

Biostratigraphy of section of Murshe-1 Well, Bornu Basin, Northeastern Nigeria

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ABSTRACT

Biostratigraphic work using palynology was undertaken in order to re-assess the lithofacies, chronostratigraphy and paleoenvironments of deposition of sediments in Murshe-1 well, Bornu Basin, northeastern Nigeria. Two hundred and ninety ditch cutting samples obtained from the exploratory well Murshe-1 located in Bornu Basin were used for lithological description. Out of these, twenty one (21) samples were selected at 27.4m interval for palynological analysis. ~~Samples were analyzed under microscope for litho-description while the selected samples were used for palynological slide preparation.~~ The latter were taken through sediment digestion and floatation of macerals. Four known formations (Gongila, Fika, Gombe and KerriKerri) are encountered in the Murshe-1 well and ~~Various lithofacies relationship is present and~~ five palynological zones ~~were~~ are established.

The palynological zones established are *Triorites africaensis* assemblage zone 1 characterized by the co-occurrence of *Classopollis brasiliensis*, *Triorites africaensis*, and *Retimonocolpites* sp; dated Turonian ~~age~~. *Syncolporites* sp/*Milfordia* sp assemblage zone 2 is dated Senonian to Campanian based on the assemblage of *Syncolporites* sp, *Milfordia* sp, *Mauritiidites crassibaculatus*, and *Aequitridites* sp. The *Spinizonocolpites baculatus* assemblage zone 3 is defined by the co-occurrence of *Longapertites marginatus*, *Periretisyncolpites* sp, *Trichotomosulcites* sp, *Auriculiidites* sp, *Foveotriletes margaritae*, *Spinizonocolpites baculatus*, *Monocolpites marginatus*, *Striatopollis bellus* and *Retidioporites magdalenensis*; depictive of Maastrichtian age. The *Proxapertites cursus* assemblage zone 4 dated Paleocene, is distinguished from the older Maastrichtian sediment based on the paucity of palynomorphs and the appearance of *Verrutricolporites* sp. Zone 5 ~~(70-315m)~~ is dated Eocene-~~Younger-Recent~~ based on the co-occurrence of *Monoporites annulatus*, *Retibrevitricolporites protrudens*, *Longapertites vernendenburgi* and *Lycopodium phlegmaria*.

Key Words: Bornu Basin, Palynology, Lithostratigraphy, Biostratigraphy, Chronostratigraphy, Palynological zone, Marginal marine.

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1 Introduction

Lithostratigraphy and biostratigraphy study of the Murshe-1 well was carried out to contribute to the Bornu Basin is imperative in understanding of the stacking pattern and chronostratigraphy framework of the Bornu basin, northeastern Nigeria. Palynological technique was employed to investigate the lithostratigraphy and biostratigraphy of Murshe -1 well in Bornu Basin, northeastern Nigeria. Intensive stratigraphic studies have not yet been carried out on this basin compared to other basins such as the Niger Delta, Anambra Basin, Benue Trough and Dahomey Basin in Nigeria. Previous work on the stratigraphic study of the basin include Adegoke et al., (1978); Odusina et al., (1983); Avbovbo et al., (1986); Olugbemiro, (1997); Adegoke, (2012). Other published works on the basin include Poppo et al, (1986); they who investigated the Upper Cretaceous Gongila and Pinginga Formations using ammonite zones in the Upper Cenomanian-Lower and Middle Turonian sediments.

Among the recent geologic studies on the Bornu Basin include differentiations of Chad Formation into members and their associated environments of deposition (Ola-Buraimo, 2005); granulometric studies of Kerikerri sandstone (Ola-Buraimo, 2009); Palynological investigation of Bima Formations dated Albian-Lower Cenomanian (Ola-Buraimo and Boboye, 2011); detailed lithofacies and palynological study of Bima Group and age definition of the formations within (Ola-Buraimo and Oluwajana, 2012); Biostratigraphy and paleoenvironment of Fika Formation dated Turonian to Coniacian – Santonian on the basis of miospores and foraminifera forms (Adegoke, 2012) and lithostratigraphy and palynostratigraphy of Tuma-1 well with establishment of seven zones ranging in age from Cenomanian-Late Miocene /Pliocene (Ola-Buraimo, 2012). Despite the amount of work done on the basin, stratigraphic relationship among Formations have not been well articulated and intensive palynological study on Gongila Formation and other units is still inadequate. Therefore, this study is aimed to augment and reassess both lithological and relative stratigraphic age and paleoenvironments of deposition of sediments encountered in Murshe-1 well stratigraphic section.

