

Palynomorphs Distribution, Biostratigraphy and Paleoecology Study of the Superficial Sediments in Parts of Gombe Formation, Upper Benue Trough, Nigeria

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Abstract

Paleoecological conditions of part of Gombe formation of Upper Benue Trough were studied using outcrop samples from 22 sites of 1.5 m deep each. The samples were crushed, standard maceration method employed for analysis and slides prepared. The slides were examined for identification and counting using transmitted light microscope with times one hundred oil immersion objective lenses. The result showed a fairly rich assemblage of palynomorph which includes age diagnostic palynomorphs: *Cingulatisporites ornatus*, *Proteacidites sigalli*, *Constructipollenites inflectus*, *Echitriporites trianguliformis*, *Longapertites microfoveolatus*, *Monocolpites* sp. and *Tricolpites* sp. which effectively assigned the upper Maastrichtian age to the sequence. Also the abundance of woody and vegetal materials which are land derived in the shales, siltstones and kaolinite rich claystone at the upper part of the sequence studied suggest the prevalence of fresh water conditions. The presence of Ephedripites in some sections of the sequence studied reflects occasional dry conditions. The high abundance of *Acrostichum aureum* in sample BA-8 signifies flooding of the region in Maastrichtian times by the sea characterized by shallow water depth and restricted ecological circulation which also occurs in mangrove forest and other wetlands.

Keywords: Palynomorphs; Paleoecology; Sediments; Paleodepositional environment; Gombe formation

Introduction

Pore-and-spore assemblages from superficial sediments provide useful information that can aid the proper understanding of depositional environments and stratigraphy of geologic formation. Therefore, it is a means of elucidating the environment represented by a particular lithologic sequence. Onoduku [1] noted that the study of fossil remains in sedimentary succession had become valuable tools which is universally accept method for evaluating the stratigraphy and source rocks potentiality of sedimentary basin.

The Benue rift basin is a sediment-filled northeast trending structure in Nigeria. It is divided geographically into the lower, middle and upper Benue regions and has been a subject of several publications and discussions. Recent studies [1,2] suggested the importance of sinistral wrenching as a dominant process for the structural readjustment and geometry of the different sub-basins consisting of estuarine and deltaic sandstones. Two sub basins, the NNE/SSW trending Gongola and the E/W trending Yola Basins, are delineated in the Upper Benue Trough. The Gongola arm is a N-S trending basin separated from the E-W Yola arm by the Zambuk ridge (an area of shallow basement rock) the area falls within the latitudinal range 10° 07' North of the equator and longitudinal ranges 11° 10' East of the Greenwich Meridian. The Benue trough is a linear northeast southwest trending basin 800 km long and 90 km wide on the average. It is considered to have originated as an Aulacogen on the Precambrian shield as a result of the separation of the African and American plates in early Cretaceous times [3,4].

Palynomorphs have an advantage over other fossils (which can equally be used for study of this nature) in that, Palynomorphs are widely distributed; they can be found in either terrestrial, freshwater, saltwater, or estuary sources of sedimentary rocks. Therefore, this study is aimed at investigating the palynomorphs biostratigraphy and paleoecology of the study area [5-7]. The work will statistically contribute to the understanding of the sequence stratigraphic frame

work and paleodepositional environments of the sedimentary strata in the basin based on exposed outcrops.

Geomorphology of the Study Area

The area studied experiences two distinct climate, the dry seasons (November-March) and rainy season (April-October) with an average rainfall of 850 mm. The vegetation is Sahel savannah characterized by scattered trees and thorny shrubs. This is as opposed to the tropical rainforest belt of the Niger Delta basin [8]. The soils are shallow to deep sandy clay, and loam with cracking clay that have weathered from shales. The land is used mainly for agriculture purpose.

The studied area is part of the central Nigeria highlands, but the flat landscapes in the Northern and Southern part of the basin have isolated hills. The relief of the area ranges between 650 m in the Western part to 370 m in the Eastern parts. While the elevation of the plain is at 600 m above sea level, the hills reach between 700 m and 800 m. The Gongola River is the drainage system, running approximately North South towards the Benue river basin, but the principal tributaries draining from West to East into river Gongola.

