PALAEOPALYNOLOGY AND PALAEOECOLOGY OF THE MAMU FORMATION AROUND OZALLA, ANAMBRA BASIN, SOUTH-WEST, NIGERIA.

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ABSTRACT

The Mamu Formation around Ozalla has been palynologically examined from surface outcrop, 44 Palynoflora species were recorded and Late Maastrichtian to early Eocene age has been assigned. Mangrove swamp to fresh water swamp paleoenvironments is inferred based on the Palynofacies, *Inaperturopollonites* sp., Sp*inizonocolprite baculates*, *Longapertites*, *Tricolporopolenites* sp., *Proxpertites cursus*, *Diporites* sp., *Monocolpites marginatus*, *Monoulcites* sp., *Tricolpites* sp., *Leiotriletes adrennis, Bombacacildites* sp, and *Ctenoloplophonidites costatus*. A mean annual precipitation of 1003 to 1520 mm which indicate a moist tropical climate condition predominating over the study area.

INTRODUCTION

The study area lies between longitudes $5^{0}57^{1}$ to $6^{0}00^{1}$E and latitudes $6^{0}46^{1}$N to $7^{0}00^{1}$N. it is bounded to the North by Uhomora and to the west by Umokpe (Fig. 1). It falls within the southwestern flank (ie Benin Flank of the Anambra Basin. Stratigraphically, the study area consists of the Mamu Formation and the Ajali Sandstone. The Anambra Basin has attracted so much attention. By many workers such as Reyment (1965), Van Hoeken-klinkernberg (1966), De Swardt and Casey (1963) and Umeji (2005) among others.

The Mamu Formation (Reyment, 1965) was first referred to as the lower coal measures (Simpson, 1954). De Swardt and Casey (1963) reported the occurrence of a rhythmic sequence in the Mamu Formation around Enugu where the formation is more sandy, becoming more shaly and thicker at Okaba and Odakpono. Van Hoeken. Klinkenberg (1966) identified the K/T boundary in GSN Borehole no. 118 with a high frequency of *Longapertites marginatus* and the appearance of *Mauritidites crassibaculatus.* Umeji (2005) investigated the Okaba coal seams palynologically, and assigned Late Maastrichtian – Palaeocene. This paper describes the palaeopalynology and palaeoecology of the Mamu Formation. However, much information have been published on the eastern sector of the basin, but the palaeopalynology is incompletely known. The poor geological knowledge of the southwestern sector is mainly because of poor exposure and difficult access into the jungle covered terrain. Despite these difficulties, few outcrops encountered in the river Ozalla at low water levels during the recent Exxon Mobil sponsored mapping formed the cornerstone of our study.

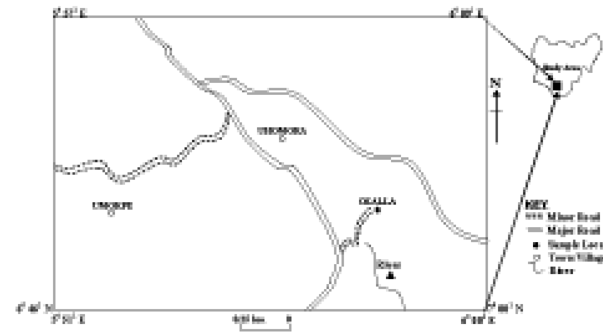


Fig 1: *Location map of the study area*

Regional Geology and Stratigraphy of Anambra Basin

The tectonic evolution of the Anambra Basin cannot be discussed in isolation without making references to the Benue Trough since similar tectonic event led to their formation, although Anambra Basin was formed much later (Reijers, 1996). The Anambra Basin is one of the basins that constitute the Benue Aulacogen that resulted from a rift associated with the splitting up of the Gondwanna supercontinent. Murat (1972) noted that two depositional cycles were associated with the Anambra Basin and were formed by three tectonic phases. The first phase was quiet in the Anambra Basin but led to deposition of marine transgressive sequence of the Asu River Group during the Middle Albian times. In the second phase, there was further marine transgression during the Turonian, and this led to the deposition of the Eze-Aku Formation in the lower Benue Trough and the Anambra platform. The transgression extended into the Coniacian resulting to the deposition the Agwu Shale. During the third tectonic phase in Santonian there was compression in the region, which resulted in the uplift and faulting in the Abakaliki Trough. The upliftment and folding led to the exposure and subsequent erosion of the earlier deposited sediments. Consequent to this uplift, two depocenters – the wide Anambra Basin 'proper' and the narrow Afikpo Syndine-were formed (Nwajide and Reijers, 1996). These later became the main foci of deposition for other post -santonian deposits. The campanian began with a short marine transgression and regression, during which the Nkporo Shale and its equivalents - the Enugu Shale and Owelli Sandstone – were deposited. The sea became shallower leading to the deposition of the parallic sequence of shale and sandstone of Mamu Formation. This was followed by the deposition of the Ajali Sandstone during the Upper Maastrichtian. The Nsukka Formation was deposited under partially parallic conditions during the Paleocene. This was followed by the deposition of the Imo Shale, Ameki Formation and lastly the Ogwashi-Asaba Formation (Table 1).

