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PALYNOZONATION AND PALEO DEPOSITIONAL ENVIRONMENT OF EOCENE-OLIGOCENE SEDIMENTS OF NORTHWESTERN NIGER DELTA BASIN IN NIGERIA

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ABSTRACT

Fifty non-composited well cutting samples from a depth range of 486 – 3216 m of the BIMOL-1 well located in the north-western area of the Niger Delta Basin, were subjected to palynological and lithofacies analyses for the purpose of zonation and paleo depositional environment interpretation. Forty two miospore and ten dinocyst species were identified and used to age-date the sediments as Ypresian – Rupelian in age. Occurrence and abundance of age-significant species enabled four non-formal assemblage zones equivalent to existing palynological zones (P300 – P560) of the Niger Delta Basin to be erected. A subdivision of the extant P420 zone that spans the Upper Ypresian – Lower Lutetian into a lower and an upper subzone with the Ypresian – Lutetian boundary as the boundary of the two new subzones A and B was done, which will enable a finer scale well-well and field-wide correlation in the BIMOL-1 well area. Two gross depositional environment (continental and marine) were defined. Sediments in the depth interval(s) of 648-486, 1062 and 1836 m, were interpreted as deposited in continental delta plain settings, while sediments in the depth ranges of 3216-1854, 1782-1098 and 954-828 meters, were interpreted as formed in marine environment.

Keywords: *Palynozonation, Depositional environment, Niger Delta Basin, Eocene, Oligocene*

INTRODUCTION

The division of gross stratigraphic sequences into smaller units for effective correlation of reservoir sand bodies, field-wide seals and even regional top seals, etc., is pivotal in oil exploration and production business as it enhances a clearer view of subsurface structuru-stratigraphic configurations. The increasing application of Palynozonation in the search for hydrocarbon worldwide (Chow, 1995; Helenes *et al.*, 1998; Morley, 2000; Sowunmi, 2004; Barreda *et al.*, 2009, Jansen *et al.,* 2010), has enabled many age and facies related problems to be resolved (Olajide *et al.,* 2012).

Zonation of stratigraphic sequences combined with depositional environment interpretation provides a refined tool for finer scale correlation within and across fields. Correlation based on chronological and environmental conditions of sedimentary sections lowers risks associated with exploration and production of oil and gas. Morley (1991), has shown that substantial improvement in stratigraphic resolution can be achieved through the application of quantitative palynological techniques, aimed at identifying useful bioevents.

Despite the huge importance of palynology in biozonation studies and application in oil and gas business, a dearth of published data on the Paleogene of the Niger Delta Basin in public domain still remains, thus poses huge challenge to students and researchers of biostratigraphy. Although several works on the zonation of the Cenozoic of the Niger Delta exists (Evamy *et al.,* 1978; Adeonipekun *et al.,* 2012; Oboh-ikuenobe *et al.,* 2005; Osokpor *et al.,* 2015, etc.), the need to erect a finer scale division of existing zones calls for more studies relating to the subdivision of existing zones especially for application in field-wide and inter-well correlation. In this work, we attempt a biozonation of the sedimentary sequence in BIMOL-1 well in accordance with existing zones and where possible erect a finer zonation using palynological events encountered in the well section and also to define paleoenvironment of deposition based on the lithofacies characteristics and biosignal displayed by the sediments.

Geology and Stratigraphy of the Niger Delta Basin

Ranked as one of the most prolific hydrocarbon provinces in the continent of Africa, with an impressive concentration of recoverable petroleum per rock volume, the Niger Delta Basin displays well over 12 km of clastic wedge, (Fig. 1). Recoverable reserve estimates is estimated at about 35 x 109 BBL of oil and 120 x 10^{12} SCF of gas (Ekweozor and Daukoru, 1994) to 66 x10^{9} BBL of oil equivalent (BOE; Saugy and Eyer 2003). Earlier decade's exploration and production of hydrocarbon from the Niger Delta was concentrated mostly on terrestrial and shallow water environments. The last decade has seen exploratory campaigns move out to deeper water settings resulting in gigantic deep-water finds, estimated at 109 BOE, (Bonga, Bonga SW, Agbami, Chota, Bobo, Zafiro, Erha, Usan, Etan, Ukot and Ikija).