Geology of the Study Area

The Cretaceous successions in the Upper Benue Trough are flanked by the Precambrian L-shaped (Figure 1). Paleozoic basement gneisses

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Received April 05, 2018; Accepted April 07, 2018; Published April 12, 2018

Citation: Evans UF, Sunday CE (2018) Palynomorphs Distribution, Biostratigraphy and Paleoecology Study of the Superficial Sediments in Parts of Gombe Formation, Upper Benue Trough, Nigeria. J Geol Geophys 7: 335. doi: [10.4172/2381-8719.1000335](https://doi.org/10.4172/2381-8719.1000335)

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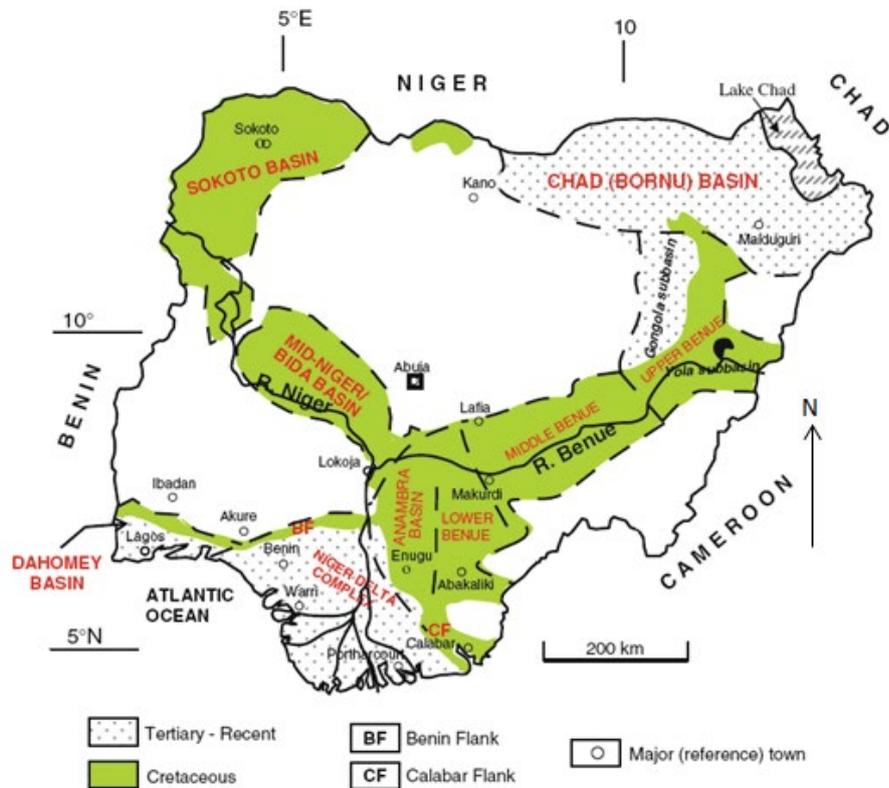


Figure 1: Upper Benue trough in the North Eastern part and other sedimentary basins in Nigeria (After Obaje, 2009).

and granite occur as inliers in the study area [9-11]. The Precambrian basement rocks are overlain by the Albian Bima Sandstone as the oldest Cretaceous sediment in the region. This is overlain by the transitional Yolde formation (Cenomanian- Turonian), and succeeded by the Marine Turonian to Coniacian Pindiga formation, Gongila formation in the Gongola Basin and its lateral equivalents; the Dukul, Jessu and Numanha Formations in the Yola Basin. These successions are overlain by the Campanian - Maastrichtian Gombe Sandstone in the Gongola Basin and the Lamja Sandstone (lateral equivalents) in the Yola Basin. The Tertiary Kerri-Kerri Formation capped the succession west of Gombe in the Gongola Basin [12].

