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Research Paper

Palynomorphs Content of Mamu Formation in Okpekpe-1, Benin Flank of Anambra Basin, Nigeria

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ABSTRACT: *Ten outcrop samples were collected at a road cut along Okpekpe road in the western part of the Anambra Basin with an aim to establish the biozones, age of the sediments and their depositional environment. The samples consist mainly of shale, sandstone, siltstone and heteroliths. The samples were processed and analyzed using standard palynological procedures. Index fossils of stratigraphic significance were used for dating the sediments. The palynomorphs recovered and identified in the study area are Laevigatosporites sp., Cingulatisporites ornatus, Cyathidites minor, Cyathidites ornatus, Retitricolporites sp., Longapertites marginatus, Longapertites sp., Milforadia marginatus, Milforadia jardinei, Retidiporites sp., Leiosphaeridia sp., Subtilisphaera sp. and microforaminiferal wall linings. Longapertites sp. biozone was erected and used to date the shale to Upper Maastrichtian to Early Paleocene geological age. The presence of microforaminiferal wall linings, marker pollens, spores and dinoflagellate cysts established that the shale was deposited in marine environment. The paucity of palynomorphs in the study area may be attributable to marine regression occasioned by eustatic sea level drop coupled by continental influence in anaerobic environment that favored coalification process within the shales. Further study on foraminifera and calcareous nanofossils in the study area is recommended to deepen the understanding of its biostratigraphy and paleodepositional history.*
KEYWORDS: *Palynomorphs, Mamu Formation, Okpekpe, Benin Flank, Anambra Basin*

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I. INTRODUCTION

Palynomorphs are microscopic plant and animal with structures encased with sporopollenin, chitin or related compounds that are highly resistant to most forms of decay other than oxidation. Palynomorphs are abundant in most sediments and sedimentary rocks and are resistant to the routine pollen-extraction procedures including strong acids, bases, acetolysis and density separation. Examples of palynomorphs include acritarchs, chitinozoans, pollens, spores, dinoflagellates and scolecodonts. Palynomorphs are very minute microscopic sizes, therefore they are easily recovered from ditch cuttings and drill cores. The extreme abundances and diversities of palynomorphs in sedimentary make them to be very useful tools biostratigraphy, paleoenvironmental analysis, paleogeographic studies, forensic evaluation and basin analysis.

The study area lies within latitude 07^0 11.4'57" North and longitude 006^0 26.8'33" East with elevation of 205 m above sea level (Figure 1). The study area is accessible using trunk 'A' Okpekpe-Auchi road in Etsakho East Local Government Area of Edo State, Nigeria. The samples location is a road cut exposure of the Mamu Formation situate in the Benin Flank (western part) of the Anambra Basin, Nigeria. The study area is straddled by settlements such as Imiegba, Imiakebu, Apana, Agenebode, Ogbonna, etc.

II. REGIONAL GEOLOGY OF ANAMBRA BASIN

Anambra Basin is one of the southern Nigeria sedimentary basins. It represents the general name given to the upper part of the Lower Benue Trough (Figure 1). It is bordered on the northwest and northern ends by Benin Flank and Bida Basin, respectively, and southern part by the Abakaliki fold belt.

Anambra Basin is a synclinal intracratonic basin in southeastern Nigeria and it is a child of the parent Benue Trough (aulacogen) formed via the separation of Africa from South America and the opening of South Atlantic Ocean [5], [4], [7], [11]. During the Albian-Santonian, the Benue Trough was essentially an intracratonic mobile sediments basin, whereas the proto-Anambra Basin was a platform only thinly draped by older sediments. During the Santonian compressional event, Abakaliki Basin folded and uplifted with a westward transition that took place in the depocenter towards the Anambra Basin. Sediments were derived from

the uplands beyond the Benin hinge line, the Abakaliki uplands and the Benue fold belt. Anambra Basin became an active depocenter after the Santonian tectonic event [14].

