Available online at www.elixirpublishers.com (Elixir International Journal)

Geoscience

Elixir Geoscience 69 (2014) 22812-22818

ISSN: 2229-712X

Biostratigraphy of the Campano-Maastrichtian Uzeeba Shale deposit, Dahomey Basin Southwestern Nigeria

Ola-Buraimo A.O[1], Oluwajana O.A[2], Ehinola O. A[3] and Ogundana O[2]

[1]Department of Chemical and Geological Sciences, Al-Hikmah University, Ilorin, Nigeria.

[2]Department of Geology and Applied Geophysics, Adekunle Ajasin University, Akungba Akoko, Nigeria.

[3]Department of Geology, University of Ibadan, Nigeria.

ARTICLE INFO

Article history:

Received: 7 October 2013;

Received in revised form:

19 March 2014;

Accepted: 29 March 2014;

Keywords

Index fossil,

Stratigraphy,

Pollen Assemblage Facies (PAF),

Transitional.

ABSTRACT

Uzeeba Shale is investigated for the first time for palynological content in order to determine its geological age and suggest its lithological equivalent. This is based on the recovery of miospores through laboratory processes that involved digestion, maceral floatation and mounting of the organic matter on slides for analysis under the microscope. However, the occurrences of index fossils that are stratigraphically important were used for dating of the Uzeeba sequence. The shale is generally light to dark grey in color and fissile in nature. An informal zone *Milfordia jardinei/Foveotriletes margaritae* assemblage zone is established for the studied section. The lower part of the outcrop section is dated Campanian based on the co-occurrence of *Milfordia jardinei, Milfordia sp, Cupanieidites reticularis, Tetradites sp* and quantitative occurrence of monocolpate pollen; while the upper lithofacies segment is assigned Lowermost Maastrichtian age based on the co-occurrence of *Proteacidites sp, Retidiporites magdalenensis*, low frequency of *Monocolpites marginatus, Ctenolophonidites costatus, Longapertites marginatus, Periretisyncolpiyes sp, Syncolporites sp, Proxapertites cursus, and Constructipollenites ineffectus*. Some of the forms that are diagnostic of Maastrichtian are found to have evolved in Campanian time. The Uzeeba Shale is laterally equivalent to Nkporo Shale lying in the adjacent Anambra Basin based on lithology, palynofacies and age. Thus, the Uzeeba Shale is here dated Campanian–Lowermost Maastrichtian age. The paleoenvironment of deposition of the Uzeeba Shale is mainly marginal marine characterized by co-occurrence of dinoflagellate cysts such as *Phelodinium bolonienae, Senegalinium sp, Paleocysttodinium golzownse*, microforaminiferal wall lining and *Botryococcus braunii* which are known to be environmentally significant for transitional environment.

Introduction

Palynological study was carried out on Uzeeba shale outcrop samples. The type section of the studied shale sequence is situated on latitude N6°58′ and longitude E005°51′, along Uzeeba – Ifon road in Edo State Nigeria (Fig. 1); belonging to the Dahomey Embayment of the southwestern Nigeria. Palynology as a an aspect of biostratigraphy has proved to play important roles in deducing geological age, understanding sequence stacking pattern, paleoclimatic change (Morley, 1995; Ola-Buraimo and Akaegbobi, 2013a) and reconstruction of paleoenvironment of deposition of sediments (Ayinla et al, 2013; Adeigbe et al, 2013) towards improving exploration and exploitation of oil and gas. The spores, pollen, dinoflagellates algae, and foraminiferal test linings were employed to date and reconstruct paleoenvironment of Uzeeba Shale.

It is note worthy to mention that this study will serve as the first palynological research work on Uzeeba Shale deposit. Therefore, this study aims at combining palynology and sedimentology to decipher the relative age and paleenvironment of deposition of the studied section. Important works had been carried out on the sedimentology, paleontology and geochemistry (organic and inorganic) of the Nigeria sector of the Dahomey Basin (Adegoke, 1969; Murat, 1972; Okosun, 1990; Petters, 1982, Olabode, 2006; Nton et al 2006; Bankole et al. 2006; Imeokparia and Onyeobi, 2007; Ola-Buraimo and Adeleye, 2010; Ikhane et al, 2011; Ola-Buraimo et al, 2012).

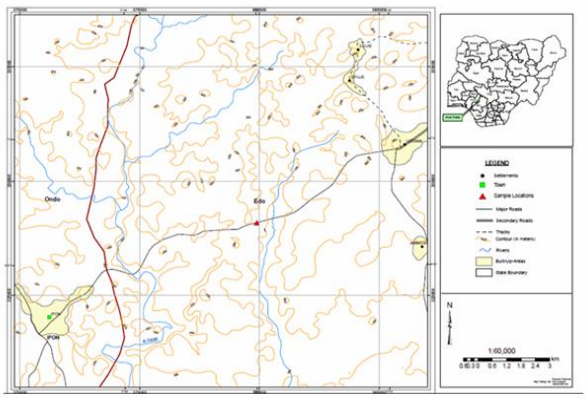


Figure 1: Map showing the location of the studied section

However the works of Mebradu (1988) on Auchi Shale; Ola-Buraimo and Akaegbobo, (2013b) on Asata/Nkporo Shale seems relevant to this present study because of similarity in stratigraphy and palynomorph assemblages.