According to Dessauvage and Benkhelil [13-15] the depocenter which started migrating northwest during the Senonian finally located on the western merging of the Cretaceous basin. Sedimentation resumed there in the Late Campanian when renewed rifting took place [16] and in the East Niger rifts [17]. There was infilling by the Maastrichtian paralic deltaic Gombe Sandstone [18]. The Benue trough was subjected to four main depositional cycles, each of which was associated with transgression and regression of the sea. The first sedimentary cycle lasted from the middle Albian to late Albian and is thought to have been initiated by the opening of the South Atlantic Ocean. This is associated with the deposition of the Asu River Group, which is a lateral equivalent of the Bima Sandstones in the Upper Benue Trough, and Awe/Arufu/Uomba Formations in the middle Benue Trough. The Asu River Group is represented in the study area by the 500 m thick seam of Abakaliki shale, which occupies the core of the Abakaliki Anticlinorium and extends to Mamfe Embayment of the South Eastern Nigeria [19,20].

The second sedimentary phase occurred between the Upper Cenomanian and Middle Turonian and was associated with the deposition of Eze-Aku shale. Its lateral equivalents are the Amasiri and Makurdi sandstones in the Afikpo basin and middle Benue Trough respectively, while Gongila, Jessu and Dukul Formations are its lateral equivalents in the upper Benue Trough. This is approximately 1 km in thickness [14,21,22].

The third sedimentary cycle ranged from the Upper Turonian to the Lower Santonian. It is associated with the deposition of the Awgu shale and Agbani sandstones, which are lateral equivalents of the Fika/Sekunle shale in the upper Benue Trough. The Turonian transgression, which marked the start of this cycle, is believed to have commenced from the Gulf of Guinea through the Anambra basin to the Benue Trough. Most of the deposits of this cycle have been eroded as a result of the Late Cretaceous tectonic activity. It is approximately 920 m in thickness [10,23].

The fourth sedimentary cycle was marked by deposition of the Nkporo shales, Owelli sandstones, Afikpo sandstones and Enugu shales during the Campanian-Maastrichtian transgressive phase. This cycle also marked the deposition of the coal measures including: the Mamu Formation, Ajali sandstones and Nsukka Formation. Their lateral equivalents are the Numanha shale, and Gombe sandstone in the upper Benue Trough [12,24].

Methodology

A total of 22 core samples were obtained from 22 outcrop sites and

processed following standard palynological analysis of demineralization and maceration. The samples were crushed and hydrofluoric acid (HF) was added to 15 g each of the crushed sample. The mixture was stirred properly for digestion and allowed to stay for 24 hours. After which distilled water was added to enable the silicate content to float to the surface. The samples were decanted three times at an interval of an hour. It was followed by the addition of 10% Hydrochloric acid (HCl) and application of heat for 30 minutes to rid-off carbonates from the processed samples. Thereafter, water was added and the samples were decanted three times again at an interval of one hour each. This was followed by acetolysis. The samples were sieved using Branson sonification with the aid of a 5 micron sieve to filter away the remaining inorganic materials. This enhances the recovery of more palynomorphs. The residues were placed in well labelled test tubes and put in a centrifuge to recover organic matters which were uniformly spotted and arranged in glass slides of 22 mm by 23 mm and allowed to dry or placed on a hot plate to yield quick drying before mounting. The mounted slides were allowed to dry under sunlight for 5 minutes.

The method of palynological analysis involves accurate identification and logging of acid insoluble organic species [6]. This was carried out using a first class optical compound microscope with phase contrast, because the size of most palynomorphs (usually between 10-

20 microns). The palynomorphs were grouped into A and B species for those species transported to the depositional basin and for those found in situ respectively.

If A is over abundant, $(A)/(A+B)$

If B is over abundant, $(B)/(B+A)$

Pollen sum of all the A species was calculated. This was because the A species gives the original pictures of the palynoflora of a section or an area being derived from sources outside the basin of deposition. However, doubtful grains were preserved in immersion oil and further studied under a magnification of 100X for succinct identification of species.

Results and Discussion

Palynological biostratigraphy and paleoecology

The 22 outcrop sites studied in the Upper Benue Trough yielded fairly rich palynomorphs. The Palynomorphs abundance and species diversity which permitted the study of the palynomorphs assemblage is presented in the form of bar chart (Figure 2). The results obtained are shown in various charts detailed as (Figures 2 and 3) and histogram.