Murat [9] and Obi et al. [13] believed that the sedimentological and stratigraphic settings of the sediments within Anambra Basin were defined by three main evolutionary phased stages, namely:

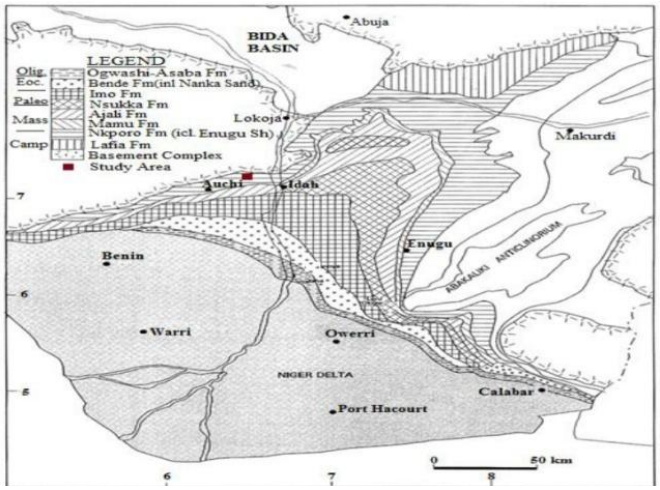

Figure 1: Geological map of Anambra Basin showing location of the study area [1]

The first phase that defined a pre-Santonian history that was characterized by a strong subsidence in the Abakaliki domain of the Benue Trough, while the Anambra domain remained a platform where mud was deposited in a shallow restricted marine environment.

On the other hand, the second phase that started during the Campanian was dominated by the uplift of the Abakaliki sub-basin of the Benue Trough and the subsidence of the Anambra platform transgressed by a shallow marine incursion. Consequently, Nkporo/Enugu shales and Lower Coal Measure (Mamu Formation) were deposited and a regressive fluvio-deltaic phase that took place during the Maastrichtian led to the deposition of the regional Ajali Sandstone and Nsukka Formation.

The third and last phase took place during the Lower Tertiary and was dominated by the formation of the Niger Delta, which prograded along the Anambra Basin axis. This was characterized by the deposition of Imo shale and Bende-Ameki Groups, especially in the southern part of the Anambra sub-Basin during the Paleocene and Eocene periods, respectively.

2.1 LITHOSTRATIGRAPHIC UNITS IN THE ANAMBRA BASIN

Anambra Basin is made up of Campanian to Early Paleocene (Danian) lithostratigraphic units, namely: Nkporo Shale, Mamu Formation, Ajali Sandstone and Nsukka Formation. Anambra Basin has a roughly triangular outline with twice indented base [11]. According to Reyment [14] and Nwajide [11], the oldest lithostratigraphic unit in Anambra Basin is the Campanian aged Nkporo Shale, also called Nkporo Formation, that unconformably overlies the Santonian aged Agwu Formation.

Nkporo Shale was deposited during the Late Campanian transgression into the Anambra Basin. It resulted from the first marine transgression in the Anambra Basin. It consists of shales, mudstones and fine sandstone interbeded by limestone at its basal portion. The shales are highly fossiliferous, pyritic or gypsum-bearing, fissile and grey in colour [11].

Mamu Formation, initially called the Lower Coal Measure by Tattam [16], overlies the Nkporo Formation. It is composed of mainly white to yellow, fine- to medium-grained, well-sorted sandstones, with interbeds of carbonaceous shale with sparse microfauna and coal seams. The coal seams range from a few centimeters to about 4m in thickness. The coal beds and carbonaceous shale are abundant toward the basal sections of the formation but very sparse at the top sections. Agagu et al. [1] inferred stranded plain or deltaic depositional environment for the formation. Mamu Formation is Campanian to Maastrichtian in age [15], [14], [11], [12].

Ajali Formation overlies Mamu Formation and was originally named White False Bedded Sandstone and Eagle Rock Sandstones [3]. Reyment [14] named it the name Ajali Formation. It is Upper Maastrichtian in age and composed of white, friable, coarse-grained, moderately to poorly sorted, cross-bedded sandstone with thin belt of whitish claystone and several bands of variegated carbonaceous shale or mudstone. Hoque and Ezepue [6] assigned a fluvial-deltaic environment to Ajali Formation.

Tattam [16] described Nsukka Formation as the Upper Coal Measures, but Reyment [14] gave it its current name. The formation consists of cross-bedded sandstones, shale and beds of coal seams. Nsukka

Formation is Maastrichtian to Paleocene (Danian) age [15], [11] and it was deposited under paralic condition that prevailed during the second Post-Santonian transgressive cycle [17].