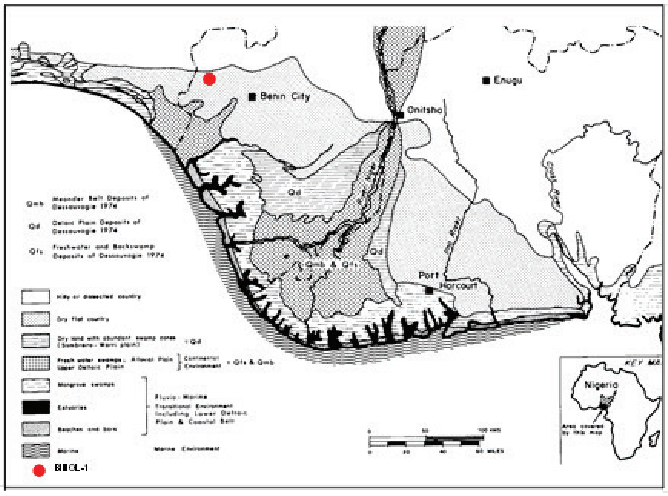


Fig. 1: A map of the Niger Delta oil province showing main sedimentary environments and the location of BIMOL-1 well (Source: Allen, 1965; Whiteman, 1982)

Since the Eocene the Niger Delta Basin sedimentary pile has prograded into the Atlantic Ocean underlain by continental and adjacent oceanic crust (Evamy et al., 1978). Although the sedimentary sequence of the Niger Delta is generally subdivided stratigraphically into a three-fold age diachronous units, named Akata, Agbada and Benin formations, (Short and Stauble, 1967; Doust and Omatsola 1989; Morgan 2003), older stratigraphic units exists in the northern parts of the basin. These include the Imo Shale Formation of Paleocene – Eocene age, Ameki Formation and the Ogwashi-Asaba Formations Short and Stuable, 1967; Whiteman, 1982; Ogbe, 1972, etc.). The Akata Formation with a thickness of 3 – 4 km, consists of overpressured laminated mud formed in deep marine pro-delta environment (Short and Stauble, 1967; Doust and Omatsola 1989; Haack et al., 2000). Unconformably overlying the Akata Formation is the over 3 km thick Agbada Formation composed of mixed clastic sediment. Sand bodies of the Agbada Formation formed in a paralic environment, act as reservoir rocks for hydrocarbons, while the shale act as cap rocks and seals in traps in the basin. Sub aerially overlying the Niger Delta is the Benin Formation of mainly continental origin. The Benin Formation consists of poorly sorted sands formed in fluvial environment (Whiteman, 1982)

The Imo Shale Formation an up-dip equivalent of the Akata Formation, consist of shale formed in shallow marine environment. The age ranges from Paleocene to Ypresian (Murat, 1972; Ogbe, 1972; Whiteman, 1982, etc.). The Ameki Formation of Eocene age, consist of shale, sand and limestone (Murat, 1972; Ogbe, 1972; Whiteman, 1982, etc.), while the Ogwashi-Asaba Formation (The

Lignite Series of Parkinson 1906), with an estimated thickness of about 250 meters, consist of dark shale, lignite and sand. The Ogwashi-Asaba Formation has an Oligocene age (Simpson, 1955; Reyment, 1965; Murat, 1972; Ogbe, 1972; Nwajide, 1980; Whiteman, 1982; Arua, 1980).

MATERIALS AND METHODS

Fifty non-composite ditch cutting shale and sand samples from a depth range of 486 – 3216 m of BIMOL-1 well located in the western part of northern Niger Delta Basin were selected and subjected to lithofacies and palynological analysis. The well from which the samples were retrieved is a property of Shell Petroleum Development Company (SPDC), but for confidential reasons, is here coded BIMOL-1 well. The samples were subjected to lithological description for whole grain attributes with a general sampling range of 48.82 m for the well section.

Palynological sampling and Analysis

In accordance with sample analytical techniques described by Traverse (1988), fifty non-composited whole rock shale samples were subjected to various stages of acid treatment to liberate the sedimentary organic component of each sample that were subsequently used for palynological slide preparation. Age determination for the well section was done with reference to published data by Muller (1959), Gemeraad (1968), Adegoke (1969), Legoux (1978), and Sowumi (1981b).