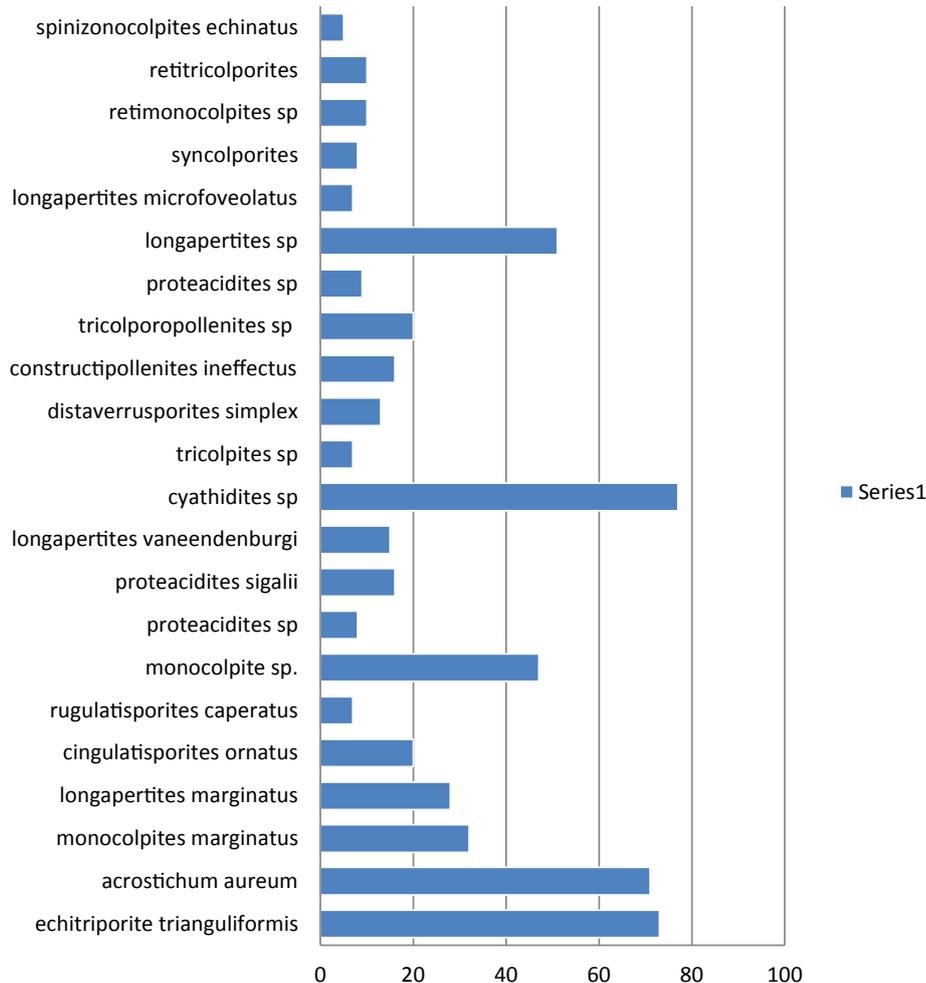


Figure 2: Bar chart representation of the palynomorphs and frequencies in the part of upper Benue trough.

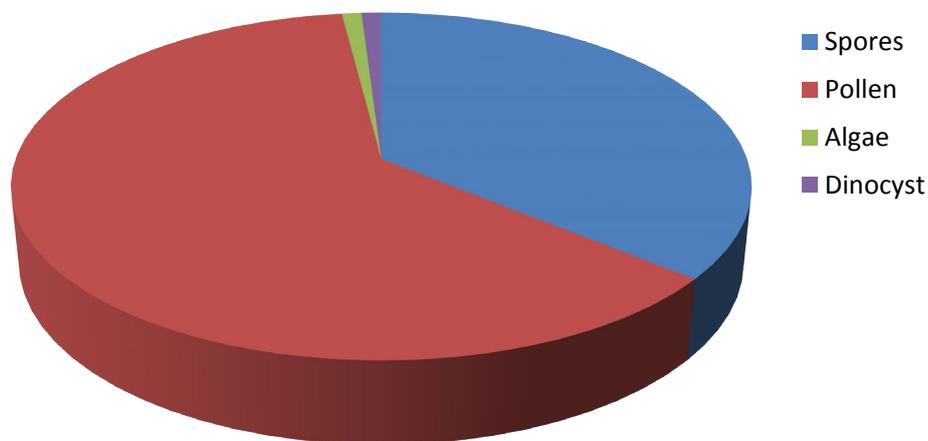


Figure 3: Percentage of palynomorphs distribution in part of the upper Benue trough.

