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Research Article

PALYNOLOGY AND PALEOENVIROMENTAL STUDIES OF BENDE-1 WELL. ANAMBRA AND NIGER DELTA BASINS, NIGERIA

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ABSTRACT

Palynological study has been carried out on ditch cutting and outcrops samples from of the Anambra and Niger delta Basin as penetrated by Bende-1 well. An attempt was made to determine the relative age, Paleoecology, paleobathymetry and depositional environment of the study area. A lithostratigraphic analysis of the the area shows that the samples are made up of shale, claystone and siltstone which are grey to dark grey and brown in colour with intercalations of medium to fine grained sandstone beds.Based on the paleobathymetric divisions and depositional environments observed in the study, the interval are from littoral, inner neritic to outer neritic environment. . The paleo-environment of deposition were determined to range from littoral to proximal offshore in a shallow marine setting. The age range from Late Campanian – Early Eocene

INTRODUCTION

The Anambra Basin is one of the Cretaceous sedimentary basins of Nigeria, bounded on the Southwestern flank by the Niger Delta hinge line, northwest by the Benue flank and southeast by the Abakaliki fold belt. The basin is roughly triangular in shape and covers an area of about 40,000 square kilometers with sediment thickness increasing southwards to a maximum thickness of 12,000m in the central part of Niger Delta. The basin fill consists of over 4,500m of sediments packaged as the NKPORO GROUP and the COAL MEASURES, which respectively document a major transgression and a major regression of the late Cretaceous sea.

LOCATION OF STUDY AREA: The study area falls within the Anambra and Niger Delta Basin. It is geographically located between longitudes 7^0 and 8^0E and Latitudes5^0 and 7^0N.

OBJECTIVE OF THE STUDY:

1. Using the relative abundance of terrestrially derived pollen/spores and marine derived dinoflagellates to predict the depositional environment and paleoclimatic conditions.
2. Using the change in the representation of terrestrially derived palynomorphs, develop a link between fluctuations in sea level and characters' of coastal vegetation.
3. To establish the ages of the sediments and carryout a chronostratigraphic correlation across the basin, using the biostratigraphic characteristics of each systems tract.

METHOD OF STUDY

There are two methods of study, laboratory and field study. The samples studied was obtained from the Geologic Survey Agency, Kaduna and those obtained from the fieldwork (i.e outcrops) located in the Anambra and Niger Delta Basins.

(i) Field Method: Field visit of studied rock outcrops was undertaken during which rock section were logged and rock samples collected vertically form the various horizons. Sedimentary structures were noted. Graphic logs of the horizons were erected. The collected rock samples were then subjected to laboratory analysis and interpretation.

(ii) Laboratory method:

(a) Palynological Sample Preparation: Two to three grams of the samples were broken to a grain size of 4mm, and transferred to a plastic breaker cup. The beakers were then labeled according to the depth of the samples. All the samples were then treated with commercial grade hydrofluoric acid. The essence of these was to separate the fossils from the rock debris. Most of the calcareous samples showed effervescence.The length of time needed for the samples to digest varies depending on the quantity of silt and sand. But once the initial heat of reaction had been dissipated, hydrofluoric acid concentration was increased

(b)Slide preparation: The stained specimen above is further diluted and washed out with water and the finished residual transferred into a tube with two drops of diluted solution of glue is added. A few of the residual is pipetted out on a clean dry cover slip, allowed to dry on a hot plate. Canada balsam is smeared on a slid on a hot plate at 100^0C. When warmed enough, the dried cover slip was stuck to the slide, pressed uniformly to avoid air bubble and allowed to dry. The prepared slide is cleaned, labeled correctly and properly stored after cooling. A total of One Hundred and Fifty (150) palynological slides were produced.

(c) Examination of sample: Tschudy (1969), recommended steps to be followed, it involves the preliminary examination of the prepared material followed by a quantitative listing of the pollen and spore flora. Secondly, a quantitative determination of the dominant palynomorphs present.

In carrying out the first step, the essence is to yield or provide information as to the reliability of the sample. If the sample is reliable, the most useful information normally gained is a record of the total composition of the flora. This will give clue as to the knowledge of the range in time of specific taxa, floral origin, evolution and the nature of facies and the climate at the time of deposition. Whereas, quantitative determination provides information on the dominate palynomorphs, base on absolute figures, percentages or both.

