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Palynology, An Important Tool In Evaluating Sea Level Changes, Paleoenvironment And Paleoclimatic Conditions In Geologic Time.

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ABSTRACT

Palynological data was used through the integration of palynomorph abundance and diversity with miospores derived from land, associated with data-set of paleoenvironment, considering in particular the gonyaulacacean and peridinoids, their G/P ratio and the presence of non - pollen palynomorphs (NPP) as a new technique geared towards interpreting the relative position of sea levels, the associated climatic condition and various paleoenvironments of deposition of the sediments. Definite trend in palynomorph abundance and diversity values were used to interpret analyzed stratigraphic section. High values of the abundance and diversity indicate trangressive/ highstand systems tracts (TST/HST) representing rising to high sea water level. This situation is interpreted to represent wet climate. In contrast low abundance and diversity values suggest LST characterized by low sea water level influenced by dry climatic condition.

In all three major trangressive phases were recognized in the Asu River Group, Eze- Aku Group and Awgu Shale within the analyzed stratigraphic section of well –X in Anambra Basin, Nigeria. The periods are the Late Cenomanian in the Asu River Group; Late Turonian in the Eze Aku Group and Late Coniacian in the Awgu Shale section. The paleoenvironment of deposition interpretation, also an integrated approach and a hybrid technique of combined land derived forms, marine derived forms (dinocyst), G/P ratio and non-pollen palynomorphs (NPP) show that the entire sequence analyzed was mainly deposited within the alternating marginal marine and open marine systems.

Key words: Abundance, Diversity, Systems tracts, Dinocyst, Transgressive, Prograding

Introduction

The Anambra Basin is a Cretaceous to Tertiary sedimentary pile situated in the southeastern Nigeria. Exploration and exploitation of oil and gas has shifted to the area due to the fact that both sedimentological features and organic geochemical data show that the region is capable of generating hydrocarbon and also contain prerequisites for trapping and accumulation of oil and gas. On the eastern side of the basin is Calabar Flank while lying southerly is Niger Delta; in the north of the basin are Benue Trough and Bida Basin, while to the west is Dahomey Embayment.

The evolution of the Anambra Basin is controversial but the fact remains that it was formed as a result of the separation of the Gondwana land leading to the separation and formation of the South America in the north and Africa continent in the south during the Late Jurassic – Early Cretaceous (Reyment, 1980a, Reyment and Dingle, 1987)

Three different tectonic episodes were suggested for the evolution of the Anambra Basin (Short and Stauble, 1967; Murat, 1972; Obi et al, 2001) and such school of taught is now doubtful because our experience and present knowledge on the chronostratigraphy of the basin shows that the oldest sediment in the basin is Albian in age and in fact both the pre and post Santonian sediments contain substantial amount of evaporates like gypsum.

This paper intends to showcase the importance of palynology and to present how effective the application of palynological studies could be used in evaluating the paleoenvironment and paleoclimatic conditions of an area both in the late and resent sediments. Therefore, a classical example is taken from well – X, Cretaceous sediments of Anambra Basin, southeastern Nigeria.

Geologic Setting

The first marine incursion into the area commenced in the Late Albian and continued until the Cenomanian. It resulted in the deposition of the marine (upper) part of the Asu River Group and the Odukpani Formation. Complete marine regression occurred during the Turonian resulting in the deposition of the Eze-Aku Shale. Crustal movements occurred during the Early Santonian times resulting to flooding and uplift and then the erosion of Coniacian-Albian deposits of parts of the region (e.g. Abakaliki Anticlinorium; Figure 1)

The Santonian folding phase was followed by subsidence which initiated a new marine transgression resulting in the deposition of Nkporo Shale. The marine regression occurred during the Maastrichtian and a new phase of marine transgression began in the Paleocene. Marine regression during the Early Eocene resulted in the deposition of the sandier Ameki Formation and terminated sedimentation in the Anambra Basin. Subsequent sedimentation in the Late Eocene occurred in the Niger Delta. Some of these ideas about sedimentation and time of deposition in Anambra Basin has become controversial because recent research by the author has shown that they are questionable. In another paper palynological evidences have proved that there are in fact Neogene deposits in Anambra Basin (Ola-Buraimo and Akaegbobi, 2012).

