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Paleoecology and Paleoenvironment of RecoveredPalynomorphs from Well PCL, boundary of Nigeria and Benin Republic sectors of the offshore eastern Dahomey Basin.

[1]J. Ayok,[2]**N**.Musa,[1]H. A. Ayinla,[1]Z. Sani,[1& 3]A. Toyin.
[1]*Deparment of Geology, Federal University Lokoja*
[2]*Department of Geology, Federal University Lafiya*
[3]*Institute of Geosciences, China University of Petroleum, Beijing.*

Abstract
Background: *The PCL well is located in Block 1 Seme Field of Benin Republic, Dahomey Basin. Effort is now being focused on the hydrocarbon exploration ofthe eastern Dahomey Basin in Nigeria and oil producing Tano Basin in Ghana so as to attract more investors and document information about it. Therefore, Palynostratigraphy of the Tertiary Offshore Dahomey Basin was carried out toexamine an important component of the organic matter forprovide better understanding of its Paleoecology and Paleoenvironmentusing the PCL- well as a case study. This study will give more insight on the offshore part of the basin (Seme Block1).*
Materials and Method: *After thorough laboratory sample preparation, 70 ditch samples were analyzed. About 25g of crushed samples of approximately 2-5mm treated with 36% concentrated HCl to remove calcium carbonate, and 60% HF to remove the silicates materials. The hydrofluoric acid formed was removed by addition of warn and then cold HCl. All acids treatments (HCl and HF) and rinsing with distilled water were done at 2000rpm centrifuging and supernatant solutions were decanted. Zinc bromide of 2.2s.g. was added, stirred and centrifuged for 10 minutes at 1600 rpm. The floating top part which consists of organic material was gently decanted into a newly marked tube. This process was repeated twice to get more organic material. Samples was mildly oxidized and the heavy minerals were separated using Zinc bromide (ZnBr2) at 2.1 g/cc. obtained residues were mounted on glass slides with DPX. Observed palynomorphs were identified under microscopy and Photomicrographs of diagnostic species were taken.*
Results: *Stratigraphic distribution of the palynomorph assemblages retrieved from PCL well in the offshore Dahomey Basin southwestern Nigeria shows that the analyzed sediments yielded moderately rich, well preserved and diversified palynomorphs. A total of 73 palynoflora taxa assemblages were observed from 28 slides of PCL well. This comprises of 47 Pollen grains, 15 spores, 3 freshwater algae, 6 dinoflagellates, while others are fungal spores, and Foraminiferal test lining. Most of the palynoflora assemblages were dominated by angiosperm pollen, followed by pteridophytic spores and dinoflagellages cysts.Although, the distribution of the pollen grains is highly variable, taxa such as Monoporitesannulatus, Zonocostitesramonaeand Monocolpitessp. occurred in high abundance. The spores are dominated by Laevigatosporitessp., Acrostichumaureum, Polypodiaceoisporitessp., Verrucatosporitessp. and fungal spore/hyphae. Among the three algae recorded (Botryococcusbraunii, Concentricystcirculusand Pediatriumsp.,) Botryococcusbrauniidisplay clear predominancein all the sampled intervals while, Concentricystcirculus occur only at the intervals between 240 to 1320ft.DinoflagellatesrecoveredareLingulodiniumsp., Systemaphoratareolata, Operculodiniumcentrocarpum, Lingulodiniummechaerophorum, and Operculodiniummechaerophon,occurringperiodicaily. Leiosphaeridessp.is the only Acritarch recoveredoccurring at only few depth intervals (1400-1440ft, 1680-1720ft, 1840 1880ft, 2080- 2120ft and 2240 – 2280ft).*
Conclusion: *Integrated quantitative and quality studied of the PCL well shows five paleoecological zones which are: fresh water, lowland rainforest, savanna, brackish water and beach vegetation. Paleoenvironment deduction indicated that most of the samples were deposited within lacustrine, lagoonal or estuarine environment (brackish water environment), while others were deposited in fresh water environment.*

Keywords: *Paleoecology, Paleoenvironment, offshore Dahomey Basin, Monoporitesannulatus, Zonocostitesramonae,Monocolpitessp.*

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I. Introduction

The Dahomey Basin is an extensive sedimentary basin on the continental margin of the Gulf of Guinea. It extends from the Volta Delta in Ghana in the west to theOkitipupaRidge/ Benin Hinge line in the east of Southern Nigeria (Ogbe, 1972; Omatsola and Adegoke, 1981; Whiteman, 1982; see Figs.1&2). The basin is a marginal pull-apart (Klemme,1975) or marginal sag basin (Kingston *et al*., 1983) which developed in the Mesozoic Era as the African and South American lithospheric plates separated and thecontinental margin foundered (Burke *et al*., 1971; Whiteman**,**1982). The basin has attracted the attention of investors recently particularly the offshore part of the basin due to thehydrocarbon exploration in Lagos, eastern Dahomey Basin in Nigeria and Tano Basin in Ghana which is presently producing oil (Adekeye *et al*., 2019).Thishas thereby rekindled andincreased motivation for intense study of the basin.

One of such studies is this palynological analysis of the Tertiary Offshore Dahomey Basin which examines an important component (palynomorphs) of the organic matterusing the PCL- well as a case study.This current study is crucial as thereis no much documentation on the offshore part of the basin. Therefore, this research centres on studying the recovered pollen, spores, dinoflagellates, fungal spores,foraminiferal test wall and other forms in details to decipher their paleoecology and environment of deposition penetrated by the PCL well ofSeme Block1.

