

# Palynostratigraphy, Palynozonation and Depositional Systems in Kombo-001 Well, Niger Delta Nigeria

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**Abstract:-** Fifty ditch cuttings from Kombo-001 well were sampled and analysed for their palynological content in order to determine the palynostratigraphy, Palynozonation and depositional systems in Kombo-001 well. The study followed standard sample lithologic descriptions and palynological sample preparation using the non-mineral acid method of palynological sample preparation. The sample description which were presented as lithological log, sand/shale ratio and gradational profile showed alternation of sand and shale characteristic of the Agbada Formation in the Niger Delta. The palynomorphs identified in Kombo-001 well are abundant and diverse including gymnosperm and angiosperm pollen, pteridophyte and bryophyte spores, dinoflagellates, foraminiferal test linings, freshwater algae, dinocysts, diatom and fungal spores. The palynofloral assemblage consists of 45 (forty-five) pollen species representing 37 (thirty-seven) pollen genera, 18 (eighteen) pteridophyte and bryophyte spore species which comprise of monoletes, triletes and alete, and few fungal spores, freshwater algae and diatoms. The palynostratigraphy of Kombo-001 well indicated dominance in mangrove pollen species suggesting deposition within coastal to marginal marine settings under wet climatic condition. The palynological zones identified included P820 and P830 with boundary marked based on Quantitative Base Occurrence of *Stereisporites sp.* at 9110 ft and corresponding to late Miocene. Generally, the depositional systems and systems tract of the studied intervals in Kombo-001 well lies within the highstand systems tract (HST).

**Keywords:-** Palynostratigraphy, Palynozonation, Depositional Systems, Systems Tract, Mangrove Pollens.

## I. INTRODUCTION

The Niger Delta has undergone different syn-depositional and post-depositional deformation at various degrees. The primary deformation in the Niger Delta is gravity tectonism which has given rise to several regional faulting resulting into different depositional centres generally referred to as depobelts (Ukpabi 2020).

The stratigraphy of the Niger Delta is complicated by these syndepositional collapse of prograding clastic wedge into underlying over pressured mobile shales (Doust and Omatsola, 1990).

In Tertiary basins like the Niger Delta, palynostratigraphy can provide much more valuable information on the stratigraphic sequences than mere identification of condensed sections utilizing foraminiferal, nannofossil, and dinocyst abundance and diversity peaks (Morley 1996).

Consideration of miospore assemblages, which may indicate changes in the nature of coastal geomorphology during times of sea level fall, sea level rise, or stillstand, may enable the use of palynology to distinguish system tracts (Rull, 1992). Changes in terrestrially derived palynomorphs may also impact the nature of stratigraphic sequences and how they might be used to distinguish system tracts. The three main systems tracts associated with stillstand, rising, and falling sea levels can be identified by building theoretical models of miospore deposition based on the recovered palynomorphs from the study wells and taking into account the various depositional and erosional styles (Rull, 1992). Since the vegetation is what will produce the majority of the miospores discovered in marine sediments, particular attention is given to patterns of coastal sedimentation in Kombo-001 well as well as the representation of various coastal vegetation types during the deposition of each systems tract in Kombo-001 well.

The objective of this study is to use palynostratigraphy to determine biozonation, depositional sequences and systems tracts based on miospore occurrences and distributions in Kombo-001 well.

## II. METHOD OF STUDY

The method of study includes data acquisition, data trawling and discussion. Data acquisition include sample lithologic descriptions, palynological sample preparation and analysis.

Fifty samples were prepared and analysed. All the samples were prepared at the Palynology Laboratory, Department of Geology, University of Port Harcourt. Dinoflagellate Cysts, other aquatic palynomorphs, and terrestrial palynomorphs were concentrated following the standard palynological preparation techniques.

Data trawling include application of StrataBugs V2.0 in data scanning and display to determine patterns in palynofloral distributions. Data discussion include

interpretation of palynostratigraphy, biozonation and depositional systems and systems tracts.

Kombo-001 well is located in the shallow marine part of the Niger Delta, Southern Nigeria, and lies within Longitude 4°35'58.793"E and Latitude 4°32'2.8"N (Fig. 1).

