PALYNOFACIES AND SEDIMENTOLOGY OF HB-001 WELL

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ABSTRACT

The palynofacies and sedimentological analyses of the sedimentary succession of the HB-001 well were carried out to establish biozones and the palaeoepisodional environment. Ninety-six samples of ditch cutting within intervals of depth of 1250 - 4011 m were analyzed. Most of the previous researchers established biozones with alpha-numeric method. The use of palynomorphs and palynofacies analyses to delineate paleoenvironment of deposition has been applied to a limited extent in the Niger Delta Basin in Nigeria. The analysis produced fairly diverse and moderately abundant pollen and spores with high recoveries of palynomaceral 1 and 2 and minimal retrievals of palynomaceral 3 and 4. The textural, lithologic, as well as wireline log data point out that the whole studied interval in the HB-001 well fit in to the Agbada Formation. Late Miocene age was assigned on the bases of the analysis of stratigraphic age range of indicative palynological markers for example Zonocostites ramonae, Verrucatosporites sp., Laevigatosporites sp., Monoporites annulatus, Pachydermites diederi and Psila,tricolporites crassus. Two assemblage zones were established in the well with the use of the International Stratigraphic Guide for the biozones establishment. The two recognized palynostratigraphic zones are Cyperaceaepollis sp. - Nymphaeapollis clarus, and Stereisporites sp Zones. Lower delta plain, pro-delta and delta front depositional environments have been deciphered with the use of the palynofacies association, palyno-ecological groupings, and sedimentological features. Bodies of sand that signify sub-environments inside these settings are deposited in sequences. Every sequence begins with a transgressive stage, after that considerable regression. The palyno-ecological groupings of the retrieved palynomorph taxa revealed that the well intervals studied were deposited under alternating wet and dry paleoclimatic settings. The zones of dry climate presented high account of montane and savannah taxa and low incidence of rainforest, mangrove and freshwater taxa. The zones of wet climate signified increased account of rainforest, freshwater and mangrove taxa and lower incidences of montane and savannah taxa.

KEYWORDS

Palynofacies; Biozones; Formation; Palaeodepositional; Sedimentological

1. INTRODUCTION

Precise biozonation and paleoenvironmental analyses within a field or basin have posed a great challenge to hydrocarbon exploration. Therefore, detailed biozonation and paleoenvironmental analyses are necessary for successful exploration. Alpha-numeric biozonation has been utilized by some Niger Delta basin workers, and several other researchers have also established their biozones using the same technique. Thus, a uniform biozonation scheme in accordance with the global stratigraphic guidelines for the creation of biozones is necessary. A group researchers gave details of the use of palynofacies in examining the depositional paleoenvironment (Tyson, 1995; Durugbo and Uzodimma, 2013; Chukwuma-Orij et al., 2017). There are few published works on the integration of palynofacies, pollen of spores biostratigraphy and biozonation, sedimentology of the Paleogene-Neogene Niger Delta. This research was required due to the necessity for an integrated strategy utilizing palynofacies, sedimentology, and wireline logs in the exploration of petroleum for a more positive conclusion.

Some researchers were the first to contribute to our understanding of microflora in Nigeria (Van Hoeken-Klinkenberg, 1964; 1966; Clarke, 1966). Peregrinipollis nigericus was discovered in the Upper Tertiary Niger Delta (Clarke, 1966). In addition, Clarke and Frederiksen discovered and described eight new species of pollen in the sediments of Paleogene-Neogene strata in Nigeria, assignable to three new genera: Marginipolpis, Areolipolis, and Nummulipolis (Clarke and Frederiksen, 1968). They came to the conclusion that the present families Acanthacea and Lecythidaceae are connected to these forms. A group researchers produced the most thorough addition to our understanding of the palynology of the Niger Delta (Germeraad et al., 1968). The palynomorph assemblages of the Tertiary deposits from three tropical regions—parts of South America, Asia, and Africa (Nigeria)—were the foundation for their study. They identified three primary zones: Pan-tropical, Trans-Atlantic, and Intracontinental based on chosen zonal marker species. Palynostratigraphic and paleoenvironmental studies of the eastern Niger Delta basin were conducted (Ajaegwu et al., 2012). The zonation and dating of the studied sections were made possible by the diagnostic palynomorphs that were found. The examined section’s age of Late Miocene to Early Pliocene was determined using the First Appearance Datum (FAD) of Nymphaeapollis clarus and an increase in Monoporites annulatus. The interpretation of the paleoenvironment of the strata that were penetrated by the well, demonstrated that the overall environment ranged from coastal to marginal marine. According to Olayide analysis of the strata in the offshore Niger Delta that were reached by the CHEV-2 well, the sediments were
deposited at the time of the Miocene age (Olajide, 2013). The stratigraphic ranges of Psilatricolporites crassus, Reliricolliporites irregularis, Zonocostites ramonae, Echitricolporis spinosus, Monoporites annulatus, Foveatricolporites crassissius, Multiaerolites formosus, Psilatricolporites operculatus, Podocarpus milanjianus and a number of other marker species were utilized to distinguish five informal palynological zones in the research area. Olotro identified two pollen and spore zones and four dinocysts correspondingly in the Niger Delta Igbomoton-1 well palynological studies (Olotro, 2014). The zonation of pollen and spore is made up of Magnastraetis howardii and Verrucutosporites umensiss zones. The zones are subdivided into the Upper Miocene, Lower Pliocene, and Upper Pliocene to Pleistocene ages. Combined maceral, palynological, and sedimentological data reveals that deposition took place in a marine environment that got gradually shallower up section, near to the shore.

