Palynology And Paleoenviromental Study Of Akukwa-1 Well, Niger Delta And Anambra Basins, Nigeria

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ABSTRACT: A sequence biostratigraphic study of Upper Cretacerous to Tertiary sediment of part of Anambra and Niger Delta basins were carried out using sample from three exploration wells and outcrops located in the basins. Akukwa-1 (1000ft – 7990ft). The wells penetrated key stratigraphic units in the Anambra Basin (the Nkporo, Mamu, Nsukka) and those of the proto Niger Delta (Imo and Ameki).. Akukwa yielded (21 genera and 100 species of palynomorphs), The paleo-environment of deposition were determined to range from lithoral to proximal offshore in a shallow marine setting. A detailed categorization of the palynomorphs into terrestrially derived palynomorphs and marine derived palynomorphs based on the distribution of three broad vegetation type; mangrove, fresh water swamps and hinterland community were used to evaluate sea level fluctuations with respect to sediments deposited in the basin and linked to a particular depositional system tracts

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 has received considerable geological interest since 1903 when exploration for coal started. All of Nigeria's commercial Coal production to date comes from the basin and an estimated reserve of 800million tonnes still exist in it. (Agagu et al, 1985). The search for oil and gas in the basin started in 1938, and since then over 40 oil exploration wells have been drilled, but because no significant oil has been discovered, the search has been abandoned. The outcome of the drilling campaigns resulted in one oil and five gas discoveries (Ofoma et al, 2008). The Niger Delta is an important Basin because of its hydrocarbon resources. It is the largest basin in the West African Coast. Larger amount of data from the several thousands of drilled wells has lead to a considerable understanding of the stratigraphy and regional geology of the delta. Over 90% of Nigerian foreign revenue is derived from the Niger Detla Basin/Region.

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.

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.

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. The well sample belong to those of Akukwa-1, A breakdown of the samples shows that Akukwa-1 well has 253 samples,

(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. See Figure 1

(ii) Laboratory Method At the laboratory a detailed lithologic description of the various sample were described, each sample was tested with dilute hydrochloric acid. The degree of reaction of the samples with the acid was noted and expressed as calcareous, when there is effervescence and non-calcareous when there is no reaction with the acid. The step of laboratory analysis are explain below.

(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. The samples were displaced in a water bath and stirred, with plastic rods twice a day for the period of maceration. The effect of the acid was neutralized by decanting and settling method.The residual rock particle and megafossils were separated from the finer disaggregated material by passing them through a mesh of 106μm and 200μm. The filtrate was thoroughly washed with water using the 10μm mesh nylon sieve. The subsequent residue was swirled on a 24cm diameter watch glass. The lager residual was discarded while the final top material was boiled for a few seconds in water to which a few drops of concentrated hydrochloric acid was added. The residual was again washed in the 10µm mesh nylon sieve and stained with safranin- O in a mild alkaline medium stored in small glass centrifuge tubes and labeled.

(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

(A) LITHOSTRATIGRAPHY

Lithostratigraphic is the defined as a body of rock which is distinguished and delimited on the basis of lithic characteristics and stratigraphic position. A lithostratigraphic unit generally conforms to the Law of Superposition and is commonly stratified and tabular in form. The Akukwa – 1 Well is lithologically characterised by a coarsening upward sequence from a sequence of interbedded Shale and Siltstone into Sandstone units. The basal part is predominantly shale, siltstone and minor sandstone units corresponds from prodeltaic to delta front environments where normal sea water is diluted by rain and run-off (Ojo, 1999; Ojo et al., 1999, Ojo and Akande 2004). At the upper part of the section, the sandstone to siltstone units corresponds to delta plain dominated by continental condition as indicated as lack of dominance of marine forms See **figure 1** below:

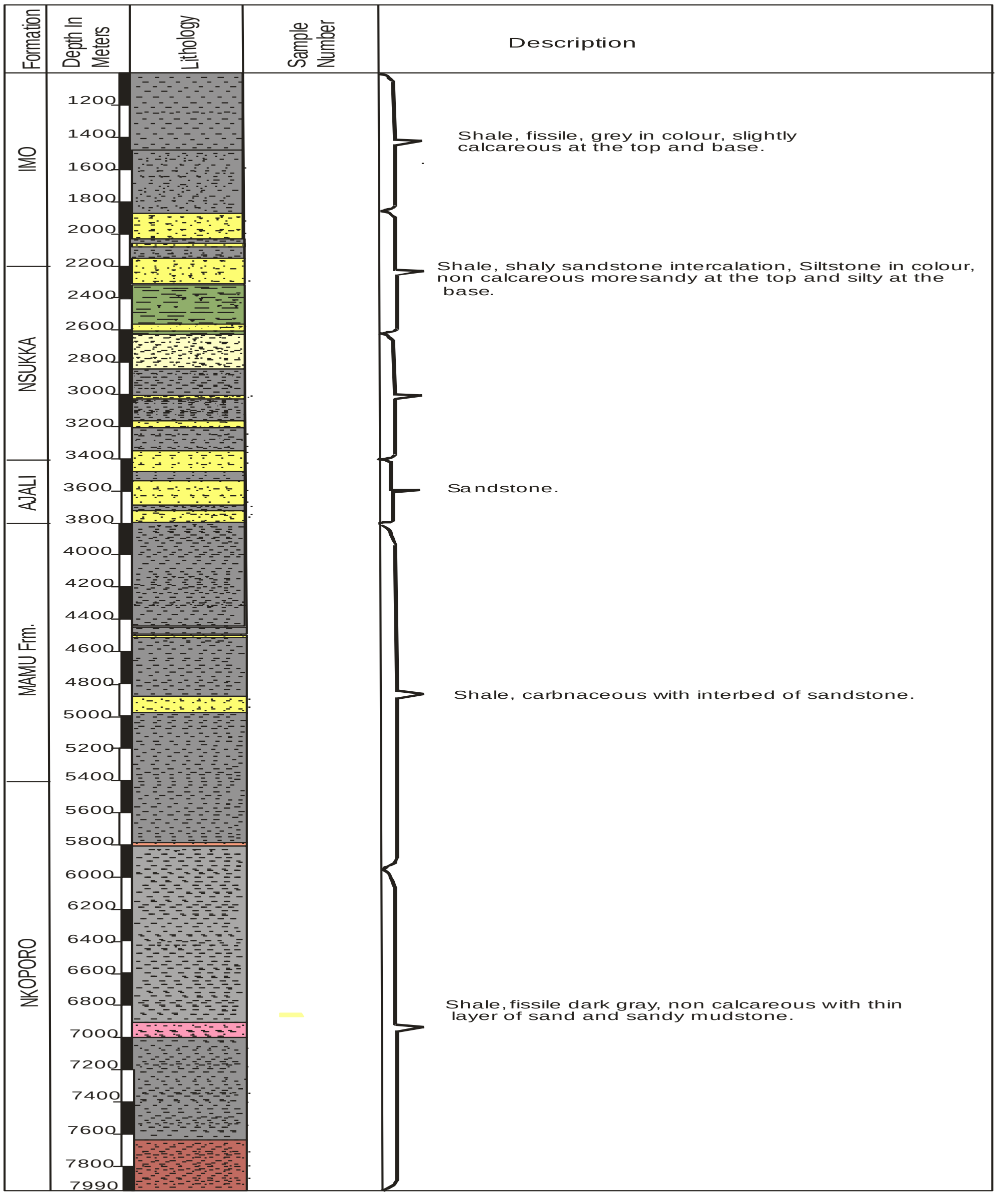


Figure 1: Lithostratigraphy of Akukwa-1 Well

(B) PALYNOLOGY

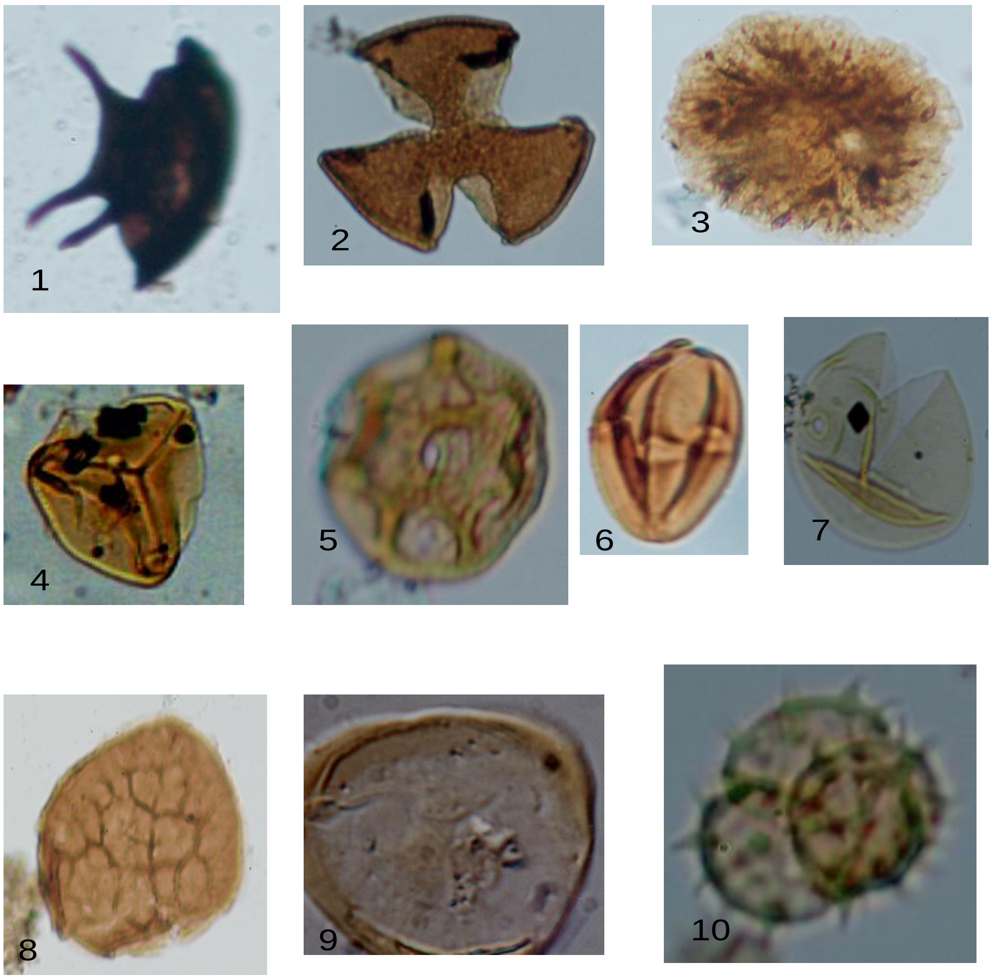
(I) POLLEN AND SPORES Hexaporotricolpites emelianova, Disulcites kalewensis, Longapertites sp, Longapertites marginatus – Distaverrusporites simplex Lycopodiumsporites sp., Tubistephanocolpites cylindricus,Macrotyloma brevicaule, Ephedripites sp, Spinizonocolpites echinatus ,Proteacidites, longispinosus,Classopolis sp., Leiotriletes adriennis,Cingulatisporites ornatus,Chlorophytum tuberosum**,** Foveotriletes margaritae, Monocolpopollenites sphaerodites,Cyathides minor, Ariadnaesporites spinosus Ariadnaesporites sp.,Adenantherites sp.Gleichniidites senonicus – Pioss, Retidiporites magdalenensis, Spinizonocolpites adananteus, Syncolporites marginatus

(II) DINOFLAGELLALATES and Foram Linings
Deflandrea sp.**,**Apectodinium sp.**,** Paleocystodinium sp.**,**Paleocystodinium australinium, Homotryblium sp.**,**Paleocystodinium golzowense, Paleocystodinium Gabonese, Lejeunecysta communis**,** Achomosphaera alocormu, Apectodinium homomorphum , Achomosphaera sp.

(III). PALYNOLOGICAL ZONATIONS (POLLEN AND SPORES)
The zones are defined by the first occurrences of two or more species. The following pollen and spore assemblage zones are described below:

(i). Cingulatisporites ornatus Zone: Early - Late Maastrichtian Depth:7990ft Species having their first appearance are difficult to differentiate because this zone represents the base of the well, species appearing within the zone include: Hexaporotricolpites emelianova, Disulcites kalewensis, Longapertites sp, Longapertites marginatus, Distaverrusporites simplex, Lycopodiumsporites sp, Tubistephanocolpites cylindricus, Macrotyloma brevicaule, Ephedripites sp, Spinizonocolpites echinatus, Proteacidites longispinosus, Classopolis sp, Leiotriletes adriennis, Cingulatisporites ornatus, Chlorophytum tuberosum, Foveotriletes margaritae, Monocolpopollenites sphaeroidites, Cythides minor, Ariadnaesporites spinosus, Ariadnaesporites sp, Adenantherites sp, fungal spore, Gleichnoiidites senonicus. Top of the zone is marked by Upper Maastrichtian forms such as Retidiporites magdalenensis, Spinizonocolpites adananteus, Syncolporites marginatus, Circulina parva, Leiotriletes sp and Matonisporites sp.

