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Research Article (Subject – Micropaleontology, Sequence stratigraphy)

Palynofacies and Sequence Stratigraphic Studies of ODPX-1 Well, Offshore Western Niger-Delta, Nigeria

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Abstract

This work presents the result of an investigation from ODPX-1 well to understand the palynology, biozonation and paleoenvironment. Biostratigraphic study has been carried out on twenty (20) cutting samples recovered from ODPX-1 Well in South-South region of Nigeria, Niger Delta Basin. Samples were taken at 60ft interval ranging from 4420ft to 5560ft depth. The lithology of the studied well sections are comprising of shales, silts, sandstone and shales, having very fine to coarse grained sandstone beds. A total of 1,313 palynomorphs and 2,015 kerogen were recognized from which some were labeled for microphotography. The diagnostic marker palynofossils like *Pachydermites diederixi, Crassoretitriletes Vanraadshooveni* and *Retibrevitricolporites obodoensis* were used for biozonation and dating of the analyzed sections of the wells. A Middle to Upper Miocene age was assigned to the studied section and the boundary sited at 5020ft; 4980ft. A key palynological zone established was P800 with subzones of P680, P720 and P850 and this zone is correlated with the broad Pan-tropical zone of *Echitricolporites spinosus*. Two palynofacies associations (P-1 and P-2) have been recognized and range from distal shelf to marginal basin to proximal shelf in total a shallow marine environment. A sequence characterization was also identified based on the maximum abundance and diversity of palynomorphs and kerogen assemblage from the sequence stratigraphic analyses of wells.

Keywords: Palynofacies, Palynomorphs, Sequence stratigraphy, Paleoenvironment, Miocene, Niger Delta.

Introduction

The study area falls within the Southern region of Nigeria and is located within the Shallow Offshore Depobelt of Well ODPX-1 of Longitude 6° 20' 30" E and Latitude 3° 53'18" N and Coastal Swamp Depobelt of Well ODPX-2 of Longitude 8° 18' 12"E and Latitude 4° 30'21" N on a scale of one centimetre to three thousand eight hundred metres (1cm – 3800 m) part of Offshore Western Niger Delta Basin that falls within the Tertiary Agbada Formation of the Anambra Basin of Niger Delta, Nigeria.

The basin is located between Latitudes 3° and 6°N and Longitudes 5° and 8°E (Reijers et al., 1997). The

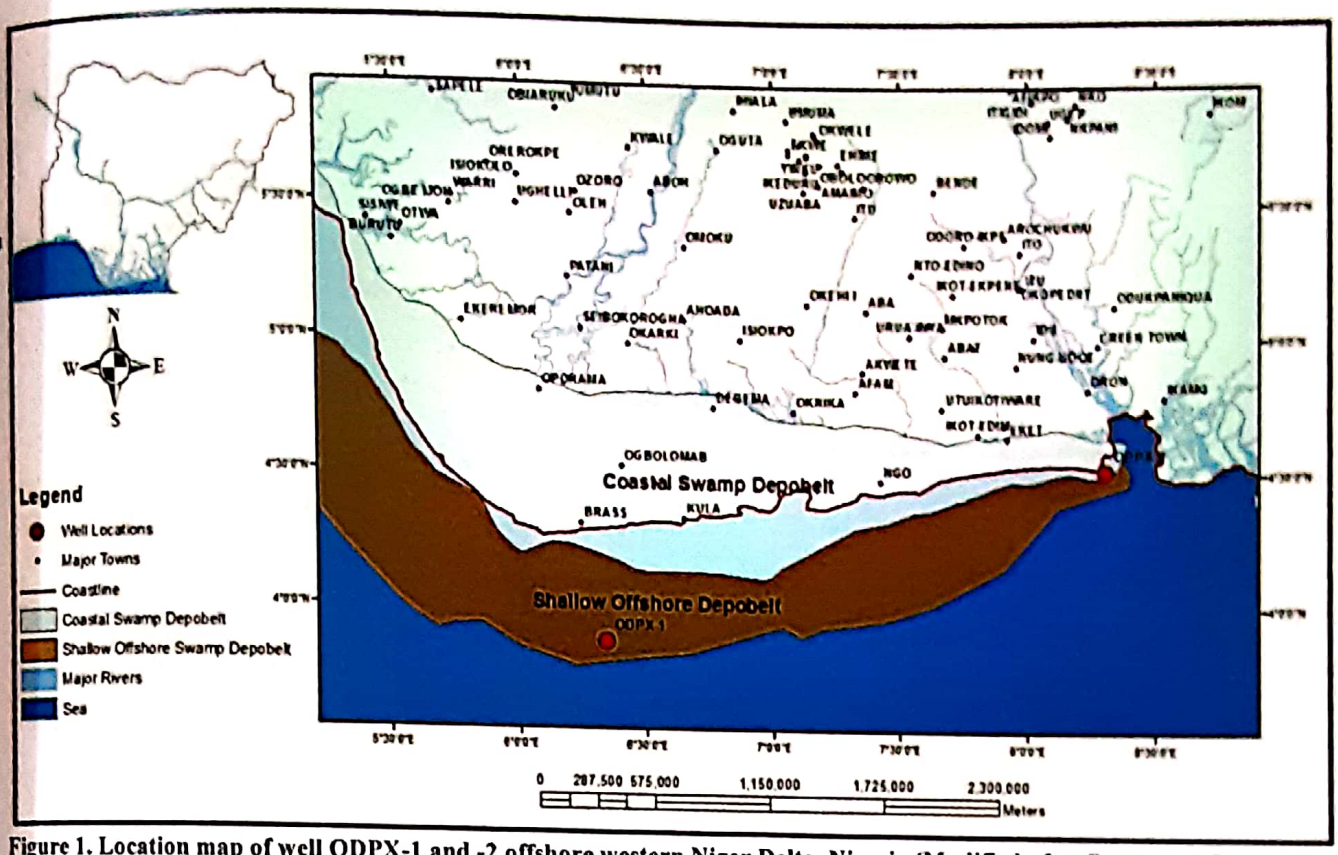

Figure 1. Location map of well ODPX-1 and -2 offshore western Niger Delta, Nigeria (Modified after Doust and Omatsola, 1990).

