



# **Geology, Palynomorphs Distribution, Stratigraphy and Depositional Environments of Lewumeji and Idogun Wells, Eastern Dahomey Basin Southwestern, Nigeria**

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### **Authors' contributions**

*This work was carried out in collaboration between both authors. Author OCA designed the study, wrote the protocol, manage the literature search, manage the analyses of the study, read, correct and supervise the final draft manuscript. Author CBO collected the core samples, did the litho logy description and palynological analysis under the supervision of author OCA wrote the first draft of the manuscript and performed the statistical analyses where necessary. Both authors searches, read and approved the final manuscript.*

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## **ABSTRACT**

Selected composited samples from Lewumeji (0-111m) and Idogun (0- 54m) wells, from Abeokuta Group, Eastern Dahomey Basin, Nigeria, were subjected to detailed lithologic and palynological studies. The studies aimed at determining the lithological sequence, relative age, palynological zone and paleoenvironments of deposition. The core samples were subjected to lithological description and palynological analysis using standard procedure in order to determine palynomorphs contents such as pollen, spore and dinoflagellates. The lithologies from both wells consist of reddish to brown clay, reddish to brown colour, rounded to sub rounded sandstone, dark grey shale denoting possibly fluvial, brackish, lagoonal and marine environments. A total of 31 well

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preserved low to moderate diverse palynomorphs were recovered from the studied area. The palynomorphs frequency percentage distribution shows that both wells have a higher ratio of land-derived pollen and spores to the marine dinoflagellates; (75%, 25% and 61%, 39%) for Lewumeji and Idogun wells respectively. The microfossil assemblages include abundant *Cyathidites* sp., *Cyathidites minor*, *Tubistephanocolpites cylindricus*, *Proteacidites* sp., Trilete spore, *Foveotriletes margaritae*, *Monocolpites marginatus*, *Monoporites annulatus*, *Pteris* sp, *Distaverrusporites simplex* and *Laevigatosporites* sp. The dinoflagellates recovered were characterized by the likes of *Leiosphaeridia* sp., *Senegalinium* sp., *Oligosphaeridium* sp., *Paleocytodinium* sp., *Cerodinium* sp. and *Subtilisphaera* sp. The wells fall within *Cyathidites Minor* zone, characterized by the diagnostic occurrence of *Cyathidites minor*, *Cyathidites* sp. and *Monocolpites marginatus* dated Upper Maastrichtian to early Paleocene. Paleoenvironmental interpretations based on the abundance of freshwater swamps pollen and Spores, diagnostic dinoflagellates cyst and the Palynomorphs Marine Index (PMI) are suggestive of environmental settings that vary from continental to brackish water and shallow marine.

**Keywords:** *Palynomorphs Marine Index (PMI); lithostratigraphy; palynology; paleoenvironment.*

## 1. INTRODUCTION

The applications of biostratigraphy in the palynological studies have become valuable tools for evaluating the stratigraphy and source rock potential of sedimentary basins. These microfossils include the modern and fossil pollen, spores and dinoflagellates cysts. This marker species gives reliable and accurate information about paleoenvironments. When these markers are efficiently utilized, many of the hindrances encountered in paleoenvironmental synthesis such as age, stratigraphic correlation as well as depositional environments can be avoided [1]. The study area, Lewumeji and Idogun wells, falls within the Abeokuta Group of the Eastern Dahomey Basin (Figs. 1, 2). The Abeokuta Group which comprises of three (3) formations has the oldest formation (Ise Formation) in the Dahomey Basin, Nigeria and it lies non-conformably on the basement [2]. Abeokuta Group has an average thickness of 200m onshore and increases up to 1000m offshore [3,4]. The basin is a pre-cratonic basin that was developed during the initiation of rifting associated with the opening of the Gulf of Guinea in late Jurassic to early Cretaceous [5,6]. [7] Illustrated and described the lithostratigraphy of the basin to be dominated by continuous alternation of sandstone and shale with minor proportions of limestones and clay.

Several workers have carried out researches to characterise and deduce the age of the sediments in the basin [8,9,10,11]. Also, the

stratigraphy of the Dahomey Basin has been well established by different authors [2,8,12,13,14]. The studied wells are situated between latitudes 06°30'0" N - 06°37'0"N and longitude 04°45'0" E - 05°00'0"E and falls within the Abeokuta group of the Eastern Dahomey Basin (Figs.1 and 2). The present study aimed at employing palynological, lithostratigraphic and biostratigraphic data to corroborate the existing literature by enhancing the detailed general lithological descriptions age dating, biozonation, interpretation of the environment of deposition and possible correlation of the sediments of Lewumeji (0.00 – 111.00m) and Idogun wells (0.00 – 54.00m).

## 2. METHODOLOGY

The core samples used for this study were collected from the Bitumen project base Ore in Ondo state, Nigeria. The cores were sampled at every 3.0 meters interval from top to bottom of the Boreholes. A total of four composited samples from the Lewumeji well and five composited sample from Idogun well were used for this study.

### 2.1 Lithologic Description

Detailed lithologic descriptions were made for the core samples, using standard methods; magnifying lens, reaction with dilute HCl, and physical examination. The description was based on rock texture, fissility, colour, fossil content and whether they are carbonaceous or not.

