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Palynological Studies of Some Coaly Shales around Gamawa Kumo area, Gongola Basin, Northern Benue Trough, Nigeria

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Abstract

Thirty (30) outcrop samples from a section at Gamawa area, Gongola basin, Northern Benue trough were palynologically analyzed to determine age, and paleo-depositional conditions of the strata. Lithological the section is composed of silts, clays and sandstone intercalations at the base followed by coaly shales and bioturbated silty to fine-grained sandstones at the top. Samples were treated with Hydrochloric and Hydrofluoric acids to remove carbonates and silicates respectively and slides were prepared using standard techniques. A total of 1250 palynomorph specimens were recovered. A palynological age of Upper Maastrichtian was assigned to this interval best on the assemblage of Maastrichtian diagnostic marker species of Longapertites marginatus, Proxaperties operculatus, Spinizonocolpites Baculatus, Monocolpites marginatus especially by the abundance of Pollen Spinizonocolpites Baculatus. Based on the low palynomorph marine index and dominating presence of Palme group species, especially the Spinizonocolpites Species the study suggested a paleodepositional condition of a mangrove forest with evidence of tidal dominated estuarine conditions in mostly brackish water and a temperate climate.

Keywords- Palynology, paleodepositional environments, *Spinizonocolpites Baculatus*, coaly shales, Upper Maastrichtian

Introduction

Over the years the study of pollen and spores has become a universally accepted method of studying the history of basins and a bases for age and paleoenvironmental correlation. Palynomorphs have unique characteristics that makes them valuable in recovering stratigraphic information from sedimentary strata. The palynological application of plant microfossils is still a very important part of researches by pre-Quaternary palynologists. But over the past ten years, there has been a greater focus on the vast differences in the composition of organic facies linked to various rock types, which has sped up study in other non-palynostratigraphic fields.

The Gombe Formation is a part of the Gongola sub-basin, an important hydrocarbon system of the Upper Cretaceous Northern Benue Trough, which has received little research attention. It contains Coal, together with related mudstones and shales that include terrigenous organic matter, these are the main features of the Formation. These materials are deposited in a deltaic environment, particularly in the Maiganga and Yaya-Ngari regions. The coaly shales that are

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mostly found in the Gombe sandstone in the Gongola Sub basin in the Northern Benue Trough of Nigeria are the subject of the current investigation. The study area is situated around Gamawa, Kumo area (Fig. 1).

Due to restricted access to subsurface samples few workers like (Obaje, 2009; Abubakar, 2014) where the pioneers to study these coals. Other workers have also studied the Coal seams within the Gombe formation for geochemical and age determinations examples include (Onoduku, 2017, Habeeb, 2018 and Ojo and Akande, 2004). There are still certain gaps in the stratigraphic and geochemical evaluations that need to be filled in, notwithstanding the efforts of previous researchers., Hence, this study is undertaken to help in generating more palynological data to fill up the missing stratigraphic information.