PLATE 1



1.Elaterosporites spp., 2.Tricolpites microstriatus, 3. Botryococcus braunii, 4. Cyathidites minor, 5. Cretacaeiporites scabratus, 6.Retitricolporites annulatus, 7.Monoporites annulatus, 8. Zlivisporis blanensis, 9. Classopollis obialosenis, 10. Droseridites senonicus

(ii) Ephedripites regularis zone: Late Campanian – Early Maastrichtian (7990ft – 7560ft) The base of this zone marks the top of the zone A, characterized by the last downhole occurrence of Ephedripites regularis, Callamuspollenites pertusus, Proteacidites miniporatus.

(iii) Lygodiumsporites adriennis Zone: Early – Middle Maastrichtian 7560ft – 7400ft

The base of this zone marks the top of the zone B characterized by the last downhole occurrence of the following: Lygodiumsporites adriennis, Psiladiporites nnewiensis and Polyadopollenites macroreticulatus.

(iv) Syndemicolpites ornatus Zone: Maastrichtian 7400ft – 7320ft

This zone is characterized by the last downhole occurrence of the following: Syndemicolpites ornatus, Zlivisporis blanensis, Lycopodiumsporites fastinoides. It marks the top of Zone C.

(v) Echitriporites trianguliformis Zone: Late Campanian to Maastrichtian 7320 – 7240ft

The base of this zone marks the top of Zone D, characterized by the last downhole occurrence of the following: Echitriporites trianguliformis, Triporites sp and Echimonocolpites rarispinosus.

(vi) Buttinia andreevi Zone: Late Campanian to Early Maastrichtian 7240ft 7090ft

The base of this zone is the same as the top of zone E, marked by the last downhole occurrence of Retidiporites sp, Trichotomosulcites sp, Retitricolpites punctatus, Buttinia andreevi, Ephedripites ambonoides, Gemmatriletes clavatus, Triorites sp, Polypodiidites sp, Syncolporites sp.

(vii) Auriculidites reticulatus Zone: Late Campanian to Mid Maastrichtian 7090ft – 6390ft

The base of this zone is the same as the top of Zone F, charcaterised by the last downhole occurrence of the following: Auriculidites reticulatus, Pelleteria minutnestriada, Todisporites sp, Ephedripites procerus, Lycopodiumsporites sp, Crototricolpites densus.

(viii) Ullmipollenites undulosus Zone: Maastrichtian – Lower Miocene 6930ft – 6390ft

The base of this zone marks the top of Zone G, characterized by the last downhole occurrence of Selaginella myosurus and Ullmipollenites undulosus.

(9) Rugulatisporites caperatus Zone: Early – Late Maastrichtian 6390ft – 6310ft

The base of this zone is the same as the top of Zone H, characterized by the last downhole occurrence of the following: Rugulatisporites caperatus, Retibrevitricolpites triangulates, Zonosulcites parvus, Elaterocolpites sp and Longapertites microfoveolatus.

(10) Retidiporites adegokei Zone: Upper Maastrichtian 6310 – 6110ft

The base of this zone is the same as the top of Zone I, characterized by the last downhole occurrence of the following forms: Syndemicolpites sp, Retidiporites adegokei, Retimonocolpites pluribaculatus and Syndemicolpites typicus.

(11) Constructipollenites ineffectus Zone: Early to Late Maastrichtian 6100ft - 5750

The base of this zone is the same as the top of Zone J, characterized by the last downhole occurrence of the following: Retitricolpites sp, Psilamonoporites sp, Constructipollenites ineffectus, Ariadnaesporites longiprocessum, Periretitricolpites anambraensis.

(12) Foveotricolpites giganteus Zone: Mid Maastrichtian 5750ft – 5570ft

The base of this zone is the same as the top of Zone K, characterized by the last downhole occurrence of Foveotricolpites giganteus, Triporotetradites hoekeni, Pediastrum sp., Baculatisporites wellamani, Monocolpites marginatus, Verrucosisporites obscurilaesuratus.

(13) Proxapertites anisoculpturs Zone: Early – Late Maastrichtian 5570ft – 4970ft

The base of this zone is the same as the top of Zone L, characterized by the last downhole occurrence of the following forms: Striatricolporitea pimulus, Proxapertites anisoculpturs, Taxodiaceaepollenites hiatus, Cycadopites sp, Rugulatisporites sp, Psilatricolpites sp, Cicatricosisporites sp and Proteacidites dehaani.