In determining the relative abundance, identification and counting was continued until all the samples were exhausted under high as well as low, power microscope and results recorded.Depths where palynomorphs were encountered are analyzed and identified, whereas certain depths were scanty and most were barren or sample not seen

PRESENTATION OF RESULT

I. LITHOSTRATIGRAPHY:

Lithostratigraphical analysis was carried out on the samples . Physical characteristics such as colour, texture, hardness, fissility, rock type etc were noted. Chemical tests to determine the presence of calcareous materials was also carried out using 10% dilute Hcl. **See figure 1**.

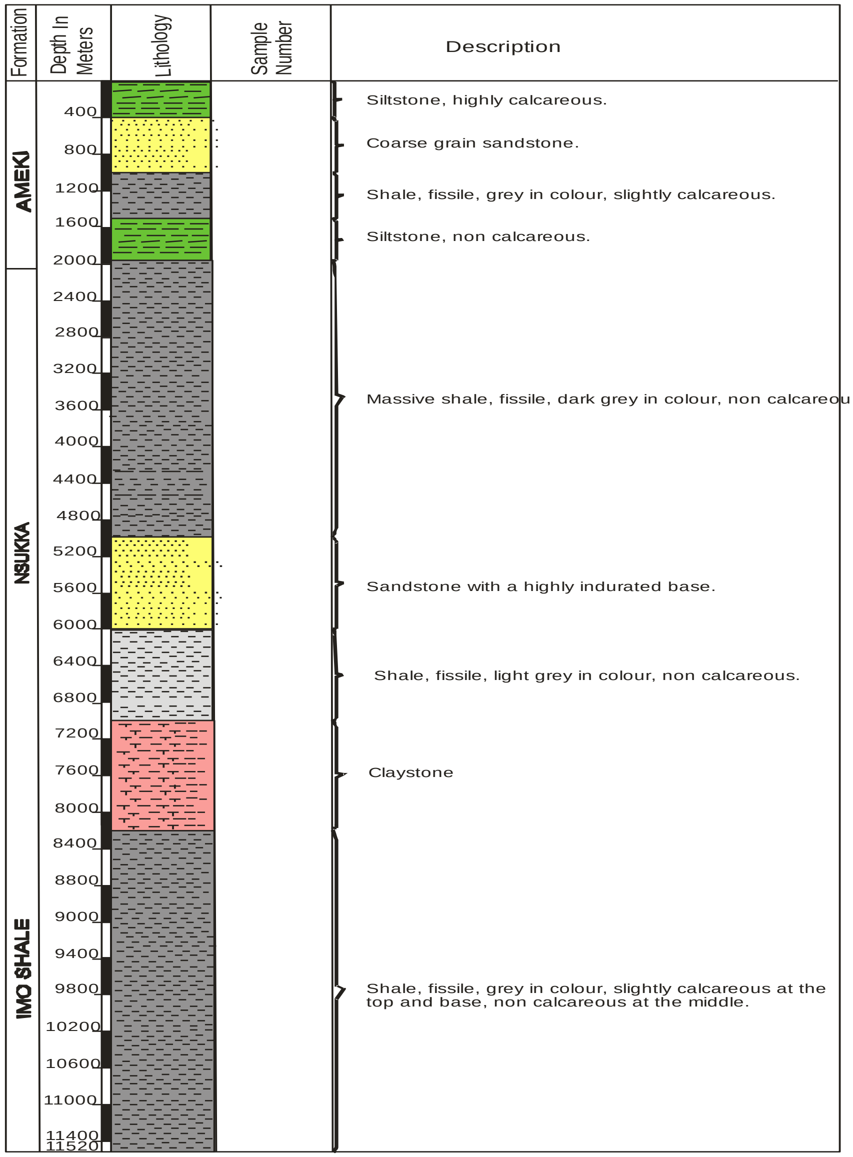

Figure 1: Lithostratigraphy of Bende-1 well

(II) PALYNOMORPH DISTRIBUTION:

The palynomorphs recovered from the well are as shown in the stratigraphic range charts (Pollen and Spores, Dinoflagellates / foramlining The lists of the forms as extracted from the chart are listed below. They are also categorized into Marine and Terrestrial forms. An attempt was also made to classify them into their ecological groupings (35).