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2 Geologic Setting

Geologic investigation of the Bornu Basin started with Falconer, (1911); Carter et al (1963) and Barber, (1965) and Reyment, (1965). The formation of Bornu Basin was predicated on third and failed arm of triple junction formed during the Early Cretaceous in response to opening of the South Atlantic (Wright, 1968; Burke et al, 1972; Olade, 1975). Other authors that supported this theory include Genik, (1992, 1993), Kings, (1950), and Avbovbo et al, (1986); Fairhead and Binks, (1991).

Tectonic framework of Bornu Basin and its evolution was divided into four phases:

- Phase 1- Pan-African crustal consolidation (750-550Ma),
- Phase 2- Early rift stage (130-95Ma),
- Phase 3- Late rift stage (98-75Ma), and
- Phase 4- Post rift stage (66-0Ma).

These phases were described to have led to the cessation and collapse as sub-crustal swells, associated with folding, faulting, sedimentation, erosion and volcanism. Other—Another associated event is stress redistribution and initiation of secondary situation; followed by Tertiary-Recent event characterized by continental-lacustrine sedimentation and volcanism (Avbobvo et al., 1986). The geologic evolution of Bornu Basin and Benue Trough are related (Odusina, et al., 1983).

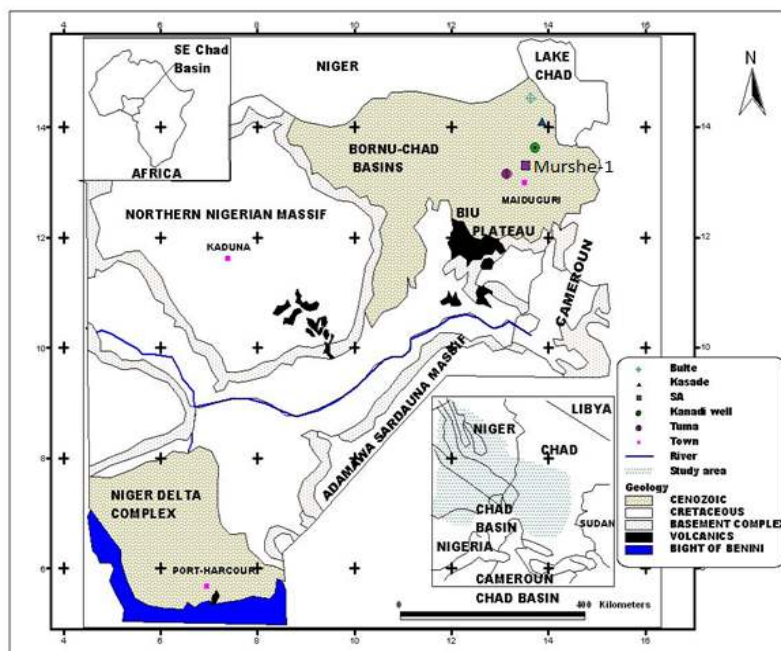
The stratigraphy of Bornu Basin was described to be divided into group and formations ranging in age from Albian to Recent (Adegoke et al., (1978); ~~Avbovbo et al., (1980);~~ Petters, (1981), Whiteman, (1982); Okosun, (1992, 1995); Ola-Buraimo and Oluwajana, (2012)); ~~overlain by Gongila Formation, Fika, Gombe, Kerikerri and Chad Formations.~~ Bima Formation is the oldest stratigraphic unit deposited under continental environment. The formation is diachronous and ~~is~~ Albian-Turonian ~~in~~ age (Carter et al, 1963). Lithologically, it was described to be poorly sorted, sparsely fossiliferous, thickly bedded, cross stratified; sand size varies from feldspathic coarse to conglomerate.

