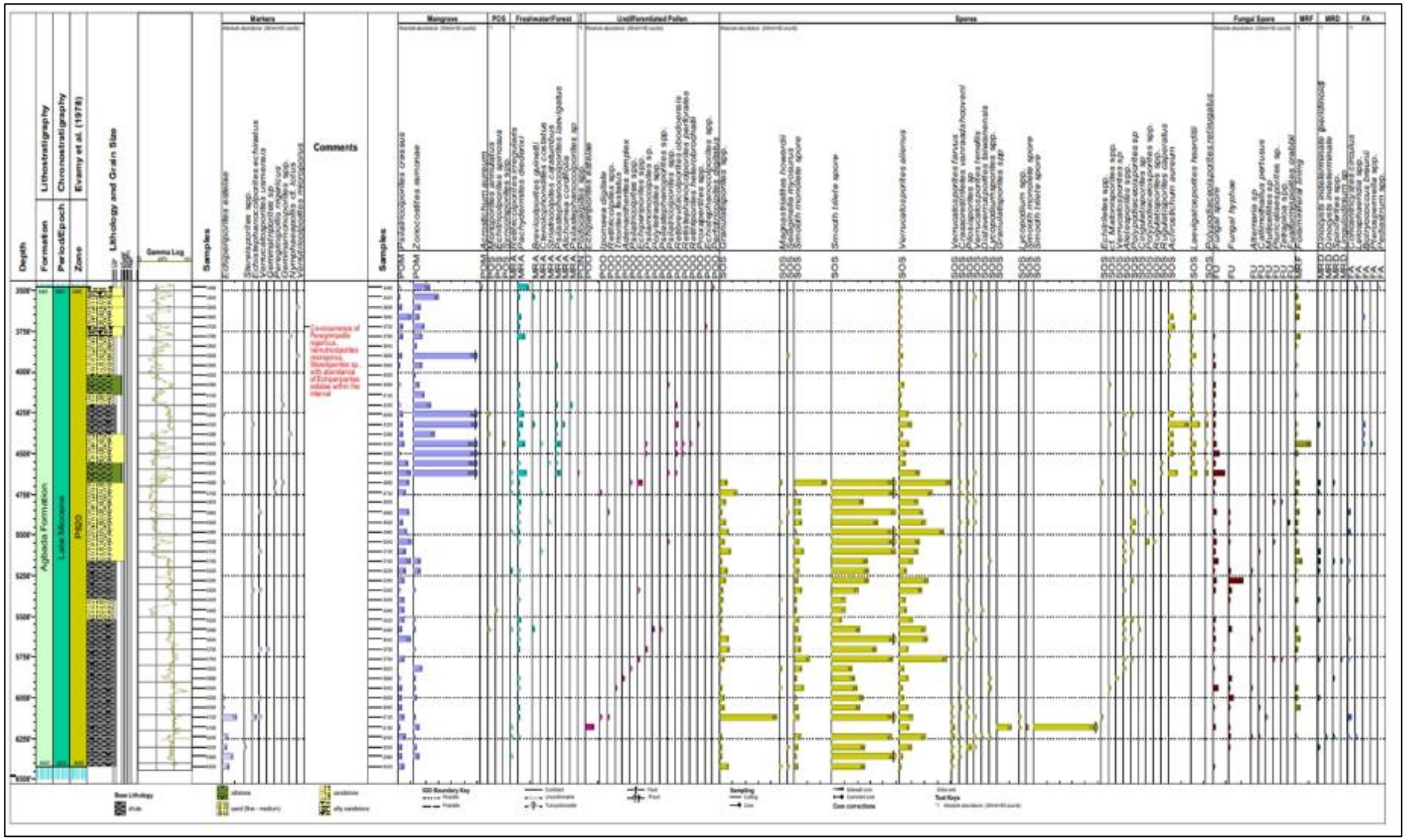


Figure 5 Palynomorph Distribution Chart

Supporting the penetration of this zone is the abundant occurrence of Echiperiporites estelae towards the base of this well section, rare presence of Nympheapollis clarus and Verrutricolporites microporus, abundant occurrence of Zonocostites ramonae at the upper section and Smooth trilete spore at the lower section, presence of Peregrinipollis nigericus moderately high to abundant occurrences of pteridophyte spores /fungi taxa from top to base, scanty occurrence of savanna elements (Monoporites annulatus), low occurrence of fresh water algae (Botryococcus brauni & Concentricystes circulus co-occurring with moderately low /high occurrence of marine indicator elements

9. Paleoenvironment

Integration of sedimentological, wireline log characters and palynological characteristics have enhanced the deductions of varying depositional environments over the analyzed interval (3480 – 6420ft) of Well E 001.