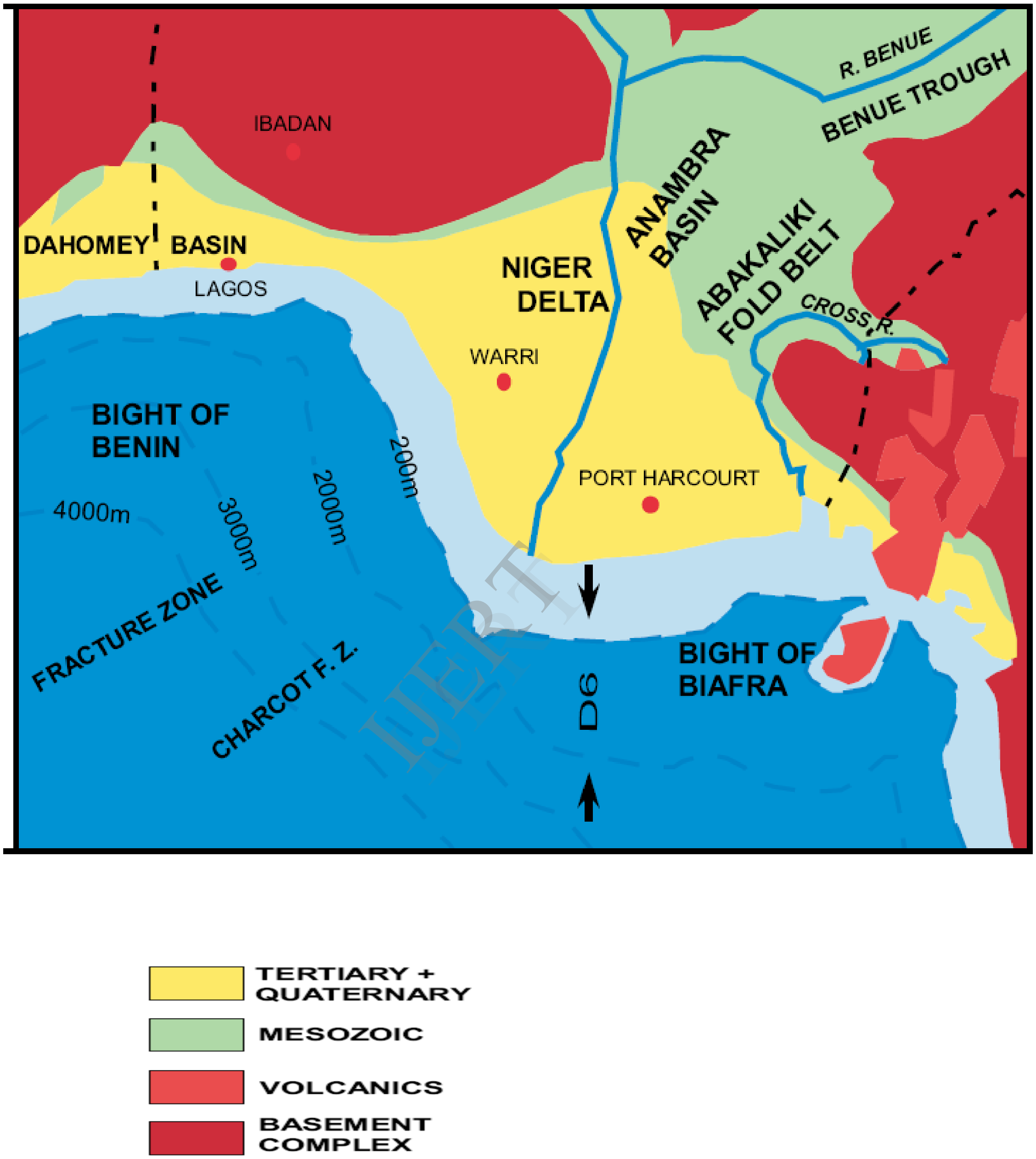

Fig.1: Index map of Niger Delta and offshore Nigeria showing the Anambra Basin and Abakaliki Fold belt (After Doust and Omatsola, 1989).