Avbovbo et al, (1986) identified marine shale sequence deposited over localized conglomerates and poorly sorted alluvial deposits lying unconformably on the basement. The distinct continental deposit (conglomerate) is termed the Pre-Bima ~~and is~~ dated Albian ~~age~~-(Oti, 1990; Ola-Buraimo and Boboye, 2011; Ola-Buraimo and Oluwajana, 2012). The Gongila Formation is a transitional sequence that lies in-between the underlying marine shale of Bima Formation and typical marine setting of the overlying Fika Formation.

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Figure 1: Geological map of Nigeria showing the location of Bornu Basin and the studied well; upper inset shows the larger Chad Basin in Africa, while the lower inset describes the lithostratigraphy of the area (modified after Genik,



3 MATERIALS AND METHODS

About 290 ditch cutting samples ranging in depth from 70-1930m from the Murshe-1 well were arranged serially in order of depth. The samples were initially washed in order to remove the drilling mud present. Lithologic description of samples was undertaken by observation of the samples under the microscope and by considering textural parameters which were compared with standard monograph plates of Western Atlas. Textural features considered include grain size, shape in term of roundness and angularity. Other parameters include sorting, colour, lithology, post depositional effect such as ferruginization; fossil contents and presence of accessory minerals. Dilute hydrochloric acid was used to test for the presence of carbonate in the samples. Samples for palynological purpose were selected at 27.4m (90ft) interval, thoroughly washed with distilled water through a 5µm polyester sieve in order to remove drilling mud contaminants and then dried for 24hrs at 50°C.

About ten (10) grams of each sample was digested with 10% Hydrochloric acid (HCl) acid to remove carbonates. The samples were later soaked in 60% Hydrofluoric acid (HF) for 24hrs to digest the silica. The content was sieve-washed (5µm) with water and later oxidized in Schulze solution (mixture of Nitric acid and Potassium chloride) for 30minutes; washed with 10% Potassium hydroxide, followed by heavy liquid separation with Zinc bromide (Zn₂Br₄) through centrifuging. The aliquots were dispersed with Polyvinyl alcohol, dried and then mounted on glass slides with Depex (DPX) mountant. The biostratigraphic study involved the analysis of pollen, spores, dinoflagellates and algae counts under the microscope for chronostratigraphic biozonation. Important palynomorphs were photographed using Nikon Coolpix P6000 digital camera.

4.0 RESULT AND DISCUSSION

4.1 Lithostratigraphy

Four known formations in the basin are marked out in this study on the basis of correlation with lithological ages within the stratigraphic interval of Murshe-1 well. The formations encountered in the well are discussed below (Figure 2).

4.1.1 Gongila Formation

The Gongila Formation is characterized at the base by black, fissile, calcareous and fairly ferruginised shale sequence (1880-1930m). The 50m thick marine shale is overlain by intercalated sand and shale. The light grey sandy shale is defined by fine to medium sand grains, well sorted sediment. The 60m heterolith facies (1820-1880m; Figure 2) forms the uppermost part of the Gongila Formation, deposited in a prograding deltaic setting in this well. It is remarkable that volcanic intrusive reported by earlier workers ([references](#)) in this formation is not visible in the studied well, therefore, it is suggested that the intrusion was a local effect.

4.1.2 Fika Shale

This formation varies in depth from 620-1820m with an estimated thickness of 1200m. This seems to be the greatest thickness compared to the work of Carter et al, (1963); Okosun (1995) and Olugbemiro (1997); but it compares favourably with the thickness derived from seismic data of [avbovbo](#) [Avbovbo](#) et al, (1986). The Fika Formation lies unconformably on the Gongila Formation (~~Ola-Buraimo, 1990~~). The formation is not entirely shaly but rather shows intercalated gypsum at the lower to middle part of the sequence; while the middle part is characterized by silty shale deposited between interval 840-890m (50m thick). The uppermost part is a shale facies, shows rare coarse to pebble sand grains; calcareous and rare occurrence of gypsum serves as accessory mineral (Figure 2). The paleoenvironment of deposition is suggested to be marginal to open marine while transporting medium was of relatively high energy and erosive in nature (turbidity currents) which might be responsible for clast particles present in the shale ~~sediment~~ during deposition.

