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# Contents

Volume 14, 2015

Authors' Guide	iii
Palyno-environmental study of the Araromi-1 Well, eastern Dahomey Basin, south-west Nigeria <i>Adeigbe O. C. and Amodu O. I.</i>	1
Air and heavy metal pollution around a steel foundry in Ogijo, Ogun State, Nigeria <i>Olayinka, O. O. Adedeji, O. H. and Balogun, Y.</i>	9
A comparative analysis of the binding site of <i>Plasmodium falciparum</i> histone deacetylase-1 and human histone deacetylase-8 <i>Odozi, N. W. and Fristrup, P.</i>	17
Determination of the pKa values of some selected aromatic amines and naturally occurring compounds in polar and non-polar solvents at 25°C <i>Eugene-Osoikhia, T. T., Taiwo, O. T. and Adegbemigun, A.</i>	22
Subsistence of four bacteria isolated from Nigerian aquaculture farms on oxytetracycline <i>Adelowo, O. O., Lawal, O. E. and Adekanmbi, A. O.</i>	27
Biosorption of cadmium (II), copper (II) and lead (II) ions by citric acid modified and unmodified cocoa pod shell: Equilibrium, kinetics and thermodynamics <i>Alabi, A. H., Awoyemi, R. F. and Ayedogbon, A. S.</i>	36
Computational studies of the corrosion inhibition potentials of some derivatives of 1H-Imidazo [4, 5-F] [1, 10] phenanthroline <i>Obi-Egbedi, N. O. and Ojo, N. D.</i>	50
Effect of inositol hexakisphosphate on sulphhydryl reactivities of low (cat) and high (human) oxygen affinity haemoglobins <i>Olatunde, A. M., Babalola, J. O. and Okonjo, K. O.</i>	57
Structural equation modelling of academic performance in statistics degree programme: A case study of University of Ibadan <i>Olubusoye, O. E. and Adejumo, N. A.</i>	64
Depositional environment and reservoir quality appraisal of offshore 'K-Field', Niger Delta, Nigeria <i>Boboye, O.A. and Akinsebikan, O. A.</i>	73
Effects of crude oil contaminated-soil on the germination and growth of cowpea <i>Vigna unguiculata</i> (L.) Walp <i>Enajeria, G., Raimi, I. O. and Odiwe, A. I.</i>	90
Kinetic studies of thiocyanate ions removal from aqueous solution using carbonaceous guinea-corn <i>Ofudje, E. A., Akinbile, B., Awotula, A. O., Oladipo, G. O. and Adedapo, E. A.</i>	98
Facies model building of integrated multiscale data in Dn-Field, Onshore, Niger Delta, Nigeria <i>Nton, M. E. and Arigbe, O. D.</i>	107
Bioremediation of spent diesel oil contaminated-soil by <i>Pleurotus ostreatus</i> (Jacq. Fr) P. Kumm <i>Onakpharkpote, E. E., Adenipekun, C. D. and Oyetunji, O. J.</i>	117
Physical and biochemical characterisation of bacteriocins produced by three <i>Lactobacillus</i> species <i>Odeniyi, O. A. and Olabode, T. P.</i>	125
Isolation and identification of thermophilic cellulolytic yeast from cassava waste dump <i>Onilude, A. A., Adekoya, A.O., Wakil, S. M., Fasiku, S. A. and Ja'afaru, I. M.</i>	131
Authors' index to Volume 14	145

## Authors' Guide

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### Examples of References

- [1] Hellstrom, L., Persson, B., Bridin, L., Grawe, P. K., Oborn, I. and Jarup, L. 2007. Cadmium exposure pathways in a population living near a battery plant. *Sci. Total Environ.* 373: 447- 455.
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sustainable agriculture for the humid and sub-humid tropics of Africa. In: Amadon-Tidiane, B.A., Ndoye, M. (eds). *The role of biology in resolving the food crises in Africa*, African Biosciences Network (ABN) Dakar, Senegal, pp. 136-143.