General stratigraphy

Sedimentary rocks of this region are not well exposed because of intensive weathering, lateralization and thick cover of vegetation. The rocks range in age from Cretaceous to Tertiary and they are underlain by the crystalline basement complex rocks. The basement forms part of the West African Craton and consists of metamorphic and igneous rocks whose deformation occurred during the Pan-African Orogeny (Precambrian- Paleozoic).

The stratigraphic history of the region is characterized by three sedimentary phases (Short and Stauble1967; Murat, 1972) during which the axis of the sedimentary basin shifted. These three phases are:

a) The Abakaliki-Benue phase (Aptian-Santonian)

b) The Anambra Basin phase (Campanian-Mid Eocene)

c) The Niger Delta phase (Late Eocene-Pliocene)

More than 300 meters of rocks comprising the Asu River Group and the Eze Aku and Awgu Formations, were deposited during the first phase in the Abakaliki-Benue Basin, the Benue Valley and the Calabar Flank (Figure 2), the second sedimentary phase resulted from the Santonian folding and uplift of the Abakaliki region and dislocation into the Anambra Platform and Afikpo region. The resulting succession comprises the Nkporo Group, Mamu Formation, Ajali Sandstone, Imo Formation and Ameki Group (Figure 2). The third sedimentary phase credited for the formation of the petroliferous Niger Delta commenced in the Late Eocene as a result of a major movement that structurally inverted the Abakaliki region and displaced the depositional axis further to the south of the Anambra Basin. The generalized stratigraphy sequence in the Anambra is shown in Figure 2. Reijers et al, 1997 also showed the time equivalent formation of the Anambra Basin in the Niger Delta. The oldest sediments are referred to as Asu River Group.

Asu River Group

This group consists mainly of shales, sandstones and subordinate limestones. The group thicken toward the southeast and is absent in the Idah area. Fossils recovered from the sediments include: ammonites, palynomorphs, foraminifera and radiolarian. Reyment, (1965**)** dated the group Middle-Upper Albian on the basis of the ammonites content. The group is estimated to have a minimum thickness of 3,000m.

Awi Formation

This formation consists of a sequence of conglomerates, variously coloured micaceous to feldspathic sands and sandstones, dark (sometimes carbonaceous) shales, clays and mudstones and fine variegated siltstones. The formation was erected by Adeleye and Fayose (1978), for a sequence that formed the lower part of earlier workers Odukpani Formation. The total thickness of the Awi Formation is unknown as a considerable part of it is not exposed. A minimum thickness of 45m has been proved. Rich microflora (palynomorph) assemblages indicate an Upper Albian-Lowermost Cenomanian age for the formation.

Odukpani Formation

This formation overlies the Awi Formation comfortably. It is a sequence of alternating shale, sand shale, sandstone and limestone with total thickness of about 750m. Odukpani Formation is richly fossiliferous and has yielded ammonites, foraminifera, ostracodes, gasropods, algae and palynomorphs. Its age ranges from Albian to Lower Turonian (Reyment, 1965). Overlying the Asu River Group in the Anambra Basin and the Odukpani Formation on the Calabar Flank is the Eze-Aku Shale.

Eze-Aku Shale

This formation consists dominantly of grey to black shales and siltstones of shallow marine origin. Local development of sandstones, limestone and sandy limestone occur in numerous areas. The formation thickens southwestwards and attains a maximum thickness of 2,000m in the Owerri-Aba area. Fossils recorded to date from the formation include ammonites, pelecypods, gastropods, echinoids, fish fragment, decapods, foraminifera and dinoflagellates. These fossils indicate a lower Turonian age for the formation. Awgu Formation overlies the Eze-Aku Shale in Anambra Basin but the formation is missing on the Calabar Flank having been eroded or not deposited at all.

Awgu Shale

This formation consists of bluish grey shales with interbeds of fine-grained calcareous sandstones and black bioclastic limestones. Dolerite sills occur in a borehole drilled 30km southwest of Otukpo. The formation thickens southwestwards, attaining a maximum thickness of

1,000m around Enugu and Owerri. Fossils (like Ammonites and Ostracodes) recorded from the formation indicate a Coniacian-Santonian age. The Nkporo shale overlies the Awgu shale in the Anambra Basin and the Eze-Aku on the Calabar Flank.