4.1.3 Gombe Formation

The Gombe Formation occupies interval 385-620m with a thickness of 235m. The formation is characterized by a basal sandstone unit of about 30m (590-620m). The sand is a brownish coloured conglomerate, fine to pebbly in grain size, and very poorly sorted. The overlying interval 385-590m contains light brown to light grey bulky claystone with an interbed of sand (Figure 2). The environment of deposition is suggested to be of distal continental to proximal fluvial paleoenvironment.

4.1.4 Kerikerri Formation

The Kerikerri Formation is Eocene in age, lacustrine at ~~the~~ upper part was deposited in a lacustrine to proximal fluvial environment of deposition. The lower sandy part is from depth 280-320m (40m thick). The sand is milky to pinkish in colour, conglomeratic in nature; poorly sorted with grain size varies-varying from medium to pebble, subangular to rounded, and poorly sorted. The basal sandstone marks the unconformable contact with the older underlying clayey Gombe Formation (Figure 2). The sandstone is overlain by a light grey claystone intercalated by light grey bulky shale.

Figure 2: Summary of the Lithostratigraphy, Chronostratigraphy, Formation and Paleo-environments of Murshe-1 well, Bornu Basin, Nigeria. (Not to scale)

Depth(m)	Litho-log	Description	Formation/ Age	Paleo-environment
70		Very light grey claystone	Kerikeri Eocene	Lacustrine To Proximal Fluvialite
		Light grey bulky shale		
280		Milky to pinkish coloured sandstone, conglomeratic in nature, size varies from fine to medium pebble, angular to rounded, poorly sorted		
320		Reddish brown, bulky mudstone		
385		Light brown to light grey bulky claystone with intercalated sandstone	Gombe Paleocene	Continental
525		Brownish coloured conglomeratic sandstone; fine to pebble in size, very poorly sorted.		
590		Dark grey to black fissile shale, rare coarse to pebble sized grains, calcareous with gypsum		
620		Black fissile silty shale	Fika Campanian-Maastrichtian	Marine
840		Dark grey to black fissile shale		
890		Black fissile shale with intercalated gypsum		
1185		Black fissile shale with intercalated gypsum		
		Light grey sandy shale; sand size varies from fine to medium, well sorted	Gongila Turonian-?senonian	Deltaic To Marine
1820		Black fissile shale, calcareous and fairly ferruginised		
1880				
1930				

4.2 Palynological Assessment

Miospore recovery is moderate to barren at different intervals. However, palynomorph preservation is good. Microplanktons are as well present in the well and their presence is used to determine the paleoenvironment of deposition. Palynozonation interpretation is generally based on the evolution of the miospores, their extinction and their relative frequencies dependent on the ecology and other environmental factors. Thus, five palynozones were erected based on the assemblages of diagnostic forms which were compared with the works of earlier researchers including Jardine and Magloire, (1965); Germaraad et al, (1968); Evamy et al, (1978); Lawal and Moullade, (1986). Details of the basis of establishing the palynozones are given below:

Zone: Triorites africaensis assemblage zone 1

Interval: 1755-1930m

Age: Turonian

Characteristics: The base of the interval is placed at 1930m where the analysis commenced. It is characterized by paucity of miospores and the appearance of *Classopollis brasiliensis* and *Histrichosphaeridium sp.* The near base of the interval has the admixture of dinoflagellates such as *Andalusiella sp* and *Senegalinium sp*; pollen such as *Liliacidites sp* and *Inaperturopollenites sp.*

The top of the interval is marked by the top appearance of *Triorites africaensis* and appearance of *Retimonocolpites sp* and *Monosulcites sp.* The interval is stratigraphically equivalent to Gongila Formation (Figure 2).

Zone: Syncolporites/Milfordia sp assemblage zone ~~11~~ 2

Interval: 1580-1755m

Age: Senonian-Campanian

Characteristics: This interval is composed of assemblage of palynomorphs that are depictive of Senonian and Campanian ages. The interval 1665-1670m has new appearances of

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Syncolporites sp, *Milfordia sp*, *Aequitrinites sp*, *Monosulcites sp* and *Cyathidites sp*. Microplanktons such as *Senegalinium sp 2*, *Phelodinium bolonienae*, and *Dinogymnium undulosum* and microforaminiferal wall lining ~~occurred at this interval~~.

