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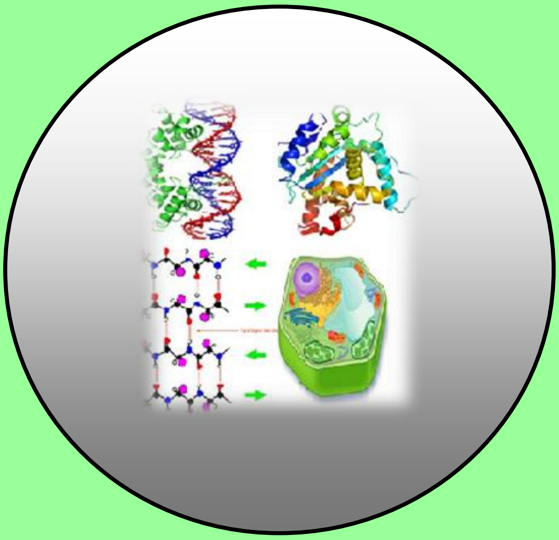
ISSN 0970-4973 Print
ISSN 2319-3077 Online/Electronic

Journal Impact Factor: 4.275
Global Impact factor of Journal: 0.876
Scientific Journals Impact Factor: 3.285
InfoBase Impact Factor: 2.93
Index Copernicus International Value
IC Value of Journal 47.86 Poland, Europe

J. Biol. Chem. Research
Volume 33 (1) 2016 Pages No. 188-205



Journal of Biological and Chemical Research

An International Peer Reviewed / Refereed Journal of Life Sciences and Chemistry

Indexed, Abstracted and Cited in various International and National Scientific Databases

Published by Society for Advancement of Sciences®

J. Biol. Chem. Research. Vol. 33, No. 1. 188-205, 2016
(An International Peer Reviewed / Refereed Journal of Life Sciences and Chemistry)
Ms 33/1/70/2016

ISSN 0970-4973 (Print)
ISSN 2319-3077 (Online/Electronic)

Ola-Buraimo A.O.
http:// www.sasjournals.com
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RESEARCH PAPER

Received: 14/01/2016 **Revised: 22/01/2016** **Accepted: 23/01/2016**

High Resolution Palynostratigraphy and Paleoclimatic Condition of Prograding Deltaic Facies. 3 wells Located in Forcados Yokri Field (Upper Early Miocene) Nigeria

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ABSTRACT

Analysis of 19 core and 16 ditch cutting samples retrieved from 3 offshore wells. Fy-125ST1, Fy-142ST1 and Fy-144 located in Niger Delta were subjected to laboratory preparation of palynological slides through standard procedures. The study was carried out with the view to palynologically determine the chronostratigraphy, paleoclimatic condition of the wells and their application for correlation and paleoenvironment of deposition.

All the three wells analyzed belong to a major Magnastriatites howardii zone and P600 zone of subzones P680, P670 and P650 suggestive of Upper Early Miocene age. The subzone P680 is marked by quantitative occurrence of Pachydermites diederixi, and co-occurrence of diagnostic marker forms such as Psilatricolporites crassus, Gemmamonoporites sp, Magnastriatites howardii, Crassoretitriletes vanraadshooveni, Ctenolophonidites costatus, Peregnipollis nigericus, Echiperiporites estalae, Racemonocolpites hians, Stritricolpites catatumbus and Acrostichum aureum. The P670 subzone is characterized by the quantitative base occurrence of Magnastriatites howardii and the co-occurrence of some of the forms encountered in P670 subzone. The P650 subzone is defined by assemblage of Acrostichum aureum, Steisporites sp, Pachydermites diederixi, Psilatricolporites crassus, Magnastriatites howardii, Sapotaceae and Pteris spp. The subzone P680 is correlable across the 3 wells. 2 wells containing subzone P670 are also correlable because their pollen contents are similar with the exception of well FY-142ST1 that did not penetrate it.

However, only well FY-125ST1 penetrates subzone P650 and it is characterized by fault structure or unconformity due to the missing or unrecognizability of subzone P660.

However, the paleoenvironment of deposition is mainly mangrove setting of a prograding deltaic system characterized by preponderance of palmae taxa.
The paleoclimatic condition is wet for the 3 wells, characterized by dominance of mangrove pollen; the pronounced peaks in the climatic cycle are indicative of flooding surface, maximum flooding surface and condensed section within the well sections.
Key words. Palynostratigraphy, Palynozone, Subzone, Climatic Cycle, Mangrove, and Wet climate.

INTRODUCTION

The Niger delta is situated on the continental margin of the Gulf of Guinea on the west coast (equatorial) of Africa, and the basin is geographically located between Latitudes 3º and 6ºN and Longitudes 5ºand 8ºE (Fig. 1.; Stacher, 1995; Reijers et al., 1997). The southeastern boundary of the Niger Delta is delineated by the Calabar Flank with the Abakaliki Anticlinorium (Abakaliki Fold belt) defining the northeastern limit (Fig. 1). To the west, the Niger Delta basin is bounded by the Dahomey Basin. The Anambra Basin is situated to the north of the Niger Delta; to the south is offshore Gulf of Guinea. The science of petroleum exploration and production is multi-tool based with each tool complementing the other. One of these important tools is palynostratigraphy. Palynology is an aspect of biostratigraphy; a scientific study of pollen, spores, dinoflagellates, algae and other important fossils or material present to determine the chronostratigraphy, relative age dating for the geologic purposes, evidence of sediment rework, detection of unconformity, sequence stratigraphy, climatic changes, organic richness, kerogen type, source rock thermal maturity and other important uses as set objectives of the researcher (Ola-Buraimo et al, 2015).

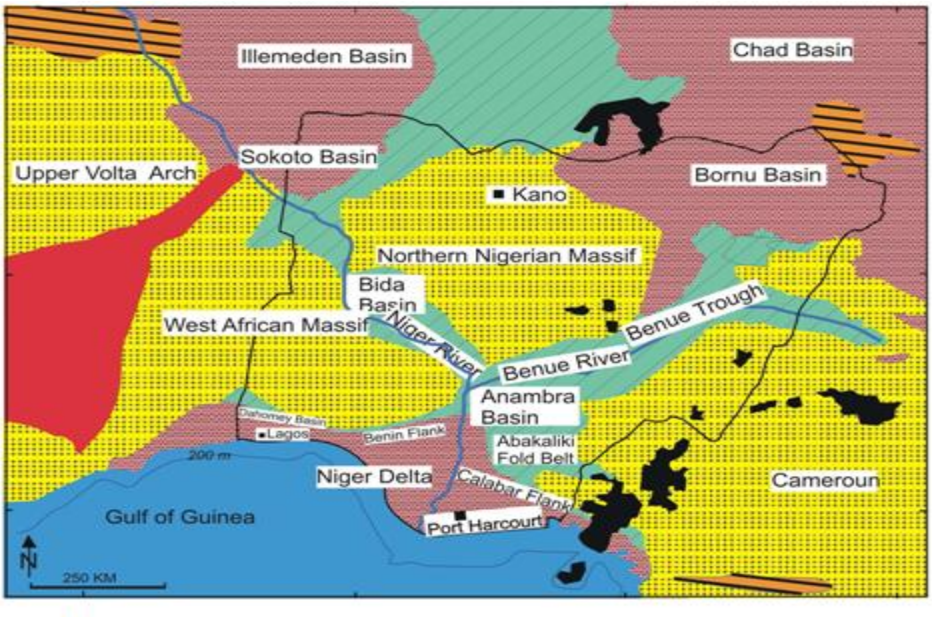
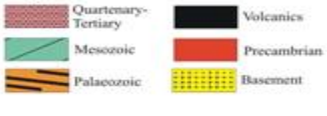


Fig. 1: Simplified geological map of Nigeria showing the location of the Niger Delta and some other Nigerian basins. Modified after Stacher, 1995.