Imo Formation rests unconformably on Nsukka Formation. Imo Formation is the surface exposure of the subsurface Akata Formation in the Niger Delta Basin of Nigeria. It consists of grey to bluish, fine shale with occasional clay to ironstone, thin sandstone and sandy limestone bands, which are highly indurated and fossiliferous. In southeastern Nigeria, this Paleocene Imo Formation shows lateral variation into the sandstones [14], [2]. Its lateral equivalents are the Agbabu, Ebenebe and Mamuna Sandstones, respectively. It is mainly of marine deposition in a tropical, lithoral-neritic condition. The type locality is found along Imo River, Umuahia and Okigwe in southeastern Nigeria where it attains a thickness of 500 m [15].

2.2 LOCAL GEOLOGY OF THE STUDY AREA

In the study area, eleven strata of the Mamu Formation are exposed by the road cut. The Brownish to dark carbonaceous shale dominates the base of the formation and overlaid by sequence of interbeded sandstone, ferruginised siltstone and mudstone in graded bedding setting. The surface of the outcrop is highly weathered. Sedimentary structures include ferruginised shale lag deposits which occur close to the base of the formation, graded bedding (coarse at the base, followed by fine grains at the top) (Figure 2).

Figure 2: Photographs of Lithostratigraphic Sections of Study Area

In Okpekpe-1, at the base depth of ≥ 11.0 m is ferruginized carbonaceous shale with abundant ichnofossils. Dark carbonaceous shale occurs at the depths of 7.0 m – 11.0 m, it is overlaid by brown mudstone at the depths of 6.0 m – 7.0 m. The brown mudstone is overlaid at the depths of 5.0 m – 6.0m by siltstone and shale beds. Fine- to coarse-grained sandstone occurs at depths of 4.0 m – 5.0 m. Above this unit are cyclic sequence of siltstone and sandstone as follows: siltstone (3.0 m – 4.0 m) followed by sandstone (2.0 m – 3.0 m), then siltstone (1.0 m – 2.0 m) and finally, sandstone capping (0 m – 1.0 m) (Figure 3).