2. THE LOCATION OF STUDY WELL

The Basin of the Niger Delta is situated between latitudes 4° and 6°N and longitudes 3° and 9°E in Southern Nigeria. HB-001 well lies within latitudes 4° 08’ 48.6” N and longitudes 5° 58’ 40.5” E in the shallow offshore of the Western Niger Delta (Figure 1).

2.1 Geology of Niger Delta Basin

The Niger Delta is Nigeria’s most significant sedimentary basin from the perspective of sediment bulk and thickness. Likewise, the region is crucial from an economic perspective as well because of its oil deposits, which account for a sizable portion of the nation’s foreign exchange earnings. There is general agreement that the current Niger Delta was built on an oceanic crust from pre-continent drift, which suggests that NE Brazil had a significant impact on the current Niger Delta (Stoneley, 1966). Other geological and geographical observations include the existence of a series of linear, subdued, and alternately negative and positive anomalies underneath the Niger Delta, which interpreted as seafloor spreading lineation (Burke et al., 1971; Mascle, 1976).

Three major sequences of sedimentation have been recognized in the Niger Delta in addition to other sections of the southern Nigerian Sedimentary Basin (Murat, 1972; Short and Staud, 1967). These are the:

i. Lower Cretaceous to Santonian Cycle (oldest);
ii. Campanian to Paleocene Cycle; and
iii. Paleocene/ Lower Eocene to Date Cycle (youngest)

The majority of the delta’s expansion can be attributed to the third sedimentary period, which started in the Paleocene/Early Eocene. The youngest (Tertiary) sedimentary cycle’s thick sequence of rocks encloses the region where the Niger Delta oil province and its lucrative oilfields are located. The Niger Delta exhibits the three primary depositional environments typical of deltaic settings (marine, paralic, and continental) (Murat, 1972; Evamy et al., 1978).

![Figure 1: Location Map of the study area in the superficial offshore depobelt of the Niger Delta (Samuel, 2009; Oluwajana, 2019)](image)

3. MATERIALS AND METHODS

Ninety-six (96) samples of ditch cutting and wireline logs within intervals of depth of 1250 - 4011 m provided by Shell Production and Development Company, Nigeria were employed for the analyses. The laboratory analyses and sample preparation for the study were performed at Crystal Age Limited, Lagos, Nigeria. The descriptions of lithology were done mostly by examining the signatures of the gamma-ray log, the ditch cuttings samples physical examination, along with microscopic analysis of the washed samples. Low and high values of gamma-ray logs indicate sandstone and shale lithologies, respectively (Olayiwola and Bamford, 2016). The upward coarsening and fining signatures of the gamma ray logs indicate coastal and marine environments.

The samples were cleansed with distilled water and the carbonates were sieved out. This was trailed by adding thirty millilitres (30 ml) of 40% hydrofluoric (HF) acid so as to remove the inorganic silicate from the samples. The samples were washed with distilled water thrice and then sieved by means of 5 and 10μm mesh sieves. Under a light microscope, the samples were examined, identified, and counted (Erdtman, 1952; Gonzalez-Guzman, 1967; Germeraad et al., 1968; Knaap, 1971; Legoux, 1978; Adegboke et al., 1978; Jan du Chene et al., 1978; Salard-Cheboldaef, 1975, 1976; 1978; Salami, 1983; Agip, 1987).