Legend



This study deals with the rock samples derived from thee (3) wells named FY-125ST1, FY142ST1 and FY144 respectively and located within the Forcados Yokri field in the offshore depobelt of the Niger Delta (Fig.2)

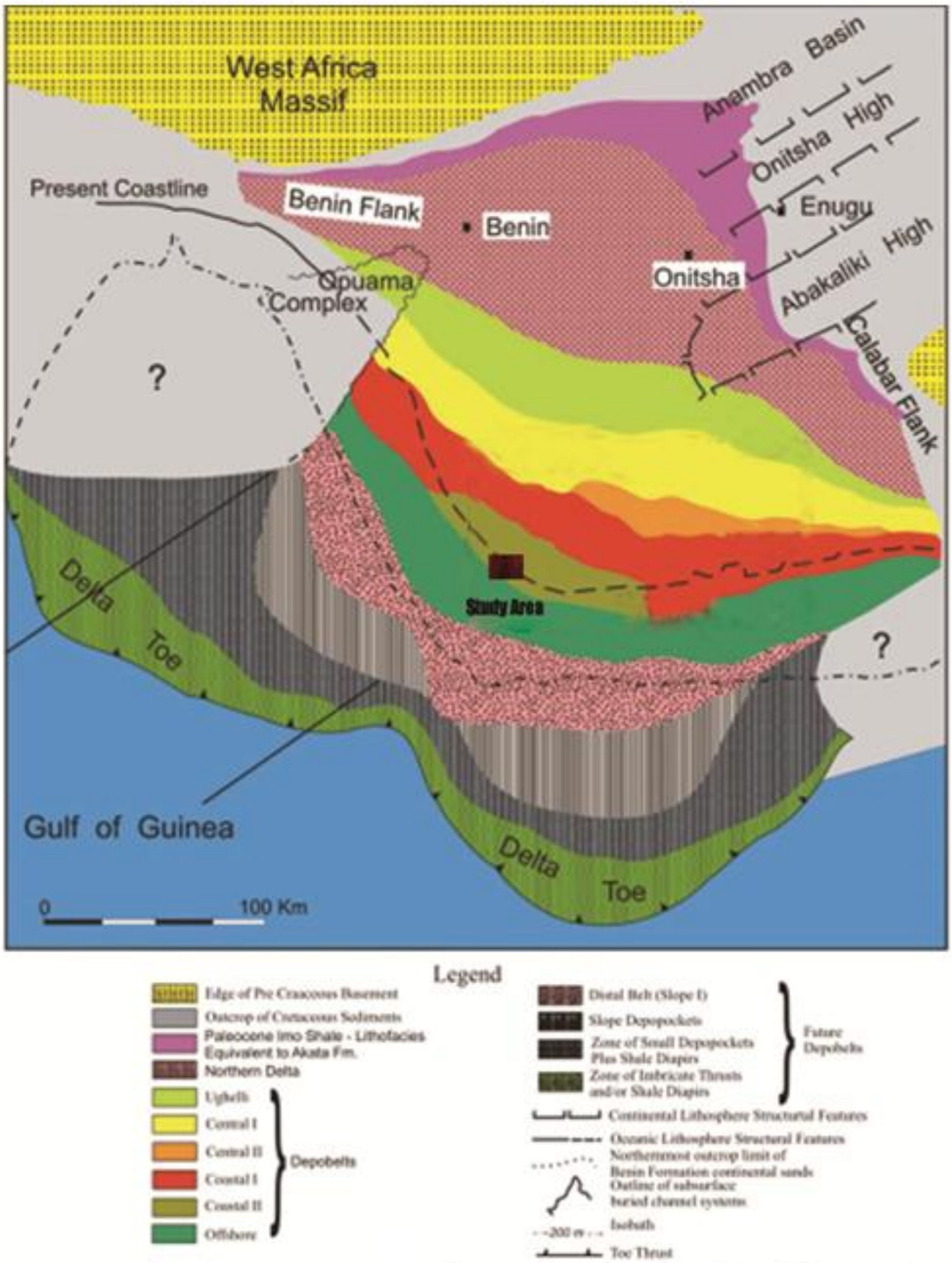


Figure 2. Map showing the Depobelts of the Niger Delta and location of the study area. Modified after Doust and Omatsola, 1990.

The integration of palynology with other geological disciplines, such as sedimentology, geophysics, geochemistry, and petrophysics, is needed for geological modeling and petroleum system studies, which in turn are essential for planning and developing better exploration strategies and for optimizing reservoir exploitation.

In the Niger Delta basin, exploration for oil and gas has been an ongoing work and various tools have been used by past workers to study its sedimentology, stratigraphy and economic prospects (Short and Stauble, 1967; Weber and Daukoru, 1975). High resolution palynolgy is no doubt a recent tool for these purposes, it requires the use of ecostratigraphic (phytoecological) logs, as well as the integration of sequence stratigraphy with its' multidisciplinary approach to the study of genetically related facies within chronostratigraphically significant surfaces (Van Wagoner et al., 1990). It provides a potential unifying framework for interpreting much of rock records, and has considerable economic significance as it helps in identifying exploration prospects and predicting source rocks, seals and potential reservoir traps.

In this work, the emphasis is on the use of palynology to establish palynostratigraphy, palynozones and application of abundance of environmentally diagnostic forms to construct paleoclimatic cycles for the three wells.

Geologic Setting

The geological evolution of the Cenozoic Niger Delta cannot be completely understood in isolation of the other sedimentary basins in southern Nigeria, most especially the aulacogen Benue Trough. Reijers et al., (1997) considered the Niger Delta to be the youngest among the chain of sub-basins (Gongola, Yola, Abakaliki, Anambra and Afikpo) in the Benue Trough. The evolutionary history of the Cenozoic Niger Delta has been extensively discussed and documented by earlier researchers (Hospers, 1965; Short and Stäuble, 1967; Weber and Daukoru, 1975; Lehner and De Ruiter, 1977; Evamy et al., 1978).

The Benue Trough evolved during the opening of the South Atlantic margin which leads to the separation of the African and South American continents during the Cretaceous. The trough represents the failed arm of a triple junction (aulacogen). Since its Early Cretaceous opening, the trough has witnessed series of depositional cycles from Aptian through Paleocene (Short and Stäuble1967; Weber and Daukoru, 1975). The first marine transgression into the trough, which took place in the Albian, resulted in the deposition of Asu River Group dated Albian to Lower Cenomanian (Short and Stäuble, 1967; Reijers et al., 1997; Ola-Buraimo and Akaegbobi, 2013c; Table 1). This was followed by a Mid-Cenomanian regressive phase which resulted in a deltaic environment leading to the deposition of the Keana Formation. Another major transgression which took place in the Turonian led to the deposition of the Eze Aku Shale dated Upper Cenomanian to Turonian (Ola-Buraimo, 2013c). This transgression was succeeded by a Late Turonian regression. The third major transgression took place during the Coniacian and resulted into the deposition of Awgu Shale dated Coniacian age but became terminated with a brief phase of folding of Santonian age (Short and Stäuble, 1967; Ola-Buraimo, 2013d). During the Santonian regional folding, the Abakaliki Trough was uplifted to form the Abakaliki High, the Anambra Platform down-warped to form the Anambra Basin and there was also the formation of the Afikpo Syncline (Weber and Daukoru, 1975; Reijers et al., 1997). However, evidence has emerged to show that Anambra basin is a graben type which contains Middle cretaceous sediments buried deep in the subsurface (Ola-Buraimo and Akaegbobi, 2013c). After the folding and uplifting, the deltaic sedimentation became permanently established in the southern Benue Trough which culminated in the formation of the present Niger Delta.

The Tertiary Niger Delta covers an area of approximately 75000sq Km with cumulative sedimentary sequence of about 12,000m (Knox and Omatsola, 1989).

The sequences in Niger Delta have been subdivided into three major sedimentary units, namely the Akata, Agbada and the Benin Formations (Table 1). The oldest of these three formations is the Paleocene to Recent Akata Formation (Short and Stäuble, 1967; Reijers et al., 1997). The Akata Formation, characterized by continuous, uniform shale deposition was laid down in a marine environment. The formation is characteristically composed of dark gray shale, sometimes sandy or silty of prodelta origin (Short and Stäuble, 1967; Akpoyovbike, 1978). The shale of this formation is largely under-compacted (Akpoyovbike, 1978).