south-eastern boundary of the Niger Delta is delineated by the Calabar flank with the Abakaliki anticlinorium (Abakaliki Foldbelt) defining the north-eastern limit. The Tertiary Niger Delta covers an area of approximately 140,000 km2, with cumulative sedimentary sequence of about 12,000m Knox and Omatsola, (1989). The sequences of the Niger Delta have been subdivided into three major sedimentary units, namely the Akata, Agbada and the Benin Formations. The oldest of these three formations is the Paleocene to Recent Akata Formation. Reijers et al., (1997), characterised by continuous uniform shale deposited down in a marine environment. On top of the marine sequence is the Eocene to Recent Agbada Formation. The paralic Agbada Formation constitutes the actual deltaic portion of the sequence. It is considered to have been accumulated in deltaic front, delta-topset and fluvio-deltaic environments (Corredor et al., 2005). Capping the sequence is the mainly continental Benin Formation, deposited during the Oligocene to Recent Reijers et al., (1997). It consists of coarse grained, gravelly, and locally fine grained, poorly sorted, subangular to well-rounded sandstones, and bears lignite streaks and wood fragments.

Twenty (20) cutting samples recovered from ODPX-1 Well in Offshore Western Niger-Delta Nigeria and were analyzed in this study (Figure 1 & 2). Several related studies have been done on the Palynofacies and sequence stratigraphic studies offshore part of the basin and reported in several literatures. Morley and Richard (1993), pioneered the attempt to employ palynology in sequence stratigraphic study in the Neogene Niger Delta when he compared the palynological characterization of system tracts from the Niger delta and Southeast Asia (India, Indonesia, and Malaysia). The study highlighted application of palynology in the Tertiary basins, essentially in correlation rather than dating and concluded that the integration of data from both palynomorphs and marine microfossils (foraminiferal, nannofossils) can provide a much enhanced basis for system tracts interpretation than when used singly. Pocock et al., (1988), used a structured phytoclast- biodegraded phytoclast –