(IV) DINOFLAGELLATE ZONATIONS

The zones are defined by the first occurrence of two or more species. The following dinoflagellate zones are described below:

(i). Apectodinium paniculatum Zone: Maastrichtian Depth: 7990ft

Species having their first appearances are difficult to differentiate because this zone represents the base of the well. The zone is marked by the first downhole occurrence of Deflandrea sp, and Apectodinium paniculatum.

(ii). Paleocystodinium austrialinium Zone: Upper Maastrichtian Depth: 7990ft – 4000ft

The base of this zone is the same as the top of Zone A marked by the last downhole occurrence of the following: Paleocystodinium sp, Paleocystodinium austrialinium, Cerodinium speciosum, Lejeunecysta hyaline, Homotryblium sp., Paleocystodinium golzowense.

(iii) Apectodinium homomorphum Zone: Upper Maastrichtian – Late Paleocene Depth: 4000ft – 2550ft

The base of this zone is the same as the top of Zone B characterized by the last downhole occurrence of the following: Paleocystodinium Gabonese, Lejeunecysta communis, Achomosphaera alicormu, Apectodinium homomorphum, and Achomosphaera sp.

(iv) Homotryblium palladium Zone: Paleocene – Early Eocene Depth: 2550ft – 1520ft

The base of this zone marks the top of Zone C, characterized by the last downhole occurrence of the following: Apectodinium parva, Adnaetosphaeridium multispinosum, Ifecysta pachyderma, Adnaetos-phaeridium membramophorum, Deflandrea denticulatum, Polysphaeridium pastulsii, Areosphaeridium sp, Alisogymnium sp, Adnaetosphaeridium sp, Lejeunecysta fallax, Apectodinium quinquelatum, Spiniferites ramosus, Lejeunecysta diversiformis and Homotryblium palladium.

DISCUSSION

(A) AGE CHARACTERIZATION The stratigraphic ranges for Akukwa – 1 well yielded twenty – three (23) biozones for pollen/spores and four (4) Dinoflagellate cyst zones. Assemblage Zones in Akukwa is based on its stratigraphic position and series of last downhole occurrence corresponds to Late Campanian – Late Maastrichtian of Oloto (1994) and Germeraad et al Proteacidites dehaani zone, characterized by key species like Buttinia andreevi, Cingulatisporites ornatus, Rugulatisporites caperatus, Echitriporites trianguliformis etc. The age assigned corroborates with Oloto (1994) dinoflagellate zone of Jain and Millepied (1975) with key dinoflagellate cyst such as

Apectodinium paniculatum and Paleocystodinium australinium in the present study.

(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. From the charts 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. Helenes et al., (1998) applied palynological marine index (PMI) values to interprete the depositional environments. PMI which is the ratio of abundance of marine to terrestially derived palynomorphs was calculated and a plot of marine index plot (fig. 2) in the Akukwa – 1 well, based on the plot, sediments in the lower part of the section indicate a marine influence. Based on the plot, sediments in the lower part of the section indicate a marine influence and a rather parallic condition, leading to a more continental condition, hence the dominance of pollen and spore assemblage suggests a parallic condition in a shallow marine setting. This is further supported by the presence of organic walled microplankton such as Paleocystodium australinium, Homotriblium palladium, Lejeunecysta hyaline and Pediastrium. The P. australinium peak zone in the Maastrichtian of New Jersey (U.S.A) was interpreted as a phase of marine regression.(May, 1980) The cretaceous microfloral provinces as discussed by Herngreen and Chinova (1981) shows that West Africa belongs to the Late Cretaceous Palmae Province. This is confirmed by the recovered microflorals in the Palmae Province and those obtained from the study area. At 7850ft, the amrine Index forms dominate the assemblage with 64.3%, while the terrestrial Index forms stands at 35.7%. Beginning at 7850ft to 7560ft the values of the terrestrial markers fluctuate between 66.6% to 68.9%. Between 7560ft depth to 5900ft, the values of the terrestrial markers fluctuate between 92.4% to 86.4%, while marine forms recorded low values ranging from 6.7% to 33.4% at a depth of 5980ft showing a slight growth and declines to 26.1% at 5900ft. The interval between 5900ft – 3860ft, corresponds to the Mamu Formation. It recorded a high percentage of terrestrial markers, increasing from 73.9% at 7550ft to 86.8% at 3860ft; whereas there is a sharp decrease of Marine Index forms from 40% at 5640ft to 13.2% at 3860ft. The interval between 3860ft – 3400ft, corresponding to the Ajali Sandstone, maintained a high percentage value of terrestrial derived forms. Ranging from 91.1% at 3780ft to 96.97% at 3400ft. The marine index forms varies from 8.9% at 3780ft, decreased to 8% at 36.70ft, a further decrease to 7.8% at 3590ft and an increase to 12.7% at 3510ft and a sharp decrease to 3.03% at 3400ft. The interval between 2200ft – 1080ft corresponds to the Imo Formation. It recorded high percentage values of terrestrial markers beginning with 84.5% at 2120ft to 92.0% at 1160ft. In between the two end values, the values fluctuated between 74.2%, 61.1%, 76.4% and 80.7%, 62.6% and 75.5% at 1080ft (the Top).The marine forms show a gradual increase between 16.1% at 2120ft to 24.5% at the top (1080). The highest peak of marine forms occurred at 1860ft with 38.9% and 37.2% at 1240ft