Overlying the marine sequence is the Eocene to Recent Agbada Formation. The paralic Agbada Formation constitutes the actual deltaic portion of the sequence. It is considered to have been accumulated in deltaic front, delta top-set and fluvio-deltaic environments (Corredor et al., 2005). It is composed mainly of alternating sandstone/shale. The Agbada Formation is considered to be composed of cyclic sequences of marine and fluvial deposits (Weber, 1971). Capping the sequence is the continental Benin Formation, deposited during the Oligocene to Recent (Reijers et al., 1997). Its deposits range from coarse to medium-grained sands/sandstone; generally coarse grained, very granulate to fine in size (Short and Stäuble, 1967).

Subsurface			Surface outcrops		
Youngest known age		Oldest known age	Youngest known age		Oldest known age
Recent	Benin Formation Afam/ Qua Iboe	Oligocene	Plio. Pleistocene	Benin Formation	Miocene ?
Recent	Agbada Formation	Eocene	Miocene	Ogwashi-Asaba Formation	Oligocene
			Eocene	Ameki Formation	Eocene
Recent	Akata Formation	Eocene	Late. Eocene	Imo Formation	Paleocene
			Paleocene	Nsuka Formation	Maastrichtian
Equivalents not known			Maastrichtian	Ajali Formation	Maastrichtian
			Campanian	Mamu Formation	Campanian
			Campanian/ Maastrichtian	Nkporo Shale	Santonian
			Coniacian/ Santonian	Agwu Shale	Turonian
			Turonian	Eze Aku Shale	Turonian
			Albian	Asu River Group	Albian

Table 1. Table of formations, Niger Delta area, Nigeria. Modified after Akpoyovbike (1978). The original modified after Short and Stäuble (1967).

MATERIAL AND METHODS

Core and cutting samples collected from 3 offshore wells. FY-125STI, FY-142STI and FY-144 located in the Forcados Yorkri field were selected for this study. A total of 19 core samples and 16 cutting samples were analyzed in this study. The formation thickness of each well is as follows. FY-125STI= 65ft, FY-142STI= 270ft and FY-144= 60ft.

The other materials used for the palynological analysis are mortar and pestle, weighing balance, sample plastic cups, pipettes, 5 micron sieves, centrifuge, fume cupboard, Branson sonifer 250, distilled water, test tubes, glass slide and cover slip, hydrochloric acid (HCl), hydrofluoric acid (HF), filter paper, glycerine ($C_3H_8O_3$), 250 ml polypropylene beakers, Nitric acid (HNO_3), Zinc Bromide ($ZnBr_2$), TPX (a mounting medium), Potassium hydroxide (KOH) and personal protective wears such as safety gloves, glasses and coverall. The samples were weighed to about 10gm, soaked overnight in Hydrofluoric acid (HF), and stirred intermittently for effective digestion. To completely remove the fluoro-silicate compounds that usually form from the reaction with HF, the content was again treated with warm 10% HCl and finally completely neutralized with distilled water. This is followed by sieving process with 5µm mesh in order to remove clay particles present, enhance collection of the debris and to achieve clean slide making. The retrieved debris of the samples was mildly oxidized, followed by heavy mineral liquid separation of the macerals using Zinc bromide ($ZnBr_2$) at 2.1g/cc. The collected residue was mounted on glass slides with DPX. The preparation method was in accordance with standard methods.
Pollen, spores, dinoflagellates, fungal spores, microforaminiferal wall linings and other stratigraphically significant forms present were determined for each sample in terms of abundance and diversity; and were interpreted by comparison with established works. During visual assessment of each sample, a total of 528 palynomorphs (pollen, spores, dinocysts, microforaminiferal test lining) were counted where possible, comprising of about 58 species. However, diagnostic species photographs were taken with Nikon Koolpix P6000 digital camera.

RESULTS AND DISCUSSION

Palynostratigraphy and Paleo environment

The detailed palynological analysis of the three wells yielded well preserved, moderate abundant and diversity of palynomorphs. The palynozonation of the wells was compared with the works of Germeraad et al., (1968) for Pan Tropical zones and Evamy et al., (1978) for Niger Delta, Nigeria. The details and basis of characterization of the established zones and subzones for the wells are briefly discussed below.

Well. FY-125ST1

One major zone established is *Magnastrites howardii* after Germeraad et al., (1968) and P600 zone associated with delineated three subzones P680, P670 and P650 after Evamy et al., (1978). The details and basis of establishing the zone and subzones are given below.

Interval. 5816-5837ft

Zone. *Magnastriatites howardii* Zone; P600

Subzone. P680

Age. Uppermost Early Miocene

Characteristics. The top of the subzone is equivalent to the top of the interval where analysis commenced. The top is marked by relative quantitative occurrence of *Pachydermites diederixi;* co-occurrence of *Gemmamonoporites sp, Trilete spore, Psilatricolporites crassus, Magnastriatites howardii, Verrucatosporites spp, Acrostichum aureum* and *Pteris spp.* The base is defined by the quantitative occurrence of *Pachydermites diederixi, Psilatricolporites crassus* and *Acrostichum aureum* (Fig.3).

The interval is characterized by the co-occurrences of *Gemmamonoporites spp, stereisporites sp, Pachydermites diederixi, Psilatricolporites crassus, Retitricolporites irregularis, acrostichum aureum, Laevigatosporites sp* and *Pteris spp.* Other important forms present are *Crassoretitriletes vanraadshooveni, Lycopodium sp, Ctenolophonidites costatus, Peregrinipollis nigericus, Striatricolpites catatumbus, sapotaceae sp, Echiperiporites estalae,* near base appearance of *Racemonocolpites hians* and rare occurrence of *Monoporites annulatus* (Fig.3). The interval is dated Uppermost Early Miocene age based on the striking characteristics described and similar in assemblage to the subzone described after the work of Evamy et al, (1978; Table 2).

The sediments are suggested to have been deposited in mangrove environment based on the relatively moderate diversity and abundance of palmae taxa such as *Psilatricolporites crassus, Pachydermites diederixi, magnastriatites howardii,* and *Echiperiporites estale* (Fredericksen, 1985, Ola-Buraimo and Adeleye, 2010). However, the rare occurrence of freshwater form- *Botryococcus braunii* and marine water dinoflagellate cyst- *Polysphaeridium zoharyi* is an indication of transitional environmental setting where there is inflow of river and intermittent incursion of the marine water into the environment.

DEPTH IN FEET	SERIES	SUB-SERIES	GERMERAAD et al;(1968)	EVAMY et al; (1978)		DIAGNOSTIC BIODATUM
				ZONE	SUB-ZONE	
5810	MIOCENE	EARLY MIOCENE	MAGNASTRATITES HOWARDI ZONE	P600	P680	
5820						
5830						Quantitative base occurrence of Pachydermites diederixi
5840					P670	
5850						
5860						Base rich occurrence of Magnastrtiteshowardi
5868					P650	

Table 2. Summary of Palynozones and Ages of Well FY-125ST1

Interval. 5837-5864ft

Zone. P600; *Magnastriatites howardii* zone

Subzone. P670

Age. Upper Early Miocene

Characteristics. The top of the interval coincides with the base of the overlying subzone P680; characterized by quantitative occurrence of *Pachydermites diederixi*, while the base of the interval is marked by relative moderate occurrence of *Magnastriatites howardii*.

The interval is further marked by consistent moderate frequencies of *Laevigatosporites spp, Verrucatosporites spp, Acrostichum aureum, Pachydermites diederixi, Peregrinipollis nigericus, Ctenolophonidites costatus, Echiperiporites estalae, Sapotaceae sp* and rare occurrence of *Monoporites annulatus* (Fig.3). The interval is dated Upper Early Miocene based on similar palynomorph assemblages compared with the work of Evamy et al, (1978; Table 2). The sediments deposited within this interval belong to mangrove environment due to the presence and dominance of palmae pollen (Fredricksen, 1985; Sowunmi, 1986).