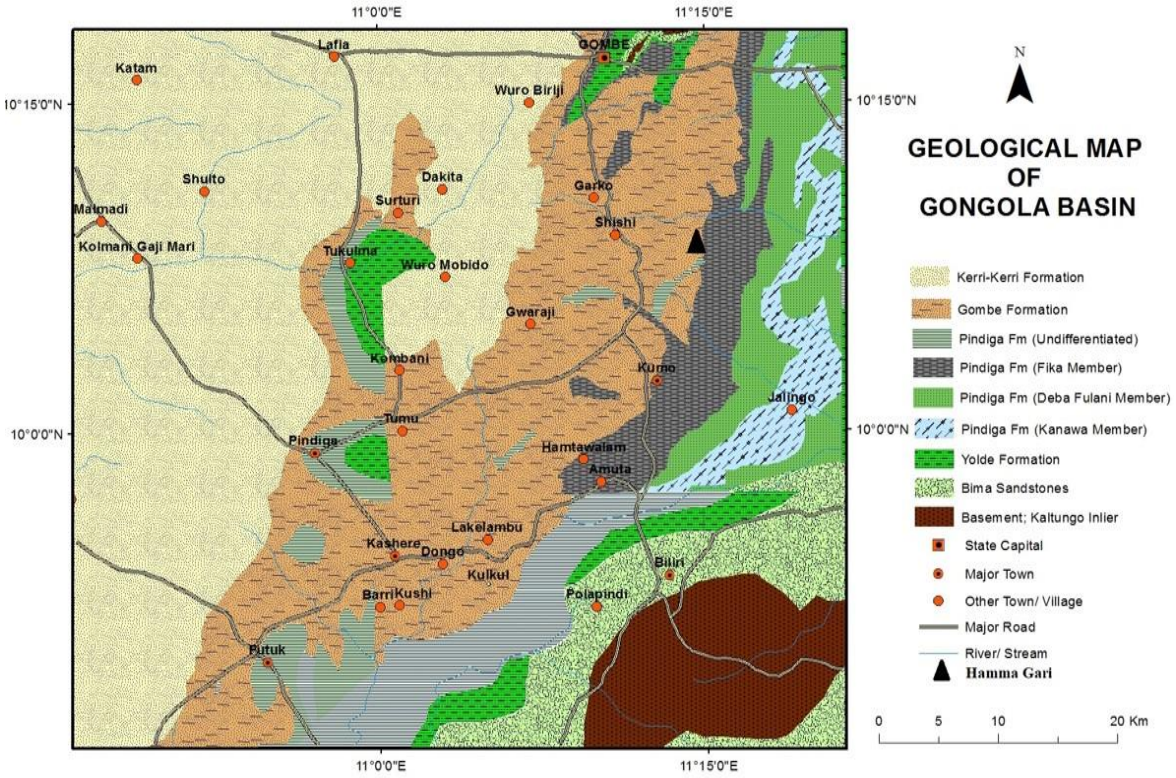

Fig 1. Geological Map of the Gongola Sub-Basin showing the Position of the Hamma Gari in the Gongola Sub-Basin.

Geology of the study area

The Gongola basin is situated to the northeast of the Benue Trough. The Benue Trough is Approximately 800 km long and 150 km broad, it is a rift basin that trends northeasterly and contains up to 6km of sedimentary Cretaceous-Tertiary rocks. It developed as a rift structure in the Pan-African mobile belt (Nwajide, 2013). Geographically speaking, Zaborski (1998) separated the trough into Lower, Middle, and Upper; Nwajide (2013) separated it into Southern, Central, and Northern, respectively. The Gongola Sub-basin contains both post deformational Strata of Campanian-Maastrichtian to Tertiary ages according to (Akande and Erdtmann, 1998). It also contains strata pre-dating the mid-Santonian compressional phase which have been faulted, folded and uplifted, resulting in anticlines and synclines (Benkhelil, 1989). During the mid-Santonian magmatism and tectonism, the Benue Trough's depositional axis was moved. The Northern Benue Trough is composed of the Gongola Sub-basin and the Yola Sub-basin. The Lau-Gombe Sub-basin is the third basin; while it is not well-known, some

authors have acknowledged it (Akande et al; 1998 Whiteman, 1982). Fig 2 depicts the geologic sequence in the Gongola basin. During the Albian, the lacustrine to fluvial Bima Sandstone was deposited in an unconformable manner on Precambrian basement. The formation has shales, carbonaceous clays, and mudstones. Carter et al. (1963) categorized the Bima Sandstone into three units consisting of Lower, Middle, and Upper Units. The Middle member was suggested to have been deposited under anoxic conditions (lacustrine, briefly marine), it has occasional limestone intercalations. The Bima sandstone has a conformable relationship with the Cenomanian Yolde Formation. This formation, which was deposited in a transitional/coastal marine environment, marks the start of a marine transgression into the Benue Trough. It is made up of clays, claystones, shales, limestones, and sandstones. From the Turonian to the Late Maastrichtian period, a total marine invasion of the Northern Benue Trough is represented by this Formation. Lithologically, the Kanawa Member is represented by Shales, pale limestones, and minor sandstones that are intercalated with dark or black carbonaceous limestones. The Middle Marine Sandstones Members of Dumbulwa, Daben Fulani, and Gulani are then deposited on top of this formation in some areas. The Fika Shale consist of extremely fissile, bluish-green carbonaceous, occasionally pale-colored gypsiferous shales associated with rare limestones. The Late Cretaceous strata are represented by the Gombe Sandstone and followed by the almost fully continental Kerri-Kerri Formation. The Gombe sandstone dominantly composed of sandstones, clay, coal, lignite and coaly shale intercalations. The Gombe sandstone is mostly made up of intercalations of clay, lignite, coal, and sandstones with coaly shale. The Tertiary Kerri-Kerri Formation consists of sandstones, claystones, and siltstones.