RESULTS

Biostratigraphy

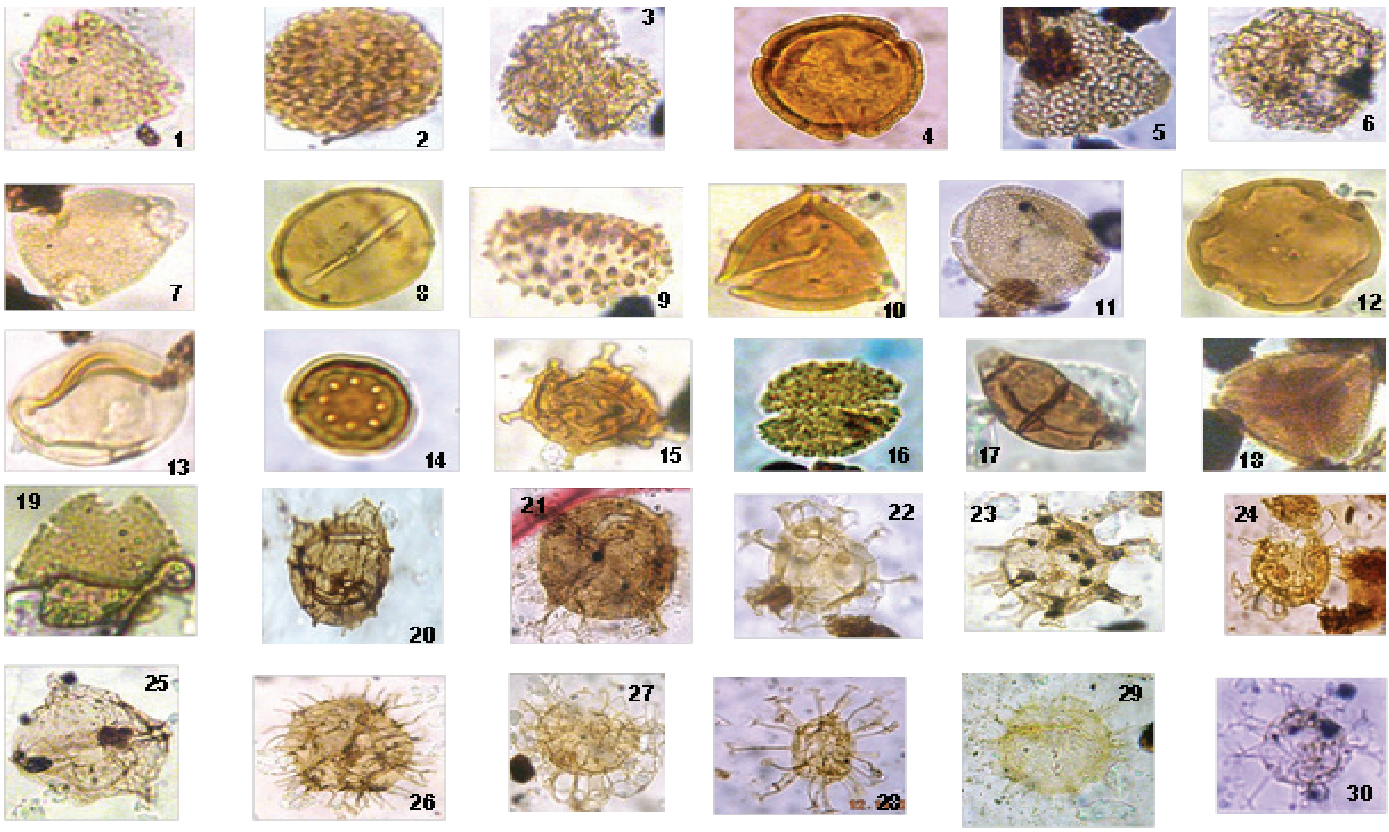
Some significant representative palynomorph form species recovered from the studied samples and identified are presented in figure 2. Figure 3 presents a range distribution of forms with depth while figure 4 presents a quantitative distribution of species in relation to the associated vegetation type in the well. A total of forty two (42) species of miospores and ten (10) dinoflagellate cysts species were identified from the recovered forms present in the samples (fig. 2).

Biostratigraphy

Geologic Age Determination

From the many pollen grains and spores that were recovered from the samples, the following index forms were identified:

Cleistophollis patens, Pachydermites diederixi, Grimsdalea polygonalis, Grimsdalea magnaclavata, Cyathidites sp., Verruscatosporites usemnsis, Retibrevicolporites triangulates, Retitribrevicopites obodensis, Praedapollis africanus, Praedapollis flexibilis, Polypodiaceisporitessp., Racemonocolpites hians, Cinctiperiporites mulleri, Arecipites exilimuratus and Proxaperites cursus (Fig. 2),