The entire well is characterized as a Continental environment comprised of Mangrove environment at the top of the well and Fresh water environment at the middle to lower part of the well. The upper section of the well is characterized by the Mangrove miospore Psilatricolporites crassus and Zonocostites ramonae which is about 30% in miospore abundance ranging from a depth of 3480 to 4620ft indicating a Mangrove environment at this depth interval of the well. Then the middle to the lower section of the well is characterized by Fresh water swamp miospores which are Magnastriatites howardii, Seleginella myosorus and Verrucatosporites which is about 25% in miospore abundance and a large occurrence of Smooth monolete spore and Smooth trilete spore in the middle to lower part of the well which is about 45%. This depth ranges from 4620 to 6480ft. It can be deduced from the data gotten from this well that there is a transition from Mangrove environment at the top of the well to Fresh water swamp and Terrestrial environment from the middle to the lower part of the well. The Marker species found in this well are Echiperiporites estelae, Fresh water swamp palynomorphs such as Stereisporites spp., Verrucatosporites usmesis, Gemmamonoporites sp., Nymphaeapollis cf. lotus. Also, other marker fossils found in the well are Savanna Peregrinipollis nigericus, Verrutricolporites microporus, Echistephanocolporites echinatus, the Algae Botrycoccus braunii, Fresh water algae Leiosphae spp., and Concentricysts circulus. From the gamma ray log of the entire well, the upper section depicts a Boxcar gamma ray signature which indicates a deltaic distributary channel environment at this section ranging from a depth of 3480 to 4620ft. While the middle to lower section (4620-6420ft) depicts a Bell-shaped gamma ray signature indicating a Fluvial distributary channel environment.

Table 1 The different Palynomorphs found in Well E 001 and the diagnostic environment they represent

S/N	Ecology	Genera	Species
1	Mangrove	Zonocstites	ramonae
		Psilatricolporites	crassus
2	Brackish swamp	Acrostichum	aureum
3	Freshwater swamp	Retibrevitricolporites	obodoensis
		Pachydermites	diedirixi
		Ctenolophonidites	costatus
4	Savannah	Peregrinipollis	nigericus
5	Freshwater algae	Botrycoccus	braunii
		Concentricystes	circulus
6	Marine	Dinocyst	inderterminate (Peridinoid)
		Lingulodinium	spp.,
		Spiniferites	spp.,

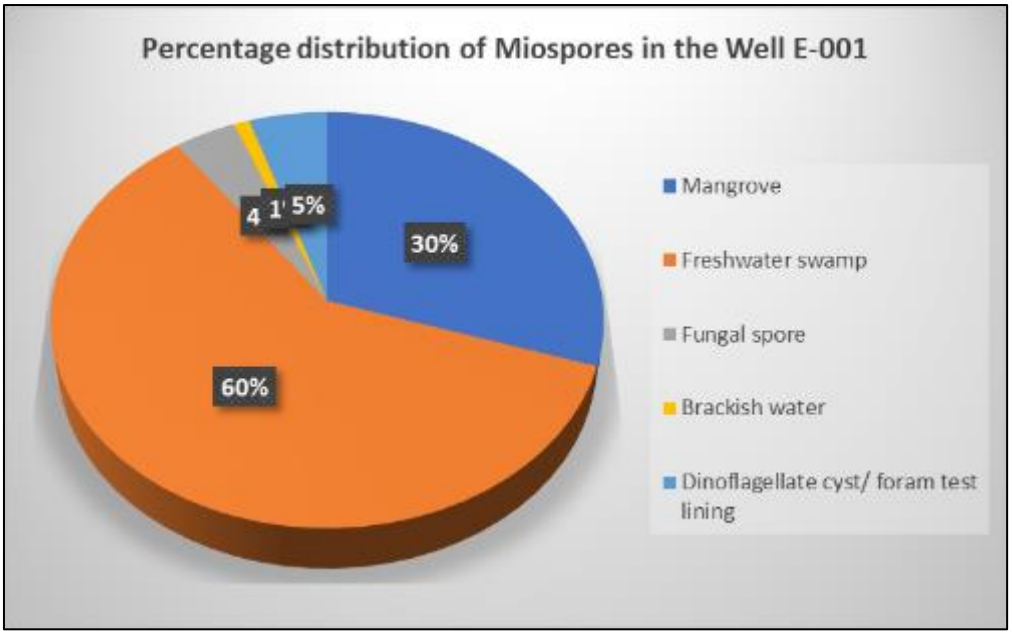


Figure 6 Percentage of Palynomorph distribution in the Well E 001 well.