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## Palyno-environmental study of the Araromi-1 Well, eastern Dahomey Basin, south-west Nigeria

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### Abstract

The exploration of many inland basins in Nigeria for their hydrocarbon potential is important to maintain her position in the global world oil market. A total of 23 core samples extracted from Araromi-1 Well, Eastern Dahomey Basin, south-west Nigeria, were carefully studied through lithostratigraphy and palynology with a view to determining the lithological sequence, relative age, palynological zone and paleo-environments of deposition. The lithological characterisation revealed a wholly shale unit with thin layer of clay towards the top of the well. A total of 58 palynomorphs were recovered and this indicates well preserved samples with abundant and highly diverse pollen, spores and dinoflagellate cysts. The microfloral assemblages include abundant *zonocostites ramonae*, *monoporites annulatus*, *retitricolporites irregularis*, *monocolpites marginatus*, *acrostichum aureum*, *cyathidites minor*, *cyathidites sp*, *laevigatosporites sp* and *proxapertites cursus*. Abundant quantities of dinoflagellate cysts particularly *palaeocystodinium australinium*, *cerodinium diebeli*, *leiosphaeridia sp*, *palaeocystodinium sp*, *seleiropemphix homotryblium oceanicum*, *odontochitina operculata*, *achromorphaera ramulifera* and *spiniferites sp*. were recovered. Common deep water indicator, microforaminiferal wall linings was also recorded. The