1. Retribrevitricolpites triangulates, 2. Cleistophollis patens, 3. Retitricolporites irregularis, 4. Psilatricolporites crassus, 5. Syndemicolpites typicus, 6. Praedapollis africanus, 7. Retribrevitricolporites. Obodensis, 8. Psilamonocolpites marginatus, 9. Verrucatosporites usmensis, 10. Dualaidites sp., 11. Proxapertites cursus, 12. Pachypermites diederixi, 13. Laevigatosporites sp., 14. Cinctiperiporite mulleri, 15. Grimsdalea magnaclavata, 16. Racemonocolpites hians, 17. Fungal spore, 18. Loranthacidites nataliae, 19. Proteacidites dehaani, 20. Kenleyia lophophora, 21. Muratodinium fimbratum, 22. Homotryblium tenuispinosum, 23. Homotryblium palladium, 24. Systematophora, 25. Palaeoperidinium, 26. Apectodinium homomorphum, 27. Adnatosphaeridium vittatum, 28. Distatodinium, 29. Lingulodinium macphaerophorum, 30. Spiniferites pseudocatus

Fig. 2: Photomicrographs of some recovered miospores and dinocyst from BIMOL-1 well used for age and Paleoenvironmental diagnosis.

Their application were based on either First Appearance or Last Appearance or both including abundance and regular occurrence in the stratigraphic column. These index forms enabled an age range of Lower Eocene to Lower Oligocene for the studied well section to be established as summarized in the following section.

Lower Eocene: 3216-2856 m.

The occurrence and subsequent disappearance of Cyathidites sp., at this depth interval indicate lower Eocene. This age is also confirmed by the interval being immediately below the first appearance datum of Mid-Eocene markers: Cleistopholis patens and Pachydermites diederixi (Figs. 2 and 3). Other forms encountered within this interval include Zonocostite ramonae, Laeviatosporites sp. and Monolete spore.

Middle Eocene: 2856-1782 m.

The interval is characterized by the first appearances of *Cleistopholis patens, Praedapollis africanus* and *Pachydermites diederixi* (Figs. 2 and 3), which indicate Middle Eocene age (Legoux, 1978). The occurrence of *Grimsdalea polygonalis* and *G. magnaclavata* within this interval further confirmed this age. Other palynomorph form species recovered from this interval includes *Retibrevitricolporites obodoensis, Retitricolpites irregularis, Retribrevicolporites triangulatus and Laevigatosporites sp*. These forms according to, Adegoke (1969) are common in Middle Eocene but not restricted to it.

Upper Eocene: 1782-954 m.

This interval is characterized by the first appearance of Racemonocolpites hians and Cinctiperiporites mulleri both of which are characteristic of Upper Eocene age (Muller, 1968). Other forms recovered from this interval include *Polypodiacesporites sp., Retibrevitricolpites obodoensis* and *Retimonocolpites obaensis* (Figs. 2 and 3). These forms according to Sowumi (1981) are characteristic of Upper Eocene but no restricted to it.

Lower Oligocene: 954-486 m.

This interval is characterized by regular and increased occurrence of *Arecipites exilimuratus*. The regular and increased occurrence of this form indicates a Lower Oligocene (Legoux, 1978). Other forms identified within this interval include *Retitricolpites irregularis* and *Verruscatosporites usmensis.*

Palynological Zonation

According to Muller (1968) and Germeraad *et al.,* (1968), a palynological zonation may consist of an assemblage zone which is based on all kinds of fossil forms present or some species. It could be a range zone which is the floral subdivision of selected species of the total assemblage of the fossil pollen grains and spores in a stratigraphic sequence (Herberg, 1976). Furthermore, Germeraad *et al.,* (1968) have shown from their studies of Tertiary sediments in tropical areas that the zonation of stratigraphic sequence depends on the evolution and migration of the floral assemblage. They noted that evolution manifest itself in the sudden appearance of new forms, the gradual modification of existing forms and the disappearance or extinction of others. Variation or changes in climate and edaphic condition is believed to have the same effect. Migration on the other hand caused by changes in climatic and edaphic conditions can be responsible for temporary or lasting changes in the composition of the flora. These factors were considered in the zonation of the well “BIMOL-I”.

Four non-formal palynological assemblage zones have been identified in this study: (B-1, B-2, B-3 and B-4) and a composite floral diagram using selected markers to demarcate these zones is shown in figure 3:

B-1 Zone (Cyathidites assemblage zone): Lower Eocene

This zone is recognized at depth interval of 3216 – 2856 m (Fig. 3). This zone is characterized by high occurrence of *Cyathidites sp.* at its base. The disappearances of this spore (Cyathidites) also characterize the top of this zone.

Other forms that occur within this zone include *Leavigatosporites sp.*, *Retitricolpites irregularis*, *verruscatosporites usmensis* and *Monolete spores*. The top of this zone is also marked by the first appearance of *Retibrevitricolporites Ibadanesis.*

The biosignals presented by zone B-1 enabled a subdivision of the Ypresian into three subzones A, B and C equivalent to P330, P370 and P420 of Evamy *et al.,* (1978) based on the first appearances of species within this interval (Fig. 3). Subzone C straddles the Ypresian-Lutetian boundary (Upper Ypresian and Lower Lutetian). Subzone C is further subdivided into a lower (L) and an upper (U) units. Based on this finer subdivision of the Upper Ypresian and Lower Lutetian, the Evamy et al. (1978) P420 zone is split into two (Fig. 3).