4. RESULTS AND DISCUSSION

4.1 Lithologic Description and Sedimentological Analyses

Sand and shale units alternate within the lithology, indicating rapid coastline progradation. In the bottom of the well, the grain size is...
predominantly fine to medium, with occasional coarse to granule-sized grains. At the top of the well, the grain size is predominately fine to medium, with occasional coarse to granule-sized grains. The majority of the sands have sub-angular to sub-rounded edges, are infrequently rounded, and are often weakly to fairly sorted. Ferruginous debris, carbonaceous detritus, glauconite pellets, shell pieces, and pyrites predominate among the accessory minerals, with sporadic occurrences of mica flakes (Figure 2). The combination of wire line log motifs, lithologic/textural attributes and the circulation of the accessory materials were used to make sedimentological deduction. As a result of the deductions, the Agbada Formation was able to be assigned to the entire examined section (1250–4011 m) of the HB-001 well. These criteria allowed for the identification of two major lithofacies sequences within the well section: The Marine Paralic and Paralic Lithofacies Sequences (Figure 2). The majority of the sands in the Paralic Lithofacies Sequences are quartzose, slightly feldsparic, fine to medium in size, infrequently very coarse to coarse in size, and granular. Sands are typically weakly to well-sorted and are intercalated with relatively thick layers of shales.

4.2 Palynofacies

The diverse palynomorph taxa in addition to the varieties of palynomacerals recovered from the examined intervals are shown in figure 3. Moderately varied and fairly abundant palynomorphs were recognized. There is a high retrieval of palynomaceral 1 and 2 with palynomaceral 3 appearing at low occurrences.

4.2.1 Palynomaceral 1 (PM 1)

The retrieved palynomacral 1 (Alganite) from this research looked to be dense, opaque, structureless, irregular in shape, and orange brown to dark brown in color. It is diverse, of higher plant origin, and some of it is the result of exudation activities, like the plant detritus gelification in sediments. Palynomaceral 1 comprises irregularly shaped resinous cortical materials, tiny, medium, and large sizes of flora debris, and compounds that resemble humic gel.

4.2.2 Palynomaceral 2 (PM 2)

As of this research, palynomaceral 2 (Exinites) is an irregularly shaped, brown-orange structural substance. It contains algal debris, platy-like structural plant materials, a trace amount of humic gels, and resinous compounds. Being thinner than Palynomaceral 1, it is more buoyant than Palynomaceral 1.

4.2.3 Palynomaceral 3 (PM 3)

The retrieved palynomaceral 3 (Vitrinite) from this investigation has a color ranging from white to brown, is rather thin, has an irregular shape, is translucent, and includes stomata dispersed throughout. Degraded aqueous plant material and structured plant material, primarily of cuticular origin. It floats higher than Palynomaceral 2.

Figure 2: Sedimentological and Lithologic chart of HB-001 well

The Marine Paralic Lithofacies sequences are primarily composed of shales with intercalations of relatively thin sand. Sands are primarily quartzose, somewhat feldsparic, fine to medium-grained, sporadically coarse to very coarse-grained, and moderately to well-sorted between 2573 and 3559 meters. Below 3559 m, sands are quartzose, fine to medium, intermittently coarse-grained as well as well sorted.

4.2.4 Palynomaceral 4 (PM 4)

The palynomaceral 4 (Inertnite) found in this study is made up of opaque, blade-shaped components that range in color from black to dark brown and have no discernible structure. Compressed humic gels, charcoal, and geothermally fused material make up this substance. Its substance is formed like a blade or a needle.

Figure 3: Palynofacies and palynomorphs distribution chart of HB-001 well

Palynomaceral 4 has a blade-like or equidimensional form and is resistant to deterioration. As a result, they are frequently moved over great distances. In an environment with strong energy, PM 4 predominates.