well falls within just a zone, P100 to P200, characterized by the occurrence of *palaeocystodinium australinium*, *cerodinium diebeli* and *odontochitina operculata* dated Late Maastrichtian to Late Paleocene. Paleoenvironmental deductions were based on the relative abundance of freshwater swamps pollen and spores, diagnostic dinoflagellate cysts and deep marine indicator inferring brackish to deep marine setting.

**Keywords:** Pollen; spores; dinoflagellate cysts; palynozone; brackish-deep marine.

### Introduction

Biostratigraphy is one of the numerous tools employed in the search for hydrocarbon and in a location like Nigeria where new discovery is needed to shore up her economic base and improve the standard of living of the average citizenry, there is a need for deeper search for oil especially in the estwhile marginal basin. The study-area, Araromi-I Well, falls within the Nigeria sector of the Dahomey Basin (Figure 1). The basin is a marginal pull-apart basin initiated during the separation of South American and African plates in the Early Cretaceous thereby constituting part of a system of West African pre-cratonic basins developed during the commencement of rifting, associated with the opening of the Gulf of Guinea in the Late Jurassic to Early Cretaceous [1].

Several works had been done in the past to ascertain

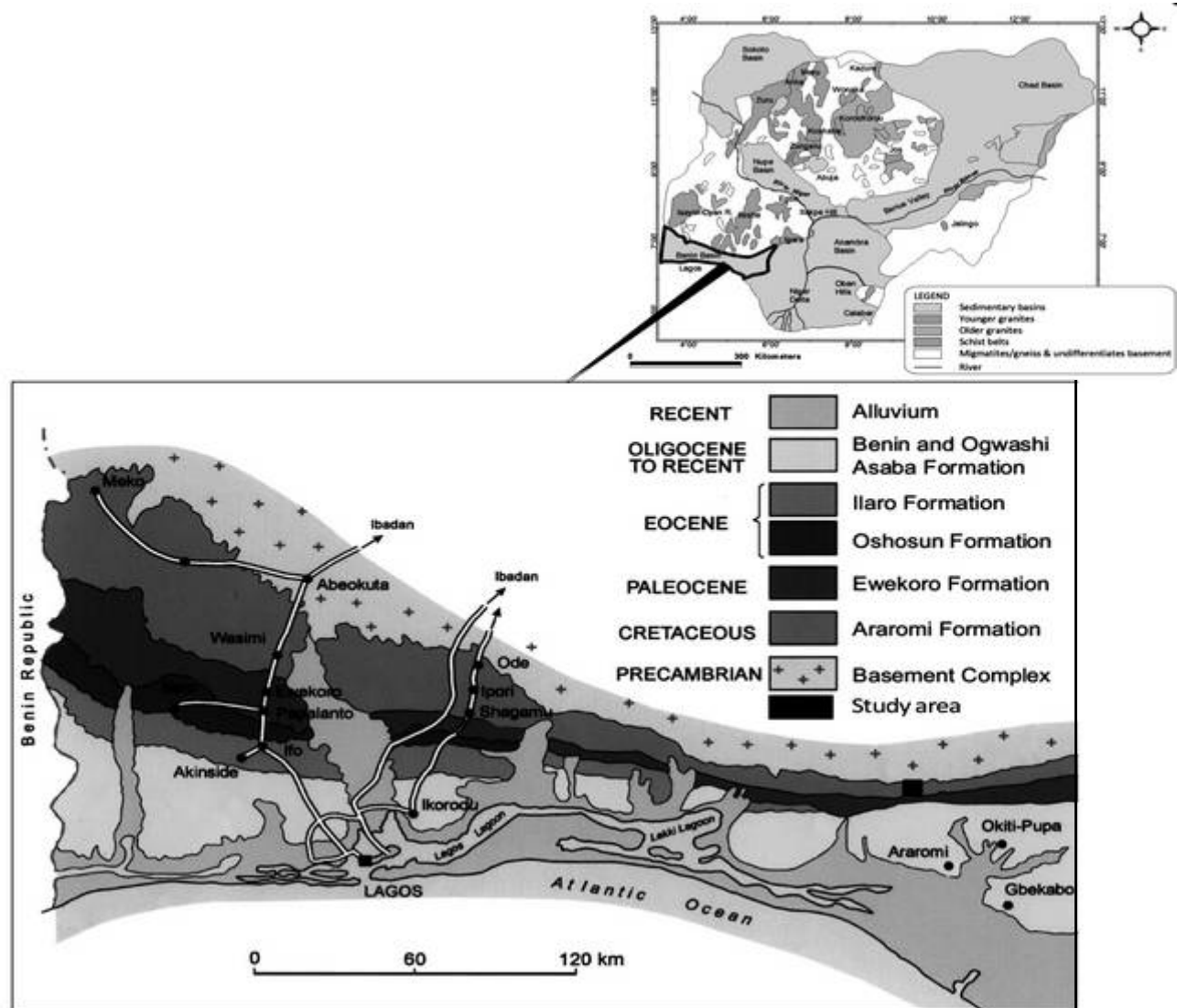
the age of the Cretaceous sediments of the Dahomey Basin, Nigeria [2-7]. The stratigraphy and stratigraphic architecture have been well established by various workers [8-12].