Geologic setting and Stratigraphy

Dahomey Basin is an arcuate coastal basin, the onshore parts of which underlie the coastal plains of southwestern

Tele:

E-mail addresses: rolaburaimo@yahoo.com

Nigeria, Benin, and Togo. A faulted basement high, the Okitipupa Basement Ridge separated the Dahomey Embayment from the Anambra Basin (Fig. 2) until the Campanian–Maastrichtian subsidence and marine transgression that united both basins (Petters, 1980).

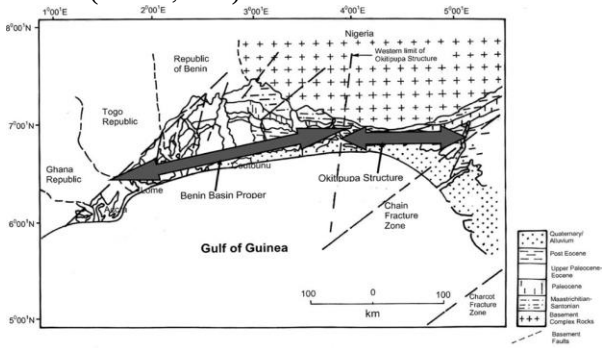


Fig. 2: Simplified regional map of Dahomey (Benin) Basin from Ghana in the west to Nigeria in the east. The Nigerian part shows both the Cretaceous and Tertiary rocks (Olabode, 2006)

Most of the Campanian–Maestrichtian sedimentary rocks in the western part were deposited over a wide area (Adeleye, 1975). In southwestern Nigeria, (west of the river Niger), the sedimentary sequence began during the Cretaceous with the deposition of the Abeokuta Group which encompasses Ise, Afowo and Araromi Formations lying on the basement unconformably. The oldest Ise Formation is predominantly sandy at the base and becomes increasing shally upwards (Kogbe, 1989). The Abeokuta Group is overlain by the Ewekoro and Akinbo Formations successively (Fig. 3) (Imeokparia and Onyeobi, 2007).

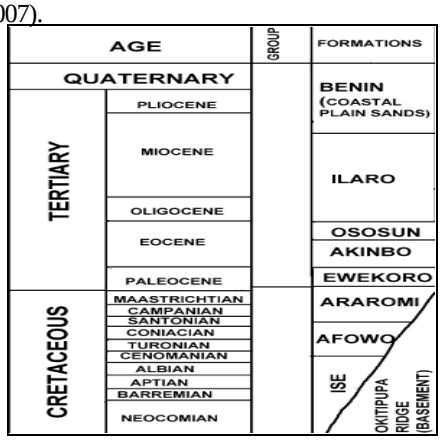


Figure 3: Simplified Cretaceous and Tertiary stratigraphy of Nigeria part of Dahomey Basin (Source: Olabode, 2006)

The Tertiary sediments consist of Ewekoro, Akinbo, Oshosun, Ilaro and Benin (coastal plain sand) Formations. Ewekoro Formation is made up of fossiliferous, well-bedded limestone while Akinbo and Oshosun Formations are made up of flaggy grey and black shales. Glauconitic rock bands and phosphatic beds define the boundary between Ewekoro and Akinbo Formations. Ilaro and Benin Formations are predominantly coarse sandy estuarine, deltaic and continental beds (Kogbe, 1975).

Material and Method

Ten shale samples used for this present study were recovered from field work untaken in Edo state around Uzeeba town. The outcrop was sampled from the base to the top and numbered in that order. The sampling interval is irregular (0.2 – 0.4m) in order to cover the entire sequence. The collected samples labeled 1-10 represent from base to topmost part of the outcrop; well labeled, kept in sampling bags and ready for laboratory preparation. The ten samples were taken through different stages that involved digestion of the samples with Hydrofluoric acid (HF), followed by sieving with 5µm mesh. Separation of the macerals with heavy liquid was done using Zn2Br4 and final mounting of the residue on glass slides with DPX mountant.

The preparation was followed by analysis of the prepared slides under the binocular microscope with the aim of point counting of important palynomorphs such as pollen, spore, dinoflagellates, microforaminiferal wall lining, algae, and fungal spores present in the slides for stratigraphic purpose. Important palynomorph pictures were taken under the microscope using Nikon Coolpix P6000 digital camera.

Result and Interpretation

Lithologic Attributes

The observed lithologic section consists of rhythmically bedded shale and ironstones, clayey sand and lateritic overburden at the top of the section (Fig. 4). The thickness of the section is 4.2m. The shale beds have an average thickness of 0.4m and are dark to grey, lightly micaceous, carbonaceous and fissile.