4.3 Palynostratigraphic Zonation and Biochronology of HB-001 Well

The Stereisporites sp. assemblage zone and the Cyperaceaepollis sp. – Nymphaeapollis clarus assemblage zone were recognized as two assemblage zones in the HB-001 well (1250 - 4011 m). The palynoflora assemblages of marker and associate marker species identified in the well were used to achieve this. Based on the determined age range of marker and related marker species that defined the body of strata, the assemblage biozones were created (Murphy and Salvador, 1999). The two (2) subzones subdivision of the assemblage zones are the Nymphaeapollis- Echitriletes pliocenicus subzone (1250 - 2896 m) and the Cyperaceaepollis- Elaeis guineensis subzone (2896- 3833 m).

Cyperaceaepollis sp. - Nymphaeapollis clarus Assemblage Zone

Depth: 1250 - 3833 m

Age: Late Miocene

Echitriletes spinosus zone of P860 palynological subzone, and P850- P840 palynological subzone are comparable palynological subzones (Germeraad et al., 1968; Evamy et al., 1978). With a succession of shale and argillaceous sandstones that is roughly 2583 m thick, this assemblage biozone is the youngest in age. The interval was marked by the palynoflora marker species Cyperaceaepollis sp., Nymphaeapollis clarus, Echitriletes pliocenicus, and Elaeis guineensis. This assemblage zone has the stratigraphically relevant ranges of the important marker species Cyperaceaepollis sp. and Nymphaeapollis clarus. It is possible that the true top of the zone is stratigraphically higher than the first sample, which was examined at 1250 m, based on the presence of Cyperaceaepollis sp. (1387 m), which is close to the measured top of the well. The base occurrence of
Cyperaceaepollis sp., designated at 3833 m, establishes the lower limit. Abundant prevalences of Verrucatosporites sp., Monoporites annulatus, Zonocostites ramonae, Laevigatosporites sp., Palistrichopollenites crassus and Pachydermites diecidri quantitatively typified the biozone. Two (2) subzones are recognizable inside this assemblage zone and discussed below:

Nymphaeapolls clarus - Echitricolporites spinosus subzone
Depth: 1250 - 2896 m
Age: Late Miocene (Messinian-Tortonian)

The base of the subzone is indicated by the location of Nymphaeapollls clarus, which has been determined to be at 2896 m. The Zonocostites ramonae, Verrucatosporites sp., and Retricticolporites irregularis are abundant in the Nymphaeapollls clarus-Echitricolporites spinosus subzone, while Peregrinipollis nigericus and Echitricolporites spinosus are scarce to uncommon and Sapatoceae and Nymphaeapollls clarus are both frequently found. This subzone connects with the P860 subzone and the Echitricolporites spinosus palynological zone (Evamy et al., 1978; Gemmerraad et al., 1968).

Cyperaceaepollis sp. - Elaeis guineensis subzone
Depth: 2896 - 3833 m
Age: Late Miocene (Tortonian)

The base occurrence of Nymphaeapollls clarus at 2896 m marks the top of this subzone. The Cyperaceaepollis sp. base occurrence, designated at 3833 m, serves as a marker for the base. This subzone was further characterized by the presence of Elaeis guineensis, the sparse prevalence of Magnastraatites howardii and Echitricolporites estelae, and the reduced abundance of Verrucatosporites sp. and Acrostrichum aureum. This subzone is related to the P850-P840 (undifferentiated) subzone of and the Echitricolporites spinosus palynological zone described (Evamy et al., 1978; Gemmerraad et al., 1968).

Stereisporites sp. Assemblage Zone
Depth: 3833- 4011 m
Age: Late Miocene (Tortonian)

This zone has been linked to the P830 palynological subzones and the Echitricolporites spinosus zone (Evamy et al., 1978; Gemmerraad et al., 1968). The presence of marker species like Stereisporites sp., an abundance of Corylus sp., and Pachydermites diecidri are characteristics of this assemblage zone.

4.4 Palaeoenvironment of Deposition

Palaeoenvironment of deposition is used to infer the periodic changes in the depositional environment over geologic time. Understanding different depositional settings and the characteristics of their reservoirs, such as porosity, permeability, and architecture, requires the interpretation of paleodepositional environments. Quantitative variations of the palynoecological groups of the investigated palynomorphs; they include Botryococcus brauni, Cyperaceaepollis sp., Pachydermites diecidri, and Zonocostites ramonae (Table 1).

Freshwater swamp taxa have the highest representation of all recovered palynomorphs, according to the examined well, which is followed by mangrove and savannah taxa. When the freshwater and rainforest swamps get larger and the sea level drops, the amount of mangrove pollen will increase (Figure 5) (Morley, 1995 and Rull, 2002). The lack of dinocysts and poorly sorted palynomacerals 1 and 2 are characteristics of coastal habitats, as are frequent to abundant fungal spore occurrences.