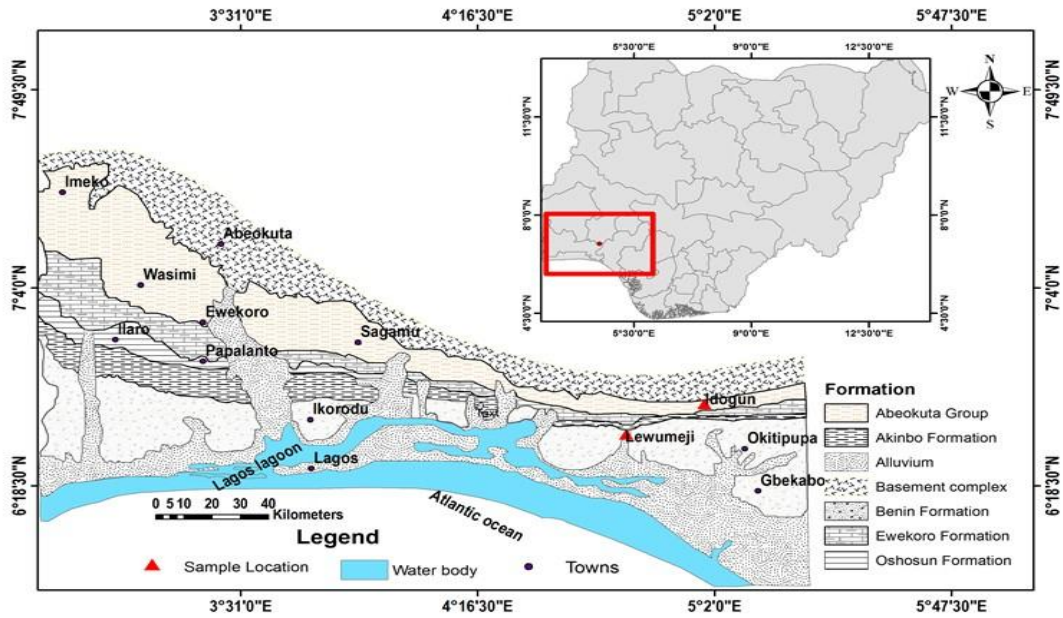


Fig. 1. Map of Nigeria showing the study area and the geological scheme of the Dahomey Basin (modified from [13])

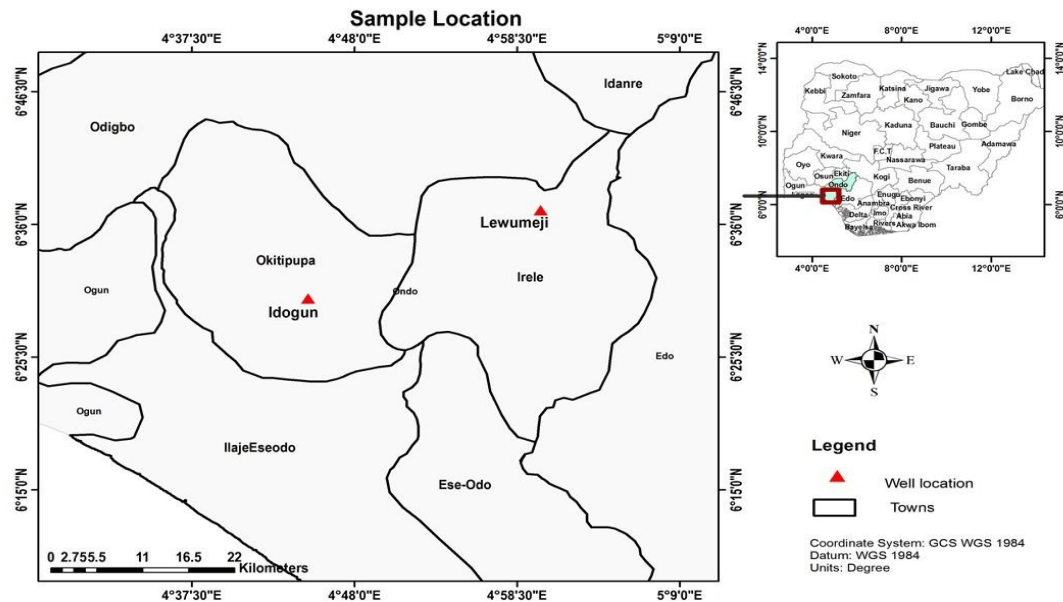


Fig. 2. Location map of the exploration wells for this Study, Eastern Dahomey basin, Southwestern Nigeria. (Inset map illustrates the position of Dahomey basin in Nigeria)

## 2.2 Palynological Analysis

The purpose of palynological preparation is to separate the fossil palynomorphs from the rock or sediment matrix. A standard extraction method

was used. 10 g of each sample was weighed, gently crushed to avoid deforming the palynomorphs, and poured into a well-labelled plastic beaker and placed in a fume cupboard. Each sample was digested with 10%

hydrochloric acid (HCl) for about 15 minutes for carbonate removal and soaked overnight with 40% hydrofluoric acid (HF) for the removal of silicate. From the preceding preparatory stage, a drop of potassium chlorate (KClO<sub>3</sub>) was added, which was stirred and left for about 5 minutes so as to render the organic matter more translucent, so that the exine structural details of the palynomorphs will be clearer. It was then rinsed twice to remove the KClO<sub>3</sub>. A 5-micron sieve was then used under a Branson sonifier to wash out the inorganic matter (mud and clay). The recovered organic matter were uniformly spotted and arranged in a cover slips and then mounted on glass slides with the aid of Norland optical adhesives. The slides were then studied was then deposited on the slides to be used. The slides were studied under transmitted light microscope to obtain the palynomorphs images.