Nkporo Shale

This formation consists of dark shale and mudstone with occasional thin beds of sandy shale, sandstone and shelly limestone. It thickens in a southwest direction and attains maximum thickness of 1,200m around Warri-Owerri-Aba axes; north of Awgu shows a coarse grained sandstone facies referred to as the Owelli Sandstone. The Owelli Sandstone member is about 600m thick. The coarse, pebble channel fill Afikpo sandstone represents another lithofacies variation of the Nkporo Formation.

In the Anambra Basin, the Nkporo Shale is unconformable with the underlying Awgu Formation and may overstep it and the Eze-Aku Shale to lie directly on the Asu-River Group. On the Calabar Flank, the Formation consists predominantly of thick layers of black shale alternating with thin bands of brown to grayish siltstone, sandstone and limestone. When present, mudstones layers are thin and brown. The sandy and silty layers become more prominent towards the top of the formation.

The fauna of the Nkporo Shale consists mainly of bivalves, ammonites and foraminifera. They indicate a Campano-Maastrichtian age. On the Calabar Flank, palymorphs were recorded from the formation by Odebode and Sharby (1980) and on the basis of its *Heterohelicid* Foraminifera assemblage; the age has been ranged back to Late Santonian. Both on the Calabar

Flank and in the Anambra Basin, the Nkporo Shale is conformably overlain by the Mamu Formation.

Mamu Formation

It consists of an alternation of fine to medium grained sandstone, dark grey and dark blue or grey mudstone. Five Coal Seams which range from 4cm to 3.5m in thickness occur in this formation in the Enugu area (Reyment, 1965). Mamu Formation is not widespread. On the Calabar Flank, it outcrops in a very limited area west of Uwet. The major distribution of the Mamu Formation is along the east - west direction with a minor trend along a NW-SE direction. The Formation attains maximum thickness of about 500m southwest of Nsukka and is absent in Warri area.

The Formation is dominantly terrestrial in origin based on the presence of some brackish water foraminifera. There is occurrence of some ammonites in a number of shale intercalations. Pollen and spores described from the formation indicates a Maastrichtian age. The Mamu Formation is overlain in the Anambra Basin by the Ajali Formation.

Ajali Sandstone

This formation previously referred to as the False-Bedded sandstone, consists of mainly friable poorly sorted, whitish, fine to coarse-grained, non fossiliferous sandstone. The sandstone is frequently cross-bedded and may contain thin interbeds of mudstone and occasional plant impressions. At its type locality (around Enugu), the formation attains a thickness of approximately 450m. Fossil remains are rare and only fragmentary plants and worn tracks have been recorded from the formation to which a Maastrichtian age has been assigned. It is possible that all the Tertiary formations in the Anambra Basin also occur in the subsurface on the flank. However, only the coastal plain sands (mainly Pleistocene) and Alluvium (Holocene) outcrop on the flank and these invariably rest directly on the cretaceous (Cenomanian-Maastrichtian) sediments. In the Anambra Basin, the Ajali Standstone is succeeded by the Nsukka Formation.

Nsukka Formation

This formation was formerly called the Upper Coal Measures. It consists of an alternating succession of sandstone, dark grey shale with thin interbeds of Coal Seams. The basal part of the formation consists of sandstones up to 120m thick, succeeded by shales with interbeds of low grade coal. The formation has a maximum thickness of 450m (in the Nsukka area). Nsukka Formation contains a very poor fossil fauna. However, the occurrence of some palynomorph species and *Afrobolivina* indicates an Upper Maastrichtian age for it. The Nsukka Formation is succeeded by the Imo Shale.

Imo Shale

This facies is consists of two lithologic units. The lower unit is composed of fine to coarse-grained sandstones with interbeds of calcareous shale and thin shelly limestone. The upper unit consists of coarse, cross-bedded sandstones with sandy clay interbeds. In the subsurface Niger Delta section of the Ameki Formation is referred to as the Agbada Formation (Short and Stauble, 1967).