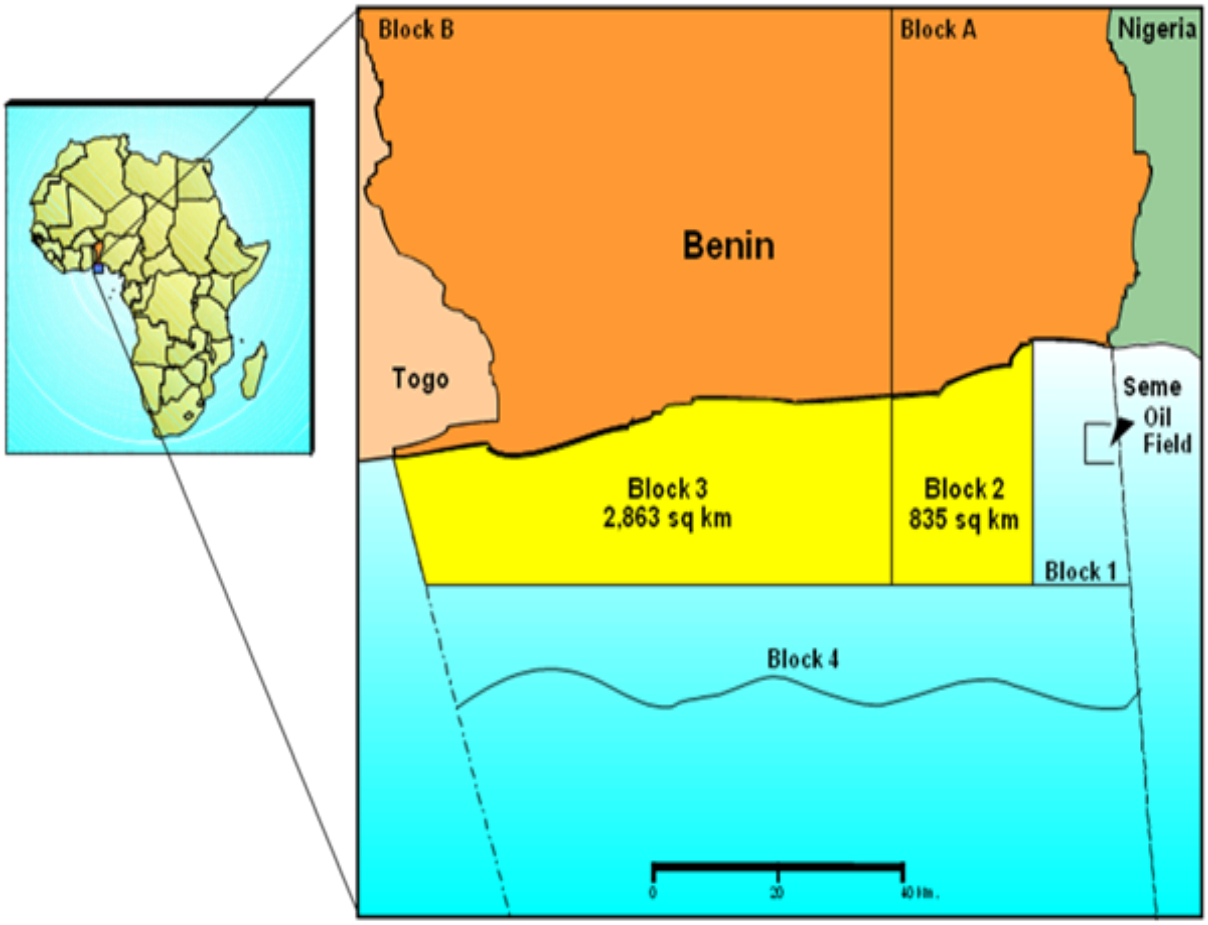


Figure1: Location map of the study area (Block 1) offshore, Dahomey Basin (source, SAPETRO).

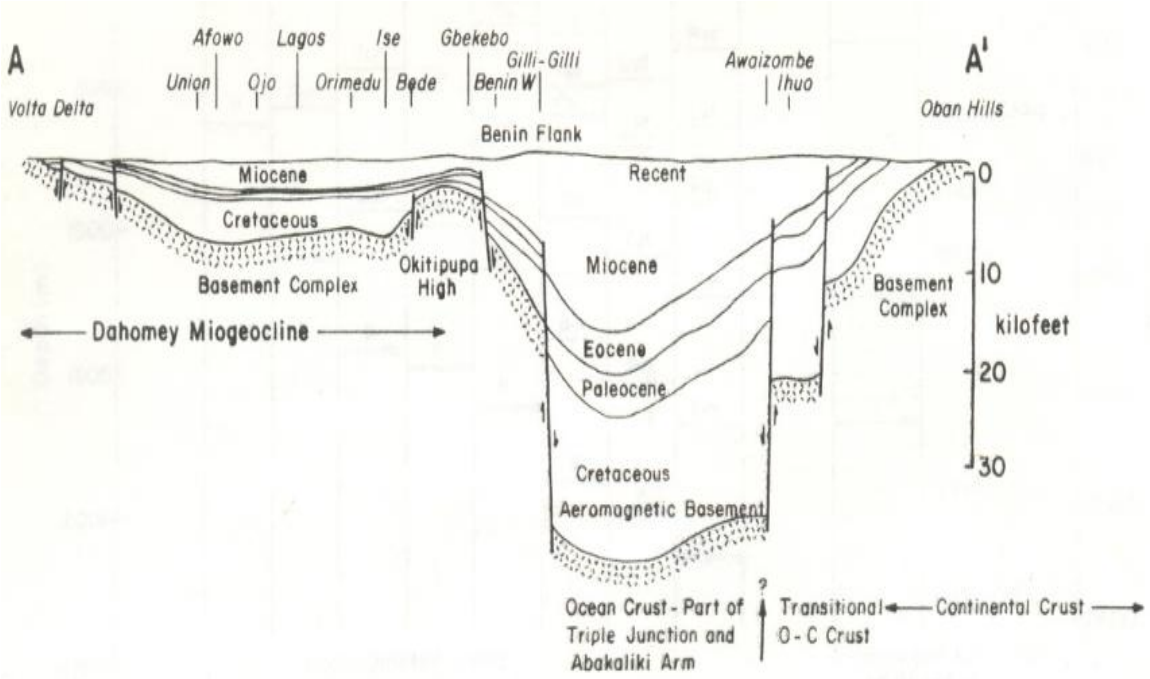


Figure 2: East-West section showing sediment thickness variations in the onshoreDahomey Basin and the upper part of the Niger Delta (Whiteman, 1982).