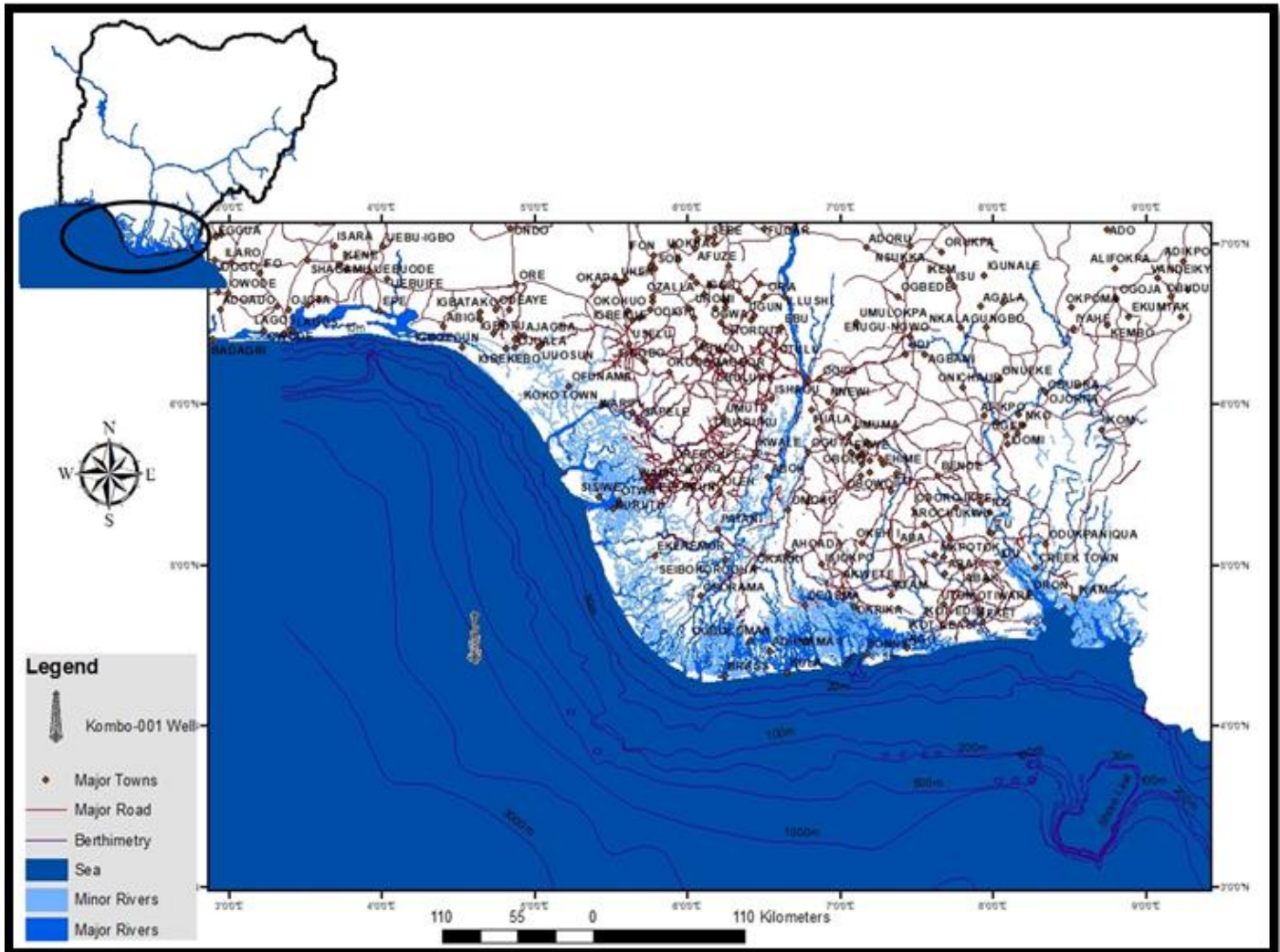


Fig 1 Map of Kombo-001 well

**III. RESULTS**

➤ *Lithostratigraphy of Kombo-001 Well sequences*

Lithologic sequences in Kombo-001 well covered a depth range of 7240 ft – 10190 ft, with a total thickness of 2950 m (Tables 1 and 2, figure 2)

The upper 310 ft (7240 – 7550 ft) of the studied interval of Kombo-001 well consists of sand with shale streaks and minor silt bands, the sand ranged from very fine to medium grained in texture. The sand is grey, very fine to medium grained, very silty, very well sorted, clayey and loosely consolidated.

Accessory minerals in the section include few heavy minerals, rare mica flakes and pyrite.

Below the section is a thick aggradational shale sequence measuring about 1860 ft (7550 – 9410 ft). the shale is dark grey, very silty, calcareous, frangible with accessory minerals such as few pyrite and plant remains, rare mica flakes and shell fragments. Following the shale

down the well is another shale bed with grey silty streaks. The shale is dark grey, very silty, slightly calcareous, frangible. Accessory minerals in this section include common carbonaceous material, few pyrite, and rare mica flakes.

The lithological description of Kombo – 001 well ditch cutting sample is presented as a lithological log in figure 2, while the result of the wet-sieve analysis in table (2) was plotted into sand/shale ratio and gradational profile and presented in figure 3.

Table 1 Summary of the Lithostratigraphic Description of Kombo-001 well.

Depth (ft)	Lithology	Lithostratigraphy
7240 - 7550	Sand with shale streaks and, minor silt bands	Agbada Formation
7550 - 9410	Shale	
9410 - 10190	Shale with sand streaks and minor silt band	