Table 1: Stratigraphy of the Anambra Basin (Modified after Reyment, 1965; Nwajide and Reijers, 1996).

Age	**Stratigraphic sequence**	**Lithology**	**Environment deposition**	**Present Study**
MIOCENE	OGWASHI – ASABA FORMATION	Sandstone, shale + lignite	Continental	
OLIGOCENE				
EOCENE	Ameki Formation	Calcareous + clayey sandstone	Estuarine	
PALEOCENE	Imo Shale	Shale, sandstone	Marine	
DANIAN	Nsukka Formation	Shale + coal seams	Shallow marine	
MAASTRICHTIAN	Ajali Sandstone	Sandstone + few claystone	Continental	
	Mamu Formation	Sandstone, shale + coal seams	Deltaic	Swamp
CAMPANIAN	Nkporo shale/Enugu Shale/Owelli Sandstone	Shale, sandstone	Shallow marine	
CONIACIAN-SANTONIAN	Awgu Shale	Shale and limestone/calcareous	Marine	
TURONIAN	Eze-Aku Formation	Shale, limestone, siltstone	Marine	
CENOMANIAN	Odukpani Formation	Sandstone, limestone, shale	Shallow marine	
ALBIAN	Asu-River Group	Shale, siltstone, sandstone	Marine	
LATE PALEOZOIC	Crystalline Basement	Gneiss, schist Granite/Quartzite		

METHODOLOGY

Detailed field mapping was carried out on the exposed outcrops; sediments were described in terms of colour, grain size, sedimentary texture and stratigraphic succession. Samples were collected for palynological analysis and macerated following conventional procedures of Wood *et al*. (1996) and washed through acid resistant sieves gauze of an 8 mm mesh screen using distilled water. The residue retained on the mesh was then mounted onto a glass slide by strewing onto cover slips and allowing to dry. An inverted cover slip was then glued onto a slide with the aid of araldite. Pollen count, observation and identification were carried out using the binocular microscope.

DESCRIPTION OF THE STRATIGRAPHIC SECTION

The study area consists of sedimentary rocks which include sandstone and shale. Generally the area is poor in rock exposures except where rivers cut deep into the surface thereby exposing the rock successions. The Mamu Formation that is exposed at the Ozalla stream forms the main scope of this present study. About 7m thick of rock succession was exposed by this stream. The rock succession consists of basal thick shale with intercalations of thin sandstone towards the top, this was followed by a thick ferruginized sandstone (Fig. 2). The basal shale ranges from brown to dark brown in colour, it is thickly laminated and fissile. It is generally rare in macrofossils although, some polymorphs (pollen and spores) have been recovered from it (this volume). The shale grades to sandstone on top, this sandstone is well bedded and interbedded with shale. Palynomorphs associations in 5m thick shale suggest sediments deposition under mangrove swamp to back mangrove environmental settings (Fig. 2). This shale and its intercalation sandstone is made up of medium to coarse grained, poorly sorted, massive at the base while it is thinly bedded. The sandstone has a variety of colour (reddish – brown, brown to grey). It is ferrugenized and is about 2m thick. It is likened to a stratigraphic unit described by Reyment