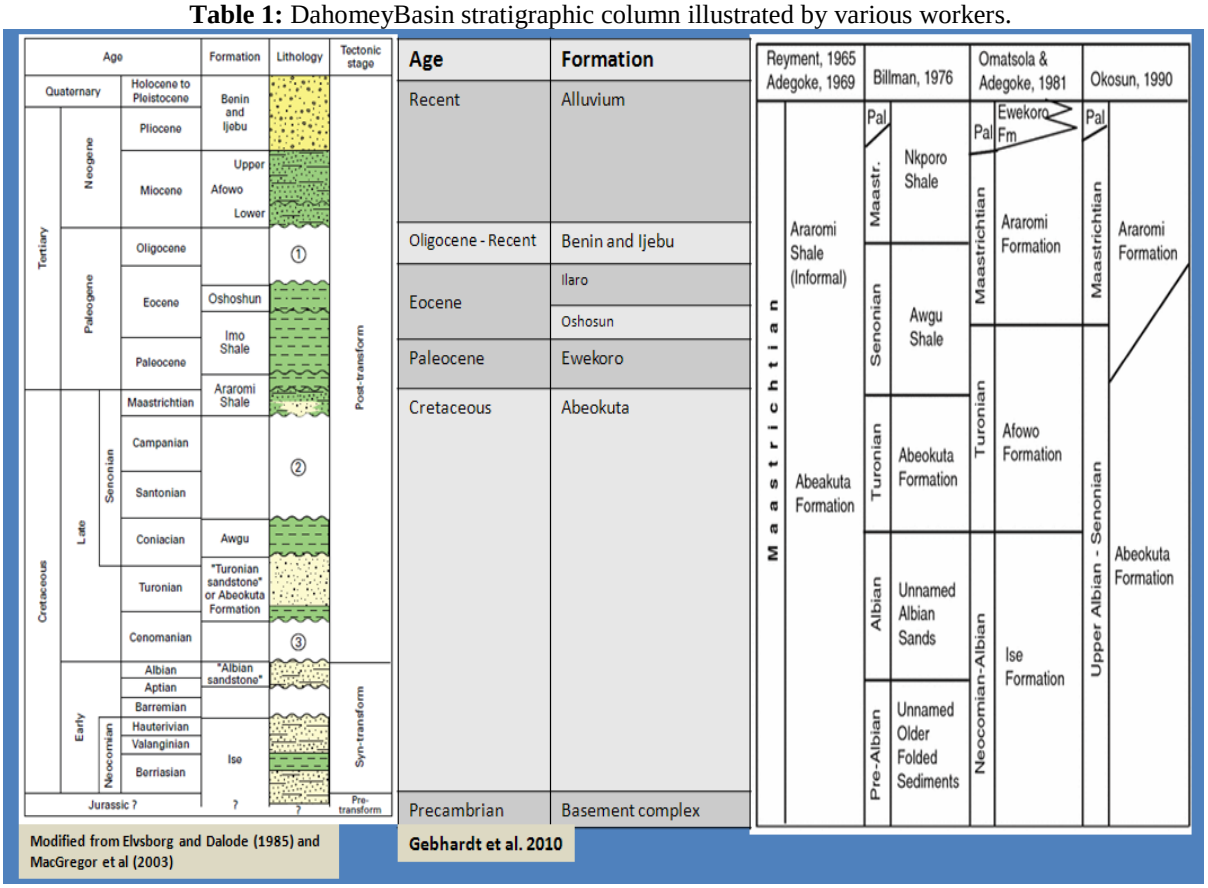
II. Geological Setting and Startigraphy

The PCL well is located in Block 1 Seme Field of Benin Republic, Dahomey Basin (Fig.1)**.** The Dahomey Basin evolved in the Late Jurassic-Early Cretaceous as a result of the separation of the Africa and South America plates which led to the opening of South Atlantic Ocean. The stratigraphic setting, tectonic evolution, sedimentologic, biostratigraphic and organic geochemistry studies of the different parts of the basin have been reported by several authors (Jones and Hockey, 1965;Adegoke, 1969;Adegoke *et al*., 1970;Fayose, 1970;Ogbe, 1970;Billman, 1976;Kogbe 1976;Omatsola and Adegoke, 1981; Whiteman, 1982;Coker and Ejedawe,1983;Okosun, 1990;Ekweozor, 1990]. Other important works include the following(Nwachukwu *et al*., 1992;Idowu *et al*., 1993;Nton, 2001;Elueze and Nton, 2004 and Adekeye, 2019). Palynological studies of the basin include those of(Salami, 1983, Salami, 1984, Ola-Buraimu and Adeleye, 2010, Ikhane *et al*., 2012, Ola-Buraimo *et al*., 2012, and Adeigbe *et al*., 2013, Adebiyi (2015), Anthony and Johnson (2020) and Ayok *et al*. 2020). The southwesternDahomey Basin of Nigeria is a wrench modified sedimentary basin containing rocks ranging in age from Cretaceous-Recent Idowu*et al*.(1993). The basin extends from Southeastern Ghana (Volta Delta) in the west, to the western flank of the Niger Delta in the east (Jones and Hockey, 1965; Ogbe, 1970;Omatsola and Adegoke, 1981;Whiteman, 1982). It is characterized by both block and transform faulting which superimposed across an extensive Paleozoic basin during the breakup of the African and South American continents (Burke *et al.*, 1971;Adeigbe*et al*., 2013). This led to the formation of continental margin and coastal margin which was filled up by Cretaceous and Tertiary sediments. The resultingstratigraphic setting of the Dahomey Basin has been described in detail in the works of Jones and Hockey (1964),Adegoke (1969), Ogbe (1970), Kogbe (1974), Billman (1976), Omatsola and Adegoke (1981), Ako*et al*. (1980), Okosun (1990), Idowu*et al*. (1993), Adekeye (2004) and Adekeye*et al*. (2006).

Work ofJones and Hockey (1964) based on the outcropping Dahomey Basinindicated thatthe stratigraphic successionrepresents a single unit refers to as the Abeokuta Formation.Otherauthors likeOmatsola and Adegoke (1989) and Okosun (1992) considered it as a Group but comprising of different formations though with contrasting schemes. These authors rejected the scheme provided by Billman (1992) because of adoptionof names having age equivalent beds in the Anambra Basin and Benue Trough. In the southwestern Nigeria, the continental clastic unitoftheNeocomianIse Formationis at the bottom of the succession(see Table 1). This basal unit is predominantly made up of conglomerates followed by gritty, coarse to medium-grained loose sands interbedded withwhitish kaolinitic clays. Above the IseFormation is the MaastrichtianAfowo Formation,mostly of medium to fine-grained sandstones and interbedded with relatively thick siltstone and shale. The shales are rich in organic matter, showing brackish water condition below, but becoming more marine towards the top, with increasing shaliness in the same direction. Marinefine-grained fossiliferous horizons oftenalternate with well-sorted, sub-rounded clean, loose sands of continental origin in the area. In some areas, the Afowo Formation overlies the basement directlywhich are bituminous in both surface and sub-surface sections. The

Araromi Formation is the topmost unit of the group. It is made up of sands at the base overlain by siltstones and shalesinterbedded with bands of limestones, sands and lignite towards the top. The shales are dark to grey and are rich in organic matter. Both the sands and shales are bituminous in many places.These sediments of the Dahomey Basin overlie the Basement Complex showing homoclinal, essentially south-dipping strata, most of which outcropped onshore. Additionally, the basin contains sediments of the Avon Canyon in the western areas. In some parts of the basin, these canyon-fill deposits have completely eroded the older Tertiary Delta sediments and are deeply embedded in Cretaceous sequences.

Table 1: DahomeyBasin stratigraphic column illustrated by various workers.



III. Material and Methods

Seventy ditch samplesof the Offshore Dahomey Basin collected from South Atlantic Petroleum Company (SAPETRO) were composited at 40ft interval for palynological studies. The depth range of the well is 1240-2690ft. The name of the well was not given at the time these samples were collected. Therefore, PCL-wellis assigned for reference purpose in this study.

The seventy ditch samples were taken to the laboratory for preparation and analysis. The samples were weighed at 25g and crushed in a porcelain mortar with a pestle to approximately 2-5mm sized particles to create more surface area for proper chemical reaction. It was then treated with 36% concentrated HCl to remove calcium carbonate. Then the samples were stirred intermittently, allowed to soak overnight and later rinsed with distilled water. The residue was treated with 60% HF and leftovernight to remove all the silicates materials. The hydrofluoric acid formed was removed by addition of warm and then cold HCl. All acids treatments (HCl and HF) and rinsing with distilled water were done at 2000rpm centrifuging and supernatant solutions weredecanted. Zinc bromide (specific gravity of 2.2) was added and stirred properly with a glass rod. This was centrifuged for 10 minutes at 1600 rpm. The floating top part which consists of organic material was gently decanted into a newly marked tube. This was repeated twice to recover as much organic material as possible.Samples were mildly oxidized, followed by heavy mineral liquid separation of the macerals using Zinc bromide (ZnBr2) at 2.1 g/cc. The collected residue was mounted on glass slides with DPX. The preparation method was in accordance with standard methods. Palynological album and comparison with published literatures such asGermeraad *et al*., (1968), Evamy *et al*., (1978) and Muller *et al*., (1987) were used inidentifying thepalynomorphs. Photomicrographs of diagnostic species (see plate 1)were taken with Nikon Cool pix P6000 digital camera.Abundance of pollen, spores, dinoflagellates, fungal spores, and other stratigraphically significant forms

present were determined for each sampleas shown on the palynologicalchart (Fig. 3). This was done to decipher the paleoecology and paleoenvironment of the studied Dahomey Basin samples.

IV. Result:

Recovered Palynomorphs Assemblages

Stratigraphicdistribution of the palynomorph assemblages retrieved from PCL well in offshore Dahomey Basinsouthwestern Nigeria is shown in figure 3 and plate 1. The analyzed sediments of PCLwellyielded moderately rich, well preserved and diversifiedpalynomorphs(Fig. 3). Thiscomprises of a total of 73 palynoflora taxa assemblages analyzed from 28 slides of PCL well.Out of the73palynologiccal taxa, 47 are pollen grains, 15 spores, 3 freshwater algae, 6 dinoflagellates,while others are fungal spores,and foraminiferal test lining.Photomicrographs of some important taxa retrieved from the well are shown in plate1.