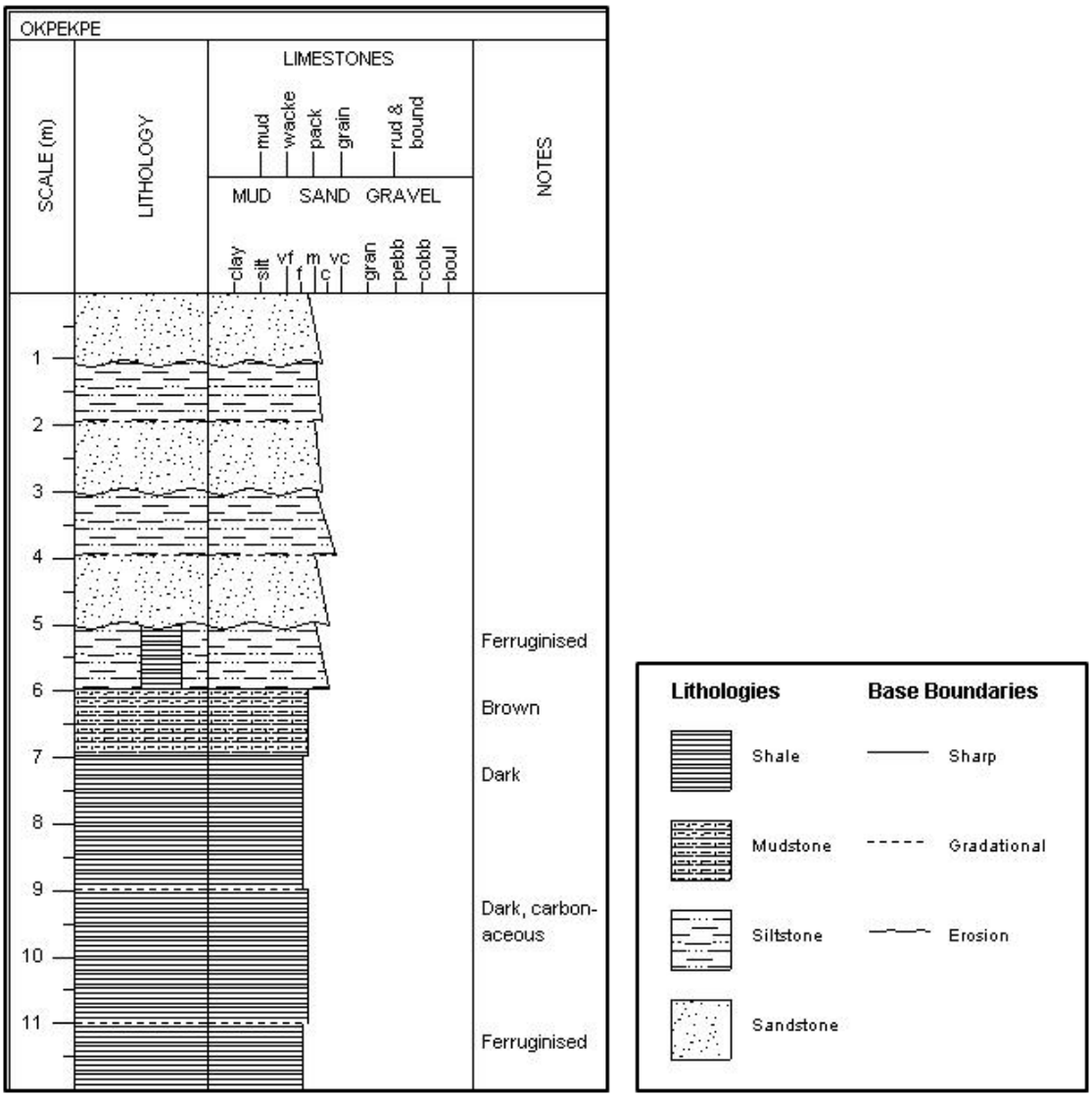

Figure 3: Lithology log of the Study Area (Okpekpe-1 exposed along Auchi-Igarra road)

II. MATERIALS AND METHODS OF STUDY

Method of investigation involved both field and laboratory analyses. During the fieldwork, the surface exposure of the Mamu Formation sediments were carefully studied and logged from the base to the top (Figures 2 and 3). Bedding characteristics in term of structure, texture, attitude and lithology were studied and described. Ten fresh surface samples were collected from the stratified outcrop and taken to the laboratory for analysis. The collected surface samples were transported in water proof well labelled bags to the laboratory for analysis.

In the laboratory, the samples were disaggregated and properly cleansed. The carbonates were removed using HCl procedure, while the silica and silicates were removed using HF procedure in a fume chamber to successfully extract out the hazardous acid fumes. The palynomorphs were bleached using Sodium hypochlorite and hydrogen peroxide procedures. 65 mesh residues were mounted using Canada balsam for microscopic identification of palynomorphs.

III. RESULT

Ten surface samples from Okpekpe-1 (also abbreviated to 'Oke-1') location were carefully prepared and analysed for the palynomorphs content.

The samples yielded few pollens, spores and dinoflagelate cysts. The identified pollens and spores from the study area are *Longapertites marginatus, Longapertites* sp., *Retitricolporites* sp., *Milforadia marginatus, Milforadia jardinei, Retidiporites* sp., *Cingulatisporites ornatus, Cyathidites minor, Cyathidites ornatus, Laevigatosporites* sp., respectively, while the dinoflagellate cysts are *Subtilisphaera* sp. and *Leiosphaeridia* sp. and microforaminiferal wall linings. The palynomorphs were recovered at depths of 4.34 m to 9.92 m. Diversity and abundance of spores were recorded at depths of 6.06 m and 9.92 m, while those for the

pollens were observed to be confined to depths of 6.06 m to 8.06 m. On the other hand, the diversity and abundance of dinoflagellate cysts were detected at depths of 4.96 m to 8.06 m. The recovered palynomorphs are presented in Figures 5 and 6.