B-2 Zone (Cleistophollis patens assemblage zone): Middle Eocene

This zone is recognized at the depth interval of 2856 – 1782 m (Fig. 3). The base of this zone is marked by the first appearance of *Cleistophollis patens* and *Pachydermites diedeirixi. Retimonocolpites obaensis, Retibrevitricolpites traingulatus* and *Grimsdalea polygonalis* also have their highest occurrence at the base of this zone. Proxerpatites cursus occurs regularly from the middle to the top of the zone. The first appearances of *Psilamonocolpites marginatus, Brevicolpite sp*. and *Praedopollis flexibilis* occur within this zone.

Other form species characteristics of this zone include the regular occurrence of Laevigatosporites sp. throughout the zone; occurrence of long ranging forms such as *Verrucatosporites usmensis, Retricolporites irregularis, Retitribrevitricolporites obodoensis,* and sparse occurrence of *syndemicolpites typicus*. This zone correlates with P430 zone of Evamy *et al.*, (1978).

B-3 Zone (Racemonocolpites hians assemblage zone): Upper Eocene

This zone occupies the depth interval of 1782 – 954 m (Fig. 3). The base of this zone is marked by the first appearance of *Racemonocolpites hians* and characterized by an abundance of Proxerpetites *cursus. Praedapollis africanus, Retitribrevitricolpites obodoensis, Retitribrevicolpites ibadaensis*, and *Polypodiacesporites sp*. all have regular appearance within the middle of this zone. Forms that occur at the top of this zone include Cinctiperiporites mulleri and Praedapollis flexibilis. Zone B-3 (Fig. 3) is subdivided into a lower zone A, equivalent to P450 and an upper zone B equivalent to P520 of Evamy *et al.,* (1978).

B-4 Zone (Filtrotrilete nigerensis assemblage zone): Lower Oligocene

This zone occupies depth interval of 954 – 486 m (Fig. 3). Filtrotrilete nigerensis has its lowest occurrence at the base of this zone. The initial regular occurrence of Arecipites exilimuratus is noticed from the base to the middle of this zone. Forms such as *Spinozonocolpites baculatus* and *Echitriporites trianguliformis* occur at the top of this zone. Other forms that occurred in the zone include *Praedapollis flexibilis, Doualaidites sp.*, and *Cleistophollis patens*. Zone B-4 is subdivided based on observed biosignal trend into A and B subzones equivalent to Evamy *et al.,* 1978 P540 and P560 zones.