Most of the palynoflora assemblages were dominated by angiosperm pollen, followed by pteridophytic spores and dinoflagellages cysts. The pollen grains are*Monoporitesannulatus,Zonocostitesramonae,Brevicolporitesguinetii, Sapotaceoidaepollenites*sp., *Nymphaepollisclarus, Psilastephanocolporitesminor,Crototricolporitescrotonosculptus, Protaeciditescooksonni, Marginipollisconcinnus, Peregrinipollisnigericus, Psilastephanocolporitessapotaceae, Psilatricolporitesoperculatus,Psilastephanocolporites*sp., *Spirosyncolpitesbruni, Protaeciditess*p., *Psilatricolporitescrassus, Psilatricolporites*sp., *Retitricolporitesirregularis, Monocolpitesmarginatus, Retitricolporites*sp., *Monocolpites*sp., *Pachydermitesdiederixi, Proxapertitescursus, Verrutricolporites*sp., *Arecipitesexilimuratus, Arecipites*sp., *Striatricolporitescatatumbus, Canthiumidites*sp., *Chenopodiacaea*sp.,*Echiperiporitesestalae, Echiperiporites*sp.,*Longapertitesmarginatus, Inaperturopollenitesgemmatus, Inaperturate pollen, Retistephanocolporites*sp.,*Pollen indeterminate,Adnenatherites simplex, Praedapolli*ssp., *Psilatriporitesrotundus, Psilatriporites*sp., *Psilatricolporites*sp., *Racemonocolpiteshians, Retibrevitricolporites*obodoensis/protrudens, *Retimonocolpites*sp.,*Syncolporites*sp.,*Spirosyncolpites*sp.,*Striamonocolpitesrectostriatus* and *Verrutricolporitesscabratus*. The distribution of the pollen grains is highly variable. Some taxa such as *Monoporitesannulatus, Zonocostitesramonae*and *Monocolpites*sp. occurred in high abundance. A typical example is thenumber of *Monoporites*sp.whichincreased down the stratigraphic sectionthoughsporadically(Fig.3).

The spores are*Magnastriatites*sp., *Acrostichumaureum,Stereisporites*sp.,*Aletesporites*sp.,*Laevigatosporites*sp., *Polypodiaceoisporites*sp., *Verrucatosporites*sp.,*Crassoratitriletesvanraadshooveni*and *Verrucatosporitesusmensis,Selaginellamyosorus, Mangnastriatites*sp., *Cyathidites*sp., *Distaverrusporites simplex, Lycopodium spp., Charred graminaecurticle*, as well as fungal spores and hyphae. The spores' abundance was dominated by *Laevigatosporites*sp., *Acrostichumaureum,Polypodiaceoisporites*sp.,*Verrucatosporites*sp.and fungal spore/hyphae.Among thethree algae present in the studied samples (*Botryococcusbraunii, Concentricystcirculus*and *Pediatrium*sp.,)*Botryococcusbraunii*occurredthroughout the depths intervalwhile,*Concentricystcirculus* occur only at the between 1240 to 1320ft.

Recovered*Dinoflagellates*are*Lingulodinium*sp., *Systemaphoratareolata, Operculodiniumcentrocarpum, Lingulodiniummechaerophorum*,and *Operculodiniummechaerophon*.It was observed that occurrence of these palynomorphsin the studiedwell samplesis periodical.The only Acritarch recovered is *Leiosphaerides*sp. Its occurrence is infrequent as it only occurred at few depth intervals(1400-1440ft, 1680-1720ft, 1840 1880ft, 2080-2120ft and 2240 – 2280ft see figure 3).

PLATE 1

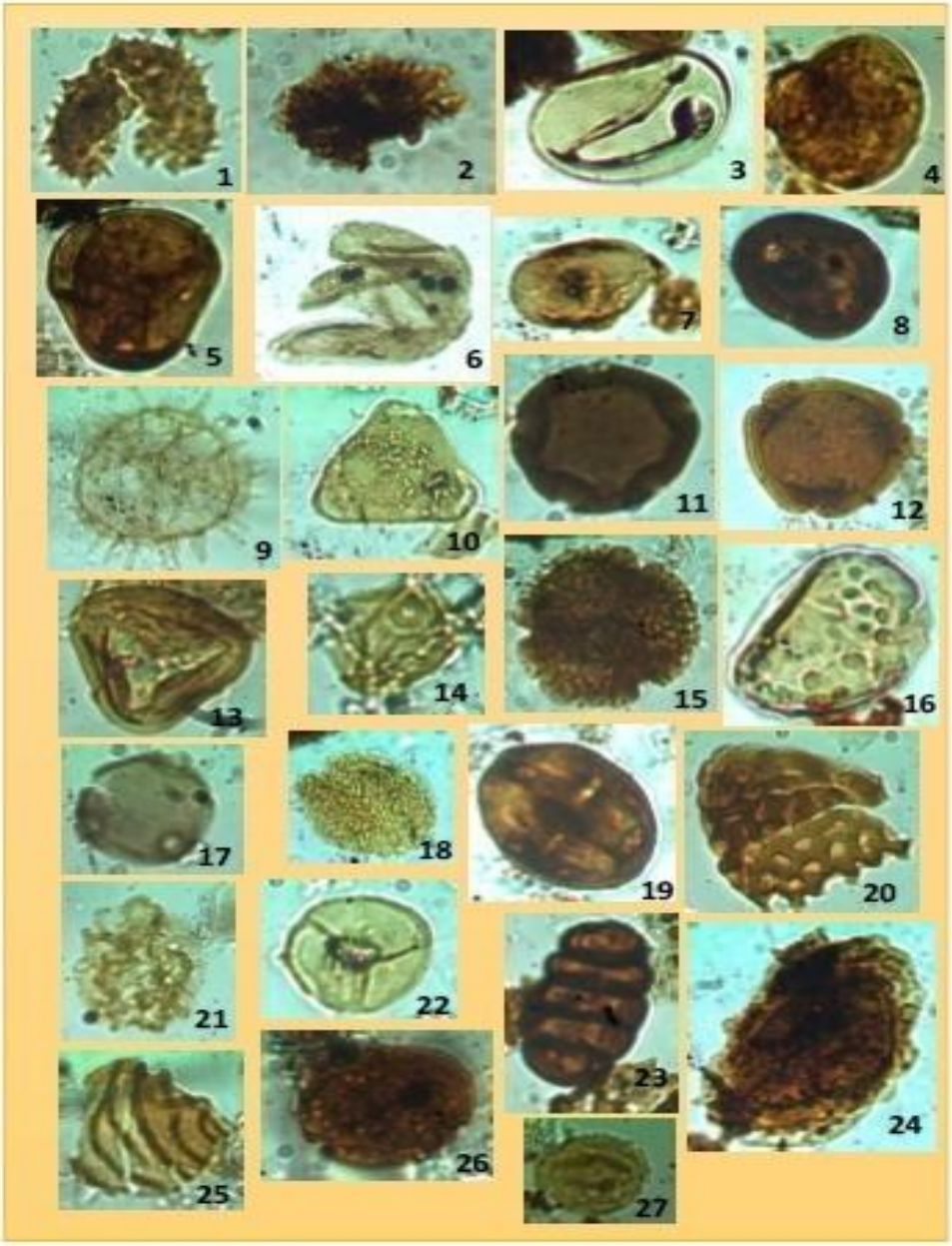


PLATE 1

1. ECHIPERIPORITES INCACINOIDES
2. BOTRYOCOCCUS BRAUNII
3. LAEVIGATOSPORITES SP
4. MONOCOLPITES SP
5. ACROSTICHUM AUREUM
6. STRIATRICOLPORITES CATATUMBUS
7. PSILATRICOLPORITES SP
8. NYMPHAEAPOLLIS CLARUS
9. OPERCULODINIUM CENTROCARPUM
10. PROTEACIDITES COOKSONNI
11. PACHYDERMITES DIEDERIXI
12. PSILATRICOLPORITES CRASSUS
13. POLYPODIACEOISPORITES SP
14. MONOPORITES ANNULARUS
15. RETITRICOLPORITES IRREGULARIS

16. VERRUCATOSPORITES SP
17. RETIBREVITRICOLPORITES OBODOENSIS
18. RACEMONOCOLPITES HIANS
19. PSILASTEPHANOCOLPORITES SAPOTACEAE
20. CRASSORETITRILETES VANRAADSHOOVENI
21. PEREGRINIPOLLIS NIGERICCUS
22. STEREISPORITES SP
23. FUNGAL SPORE
24. SPIROSYNCOLPITES BRUNI
25. MAGNASTRIATITES SP
26. CANTHIUM SP
27. VERRUTRICOLPORITES SP