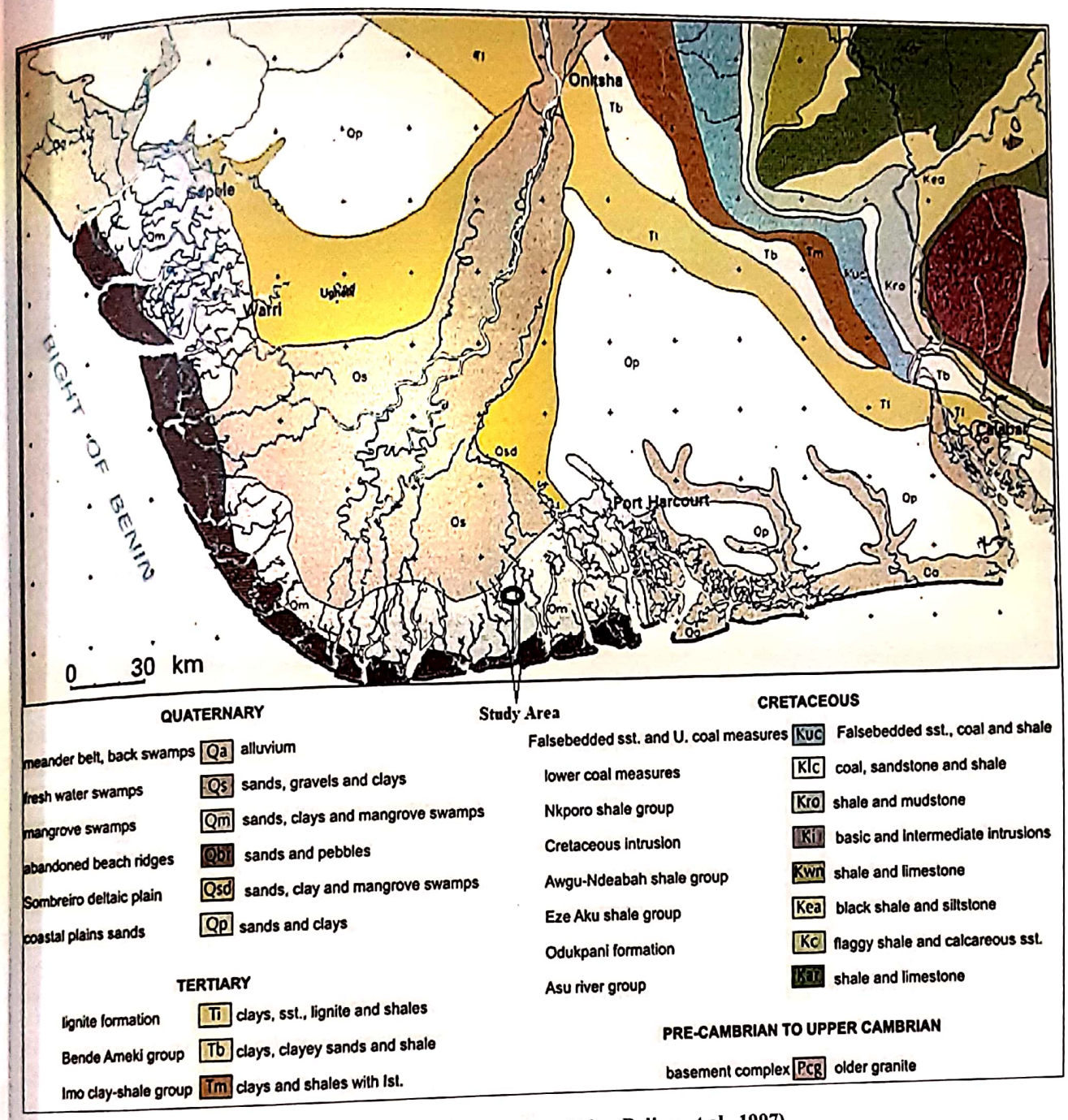

Figure 2. Niger -Delta Surroundings and Location of Study area (After Reijers et al., 1997).

(yellow + grey Amorphous Organic Matter) plot to indicate the style degradation, with supposed transitions from structured to biodegraded in oxidizing environments, and from structured to amorphous in reducing environments. Sowunmi, and Kogbe (1975), reported that angiosperm palynomorphs are predominant in the Niger Delta Post- Eocene sediments with no records of gymnosperms. Evamy et al., (1978) adopted an informal palynological zonation for the Niger delta using alphanumeric nomenclature. Legoux, (1978) analyzed and used *Praedapollis africanus*, *P. flexibilis*, *Verrutricolporites rotundiporus* and other taxa for the zonation of some parts of the Neogene Niger delta. According to Whitaker et al., (1992) four palynomacerals (known as kerogen or palynodebriss) are recognized and they are Palynomaceral 1 was considered to comprise orange-brown or dark brown structured or

structureless dense material of variable shape and preservation. Palynomaceral 2 was assumed as brown-orange or structureless material of irregular shape. It may include structured plant material (some leaf, stem or small rootlet debris) algal detritus and to a lesser extent, humic gel and resinous substances. Palynomaceral 3 was considered as pale, relatively thin, irregular shape usually structured material bearing stomata occassionaly. It is considered the most buoyant of palnomacerals 1-3. Palynomaceral 4 were viewed as black or almost black, equidimensional, blade- or needle-shaped material, which is usually uniformly opaque and structureless, but may rarely show cellular structure. In precise, Oboh, (1992) used palynomorphs from the middle Miocene onshore Kolo Creek Field to show that the depositional conditions were similar to todays but the climate was somewhat drier and studied the palynology and lithology of Miocene strata of the well Igbomotoru -1, coastal swamp and interpreted the environment of deposition as transitional with marine influence. Ige, (2009) investigated the palynological content of Ataka -1 well, and reported unstable wet and dry climatic conditions characterized by contrasting fluctuations between the percentage occurrence of *Rhizophora sp*., and *poaceae* pollens. Pollen and dinoflagellate cysts from cores from the western Niger Basin Durugbo et al., (2010) showed that the Plio-Pleistocene (5.0–1.3 Ma) environment was mostly dry and there were two cooling events. The data thereon attained will contribute towards better understanding of fossil floral diversity of the basin.

Several studies have been done in the area from different researchers using foraminiferal and playnology like planktic and benthic foraminiferal biozonation and correlation of ZY-1 and XY-1 field Obaje and Okosun, (2013); Late Miocene foraminiferal and palynologic events of Oborduka-1 well Boboye and Ademola, (2013); Sequence stratigraphic and paleoenvironment studies of palynoflora from E12 well Odede et.al., (2012); Sequence palyno-stratigraphic study of Dell-2 well Ojo and Gbadamosi, (2013) and Palynological analysis of T-well Inyang et.al., (2016) Offshore Western Niger Delta. This study focus on integrating palynofacies or kerogen study in addition to sequence stratigraphic studies in characterising there sedimentary succession penetrated by the wells ODPX-1 and ODPX -2 well offshore western Niger Delta, Nigeria.

Objectives

The following objectives are:

1. To document the distribution, abundance and diversities of the palynomorphs encountered.
2. To determine the age, biozones and correlation of the wells.
3. Deducing the paleoenvironment of deposition of the sediments using the recovered palynomorphs and palynofacies or kerogen.
4. To determine the sequence stratigraphy of the section penetrated by the studied wells.

Material and Methods

Twenty grams (20g) of each samples was weighed using an electronic balance. Indurated samples were disaggregated by crushing in a mortar. 10%. Concentrated hydrogen peroxide (H2O2), sodium hexametaphosphate [(NaPO3)6], sieves (106 mesh microns), glass funnel, filter paper, oven, slides, and Leica transmitted light optical microscope.

Sample Preparation for Palynofacies analysis

Twenty (20) ditch cutting samples collected at 60ft interval depth in a total of 1140ft thick depth from ODPX-1 well were analysed for kerogen and palynomorphs characterization. The ditch cuttings was stored in labelled envelopes and studied lithological with the aid of hand lens and binocular microscope and integrated with the gamma logs obtained to produce the final lithological logs for the studied wells.

The wash bottle was used in rinsing the ditch cutting sample to remove drilling mud and then dried after been heated for few minutes. A standard weight (twenty grams 20g) of each dried up sample placed inside a well labelled glass beaker was gently soaked with 400 ml of warm pure water and hydrogen peroxide was added into the beaker, stirred thoroughly for digestion and left overnight. Therefore, the disaggregated sample was filled with pure water for

about an hour and then decanted by washing it under a running tap over 106 mesh micro sieves and the beaker was placed on a magnetic hot plate set at a moderate heat level with a plastic-coated magnetic stirrer and stirred, the mixture was agitated thoroughly. About 40 ml of sodium hexametaphosphate [(NaPO3)6] flakes were added to the sample vessel on the stirred hotplate and then the mixture was stirred magnetically for about twenty minutes and was sieved with 10 micro meter nylon mesh. After these, resistant minerals in the residue was removed by swirling with a wash glass and dried on a hot plate, separated into fractions (fine, medium and coarse) before picking using the picking pins and tray. The picked microfloral were carefully transferred into slides and identified using Leica transmitted light optical microscope of 400x magnification.