The presence of Maastrichtian pollens and spores markers such as *Ephedripites ambonoides*, *Retidiporite magalensis*, *Syncoloporite magrinatus*, *Constrictipollenites inflectus*, *Echitriporite trianguliformis*, *Macrotyloma brevicaulis*, *Onosulcites pravus*, *Buttinia andreevi*, *Cingulatisporites ornatus* and the Dinoflagellates; *Andalusiella mautheii*, *Lejeunecysta* sp probably indicates Maastrichtian age for the Gombe Formation. In addition, the presence of P170 and P190 pollen zones of *Reditiportites magdalensis* zone D-1, Germeraad, Magdalensis zones was noted by [18] to be equivalent to dinocyst zone F (upper Maastrichtian) just after was Danian dinocyst zone G.

Generally, most of the palynomorphs identified were of late Cretaceous age: *Regulatisporites caperatus*, *Gleicheniidites* sp, and *Proteacidites*, which occurs in upper to late Cretaceous and point to a Turonian - Coniacian age for the Gombe Formation. The poor occurrence of benthic foraminifera in these study area suggested an anaerobic bottom conditions at those intervals, which was unfavourable for the benthic communities as earlier observed by [10]. The high abundance of *Acrostichum aureum* in sample BA-8 is a pointer to flooding of the region during this period by a sea that was characterized by a shallow water depth and restricted ecological circulation which also occur in mangrove forest and other wetlands (Figure 3). shows that the total percentage of the analyzed; Pollen 62%, spores, 36%, Dinocyst 1% and Algae 1%. This strongly suggests that the study area has high pollens of palynomorphs and powdered minerals, which can be very useful in Quaternary palynology investigations.

A precise Maastrichtian age is suggested for the Gombe Formation based on palynomorphs assemblages found in the study section, such as *Monocolpites* sp, *Echitriporites trianguliformis*, *Tricolporites* sp and *Longaperites microfoveolatus* agreed [5]. This correlates with the palynomorphs found in the Anambra basin Lower Benue Trough. The abundance of woody and vegetal materials which are land derived in the shales- siltstone and kaolinite rich clay-stone at the upper part of the section indicate prevalence of fresh water conditions.

Conclusion

The Paleocological conditions of part of Gombe Formation, Upper Benue Trough, were studied using core samples from 22 sites (BA-1 to BA-22). The study reveals that, the Gombe Formation is a heterogeneous unit characterized by diverse palynomorph assemblages which

suggested that the study area belongs to the Paleocene - Maastrichtian age. The palynofoms identified from the formation studied include: *Echitriporites trianguliformis*, *Cyathidites* spp. *Monopores annulatus*, *Cingulatisporites ornatus*, *Rugulatisporites caperatus*, *Distaverrusporites simplex*, *Proteacidites sigalii*, *Retidiporites magdalensis*, *Foveotrites margaritae*, *cabratriporites annellus*, *Proteacidites longispinosus* and fungal spore. Stratigraphy was used in correlating and assigning relative ages of rock strata employing the fossil assemblages. Therefore, in demonstrating that a particular horizon in one geological section represents the same period of time as another horizon at some other section, the fossils abundance were deployed. This is because sediments of the same age can look completely different due to local variations in the sedimentary environment. Hence, the occurrence of diagnostic species permitted the assignment of Maastrichtian age to the part of the Gombe Formation studied. The presence of *Ephedripites* reflects occasional dry conditions. Also the abundance of *Acrostichum aureum* in sample BA-8 signifies flooding of the region during the Maastrichtian by a sea that was characterized by a shallow water depth and restricted ecological circulation which also occur in mangrove forest and other wetlands. Generally, most of the palynomorphs identified are of Late Cretaceous age: *Regulatisporites caperatus*, *Gleicheniidites* Sp, and *Proteacidites*. Occurs in upper to late Cretaceous and points to a Turonian-Coniacian age for the Gombe Formation.

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