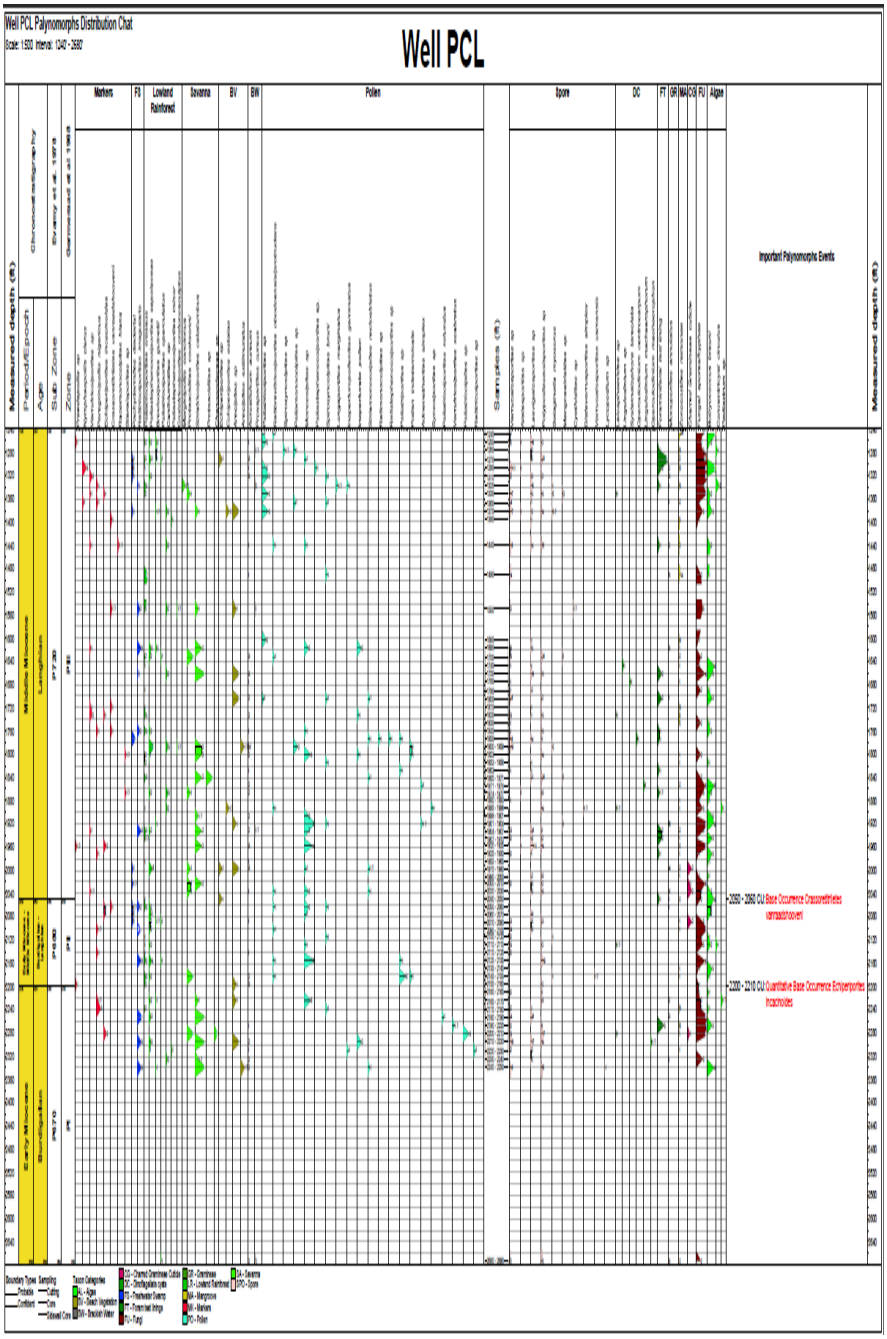


Figure 3: Palynomorphs distribution chart of depthinterval1240 to 2690ft (378 to 820 m) of well PCL, offshore Dahomey Basin (After Ayok*et al*., 2020).

V. Discussion

PaleoecologicalReconstruction based on the Recovered Palynomorphs Assemblages

From figure 3 above, thewhole palynoflora assemblages recovered from PCL well have been grouped and characterized into five ecological species which include freshwaterswamp (FS), beach vegetation (BV), brackish water swamp (BW), lowland rainforest, savannah, and marine alongside fungal elements andother forms without specific ecological affinities (see also Table 2). Thegroupings were based on the botanical affinities of the fossilpalynoflora recovered from the PCL well with new plants or closest livingrelatives.

The freshwater swamp and beach vegetation are characterized by*Pachydermitesdiederixi*,*Retitricolporitesirregularis*,*Laevigatosporites*sp., and *Echiperiporitesestalae*;and*Echiperiporites*sp., *Arecipitesexilimuratus*, and *Arecipites*sp. respectively.*Laevgatosporites*sp.,*Retitricolporitesirregularis and Arecipites*sp.,showed the most consistent occurrence. The records of the otherformsare sporadic. The brackish water swamp species are dominated by *Acrostichumaureum*, *Psilatricolporitescrassus*, *Proxapertitescursus*and*Verrutricolporites*sp. Large amounts of fossil pollen having botanical affinities that can be assigned to tropical lowland rain forest plants were also retrieved from the well. Based on decreasing number of abundance, they are*Psilatricolporitescrassus*, *Psilastephanocolporitessapotaceae*, *Canthiumidites*sp.,*Brevicolporitesguinetii*,*Psilatricolporitesoperculatus*, *Crototricolporitescrotonoscuptus*and *Psilastephanocolporitesminor*. The palynomorphsof theSavannah ecology are*Monoporitesannulatus*, *Striatricolporitescatatumbus*, *Maginipollisconcinnus*,*Proteaciditescooksonnian* and *Chenopodaceae*sp.,in decreasing order.It can be obviously observed from fig 3 that, *Monoporitesannulatus*and *Striatricolporitescatatumbus*occurredmore consistent in the stratigraphic succession than*Maginipollisconcinnus*,*Proteaciditescooksonnian* and *Chenopodaceae*which are quite sparse and infrequent, occurring only in the upper part of the studied PCLwell. *Monoporitesannulatus*is grass (or Graminae) pollen can be traced botanically to thefamily of *Gramineae*(or *Poaceae*)whichismainly confined to more open vegetation, coastal savannahs and river valleys (Germeraad*et al*., 1968;Ogbahon*et al*.,2019). Themangrove palynomorphs recovered from the investigated well section included the taxa *Zonocostitesramonae*, *Acrostichumaureum*, and *Psilatricolporites*sp.The species, *Acrostichumaureum*has been identified as fern currently growing within mangrove vegetation (Rao*et al*.,2013; Massini, 2013). These authors confirmed that *Acrostichumaureum*is adapted to coastal areas associated with mangrove vegetation, areas inundated with saline waters, open salt marshes, coastal swamps and areas along estuarine rivers. Marine-derived palynomorphsinclude*Dinoflagellates*and Acritarch. The fossil dinoflagellatesare mostly known from marine sediments (Ayinla*et al*., 2013). They constituteabout 8.2% of the entire palynomorphsidentifiedin the PCL well samples. Dinoflagellate forms identified are*Lingulodinium*sp., *Systemaphoratareolata*, *Operculodiniumcentrocarpum*, *Lingulodiniummechaerophorum*, and *Operculodiniummechaerophon*but only*Lingulodinium*sp. appeared in almost all the well section.This indicate open marine.