Interval. 5864-5868ft

Zone. P600; Magnastriatites howardii

Subzone. P650

Age. Middle Early Miocene

Characteristics. The top of the interval is marked by relative moderate occurrence of *magnastriatites howardii* while the base is placed at 5860ft where the last sample was analyzed for this well. The interval is characterized by the moderate occurrence of *Acrostichum aureum*, occurrence *of Stereosporites sp, Pachydermites diederixi, Psilatricolporites crassus, Laevigatosporites sp, magnastriaties howardii, Verrucatosporites spp, Sapotaceae sp* and *Pteris spp* (Fig.3). The interval is tentatively dated Middle Early Miocene (Evamy et al., 1978; Table 2). The environment of deposition of the sediment is mangrove system due to overwhelming abundance of palmae taxa over Monoporites annulatus (Rouse et al, 1966; Salami, 1984, 1988; Fredericksen, 1985). A suggested unconformity or fault structure relation exists between this interval (5864-5868) and overlying interval (5837-5864) due to the unrecognized or missing P660 subzone which suppose to exist between the overlying subzones P670 and the present P650. This may be as a result of faulting, non deposition or erosional removal.

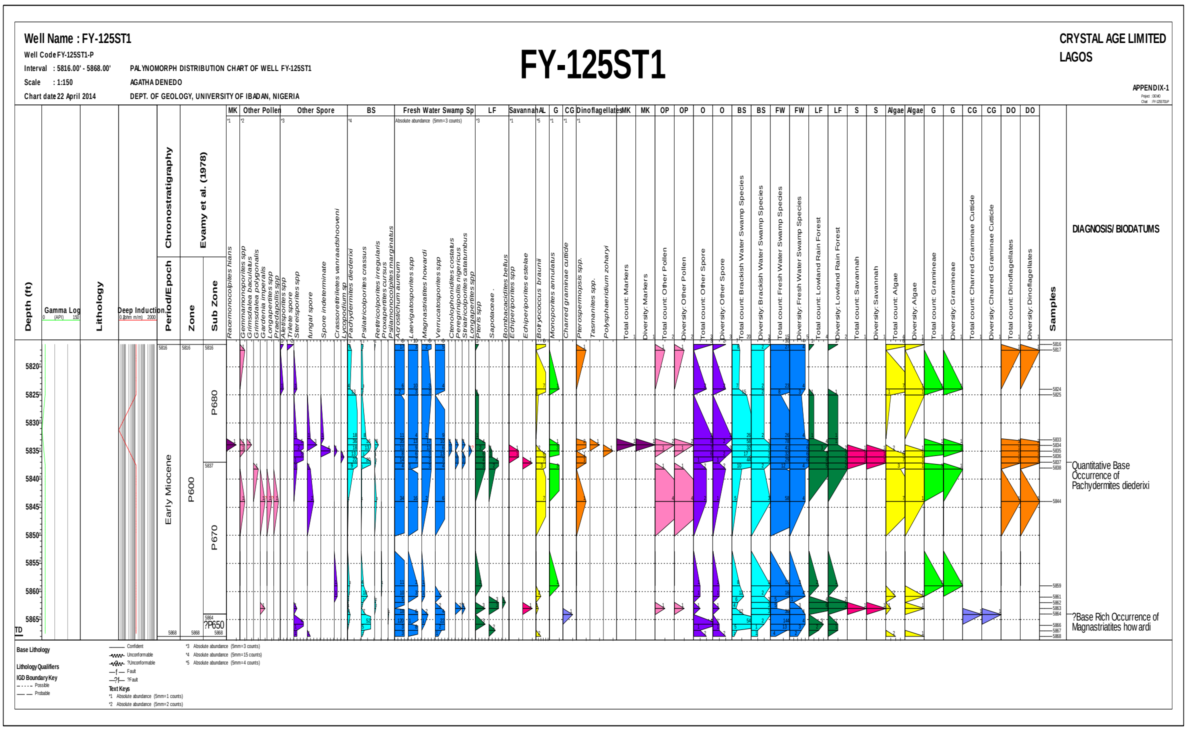


Figure 3. Distribution and Abundance chart of Important Palynomorphs in Well- FY-125ST1. Well. FY-142ST1

Three ditch cutting samples were selected from interval 6720-6780ft of Well FY-142ST1. One major zone belonging to *Magnastritites howardii* zone of Germeraad et al, (1968) and P600 zone of subzone P680 of Evamy et al, (1978) was established. The details and the basis of characterization are given below.

Interval. 6720-6780ft
Zone. P600; *Magnastriatites howardii* zone
Subzone. P680
Age. Uppermost Early Miocene
Characteristics. The palynomorphs recovered from this interval are well preserved and they are commonly land derived forms. The interval is marked by the continuous occurrence of *Pachydermites diederixi*, and co-occurrence of index fossils such as *Magnastriatites howardii,, Psilaticolporites crassus, Pteris spp, Acrostichum aureum,* and *Laevigatosporites sp*. The assemblage present is suggestive of *Magnastritites howardii* zone (Germeraad et al, 1968); P600 zone and P680 subzone of Evamy et al, (1978). The studied stratigraphic interval is hereby dated Uppermost Early Miocene age (Table 3).

The paleoenvironment of deposition of the sediments is suggested to be mangrove setting based on dominance of fluuviomarine forms such as *Pachydermites diederixi, Psilatricolporites crassus, Verrucatosporites sp* and *Magnastriatites howardii* (Fredericksen, 1985). Rare occurrence of freshwater forms such as *Botryococcus braunii* may suggest starvation of the environment with freshwater input.

DEPTH IN FEET	SERIES	SUB-SERIES	GERMERAAD et al;(1968)	EVAMY et al; (1978)		DIAGNOSTIC BIODATUM
				ZONE	SUB-ZONE	
6720 6750 6780	MIOCENE	EARLY MIOCENE	MAGNASTRATITES HOWARDI ZONE	P600	P680	CHARACTERISTICS: ➢ Consistent and regular records of Pachydermites diederixi ➢ Presence of Magnastratites howardi ➢ Abundant counts of Acrostichum aureus

Table 3. Summary of Palynozones and Ages of Well FY-142ST1.

Well. FY-144

Thirteen ditch cutting samples were selected and analyzed for palynological content. The palynomorph grains recovered are moderately rich in land derived forms, while freshwater and marine forms encountered are few and rare respectively. The studied interval (6050-6754ft) palynostratigraphically belongs to *Magnastritites howardii* zone of Germeraad et al, (1968); P600 zone, P680 and P670 subzones of Evamy et al, (1978). The basis of their characterization is detailed below.

Interval. 6050-6200ft
Zone. P600; *Magnastriatites howardii* zone
Subzone. P680
Age. Uppermost Early Miocene

Characteristics. The top of the zone is placed at depth 6050ft which corresponds to the top of the analyzed stratigraphic interval and at the point of first analyzed sample. The interval is mainly characterized by quantitative base occurrence of *Pachydermites diederixi* and continuous occurrence of *Pachydermites diederixi* within the interval. Other important forms present are *Monoporites annulatus, Acrostichum aureum, Laevigatosporites spp., Crassoretitriletes vanraadshooveni, Verrucatosporites spp, Stereisporites sp.,* and rare occurrence of *Botryococcus braunii* and dinoflagellate cyst (Fig.4). The interval is dated Uppermost Early Miocene age (Evamy et al. 1978; Table 4)

The paleoenvironment of deposition is suggested to be mangrove setting based on the occurrence of palmae pollen which characterize such depositional setting (Frederichsen, 1985; Sowunmi, 1986; Pavmot, 1987).