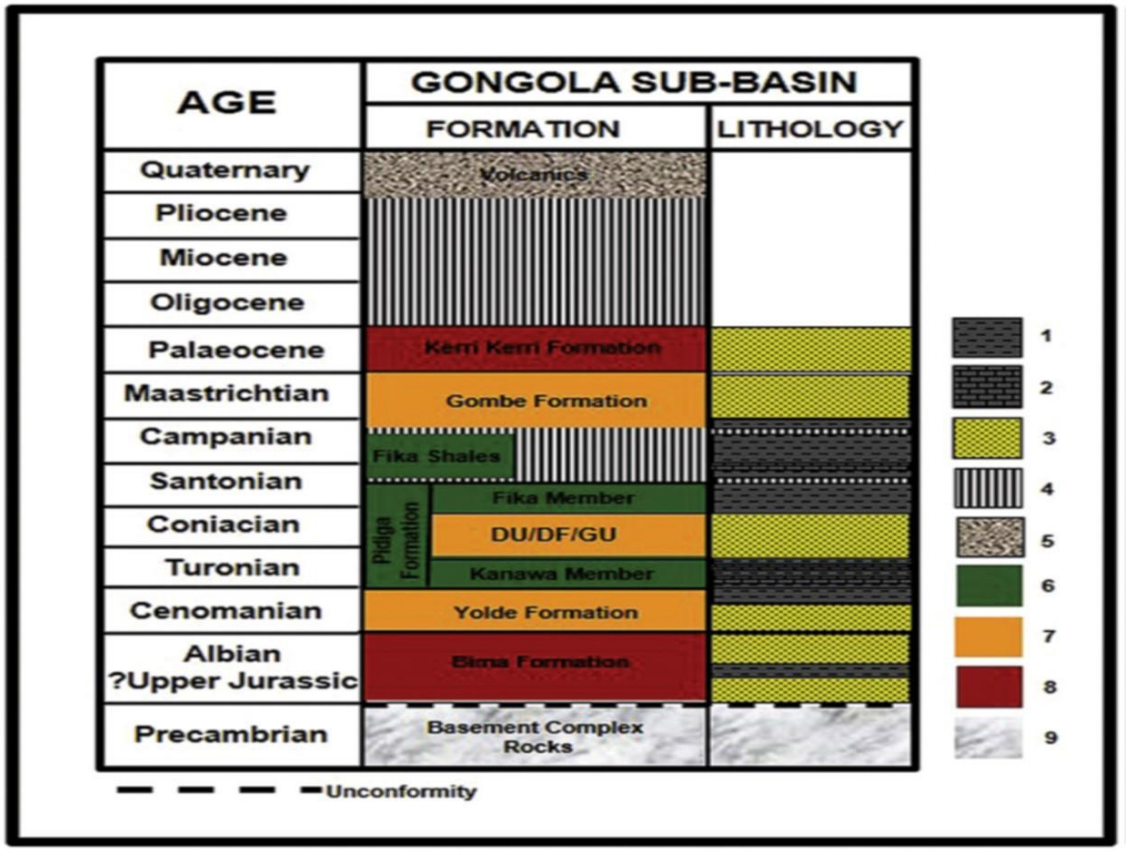

Fig 2. Lithostratigraphic Succession of the Gongola Sub-basin, (adopted from Goro et al., 2021). 1-Clays, 2-Limestones, 3-Sandstones, 4-No deposition, 5-Basalts, 6-Marine Strata, 7-Transitional-Strata, 8-Fluvial strata, 9-Pre-Cambrian Basement Dumbulwa Member (DU), Deba Fulani Member (DF), Gulani Member (GU).

Methodology

Field Method

Topographic and geological maps of the Gongola Sub- basin were used in identifying locations of the outcrop at Gamawa for logging and sampling. This outcrop is located around a stream channel and was accessed with the aid of global positioning system (GPS). The compass – clinometer was use during logging of the section for taking direction and angles. The stratigraphical section was sample vertically at 1m intervals.

