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DOI: https://doi.org/10.64388/IREV6I8-1712046

Palynological Appraisal of the Pliocene Sediments: Chronological and Lithofacies Insights from X-Well, Offshore Setting of the Niger Delta

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Abstract- Palynological analyses of X-well in Niger Delta were carried out, fifty-five ditch cuttings at the depth between 460 and 1540 m (20 m intervals) were analyzed. The lithostratigraphic intervals is composed of predominantly fine to medium grained sand with shale intercalation which is conformable to the paralic Agbada Formation. Standard technique was employed by using non-acid method Sodium-hexametaphosphate to remove the drill mud. In addition, the palynomorphs recovery yielded low to moderate and high preservation within the sampled intervals. A total of eighty-six species were documented to interpret the age that is aligned to lithostratigraphy of the formation. Common species identified are Retibrevitricolporites obodoensis, Echiperiporites estelae, Gemmamonoporites sp, Peregrinipollis nigericus, Crassoretitricolporites vanraadshooveni, Multiaerollites fomorsus, Stereisporites sp, Cyperaceoporites sp, Nympheapollis lotus, Podocarpus milanjianus, and Retistephanocolpites gracilis, and marine forms Dinoflagellate cyst, Selenopemphix sp, Operculodinium sp, Brigantedinium sp, and Lingulodinium sp. In this study, the first and last appearance datum (FAD and LAD) of diagnostic marker specie Podocarpus milanjianus was used to assign Early Pliocene – Late Pliocene age to the well. In addition, the integration of terrestrial and marine forms revealed that the sediments were deposited in shallow marine environments (Upper to Lower shoreface).

Index Terms: Lithostratigraphy, Stratigraphy, Palynology, Niger Delta)

I. INTRODUCTION

Location and background study

The Niger Delta sedimentary basin where X-Well is located (Fig.1) was initiated in the Early Tertiary times (Doust and Omatsola, 1990). It ranks amongst the most prominent and prolific petroleum producing deltas in the world as it accounts for about 5% of the world's oil and gas reserves and about 2.5% of the present-day basin area on earth (Hooper et al., 2002). Geographically, the Niger Delta is located between longitude 50 and 80E and latitude 30 and 60N (Nwachukwu and Chukwura, 1986) which is situated within the continental margin in equatorial West Africa (Gulf of Guinea). This basin occupies a total area of about 7,500km2 in the Gulf of Guinea with a sediment thickness up to 12,000m (Bustin, 1988; Burke, 1972). Reijers et al., (1997) documented that the sedimentary basin of the Niger Delta encompasses a much larger extent region than the modern delta constructed by the Niger – Benue drainage system. This includes the Cross River delta which further extends eastwards into the continental margins of neighboring Cameroon and Equatorial Guinea sub-environments. The sedimentary wedge of the Niger Delta contains a major submarine part (Reijers, 1996) which forms part of the complex continental margin intruding into the Gulf of Guinea (Fig. 2). The stratigraphy of the Niger Delta clastic wedge has been documented during oil exploration and production in which most stratigraphic schemes remain restricted to the major oil companies. Stratigraphic evolution of the Tertiary Niger Delta and underlying Cretaceous strata was described by Short and Stauble (1967). Details of the stratigraphy, depositional sequences, hydrocarbon potential, and structural framework of the Cenozoic sediments in southern Nigeria is limited to the subsurface Niger Delta because of its petrolific nature

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(Doust and Omatsola, 1990; Okereke et, al 2022; Victoria and Ndubuisi 2018).

The three major lithostratigraphic units defined in the subsurface of the Niger Delta are Akata, Agbada and Benin Formations (Fig. 3). These lithostratigraphic units decrease in age basin ward, reflecting the overall regression of depositional environments within the Niger Delta clastic wedge. Stratigraphic equivalent units to these three formations are exposed in southern Nigeria (Table 1; Short and Stauble, 1967). The formations reflect a gross coarsening-upward progradational clastic wedge (Short and Stauble 1967), deposited in marine, deltaic, and fluvial environments (Weber and Daukoru 1975). This study was undertaken to divulge the appraisal of palynology in interpreting the age and paleoenvironment of the formation to provide insights on the suitability of setting for future exploration study.