The top of the interval is composed of the assemblage of *Mauritiidites crassibaculatus*, *Aequitrinites sp*, and *Retitricolpites operculatus*. Dinoflagellates such as *Senegalinium sp*, *Senegalinium bicavatum*, dinocyst and non pollen palynomorphs (NPP) are present at the topmost interval. Thus, the lower part of the interval is suggested to belong to Senonian age, equivalent stratigraphically to uppermost part of Gongila Formation while the upper part of the interval belongs to Campanian age based on the top appearance of *Mauritiidites crassibaculatus* and equivalent stratigraphically to lower part of Fika Formation (See Figures 2 and 3). This form has been used by Lawal and Moullade, (1986); Edet and Nyong, (1994); Ola-Buraimo et al, (2012) and Ola-Buraimo, (2012) for different Campanian deposits in Nigeria.

Zone: Spinozonocolpites baculatus assemblage zone ~~111~~ 3

Interval: 620-1580m

Age: Maastrichtian

Characteristics: The base of the interval coincides with the top of the underlying zone 11 marked by top appearance of *Mauritiidites crassibaculatus*. However, the overlying interval is defined by new appearance of pollen assemblages including *Longapertites marginatus*, *Peritetracolpites sp*, *Trichotomosulcites sp*, *Zlivisporites blanensis*, *Cyathidites sp*, and *Auriculidites sp*. Other forms that characterize Maastrichtian age sediments present and similar to the work of Van Hoeken klinkenberg (1964); Ogala et al, (2009); Ola-Buraimo and Adeleye, (2010); Ola-Buraimo et al, (2012) and Ola-Buraimo, (2012) are *Stephanocolpites sp*, *Foveotrilletes margaritae*, and *Ulmoideipites krempii*. The occurrence of the typical Maastrichtian forms such as *Retidiporites magdalenensis*, *Proxapertites cursus*, *Inaperturopollenites sp*, *Ctenolophonidites costatus*, *Spinizonocolpites baculatus*, *Monocolpites marginatus*, *Distaverrusporites simplex*, *Longapertites microfoveolatus*, *Tricolporopollenites sp*, *Striatricolpites catatumbus*, *Striatopollis bellus* and *Polyadopollenites sp* were also reported in the work of Evamy et al., (1978) and Ola-Buraimo, (2012).

The top of the interval is defined by the top occurrence of *Cingulatisporites ornatus*, *Foveotricolporites sp*, *Bombacidites sp*, *Ulmoideipites krempii*, *Aquilapollenites sp*, *Triporites cf iverseni*, *Constructipollenites ineffectus*, *Foveotrilletes margaritae*, *Verrutrilletes bullatus* (Van

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Hoeken Klinkenberg, 1964), and *Retidiporites magdalenensis*. Apart from the fact that the palynomorph assemblages in this interval are conspicuously different from those in the adjoining intervals, the palynomorph abundance and diversity of the uppermost interval is quite richer than the overlying interval that is poor to barren. Such phenomenon had been observed by Lawal and Moullade, (1986) and Ola-Buraimo, (2012).

Within the interval, there are some pollen and spores that show a fairly continuous occurrence, among them are *Zlivisporites blanensis*, *Periretisyncolpites sp*, *Longapertites marginatus*, *Retidiporites magdalenensis*, and *Ulmoidites krempii*. The interval is well noted for occurrences of dinoflagellate cysts such as *Hiostrichosphaeridium atellatum*, *Phelodinium bolonienae*, *Andalusiella sp*, *Senegalinium sp*, *Histrichosphaera sergipensis*, *Andalusiella polymorpha*, *Cleistosphaeridium sp*, *Batiacasphaera sp*, and *Histrichodinium pulchrum*. The presence of the dinoflagellates known to dwell in salt water is an indication that the sediments might have been deposited in a marine environment; probably in a marginal marine setting due to the presence of peridinacean forms. Therefore, the interval (620-1580m) is conveniently dated Maastrichtian age and equivalent in part to Fika Formation (See-Figures 2 and 3)