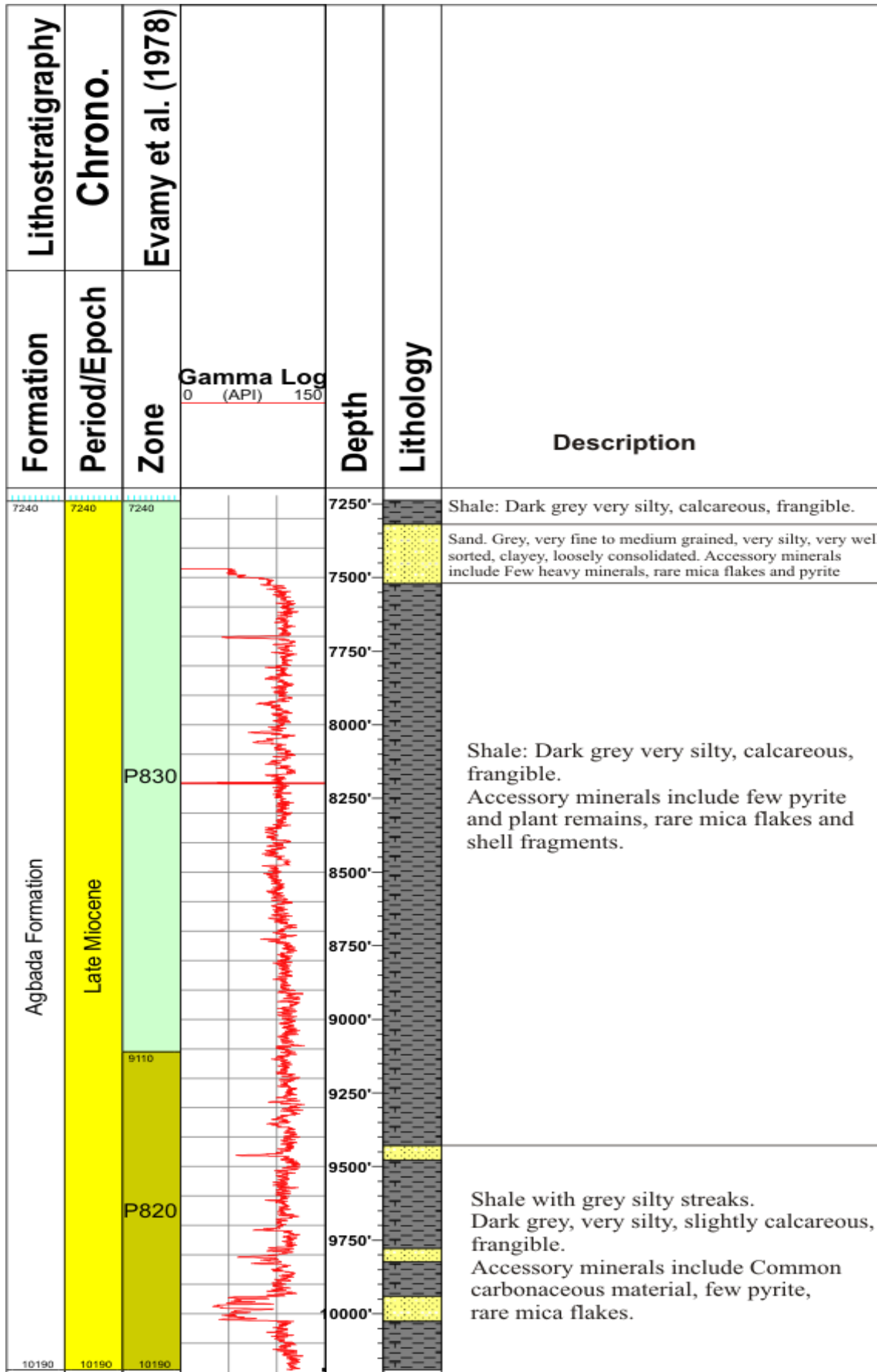


Fig 2 Lithologic Section Showing Lithostratigraphic Description of Kombo-001 well