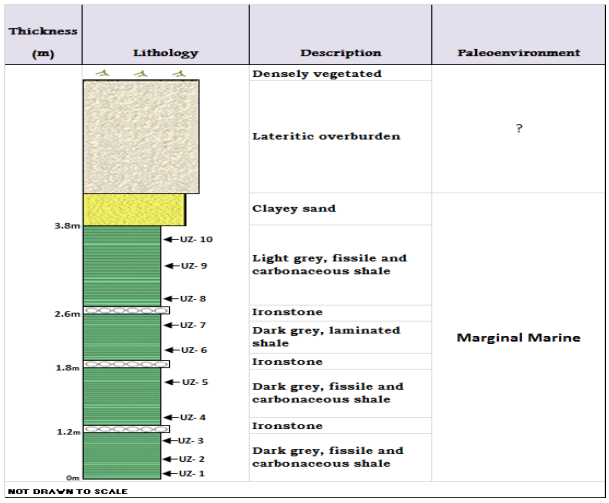


Fig 4: Lithologic section of Uzeeba shale exposure

The ironstones occur as interbeds between the shale beds with an average thickness of 0.1m (Fig. 5). The lithologic sequence is mainly dominated by shale, suggesting depositional processes dominated by quiet and low energy setting, probably transitional environment associated with deltaic processes. The sedimentation processes and paleoenvironment of deposition suggested for Uzeeba Shale is similar to that of Patti Shale in Bida Basin (Nigeria) described by Ojo and Akande (2006). The existence of ironstones indicate a diagenetic product of iron dominated mud deposited within a shallow marine setting (Ojo and Akande, 2006). It is here further suggested that mineral phase separation is accountable for the ironstone beds that intercalate in the Uzeeba Shale deposit.

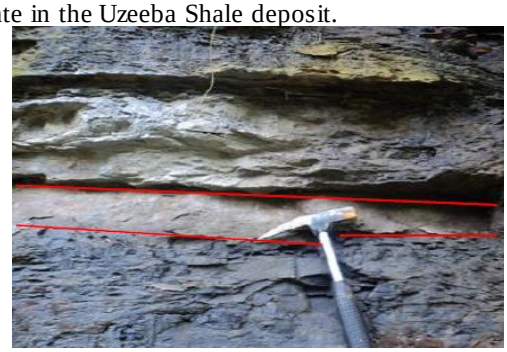
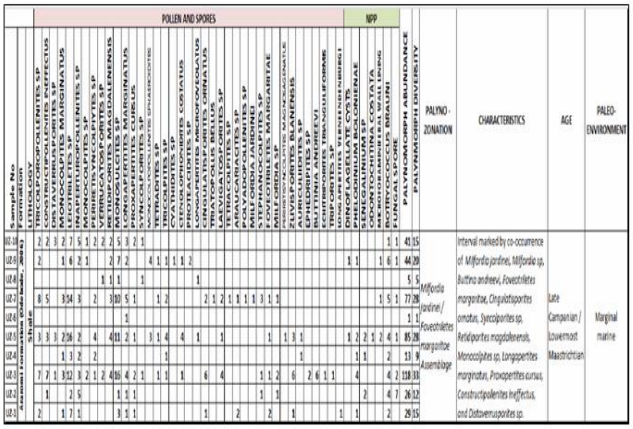


Figure 5: Road-cut exposure of Uzeeba Shale, showing the lighter shale, Ironstone (Red line) and the dark shale (below)

Palynomorph Assemblage Synthesis

The palynological age dating of Uzeeba Shale section is probably carried out for the first time in this study because there is no report of it in literature up to date. The palynomorph content varies from poor to fairly rich and the miospores are well preserved. Pollen and spores recovered vary in term of abundance and diversity, but generally moderate in frequency. Stratigraphy evolution of the Uzeeba Shale is predicated on the pollen assemblage facies (PAF) and the sequence belongs to an informal zone Milfordia jardinei/Foveotriletes margaritae assemblage zone dated Campanian-Lowermost Maastrichtian age. A high resolution palynostratigraphy of the Uzeeba Shale reveals depth to depth evolution of floral which were effectively utilized for age dating and paleoenvironmental reconstruction.

Table 1: Distribution chart of Important Palynomorphs present in the Uzeeba Shale section; Palynozone, Age, and Paleoenvironment of deposition



The deepest part (UZ-1) has total abundance of twenty one and diversity of thirteen taxa. It is composed of important grains such as *Foveotriletes margaritae, Proxapertites cursus, Cingulatisporites ornatus, Longapertites verneendemburgi, Longapertites marginatus* and *Zlivisporites blanensis*. The overlying depth [UZ-2) shows increased frequency in *Inaperturopollenites sp., first uphole appearance of Milfordia sp, Stephanocolpites sp, and Constructipollenites ineffectus*. Some of the forms reported in the underlying depth continue into the present horizon. However, the abundance of Monocolpate pollen is poor both in this horizon and underlying interval compared to the overlying interval.

Depth 3 (UZ-3) can be described as a maximum flooding surface within the observed outcrop section defined by very high abundance and diversity of palynomorphs. The total amount and diversity of pollen recorded is 118 and 33 respectively (Table 1). The characteristic features of this zone are similar to that described by Lawal and Moullade, (1986) for their zone v which shows relatively high percentages of monocolpate pollen grains for the zone. At this depth the monocolpate pollen constitutes 17.79% while *Leiotriletes sp* is 10.17%.