### 3. RESULTS AND DISCUSSION

#### 3.1 Lithological Description

The nine composited samples of the studied sections of Lewumeji and Idogun wells were carefully studied based on their Lithology, three litho units were identified in the study wells. All the three units occur in Idogun well with the alternation of shale and sandstone while two units occurred in Lewumji well with a little clay intercalation. The three litho-units are sandstone, clay and shale. The descriptions of the facies are presented below and shown as Figs. 3 and 4.

##### Litho description of Lewumeji well

Litho unit 1 (0-15m)

This unit is on the topmost layer. The sandstone is reddish brown at the upper part of the unit then a light brown at the base of the layer. It is fine to medium size grains. The unit is 15m thick and was deposited in a fluvial environment. This is further corroborated by the palynological study carried out which revealed the presence of an angiosperm pollen *Tubistephanocolpites cylindricus*

Litho unit 2 (15 – 111 m)

This unit is 96m thick. It is composed of dark to greyish, fissile to non- fissile, carbonaceous shale. Also, the occurrence of *micro wall lining* and *Laevigatosporites* spp., which are terrestrially derived miospore within the interval suggests a mixed environments.

##### Litho descriptions of Idogun well

Litho unit 1 (0 -9m)

This unit is 9m thick, it is reddish brown, non-carbonaceous silty clay. This litho unit portrays a mixed depositional environment in which there is a strong influence of tidal influence on fluvial setting (Laggonal environment).

Litho unit 2 (9 – 15m)

This interval is composed of fine to medium grain sandstone with evidence of whitish shelly material in some horizons. It is 6m thick and reddish brown to brown colour. The sediment is believed to be of fluvial environment.

Litho unit 3 (15 – 24m)

This unit which is about 9m thick. It is shaly, dark grey in colour, non- fissile and could have been deposited in a marine environment.

Litho unit 4 (24 – 42m)

This unit is made up of grey coloured sandstone. Fine to medium grained. The occurrence of *Monocolpites marginatus*, *Tubistephanocolpites cylindricus* also suggests deposition in a fluvial environment.

Litho-unit 5 (42 -54m)

This interval consists of a dark to greyish, carbonaceous, non- fissile shale. The unit is about 9m thick and the high occurrence of dinoflagellates cysts like *Senegalinium* sp, *Paleocytodinium* sp, *Subtilisphaera* sp. confirmed a marine setting for this interval.

#### 3.2 Palynological Studies

Analytical breakdown of the palynomorphs showed that the samples are well preserved with a low to moderate occurrence and moderately diverse pollen, spores and the dinoflagellates. Some of the palynomorphs recovered in Lewumeji well are *Tubistephanocolpites cylindricus*, *Proteacidites* spp., *Monocolpites marginatus*, *Cyathidites* spp., *Laevigatosporites* spp., *Cyathidites minor*, *Leiosphaeridia* spp. and marine diagnostic species *micro foraminiferal wall lining* were recorded. palynomorphs recovered in Idogun well are *Monoporites annulatus*, *Monocolpites marginatus*, *Proteacidites* spp., *Foveotriletes Margaritae*, *Mauritiidites lehmani*, *Tubistephanocolpites cylindricus*, *Cyathidites*

spp., *Laevigatosporites* spp., *trilete* spore, *Distaverrusporites simplex*, *Pteris* spp., *Leiosphaerida* spp., *Cerodinium* spp., *Oligosphaeridium* spp., *Paleocystodinium* spp., *Senegalinium* spp. *Subtilisphaera* spp. and marine diagnostic specie *micro foraminiferal wall lining*. The marine dinoflagellates cyst makes up to 39%, while the pollen and spores make up to 27.77% and 33.3% respectively of the total palynomorphs in Idogun well while the marine dinoflagellates cysts make up about 25%, while the pollen and spores makes up to 33.33% and 41.66% respectively of the palynomorphs in Lewumeji well.

**3.2.1 Palynological zones and correlation**

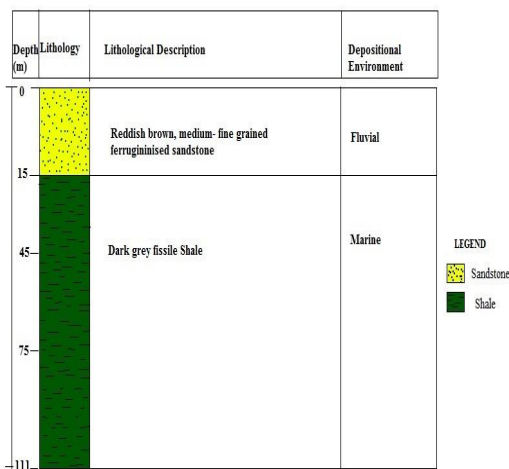
The erection of biozonations is dependent on the evolution, extinction and quantitative occurrence of marker forms present in the sediments [18]. The palynological interpretation of the analyzed interval was based on diagnostic marker species. For the entire section of the Lewumeji (0 – 111m) and Idogun (0 -54m) wells, the recovered palynomorphs enabled the delineation of one major zone which is the Cyathidites minor Assemblage zone, based on the abundance of Cyathidites minor, Cyathidites sp and Monocolpites marginatus this erected zone can also be correlated with Spinizonocolpites bacculatus zone of Lawal and Moullade [16]. The details of the palynological zones recognized for Lewumeji and Idogun well are discussed below and shown graphically in the palynology distribution chart (Fig. 5 to Fig. 8). The chart shows the ages of the recovered palynomorphs

and the Index palynomorphs which marked the zones as recorded in the bio-event section of the chart. The basis of characterizations of Lewumeji and Idogun wells are given below:

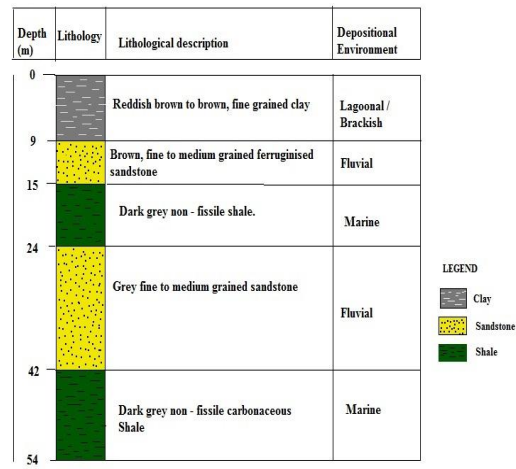
**Zone:** Cyathidites minor Assemblage zone  
**Interval:** 0.00m – 111.0m; 0.00m – 54.0m  
**Age:** Upper Maastrichtian –Paleocene

**3.2.2 Characteristics**

For the Lewumeji well, the zone is marked at the base (75.00-111.00m) by the abundance *Cyathidites* sp, *Cyathidites minor*, *Tubistephanocolpites cylindricus*, and the acritarch *Leiosphaeridia* Sp. The part near the base (45.00- 75.00m) is characterized by the new appearance of *Monocolpites marginatus*, *Laevigatosporites* spp., Microforaminiferal wall lining and continuous occurrence of *Leiosphaeridia* Spp.. Close to the top of the well (15.00- 45.00m) is the appearance of *Proteacidites* sp, continuous occurrence of *Laevigatosporites* sp and *Cyathidites* sp. while the topmost part (0.00-15.00m) is very sparse in spores and dinoflagellates cyst but marked by the single occurrence of an angiosperm pollen which is *Tubistephanocolpites cylindricus* (Table 1). Many of the palynomorphs found in this well have been reported for late Maastrichtian to Paleocene sediment in the basal part of Araromi [9,11], for the Paleocene sediment of Pan tropical area [15], for the Cretaceous sediment of Upper Benue Trough [15,17]. Major forms present in the upper Maastrichtian facies are often present in Paleocene sediments [18,19].



**Fig. 3. Litholog of the studied interval of Lewumeji well, Dahomey Basin, Nigeria**



**Fig. 4. Litholog of the studied interval of Idogun well, Dahomey Basin, Nigeria**

For Idogun well, the study interval also belongs to the *Cyathidites minor assemblage zone*. Dinoflagellates cysts dominate the basal part (42.00-54.00m) of the well, which is an indication of marine influence. These microfossils include *Senegalinium* sp, *Oligosphaeridium* sp, *Subtilisphaera* sp, *Cerodinium* sp and relatively high frequency of *Paleocystodinium* sp. The diagnostic marker forms present are *Cyathidites* sp., *Monoporites anulatus* and *Monocolpites marginatus*. At depths 24.00 to 42.00m there is re-occurrence of *Monocolpites marginatus* and new forms that are diagnostics of late Maastrichtian age, emerged, they include *Mauritiidites lehmani*, *Tubistephanocolpites cylindricus*, and *Pteris* sp. the overlying interval (15.00 – 24.00 m) is characterized by occurrence of new forms *Distaverrusporites simplex* which supports the late Cretaceous age [20]. The overlying interval 9.00 – 15.00m is relatively rich in palynomorphs, it is composed of continuous occurrence of *Cyathidites* sp. Miospores and dinocysts that appear for the first time are *Leiosphaeridia* sp, trilete Spore, Microforaminiferal body-wall lining, *Foveotriletes margaritae*, and *Laevigatosporites* sp. The topmost interval 0.00m -9.00m is characterized by the reoccurrence of *Cyathidites* sp. and new appearance of *Proteacidites* sp. as shown in Table 2.

Correlation of intervals (Fig. 9) within both wells using terrestrially sourced spores and pollen shows a lot of similarities, this suggests that the sediments were deposited under the same environmental conditions and the miospores might have come from the same origin during the same period and sediments were partly deposited under the same condition.

### 3.2.3 Environment of deposition

Interpretation of the depositional paleoenvironment was carried out using different means based on the preferable environment of deposition of environmentally indicative forms, palynomorphs frequency distribution, and comparison of land-derived forms to marine source. The palynomorphs frequency percentage distribution shows that both well has a higher frequency of land-derived miospore to the marine dinoflagellates; (75%, 25% and 61%, 39%) for lewumeji and Idogun well respectively. This suggests that the source of organomacerals are plants and environment of deposition is likely to be from continental to brackish environments [4].