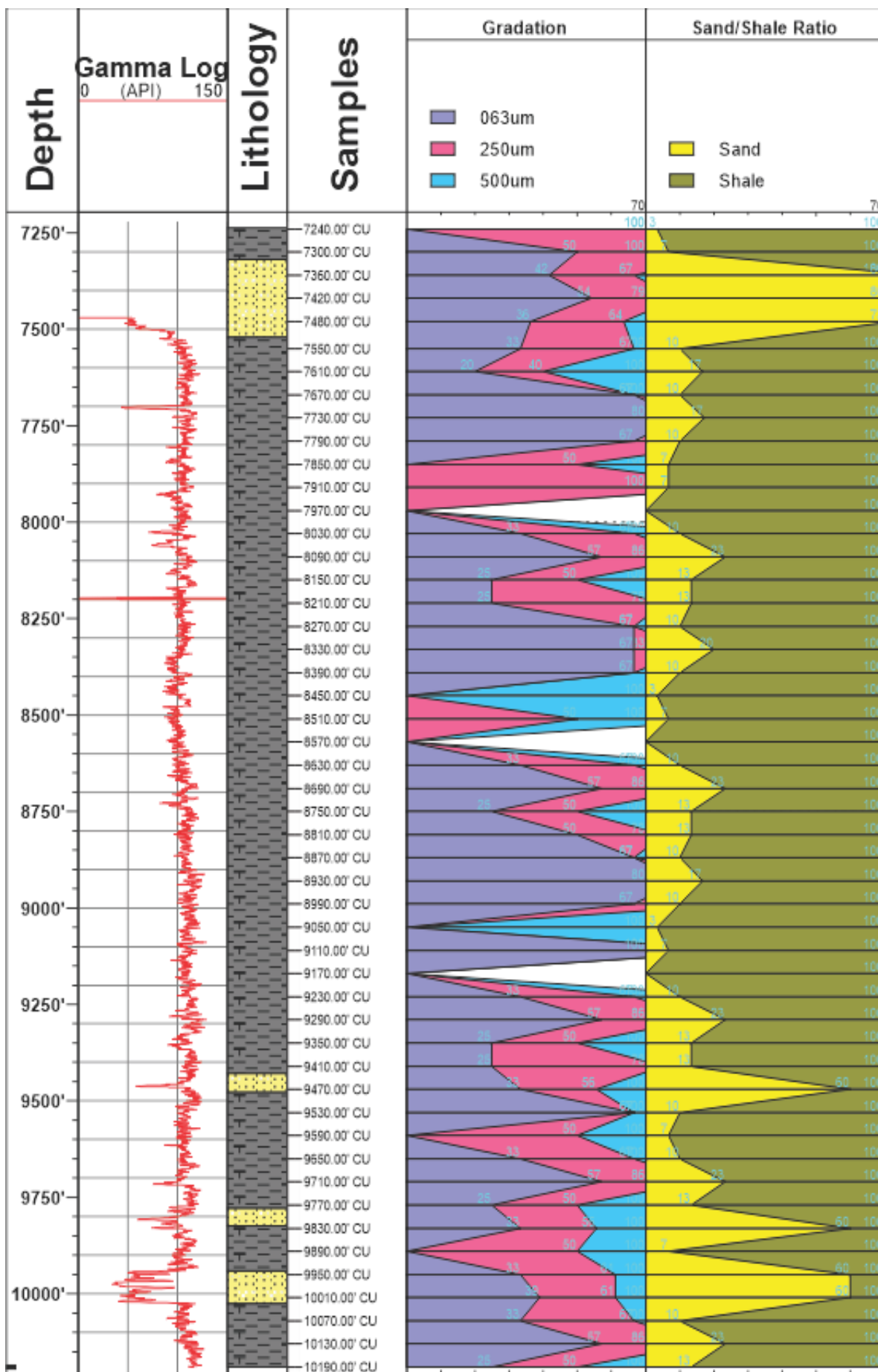


Fig 3 Plot of Sand / Shale Ratio per Depth and Gradational Profile of Kombo-001 well.

➤ *Palynology of Kombo-001 well.*

Palynomorphs identified in Kombo-001 well are abundant and diverse including gymnosperm and angiosperm pollen, pteridophyte and bryophyte spores, dinoflagellates, foraminiferal test linings, freshwater algae, dinocysts, diatom and fungal spores.

The palynological distribution pattern is presented in distribution chart and shows range and frequency of occurrence with depth of occurrence of the palynomorphs, percentage quantitative composition of environmental indicators comprising of terrestrially derived palynomorphs, marine derived palynomorphs and other palynomorphs are shown in (figures 4 and 5).

A cumulative of 45 (forty-five) pollen species representing 37 (thirty-seven) pollen genera were identified in the studied interval of Kombo-001 well. These species occurred at varying counts at different depths in the studied well and included gymnosperm pollen *Podocarpidites sp.*, and angiosperm pollens such as *Bacutriporites orluensis*, cf. *Bacutriporites orluensis*, *Cinctiperipollis mulleri*, *Corsinipollenites jussaensis*, *Ctenolophonidites costatus*, *Cyperaceapollis sp.*, *Echiperiporites sp.*, *Echistephanoporites echinatus*, *Echitriporites sp.*, *Gemmamonoporites sp.*, *Indeterminate pollen*, *Margocolporites rauvolfi*, *Monoporites annulatus*, *Multiporopollenites sp.*, *Nummulipollis neogenicus*, *Perforitricolpites digitatus*, *Polyadopollenites vancampori*, *polypotetradites sp.*, *Praedapollis flexibilis*, *Proteacidites cooksonii*, *Psilamonocolpites sp.*, *Psilaperiporites sp.*, *Psilastephanocolporites laevigatus*, *Psilastephanocolporites*

*sp.*, *Psilastephanoporites sp.*, *Psilatricolpites sp.*, *Psilatricolporites crassus*, *Psilatricolporites pseudostratus*, *Psilatricolporites rotundus*, *Psilatricolporites spp.*, *Psilatriporites rotundus*, *Psilatriporites sp.*, *Retimonocolpites sp.*, *Retistephanocolporites sp.*, *Retitricolpites sp.*, *Retitricolporites sp.*, *Retitriporites sp.*, *Spirosyncolpites bruni*, *Striatricolporites catatumbus*, *Striatricolporites sp.*, *Syncolporites sp.*, *Triorites festatus* and *Zonocostites ramonae*.

A cumulative of 18 (eighteen) pteridophyte and bryophyte spore species were identified in the studied interval of Kombo-001 well. The spores consist of monoletes spores such as *Verrucatosporites alienus*, *Smooth monolete spore*, *Pilososporites sp.*; trilete spores such as *Crassoretitriletes vanraadshooveni*, *Granulatisporites sp.*, *Echitriletes sp.*, *Foveotriletes sp.*, *Foveotriporites sp.*, *Matonisporites sp.*, *Polypodiaceosporites spp.*, *Retitriletes sp.*, *Smooth trilete spore*, *Triletes sp.*, *Selaginella myosurus*, *Rugulatisporites caperatus*, *Lycopodium sp.*, *Lycopodiumsporites sp.*, and *Aletesporites sp.* (Alete spores).