(i) Pollen and Spores: Cingulatisporitesornatus Van Hoeken-Klinkenberg,1964

Buttiniaandreevi, Polypodites sp., Echimonocolpitesrarispinosus Van Hoeken-Klinkenberg,1966, Monocolpopollenitesspheroidites, Leiotriletesadriennis (Potonie and Gelletich) Krutzsch,1959, Verrucosisporitesobscurilaesuratus, Selaginellamyosurus

Polypodiidites sp., Striamonocolpitesundostriatus, Lycopodiumsporitessp, Adenantheritessp.Retidiporitessp, Longapertitesmicrofoveolatus Jan du Chêne and Adegoke, 1978 Longapertitessp.,Foveotriletesmargaritae (Van der Hammen,1954)

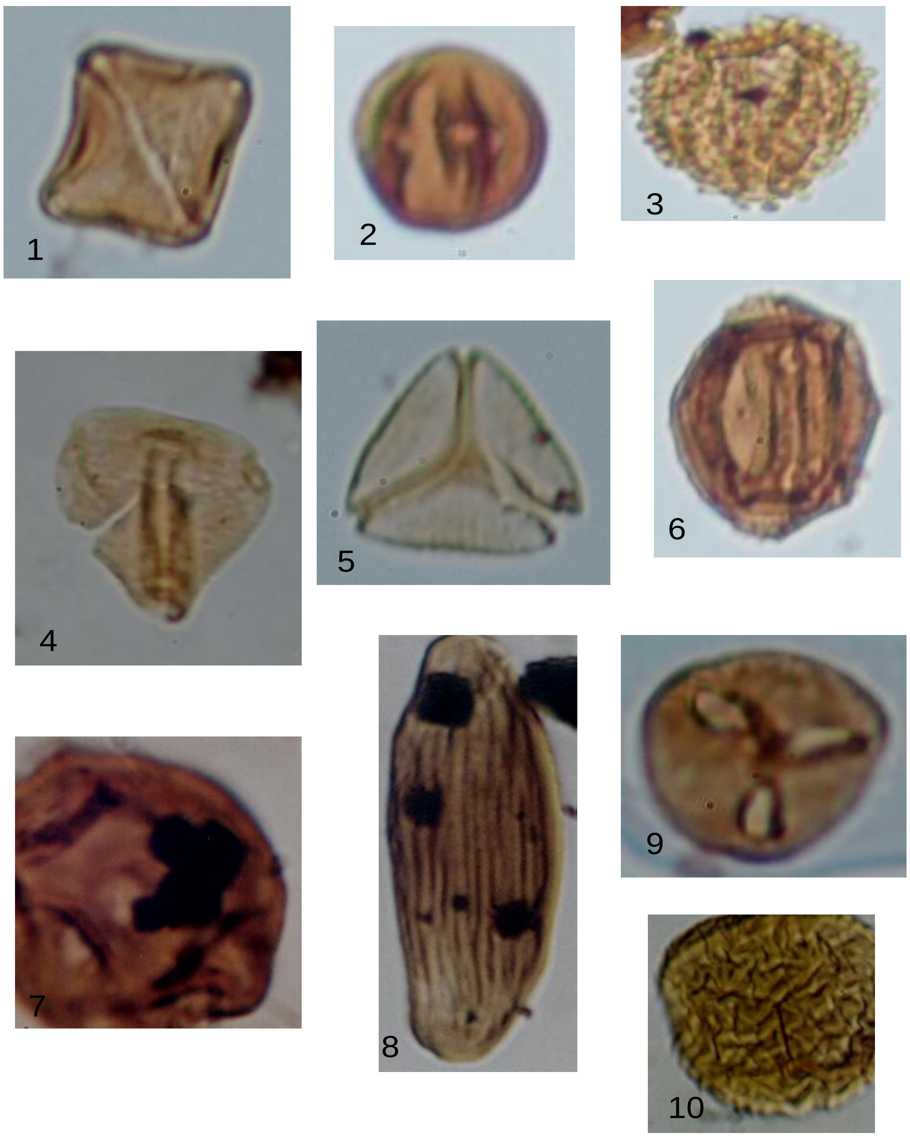

Plate 1: Showing some of the palynomorphs encountered in the study

(ii) Palynomorph Assemblage: The above classifications shows that the Palynomorphs recovered from the well are made up of; the angiosperms, gymnosperms and pteridophytic spores belonging to more than 25 genera.The angiosperms constitute about 55% and they are essentially of Monocolpate species. The Pteridophytes (dominated by the triletes) and the gymnosperm pollen constitute 28% and 2% respectively of the total population. Organic walled microplanktons account for 15% of the assemblage. Others microplanktons include the foraminiferal linings (2%) and algae (0.5%) .

(iii) Marine forms (dinoflagellate): Dinocyst indeterminate, Selenopemphix sp., Lingolodinium sp., Paleocystodinium sp., Andalusiellasp.Apectodinium sp., Homotrybliumsp, Deflandrea sp., Operculodinium sp., Homotryblium palladium Davey and Williams,1966, Hystrichokolpoma sp.

Between 10,000ft and 7500ft interval, the pollen and spore indicating continental influence dominated the assemblage except at 10,000ft when marine forms dominated with 100% within the interval mentioned, continental influence dominated with more of pollen and spores varying between 100% at 9780ft – to 66.7% at 7000ft. the interval between 6000ft – 3,000ft saw a gradual decrease of pollen and spores from 57.2% t0 29.4%, and the marine forms increasing from 42.9% at 6000ft to 70.6% at 3,000ft.