The occurrence of environmentally indicative forms in lewumeji and Idogun well such as Leiosphaeridae Sp indicative of neritic environment [19] monocolpites marginatus suggestive of coastal plain habitat [11], foraminifera wall linings suggestive of nearshore environments. However, the moderate records of fern spores such as *Cyathidites* sp, *Cyathidites minor* are indicative of open freshwater swamps [16]. And the presence of marine loving forms such as *Cerodinium* sp, *Paleocystodinium* sp, and *Senegalinium* sp and *Subtilisphaera* sp in Idogun well is indicative of shallow marine environments. This suggests a depositional environment that varies from continental to brackish to shallow marine environment with the minor influx of freshwater.

The Palynomorphs Marine Index (PMI), a semi-quantitative interpretation technique was employed to further determine the environment of deposition of the studied interval of Idogun (0.00-54.00m) and Lewumeji (0.00-111.00m). This approach employed the percentage of the ratio of the amount of marine to terrestrial palynomorphs. This allow for deduction of the paleoenvironments of fossil forms in respect of the fluvial and marine environment [21].

$$PMI = Rm/Rt + 1 * 100$$

Range of classification follows

- >100 = Fluvial environment
- 100-200 = Fluvial/ marine environments
- >200 = Marine environment.

Where  $Rt$  = Richness/number of terrestrial palynomorphs (pollen + spores + Fungal remains)

$Rm$  = Richness/number of aquatic palynomorphs (dinoflagellates+ acritarch + foraminifera wall linings + Prasinophytes). High, low and nil values of Palynomorphs Marine Index (PMI) indicate marine, brackish and freshwater environments respectively [22].

Quantitative interpretation technique applied using Palynomorph Marine Index (PMI) values show that in Lewumeji well (Table 3) PMI value of about 100 within the studied interval (0.00-111.00m) indicate fluvial deposit. This is due to the dominance of land-derived palynomorphs. The PMI values (Table 4) show that in Idogun well, intervals with PMI values of about 100 for interval 0.00-9.00m, 9.00-15.00m, 15.00-24.00m, and 24.00 -42.00m are equivalent to fluvial deposits, while the lowermost part with

the depth range of 42.00 – 54.00m has a PMI value between 100-200 which is indicating an alternation of continental and marine deposits. Therefore, from the general view of the PMI

values against analyzed stratigraphic interval (Figs 10 and 11), a brackish to Shallow marine environments with minor freshwater incursions is suggested for the study area.

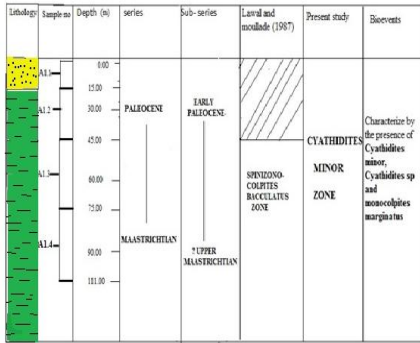


Fig. 5. Palynomorphs zones recognised in Lewumeji well

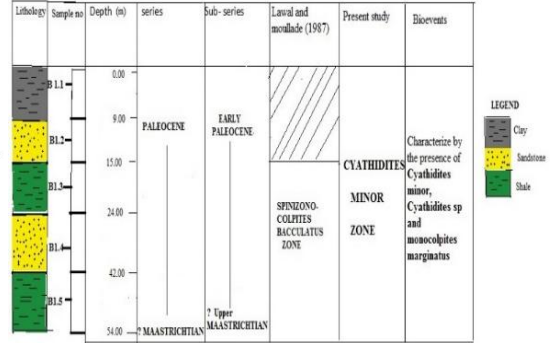


Fig. 6. Palynomorphs zones recognised in Idogun well

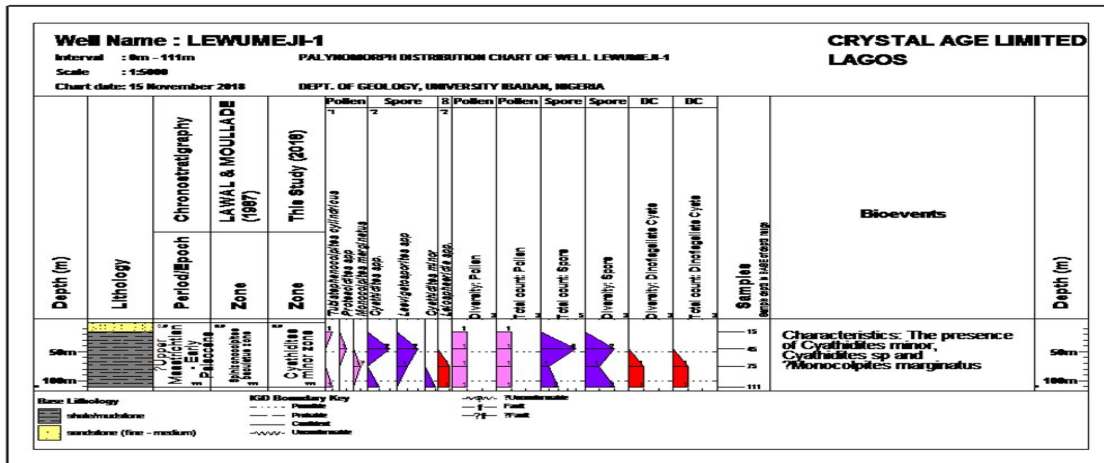


Fig. 7. Palynomorph distribution in Lewumeji well (0.00 – 111m)