The formation has a characteristic greenish grey coloration and attains a maximum thickness of 1,550m. It is richly fossileferous with molluscs, foraminifera and corals predominating. These fossils indicate Middle to Upper Eocene age.

AGE		ABAKALIKI-ANAMBRA BASIN	AFKPO BASIN
M.Y 30	Oligocene	Ogwashi-Asaba formation	Ogwashi-Asaba formation
54.9	Eocene	Ameki/Nanka formation/ Nsugbe sandstone(Ameki group)	Ameki formation
65	Paleocene	Imo formation Nsukka formation	Imo formation Nsukka formation
73	Maastrichtian	Ajali formation Mamu formation	Ajali formation Mamu formation
83	Campanian	Nkporo Oweli Formation/Enugu Shale	Npkoro shale/Afikpo sandstone
87.5	Santonian		Non-deposition/erosion
	Coniacian	Agbani sandstone/ Awgu shale	
88.5	Turonian	Eze Aku Group	Eze Aku Group (include Amasiri sandstone)
93 100	Cenomanian-Albian	Asu River Group	Asu River Group
119	Aptian Barremian Hauterivian	Unnamed Group	
PRECAMBRIAN		BASEMENT COMPLEX	

Figure 2: Correlation Chart for Early Cretaceous strata in southeastern Nigeria (After Nwajide, 1990)

Methodology

Twenty ditch cutting samples of well – X situated in the Anambra Basin range in depth from 9000 to 12044ft were used for the preparation of the palynological slides, observed under the microscope for palynomorph content . The samples were taken for preparation at 90ft interval. The sample preparation was carried out following the international standard. The lithified samples were crushed with the mortar and pestle in order to enhance maximum recovery of pollen and spores.

The crushed samples along with the friable samples were initially treated with dilute hydrochloric acid (10%) in order to eliminate carbonate substance present in them. They were later soaked in 60% hydrofluoric acid for silica and silicates digestion. The samples were not oxidized in order to avoid corrosion; but were sieved with 5µm mesh in order to maximize concentration of miospore grains and to achieve clean slides for easy identification and photography. The recovered residues were mounted on glass slides with Depex (D.P.X.).

The amount of palynomorph recovered is moderate to barren. Total count of grains present were noted and presented in the checklist for absolute representation of different important pollens and spores grains recovered.

Result and Discussion

Sedimentology

Litho – description was carried out on well – x with depth range from 8630-10,350ft. Two main lithofacies units were recognized- shale and gypsum. Lithologic unit 1 of interval 8630-8820ft and 9000-10350ft are composed of shale facies deposited during Coniacian – Santonian in a marine environment; present at the topmost part of the Asu-River Group (See Table 1). Stratigraphic interval 8630-8820m is characterized by fossiliferous, ferruginized, dark grey fissile shale. The accessory minerals occurring within the well intervals are calcite and hematite.

The presence of carbonate mineral which is calcite is thought to have formed by post depositional effect of digenesis. From this study, the shale is suggested to have been deposited in marine environment during wet climate. The second stratigraphic interval ranges from 9000-10350ft have the same lithofacies characteristics with topmost interval, but deposited during the Albian- Turonian. The facies unit belong to Eze-Aku Group but dominantly of Awgu Shale deposited in both the marginal marine to typical marine setting.

Lithologic unit 2 of depth 8910ft consists of gypsiferous shale belonging to the Eze-Aku Group, deposited during Upper Cenomanian – Turonian time. The shale is dark grey fissile shale, rarely ferruginized with only heamatite as an accessory mineral. The Gyp/Sh ratio is 45:55. This type of environmental setting is suggested to be marginal marine in nature, probably deposited under dry climatic condition (Fig. 3)

DEPTH(ft)	LITHOLOGY	LITHOLOGIC DESCRIPTION	PALEOENVIRONMENT
8630		Dark gray fissile shale,rarely ferruginized.	
8720			
8820			Marine
8910	GYP GYP	Dary gray gypsiferous shale, rarely ferruginized.	Marginal marine
9000		Dark gray fissile shale, rarely ferruginized.	Marine
9090			Marginal marine
9180			Marine
9260			Marginal marine
9350			
9440			
9530			
9620			Marine
9710			Marginal marine
9800			Marine
9880			Marginal marine
9980			
10,070			
10,160			
10,250			
10,350			Marine