Index fossils which characterize Campanian age strongly manifest here, they include *Distaverrusporites simplex* and *Echitriporites trianguliformis* (Van HoekenKlinkenberg, 1964; Lawal and Moullade, 1986). At this level also is the quantitative appearance of *Buttinia andreevi* (5.08%); *Cingulatisporites ornatus* (5.08%) and *Constructipolenites ineffectus*. Other associated forms that are stratigraphically important are *Periretisyncolpites sp, Stephanocolporites sp* of Kuyl et al, (1955); *Ephedripites sp, Milfordia sp*, appearance of *Syncolporites sp, Tricolporopollenites sp S. 152* of Jardine and Magloire, (1965); *Tetradites sp, Ctenolophonidites costatus* and *Foveotriletes margaritae*. These forms have been reported in the Campanian - Maastrichtian sediments in the works of Van der Hammen, (1954); Vander Hammen and Wijnistra, (1964); Van HoekenKlinkenberg, (1964); Lawal, (1982); Lawal and Moullade, (1986); Ogala et al, (2009); Ola-Buraimo and Adeleye, (2010); Ola-Buraimo, (2012); Ikhane et al, (2011) for the Afowo Formation; Ola-Buraimo et al, (2012) for the Arimogija-Okelese Shale, and Ola-Buraimo and Akaegbobi, (2013b) for the Nkporo Shale in Anambra Basin, Nigeria.

Depth 4 (UZ–4) does not contain high amount of pollen and spores but characterized by diagnostic form like *Auriculiidites reticularis*. This index fossil was used by Jan Muller et al, (1987) to characterize zone 11 of the northern South America dated Campanian to Lowermost Maastrichtian. Other forms present are *Periretisyncolpites sp, Monocolpites marginatus, Leiotriletes sp, Inaperturopollenites sp* and dinoflagellate cysts such as *Phelodinium bolonienae*a and *Senegalinium sp*. The presence of dinoflagellate cysts such as *Phelodinium bolonienae* and *Senegalinium sp* are indicative of shallow marine environment (Ojo and Akande, (2000); Schrank, 1984; Oloto, 1987; Edet and Nyong, 1994; Ola-Buraimo and Adeleye, 2010).

Depth 5 (UZ – 5) is richly fossiliferous and may suggest a flooding surface. Forms with maximum development are *Leiotriletes sp, Monocolpate pollen, Tricolporopollenites sp, Ctenolophonidites costatus, Zlivisporites blanensis, Distaverrusporites simplex, Periretisyncolpites sp,* and *Retidiporite smagdalenensis* (See Figure 4). Pollen grains with significant appearance are *Auriculiidites reticularis, Tetradites sp, Foveotriletes margaritae;* continuous occurrence of *Phelodinium bolonienae, Senegalinium sp* and relative quantitative appearance of *Monocolpopollenites sphaeroidites*. The *Monocolpopollenites sphaeroidites* was described to disappear in the zone v of Lawal and Moullade, (1986); though it is in contrary to our observation in this study but it does not show continuous occurrence in the outcrop section analyzed for this study. Therefore, it significantly indicates a Campanian age for the interval. Another new form that emerged at this level is *Periretisyncolpites magnosagenatus* (Kiese and Jan du Chene, 1977) which is here suggested to be stratigraphically important for Campanian sediments. The continuous occurrence of dinoflagellate cysts is indicative of marginal marine deposit.

Depth 6 (UZ–6) stratigraphically overlies Depth 5 (UZ–5) and underlies Depth 7 (UZ–7). Only one grain of *Longapertites marginatus* was derived from it. The poor recovery of palynomorph may be due to relative drop in sea level and unfavorable ecological factors associated with it. This regime may as well be well oxidized which may be another factor that did not permit fossilization of pollen and spores apart from their poor vegetation in the environment.

The ecological situation is different at Depth 7 (UZ–7) characterized by relatively rich miospores. The features outlined in the underlying intervals are still prominent especially with quantitative occurrence of monocolpate, *Leiotriletes sp, Tricolporopollenites sp, Cingulatisporites ornatus, Longapertites marginatus* and *Retidiporites magdalenensis*. Interestingly is the continuous occurrence of *Stephanocolporites sp* of Kuyl et al, (1955); *Milfordia jardinei, Tetradites sp, Milfordia sp and Proxapertites cursus* which depict Campanian age. New forms that appear at this level are *Striatopollis bellus, Tetracolpites sp, Polyadopollenites sp* and *Trichotomosulcites sp*.

Depth 7 (UZ–7) marks the top of Campanian in the Uzeeba Shale section based on the top occurrence of *Milfordia jardinie,*

Cupanieidites reticularis and appearance of *Trichotomosulcites sp*. Some of these forms have been described not to exceed Campanian age (Ola-Buraimo, 2012; Ola-Buraimo and Akaegbobi, 2013b). The upper segment of the Uzeeba Shale section (Depths 8-10) is not different in term of palynomorph facies from the underlying sequence. The Depth 8 is not rich in miospores but Depth 9 (UZ–9) is relatively richer in them. A marker fossil that prominently evolved here is *Proteacidites sp* which significantly mark Maastrichtian age (Jardine and Magloire, 1965; Germeraad *et al*, 1968). Also, *Monocolpopollenites sphaeroidites* which tend to mark the top of the *Auriculiidites reticularis* zone 7 erected by Jan Muller *et al*, (1986) for South America is also present in the upper unit. Maastrichtian age forms that characterize this depth are *Tetradites sp, Monocolpites marginatus;* high frequency *of monocolpate pollen, Ctenolophonidites costatus* and *Retidiporites magdalenensis*.