RESULTS AND DISCUSSIONS

Lithostratigraphic Description: The lithostratigraphic log of the well showed that the sediments majorly constituent of shales, silt and sandstone presented in Fig. 2 from the bottom to the top and described as follows:

Depth Interval 5560 – 5300 ft.
Lithologic Unit Shale

The shale is smoky to dark grey, fine to very fine grain, slightly calcareous, and angular to sub-rounded, poorly sorted and rare occurrence of mica flakes.

Depth Interval 5080 – 5300 ft.
Lithologic Unit Silt

This section is dominated by increase in silt and dirty grey colourisation, fine grain, slightly calcareous, poorly sorted with rare occurrence of mica flakes and plant remains.

Depth Interval 5080 – 4840 ft.
Lithologic Unit Sand

This interval is sandstone majorly; Light grey, coarse to medium to fine grain, slightly calcareous, and angular to rounded, moderately sorted, with occurrence of shell fragment.

Depth Interval 4840 – 4420 ft.
Lithologic Unit Shale

This unit is the top most and dominated by light grey to smoky fissile shaly composition, coarse to medium grain, angular to sub-rounded, moderately sorted, loosely consolidated, slightly calcareous sandstone with rare occurrence of mica flakes and plant remains.

Palynomorphs: The palynomorph assemblage consists of pollen, spores (fungal and pteridophytic) dinocysts and foraminiferal test lining in which their recovery were in abundance and diverse (about 1,313). The assemblage consists of pollen (23.2%), spores (75.1%), fungal spores (0.8%), Dinocysts (0.6%) and foraminiferal test lining (0.4%) such as *Monoporite annulatus*, *Pachydermites diederixi*, *Verrucatosporites usmensis*, *Crassoretitriletes Vanraadshooveni*, *Retibrevitricolporites obodoensis*, *Classopollis* sp, *Deltoidspora minor*, *Monocolpites* sp, *Laevigatosporites haarditii*, *Cicatricosisporites dorogensis*, *Pteris* sp, *Acrostichum aurem*, *Lingulodinium machaerophorum*, *Homotryblium plectilum*, *Eocladopyxis paniculate* and Foraminiferal test lining.

Kerogen or Palynomacerals: The palynomacerals or kerogen assemblage consists of opaque phytoclasts, non-opaque phytoclasts and amorphous organic matter and palynomorphs in which they were in abundance (about 2,015) and were recorded. The assemblages comprises of opaque phytoclasts (33.6%), non-opaque phytoclasts (18.1%), amorphous organic matter (19.2%) and palynomorphs (29.1%).

Palynostratigraphy: The palynostratigraphic analysis was based on the works of Germeraad et al. (1968), Evamy et al., (1978) and Morley and Richard, (1993) for the palynomorphs and sequence falls within the broad Pan-tropical *Echitricolporites spinosus* Zone of Germeraad et al. (1968), the P800 Zone of Evamy et al., (1978) and floral zones P6-P7, NNDP 11, NNDP19, NNDP20 of Morley and Richard, (1993) respectively. The P800 Zone has been sub-divided into P850, P720 and P680 Evamy et al., (1978) Subzones respectively (Figure 2).

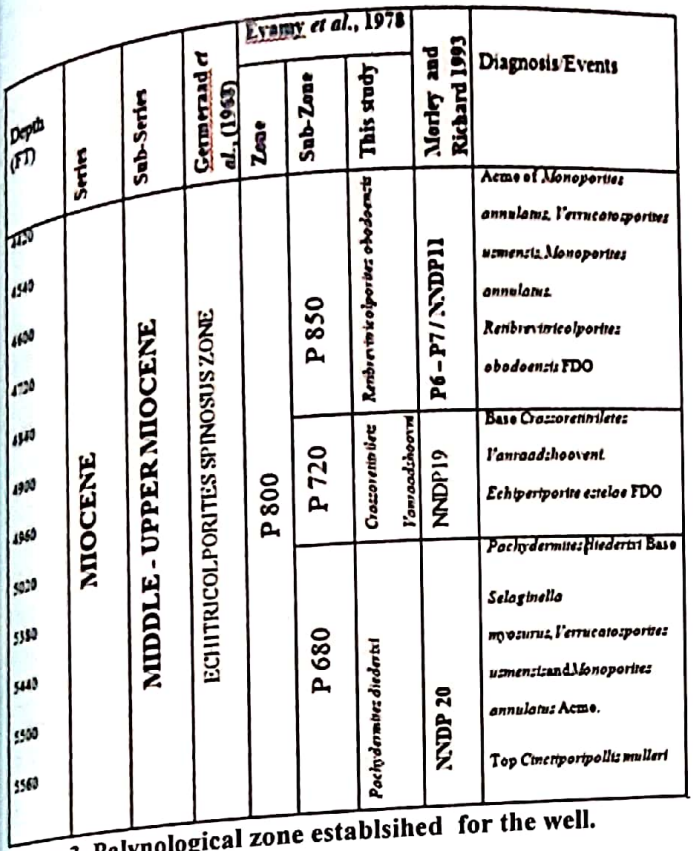

Figure 3. Palynological zone establsihed for the well.