Laboratory analysis

Thirty outcrop samples were analyzed for the work. All The samples were scraped clean with penknife in order to remove any contaminants or encrustation of fungus or algae. Each sample was crushed to 1-3 nm size fractions using a coarse copper sieve. Samples were weighed to ten grams then digested with hydrofluoric acid (HF) and hydrochloric acid (HCl) to remove silicates and carbonates, respectively, before being sieved through a five mm mesh. The samples were placed into a labeled disposable plastic beaker. Zinc Bromide (ZnBr4) was used to separate the macerals from the heavy liquid before Dibutyl phthalate Polystyrene Xylene (DPX) was used to mount the residue on a glass slide (Batten 2005). In order to detect and count significant palynomorphs, such as pollens, spores, dinoflagellates, micro foraminiferal wall linings, algae, and fungal spores, the prepared palynological slides were examined using a binocular microscope. Under a microscope, key palynomorph photomicrographs were taken using a Nikon P6000 digital camera at the Palynological Laboratory of the National Centre for Petroleum Research and Development, Abubakar Tafawa Balewa University, Bauchi.

Results and Discussion

Lithologic Description

The section is exposed along a stream channel and it is composed of four (4) lithological units (Fig 3). At the base it starts with 1m of siltstone, clays and thin sandstone intercalated beds milky colored. Above this unit is 1m o heterolithic shales and siltstones, the siltstone beds are characterized by thinning upward. This is followed by 17m thick coaly shales with some mottled clay units between them. At the top is the 13m bioturbated silty clays and a fine-grained sandstone which has undergone reworking.

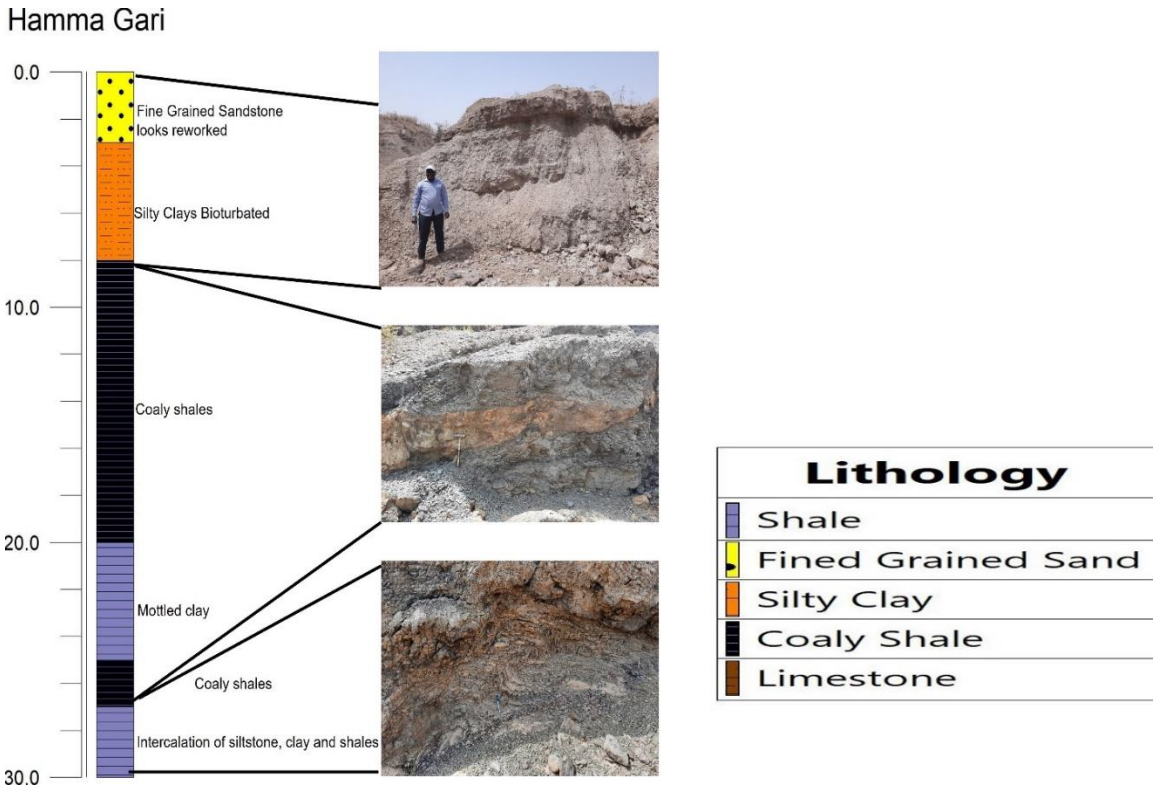

Fig. 3. Composite sedimentary log of Gamawa section.