This study focuses on establishing palynological zones, dating the sedimentary sequences penetrated by the Araromi-I Well, deducing the paleo-environment of deposition of the sediments based on the palynomorph frequency percentage distribution and occurrence of the abundance and diversities of the forms encountered as well as to interpret the chronology and biostratigraphy (biozones) of the studied interval 420-1876 ft (128.02-571.80 m).

### Sampling and methods

The sample used for this study came from Araromi-1 Well collected from Nigeria Geological Survey Agency





**Figure 1.** The map of Eastern Dahomey Basin showing the study-area [Inset is the map of Nigeria showing the position of Dahomey Basin] (modified after Gebhardt *et al.*).

(NGSA), Abuja. A total of 23 composite core samples were collected at the interval approximately 63.3 feet (19.8 meters) covering a total depth of 1, 456 ft (455 m) were used for the study. This approach followed a standard procedure.

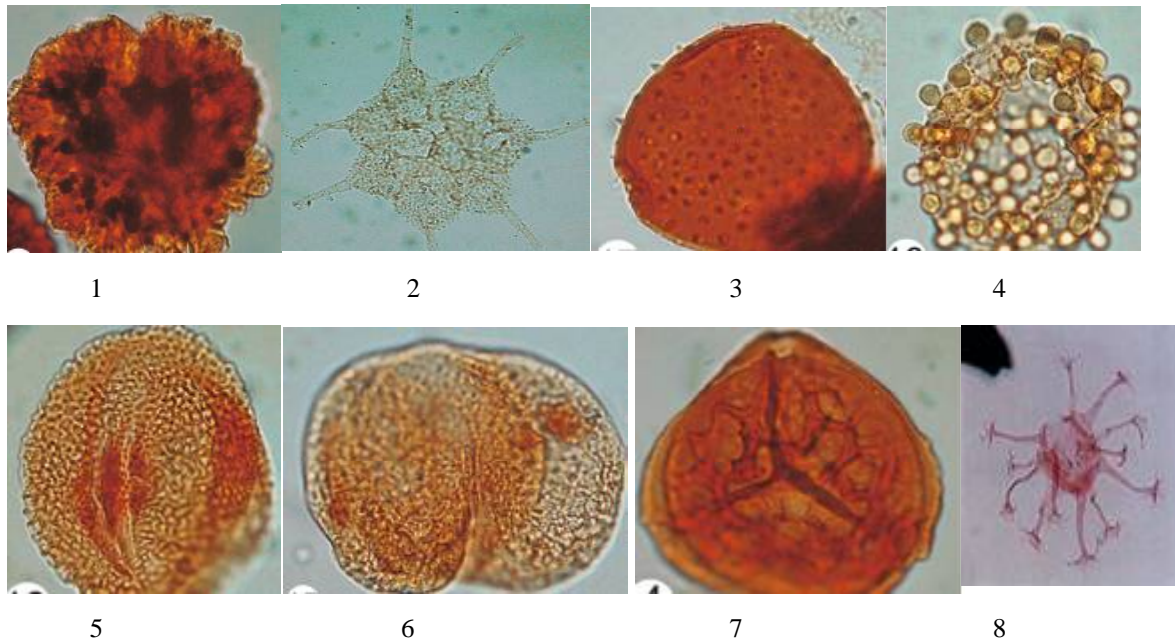
#### *Lithological description*

The lithological description of Araromi-1 Well was carefully carried out following the standard procedure for sedimentology through the use of binocular/hand lens, dil HCl, etc. Each sample through detail sedimentological procedure through textural characteristics such as grain size, shape, colour, fissility and the presence or absence of fossil contents and fragments.

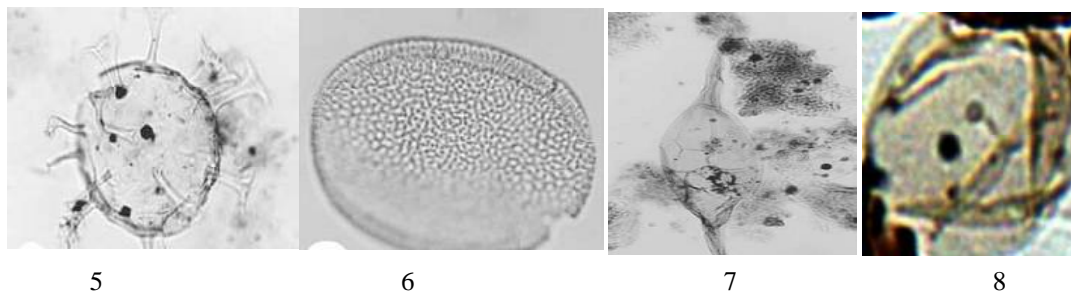
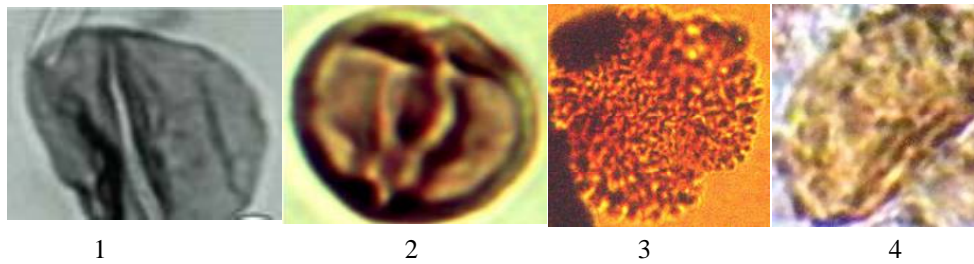
#### *Palynological preparation*