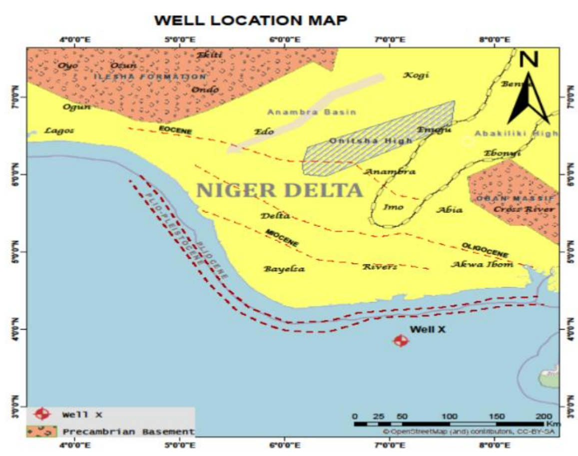

Fig. 1. Map of Niger Delta showing the studied well. (Source: This study)

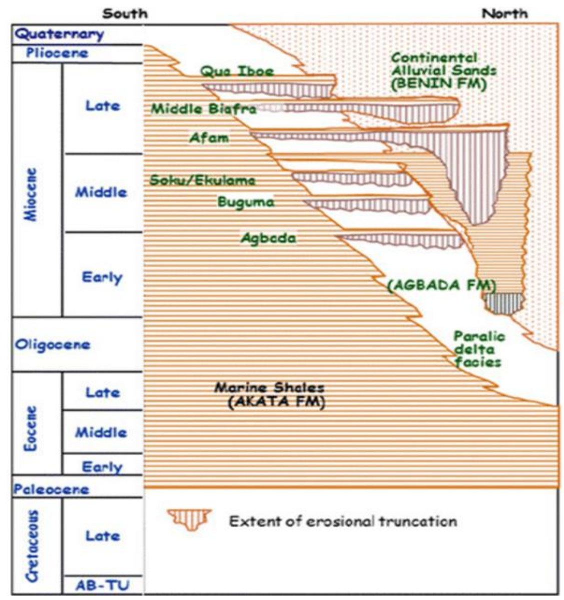

Fig. 2: Stratigraphy of the Niger Delta (Doust and Omatsola, 1990).

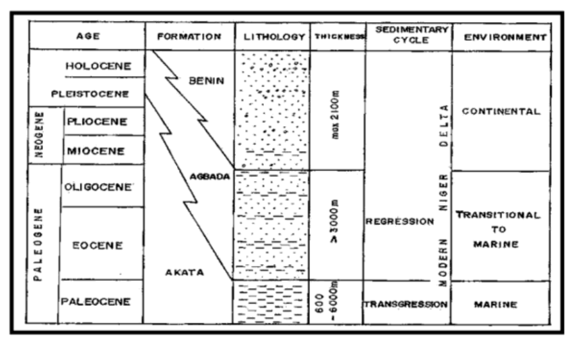

Fig 3: Correlation of subsurface and surface formations of the Niger Delta (Source: Doust, 1990).

II. METHODOLOGY

The palynological procedure in this study was based on non-acid method using Sodium-Hexametaphosphate. 25grams of each sample (Ditch cuttings) was weighed and disaggregated to increase the surface area. The disaggregated sample was placed in a labeled beaker and detergent was added to remove drilling mud. 4-10ml of water was then added and stirred, using a spatula. Water was added to the brim of the beaker and allowed to settle for one hour before decanting. This process was repeated 3 times to wash off the sodium hexametaphosphate, detergent, and drill mud. The samples were decanted into small centrifuge tubes. This is to separate the dense mineral

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fraction from the light organic residue and allow the organic residue to flow to the top of the glass residue. Upon decanting the organic residue on the slide, it was covered with a cover slip and three drops of Norland optical adhesive were added. This was placed on a hot plate, and then heated gradually. The cover slip was dried, then removed with spatula and place on the slides.

III. RESULTS AND DISCUSSIONS

Sediments of the X-Well (interval 460 – 1540 m) penetrated the Benin and Agbada Formation, respectively. The Benin Formation was delineated at 760 m as observed from the lithology (Fig 4) while the Agbada formation (interval 760-1060 m) are made up of paralic development of sands and shales (with silt intercalation), (Table 1).