10. Summary and Conclusion

The analysis of this study was carried out on 50 ditch cutting samples from Well E 001 (intervals 3480 – 7720ft) located onshore Niger Delta in the Southern part of Nigeria. The well is on latitude 4° 31′ 16.58″N and longitude 8° 18′ 24.96″E. The analyzed section of Well E- 001 (3480 – 6420ft) penetrated P800; P820 palynological zone (Evamy et al. 1978) of Late Miocene age. The sedimentology of the well described with the incorporation of gamma ray logs indicates the Erica 001 well penetrated the Agbada Formation throughout the entire depth ranging from 3480ft to 6840ft. There is an intercalation of sand and shale throughout the well. The uppermost part of the well from 3500ft to 4050ft is majorly fissile shale which then translate to medium to fine grained sand from 4050ft to 4350ft. This particular layer indicates a boxcar shaped signature as deduced from the gamma ray log response. The middle part of the well is characterized by shale with very little interaction of shale from a depth of 4350ft to 5200ft. A bell-shaped gamma ray response is implied at this interval. Then finally from this layer at 5200ft to 68400ft the well protrudes into majorly shale which is indicative of a bell-shaped gamma ray log response. In addition, several mineral accessories plagioclase feldspar, orthoclase and several authigenic minerals such as siderite and glauconite are found here. Carbonaceous detritus and rare ferruginous minerals were recorded in the well interval.

The samples were prepared using standard palynological procedures and analysed using an electron binocular transmitted light microscope and interpreted using the stratabug software for their age characterization, environment of deposition and paleoclimatic conditions. From the paleoenvironmental condition of the well it can be deduced that the well has a 60% Freshwater environment, 30% Mangrove environment, 1% Brackish water environment and 5% Marine environment. Erica 001 well is subdivided into six (6) zones from a depth interval of 3480ft to 6420ft which are Psilatricolporites crassus zone at the base of the well (6420ft), Verrucatosporites alienus zone, Granulatisporites spp., zone Pachydermites diederixi zone Zonocostites ramonae zone and finally Acrostichum aureum zone at the top of the well (3480ft). From the gamma ray log of the entire well, the upper section depicts a Boxcar gamma ray signature which indicates a deltaic distributary channel environment at this section ranging from a depth of 3480 to 4620ft. While the middle to lower section (4620-6420ft) depicts a Bell-shaped gamma ray signature indicating a Fluvial distributary channel environment. The paleoclimatic condition throughout Well E001 prognosticates a wet climate throughout the entire well due the presence of these diagnostic miospores which are Zonocostites ramonae, Pachydermites diederixi, Acrostichum aureum, Smooth Monolete spore, Smooth trilete spore and Verrucatosporites alienus