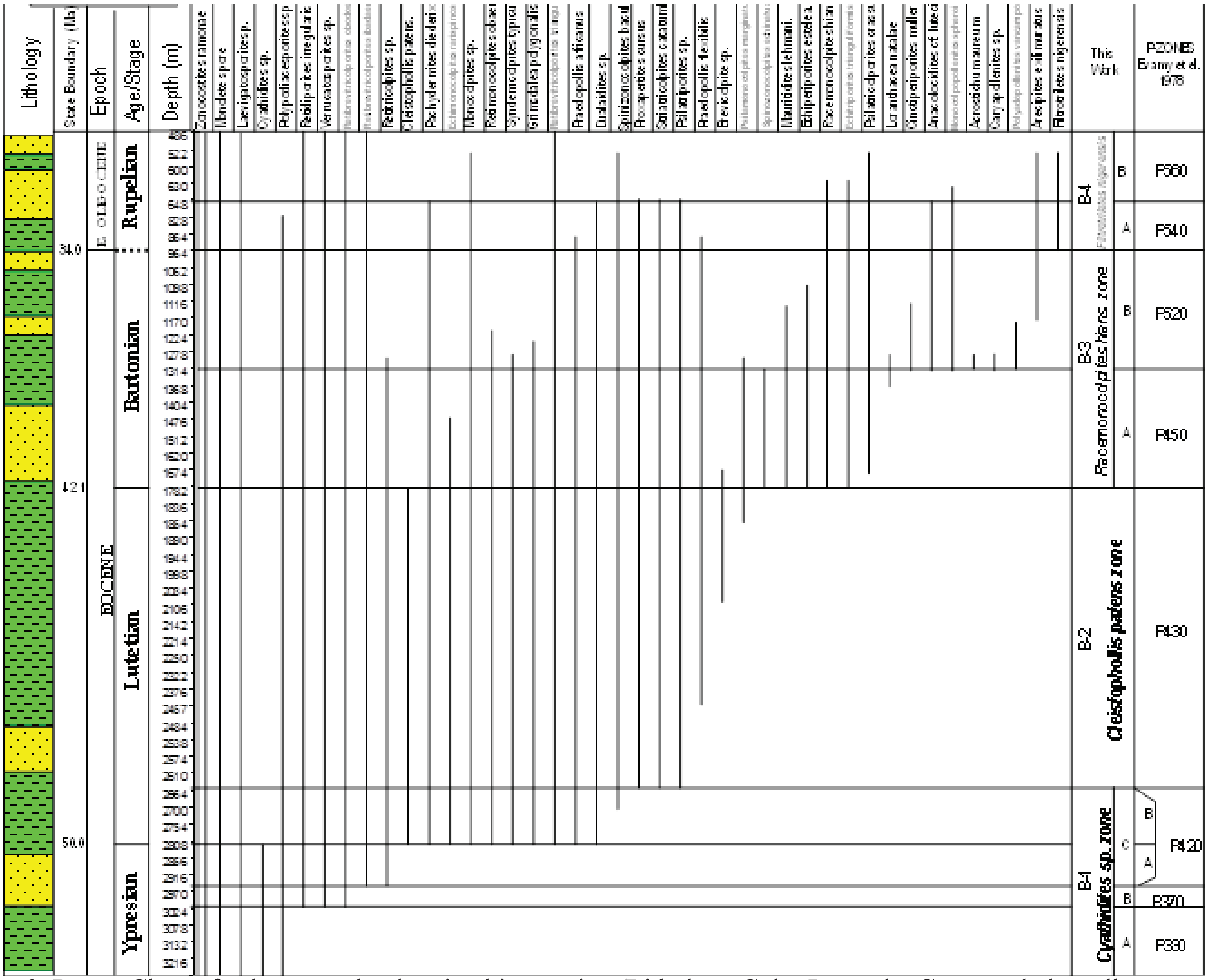


Fig. 3: Range Chart of palynomorphs showing biozonation (Lithology Color Legend – Green = shale, yellow = sand)

Paleo environmental Reconstruction

The paleo depositional environment of the sediment is defined in this study based on the understanding that a particular set of physical, chemical and biological processes interplay to create definite sedimentary deposits.

These parameters influence and determine the vegetation type(s) or vegetation mix.

Since characteristic fossils types and/or assemblage preserved in sedimentary rocks are among the most useful tool(s) for identifying past environmental setting(s), as they furnish information about paleo-water depth, energy, paleo-salinity, paleo-temperature and turbidity, it is imperative to understand their extant vegetation association (Table 1).

The quantitative depth distribution of miospores and dinoflagellate cysts of the well (Table 1) indicate deposition in two basic kinds of paleo environment. These were marginal continental/transitional and open marine.

Continental Environment: 648-486 m, 1062 m and 1836 m

These intervals and depths are characterized by very high abundance and occurrence of Zonocostite ramonae (Rhizophora pollen) with a percentage occurrence of Zonocotite ramonae in the pollen sum in excess of 50 %. On the basis of a palynological study of a 36 m core from the eastern Niger Delta Basin, Sowunmi (1981), concluded that an occurrence of Rhizophora pollen in quantities above 40% of the pollen sum in a layer of fossil sediment is an indication of the presence of Rhizophora formation, and therefore a distal coastal plain in the vicinity of the depositional environment. Risk and Rhodes (1985) defined a mangrove swamp as a salt tolerant intertidal marsh that has characteristic vegetation commonly associated with tropical coastal areas and lies between latitudes 250N and 250S of the equator. The Rhizophora pollen is generally considered a dominant vegetation element in the coastal microflora and is associated with mangrove swamp (Germeraad *et al.,* 1968).

Other forms that occur within this intervals are *Laevigatosporites sp., Verrucatosporite usmensis, Spinozonocolpites echinatus and Achrostichum aureum. Spinzonocolpites echinatus and Achrostichum aureum* which are back swamp mangrove environment forms. *Laevigatosporites sp*. is of Cyatheaceae family known to generally inhabit marsh or swamp environment (Nayar *et al.,* 1964). Therefore the occurrence of these forms together with very high occurrence of Zonocostite ramonae within these intervals indicates a coastal swamp environment.