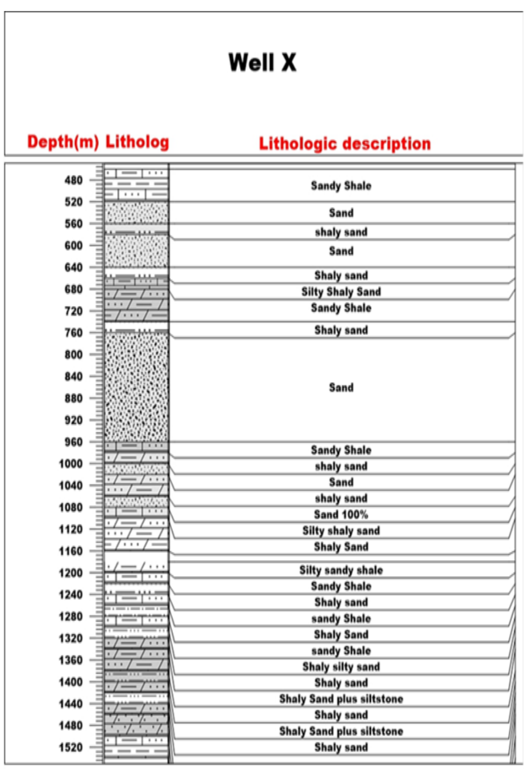

Fig. 4. Lithological Description of X – well.

Table 1. Lithostratigraphy of X – Well.

DEPTH (m)	*LITHOLOGY*	*LITHOSTRATIGRAPHY*
460 - 760	*Predominantly sand and shale with intercalation of sandstone.*	*BENIN FORMATION*
760 - 1060	*Predominantly sand with intercalations of minor shales.*	*AGBADA FORMATION*
1060 - 1400	*Predominantly sand and silt with shale interbedding.*	
1400 - 1540	*Predominantly shale and sand intercalations.*	

Table 2. Palynostratigraphic zones of X-Well (460 – 1540 m)

Interval (m)	*P zone*	*Age*	*Events*
460 – 600	*P900*	*Late Pliocene*	*The top of this zone was not defined.*

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600 – 1540	*P880*	*Early Pliocene*	*The top of this subzone was defined by the Base Occurrence of Podocarpus milanjianus at 600 m.*
1540			*Base not encountered*

3.2 Biostratigraphy

The studied intervals of X–Well (460-1540 m) indicates abundance and well preserved palynomorphs. A total of Eighty-six (86) species that were recovered includes Multiaerolites fomorsus, Cyperaceapollis spp, Podocapites sp, Nympheapollis lotus, Monoporites annulatus, Zonocostites ramonae, Gemmamonoporites spp, Retibrevitricolporites obodoensis/protrudens, Echiperiporites estelae, Stereisporites sp, Retistephanocolpites gracilis, Striatricolpites catatumbus, Pachidermites diederixi, Elaeise guineensis, Retitricolporites irregularis, Peregrinipollis nigericus. Marine indicators such as Dinocysts indeterminate (Selenopemphix sp and Operculodinium sp) and Foraminiferal Test Lining (FTL) were observed as well (Plate 1). The presence of marine environmental indicators probably indicates infiltration of marine water into the swampy terrestrial environment (Oloto, 2009).

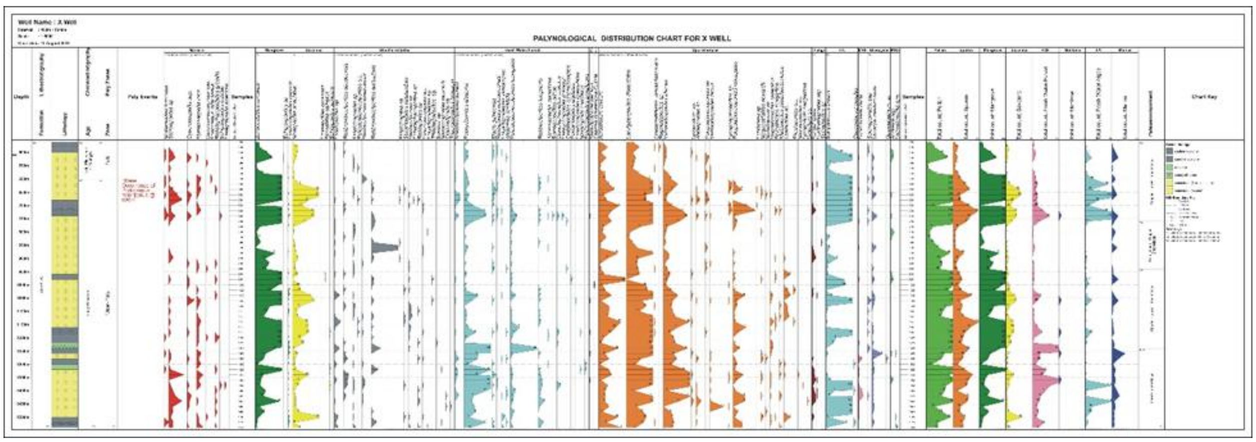

Fig. 5. Palynomorphs distribution, paleoecology and paleoenvironmental chart of X-Well.