Palynological study was carried out using the standard

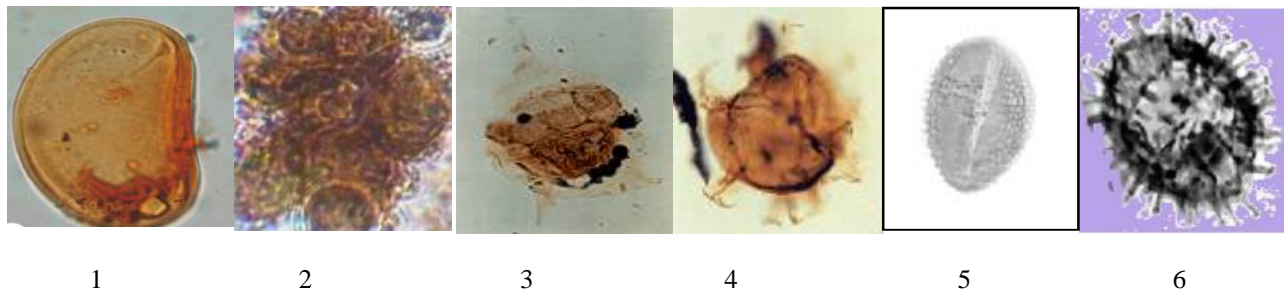
procedure for slide preparation. HCl was used to digest carbonates from the samples. HF was used for 24 hours to digest silicate minerals from the samples in a fume cupboard. HNO<sub>3</sub> was used to further remove the presence of cellulose materials from the samples and distilled water was used to neutralize the effect of the acids on the samples. Proper digesting and washing of chemicals were ensured. The samples were mounted by strewing them onto cover slips and allowed to dry and the slides so mounted were then observed under binocular microscope. Identification was done by Zeiss transmitted light microscope with 40x panchromatic objective lens used in scanning the slides and 100x panchromatic lens was used for detailed identification. The recovered palynomorphs are presented in Figures 2-4 and point counting method was used to determine the palynomorphs diversity and abundance.



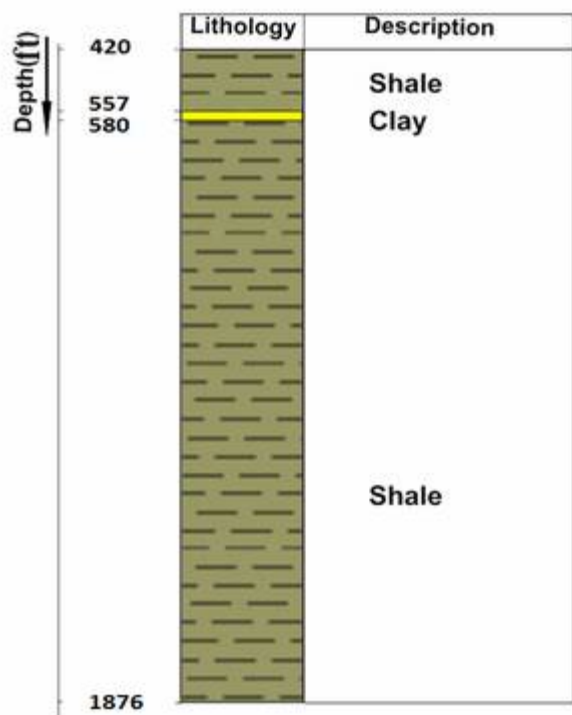
**Plate 1.** 1. *Brotryococcus brauni*, 2. *Pediastrum* sp., 3. *Echitriporites trianguliformis*, 4. *Racemonocolpites* sp., 5. *Retitricolporites irregularis*, 6. *Podocarpidites* sp., 7. *Zlivisporis blanensis*, 8. *Oligosphaeridium* sp.



**Plate 2.** 1. *Monocolpites marginatus*, 2. *Zonocostites ramonae*, 3. *Retitricolporites irregularis*, 4. *Verrucatosporites* sp., 5. *Homotryblium oceanicum*, 6. *Proxapertites cursus*, 7. *Palaeocystodinium australinum*, 8. *Monoporites annulatus*.



**Plate 3.** 1. *Laevigatosporites* sp., 2. Microforaminiferal wall lining, 3. *Deflandrea* sp., 4. *Spiniferites* sp., 5. *Retimonocolpites* sp., 6. *Polysphaeridium zorhayii*



**Figure 2.** Lithological units of Araromi-1 Well, Dahomey Basin, Nigeria.

## Results

### Interpretation and discussion

The twenty-three core samples of the studied section of Araromi-1 Well, carefully studied based on their lithology were divided into three units. These lithofacies covering interval 420 ft-1,876 ft are grouped into three units. The first unit starting from the bottom is shale (580ft-1876ft) followed by clay (557ft-580ft) and capping it at the top is another shale unit (420ft-557ft) (Figure 2).

The well revealed wholly shale over a large range of interval and they are fissile, light grey to dark grey in colour, very fine to fine grained in size with evidence of fossil and traces of fossil fragments. The clay unit is very fine grained having a brownish grey to very light grey colour and it covers a very small interval (23 ft).