The topmost sample 10 is composed of pollen such as *Constructipollenites ineffectus, Monosulcites sp, inaperturopollenites sp, Periretisyncolpites sp, Longapertites marginatus, Proxapertites cursus* and *Syncolporites sp*. The spores present are *Distaverrusporites simplex,* and *Leiotriletes sp*. The recovered pollen at the top are mainly of Maastrichtian age (see Table.1).

Therefore, the stratigraphic relationship of the assemblages reveal quite an interesting geologic age that has never been reported for any stratigraphic section in the Dahomey Basin, Nigeria. The lower part of the Uzeeba Shale section is marked by the co-occurrence *of Milfordia jardinei, milfordia sp, Cupanieidites reticularis, Stephanocolporites sp, Syncolporites sp, Distaverrusporites simplex, Ephedripites sp, Buttinia andreevi, Echitriporites triangulatus, Auriculiidites reticulates, Tetradites sp,* and *Ctenolophonidites costatus* which are indicative of Campanian age.

In this study the presence of the Campanian /Maastrichtian boundary is based on the last uphole appearance of *Milfordia jardinei, Cupanieidites reticularis, Tetradites sp*, and quantitative occurrence of monocolpate pollen. Though Maastrichtian marker forms reported by Lawal, (1982); Lawal and Moullade, (1986); Ogala et al, (2009), Ola-Buraimo and Adeleye, (2010) such as *Monocolpites marginatus, Buttinia andreevi, Retidiporites magdalenensis, Periretisyncolpites sp, Foveotriletes margaritae* and *Constructipollenites ineffectus* may actually have evolved during the Campanian period in some sediments in Nigeria Basin. Such observation was seen in the work of Lawal and Moullade, (1986); Ola-Buraimo, (2012). The upper section (Depths 8-10) is here assigned Lowermost Maastrichtian age defined by co-occurrence of *Proteacidites sp, Retidiporites magdalenensis, Monocolpites marginatus Ctenolophonidites costatus, Longapertites marginatus, Periretisyncolpites sp, Syncolporites sp, Proxapertites cursus,* and *Constructipollenites ineffectus (*Table 1).

Palynomorph assemblage of the Uzeeba Shale is comparable with sequence IV of Senegal attributed to Campanian (Jardine and Magloire, 1965); similar in part to floral assemblages reported by Kiese, (1966) on Casamanea region in the Dakar area of Senegal dated Campanian-Maastrichtian. It is also comparable with an interval reported from Brazil (Regali et al, 1974) dated Campanian to Lowest Maastrichtian age and South America (Muller *et al*, 1986). It is strongly comparable with some sediments within the basin (Ikhane et al, 2011); and sediments outside the basin (Ola-Buraimo, 2012) for the Tuma-1 well, located in Bornu Basin, Nigeria; for the Nkporo Shale in Anambra Basin, Nigeria also dated Campanian to Lowest Maastrichtian age (Ola-Buraimo and Akaegbobi, 2013b). In terms of age correlation and lithology the Uzeeba Shale can be described to be laterally equivalent to Nkporo Shale in the adjacent Anambra Basin, southeastern Nigeria. Thus, the Uzeeba Shale is conveniently dated Campanian–Lowermost Maastrichtian age.

Conclusion

Palynological research was carried out for the first time on Uzeeba Shale outcrop along Ifon-Uzeeba road, Edo State, Nigeria. A Campano-Maastrichtian age revealed in this study is the first of its kind reported in Dahomey Basin, Nigeria. This is correlable with Nkporo Shale in the adjacent Anambra Basin, southeastern Nigeria both in terms of palynomorph assemblage, age and lithofacies.

The pollen assemblage facies (PAF) that characterize the lower part dated Campanian age are *Milfordia jardinei, Milfordia sp, Cupanieidites reticularis, Tetradites sp*, and quantitative occurrence of monocolpate pollen. The upper segment dated Lowermost Maastrichtian is marked by co-occurrence of *Proteacidites sp, Retidiporites magadalenensis,* low frequency *of Monocolpites marginatus, Ctenolophonidites costatus, Longapertites marginatus, Periretisyncolpites sp, Trichotomosulcites sp, Syncolporites sp, Proxapertites cursus* and *Constructipollenites ineffectus*. The Uzeeba Shale is deposited in a marginal marine setting characterized by co-occurrence of dinoflagellates, microforaminiferal wall lining and algae.

Acknowledgement

The authors are greatly indebted to Palystrat Limited for the provision of materials used for the preparation and analysis of the samples under the microscope.