Zone: P800

Sub-zone: P850

This is the first and the youngest sub-zone recognized within the studied section. The top of this sub-zone is marked at 4,420ft and the base is marked at 4,840ft in which is marked by quantitative occurrence of *Classopollis* sp, *Laevigatosporites haarditii*, *Pilososporites* sp, *Selaginella myosurus*, *Rugulatisporites caperatus* and *Verrucatosporites* sp at the top and *Nymphea lotus*, *Psilatricolporites onitshaensis*, *Spirosyncolpites bruni*, *Spirosyncolpites* sp, *Syndemicolpites typicus*, *Syncolporites marginatus* and *Cicatricosisporites palaeocenicus* have there only occurence in this section analysed. The zone is characterized by the (abundance) acme of *Deltoidspora minor*, *Verrucatosporites usmensis* and *Monoporites annulatus* at 4,600ft and the presence of *Retibrevitricolporites obodoensis* at the base at 4,480ft characterized this subzone as upper Miocene age and P6- P7 in descending order downward according to the schemes of Evamy et al., (1978) and Morley and Richard, (1993).

Sub-zone: P720

This is the older sub-zone identified within the studied section of the well and the top of the subzone was vividly marked by the high frequencies occurrence of *Deltoidspora minor* at 4,900ft and continous co-occurence of *Verrucatosporites usmensis*, *Monoporites annulatus*, *Verrucatosporites sp*, *Laevigatosporites haarditii* while the based is placed at 5,020ft. The base occurrence of *Crassoretitriletes Vanraadshooveni* at 4,960ft and *Echiperiporite estelae* in its first downhole occurrence at 5,020ft confirm Middle Miocene (Linghian) age interval in this subzone and NNDP19 floral zones Evamy et al., (1978) and Morley and Richard, (1993).

Sub-zone: P680

This is the last and oldest sub-zone documented within the studied section and the top of this sub-zone is marked at 5,020ft while also the base is marked at 5,560ft. The top of this sub-zone is marked with maximum quantitative occurrence than other subzones in this studied section. The zone is characterized by the acme of *Selaginella myosurus*, *Verrucatosporites usmensis* and *Monoporites annulatus* at 5,380ft. The base occurence is marked with *Elaeis guineensis* and *Cinctiporipollis mulleri* as their first downhole occurence at 5,560ft and *Pachydermites diederixi* at 5,500ft which is use in identifying the age as Middle Miocene (Burdigalian) according to Evamy et al., (1978) and NNDP20 floral zone Morley and Richard, (1993).

Palynofacies analysis and classification: Based on the characteristics of the relative percentages of the kerogen constituents Kholeif and Ibrahim, (2010), this study identified opaque phytoclasts (33.6%), non-opaque phytoclasts (18.1%), amorphous organic matter (19.2%) and palynomorphs (29.1%) for the well (Table 1).

Palynofacies 1 [Opaque (OPA) Dominance – Palynomorphs (PALY) relative dominance]

This is characterised by almost dominance of opaque phytoclast throughout the depth of the well having a relative percentage abundance of 33.6% in which the

peck is marked at 4,840ft, followed by palynomorphs which is relatively percentage abundance is 29.1% and its peak was marked at 4,720ft. The phytoclast or non-opaque phytoclast and amorphous organic matter are the least in this group with relative percentage abundance of 18.1% with its peak at 4,960ft, followed by amorphous organic matter of relative percentage abundance of 19.2% with its peak marked by 5,020ft.

The dominance of opaque phytoclast in this studied well recognised the classification of kerogen Type III, which is characterised by translucent structured phytoclasts, non-fluorescent, woody fragments and partially oxidized palynomorphs, plankton-derived material and the source rock indication correspond to gas-prone material according to Tyson [1993;1995].

Sample No	Depth (FT)	Phytoclast		Amorphous Organic Matter (AOM)	Palynomorphs
		Opaque	Non Opaque		
1	4420	25	10	6	59
2	4480	14	9	4	73
3	4540	30	11	14	45
4	4600	52	16	13	19
5	4660	44	20	21	10
6	4720	7	6	2	85
7	4780	28	11	10	51
8	4840	60	16	18	6
9	4900	15	8	35	42
10	4960	19	40	19	22
11	5020	20	9	60	11
12	5080	56	32	9	3
13	5140	30	37	28	5
14	5200	29	23	13	35
15	5260	55	18	20	7
16	5320	63	9	8	20
17	5380	45	19	18	18
18	5440	21	20	21	38
19	5500	34	28	30	8
20	5560	29	23	38	10

Table 1. Total recoveries (counts) for the particulate organic matter for the well.

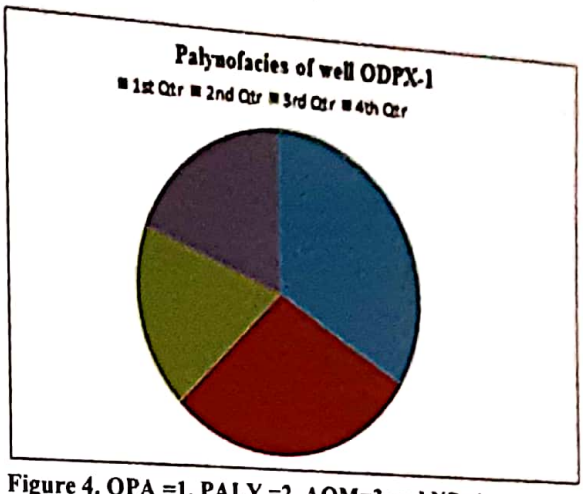

Figure 4. OPA =1, PALY =2, AOM=3 and NP=4.