Marine Environment: 3216-1854m, 1782-1098, and 954-828m

This environment is recognized from the depth interval of 3216-1854m, 1782-1098, and 954-828m. The intervals are characterized by Zonocostites ramonae percentages below 40% (Sowunmi, 1981) and common occurrence of dinoflagellate cysts (Table 1). Muller (1959), Oboh and Salami (1989) used the occurrence of dinoflagellate cysts as an important tool for identification of marine environment. The dinoflagellate cysts assemblage associated with this interval include *Kenleyia lophophora, Muratidinium fimbratum, Systematophora sp., Homotryblium tenuipinosum, Homotryblium palladium, Spiniferites pseudodacatus, Apectodinium homomorphum, Adnatosphaeridium vittatum, Distatodinium sp*. and *Lingulodinium macphaerophorum* (Fig. 2), are suggestive of marine environment (Wall *et al.,* 1977; Dale, 1996; Harland 1983; Marret and Zonneveld, 2003; Krzysztof Birkenmajer *et al.,* 2010). The common occurrence of Homotryblium genus believed to be associated with proximal shelf areas (Krzysztof Birkenmajer *et al.,* 2010; Brinkhuis, 1992), affirms deposition in marine paleodepositional environment.

The microfloral assemblages recovered from these intervals, though not typical of marine environment and occur in low percentages, include: *Zonocostites ramonae* (Rhizophorapollen), *Verrucastosporites usmensis, Pachydermites diederixi, Laevigatosporites sp*., and *Retibrevitricolporites obodensis.* Of all these, the dominant species within this interval is the *Zonocostites ramonae* which Muller (1959) and Gemeraad *et al.* (1968) considered generally to be associated with Mangrove swamp. However, the proximity of the mangrove swamp to the marine environment and the nonoccurrence of Mangrove species such as *Lygodiumsporites sp., Monoporites annulatus* within this interval further confirmed that the environment was marine and more precisely as neritic environment. In general the overwhelming abundance and statistical dominance of miospores over the dinocysts species in these interval suggests a marine setting with high influx of terrestrial organic matter, which may indicate land proximity (Krzysztof Birkenmajer *et al.,* 2010)

Table 1: Palynomorphs input reflecting the vegetative areas as observed in Bimol-I well.

					VEGETATIVE AREAS												
					Mangrove Swamp Forest				Freshwater Swamp Foerest			Lowland Rainforest			Backswamp Mangrove		
depth (m)	Total Palynomorphs	Total Pollen Grains	Total Spores	Dinoflagellate Cysts	Psilatricolpites crassus	Zonocostites romanae	Total	% Zonocostites ramonae	Pachydermites derixi	Nymphae sp.	Total	Polyapollenites vacampori		Total	Achrostichum aureum	Spinizonocolpites sp.	Total
486	116	100	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
522	1469	1434	35	0	0	1016	1016	69.2	0	0	0	0	0	0	0	1	1
600	212	196	16	0	0	100	100	47.2	0	0	0	0	0	0	0	1	1
630	453	440	13	0	0	210	210	46.4	0	0	0	0	0	0	0	0	0
648	392	347	44	1	0	289	289	73.7	1	0	1	0	0	0	0	2	2
828	94	77	15	2	0	20	20	21.3	0	0	0	0	0	0	0	0	0

Table 1: Palynomorphs input reflecting the vegetative areas as observed in Bimol-I well.- ***continued***