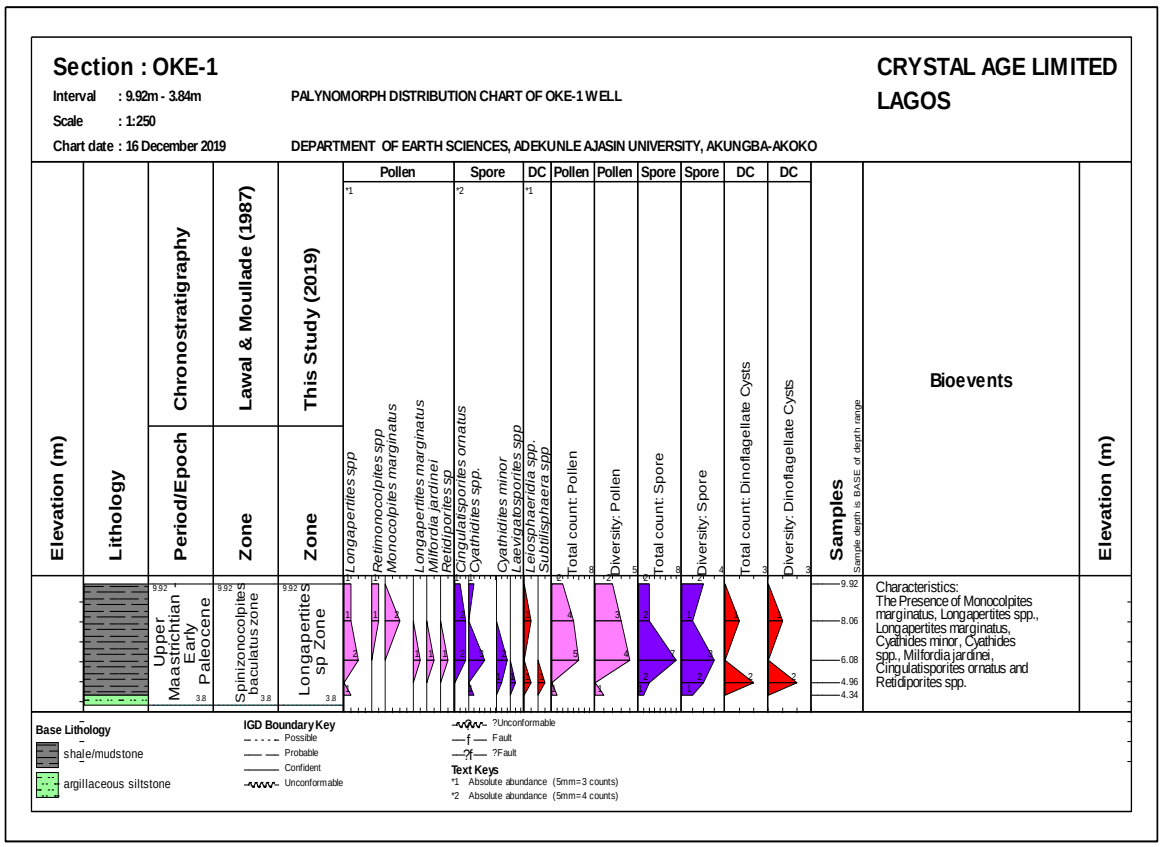

Figure 5: Palynomorphs Distribution Chart of Oke-1

IV. DISCUSSION

The recovered pollens and spores such as *Milfordia jardinei*, *Monocolporites marginatus*, *Retidiporites* sp, *Cingulatisporites ornatus* and *Cyathidites minor* indicate an Upper Maastrichtian to Early Paleocene age (Figure 5). Additionally, *Longapertites* spp. biozone was erected for the shale intervals in the study area and further confirmed an Upper Maastrichtian to Early Paleocene age for the shale in the study area. The erected biozone is a lateral equivalent of the *Spinizonocolpites baculatus* biozone of the Upper Benue Trough [8].

Few dinoflagellate cysts, namely: *Subtilesphaera* sp. and *Leiosphaeridia* sp., moderate amount of pollens and spores such as *Monocolpites marginatus*, *Milfordia jardinei*, *Longapertites marginatus*, *Longapertites* sp., *Cingulatisporites ornatus* and *Cyathidites minor* and microforaminiferal wall linings recovered and identified are indicative of marine depositional environment for the shale in the study area.