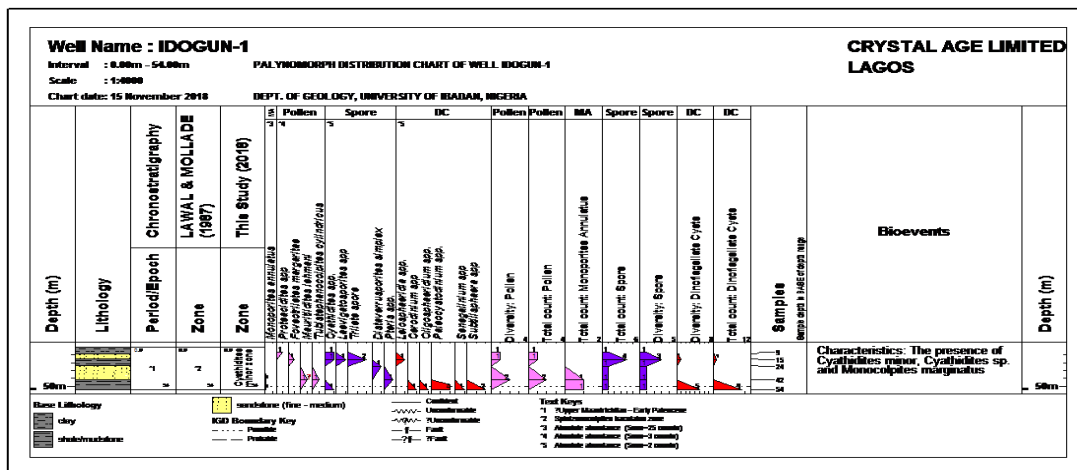



Fig. 8. The palynomorph distribution Chart of Idogun well (0.00 – 54.00m)




**Table 1. Distribution of palynomorphs species recovered in Lewumeji well and the number counts for specie type**

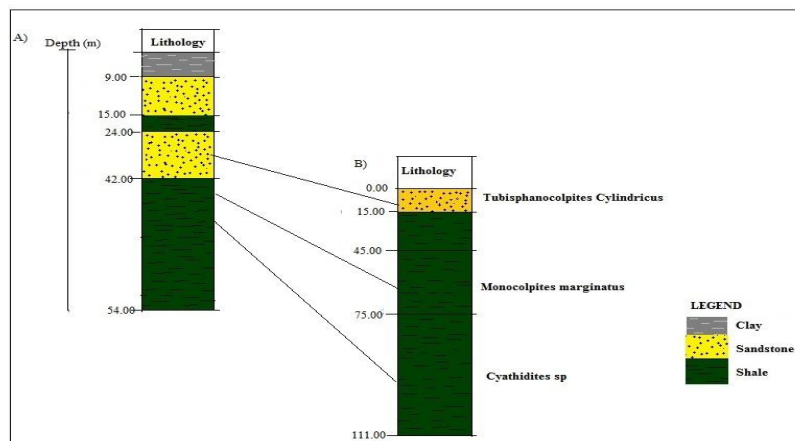
SAMPLE NO	Depth (m)	Lithology	Palynomorphs recovered	Counts/Species Type
A1.1	0 - 15.00	Shale	Tubistenphanocolpites Cylindricus	1 (P)
A1.2	15 - 45		Cyathidites sp	2(S)
			Proteacidites sp	1(P)
A 1.3	45 - 75		Laevigatosporites sp	2(S)
		Monocolpites Marginatus	1 (S)	
		Leiosphaeridia sp	1 (DC)	
A 1.4	75 - 111	Microforaminiferal wall lining	1 (DC)	
		Laevigatosporites sp	1(S)	
		Leiosphaeridia sp	1 (DC)	
		Cyathidites sp	1 (S)	
			Cyathidites Minor	1(S)
			Tubistephanocolpites Cylindricus	1(P)

**Legend**  
P - Pollen  
S - Spores  
DC - Dinoflagellates  
 Sandstone  
 Shale

**Table 2. The distribution of palynomorphs species recovered in Idogun well and the number counts for species types**

Sample no	Depth (m)	Lithology	Palynomorphs Recovered	Counts/ Species Type
B1.1	0 - 9.00	Clay	Cyathidites sp	1(S)
			Proteacidites sp	1(P)
B1.2	9.00 - 15.00	Sandstone	Leiosphaeridia sp , Trilete spores	1 (DC) , 2(S)
			Microforaminiferal wall lining , Cyathidites sp	1 (DC) , 1 (S)
B1.3	15.00 - 24.00	Shale	Foveotrilites Margaritae, Laevigatosporite sp	1(P) , 1 (S)
B1.4	24.00 - 42.00	Sandstone	Distaverrusporites simplex	1 (S)
			Monocpites Marginatus	1(P)
			Mauritidites Lehmani	1(P)
			Tubistephanocolpites Cylindricus	1(P)
B1.5	42.00 - 54.00	Shale	Pteris sp	1(S)
			Senegalinium sp	1 (DC)
			Paleocytoadinium sp	4 (DC)
			Subtilisphaera sp	2(DC)
			Cyathidites sp	1 (S)
			Monocolpites Marginatus	1(P)
			Cerodinium sp	1 (DC)
			Oligosphaeridium sp	1 (DC)
Monoporites Annulatus	2(P)			