Paleoenvironment interpretation of the studied well

The method adopted for this study was the count of kerogen or palynomacerals found in the palynological sample analysis slides in which the individual kerogen constituents are computed as percentage and Amorphous organic matter – Phytoclasts – Palynomorphs ternary (Figure 5) plot is used to infer the depositional environments and relative proximity to terrestrial organic matter sources Tyson, (1993, 1995).

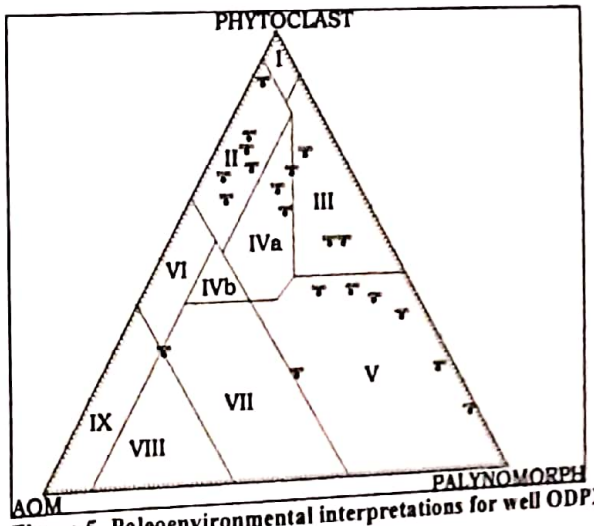

Figure 5. Paleoenvironmental interpretations for well ODPX-1 (modified from Carvalho et al., 2006).

Marginal dysoxic-anoxic basin

Field II indicates deposition in a marginal dysoxic-anoxic basin and the studied section is marked by the depths (4,660, 4,840, 5,080, 5,140, 5,260, 5,550 ft.).

This field is characteristic of dominance of opaque phtoclasts (Palynofacies 1) and is defined by Tyson, (1993) as having amorphous organic matter dilutes by high phytoclast input, though with high level of moderate to good preservation of amorphous organic matter. The amount of marine Total Organic Carbon (TOC) in this field is dependent on the basin's redox state and dilution. The relative percentage abundance of terrestrial spores is high with very low records of microplankton and exhibits Kerogen Type III which is gas prone.

Heterolithic oxic shelf (proximal shelf)

Field III shows deposition in a proximal shelf and the studied section is marked by the depths (5,200, 5,320, 5560 ft.) and 4,600ft sharing field with IVa. This field is attributing total phytoclast abundance dependent on actual proximity to fluvio-deltaic source, also Oxidation and reworking common and tendency of low amorphous organic preservation Tyson, (1993). The relative percentage abundance of terrestrial spores is high with greater abundance of dinocyst and microplankton and show evidence of Kerogen Type III or IV that is gas prone.

Shelf to basin transition

Field IVa specifies the deposition to be a passage from shelf to basin in time or space like increased subsidence and water depth to bring into being an environment as basin slope. The studied section is marked by the depths (4,960, 5,380, ft.) and 4,600ft sharing field with III. This field is feature of entire phytoclast abundance depends on proximity to source and degree of redeposition. The amount of marine Total Organic Carbon (TOC) depends on basin redox state Tyson, (1993) which eventually leads to dysoxic-suboxic deposition characteristics. The relative percentage abundance of terrestrial spores' tendency is moderate to high with very low microplankton and show evidence of Kerogen Type IIor III that is gas prone.

Mud-dominated oxic shelf (distal shelf)

Field V signifies distal shelf deposition and a low to moderate amorphous organic matter usually degraded with abundance of palynomorphs. Calcareous mudstones are typical of this field with light coloured bioturbated and the studied section is marked by the depths (4,420, 4,480, 4,540, 4,720, 4,780, 4,900, 5,440, ft.). The relative percentage abundance of terrestrial spores is usually low, yet dinocysts is dominant with microplankton common and sometimes in abundance, also this field showsindication of Kerogen Type III greater than IV that is gas prone Tyson, (1993).

Depth 5,020ft is sharing field of VII and VIII which are distal dysoxic- anoxic shelf and distal dysoxic – oxic in deposition. This is a mixed environment having the characteristics of both fields which are moderate to excellent amorphous organic matter preservation and low moderate palynomorphs. Field VII is typical of dark coloured slightly bioturbated mudstones while Field VIII is usual of organic-rich shales deposited under stratified shelf sea conditions. They are usually low in terrestrial spores and differ in microplankton diversity, prasinophytes increasing in field VIII and both are oil prone.

Sequence Stratigraphic Framework

The sequence stratigraphic interpretation of the well is based on the vertical relationship of the lithofacies associations, palynofacies assemblages, and the existing stratigraphic framework of the Neogene succession in western Niger-Delta Nigeria Figure 6 (Petters, 1983; Doust and Omatsola, 1990; Reijers et al., 1997; Obi, (2000).

Maximum flooding surface (MFS)

The Maximum flooding surfaces recognized in this section are at (4600, 5380 ft.) in ODPX-1well and dated 6.0 Ma and7.4 Ma Haq et al., (1987) which infers a brackish environment deposition of the sediments.