Other palynomorphs identified include fungal spores such as *Alternaria sp.*, *Brachysporisporites sp.*, *Diporicellaesporites sp.*, *Fungal spore*, *Fusiformisporites sp.*, *Glomus sp.*, *Monoporisporites keonigii*, *Multicellaesporites sp.*, *Multicellites sp.*, *Pluricellaesporites sp.*, *Striadiporites crucistriatus* and *Tetraploa sp.*, freshwater algae such as *Concentricystes circulus* and *Leiosphaeridia sp.*, and diatoms (Figure 4).

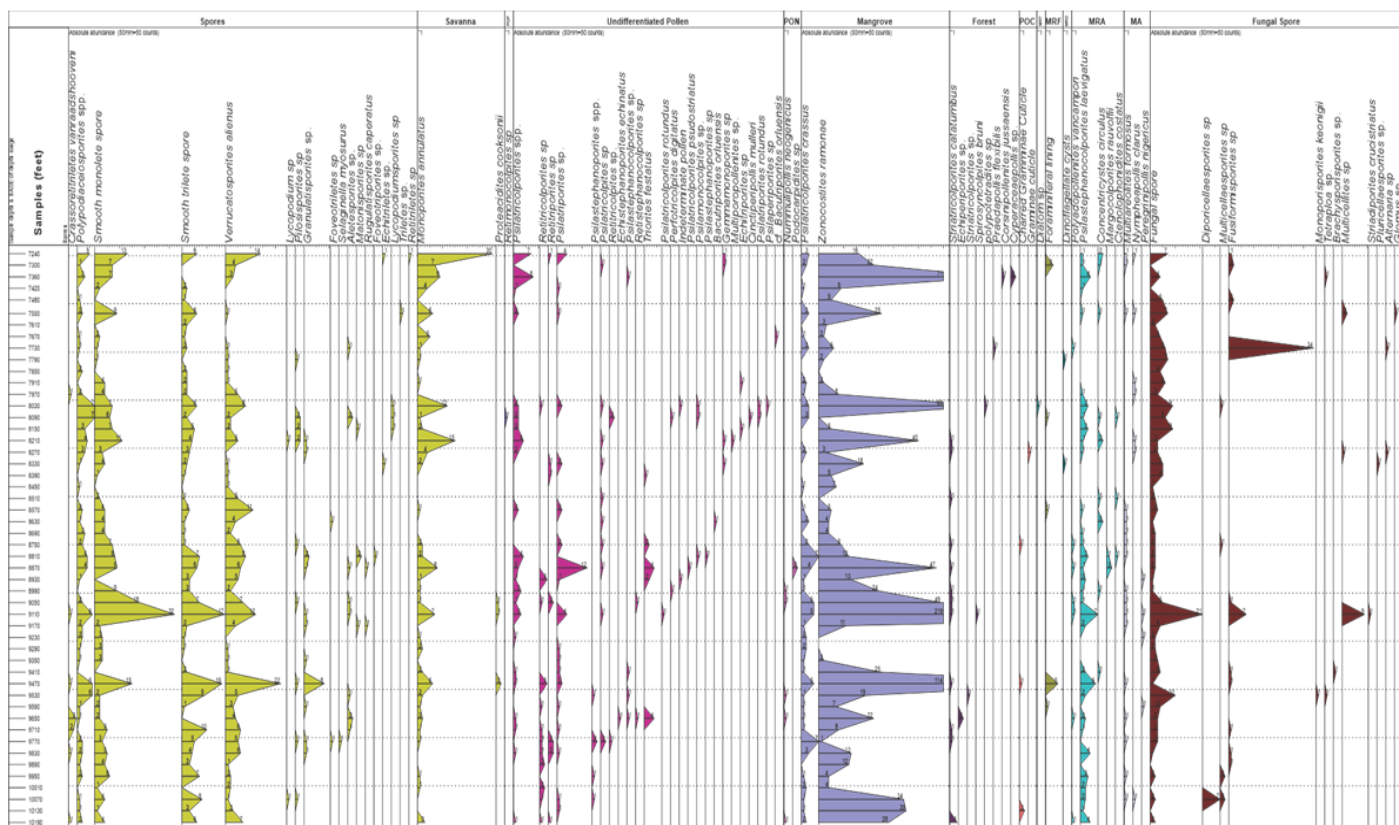


Fig 4 The Palynological Distribution Chart of Kombo-001 Well with Range and Frequency of Occurrence per Sample Depth.