DEPTH IN FEET	SERIES	SUB-SERIES	GERMERAAD et al;(1968)	EVAMY et al; (1978)		DIAGNOSTIC BIODATUM
				ZONE	SUB-ZONE	
6050	MIOCENE	EARLY MIOCENE	MAGNASTRATITES HOWARDI ZONE	P600	P680	Quantitative base occurrence of Pachydermites diederixi
6080						
6110						
6140						
6170						
6200						
6230					P670	
6260						
6290						
6320						
6350						
6380						
6410						
6720						
6750						

Table 4. Summary of Palynozones and Ages of Well FY-144.

Interval. 6200-6750ft
Zone. P600; *Magnastriatites howardii* zone
Subzone. P670
Age. Upper Early Miocene
Characteristics. The top of the subzone placed at 6200ft is marked by quantitative base occurrence of *Pachydermites diederixi* while the base of the subzone is placed at the bottom of the analyzed startigraphic section. The interval is characterized by co-occurrence of *Psilamonocolpites marginatus, Magnastriatites howardii, Peregrinipollis nigericus* and *Stereisporites sp* (Fig.4). The interval is tentatively dated Upper Early Miocene age because of the presence of assemblage of distinctive diagnostic forms characterizing the P670 subzone, also based on the stratigraphic position of the interval (Evamy et al, 1978; Fig. 4, Table 4).

Paleoenvironment of deposition of the sediment is suggested to be mangrove setting based on the preponderance of mangrove pollen such as *Pachydermites diederixi, magnastriatites howardii, and Stereisporites sp*. which characterize mangrove environment of a marginal marine system (Fredericksen, 1985; Adeigbe et al, 2013). The progradational sedimentational process synonymous with Niger Delta is apparent here whereby there was inflow of freshwater and marine water into the fluviomarine setting of a deltaic system characterizing sedimentational process and environment of deposition of the well section.

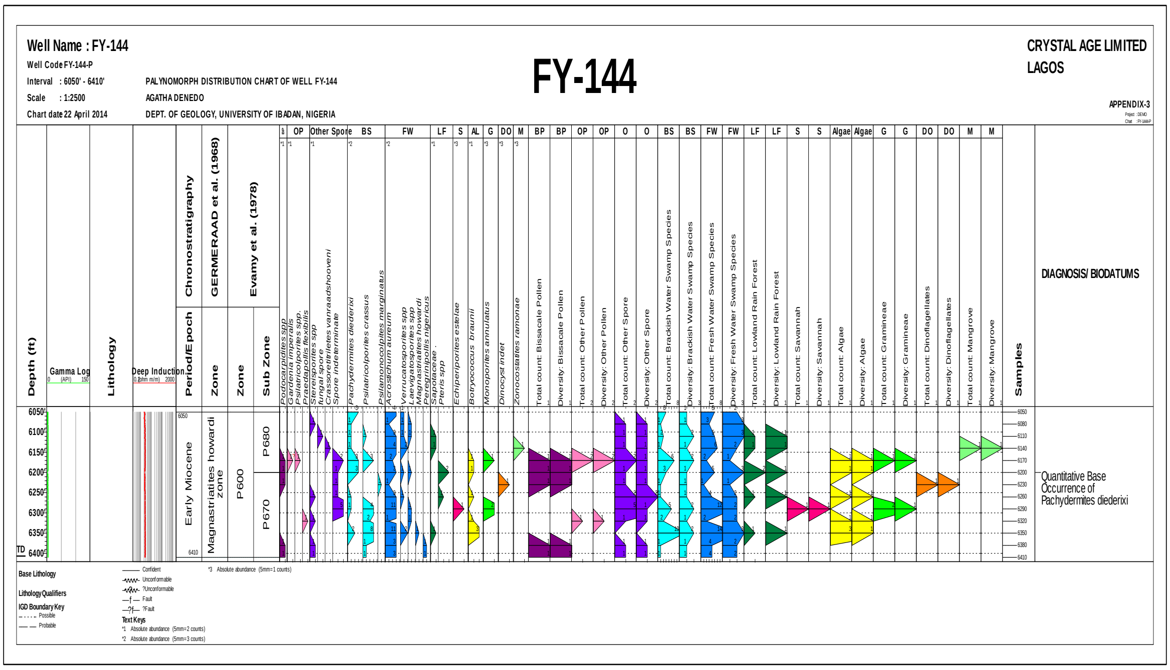


Figure 4. Distribution and Abundance chart of Important Palynomorphs in Well FY-144.

The three wells. FY-125ST1, FY-142ST1 and FY-144 show characteristically distinctive assemblages of palynomorphs which are correlable across the wells. All the three wells analyzed belong to P600 zone where subzone P680 is correlable across them. With the exception of well FY-142ST1 that does not contain subzone P670; the other 2 wells containing subzone P670 are also correlable because their pollen assemblage are similar.

However, only well FY-125ST1 penetrates subzone P650 and is most likely characterized by fault structure due to the missing or unrecognizable of subzone P660. This may as well be due to unconformity either as a result of non deposition or erosional removal of the sediments. Therefore, the correlation exhibited by the sediments of the three wells suggests that they were deposited in the same depobelt within a mangrove setting of a prograding deltaic system associated with Agbada Formation.

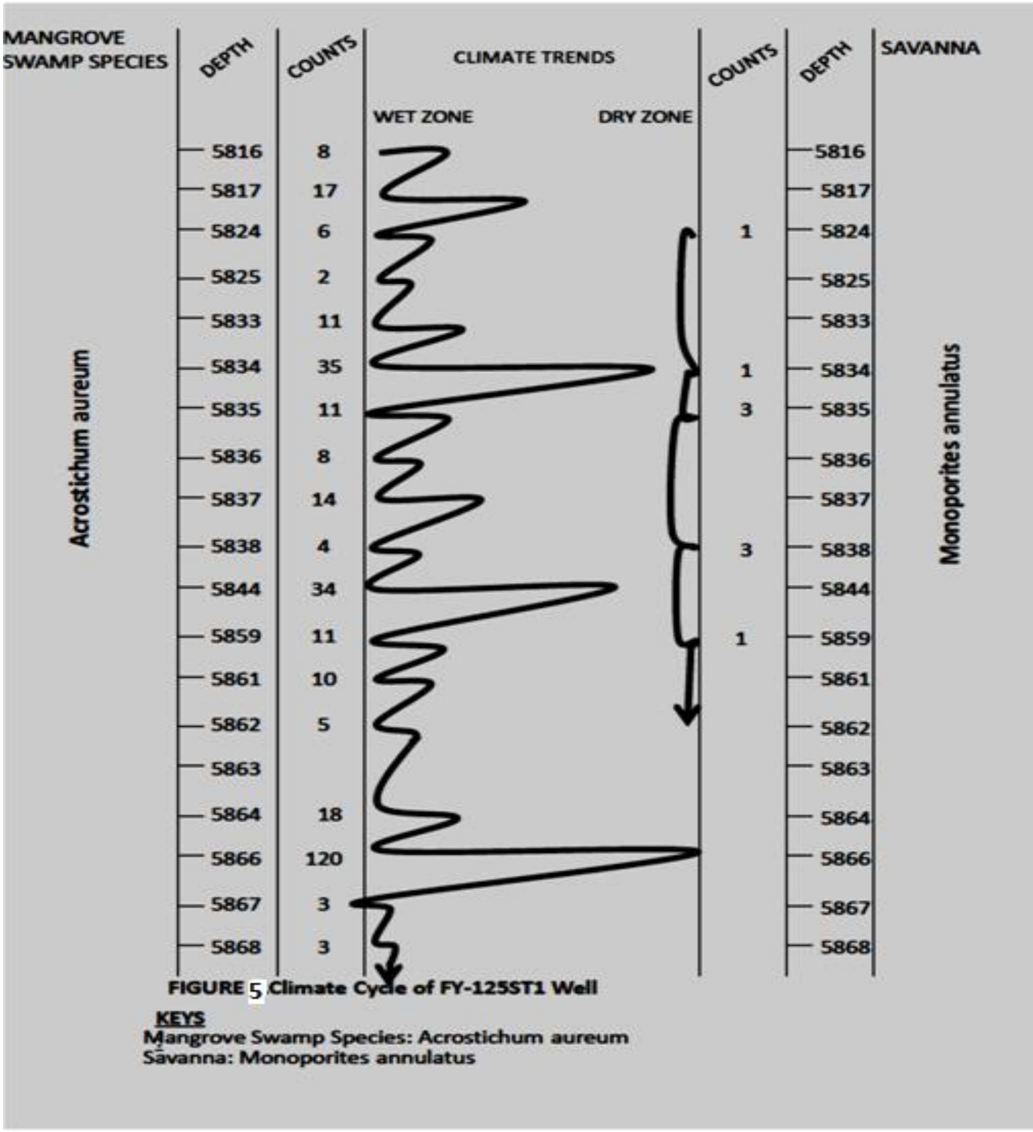


Figure 5. Climate cycle of Well Fr-125ST1.

