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

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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, Tetradiites 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, Retidiportites magdalenensis*, low frequency of *Monocolpites marginatus*, *Cenolophonidites 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 boloniense, Senegalinitium sp, Paleocysttodinium golzhownse*, microforaminferal wall lining and *Botryococcus braunii* which are known to be environmentally significant for transitional environment.

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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–Maastrichtian 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 shaly 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 undertaken 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](image)

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)](image)
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 underlining 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 triangulariformis (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 Constructipollenites ineffectus. Other associated forms that are stratigraphically important are Periretisyncolpites sp, Stephanocolpites sp of Kyul et al., (1955); Ephedrites sp, Milfordia sp, appearance of Syncolporites sp, Tricolporopollenites sp S. 152 of Jardine and Magloire, (1965); Tetradites sp, Ctenolophidites 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 Wijnnistra, (1964); Van HoekenKlinkenberg, (1964); Lawal, (1982); Lawal and Moullade, (1986); Ogala et al, (2009); Ola-Buraimo and Adeleye, (2010); Ola-Buraimo, (2012); Ikhan et al, (2011) for the Afowo Formation; Ola-Buraimo et al, (2012) for the Arimognija-Okelese Shale, and Ola-Buraimo and Akaegbohi, (2013b) for the Nkpwo Shale in Anambra Basin, Nigeria.

Depth 4 (UZ–4) does not contain high amount of pollen and spores but characterized by diagnostic form like Auriculitidis 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, Leiotorites sp, Inaperturopollenites sp and dinoflagellate cysts such as Phelodinium bolonionae and Senegalinium sp. The presence of dinoflagellate cysts such as Phelodinium bolonionae and Senegalinium sp are indicative of shallow marine environment (Ojo and Akande, (2000); Schrank, 1984; Olotu, 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 Leiotorites sp, Monocolpate pollen, Tricolporopollenites sp, Ctenolophidites costatus, Zlivisporites blanensis, Distaverrusporites simplex, Periretisyncolpites sp, and Retidiporite smagdalenensis (See Figure 4). Pollen grains with significant appearance are Auriculitidis reticularis. Tetradites sp, Foveotriletes margaritae; continuous occurrence of Phelodinium bolonionae, Senegalinium sp and relative quantitative appearance of Monocolpopollenites sphaerooides. The Monocolopollenites sphaerooides 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, Leiotorites sp, Tricolporopollenites sp, Ctenolophidites ornatus. Longapertites marginatus and Retidiporites madgalenensis. Interestingly is the continuous occurrence of Stephanocolpites sp of Kuy 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, Tetraocolpites 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 jardinei,
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 Proteacidades sp which significantly mark Maastrichtian age (Jardine and Magloire, 1965; Germerraad et al., 1968). Also, Monocolpopollenites sphaeroidites which tend to mark the top of the Auricularidites 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 Tetradies 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, inaperturapollenites 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, Tetradies 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 Proteacidades 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 Casamancea 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 comparable 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, Tetradies sp, and quantitative occurrence of monocolpate pollen. The upper segment dated Lowermost Maastrichtian is marked by co-occurrence of Proteacidades sp, Retidiporites magdalenensis, 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.

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**Plate 1**

1. Monocolpites sp
2. 5, 8 Foveotriletes margaritae
3. Monosulcites sp
4. Proteacidades sp
5. Phelodinium sp
6. Forma T
7. Tricolpites sp
10. Ephedritpes sp
11. Longapertites marginatus
12, 17 Tetraporites sp
13. Constructipollenites ineffectus
14. Longapertites verneendenburgi
15, 18 Monosulcites sp
16. Tricoporopollenites sp
19. Cl.Ulmoipolens krempi
20. Araucaricites 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
15 Cupanieidites reticularis
16 Cingulatisporites ornatus
17, 19 Retidiporites magdalenensis
18, 20 Microforaminiferal wall lining
21 Phelodinium bolonienae

Plate 3
1 Retitricolpites sp
2 Verrucososporites sp
3 Cicatricosporites sp
4 Retidiporites magdalenensis
5 Longapertites microfoveolatus
6 Leiotriletes sp
7, 8 Psilatricolporites sp
9 Tricloporopollenites 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

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 Tetradietes sp
12 Tricolpites sp
13 Perforitricolpites sp
14, 15 Periretisyncolpites sp
16 Distaverrusporites sp
17 Ctenolophonidites costatus
18 Ctenolophonidites costatus (Phase contrast)
19 Paleocystodinium golzowense
20 Periretisyncolpites giganteus
21 Monocolpites marginatus

References