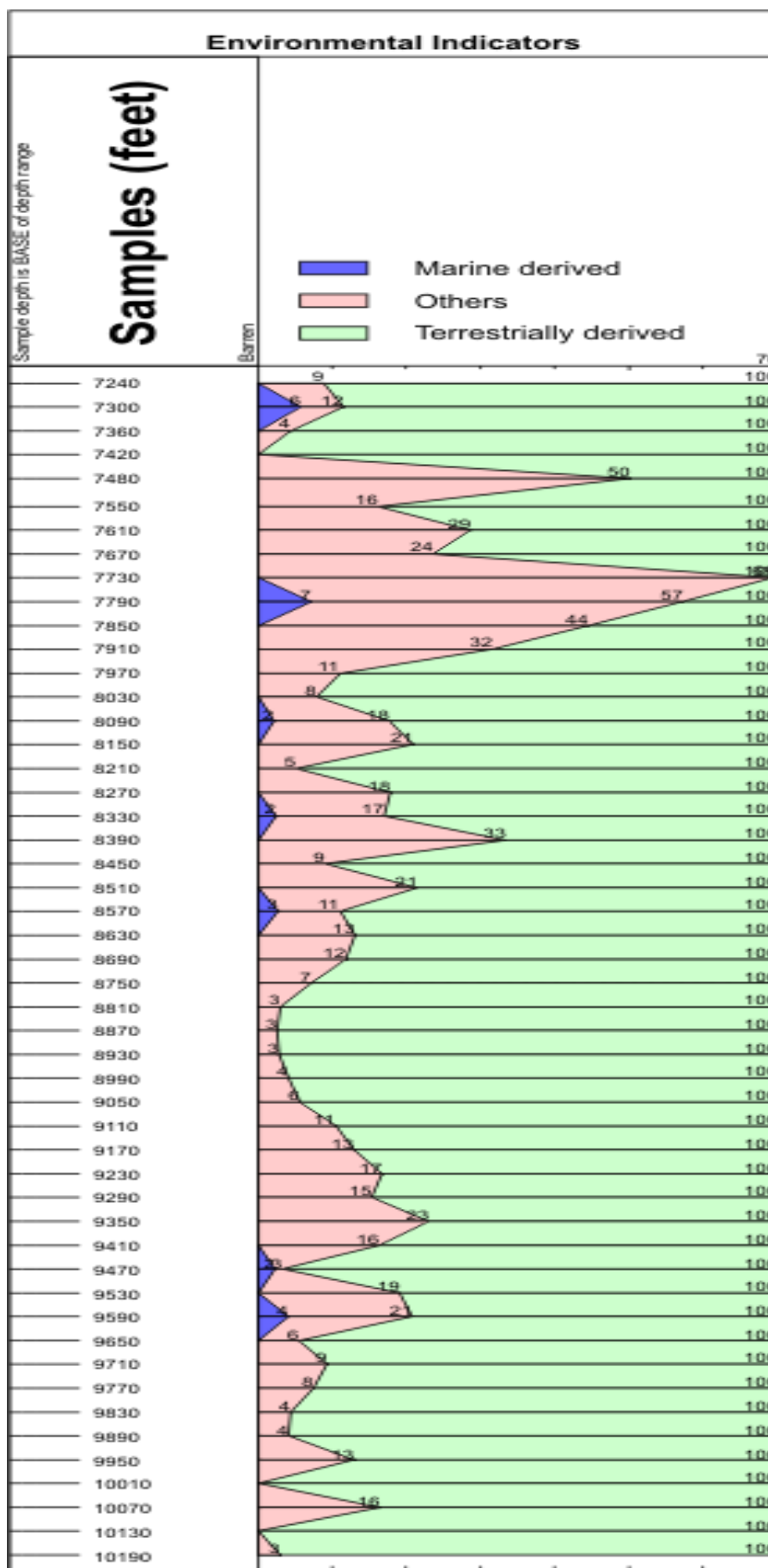


Fig 5 Percentage Quantitative Composition of Environmental Indicators Comprising of Terrestrially Derived Palynomorphs, Marine Derived Palynomorphs and other Palynomorphs Identified in Kombo-001 well.

#### IV. DISCUSSIONS

##### ➤ *Palynostratigraphy of Kombo-001 Well*

Terrestrially derived palynological group (angiosperm and gymnosperm pollen, bryophyte and pteridophyte spores) constitute over 80% of the total palynomorphs recovered at each sampled depth of Kombo-001 well. Marine derived palynomorphs comprising of foraminiferal test linings and dinoflagellates constitute less than 7% of the total palynomorphs recovered in all the sampled and analyzed depths of Kombo-001 well. Other palynomorphs comprising of freshwater algae, fungal spores and diatom constitute mostly 13% of the total palynomorphs recovered in most of the sampled and analyzed intervals in Kombo-001 well (figure 5).

Marine derived palynomorphs comprising of dinoflagellates and foraminiferal test linings are significantly low in occurrence in the studied intervals of Kombo-001 well.