Figure 3: Showing lithologic description of well X with interval 8630-10350ft

Sea Level Change

Systematic interpretation of eustatic change in sea level which is dependent on tectonic activity and climatic changes was inferred from palynological data. Such tectonic activity was prominent during the Santonian in the Anambra Bain. However, major eustatic transgressions took place in the Mid–Late Albian, Late Cenomanian, Late Turonian-Coniacian and Late Campanian-Early Maastrichtian (Reyment and Morner, 1977; Siesser, 1978; Reyment, 1980b; while Reyment and Morner, 1977 attributed these major transgression to tectonic geoidal eustatic response. Such transgression and regression periods are observed in this work.

These changes can be linked to contemporaneous deposits and genetically related facies referred to 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.

The method adopted is that widely practiced and advocated by Vail and Wornardt, (1991) and Morley, (1995). In this paper attention will be on the use of palynomorph abundance and diversity calculated from palynomorph slide analysis. The use of foraminiferal, 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.

However, for the purpose of this study a modified version after guidelines suggested by Morley (1990) was adopted. Here, total number of forms recovered in the analyzed slide represents the population while the diversity is the different species encountered per slide. The number of total fossil recovered in Cretaceous sediments is usually few, far less than the 100 specimens, thus, mangrove pollen are not excluded from the total amount against what is obtainable in the Tertiary sediments as suggested by Morley, 1995. Therefore, the palynomorph population and diversity which show or indicate the systems tracts also suggests the corresponding paleoclimatic condition that existed at the time of deposition.

A definite trend in palynomorph abundance and diversity values can be seen in Figure 4. The lowest interval 10250-10350ft which marks the top of Asu River Group is characterized by relatively high values, which represents TST/HST compared to the overlying interval. This sharp difference could be as a result of wet climate, marine environment and favourable ecological factors which support increased abundance and diversity of flora during the Transgressive/Highstand systems tracts. This period is suggested to correspond to the major transgression of Late Cenomania.

In fact, the conformable relation that exists between the older Asu River Group and youger Eze-Aku Formation is discernable by distinctive palynomorph assemblages associated with sharp difference in palynomorph abundance and diversity and corresponding sea level changes and climate. The base of Eze Aku Shale at 10160ft is marked by very low palynomorph abundance and diversity value of 2; this is relatively low compared to the underlying interval. The low value corresponds to Lowstand systems tract associated with drier climate which supports reduced diversity of flora driven by retrograding character of lowstand systems tract.

At the upper part of Eze Aku Group, the interval 9530-9680ft is relatively highly fossiliferous, associated with relatively high palynomorph population and diversity, corresponding to transgrssional/highstand systems tract of rising to high sea water level. The period also correspond to the major transgressive eustatic condition of Late Turonian recognized by Reyment and Morner, 1977; Siesser, 1978; Reyment, 1980a.

The overlying Awgu Shale is characterized at the lower part by low abundance and diversity equivalent to lowstand systems tract. However, at depth 8910ft characterized by gypsum facies is associated with relatively high values of abundance and diversity, deposited in a marginal marine environment is suggested to belong to rising sea level (TST) period, characterized by restricted or enclosed system which supported crystallization of gypsum under a dry climatic condition. This period may also correspond to major transgressive period of Late Coniacian time. However, this observation negates the conception of Ramanathan and Fayose (1990), using foraminiferal data to conclude that the Cenomanian and Coniacian transgressions were restricted to the Calabar Flank and Benue Trough respectively. This research work has proved otherwise that their observations are also present in the Anambra Basin as indicated in the Figure 4.