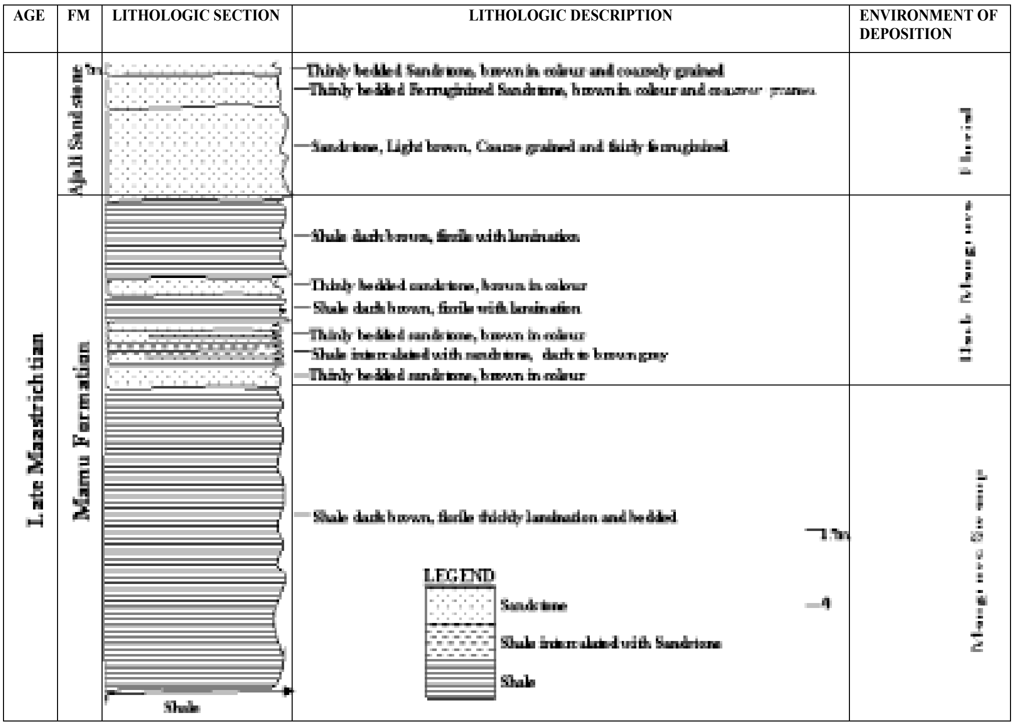
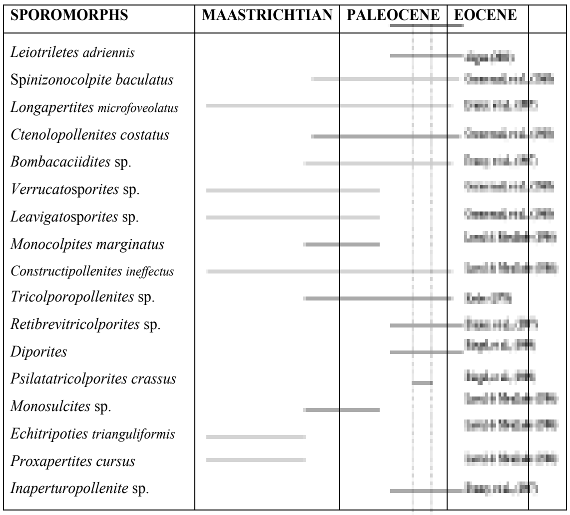


Fig 2: A detailed stratigraphic log of the Mamu Formation and Ajali Sandstone around Ozalla, SW, Nigeria.

PALYNOLOGICAL ASSEMBLAGE AND AGE

Seventeen species has been recorded, and they are mainly spores and pollen of seed bearing and vascular plants. Two informal palynological assemblage zone have been recognized in this work. The first zone is characterized by marker flora grain such as *Constructipollenite ineffectives, Monocolpitus marginatus, Longapertites marginatus, Syncolporites* sp, *Periretisynocolpites* sp. These palynofacies were assigned Maastritchtian age by (Lawal and Moullade 1986). The second zone mark the appearance of Sp*inizonocolpites echinatus, Retidiporites magdalensis, Praedapollis* sp., *Verrcato*sporites sp., *Diporites* sp., *Forveotriletes margaritae, Psilatricolporites crassus, Leotriletes adrennis, Retibreiticolporites* sp., *Proxapertites srassus, Retibreriticolporites* sp., *Proxapertites cursus, Monosulcites* sp., *Psilatatricolportes crassus, Ctenolophonidites costatus* (Table 2; Fig.4). However, due to stratigraphic range of short lived palynoflora, over long range species, short range palynoflora assemblages were used in age determination in this study. Consideration of the lithofacies and palynofacies suggest a Late Maastrichtian age (Lawal and

Table 2: Age determination of some pollen and spore associated with the Mamu Formation around Ozalla area.



PALAEOECOLOGY

A detailed quantitative paleoclimatic reconstruction of the area was carried out using the approach of Akkiraz *et al.* (2008). Seventeen taxa have been identified from the Mamu Formation but 3 species (namely *Inaperturopollenite* sp.*, Tricolporopollenite* sp., and *Longapertites* sp.) were utilized. These three species still have living representatives (Fig.3) and hence their mean annual temperature and precipitation were used to deduce palaeotemperature using coexistence interval and approach proposed by Riegel *et al*. (1999) and Akkiraz *et al*. (2008). The mean annual temperature range from 24.8 to 25^{0}C (Fig.3) while the mean annual precipitation is estimated to range from 1000 – 1500 mm (Riegel *et al*., 1999). A tropical condition with high rainfall is therefore inferred for the study area (Akkiraz *et al.,* 2008). *Psilatricolporites crassus (pelliciera)* is more sensitive to high soil salinities than other palynomorphs and develops best on wet soil shallowly flooded at high tides (Collins *et al.,* 1977). The presence of *Leiotriletes adriennis* in the sediments of the study area, which has been considered as the analogue of *Acrostichum aureum*, typical tropical inner mangrove indicator by van der Hammen (1963) were consistent with this work. The presence of *Spinizonocolpites ,* sp. and *leiotriletes adriennis* indicate mangrove to back mangrove swamp environment (van der Hammen, 1963; Jandu Chene *et al.*, 1978) and is consistent with this study.