Paleoenvironmental Reconstruction based on the Recovered Palynomorphs Assemblages

Environmental changes are usually reflected in the palynological assemblages (Ojo and Akande, 2004). It is on this ground that the composition andrelative proportions of different groups of palynomorphs are utilizedin this study for interpretation of paleoenvironment.Paleoenvironmental deductions of the analyzed interval of PCL well have been made on the basis of palynomorphs characteristics. This involves both quantitative and qualitative distribution of miospores, as well as microforaminiferal wall lining abundance, relative diversity and abundance of dinoflagellate cysts and the occurrences of Pediastrum andBotryococcus (fresh water algae). Also charred gramineae cuticles were considered. In the case of miospores, some environmentallyrestricted marker species such as *Crassoretitriletesvanraadshooveni*and*Pachydermitesdiederixi*, *Retitricolporitesirregularis*, *Psilastephanocolporites*sp. (*Sapotaceae*),*Psilatricolporitescrassus*, *Verrucatosporites*sp., *Laevigatosporites*sp., and Percentage of *Zonocostitesramonae* (Rhizophorntype) and*Monoporitesannulatus*were also considered (seeTable3). Many of thesepalynomorphsare closely similar in morphology to recent species so thatassumptions can be made about their ecological requirements(Germeraad et *al.,* 1968).For example, species indicative of coastal plain environments include *Crassoretitriletesvanraadshooveni*(a climbing fern of coastal swamp forest),*Pachydermitesdiederixi*(an angiosperm of coastal swamps) and*Zonocostitesramonae* (the mangrove group), *Monoporitesannulatus* (savannah) Lacustrine, *Laevigatosporites*sp. (Brackish to fresh water swamp).

The entire stratigraphic section of the PCL well is divided into four main sections i.e. 1240 – 1520ft, 1520 - 1800ft, 1800 -2080ft, and 2080 -2360ft. Each of this section is considered in details below:

Depth 1240 – 1520ft

A semi quantitative interpretation technique was employed to determine thepaleoenvironment of deposition of interval 1240 to 1520ft of thestudied samples from the Dahomey Basin (PCL well). This is referred to as Palynological Marine Index (PMI). The method is dependent on the amount of terrestrially and

aquatic derived palynomorphs separately. Helenes*et al.*(1998),Ayinla*et al.* (2013)andAkinsile (2016) defined PMI as: PMI = (Rm / Rt + 1) × 100.This index is used to deduce the paleoenvironments offossil forms with respect to fluvial or marineenvironments. The range of classification herebyfollows: 0 or nil =Terrestrial or freshwater environment,>0 to 50 =Brackish water influence, >50 to 100=Marine environment.

Where Rm = Richness of marinepalynomorphs(Dinoflagellates + Acritarch + Prasinophytes+Foraminifera linings) counted as the number of taxa per sample.Rt = Richness of terrestrial palynomorphs (Pollen +Spores+ Fungal remains) also counted as the number of taxa per sample.

From table 2, the PMI values of this depth range is very low. The values ranged from 0 to 16.0. At depth interval 1240 – 1280ft, 1280 – 1320ft, 1320 -1360ft, 1360 – 1400ft, 1400 -1440ft, 1440 -1480ft and 1480 -1520ft have PMI values of 3.5%, 16.0%, 6.5%, 0.0 %, 0.0%, 4.3% and 0.0% respectively. According to Helenes*et al.*,(1998) from 1240 to 1360ft is interpreted as brackishwater environment dominated by terrestrial palynomorphs over marine palynomorphs. While depths which record 0.0% ofpalynomorph marine index suggest fresh water environment. The percentage of *Monoporitesannulatus, Acrostichumaureum* and *Zonocostitesramonae* from table 3 were also considered. At depth interval of 1240 -1280ft shows zero counts of *Monoporitesannulatus*and21 count of *Zonocostitesramonae*making 91.3%. This is indicative of wet climate. *Zonocostitesramonae*dominate throughout this stratigraphic section (see figure 4). Observed increase in*Acrostichumaureum* between 1320 –1400ftover *Zonocostitesramonae*indicates an influx of saline waters, open salt marshes, coastal swamp and areas along estuarine rivers MassiniGarcia*et al.,* (2006).

Depth interval 1520 to 1800 ft

ThePMI values within this depth ranged from 0.0% to 20%. This suggests fluvial environmentas compared to the works of Helenes*et al.* (1998). Dominanceof *Monoporitesannulatus*at 1520 – 1600ft over *Zonocostitesramonae* indicates dry climate and inland environment. Within the depth of 1560 1680ft(see Fig. 5), *Rhizophora*(*Zonocostitesramonae*) has a maximum record of 75%and within this interval there is a complete absence of *Poaceae*(*Monoporitesannulatus*) indicating a brief period of wet climatic condition and the sediments were deposited within the mangrove swamp environment. This probably indicates complete replacementof grass by the rainforest vegetation during this brief interval, at least in the vicinity of depositional site. The occurrence of *Acrostichumaureum*together with *Zonocostitesramonae*dominating between 1640 to 1800ft with absence of *Monoporitesannulatus*suggest coastal areas associated with mangrove along estuarine rivers (MassiniGarcia*et al.*,2006).

Depth 1800 to 2080ft

This interval has frequent occurrence of Z. *ramonae and A. aureum*throughout the stratigraphic section but *M.annulatus* occurred only at some depths. Between 1800 -1880ft. A*crostichumaureum*is more in abundance followed b*y Zonocostitesramonae*and absence of *Monoporitesannulatus*which have 57.2%, 42.8% and 0.0% respectively (Table 3). This is indicative of lacustrine environment (Muller, 1959; Germeraad*et al.,* 1968). At depth interval of 1880 to 1960 ft*Monoporitesannulatus*becomes dominant over the two. This indicates a change from wet and warm climate to dry climate. Similarly the same scenario happens between depth intervals of 1960 to 2080 ft. The curve generally shows an alternating change from dry to wet warm climate. The PMI values of this depth interval ranged from 0.0% to 22.2% confirms that the sediments were deposited within the freshwater to brackishwater environments (Table2).

Depth interval 2080 to 2360ft

This interval is characterized by the occurrence of *Zonostitesramonae*, *Monoporitesannulatus*and *Acrotichumaureum*in addition to other palynomorphs such as *Striatricolporitescatatumbus, Retitricolporitesirregular,* fungal spore/hyphae and *Botryococcusbrauni.* The abundant occurrence of *Acrostichumaureum* from 2080 to 2200 ft as shown in figure 7 with little mixture of *Zonocostitesramonae*indicates brackish water environment. From2200 to 2320 ft shows the abundant of *Zonocostitesramonae*over the twoforms,indicating a change from the brackish water to mangrove. The abundance of Algea (*Botryococcusbrauni)* which is a fresh water indicator, and common brackish water species, *Zonocostitesramonae*within this depth suggest lagoonal or estuarine or delta plain environment (brackish water environment).

Table 2: Ecological groupofspecies diversity, abundance and marine index values of PCL Well.