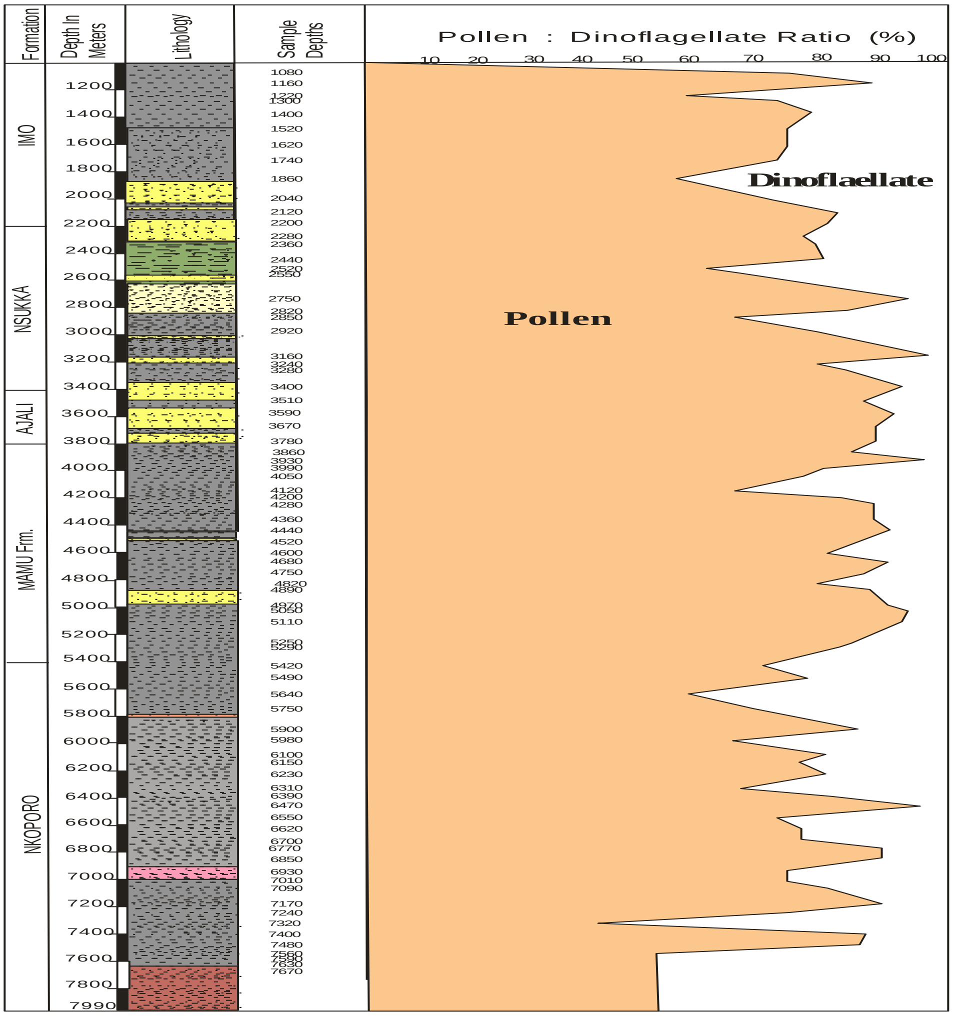


Fig. 2, Continental Marine Index Plot of Akukwa-1 Well.

In conclusion, the percentage of the terrestrial palynomorphs from the base to the top of the well, is greater than those of the Marine Index forms. Furthermore, the depth to depth percentage distribution of the palynomorph species is shown in Table It is this table that generated the table above species of palynomorphs are recorded against the depth.

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