Paleoclimate

Palynology is now a strong tool used in determining paleoclimatic conditions. The climate of an area is reflected by its vegetation type (Samant and Phadtare, 1997). These changes in plant community or variation in their composition or abundance of an assemblage or individual species are usually a direct consequence of variation in climate and / or environment.

However, the method adopted is widely practiced and advocated by Vail and Wordnardt, (1991) and Morley, (1995). Ola-Buraimo and Akaegbobi, (2013a) articulated the use of palynomorph abundance and diversity in evaluating sea level changes, paleoenvironment and paleoclimatic conditions for Cretaceous sediments in Anambra Basin, Nigeria and how it could be utilized for Recent sediments. The changes noticed in the palynomorph assemblages can be linked to contemporaneous deposits and genetically related facies referred to as systems tracts which represent the time of fall in sea water, equivalent to Lowstand systems tract; the time of rising sea equivalent to transgressive systems tract and the high sea levels representing the highstand systems tract (Ola-Buraimo and Akaegbobi, 2013a).
The use of foraminifera, nannofossils and dinocyst with respect to sequence stratigraphy studies is now widely practiced from the works of Huang and Wornardt, 1984; Shaffer, 1987; Wornardt, 1989; Shaffer, 1990; Vail and Wornardt, 1990, 1991; Powel, 1992; Wornardt, 1993; Morley, 1995; Ola-Buraimo and Akaegbobi, 2013a).

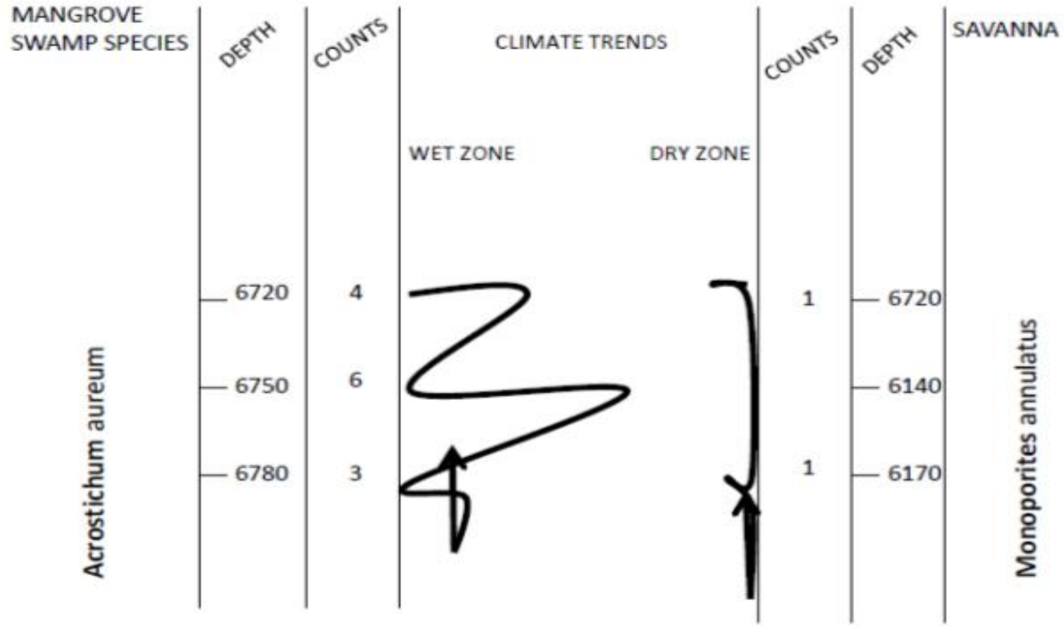


FIGURE 6.Climate Cycle for FY-142ST1 Well

KEYS:

Mangrove Swamp Species: Acrostichum aureum

Savanna: Monoporites annulatus

Figure 6. Climate cycle of Well FY-142ST1.

In this study two main palynomorph variables represented by *Acrostichum aureum* for mangrove species depicting wet climate against *Monoporite annulatus* representing savanna species and dry climate can be seen in Figure 5 for well FY-125ST1. The Figure 5 shows that mangrove pollen is dominant over the occurrence of *Monoporites annulatus*; thus suggesting that the sediment was deposited in mangrove environment under a wet climatic condition.

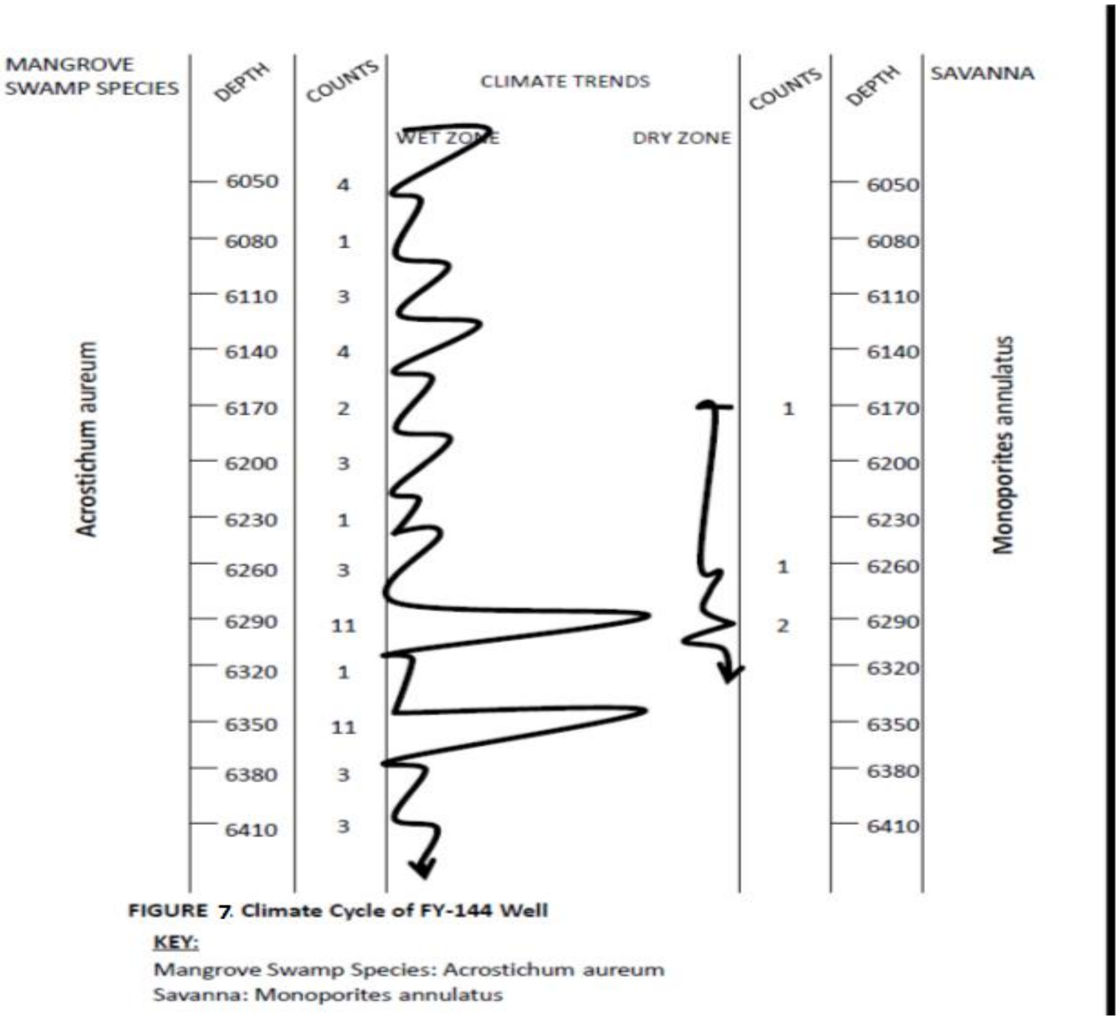


Figure 7. Climate cycle of Well FY-144.