Upper delta plain forms as a result of sea level rise and is regulated by freshwater and alluvial wetland (Adojoh et al., 2015). When the freshwater and rainforest swamps get larger and the sea level drops, the amount of mangrove pollen will increase (Figure 5) (Morley, 1995 and Rull, 2002). The lack of dinocysts and poorly sorted palynomacerals 1 and 2 are characteristics of coastal habitats, as are frequent to abundant fungal spore occurrences.

Figure 4: Palyno-ecological groups (%) of palynomorphs from HB-001 well

Small to medium organic matter that is well sorted, common to abundant palynomacerals 1 and 2, some needle- to lath-shaped palynomacerals 4, and the presence of foraminiferal linings and dinocysts are all indicators of the maritime environment (Oyede, 1992). Ferruginous materials, shell pieces, and carbonaceous detritus are the index minerals that are frequently found in shallow water habitats. Deeper water conditions can be identified with indicator minerals including mica flakes, pyrites, and glauconite pellets (Selley, 1978). For the examined intervals of the HB-001 well, lower delta plain to delta front and prodelta environment within coastal deltaic to shallow marine environment of deposition were inferred (Figure 5 and Table 2).

Figure 5: General Correlation between Palaeovegetation, Palaeoecology, Eustasy and Climate in the Tropical Setting (Adojoh et al., 2015 and Chukwuma-Orji et al., 2017)
ojoh et al., 2015; Olayiwola and

Abundant freshwater algae, Botryococcus brunii was discovered throughout the lithology. The sands display funnel-like environment known as the foreshore (Figure 4). These deductions are justified by:

<table>
<thead>
<tr>
<th>Sample depth (meter)</th>
<th>Palynomorphs</th>
<th>Palynomorphs</th>
<th>Palynomorphs</th>
<th>Palynomorphs</th>
<th>Palynomorphs</th>
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<th>Palynomorphs</th>
<th>Palynomorphs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Polyadapollis sp</td>
<td>Echinothamnites sp</td>
<td>Psilatricolporites crassus</td>
<td>Verrucatosporites sp</td>
<td>Bamburaspores sp</td>
<td>Total Montane taxa</td>
<td>Total Montane taxa</td>
<td>Total Montane taxa</td>
</tr>
<tr>
<td>125 – 0</td>
<td>28</td>
<td>28</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>20</td>
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<tr>
<td>194 – 4</td>
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<td>1</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>202 – 7</td>
<td>12</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>2</td>
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<tr>
<td>262 – 1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
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<td>13</td>
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<tr>
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<td>1</td>
<td>4</td>
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<td>5</td>
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<td>1</td>
<td>6</td>
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<td>381 – 0</td>
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<td>1</td>
<td>3</td>
<td>7</td>
<td>2</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>401 – 1</td>
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<td>1</td>
<td>7</td>
<td>13</td>
<td>3</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 1: Palyno-ecological Groups of Palynomorphs from some selected depths in HB-001 Well

The intervals are characterized by high incidence of taxa of freshwater swamp, afterward mangrove, savanna and rainforest swamp taxa amid nominal existence of montane taxa (Adojo et al., 2015; Olajiwola and Bamford, 2016). Zonocostites ramosae, Sapotaceoidaeapollenites sp., Retitricolporites irregularis, Psilatricolporites crassus, Verrucatosporites sp., Acrostichum arehurem and Laevigatosporites sp. are the exemplars of the recorded taxa. Abundant freshwater algae, Botryococcus bruni was discovered throughout these intervals, which indicates a significant inflow of freshwater; Poorly sorted, small to big palynomacerals I and II are frequently to frequently found, together with tiny to frequently occurring, small to medium sized PM III and IV (Oyede, 1992). The sands display funnel- and cylinder-shaped Gamma ray log patterns, which point to lower deltaic plain distributary mouth and distributary channel bar deposits (Sneider et al., 1978). Pebbly to fine-grained sands that have been weakly sorted and with modest shale intercalations make up the majority of the lithology.