S/N	Depth(ft)	FWSP	BWSP	SA	LR	FU	ALG	MA	PMI	SD	FREQ
1	1240-1280	1	1	0	14	8	3	21	3.5	17	66
2	1280-1320	2	4	0	4	17	9	7	16	24	112
3	1320-1360	1	6	2	2	11	6	5	6.5	19	75
4	1360-1400	1	0	0	4	3	0	5	0.0	12	42
5	1400-1440	0	1	0	2	0	2	2	0.0	10	29
6	1440-1480	0	1	0	6	2	1	14	4.3	12	25
7	1480-1520	0	0	1	7	0	0	0	0.0	3	8
8	1520-1560	2	1	0	0	3	0	0	0.0	10	13
9	1560-1600	3	0	2	8	1	0	0	0.0	8	20
10	1600-1640	1	3	4	6	2	7	9	6.3	20	54
11	1640-1680	0	4	0	4	4	4	2	16.7	14	35
12	1680-1720	0	4	0	4	2	0	5	20	13	40
13	1720-1760	3	1	0	5	2	3	5	5.9	23	54
14	1760-1800	0	8	4	6	2	1	0	7.7	17	49
15	1800-1840	0	3	4	5	2	4	2	9.5	15	29
16	1840-1880	0	4	1	6	10	3	3	11.5	15	35
17	1880-1920	3	3	3	9	9	8	2	0.0	21	42
18	1920-1960	0	4	2	3	6	3	4	22.2	21	85
19	1960-2000	1	4	1	7	0	3	3	2.2	18	34
20	2000-2040	1	1	4	9	8	4	2	0.0	16	46
21	2040-2080	2	1	0	12	3	6	2	6.7	17	47
22	2080-2120	1	1	0	4	3	2	0	4.2	21	47
23	2120-2160	0	2	2	12	5	4	2	0.0	15	47
24	2160-2200	0	3	1	7	2	3	0	0.0	15	33
25	2200-2240	0	0	2	3	10	4	5	0.0	16	38
26	2240-2280	0	3	5	7	10	3	5	14.3	21	69
27	2280-2320	0	4	3	8	3	0	2	0.0	20	48
28	2320-2360	0	0	0	6	0	4	0	0.0	14	32

Note: Fresh Water Swamp Species(FWSP), Brackish Water Swamp Species(BWSP), Savannah(SA), Lowland Rainforest Species(LR),Fungi(FU), Algae(ALG), Mangroove (MA), Species Diversity(SD), Palynological Marine Index (PMI)= $(R_m/Rt+ 1)\times100$ where R_m is Richness of Marine Palynomorph (Dinoflagellates, acritarch, and foraminiferal wall linings) counted as number of taxa per Sample, Rt= Richness of Terrestrial Palynomorphs (Sporomorphs)

Table 3: Monoporitesannulatus, Zonocostitesramonae and Acrostichumaureum composition of PCL well

S/N	Depth(ft)	M. annulatus	Z. ramonae	A.aureum	Total	%M. annulatus	% Z. ramonae	%A. aureum
1	1240-1280	0	21	2	23	0.0	91.3	8.7
2	1280-1320	5	7	3	15	33.3	46.7	20
3	1320-1360	1	5	7	13	7.7	38.5	53.8
4	1360-1400	1	5	0	6	16.7	83.3	0.0
5	1400-1440	2	2	0	4	50.0	50.0	0
6	1440-1480	3	14	1	18	16.7	77.8	5.5
7	1480-1520	0	0	0	0	0.0	0.0	0.0
8	1520-1560	0	0	1	1	0.0	0.0	100
9	1560-1600	3	0	0	3	100	0.0	0.0
10	1600-1640	0	9	3	12	0.0	75.0	25.0
11	1640-1680	1	2	4	7	14.3	28.6	57.1
12	1680-1720	0	5	4	9	0.0	55.6	44.4
13	1720-1760	0	5	1	6	0.0	83.3	16.7
14	1760-1800	0	0	8	8	0.0	0.0	100.0
15	1800-1840	0	2	3	5	0.0	40.0	60.0
16	1840-1880	0	3	4	7	0.0	42.8	57.2
17	1880-1920	5	2	3	10	50.0	20.0	30.0
18	1920-1960	0	4	4	8	0.0	50.0	50.0
19	1960-2000	4	3	4	11	36.4	27.2	36.4
20	2000-2040	5	2	1	8	62.5	25.0	12.5
21	2040-2080	0	2	1	3	0.0	66.7	33.3
22	2080-2120	0	0	1	1	0.0	0.0	100.0
23	2120-2160	0	2	2	4	0.0	50.0	50.0
24	2160-2200	2	0	3	5	40.0	0.0	60.0
25	2200-2240	3	5	0	8	37.5	62.5	0.0
26	2240-2280	0	5	3	8	0.0	62.5	37.5
27	2280-2320	1	2	4	7	14.2	28.6	57.1
28	2320-2360	0	0	0	0	0.0	0.0	0.0

Monoporitesannulatus (M.annulatus), Zonocostitesramonae (Z.ramonae), Acrostichumaureum(A. aureum)

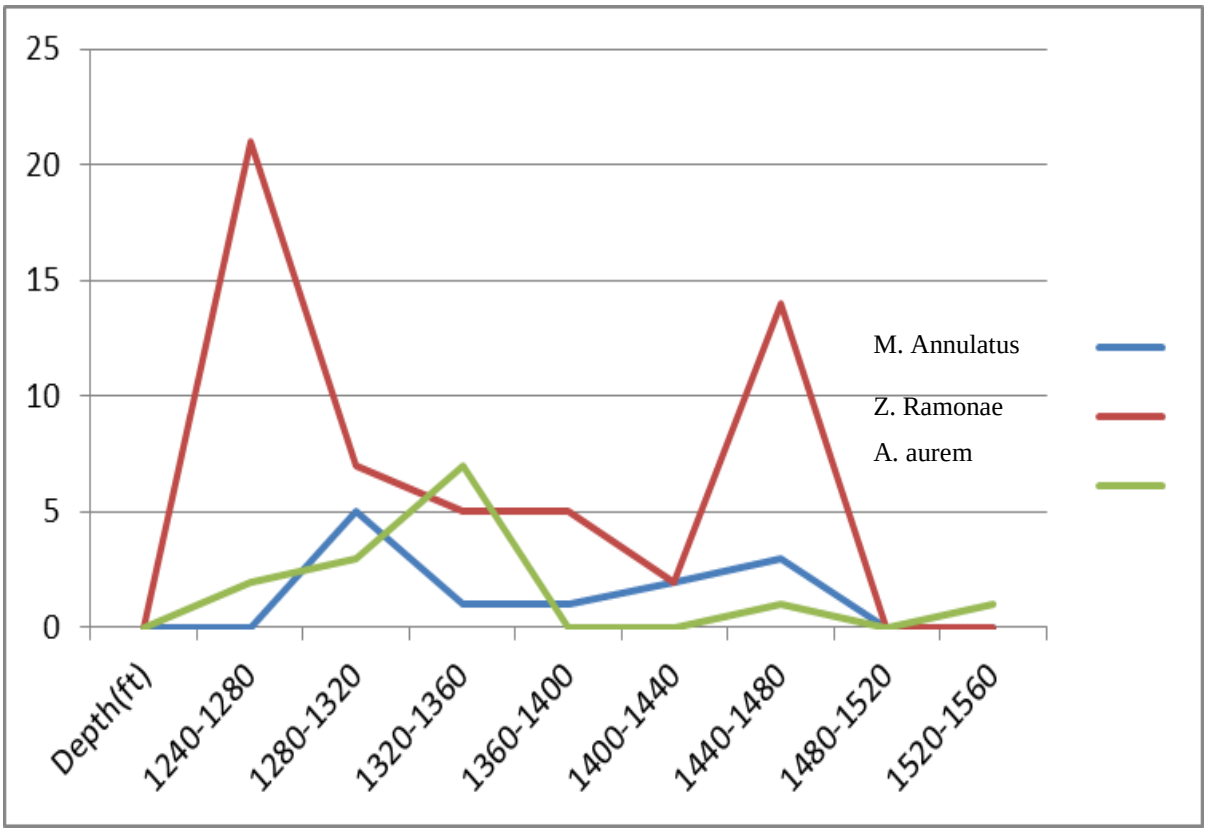


Figure 4: Plot of *Zonostitesramonae*, *Monoporitesannulatus*and*Acrotichumaureu.*