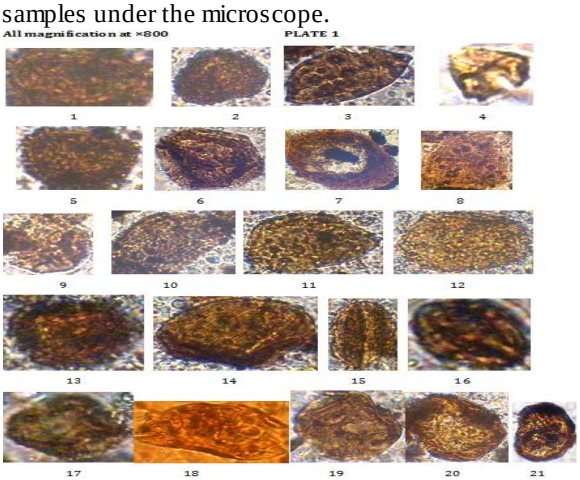


Plate 1

1 Monocolpites sp
2, 5, 8 Foveotriletes margaritae
3 Monosulcites sp
4 Proteacidites sp
6 Phelodinium sp
7 Forma T
9 Tricolpites sp
10 Ephedripites sp
11 Longapertites marginatus
12, 17 Tetraporites sp
13 Constructipollenites ineffectus
14 Longapertites verneendenburgi
15, 18 Monosulcites sp
16 Tricoporopollenites sp
19 Cf.Ulmoidipites krempi
20 Araucariacites sp

21 Monocolpopollenites sphaeroidites

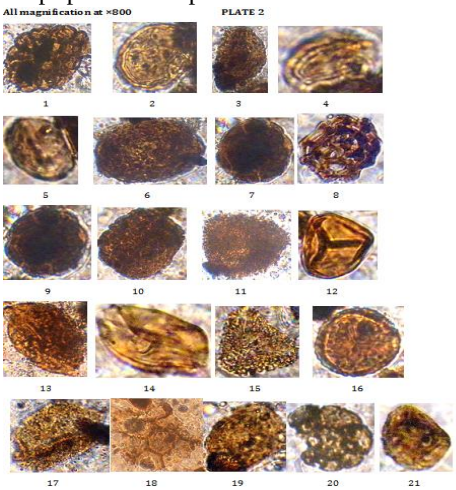


Plate 2

1 Polyadopollenites sp
2 Verrucatosporites sp
3 Periretisyncolpites sp
4, 5 Monocolpites marginatus
6 Milfordia jardinei
7, 9 Stephanocolpites sp
8 Buttinia andreevi
10 Phelodinium sp
11 Forma B
12 Leiotriletes sp
13, 14 Monosulcites sp
15Cupanieidites reticularis
16Cingulatisporites ornatus
17, 19 Retidiporites magdalenensis
18, 20 Microforaminiferal wall lining
21Phelodinium bolonienae

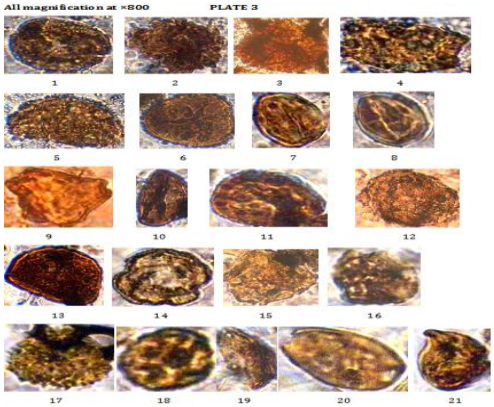


Plate 3

1 Retitricolpites sp
2 Verrucosisporites sp
3 Cicatricosisporites sp
4 Retidiporites magdalenensis
5 Longapertites microfoveolatus
6 Leiotriletes sp
7, 8 Psilatricolporites sp
9 Tricolporopollenites sp S. 152 Jardine and Magloire, 1965
10 Monosulcites sp
11 Monocolpopollenites sphaeroidites
12 Indeterminate pollen
13 Periretisyncolpites sp
14 Stephanocolpites sp
15 Leiotriletes sp
16 Ulmoideipites krempi
17 Echitriporites trianguliformis
18 Ctenolophonidites costatus
19 Monosulcites sp
20 Retidiporites magdalenensis
21 Auruculiidites sp

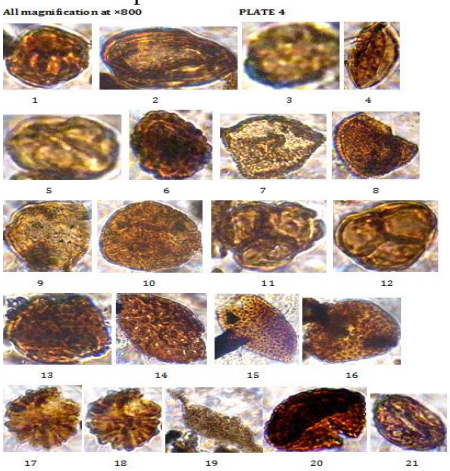


PLATE 4

1 Stephanocolporites sp in Kuyle
2 Milfordia sp
3 Retidiporites magdalenensis
4 Tricolpites sp
5 Monocolpites marginatus
6 Cingulatisporites ornatus
7 Cf Aquilapollenites sp
8, 9, 10 Foveotriletes margaritae
11 Tetradites sp
12 Tricolpites sp
13 Perfotricolpites sp
14, 15 Periretisyncolpites sp
16 Distaverrusporites sp
17 Ctenolophonidites costatus
18 Ctenolophonidites costatue (Phase contrast)
19 Paleocystodinium golzowense
20 Periretisyncolpites giganteus
21 Monocolpites marginatus