The samples were well preserved with abundant and highly diverse pollen, spores and dinoflagellate cysts. The microfungal assemblages include *zonocostites ramonae*, *monoporites annulatus*, *retitricolporites irregularis*, *monocolpites marginatus*, *acrostichum aureum*, *cyathidites minor*, *cyathidites sp*, *laevigatosporites sp* and *proxaperites cursus*.

Abundant quantities of dinoflagellate cysts, particularly *palaeocystodinium australinium*,

*cerodinium diebelli*, *leiosphaeridia sp*, *palaeocystodinium sp*, *seleiropemphix homotryblium oceanicum*, *odontochitina operculata*, *achromorphaera ramulifera* and *spiniferites sp*. were also identified.

Common deep water indicator, microforaminiferal wall linings was also recorded. The above assemblage is indicative of a brackish to deep marine environment of deposition.

### Palynological biozonation

The Araromi-1 Well (128.02m-571.80m) falls within just a Zone; the P100-P200 zone [14, 15]. The zone can also be correlated with the *Spinizorocolpites baculatus* zone [16] and the *Dinogymnium euclaense* zone [8] (Table 1).

### Characteristics

The increasing records of the diagnostic marker species *monocolpites marginotus*, *cyathidites minor*, *palaeocystodinium australinium*, *cerodinium diebelli* and *odontochitina operculata* recorded within the studied section of the Araromi-1 Well indicated a Late Maastrichtian to Late Paleocene age.

### Paleoenvironment

The Araromi-1 Well contains abundant records of pollen, spores and dinoflagellate cysts which occur from the fifth sample (737-800ft) to the last sample (1,820-1,876ft). The pollen and spores recorded include *zonocortites ramonae*, *monoporites annulatus*, *cyperaceapollens sp*, *cyathidites minor*, *cyathidites sp*, *laevigatosporites sp*, *verrucatosporites sp*, *retitricolporites irregularis* and *aetibrevitricolporites protmideos*. These forms are indicative of open freshwater swamps [16].

Highly diverse deep water dinoflagellate cysts including *homotryblium oceanicum*, *palaeocystodinium australinium*, *palaeocystodinium sp*, *cerodinium diebelli*, *senegalinium sp*, *leiosphaeridia sp*, *deflandrea sp*, *substilisphaera sp*, *odontochitina operculata*, *nematosphaeropsis sp*, *oligosphaeridium sp* and *achomosphaera ramulifera* were also recorded [20]. Abundant deep marine indicator microforaminiferal wall linings and few fresh water algae *botryococcus braunii* were also recorded within the studied well.

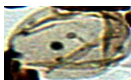





The frequency distribution of the palynomorphs encountered suggests a mixed environment of wetter and drier periods. This is confirmed by the incursion of the freshwater forms into the marine environment (Figure 3). Thus, the above recovered assemblages indicated a brackish to deep marine environment of deposition during Late Maastrichtian to Late