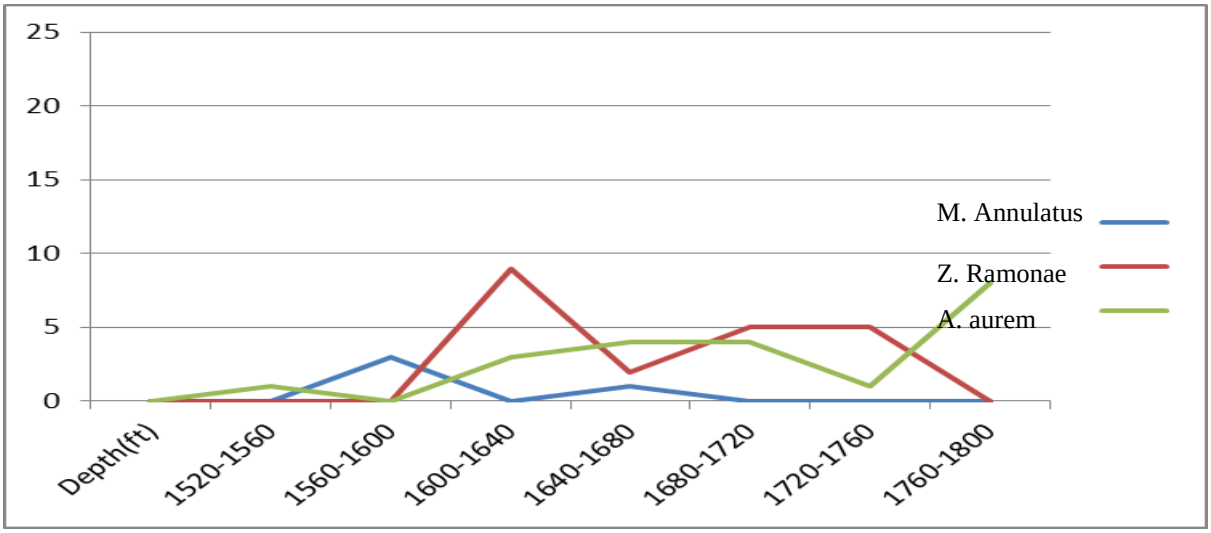


Figure 5: Plot of *Zonocoostitesramonae*, *Monoporitesannulatus*and*Acrotichumaureum.*

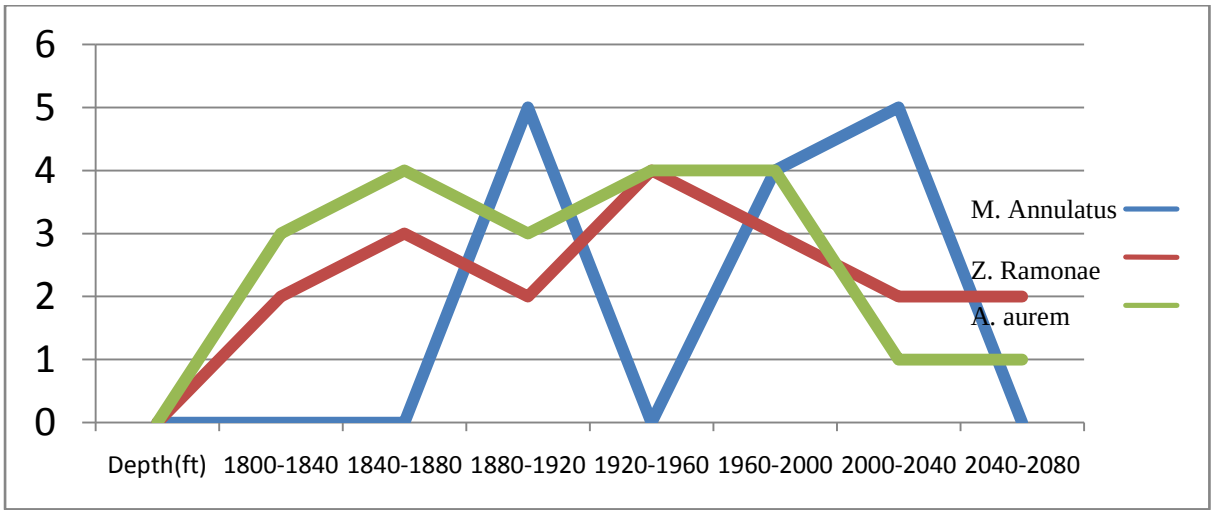


Figure 6: Plot of *Zonocostitesramonae*, *Monoporitesannulatus*and*Acrotichumaureum*

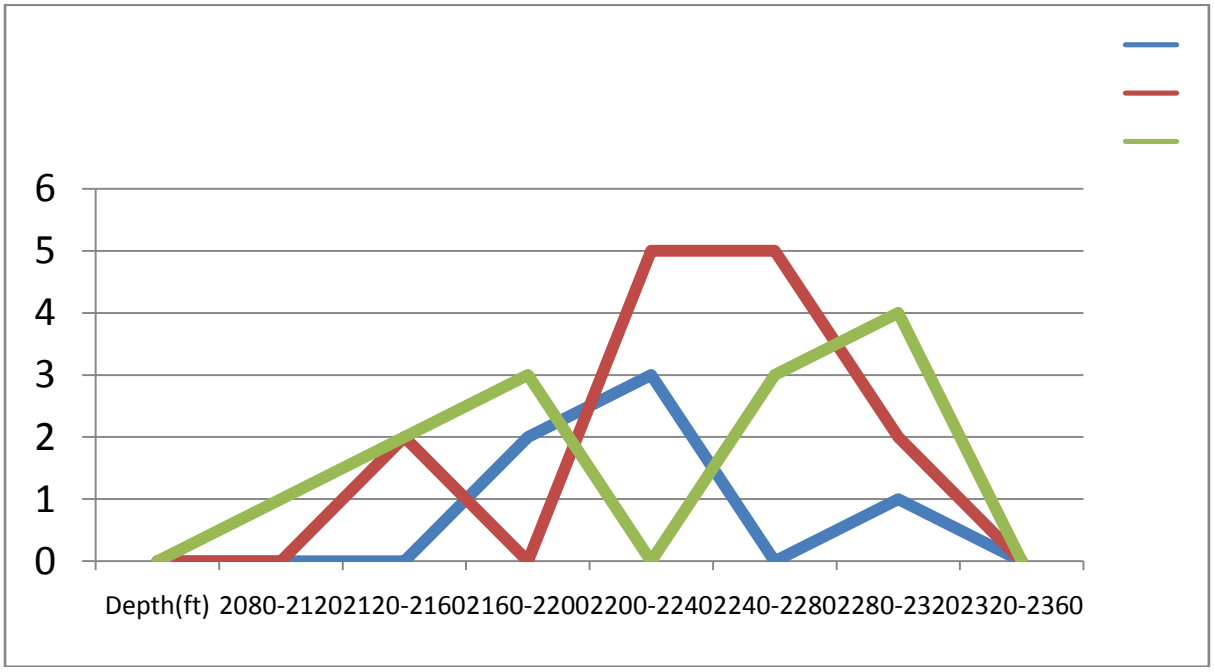


Figure 7: *Zonocoostitesramonae*, *Monoporitesannulatus*and*Acrotichumaureum.*

VI. Conclusion

Palynological study of PCL well from offshore Dahomey Basinrevealed well preserved palynofloraassemblages with high diversity. Observed and inferred evidences frompalynomorphs which integrated both quantitative and quality studied were used to interpret the paleoecologyas well as delineate different environment of deposition of the sediments. The results show five paleoecological zones which are: fresh water, lowland rainforest, savanna, brackish water and beach vegetation. In addition, most of the samples were deposited within lacustrine, lagoonal or estuarine environment (brackish water environment), while others were deposited in freshwater environment.

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