**LEGEND**  
S - Spore  
P - Pollen  
DC - Dinoflagellates cysts  
 Clay  
 Sandstone  
 Shale



**Fig. 9. Correlation chart of the study sections using the recovered palynomorphs from both wells (a) Idogun well (b) Lewumeji well**

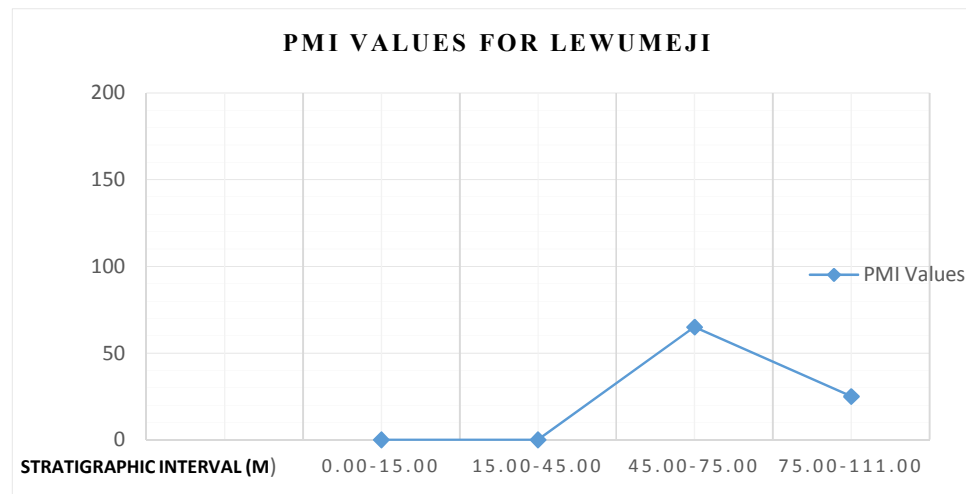


**Table 3. Paleoenvironment interpretation of Lewumeji well from P.M.I. value of the palynomorphs distribution**

Sample no	Depth (m)	Pollen	Spores	Dinoflagellate cysts	Total	PMI	Paleoenvironment
A1.1	0-15	1	0	0	1	0	Fluvial deposit/Freshwater environment
A1.2	15-45	4	1	0	5	0	Fluvial deposit/Freshwater environment
A1.3	45-75	1	1	2	4	67	Fluvial deposit/Brackish environment
A1.4	75-111	1	2	1	4	25	Fluvial deposit/Brackish environment

**Table 4. Paleoenvironment Interpretation of Idogun well from P.M.I. value of the palynomorphs distribution**

Sample no	Depth (m)	Pollen	Spores	Dinoflagellate cysts	Total	PMI	Paleoenvironment
B1.1	0-9	1	1	0	2	0	Fluvial deposit/Freshwater environment
B1.2	9-15	1	4	2	7	34	Fluvial deposit/brackish environment
B1.3	15-24	0	1	0	1	0	Fluvial deposit/Freshwater environment
B1.4	24-42	1	2	1	4	0	Fluvial deposit/Freshwater environment
B1.5	42-54	3	1	9	13	180	Marine deposit/Marine environment