Between 3000ft – 1000ft, there was a gradual dominance of the amrine indicators steadily maintaining high values as against those of the continental forms. The values of the marine forms ranges between 70.6% to 64.3%, the interval between 1000ft – 400ft saw dominance of the pollen and spores with 66.7% presence as against the 33.3% (percent) of the marine indicators.

(III) PALYNOLOGICAL ZONATION (POLLEN/SPORE):

The zones are defined by the first occurrences of two or more species. The following pollen and spore assemblage zones are described below:

A. **Cingulatisporitesornatus Zone: Early - Late Maastrichtian Depth: 11,500ft – 10,500ft** Species appearing have their last downhole occurrence and represents the base of the zone. Species like: Cingulatisporitesornatus and Buttiniaandreevi, fungal spore and Polypodites sp. occurs towards the top of the zone.

B. **Monocolpopollenitessphaeroidites Zone: Late Campanian – Late Maast. 10,500 – 10,000ft :**The base of this zone is the same as the top of Zone A characterized by the last downhole occurrence of: Echimonocolpitesrarispinosus and Monocolpopollenitessphaeroidites.

C. **Leiotriletesadriennis Zone: Early - Late Maastrichtian Depth: 10,000ft – 8500ft:** The base of this zone is the same as the top of Zone B, marked by the last downhole occurrence of the following: Leiotriletesadriennis, Verrucosisporitesobscurilaesuratus, Selaginellamyosurus, Polypodiidites sp. Species occurring at the top are Striamonocolpitesundostriatus, Lycopodiumsporitessp and

Adenantherites sp.

D. **Longapertitesmicrofoveolatus Zone: Early to Late Paleocene Depth: 8500ft – 8200ft:** The base of this zone is the same as the top of Zone C marked by the last downhole occurrence of Retidiporitessp, and Longapertitesmicrofoveolatus.

E. **Foveotriletesmargaritae Zone: Late Maastrichtian to Early Paleocene Depth: 8200ft – 6,000ft:** The base of this zone is the same as the top of Zone D marked by the last downhole occurrence of the following: Longapertitessp, Foveotriletesmargaritae, Cyathidites minor and Gleicheniiditessenonicus.

F. **Spinizonocolpitesechinatus Zone: Late Maastrichtian - Early Eocene Depth: 6000ft – 5000ft:** The base of this zone is the same as the top of Zone E, marked by the last downhole occurrence of Spinizonocolpitesechinatus and Longapertitesmarginatus.