Sequence Boundaries (SB)

In this study, sequence boundary was recognized at 4900ft. The sequence boundary is dated 6.7Ma Haq et al., (1987) due to the fact that there is a decrease in

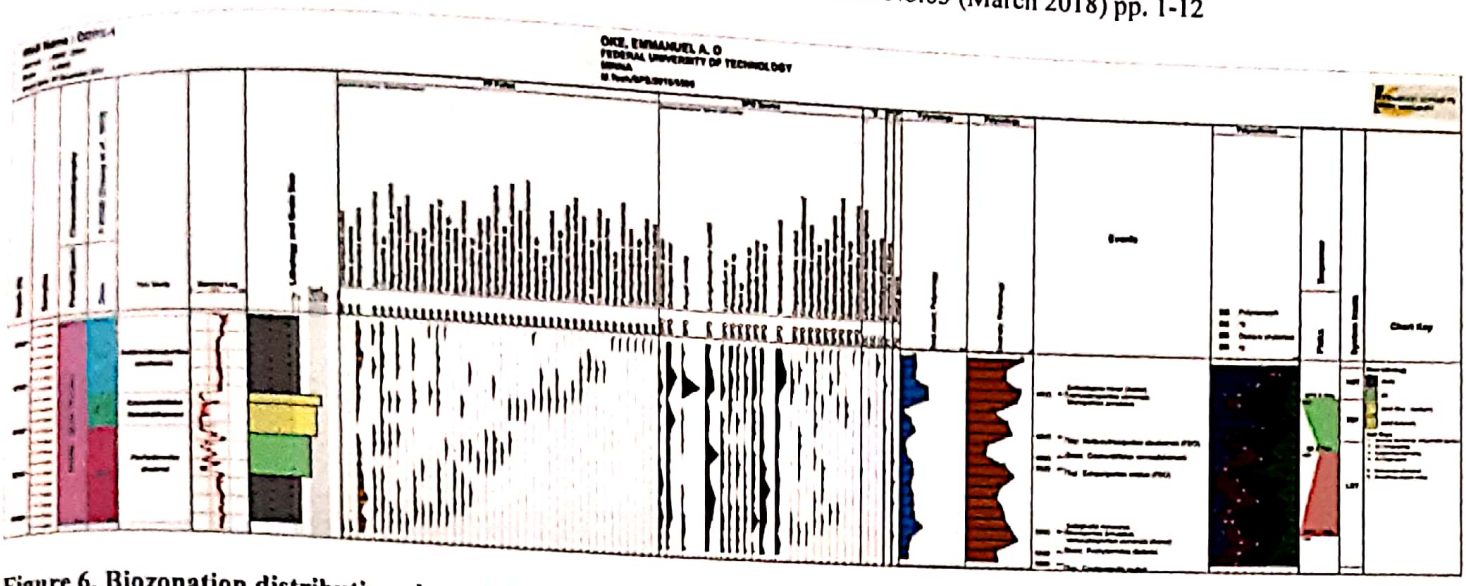

Figure 6. Biozonation distribution chart of ODPX-1 well.

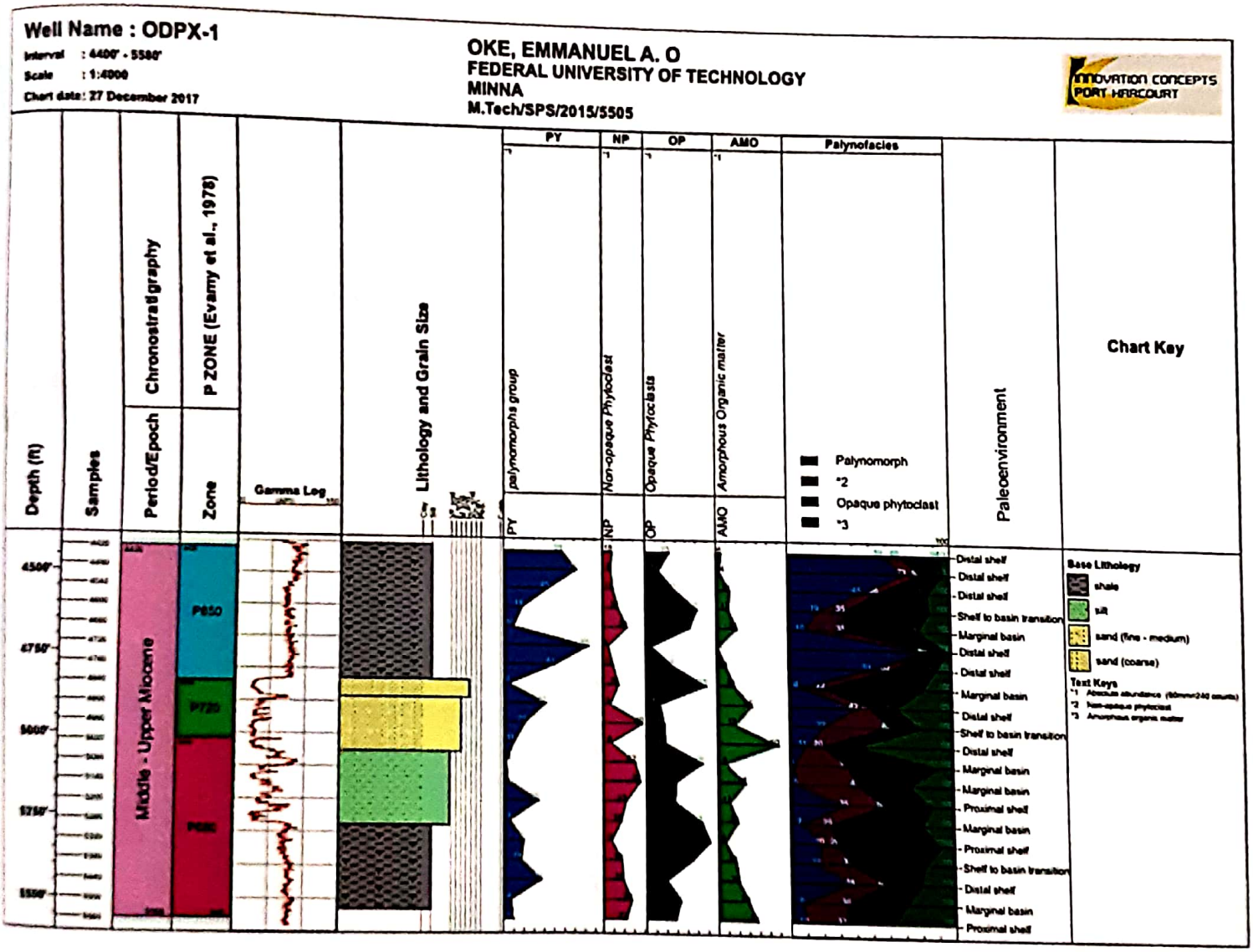

Figure 7. Palynofacies distribution chart of ODPX-1 well.