**Fig. 10. Palynomorphs Marine Index (PMI) chart of Lewumeji well**

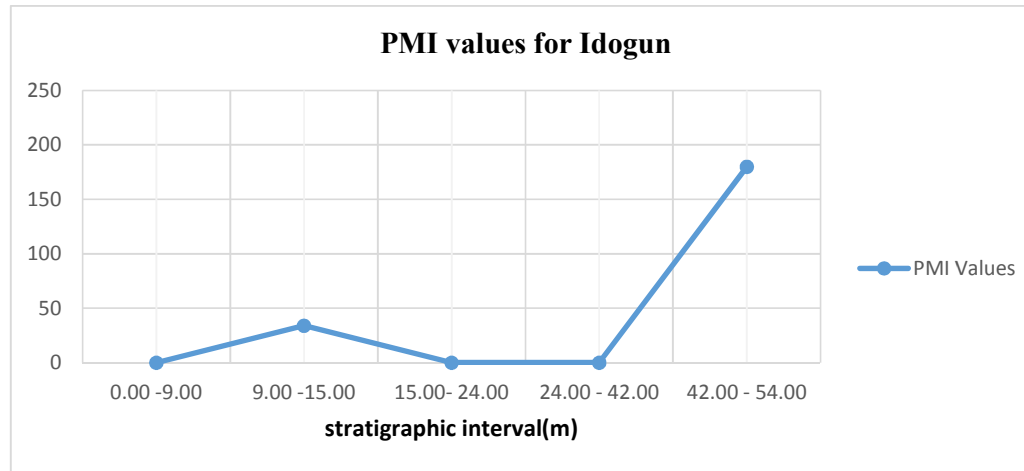
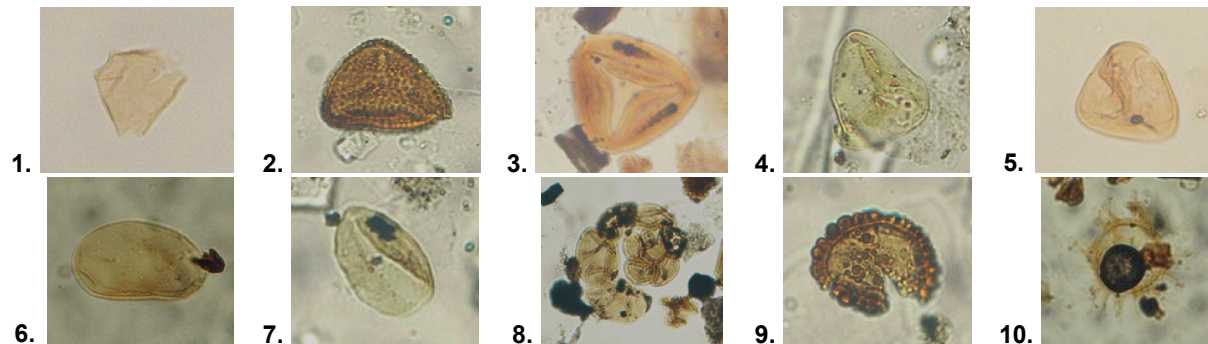
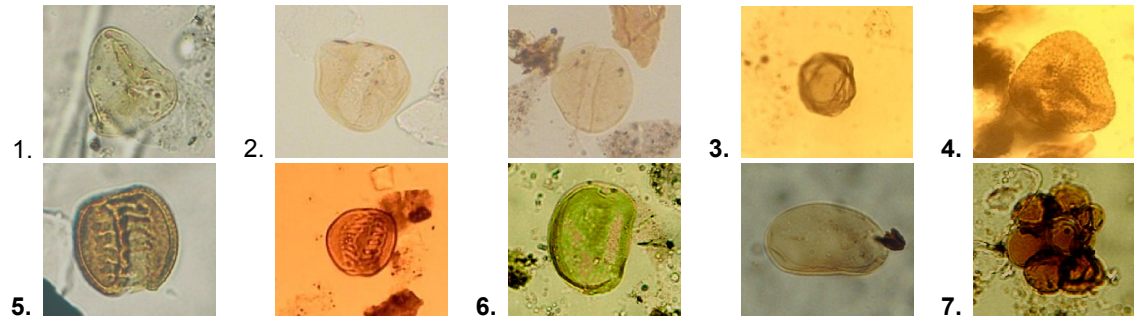


Fig. 11. Palynomorphs marine index (PMI) chart of idogun well



1. *Proteacidites* sp 2. *Foveotriletes margaritae* 3. *Pteris* sp 4 & 5. *Cyatidites minor* 6. *Laevigatosporites* sp 7. *Monocolpites marginatus* 8. Microforaminiferal wall linings 9. *Distaverrusporites simplex* 10. *Oligosphaeridium* sp.

Plate 1. Some selected palynomorphs taken from the samples of Idogun well



1. *Cyatidites minor* 2. *Monocolpites marginatus* 3. *Leiosphaeridia* sp 4. *Foveotriletes margaritae* 5. *Tubistephanocolpites cylindricus*  
6. *Laevigatosporites* sp 7. Microforaminiferal wall linings

Plate 2. Some selected palynomorphs recovered from Lewumeji-1 well

#### 4. CONCLUSIONS

The lithological and palynological studies have been appropriately employed to study the sediments of Abeokuta Group, Eastern Dahomey Basin through the use of nine (9) composited core samples from Lewumeji and Idogun wells with a depth ranging from 0 -111m and 0-54m respectively.

The wells were examined lithologically and were delineated into five units for Idogun well; two units of shale, two units of sandstone and a clay unit while the Lewumeji well has two units of sandstone and shale. Both wells are dominated by fissile to blocky, light to dark grey shale and the sand grain varies from medium to fine-grained texture and the clay unit covers a small interval having a reddish brown colouration. This lithology denotes Marine, fluvial and Lagoonal or brackish environment respectively. The thirty-one (31) palynomorphs recovered within the two wells are well preserved with low to moderate diverse pollen, spores and the dinoflagellates cysts. The microfloral assemblages include abundant *Cyathidites* sp, *Cyathidites minor*, *Tubistephanocolpites cylindricus*, *Proteacidites* sp, Trilete spore, *Foveotriletes margaritae*, *Monocolpites marginatus*, *Monoporites annulatus*, *Pteris* sp, *Distaverrusporites simplex* and *Laevigatosporites* sp. The dinoflagellates recovered were characterized by the likes of *Leiosphaeridia* sp, *Senegalinium* sp, *Oligosphaeridium* sp, *Paleocytodinium* sp, *Cerodinium* sp and *Subtilisphaera* sp. The palynological assemblage zone identified within the two wells is the *Cyathidites minor* zone, this zone is correlative with the *Spinizonocolpites bacculatus* zone of Lawal and Moullade, (1987). The zone is characterized by the presence of *Monocolpites marginatus*, *Cyathidites minor* and *Cyathidites* Sp. The studied sediments from the wells were deposited in continental to brackish to shallow marine environments with minor freshwater incursions during the upper Maastrichtian – early Paleocene period based on environmental diagnostic species, palynomorphs marine index and frequency distribution of palynomorphs.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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