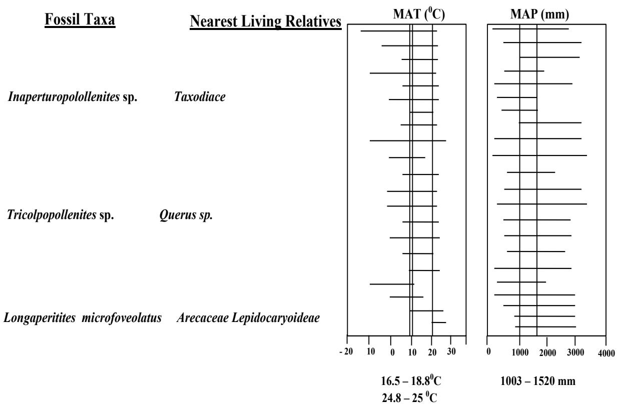


Fig. 3: Application of the coexistence approach to the Mamu Formation palynoflora in the Ozalla area. The horizontal lines mark the climatic requirement of the taxa, and the vertical line delimits the width of the coexistence interval (MAT: Mean annual temperature, MAP: Mean annual precipitation (modified after Riegel et al., 1999)

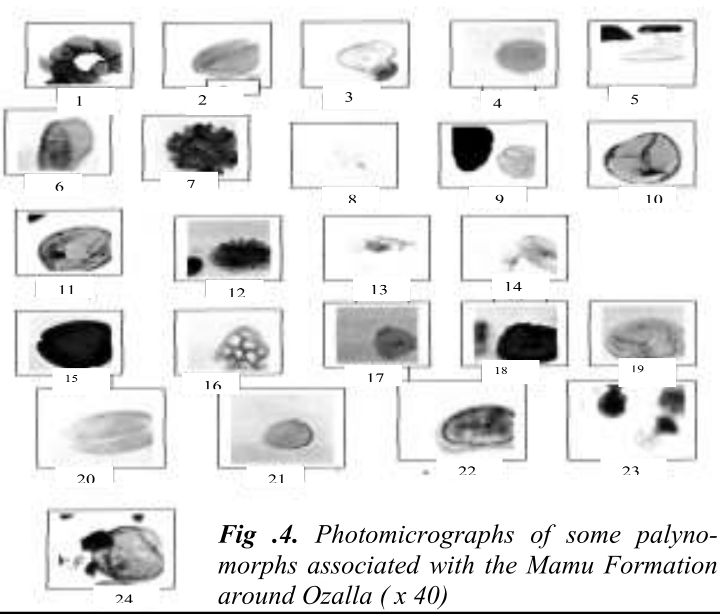


Fig .4. *Photomicrographs of some palynomorphs associated with the Mamu Formation around Ozalla (x 40)*

1. ***Microforaminiferal wall lining***
2. ***Retimonocolpites* sp.**
3. ***Bombacacidites soleaformis***
4. ***Constructipollenties ineffectus***
5. ***Laevigato*sporites sp.**
6. ***Longaperites microfoveolatus***
7. ***Ctenolophonidites costatus***
8. **Sp*inizonocolpites echinatus***
9. ***Syncolporites incomptus***
10. ***Leiotriletes adriennis (potonie and geldetich)***
11. ***Tricolporpollenites* sp.**
12. ***Periretisyncolpites* sp.**
13. ***Perietisyncolpites giganteus***
14. ***Monosulcites* sp.**
15. ***Psilatricolporites crassus***
16. ***Praedpollis* sp.**
17. ***Retibrevitricoporites* sp.**
18. **Sp*inizonocolpites baculatus***
19. ***Araucariacites australis***
20. ***Monocolpites marginatus***
21. ***Retidiporites megdalenensis***
22. ***Verrucato*sporites sp.**
23. ***Tricolpites* sp.**
24. ***Inaperturopollenites* sp.**

CONCLUSION

The palynological examination of the partially exposed outcrop of the Mamu Formation around Ozalla recorded 44 flora species. This has been dated Late Maastrichtian to early Eocene age. The presence of *Psilatricolporites*, Sp*inizonocolpites, Inaperturopollenites, Tricolpopollenites, Longapertites,* indicate the presence of mangrove to swamp fresh water environment. A mean paleotemperature of 24.8^0 to 25^0C and precipitation of 1000 to 1500 mm, indicate that a moist tropical climatic condition predominate over the study area.

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