References

Adegoke O.S. (1969): Eocene Stratigraphy of Southern Nigeria. *Bull. Bur. Rech. Geol. Min. Mem. no. 69, p. 23 – 48.*

Adeigbe O.C., Ola-Buraimo A.O., and Moronhunkola, A.O., (2013): Palynological characterization of the Tertiary offshore Emi-1 well, Dahomey Basin, southwestern Nigeria. *International Journal of Scientific and Technology Research, vol.2, issue 1, p. 58-70*

Adeleye D.R., (1975): Nigerian Late Cretaceous Stratigraphy and Paleogeography. *American Association of Petroleum geologists Bulletin, vol. 59, no. 12, p. 2302 -2313*

Ayinla, H.A., Ola-Buraimo A.O., Adeigbe, O.C., Bankole, S.A., and Adebowale, M., (2013): Biostratigraphy and high resolution paleoenvironmental reconstruction of part of Kemar-1 well, Bornu Basin, northeastern Nigeria. *Journal of Research in Environmental Science and Toxicology, vol. 2(3), p. 53-63.*

Bankole, S.I., Schrank, E. Erdtmann, B.D and Akande, S.O. (2006): Palynostratigraphic Age and Paleoenvironments of the newly exposed section of the Oshosun Formation in the Sagamu Quarry, Dahomey Basin. *Nigerian Association of Petroleum Explorationists Bulletin*, vol. 19, 1 p. 25 - 34

Edet J.J., and Nyong, E.E., (1994): Palynostratigraphy of Nkporo Shale exposures (Late Campanian-Maastrichtian) on the Calabar Flank, SE Nigeria. *Review of Paleobotany and Palynology, vol. 80, p. 131-147.*

Germeraad, J. H., Hopping, C.A. and Muller, J., (1968): Palynology of Tertiary sediments from tropical areas. *Rev. Paleobot. Palynol., vol. 6, p. 189-348.*

Ikhane, P.R., Akintola, A.I., Ola-Buraimo, A.O., Oyebolu, O.O., Akintola, G.O., and Adesanya, B.T., (2012): Palynology and paleoenvironmental reconstruction of the Early Maastrichtian Afowo Formation, Dahomey Basin, southwestern Nigeria. *Science Journal of Environmental Engineering Research, vol. 2012, issue 2, p. 1-8*

Imeokparia E.G. and Onyeobi T. U.S. (2007): Geochemical and Depositional Characteristics of Maastrichtian shales in parts of southwestern Nigeria. *Journal of Mining and Geology,* vol. *43, no. 2, p. 167-174*

Jan Du Chene, R.E., (1977): Some new pollen species of the Upper Maastricthtian Tar Sand, Abeokuta Formation. Southern Nigeria. *Reveu. Espania Micropaleontologie, vol. IX, n. 2, p. 191-201.*

Jan Muller, Estelade De Di Giacomo, and Anton W.V., (1987): A Palynological Zonation for the Cretaceous, Tertiary and Quaternary of Northern South America. *American Asscociation of Stratigraphy Palynologists Contribution Series 19, p. 16-33.*

Jardine, S. and Magloire, I., (1965): Palynologie et stratigraphic du Cretace des Basins du Senegal et de Cote d' Ivoire ler Coll. *Memoire du. Bureau RecherchesGeologiques et Minieres, vol. 32, p. 187-245.*

Kieser, G., (1966): Quelques aspect particulars de la palynologie du Cretace superieur du Senegal. Rev. *Palaeobot. Palynol., vol. 5, no. ¼, p. 199-210.*

Kogbe, C.A. (1989a): The Cretaceous and Paleogene Sediments of Sothern Nigeria In: C. A. Kogbe (ed) Geology of Nigeria. *Rock View International Tour Onyx Paris Cedix 13 France, p. 325 – 334.*

Kogbe, C.A. (1989b): Paleogeographic History of Nigeria from Albian Times. In: C. A. Kogbe (ed) Geology of Nigeria. *Rock View International Tour Onyx Paris Cedix 13 France, p. 257 – 275.*

Kuyl, O.S., Muller, J. and Waterbolk, H.T.H (1955): The application of palynology to oil geology with reference to Western Venezuela. *Geoloie en Mijnbouw, N.S., vol.17, no. 3, p. 49-76.*

Lawal, O., (1982): Biostratigraphiepalynologiqueespaleoenvirunmens des formations Cretacee de la Haute- Benoue, Nigeria mord-oriental. *These-3-cycle, Univ. Nice, 218p.*

Lawal, O., and Moullade, M., (1986): Palynological biostratigraphy of the Cretaceous sediments in the upper Benue Basin, N.E. Nigeria. *Revue micropaleontologie, vol. 29, n.1, p. 61 – 83.*

Mebradu, (1988): Stratigraphy and Palynology of Auchi sediments, Southwestern Nigeria. *Geophytology*. vol. 18 no 1, p. 41 – 46.