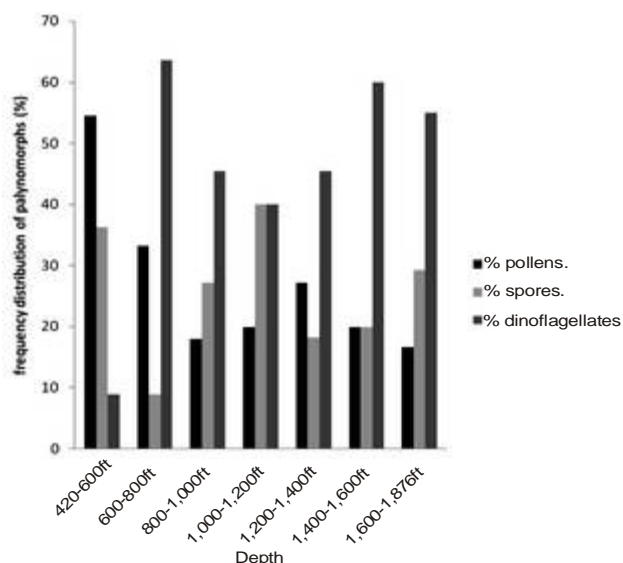


**Table 1.** Palynomorph zones recognized in the Araromi-1 Well, Eastern Dahomey Basin.

Depth (FT)	Series (This Study)	Age (This Study)	Evamy Et Al (14)	Lentin and Williams (18)	Jan Du Chene (5)	Lawal and Moulade (15)	BIOEVENTS
420 500 1,000 1,500 1,876	Maastrichtian – Paleocene	Late Maastrichtian – Late Paleocene	P100 – P200	<i>Palaeocystodinium australinium</i>	<i>Dinogymnium euclaense</i>	<i>Spinizonocolpites baculatus</i>	<p>First occurrence of <i>Monocolpites marginatus</i></p> <p>Occurrence of <i>Palaeocystodinium australinium</i>, <i>Odontochitina costata</i> and <i>Cerodinium diebelli</i></p> <p>Occurrence of <i>Dinogymnium euclaenses</i></p>

**Table 2.** Diagnostic palynomorph markers encountered in Araromi-1 Well.

Diagnostic markers	Intervals found (Ft)	Age	Habitat
<i>Monocolpites Marginatus</i> 	550-607, 1400-1,460	Late Maastrichtian [15]	Angiosperm pollen (coastal plain habitat)
<i>Odontochitina operculata</i> 	737- 800, 920-980, 1,640-1,700, 1,760-1,820	Late Maastrichtian [17]	Dinoflagellate cyst
<i>Cerodium diebelii</i> 	1,580-1,640, 1,640-1,700, 1,700-1,760, 1,760-1,820, 1,820-1,876	Late Maastrichtian-Late Paleocene)	Dinoflagellate cyst
<i>Palaeocystodinium australinum</i> 	737-800, 1,220-1,280, 1,340-1,400, 1,400-1,460, 1,580- 1,640, 1,640-1,700, 1,700-1,760, 1,760-1,820, 1,820-1,876	Late Paleocene [18]	Dinoflagellate cyst (deep marine indicators)
<i>Dinogymnium sp</i> 	1,160-1,220, 1,760-1,820, 1,820-1,876	Late Maastrichtian [8]	Dinoflagellates
<i>Cyathidites minor</i> 	1,160-1,220, 1,220-1,280, 1,340-1,400, 1,580-1,640, 1,640-1,700, 1,700-1,760	Late Maastrichtian [15]	Tropical to subtropical distribution



**Figure 3.** Percentage Distribution of Palynomorphs within Araromi-1 Well.

Palaeocene period as indicated by diagnostic marker species (Table 2). Finally, the increasing percentage of Dinoflagellates towards the base of the well is an indication of more marine influence (Figure 3).

**Conclusions**

The Araromi-1 Well (420 ft-1,876 ft) was carefully examined lithologically and three units were delineated which can be further grouped into two units of shale and clay. The well is dominated by fissile, light grey to dark grey, very fine to fine grained shale which showed evidence of fossil fragments and traces. The clay unit is very fine grained having a brownish grey to very light grey colour and it covers a very small interval.

The fifty-eight palynomorphs recovered within the samples were well preserved with abundant and highly diverse pollen, spores and dinoflagellate cysts. The pollen and spores recorded include *zonocostites ramonae*, *monoporites annulatus*, *cyperaceapollens*

*sp, cyathidites minor, cyathidites sp, laevigatosporites sp, verrucatosporites sp, retitricolporites irregularis* and *aetibrevitricolporites protmideos*. These forms are indicative of open freshwater swamps [18]. Highly diverse deep water dinoflagellate cysts including *homotryblum oceanicum, palaeocystodinium australinum, palaeocystodinium sp, cerodinium diebelli, senegalinum sp, leiosphaeridia sp, deflandrea sp, substilisphaera sp, odontochitina operculata, nematosphaeropsis sp, oligosphaeridium sp* and *achomosphaera ramulifera* were also recorded.

The palynozone recognized belong to P100-P200z one [14] and is correlatable with *Spinizorocolpites baculatus* zone and the *Dinogymnium euclaense* zone [17, 8]. The zone is characterized by the presence of *cerodinium diebelli, palaeocystodinium australinum, odontochitina operculata* and *cyathidites minor*.

The frequency distribution of the palynomorphs encountered suggests a mixed environment during the wetter and drier periods as inferred from the incursion of fresh water forms (pollens and spores) into the marine environment (dinoflagellate cysts). The studied-sediments of the well as inferred from the diagnostic markers (Table 2), were deposited within the brackish-deep marine environment during the Late Maastrichtian to Late Paleocene period.

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