The identified pollen and spores abundance and diversity were eighty-six (86) species (fig 5). The recoveries comprise of pollen, spores, algae, foraminiferal linings, acritarch, and dinocysts. However, the marker species identified were nine (9) namely, Nympheapollis lotus, Stereisporites sp, Podocarpus milianjianus, Cyperaceopollis spp, Multiaerollites fomorsus, Peregrinipollis nigericus, Echiperiporites estelae, Gemmamonoporites sp, and Retistephanocolpites gracilis (Plate 1 and 2). Based on the distribution, diversity, and abundance of pollen and spores identified, Early Pliocene – Late Pliocene (P900 and P880 subzones) was assigned to X – Well (Evamy et al, 1978). There was poor recovery of palynomorphs in samples 18 – 20 (800 – 840 m) probably the environment was not too conducive for abundant palynomorph production. From the distribution chart the inferences made from the plot (fig. 3), includes the age, palynozones (P900 and P880), miospores diversities, and abundance as well as the environment of deposition.

3.3 PALEOECOLOGY

Miospore abundance and diversity plot below shows that the diversities of the miospores are abundance in most of the samples. The mangrove species dominated the sections of samples 1(460 m) – sample 9(620 m) where the highest peak was observed, and another mangrove peaked from sample 10(640) – 12(680). The dry period was dominated by savanna peaked at sample 13 (700 m) while the wet period was dominated from sample 14 (840). Savanna grasses dominated the section of sample 21 (860 m), whereas mangrove pollen dominated sample 22 (880 m) although to sample 52 (1480 m). The dry period was dominated by savanna species with a peak of 62 species in the section of sample 53 (1500 m), there was a short period of mangrove event at sample 54 (1520 m). Another prolonged wet period with high counts of other wet climate ecological group indicators such as freshwater/forest pollen, freshwater and marine algae occurred from 620 – 1440 m when savanna pollen declined in the sample 55 (1540 m). There was a clear trend of increase mangrove/decrease savanna, due to the fluctuations between wet and dry climates of the Niger Delta Morley (1995); Adojoh et., (2017).The disparity of the increase and decrease of mangrove and savanna groups may be resulting from the fluctuation between wet and dry climates, Morley, and Richards (1993).The depositional environment was interpreted based on the sedimentological characteristics and the palynomorphs identified in the well under study. The sporadic occurrences of environmental indicators in some intervals (e.g., Dinoflagellate cysts, Botryococcus braunii, Foraminiferal Test Linning, Selenopimphix spp, and Operculodinium sp) suggest a shallow – deep marine paleoenvironment.

CONCLUSION

Fifty – five ditch cuttings retrieved from X – well were sampled at 20 m intervals from (460-1540 m) and analysed for their palynomorph components. The abundance and diversities of palynomorphs recovered were eighty-six species (86) species. Based on the distribution and occurrence of marker species, two palynozones were established for this well, (P900 and P880 - Podocarpus milanjianus). The top of this subzone was defined by the Base Occurrence of Podocarpus milanjianus at 600 m. Thus, this X-Well under study was assigned Early Pliocene – Late Pliocene. The paleoecological distributions of species recorded were highest in mangrove diversity while the least was found in the montane. The paleoenvironmental studies based on the abundance of the pollens and spores revealed that most of these species falls within the mangrove and the freshwater/algae environments.

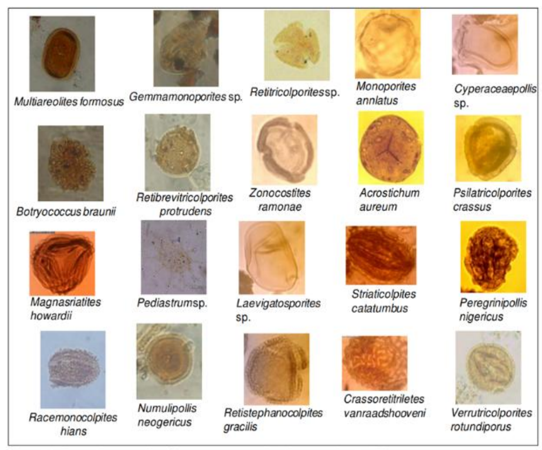

Plate 1: Microphotographs of some recovered palynomorphs (x400).

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