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DEPTH	PALYNOMORPH ABUNDANCE	PALYNOMORPH DIVERSITY	SYSTEM TRACTS	G\P RATIO AFTER HARLAND 1973	PALEO-ENVIRONMENT	CLIMATE	AGE
	1	1	LST	0	Marine	DRY	Coniacian - Santonian
8720	4	4		0			
8820	3	3		0			
8910	9	8	TST/HST	-3	Marginal marine	WET	
9000	5	4	LST	3	Marine	DRY	
9090	6	5		-2	Marginal marine		
9180	2	2		0	Marine		
9260	4	4		-1	Marginal marine		
9350	2	2		0	Marine		
9440	3	3		0			
9530	17	12	TST/HST	0.5		WET	
9620	20	15		0.4			Turonain
9710	4	4	LST	-2	Marginal marine	DRY	
9800	5	4		2	Marine		
9880	9	6	TST/HST	-4	Marginal marine	WET	
9980	9	9		3	Marine		
10,070	4	4	LST	1		DRY	
10,160	2	2		0			
10,250	29	19	TST/HST	1.7		WET	AlbianAlbian - Cenomanian
10,350	12	10		2			

Figure 4: Integrated systems tracts and corresponding conditions and chronostratigraphy

Paleoenvironment

The paleoenvironment of deposition of sediments have been investigated and interpreted by different workers using different approach from palynological data (Batten, 1973, 1982; Van Berger et al, 1990). Relative abundance of terrestrial pollen and spores, and marine dinoflagellates were used by Lawal, (1882); Schrank, (1984); Edet and Nyong, (1992); Ojo and Akande, (2000); and Ogala et al, (2009). However, another school of taught believes in the use of mangrove palms or those having strong affinity for sub- saline waters; among such workers are Rouse et al, (1966); Salami, (1984, 1988); Fredriksen, (1985); Sowunmi, (1986) and Pavmot, (1987).

The organic wall microplankton (dinocysts) was widely used for Campanian to Maastrichtian for reconstruction of environments by Harland, 1973; Edet and Nyong, 1993 and Ogala et al, 2009. The paleoenvironment of deposition interpreted for the well section was based on an integrated approach, a new hybrid technique whereby total miospore value derived from the land is combined with the two main types of dinoflagellate, that is the gonyaulacacean and peridinoid forms. The gonyaulacaceans are otherwise referred to as spiniferate forms characterized by short spines or processes, indicative of marine environment. Serjent et al, 1987 described their complex morphological features as being responsible for enhancement of floatation and their presence signify deeper marine environment. Whereas, the peridinoids as described by Schrank (1984) have longer processes and they inhabit marginal marine environment. Therefore, Harland, (1973) gonyaulacacean/ peridinoid (G/P) ratio was also integrated along with the non pollen palynomorphs (NPP). The NPP include the fresh water algae, fungal spores and the microforaminiferal wall linings. The presence of the fresh water forms depict the influence of fresh water incursion from the prograding delta, while the microforam lining further suggest deposition of the sediment in an open marine setting.

It is apparent from the Figure 5 that the interval 9980-10359ft at the lower part of stratigraphic section have G/P ratio value that ranges from 0-3 , dominated by gonyaulacacean form, suggested to belong to an open marine system. However, no NPP form was recovered in this interval. The overlying horizon (9880ft) is defined by low miospore recovery, and relatively high peridinoid forms such as *Senegalinium spp,* and *Andalusiella spp;* depictive of marginal marine. Other overlying intervals were interpreted based on the aforementioned factors. The entire sequence is characterized by alternating marine and Marginal marine environment of deposition.

Stratigraphic positions where there is occurrence of algae and fungal signify fresh water influence into the system which could either be mild or strong depending on the low and high values of the fresh water forms. The use of positive and negative signs signifies the boundary between the marine and the transitional environment represented by the shoreline position. Thus, a negative value indicates preponderance of peridinoid over the gonyaulacaceann forms which suggests deposition in marginal marine environment. For the purpose of understanding, transitional or marginal marine environment is here interpreted to mean and include the distal part of fluviatile, the mangrove, deltaic and the barrier island sometimes covered by the marine water during the high tide.

In contrast, horizons or intervals such as 9800ft, 9750 – 9620ft, 9180ft, 9000ft and the uppermost part of the stratigraphic section show positive values. These suggest relatively higher presence of gonyaulacaceans forms such as *Polysphaeridium*, *Subtilisphaera*, *Spiniferites* forms over the peridinoids; and they suggest deposition in the typical marine setting.