VEGETATIVE AREAS																	
					Mangrove Swamp Forest				Freshwater Swamp Foerest			Lowland Rainforest			Backswamp Mangrove		
depth (m)	Total Palynomorphs	Total Pollen Grains	Total Spores	Dinoflagellate Cysts	Psilatricolpites crassus	Zonocostites romanae	Total	% Zonocostites ramonae	Pachydermites deirixi	Nymphae sp.	Total	Polyapollenites vacampori		Total	Achrostichum aureum	Spinizonocolpites sp.	Total
864	183	160	16	7	0	47	47	25.7	0	0	0	0	0	0	0	0	0
954	256	200	55	1	0	42	42	16.4	0	0	0	0	0	0	0	0	0
1062	171	163	8	0	0	90	90	52.5	2	0	2	0	0	0	0	0	0
1098	323	266	54	3	0	50	50	15.5	0	0	0	0	0	0	0	0	0
1116	329	241	88	0	1	49	50	15.2	2	0	2	0	0	0	0	0	0
1170	401	281	120	0	0	35	35	8.7	0	0	0	1	0	1	0	0	0
1224	462	281	180	1	0	50	50	10.8	5	0	5	1	0	1	0	0	0
1278	428	320	105	3	0	37	37	8.6	0	0	0	0	0	0	0	0	0
1314	463	346	116	1	0	73	73	15.8	10	0	10	1	0	1	2	1	3
1368	432	333	96	3	0	56	56	13.0	11	0	11	0	0	0	0	0	0
1404	329	292	36	1	1	35	36	11.0	0	0	0	0	0	0	0	0	0
1476	455	330	120	5	0	59	59	13.0	3	0	3	0	0	0	0	5	5
1512	43	41	2	0	0	5	5	11.6	1	0	1	0	0	0	0	0	0
1620	476	345	126	5	0	50	50	10.5	0	0	0	0	0	0	0	3	3
1674	414	360	53	1	0	30	30	7.2	1	2	3	0	0	0	0	0	0
1782	358	281	50	27	0	29	29	8.1	0	0	0	0	0	0	0	3	3
1836	95	32	5	8	0	50	50	52.6	0	0	0	0	0	0	0	0	0
1854	56	41	12	3	0	13	13	23.2	0	0	0	0	0	0	0	0	0
1890	62	59	1	2	0	9	9	28.1	0	0	0	0	0	0	0	0	0
1944	73	50	23	0	0	10	10	13.7	0	0	0	0	0	0	0	0	0
1998	439	370	65	4	0	7	7	1.6	0	0	0	0	0	0	0	0	0
2034	84	59	20	5	0	8	8	9.5	0	0	0	0	0	0	0	0	0
2106	96	45	2	49	0	2	2	2.1	0	0	0	0	0	0	0	1	1
2142	127	100	18	9	0	4	4	3.1	0	0	0	0	0	0	0	0	0
2214	96	72	2	22	0	1	1	1.0	0	0	0	0	0	0	0	0	0
2250	57	47	10	0	0	11	11	19.3	0	0	0	0	0	0	0	0	0
2322	58	54	2	2	0	5	5	8.6	0	0	0	0	0	0	0	0	0
2376	201	137	61	3	0	10	10	5.0	0	0	0	0	0	0	0	0	0
2457	164	113	12	39	0	7	7	4.3	0	0	0	0	0	0	0	0	0
2484	152	96	53	3	0	4	4	2.6	0	0	0	0	0	0	0	0	0
2538	76	65	5	6	0	3	3	3.9	1	0	1	0	0	0	0	0	0
2574	56	33	23	0	0	2	2	3.6	0	0	0	0	0	0	0	0	0
2610	55	47	3	5	0	7	7	12.7	0	0	0	0	0	0	0	0	0
2664	123	82	36	5	0	16	16	13.0	2	0	2	0	0	0	0	0	0
2700	124	110	12	2	0	10	10	8.1	0	0	0	0	0	0	0	0	0
2754	60	38	22	0	0	3	3	5.0	0	0	0	0	0	0	0	0	0
2808	515	467	39	9	0	10	10	1.9	3	0	3	0	0	0	0	0	0
2862	439	353	85	1	0	57	57	13.0	2	0	2	0	0	0	0	0	0
2916	272	231	38	3	0	30	30	11.0	0	0	0	0	0	0	0	0	0
2970	130	116	14	0	0	7	7	4.1	0	0	0	0	0	0	0	0	0
3024	116	113	3	0	0	10	10	8.6	0	0	0	0	0	0	0	0	0
3078	137	100	37	2	0	13	13	9.5	0	0	0	0	0	0	0	0	0
3132	177	174	3	0	0	5	5	2.8	0	0	0	0	0	0	0	0	0
3216	155	111	44	0	0	4	4	2.6	0	0	0	0	0	0	0	0	0

486	116	100	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
522	1469	1434	35	0	0	1016	1016	69.2	0	0	0	0	0	0	0	1	1
600	212	196	16	0	0	100	100	47.2	0	0	0	0	0	0	0	1	1
630	453	440	13	0	0	210	210	46.4	0	0	0	0	0	0	0	0	0
648	392	347	44	1	0	289	289	73.7	1	0	1	0	0	0	0	2	2
828	94	77	15	2	0	20	20	21.3	0	0	0	0	0	0	0	0	0

CONCLUSION

The quantitative depth occurrence of palynomorphs within the BIMOL-1well has been applied in the erection of four informal palynozones (B-1to B-4) which spans a Lower Eocene to Lower Oligocene age of the Cenozoic Niger Delta Basin. These zones correlates with existing scheme erected by Evamy *et al., (*1978). The upper parts of zone B-1 classed as subzone C, equivalent to P420 zone of Evamy *et al.,* 1978, was subdivided into two smaller subzones A and B, hence effectively divided P420 into two finer zones. This subdivision of P420 into two smaller zones is novel in this part of the Niger Delta.

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