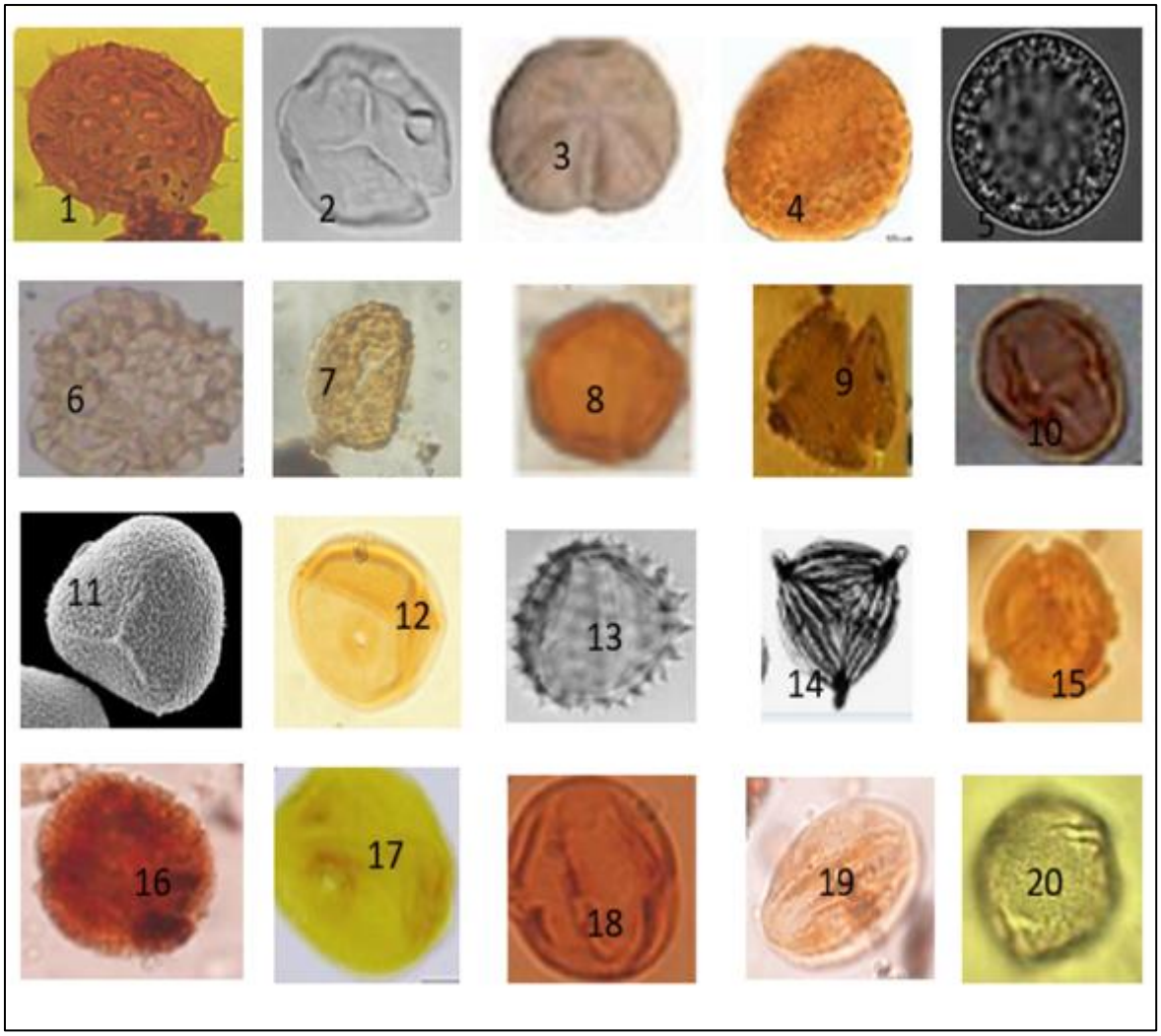


Figure 7 Miospores present in the Well E 001

Table 2 Miospores present in the Well E 001

1 Echiperiporites estelae	*8 Verrutricolporites microporus*	*15 Pachydermites diederixi*
2 Stereisporites spp.,	*9 Psilatricolporites crassus*	*16 Ctenolophonidites costatus*
3 Echistephanocolporites echinatus	*10 Zonocostites ramonae*	*17 Psilastephanocolporites laevigatus*
4 Verrucatosporites usmensis	*11 Acrostichum aureum*	*18 Striatricolpites catatumbus*
5Gemmatriporites sp.	*12 Echitricolporites spinosus*	*19 Monoporites annulatus*
6 Peregrinipollis nigericus	*13 Syncolsporites spp.,*	*20 Alchornea cordifolia*
7 Nymphaepollis cf. lotus	*14Retitricolporites irregularis*	