Palynostratigraphy

The palynostratigraphic distributions plotted against the composite lithologic section (Fig. 4) shows that the assemblage of palynomorphs recovered from Gamawa is comparable to those of (Lawal and Moullade, 1986; Schrank, 1987 Jardine and Magloire, 1965; Herngreen, 1972, Van Hoeken-Klinkenberg, 1964, 1966;). And also, Correlatable with other coeval basins in West and Central Africa and South America. The recovered palynomorphs includes *Longapertites marginatus, Proxaperties operculatus, Spinizonocolpites Baculatus, Monocolpites marginatus, Longapertites Microfoveolatus, Longapertites Proxapertitoides, Retibevitricolpites brevicolpatus, Milfordia Jardinei, Araucariates australis, Tricolporopollenites sp 5, Gleicheniidites senonicus, Ephedripites sp, Tricolpates Echinate Retimonocolpites sp 2, Stephanocolpites costatus, Monosulcite sp.* Only three Species of dinoflagellates were recovered which includes *Delandrea laevigata, Apteodinium sp. Dinogymnium sp.* (Plate 1). For the examined section, an Upper Maastrichtian palynological age was determined based on the assemblage of *Longapertites marginatus, Proxaperties operculatus, Spinizonocolpites Baculatus, Monocolpites marginatus, Longapertites Microfoveolatus, Longapertites Proxapertitoides, Retibevitricolpites brevicolpatus,* diagnostic marker species especially by the abundance of Pollen *Spinizonocolpites Baculatus***.** And others like *Proxaperties operculatus, Milfordia Jardinei, Monocolpites marginatus* and the *Dinoflagellates Delandrea laevigata, Apteodinium sp. Dinogymnium sp.* which are key members of the Maastrichtian flora as indicated by various scholars in other tropical West African basins.

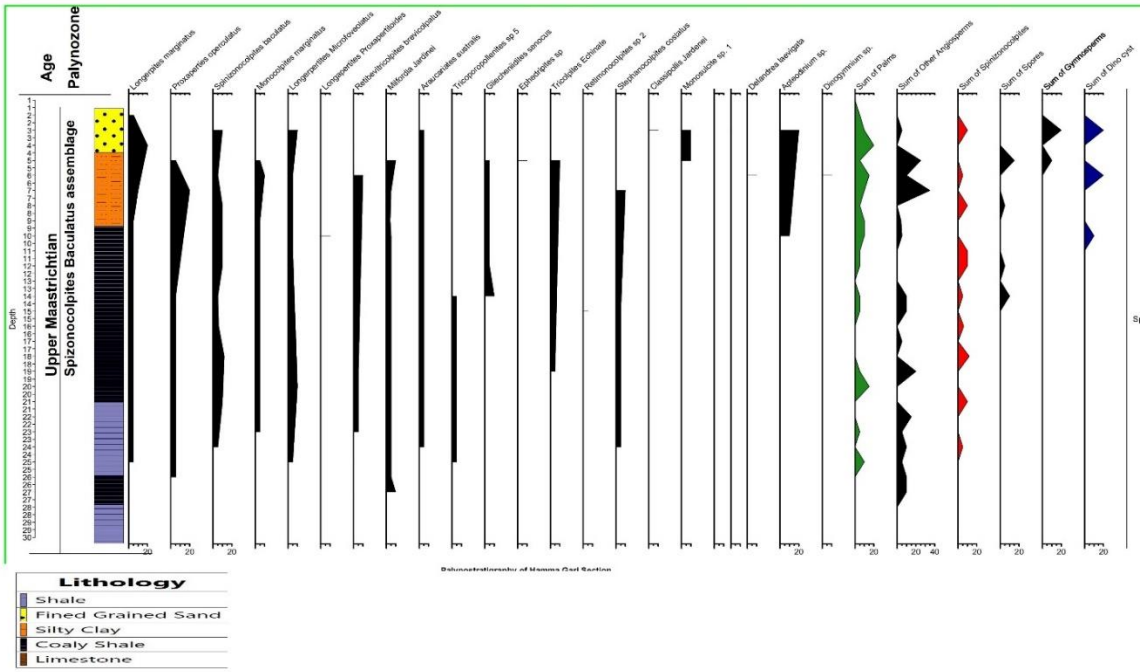

Fig.4. The Palynologic Distribution Chart of the Hamma Gari section highlighting the stratigraphic ranges of several taxa.