Morley, R.J., (1995). Biostratigraphic characterization of systems tracts in Tertiary sedimentary basins. *Indonasian Petroleum Association, Proceedings of the International Symposium on sequence stratgraphy in SE Asia, p. 49-71.*

Murat, R.C. (1972) Stratigraphic and paleogeography of the Cretaceous and Lower Tertiary sediments in southern Nigeria. In: Dessauvagie, T.F.J. and Whiteman, A.J. (eds) Africa Geology. *University of Ibadan Press, p. 251 – 266.*

Nton M.E., Ezeh F.P. and Elueze A.A. (2006): Aspects of Source Rock Evaluation and Diagenetic History of the Akinbo Shale, Eastern Dahomey Basin. *Nigerian Association of Petroleum Explorationists Bulletin. vol. 19, no. 1, p. 35 - 49*

Petters, S.W. (1982): Central West African Cretaceous – Tertiary Benthic Foraminifera and Stratigraphy. *Palaeontograhica Abt A Bd. 179: Lfg. 1 – 3, p. 24 – 25.*

Ogala, J.E., Ola-Buraimo A.O., and Akaegbobi, I.M., (2009): Palynological investigation of the Middle- Upper Maastrichtian Mamu Coal facies in Anambra Basin, Nigeria. *World Applied Sciences Journal,* vol. 7, *no. 12, p. 1566-1575.*

Ojo, O.J., and Akande, S.O., (2000): Depositiona environments and diagenesis of the carbonate facies of Dakul and Jessau formations in the Yola Basin N. E Nigeria. Implications reservoir potential. *Nigeria Association of Petroleum Explorationists Bulletin, vol. 15, p. 47-50.*

Ojo O.J and Akande S.O (2006): Sedimentological and Palynological studies of the Patti Formation, southeastern Bida basin, Nigeria: Implications for Paleoenvironments and. *Nigerian Association of Petroleum Explorationists Bulletin. vol. 19, no. 1, p. 61 – 77*

Okosun, E.A. (1990): A review of the Cretaceous stratigraphy of the Dahomey Embayment, West Africa. - *Cretaceous Research, vol. 11, p. 17-27.*

Olabode S.O. (2006): Siliciclastic slope deposits from the Cretaceous Abeokuta Group, Dahomey (Benin) Basin, southwestern Nigeria. *Journal of African Earth Science,s vol.46* p. *187–200.*

Ola-Buraimo A.O. (2012): Lithostratigraphy and Palynostratigraphy of Tuma-1 well, Bornu Basin, northeastern Nigeria. *Journal of Biological and Chemical Research, vol. 29, no.2, p. 206-223.*

Ola-Buraimo A.O., and Adeleye M., (2010): Palynological characterization of the Late Maastrichtian Ute Coal measure deposit, Southwestern Nigeria. *Science Focus, vol. 15, n. 2, pp. 276-287.*

Ola-Buraimo, A.O., and Akaegbobi, I.M., (2013a): Palynology, an important tool in evaluating sea level changes, paleoenvironment and paleoclimatic conditions in geologic time. *International Journal ofEngineering Research and Technology, vol. 2, issue 3, p. 1-29.*

Ola-Buraimo, A.O., and Akaegbobi, I.M., (2013b): Palynological and paleoenvironmental investigation of the Campanian-Lowermost Maastrichtian Asata/Nporo Shale in the Anambra Basin, southeastern Nigeria. *British Journal of Applied Sciences and Technology, vol. 3(4), p. 898-915.*

Ola-Buraimo, A.O., Oluwajana, O.A., Olaniyan, A., and Omoboriowo, A.O., (2012): Palynological investigation of a type section of Early Maastrichtian Arimogija-Okeluse Shale sequence, Dahomey (Benin) Embayment, southwestern Nigeria. *International Journal of Science and Emaerging Technologies, vol. 3, no. 1, p. 37-45.*

Oloto I.N., (1987): Maastrichtian dinoflagellate cyst assemblage from the Nkporo shale on the Benin Flank of the Niger Delta. *Review of Palaeobotany and Palynology, 57, pp. 173-186.*

Petters, S.W (1980): Biostratigraphy of Upper Cretaceous Foraminifera of the Benue Trough, Nigeria. *Jour. Foram. Res., 10: 191 – 204*

Regali, M.S., Uesegui N., and Sanios A.S., 1974: Palinologia dos sedimentos mese- cenozoios do Brazil. *Bol. Tec Petrobro , vol. 17, p. 177-191.*

Simmons, M.D.,Bidgood, P. Brenac,P.d. Crevello, J.J. Lambiase, and C.K.Morley, (1999): Microfossil assemblages as proxies for precise palaeoenvironmental determination – An example from Miocene sediments of Northwest Borneo, in R. W. Jones and M.D. Simmons, eds., Biostratigraphy in Production and Development Geology. *Geological Society Special Publication, no. 152, 219p*

Van der Hammen, T., 1954: El desarrolla de la flora Colombiana en los periodos geologieos 1, Maestrichtiano basia Terciaro mas inferior. *Buletin Geologico (Bogata), vol. 2, n. 1, p. 49-106.*

Van der Hammen, T., and Wijmstra T.A., (1964): A palynological study of the Tertiary and Upper Cretaceous of British Guians. *Leidese Geologische Mededelingen, vol. 30, p. 209-231.*

Van Hoeken-Klinkenberg, P.M.J., (1964): A Palynological Investigation of some Upper Cretaceous sediments in Nigeria. *Pollen et Spores, vol. 6, no. 1, p. 209-231.*