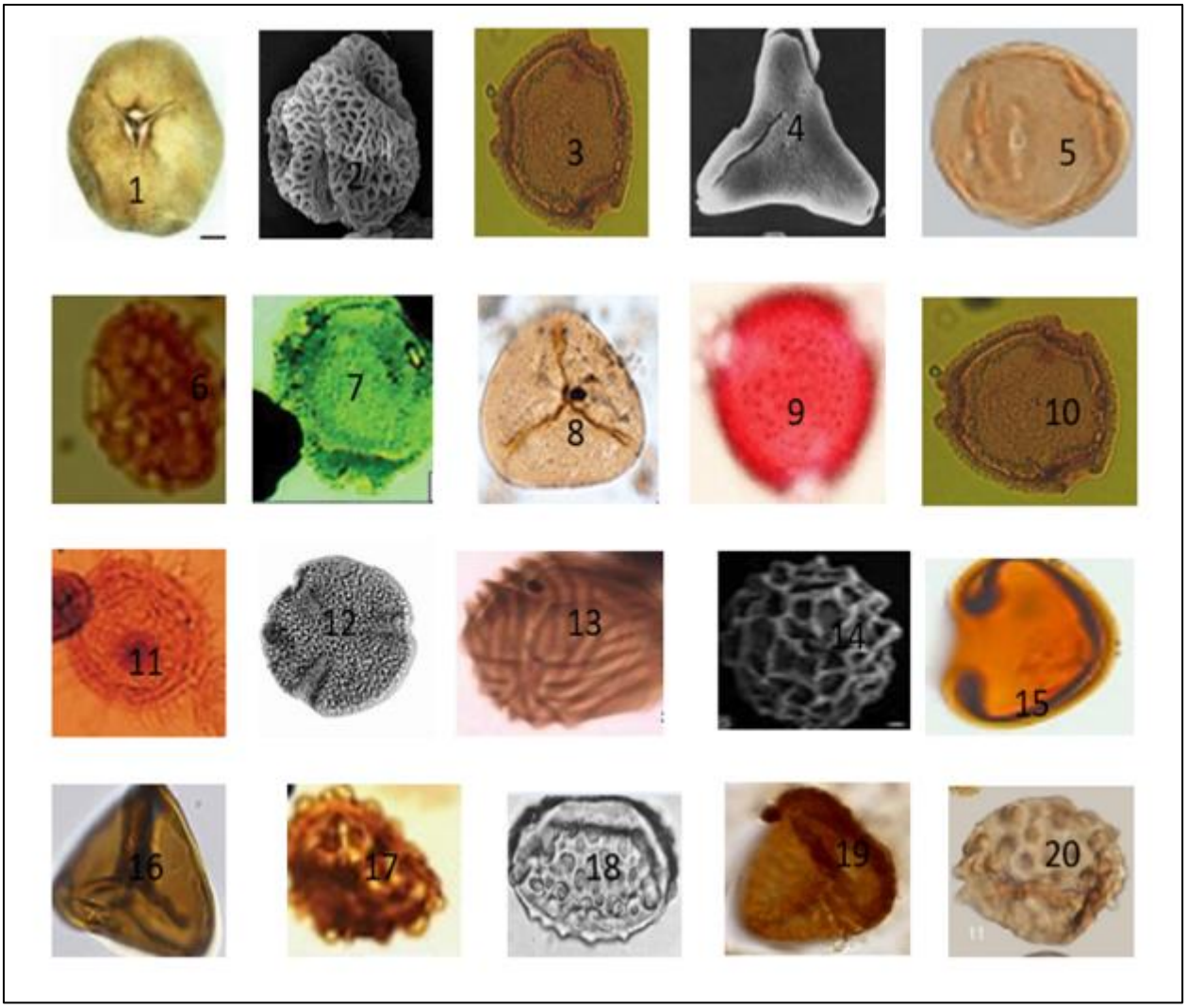


Figure 8 Miospores present in the Well E001

Table 3 Miospores present in the Well E001

1 Ipomaea digitate	*8 Granulatisporites spp.,*	*15 Smooth monolete spores*
2 Retitricolpites spp.,	*9 Proxapertites spp.,*	*16 Smooth trilete spores*
3 Triorites festatus	*10 Retitriporites heterobrochatii*	*17 Verrucatosporites alienus*
4 Adenantherites simplex	*11 Psilastephanocolporites perforates*	*18Verrucatosporites farvus*
5 Psilamonocolpites sp.	*12 Perfotricolporites digitatus*	*19 Crassoretitriletes vanraadshooveni*
6 Echiperiporites spp.	*13 Magnastriatites howardii*	*20 Verrucatosporites tenellis*
7 Retibrevitricolporites obodoensis	*14 Selaginella myosurus*	

11. Conclusion

This study evaluates the palyno-stratigraphy and depositional environment of Well E001 in the Niger Delta Basin, utilizing 50 ditch cutting samples collected at 60-foot intervals from depths of 3,480 to 6,420 feet. Palynological analysis identified six zones: Acrostichum aureum**,** Zonocostites ramonae**,** Pachydermites diederixi**,** Granulatisporites spp.**,** Verrucatosporites alienus**, and** Psilatricolporites **crassus**, which correspond to the P820 palynological zone of Evamy et al. (1978), assigning a Late Miocene age to the sediments. The lithological sequence revealed intercalated shales and sandstones consistent with the Agbada Formation, featuring distinct gamma ray log patterns indicative of deltaic to

fluvial environments. The paleoenvironment transitions from mangrove-dominated settings in the upper intervals to freshwater swamp conditions at deeper depths. This fluctuation aligns with miospore abundance data, with freshwater palynomorphs comprising 60%, mangrove 30%, brackish 1%, and marine 5%. These findings elucidate the depositional history and paleoclimatic conditions of Well E001, contributing to a refined understanding of Niger Delta stratigraphy and petroleum prospectively.

Compliance with ethical standards

Disclosure of conflict of interest

I declare that there is no conflict of interest.

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