Table 2: Depositional Environment in HB-001 Well

<table>
<thead>
<tr>
<th>HB-001 well intervals (m)</th>
<th>Inferred environment of deposition</th>
</tr>
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<tbody>
<tr>
<td>1250 – 1768</td>
<td>Delta plain (lower delta plain/foreshore)</td>
</tr>
<tr>
<td>1768 – 2573</td>
<td>Subaqueous delta plain (delta front/upper shoreface)</td>
</tr>
<tr>
<td>2573 – 4011</td>
<td>Subaqueous delta plain (delta front to prodelta/upper shoreface to proximal offshore)</td>
</tr>
</tbody>
</table>

The sequence contains abundant accessory minerals, with shell fragments, carbonaceous detritus, mica flakes, and ferruginous elements predominating. Glauconite pellets indicate shallow water clastic inflow (Selley, 1975).

The intervals of the HB-001 well between 1768 and 2573 m were thought to have been deposited in a delta front environment. This corresponds to upper shoreface (Figure 4). These deductions are justified by:

Savanna taxa are more common during the intervals, which are composed primarily of abundant freshwater marsh and mangrove swamp taxa. Taxa from the montane and rainforest swamps are rarely represented. Examples of taxa found in the intervals include Botryococcus braunii, Sapotaceoidae pollensites, Monospores ramoneae, Pollarcitoceras crassus, Retribritelliporites prostrudens, and Monosporites annulatus.

Poorey sorted, small to big palynomacerals I and II that are frequently to occasionally present, and few palynomacerals III and IV (Oyeade, 1992):

The main funnel, cylinder, and smallest bell-shaped motifs in the log characteristics of the intervals suggest deposition in the delta front and range from barrier bars, distributary channels, and tidal channel (Snieder et al., 1978 and Beko and Oti, 1995). The shale is moderately firm, grey, platy to flaggy, ranging in color from dark grey to brownish grey. Uncommon to common ferruginous minerals and infrequent to abundant carbonaceous detritus indicate shoreface deposition (Selley, 1978).

The lowermost portions of the HB-001 well, the intervals 2573 - 401 m, were designated to be deposited in a delta front to prodelta depositional environment. The similar environment is the lower shoreface to proximal offshore (Figure 5). These standards govern this inference:

At the intervals with increased prevalence of rainforest swamp species, there is a strong dominance of freshwater swamp and mangrove swamp taxa. Savanna and montane taxa are less prevalent, implying proximate offshore (Adojo et al., 2015; Olajiwola and Bamford, 2016):

Palynomacerals I and II are small to large, somewhat sorted, common to abundant, and have widespread palynomacerals IV (Oyeade, 1992):

The sands are sub-angular to sub-rounded, milky white, fine to medium grained, intermittently very coarse to coarse grained, moderately to highly sorted, and fine to medium in texture. The shale is silty, platy to flaggy, somewhat hard, and dark grey to grey in color. Guide minerals are subjugated by ferruginous materials carbonaceous detritus and glauconite pellets which indicates barrier bar/outer shelf source (Selley, 1978). The multiserrate upward coarsening, cylinder, and fining upward outlines are barrier bars, subaqueous channel, and tidal channel deposits, according to the sand’s log characteristics. The sediments of those intervals are deposited down in coastal deltalic to inner shelf settings.

5. CONCLUSIONS

Palynofacies, sedimentological and paleoenvironmental analyses were conducted in sedimentary sections penetrated in HB-001 well, with the usage of samples from ditch cutting and wireline logs given by Shell Production and Development Company. Palynomacerals 1 and 2 were found in large sizes, and palynomacerals 3 and 4 were found infrequently to frequently. Rapid coastal progradation is revealed by the observed lithological alternation of sand and shale units. Ferruginous materials, glauconite pellets, carbonaceous detritus, shell fragments, and pyrites are the most prevalent index minerals and accessories, with sporadic occurrences of mouse flakes. The whole interval examined in the HB-001 well is believed to represent a part of the Agbada Formation based on the lithologic, textural, and Gamma Ray Log data. Two palynostratigraphic zones were delineated in the well using the worldwide stratigraphic guide. The stratigraphic age range of the recovered diagnostic marker species implies Late Miocene age for the examined periods. With the help of palyno-ecological groupings, palynofacies associations, and sedimentological features, the lower delta plain, delta front, and pro-delta environments of deposition have been effectively explained. The recovered palynomorph taxa’s palyno-ecological groupings demonstrated that the examined well intervals were formed under a cycle of wet and dry paleoclimate conditions.

REFERENCES