However, the mangrove peaks are indicative of flooding surfaces while the peak at the base at 5866ft is the maximum flooding surface (MFS). This is the point at which the marine inundation was at the maximum landward limit from the shoreline (Fig.5).

The paleoclimatic interpretation of well FY-142ST1 is not different from that of Well FY-125ST1 except that the stratigraphic interval is short and the effect of sea level changes as it affects deposition is not apparent. However, the abundance of *Acrostichum aureum* which indicates wet climate is still dominant over relatively rare abundance of *Monoporites annulatus* which indicates dry climate (Fig. 6). Therefore, the prevailed climatic condition in well FY-142ST of interval 6720-6780ft is wet climate while the sediments were deposited in a mangrove setting. This corroborates the fact that climatic change can influence both the environmental and ecological conditions of an area at any point in time (Ola-Buraimo and Akaegbobi. 2013).

In the case of Well FY-144, the same phenomenon is at play. The mangrove swamp species (*Acrostichum aureum*) is continuously present at moderate abundance but relatively high at intervals 6290ft and 6350ft represented by value 11 showing very high peaks suggestive of condensed section within which is a maximum flooding surface.

Magnification ×800

PLATE 1

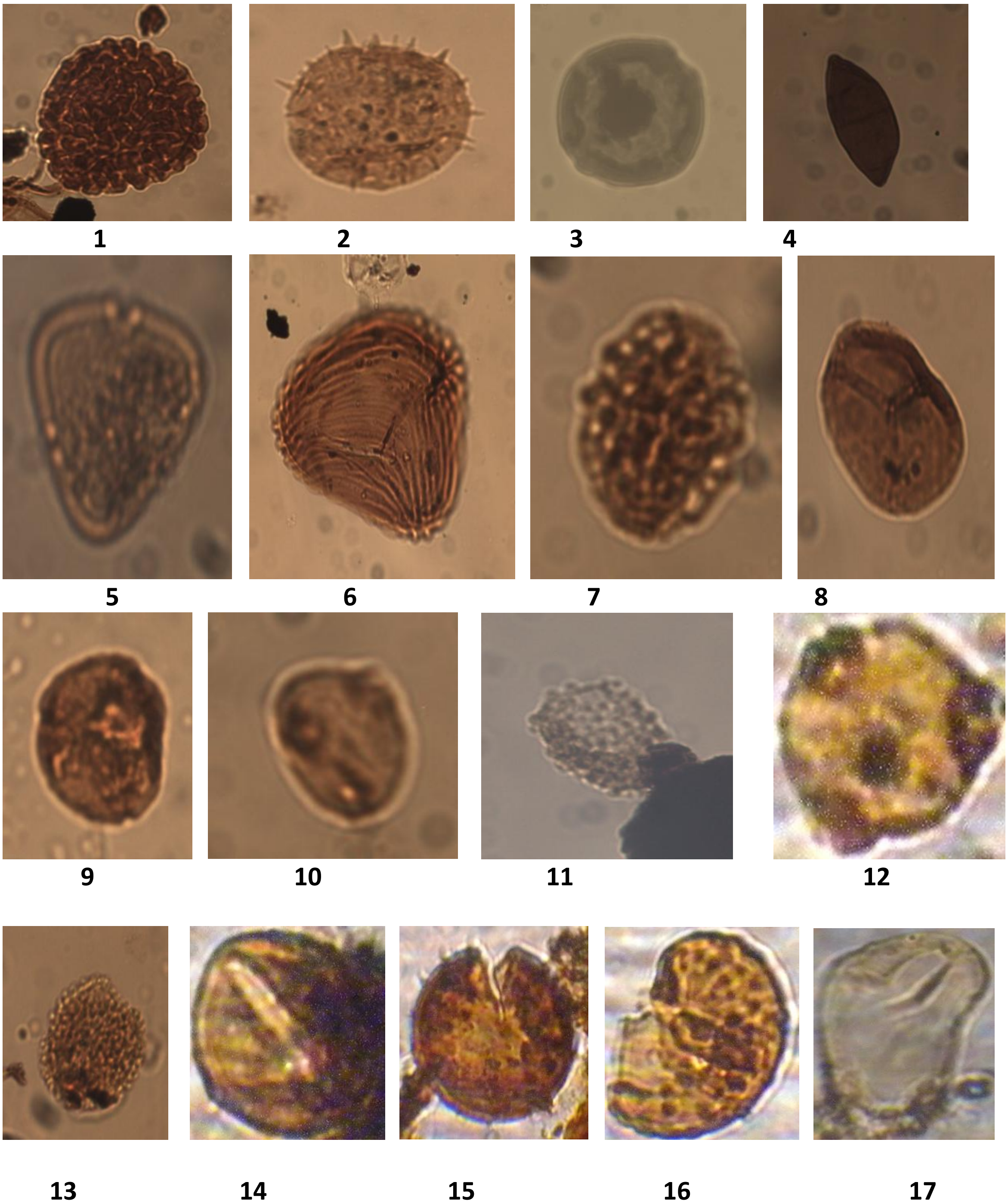


PLATE 1: (1) Crassotriletes vanraadshooveni, (2, 15) Echiperiporites estalae (3) E. pachydermites diederixi, (4) Fungal spore (5) Bombacasidites annae (6) Magnastriatites howardii (7)Peregrinipollis nigericus (8) Stereisporites sp (9) Psilatricolporites crassus (10,12) Retibrecitricolporites obodoensis (11) Gemmamonoporites sp (13)Rracemonocolpites hians (14) Monocolpites marginatus (16) Verrucatosporites usmensis (17)Laevigatosporites sp

The corresponding *Monoporites annulatus* recovery is rare to poor. This indicates that the stratigraphic interval (6050-6410ft) was under the influence of wet climatic condition while the sediments were deposited in mangrove setting of a prograding deltaic system (Fig. 7).
The paleoclimatic analysis of the three wells suggests wet climatic condition. It further corroborates the fact that the sediments of the three well sections are contemporaneous deposits which are genetically related facies represented by the time of rising sea equivalent to transgressive systems tract whereby sediments were deposited in mangrove environment of the same swampy depobelt.

CONCLUSION

Palynological study of the 3 wells located in the Forcados Yokri Field yielded information on the biostratigraphy of the penetrated stratigraphic sections. A *Magnastriatites howardii* zone of Germeraad et al, (1968); P600 zone and P680, P670 and P650 subzones after Evam et al, (1978) were established. Well FY-125ST1 has three subzones- P680, P670 and P650; Well FY-142ST1 has one subzone P680 while Well FY-144 has two subzones P680 and P670. The P680 subzone is correlable across the three wells based on similar assemblage of palynomorphs while P670 was correlable across two wells FY-125ST1 and FY-144. The Well FY-142ST1 did not penetrate both subzones P670 and P650. Well FY-144 did not penetrate P650 subzone, therefore, not correlable with other wells. An unconformity or fault structure is suggested between subzone P670 and P650 in Well FY-125ST1.
The paleoclimatic investigation shows that sediments in the well sections were deposited under wet climate in a mangrove setting of a deltaic prograding complex within the same swampy depobelt. The mangrove peaks in the climatic cycle yielded information on the flooding surfaces, maximum floding surface and condensed section present within the well sections.