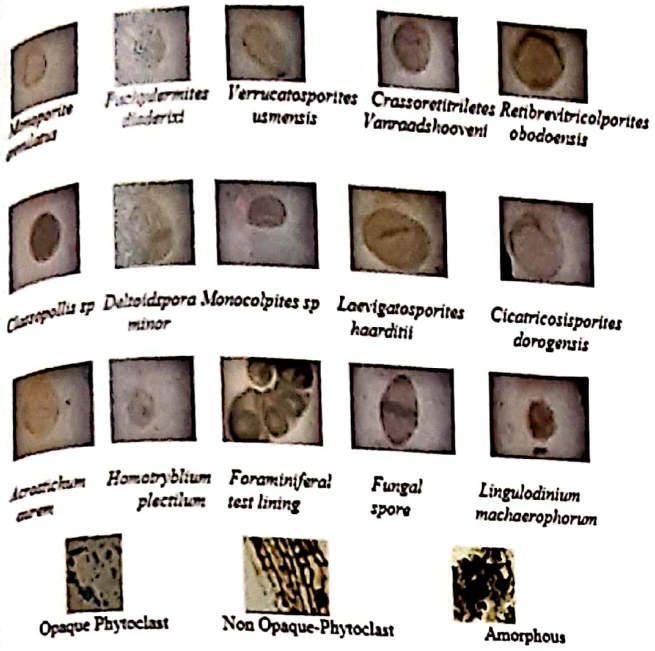

Plate 1. Some of the palynomorphs and kerogens recorded within the ODPX-1 well

the palynoforms and a point of change between the coarsening upward and fining upward and stratigraphic position in the sequence.

Lowstand System Tract (LST)

The lowstand system tract takes account of deposits that accumulate after the onset of relative sea level rise Posamentier and Vail, (1988). In this study section, coarse to fine grained sandstone to siltstone and shaly at depth 4840ft to 5560ft, marks the lowstand systems tracts. This sequence may serve as the main reservoir rocks in the study area. A distributary mouth bar is interpreted based on textural characteristics and palynofossils (Allen, 1965).

Transgressive Systems Tract (TST)

Transgressive System Tract is formed when the sequence exhibited a transgressive surface and is overlain by the maximum flooding surface and the marine sediments reach their most landward position (Bhattacharya and Posamentier, 1996). The evident is sited at depth interval 4680ft to 4840ft of the well and a brackish to shallow marine environment of deposition is interpreted.

Highstand Systems Tract (HST)

The highstand system tract made up the upper system tract and lies directly on the flooding surface which may have formed when marine sediments reach their most landward position (Bhattacharya and Posamentier, 1996). In this study, highstand stystems tract was recognized in the well at depth interval of 4420ft to 4600ft shaly stone and a brackish to shallow marine environment is inferred.

Conclusions

Twenty ditch cuttings samples for ODPX-1 well (depth interval 4420 – 5560ft.) were analysed for palynological, palynofacies and sequence stratigraphy evidences useful for age delineation, paleoenvironmental interpretation and correlation. The age, zonation, environment of deposition and sequence stratigraphic characterizations of the sedimentary succession of the studied well have been determined. The studied interval has sediments consisting of about 30% sand/sandstone and70% shale with shale/sand ratio penetrating major sedimentary formation in Niger Delta (Agbada Formation) which comprise of shaly sandstone and sandymudstone. The palynoflora of the study section yielded a total count of one thousand three hundred and thirteen (1,313) palynomorphs and two thousand and fifteen (2015) palynofacies, which show that they were dominantly land derived. The Palynological zonations were established based on some stratigraphic index palynomorphs of *Retibreitricolporites obodoensis, Crassoretitriletes vanraadshooveni* and *Pachydermites. diedeerixi.* The assemblage zone of P800 was established with three Subzones of P850, P720 and P680 (ODPX-1) and correlates with the broad Pan-tropical *Echitricolporites spinosus* Zone and it is Middle to Upper Miocene. The well sediments revealed

P-1 revealed Opaque Phytoclast (OPA) Dominance – Palynomorphs (PALY) relative dominance and are characterized by distal shelf, Shelf to basin transition, proximal shelf, marginal dysoxic-anoxic basin and distal suboxic-anoxic basin, distal dysoxic-oxic, distal dysoxic-anoxic shelf, Shelf to basin transition/ proximal suboxic-anoxic shelf, highly proximal shelf or basin with immature organic matter of Kerogen Type II-III, implying its sediments are proneness oil and gas (Tyson, 1993, 1995). Therefore, the

paleoenvironment suggested the dominance of freshwater/Brackish water, swamp, forest and ferns palynomorphs association over savanna floral elements represent warm and wetter climate of littoral environment and the paleobathymetric data of species of dinocyst recovered showed that the sediments were shallow marine to marginal marine environments deposit ranging from Inner Neritic to Littoral.

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