G. **Proxapertitesoperculatus Zone: Late Maastrichtian - Late Eocene Depth: 5000ft – 4500ft:** The base of this zone is the same as the top of Zone F, marked by the last downhole occurrence of Retimonocolpitessp, Proxapertitesoperculatus, Circulinaparva, Psiladiporitesnnewiensis, Spinizonocolpitesadananteus, Gabonisporisvigourouxii, Ctenolophoniditescostatus, Ariadnaesporites sp.

H. **Mauritiiditescrassibaculatus Zone: Late Maastrichtian - Early Paleocene Depth: 4500ft – 4060ft :** The base of this zone is the same as the top of zone G, marked by the last downhole occurrence of Chlorophytumtuberosum and Mauritiiditescrassibaculatus

I. **Mauritiiditescrassiexinous Zone: Paleocene – Eocene Depth: 4060ft – 4020ft :**The base of this zone is the same as the top of Zone H, marked by the last downhole occurrence of Syndemicolpitestypicus, Retidiporitesmagdalenensis, Maurittiditescrassiexinous and Syncolporites sp.

J. **Retistephanocolpiteswilliamsi Zone: Paleocene – Oligocene Depth: 4020ft – 3,500ft :**The base of this zone is the same as the top of Zone I, marked by the last downhole occurrence of the following forms: Trioritesafricaensis, Retistephanocolpiteswilliamsi, Syncolporitesmarginatus, Reti-monocolpitespluribaculatus, Retitricolpitessp, Tricholomosulcites.

K. **Proteaciditeslongispinosus Zone: Late Maastrichtian – Recent Depth: 3,500ft – 3000ft :** The base of this zone is the same as the top of Zone J characterized by the last downhole occurrence of Proteaciditeslongispinosus, Crototricolpitescrotonoisculptus.

L. **Triporopollenitesbituitus Zone: Paleocene Depth: 3000ft – 2505ft:** The base of this zone is the same as the top of Zone K characterized by Distaverrusporites simplex, Triporopollenitesbituitus, Crototricolpitesdensus, Lygodiumsporitesadriennis, Ephedripites sp.

M. Spinizonocolpitesbaculatus Zone: Paleocene Depth: 2505ft – 2500ft: The base of this zone is the same as the top of Zone L and is characterized by the last downhole occurrence of Longapertitesreticulatus, Zonosulcitesscollardensis, Leiotriletessp, Polycolpitespocooki, Spinizonocolpitesbaculatus.

N. Retitricolporitesamazoensis Zone: Depth: 2500ft – 1560ft: The base of this zone is the same as the top of Zone L and is characterized by the last downhole occurrence of Psilastephanocolporitessp, Retitricolporitesamazoensis and Retitricolporites sp.

O. Retibrevitricolporitesibadanensis Zone: Mid Eocene Depth: 1560ft – 400ft

The base of this zone is the same as the top of Zone N, marked by the last downhole occurrence of Retibrevotricolporitesprotrudens, Retibrevitricolporitesibadanensis, Psilatriporitessp, Brevicolporitesguinetu, Retitriporites sp., Retitricolporitesirregularis.

DISCUSSION OF RESULT

(A) AGE CHARACTERIZATION: The zonal divisions discussed here are mainly based on the distribution of species in Bende – 1. The zones are discussed in two parts, the first is based on the pollen/spores assemblage and Dinoflagellate cysts.

The zones were defined by the first occurrences of two or more species. The use of first occurrences in dinoflagellate stratigraphy has been shown to yield a high level of biostratigraphical resolution in the Paleogene of north western Europe (Costa and Downie,1976). Ages of the delineated zones were determined by comparison with assemblages from European surface sections and other areas. The zones were compared with those of Oloto (1994), Williams and Bujak (1977) which were based on dinocyst study by Willams and Brideaux (1975) on the Grand Banks shallow coreholes, Canada; Hansen (1977) on the Upper Maastrichtian and Danian of Denmark; and Bujak, Downie, Eaton and Williams (1980) on the Eocene of Southern England.