The gymnosperm and angiosperm pollen component of the terrestrially derived palynomorphs were further categorized into pollen groups. The statistics of the different categories of pollens indicated that mangrove pollen species (POM) are the most dominant species in many of the sampled depths. Percentage occurrence of mangrove species of the total pollen species in the studied intervals ranged from above 50% to 100% in many of the studied depths and from about 20% to 46% in few other depths. Savannah and forest pollen species (POS and POF) occurred sporadically but continuously top to base of the studied interval. Quantitative occurrence of Savannah and forest pollen species are low to barren. Maximum occurrences of Savannah pollen species were encountered at the top of the study well with about 46% of the total pollen encountered at the depth. Savannah species ranged between 2% to about 14% in other depths within the sampled intervals. Forest pollen species in the studied intervals ranged from about 1% to 27% with a maximum peak of about 67% at 8510 ft. Other pollen species encountered included montane pollen species (PON) which occurred sporadically in 6 (six) depths within the range of about 1% to 3%, palmae pollen species (POP) which occurred only at 1 (one) depth with about 7% of the total pollen encountered, charred graminiae cuticle (POC) which occurred only in 3 (three) depths, within the range of about 1% to 7% of the total pollen encountered. Other pollen species encountered include undifferentiated species and markers.

Mangrove pollen (POM) dominates the studied interval, followed by savannah pollen (POS), while Palme pollen (POP), montane pollen (PON) and charred graminiae cuticle (POC) are among the least occurring categories.

Statistical compilation of the palynomorphs indicated dominance in terrestrially derived palynomorphs (Pollen and spores) over marine derived palynomorphs (Fig. 5). The pollens are predominantly higher than all other palynological groups in most of the sampled interval as

indicated in the following depths (7240 ft – 7730 ft; 8030; 8210 ft – 8450 ft; 8750 ft – 9170 ft; 9410 ft – 9650 ft; 9830 ft – 9890 ft; 10010 ft – 10190 ft). Pollen and spores showed equal highest occurrences at 7790 ft; 7910 ft and 9770 ft, while spores showed highest occurrences at 7850 ft; 7970 ft; 8090 ft – 8150 ft; 8510 ft – 8690 ft; 9230 ft – 9350 ft; 9710 ft and 9950 ft.

Terrestrially derived palynomorphs (pollen and spore) in the studied interval ranged from 70% - 100% at various depths with significant drop between 7730 ft – 7850 ft, ranging between 31% - 56% in occurrence.

Marine derived palynomorphs (dinoflagellates and foraminiferal test linings) are very rare to barren with sporadic low occurrence. They constitute 0% of the total palynomorphs at many sampled depths and ranged between 2% to 7% at intervals, where they occurred sporadically.

Fungal spore occurrences are low to significant in many of the sampled depths while freshwater algae and diatoms are rare to barren in many of the studied samples.

##### ➤ *Biozonation*

The analysed section of the Kombo-001 well (7240 – 10,190ft) penetrated P800; P820 and P830 palynological zones (Evamy *et al.*, 1978 and Germeraad *et al.*, 1968) in late Miocene age. These palynological zones were subdivided based on their palynofloral characteristics. The boundary between P820 and P830 is marked by the Quantitative Base Occurrence of *Stereisporites sp.* at 9110 ft. The age interpretation was carried out based on the palynofloral assemblage observed in the studied samples as well as identified index marker.

- Detailed Interpretation:
- Interval: 7240 – 9110ft
- P-zone: P830
- Age: Late Miocene

The top of this P830 subzone which is usually defined by the quantitative base occurrence of *Cyperaceapollis spp.* was not encountered, but probably lies above the first depth of the analysed interval. The base is defined by the Quantitative Base occurrence of *Stereisporites spp.* at 9110ft.

This interval is characterised by moderate low occurrences of *Nympheapollis clarus*, *Elaeis guineensis*, low occurrences of *Magnastriatites howardi* and *Multiareolites formosus*, common presence of moderately high occurrences of mangrove taxa (*Zonocostites ramonae*) and savanna elements (*Monoporites annulatus*) and moderate to high occurrences of pteridophyte spores/fungi taxa, presence of rainforest taxa (*Psilastephanocolporites laevigatus* and *Sriatricolporites catatumbus*) co-occurring with low occurrence of fresh water algae (*Botryococcus brauni*)

- Interval: 9110 -10,190ft
- P-zone: P820
- Age: Late Miocene

The top of P820 subzone was defined by the quantitative base occurrence of *Stereisporites spp.* at 9110ft. The base of this zone, which is commonly defined by the quantitative base occurrence of *Multiaerolites formosus* could not be delineated because this event was not encountered, hence it is considered to be below the TD.

This zone is further characterized by the presence of *Nympheapollis clarus*, *Elaeis guineensis*, *Striatricolporites catatumbus*, low occurrences of *Multiaerolites formosus*, *Zonocostites ramonae*, and *Monoporites annulatus*, presence of *Stereisporites spp.*, *Retibrevitricolporites obodoensis*, *Aletesporites spp.*, and *Psilastephanocolporites laevigatus*.