ACKNOWLEDGEMENTS

The authors are indeed grateful to Shell Petroleum Company of Nigeria for the provision of core and ditch cutting samples used for this research work. The Geologic Service Unit of the company is also highly appreciated for granting permission to prepare palynological samples in their laboratory. The management of Palystrat Limited is also thanked for providing literature materials for the interpretation of the results.

REFERENCES

Adeigbe, O.C., Ola-Buraimo A.O. and Moronhunkola A.O., 2013. Palynology and biostratigraphy of Emi- 1 well, Moroh Field deep offshore, Eastern Dahomey Basin, southwestern Nigeria. International Journal of Scientific and Technology Research, vol. 2(1), 58-70.

Akpoyovbike A.A., 1978. tertiary lithostratigraphy of Niger Delta. The American Association of Petroleum Geologists Bulletin, 62(2), 295-306.

Corredor, F., Shaw, J.H. and Bilotti, F., 2005. Structural styles in the deep-water fold and thrust belts of the Niger Delta. American Association of Petroleum Geologists Bulletin, 89 (6), 753-780.

Doust, H. and Omatsola, E., 1992. Niger Delta. Shell Publications, UK., pp. 201-238.

Evamy, B.D., Haremboure, J., Kamerling, P., Knaap, W.A., Molloy, F.A. and Rowlands, P.H., 1978. Hydrocarbon habitat of Tertiary Niger Delta. The AmericanAssociation of Petroleum Geologist Bulletin, 62(1), 1-39.

Fredericksen, N.O., 1985. Review of Early Tertiary sporomorph paleoecology. American Association of Stratigraphy. Palynology Contribution. Series 15, 92p.

Germeraad, J.H., Hopping, C.A. and Muller, J., 1968. Palynology of Tertiary sediments from tropical areas. Review of Palaeobotany and Palynology, 6, 189-348.

Knox, G. J. and Omatsola, E.M., 1989. Development of the Cenozoic Niger Delta interms of the Escalator Regression model and impact on hydrocarbon distribution.Proceedings KNGMG symposium Coastal Lowlands, Geology and Geotechnology,181-202.

Huang, T.C. and Wornardt, W.W., 1986. Plio-Pleistocene sequence stratigraphy, abundance peak correlation of seven wells in Green Canyon, offshore Louisiana. MICROSTRAT INC. company reports.

Lehner, P. and De Ruiter, P.A.C., 1977. Structural history of Atlantic Margin ofAfrica. The American Association of Petroleum Geologist Bulletin, 61 (7), 961-981.

Morley, R.J., 1995. Biostratigraphy characterization of systems tracts in Tertiary sedimentary Basins, Proceedings of the International om sequence stratigraphy in SE Asia.

Ola-Buraimo, A.O., 2013a. Palynological stratigraphy of the Upper Cenomanian-Turonian Eze Aku Formation in Anambra Basin, southeastern Nigeria. Journal of Biological and Chemical Research. 30(1), 54-67.

Ola-Buraimo A.O., 2013c. Biostratigraphy and paleoenvironment of the Coniacian Awgu Formation in Nzam-1 well, Anambra Basin, southeastern Nigeria. International Journal of Scientific and Technology Research, 2(3). 112-122.

Ola-Buraimo A.O., Adebayo O.F., and Umaru M., 2015. Palynological characterization of the organic richness, Kerogen Type and Thermal maturity of source rocks in interval 905-1360m of Kemar-1 well, Bornu Basin, Northeastern Nigeria. Journal of Biological and Chemical Research. 32(2), 720-732.

Ola-Buraimo A.O. and Adeleye M., 2010. Palynological characterization of the Late Maastrichtian Ute Coal measure deposit, Southwestern Nigeria. Science Focus, 15(2), 276-287.

Ola-Buraimo, A.O, and Akaegbobi I.M., 2013a. Palynology, an important tool in evaluating sea level changes, paleoenvironment and paleoclimatic conditions in geologic time. International Journal of Engineering Research and Technology, 2(3), 1-29.

Ola-Buraimo, A.O., and Akaegbobi, I.M., 2013c. Palynological evidence of the oldest (Albian) sediment in the Anambra Basin, southeastern Nigeria. Journal of Biological and Chemical research vol. 30(2), 387-408.

Poumot, C., 1989. Palynological evidence for eustatic events in the tropical Neogene.Bull. CentresRech. Explor. –Prod. Elf-Aquitaine, 13 (2), 437-453.

Powel, A.J., 1992. Making the most microfossils. Geoscientist, 2(1), 12-16

Reijers, T.J.A., Petters, S.W., and Nwajide, C. S., 1997. The Niger Delta Basin.African Basins. Sedimentary Basins of the World, 3 edited by R. C. Selley (SeriesEditor. K. J. Hsü), 151-172.

Rouse, G.E., Hopkins Jr., W.S. and Piel, K.M., 1966. Palynology ofsome Late Cretaceous and Early Tertiary deposits in British Columbia and adjacent Alberta. In . R.M. Kosanke and A.T. Cross (Editor), Synposium on Palynology of Late Cretaceous and Early Tertiary. Geol. Soc. Am. Spec. Pap., 127, 213 – 246.

Salami, M.B., 1984. Late Cretaceous and Early Tertiary palynofacies of southwestern Nigeria. Rev. Esp. Micropaleontol. 16, 415-423

Salami, M.B., 1988. Petrography and palynology of the Upper Maastrichtian Abeokuta Formation of southwestern Nigeria. Niger. J. Sci., 22(1/2), 127-142.

Samant, B. and Phadtare, N.R., 1997. Stratigraphic palynoflora of the Early Eocene Rajpardi lignite, Gujarat and the lower age limit of the Tareswar Formation of south Cambay Basin, India.Palaeontographica Abt. B, 245, Lfg., 1-6, 1-108

Shaffer, B.L., 1987. The potential of calcareous nannofossils for recognizing Pli-Pleistocene climatic cycles and sequence boundaries on the shelf. Eight Annual Research Conference, Gulf Coast Section, SEPM, Selected Papers and Illustrated Abstracts, 142-145

Shaffer, B.L., 1990. The nature and significance of condense sections in Gulf Coast Late Neogene sequence stratigraphy. Gulf Coast Assoc., Trans., XL, 767-776

Short, K.C. and Stauble A.I., 1967. Outline of geology of the Niger Delta. A.A.P.G. Bull., 51, 761-779.

Sowunmi, M.A., 1986. Change of vegetation with time In. G. W. Lawson (Editor), Plant Ecology in West Africa. Wilcy, New York, 273-307

Stacher, P. 1995. Present understanding of the Niger Delta hydrocarbon habitat. In.M. N. Oti and Postma, G. (eds.), Geology of Deltas. A.A. Balkema, Rotterdam, 257-267.

Vail P.R. and Wornardt W., 1990. Well log seismic sequence stratigraphy. an integrated tool for the 90's. GCSSEPM Foundation 11th ann. Conf. Dec. 1990; 379-388

Vail P.R. and Wornardt W., 1991. An integrated approach to exploration and development in the 90s.Well log seismic sequence stratigraphy analysis. Gulf Coast Asso. of Geol. XL1, 630-650.

Van Wagoner, J.C., Mitchum, R.M., Camption, K.M. and Ramanian, V.D., 1990. Siliciclastic sequence stratigraphy in well logs, cores and outcrops. concept for high resolution correlation of time and facies; American Association of Petroleum Geologists Methods in Exploration, 7, 1-55.

Weber K. J., 1971. Sedimentological aspects of oil fields in the Niger Delta.Gelogieen Mijnbouw, 50(3), 559-576.

Weber, K. J. and Daukoru, E., 1975. Petroleum geology of the Niger Delta—Proc.WorldPetrl. Cong., 9, 209-221.

Wornardt, W.W., 1989. Calcareous nannofossils and condences sections in sequence stratigraphy. International Nannoplankton Association Conference, Florence, Italy, Book of Abstracts, p. 3

Wornardt, W.W., 1993. Sequence stratigraphy concepts and applications, Micro-Strat. Inc. (Wall Chart, version 2.0).

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