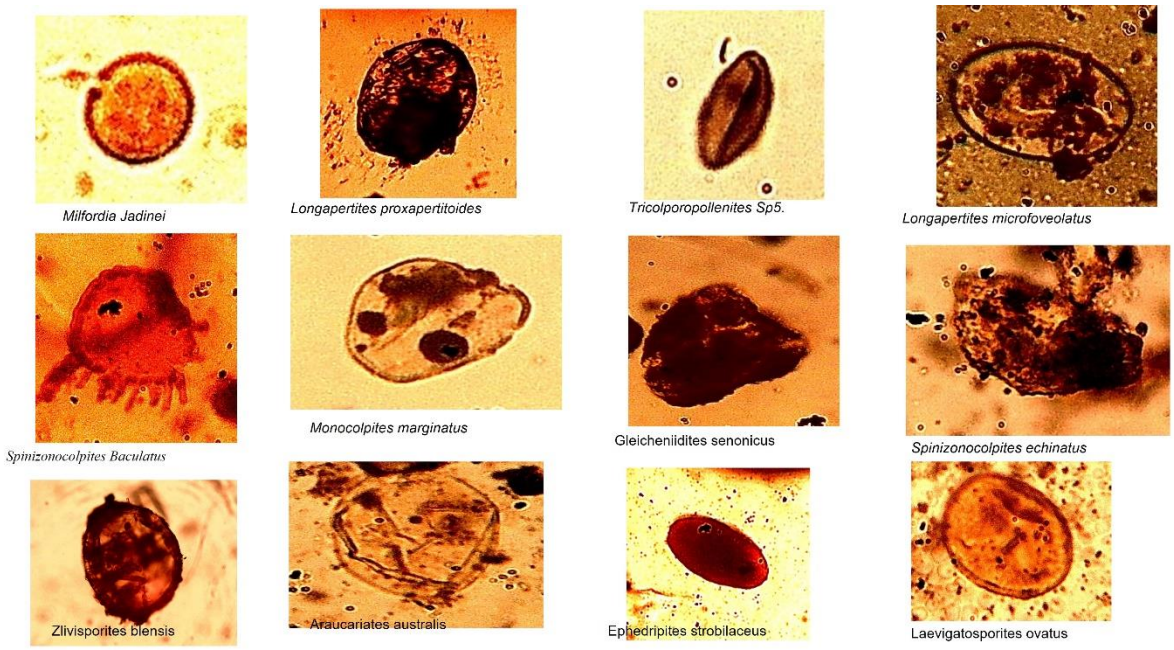

Plate 1: Some Recovered palynomorphs photomicrographs from Hamma Gari, Gongola Sub-basin (×400).

Paleoenvironmental Interpretation

In an attempt to predict the paleoenvironment of deposition, all of the palynomorphs collected from the section were divided into five categories. The physical characteristics and known taxonomic affinities of certain species were used to determine the groups. Spores, palms, marine palynomorphs, Spinizonocolpites, and other angiosperm groupings are among them (Fig. 3). The most likely paleodepositional habitat was identified using the relative abundance of each category. The most prevalent element of the palynological assemblages in this area is the Palme group. According to Rull (2000; 2002), palms are important component in coastal environments due to their ability to colonize bar sands and prograding sand deposits. Palm

pollens occurrence is associated mainly with tidal swamps in a temperate Climate (Sarmiento, 1992; 1994). The next abundant group is the *Spinizonocolpites* group which includes *Spinizonocolpites echinatus, Spinizonocolpites costatus* species and the most common being *Spinizonocolpites Baculatus.* Genus *Spinizonocolpites* is taxonomically related to present day mangrove palm – called Nypa.

It is the only palm present in mangrove ecosystems which is restricted to brackish water environments in coastal areas of Southern Asia (Germeraard et al., 1968; Rull, 1998). Moreover, according to Rull (2000; 2002) *Spinizonocolpites* are indicative of estuarine conditions with and wetter conditions. The relatively low abundance of marine palynomorphs signals the limited influence of marine activity in the depositional environment. Based on the above analysis it may be suggested that the sediments of the Gamawa area were deposited within mangrove swamp with evidence of tidal dominated estuarine conditions under a temperate climate.

Conclusion

The palynological analyses performed on samples from the Gamawa, Kumo area of the Gongola basin, which consist of lenticular-shaped sandstone, organic-rich layers, clay and sandstone interbeds, show that the Gombe Formation's coaly shales are Upper Maastrichtian in age. Additionally, it suggests that the coaly shales were deposited within a mangrove swamp within an estuary under a temperate climate.

Acknowledgements

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