Paleoclimate

The paleoenvironment have already been discussed in part along with the sea level changes. This is because it is believed that it is one of the fundamental factors responsible for fluctuation of sea levels. This is better appreciated when information (data) from the systems tracts interpreted from palynomorph population and diversity is combined with paleoenvironment data (See Fig. 5).

The analyzed section shows that the transgressive and highstand systems tracts characterized by high abundance and diversity is of wet climatic condition while the lowstand systems tract defined by low water level, associated very strong fluvial processes leading to progradation of the delta was influenced by dry climate. Though the environment of deposition of sediments is independent of climatic condition, but is controlled by processes transportation and deposition. Therefore, climatic change can influence both the environmental and ecological conditions of an area at any point in time. Deposition of evaporates such as gypsum or carbonate rock is dependent on environment and structural high; thus, where there is marine enclosure it must be free to a large extent from fresh water influx. Such deposition is usually accelerated by dry climatic condition as suggested for the gypsum deposit at 9980ft in the analyzed section of well-X in Anambra Basin, southeastern Nigeria.

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Depth	Total Miospore	Total Gonyalacecean	Total Peridinacecean	G\P ratio After Harland 1973	Total forams wall lining	Total Algae	Total Fungi	PALEO-ENVIRONMENT
8630	1	0	0	0	0	0	0	Marine
8720	3	1	0	0	0	0	1	
8820	3	0	0	0	0	0	0	
8910	5	1	3	-3	0	0	1	Marginal marine
9000	2	0	3	3	0	0	0	Marine
9090	3	1	2	-2	0	0	0	Marginal marine
9180	2	0	0	0	0	0	1	Marine
9260	3	0	1	-1	0	0	0	Marginal marine
9350	2	0	0	0	0	0	0	Marine
9440	3	0	0	0	0	0	0	
9530	8	3	6	0.5	1	4	0	
9620	5	4	11	0.4	0	0	2	
9710	1	1	2	-2	0	0	0	Marginal marine
9800	3	2	0	2	0	0	0	Marine
9880	3	1	4	-4	0	0	0	Marginal marine
9980	5	3	1	3	0	0	0	Marine
10,070	3	1	0	1	0	0	0	
10,160	2	0	0	0	0	0	0	
10,250	16	5	3	1.7	0	0	0	
10,350	10	2	0	2	0	0	0	

Figure 5: Integrated Miospores, Gonyaulacacean, Peridinoid, G/P ratio and NPP Values delineating Paleoenvironment of Deposition in Well- X , Anambra Basin, Nigeria

Conclusion

The authors strongly believe that the use of hybrid technique in interpreting for sea level position, paleoenvironment and paleoclimatic condition of Cretaceous and Quarternary sediments can easily and accurately be deduced from the advance method used here for Cretaceous sediments. Though, the general trend in geology is that the present is the key to the past, but, here it is suggested that the past can as well be used to reconstruct and be the key to the present and future geological conditions. Experience of the past can be used to solve future problems.

Three main transgressive phases were recognized. At depth 10250ft of the Asu- River Group, the TST/HST regime was noticed and it corresponds to the Late Cenomanian TST of the Haq et al, 1987. At the upper boundary of the Eze Aku Group is the presence of another TST/HST surface (9620ft) showing sharp palynomorph abundance and diversity with the overlying interval. The TST corresponds to Late Turonian transgressive phase of Haq et al, 1987. The last transgressive surface observed in the analyzed section is present at depth 8910ft equivalent to the Late Coniacian boundary within the Awgu Formation.

The method was able to delineate systems tracts which show sediments that are contemporaneous and genetically related in nature. The major controlling factor of the sea level is mainly climate which is either wet or dry in nature and to a lesser extent is tectonic factor which are directly related to the systems tracts. However, the Santonian period transgressive phase in the Awgu Shale is suggested to have been significantly influenced by tectonic factor, rather than climate, though, there was change in climatic condition during the tectonic action.

The main paleoenvironment of deposition within the stratigraphic section varies between the marginal marine and open marine system characterized by negative and positive G/P ratio respectively.

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