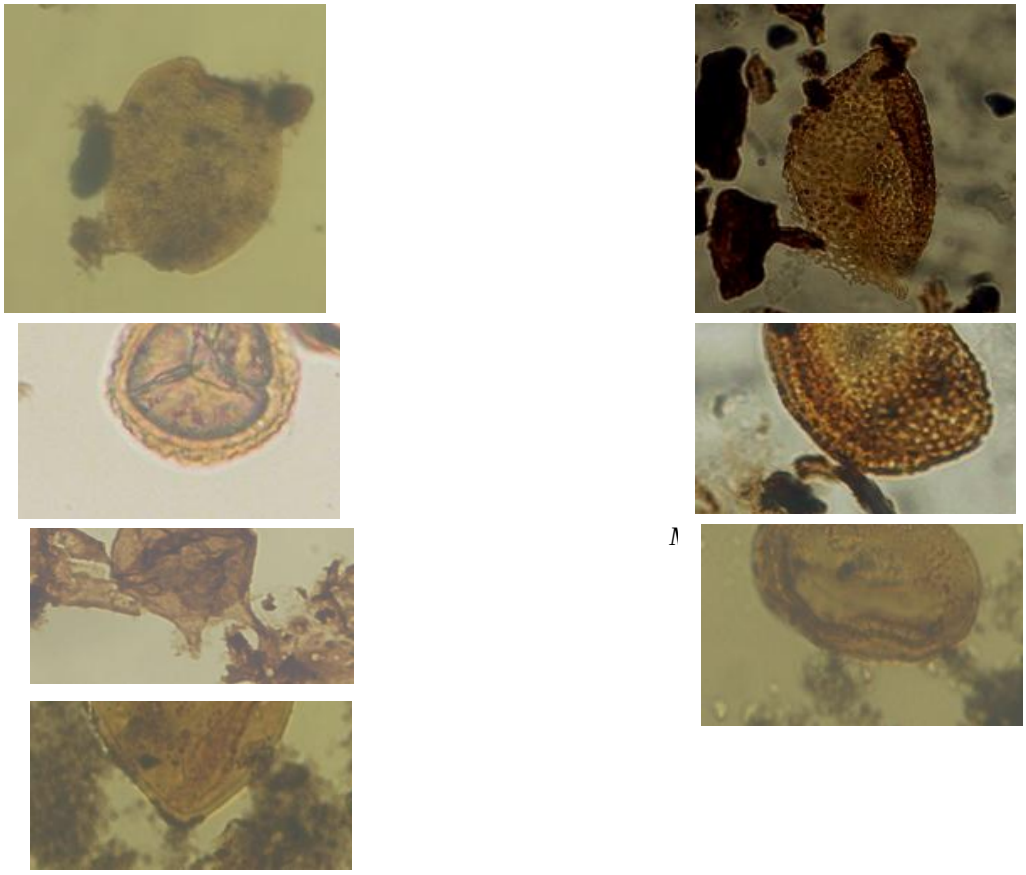

FIGURE 6: Photomicrographs of recovered palynomorphs from Oke-1

V. CONCLUSION

Mamu Formation in Okpekpe-1 is a constituent lithostratigraphic unit in the Anambra Basin. The lithology of the Mamu Formation exposure in Okpekpe-1 consists predominantly of dark carbonaceous shale, ferruginised shale with intercalation of siltstone, sandstone, siltstone and mudstone. Ferruginised shale occurs at the base at depths of > 11.0m. The sandstones are medium- to coarse-grained, while the siltstones and mudstones are thinly laminated.

The result of the palynological analysis of the surface samples indicate that samples yielded few to moderate amount of pollens, spores and dinoflagelates cysts such as *Laevigatosporites* sp., *Cingulatisporites ornatus, Cyathidites minor, Cyathidites ornatus, Retitricolporites* sp., *Longapertites marginatus, Longapertites* sp., *Milforadia marginatus, Milforadia jardinei, Retidiporites* sp., while the dinoflagellate cysts are *Subtilisphaera* sp. and *Leiosphaeridia* sp., respectively, and microforaminiferal wall linings. The paucity of palynomorphs in the study area may be attributable to marine regression occasioned by eustatic sea level drop coupled by continental influence in anaerobic environment that favored coalification process within the shales.

Longapertites sp. biozone was erected and dated Upper Maastrichtian to Early Paleocene and it is a lateral equivalence of *Spinizonocolpites baculatus* biozone of the Upper Benue Trough (Lawal and Moullade, 1987).

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