➤ *Depositional Systems And Systems Tracts In Kombo-001 Well.*

The depositional systems and systems tracts in Kombo-001 well are indicated by the nature of the coastal deposition, coastal vegetation, and miospore produced in Kombo-001 well according to Posamentier *et al.* (1988). Generally, 10190 ft to 7240 ft depth intervals in Kombo-001 well showed dominance of freshwater and alluvial swamps miospores such as savannah, freshwater/forest and mangrove suggestive of highstand systems tract (HST). 9470 ft depth interval indicated high Salinity, indicative of

marine incursion according to Rull (1992) and Rayment (1980). This corresponded with dominance in mangrove species over savanna and fresh water/forest pollen species which occurred as a result of steady increase in mangrove species resulting from flooding in the brackish water settings characteristic of the transgressive systems tract (TST) setting. 8630 ft and 7240 ft depth intervals are marked with low salinity. These depth intervals are associated with coastal vegetation marked with increasing savanna and freshwater/forest pollen species indicative of regressive (sea level fall) phase. This sequence is characterized by very low representation of coastal miospores (Mangrove species) with reduced representation of freshwater/forest and increased terrestrially derived palynomorphs from well drained inland settings. The significantly low representation of the coastal miospores (Mangrove and freshwater) results from minor falling sea level which gave rise to shrank brackish water settings in which mangrove thrive (Poumot, 1989). There is a general rhythmic interchange of minor high salinity and low salinity in the studied section of Kombo-001 well. This is indicative of sedimentation within aggradational phase.

The studied section comprised of sequences characterized by highstand systems tract (HST) figure 6.

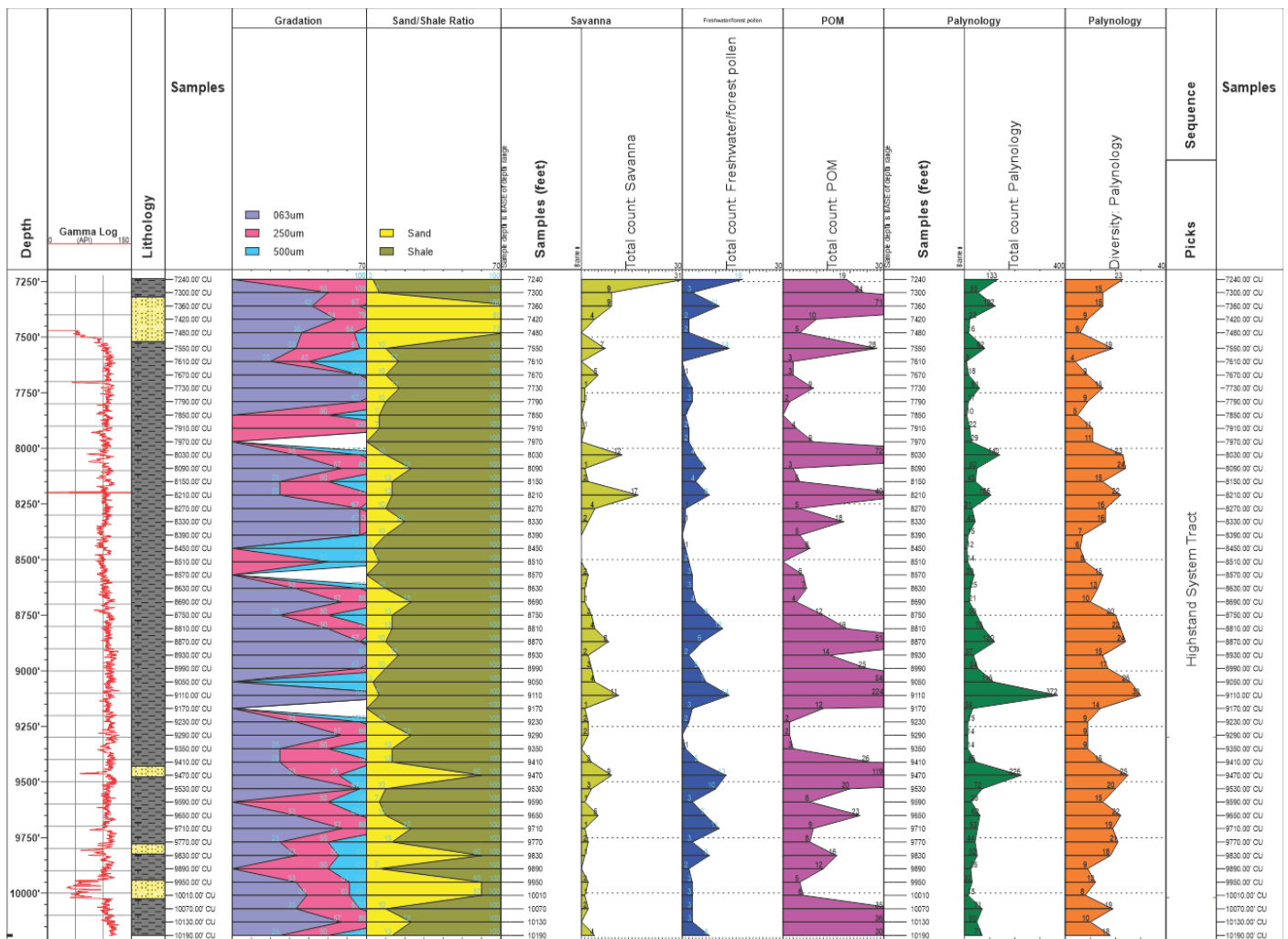


Fig. 6: Significant Principle Components Representing different Vegetation Types (Lower Coastal Plain and Alluvial Plain Components) in Kombo-001 well and Corresponding Systems Tracts.



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