The stratigraphic ranges for Bende – 1 well yielded fifteen (15) palynozones and five (5) dinoflagellate cyst zones, , and their depth to depth percentage distributions shown in Tables

Assemblage zones A – G in Bende – 1 corresponds to Late Maastrichtian to Early Paleocene characterized by the occurrence of key species like Foveotriletesmargaritae, Monocolpopollenitessphaeroidites, Cingulatisporitesornatus, Retidiporitesmagdalenensis, Spinizonocolpitesechinatus etc. this zone was compared with Oloto (1994 C – I zone and Germeraad et al (1968) Proteaciditesdehaani zone

Assemblage zones H – M of Bende – 1 well falls within Early Paleocene to Early Eocene. ThsePalynozones based on their stratigraphic positions and series of last downhole occurrence of key species, corresponds to D – I to G – I of Oloto (1994) and Retidiporitesmagdalenensis of Germeraad et al, (1968) within the aforementioned zones, H – J of Bende – 1 well, delineated the Danian based on key forms, Mauritiiditescrassibaculatus, Mauritiiditescrassiexinous, Retistephanocolpiteswilliamsi etc.

Assemblage zone N – O in the present study corresponds to Oloto (1994) H – I to J – I zones and the Monoporitesannulatus zone. Based on their stratigraphic positions and series of last downhole occurrence an Early – Middle Eocene was assigned to it.

Dinoflagellate zones C – F in Bende – 1 well corresponds to G – I – J – M zones of Oloto (1994), Hansen, 1977, Costa and Downie (1976) Apectodiniumhyperacanthum zone. Based on the above an Early Paleocene – Early Eocene was assigned.

Dinoflagellate zone G – H in Bende – 1 well corresponds to N – Q zone of Oloto (1994) and Adnatosphaeridiumreticulense zone of Williams and Bujak, 1977 and zones 3 and 4 of Eaton, 1976, resulting to assigning an Early Eocene to mid Eocene age.

Based on the above age designations three lithostratigraphic units were delineated in the Bende – 1 well namely the Nsukka Formation, Imo Shale and the Ameki Formation.

(B) PALEOENVIRONMENTAL ANALYSIS Palynological data is a useful tool in paleoenvironmental analysis (Van Bergen et al., 1990, Petters and Edet, 1996; Ojo and Akande, 2004, Oloto, 1990, 1992, 1994, Umeji 2002, 2005, 2006). Environmental changes are usually reflected in the palynologic assemblages (Oloto, 1989, Ojo and Akande, 2004) that is why the composition and relative proportions of different groups of palynomorphs are utilised in the study.

The depositional environment of the well was evaluated following detailed analysis and characterisation of the biogenic and physical features of the sedimentary lithofacies coupled with the palynological characteristics. The major groups utilised in the study are pollen/spores and dinoflagellates, other associated element includes foraminiferal test linings.

The distribution charts, showing the distribution of the various form are displayed in figs (59). Tables (39) shows the percentage distribution of each form per depth. From the table, it can be seen that terrestial derived palynomorphs dominated the assemblage. Shrank (1984) has suggested that palynomorph assemblage with higher content of large land derived miospores indicates terrestial influence and vice versa.

It can be deduced that terrestially derived palynomorphs dominated the assemblage. Using the table, a continental Marine Index Plot was obtained (fig 60). From 400ft – 3000ft, the marine forms seems to dominate and gradually decreases at 3000ft, between 6500ft, a marine incursion took place with the dinoflagellates (marine forms) dominating. From 7000ft – 9760ft, the pollen/spores dominate again. (conditions restricted to continental effects).

There is an equal fluctuations of marine and continental conditions from 9700ft to 11000ft (fig. 60). Nwajide (2006) has opined that major sea level movements do not happen in one fell swoop, rather within say, a transgression, several minor regressive and transgressive translations of the shorline takes place, the net movement being ultimate continental inundation. This explains the fluctuations seen in the figure above. Sedimentation in the Well shows a Marine Influence and a rather parallic condition leading to a more condition. The paleodepositional environment is deduced to stretch from Backshore to Proximal Offshore.

The presence of some palmae pollen (Longaperites, Spinizonocolpites and Echitriporites) and the Pteridophytes (dominated by the trilete spores) suggest thst the land was predominated by warm humid to tropical climate in the studied Well. (Hengreen, 1981; Schrank, 1994, Ojo et al, 2006).

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