Zone: Proxapertites cursus assemblage zone ~~1~~4

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Interval: 315-620m

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Age: Paleocene

Characteristics: The interval is characterized by the paucity of palynomorphs. Though the miospore assemblage present is different from both the underlying and overlying intervals, it is still not well represented. The basal interval is barren while the top interval is marked by the assemblage of *Verrucolporites sp*, *Monosulcites sp*, *Leiotriletes sp*, *Cf. Aquilapollenites sp* and *Cf. Cupaniedites reticulatus*. Other forms present are algae such as *Botryococcus braunii* and *Calcium oxalate crystals* (Ruta et al, 2007). The interval is tentatively dated Paleocene age based on the paucity of palynomorphs that characterize Paleocene age from Maastrichtian sediments. It is further based on the stratigraphic position of the interval which contains fossils that are distinctively different from the miospore assemblages of the overlying and underlying intervals which contain stratigraphically diagnostic forms. The interval is correlable to Gombe Formation (See-Figures 2 and 3)

Zone: Monoporites annulatus assemblage zone ~~4~~5

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Interval: 70-315m

Age: Eocene-Younger

Characteristics: The interval is poor of palynomorph recovery. However, the base of the interval coincides with the top of the underlying zone. It is characterized by the first appearance of *Monoporites annulatus*. At interval 225-230m there is also new appearance of *Retibrevitricolporites protrudens* in association with other miospores such as *Proxapertites cursus* and *Monosulcites sp.* The upper part of the interval is marked by the occurrence of *Longapertites vernendenburgi* while the top is defined by the appearance of *Lycopodium phlegmaria* (See-Figures 2).

The upper part of the interval shows appearance of microforaminiferal wall lining and dinoflagellate cysts. The appearance of fungal spore in the claystone is suggestive of deposition in a fluviomarine setting (Ogala et al., 2009; Ola-Buraimo and Adeleye, 2010)). However, the interval is dated Eocene to Younger age on the basis of the co-occurrence of *Monoporites annulatus*, *Retibrevitricolporites protrudens* and *Lycopodium phlegmaria*.

5 Conclusion

Lithostratigraphy of the Murshe-1 well section is composed at the base by Gongila Formation, defined by dark grey fissile shale, intercalated by light grey sandy shale; dated Turonian-?Senonian based on the establishment of *Triorites africaensis* assemblage zone 1 and partly of *Syncolporites sp/Milfordia spp* assemblage zone ~~11~~ 2. The latter is characterized by co-occurrence of *Triorites africaensis*, *Classopollis brasiliensis*, and *Retimonocolpites sp.* The Gongila Formation was deposited in a deltaic to marine environment. Stratigraphically, the Gongila Formation is overlain by Fika Shale, characterized by black fissile shale with rare occurrence of gypsum at the upper end. It belongs to the *Milfordia spp* assemblage zone ~~11~~ 2 and *Spinizonocolpites baculatus* assemblage zone ~~111~~ 3. The formation is dated Campanian to Maastrichtian based on the co-occurrence of *Milfordia spp*, *Mauritiidites crassibaculatus*, *Longapertites marginatus*, *Foveotriletes margaritae*, *Retidioporites magdalenensis*, *Trichtomosulcites sp*, *Periretisyncolpites sp*, and *Auriiculidites sp*. The Fika Shale was deposited in a marine system.

The Gombe Formation dated Paleocene ~~age~~ overlies the Fika Shale. It is composed of basal brownish coloured conglomeratic sandstone at the base, overlain by light grey bulky claystone associated with intercalated sandstone and reddish mudstone at its top.

Palynologically, the formation is characterized by paucity of palynomorphs and dated Paleocene. The Kerrikerri Formation is the youngest in the interval analyzed; composed of conglomeratic sandstone at the base, overlain successively by light grey bulky shale and light grey claystone. The formation is dated Eocene ~~age~~-based on the co-occurrence of *Monoporites annulatus*, *Retibrevitricolporites protrudens*, *Proxapertites cursus*, and *Longapertites vernendenburgi*. The Kerrikerri Formation was deposited in a fluvio-marine environment.

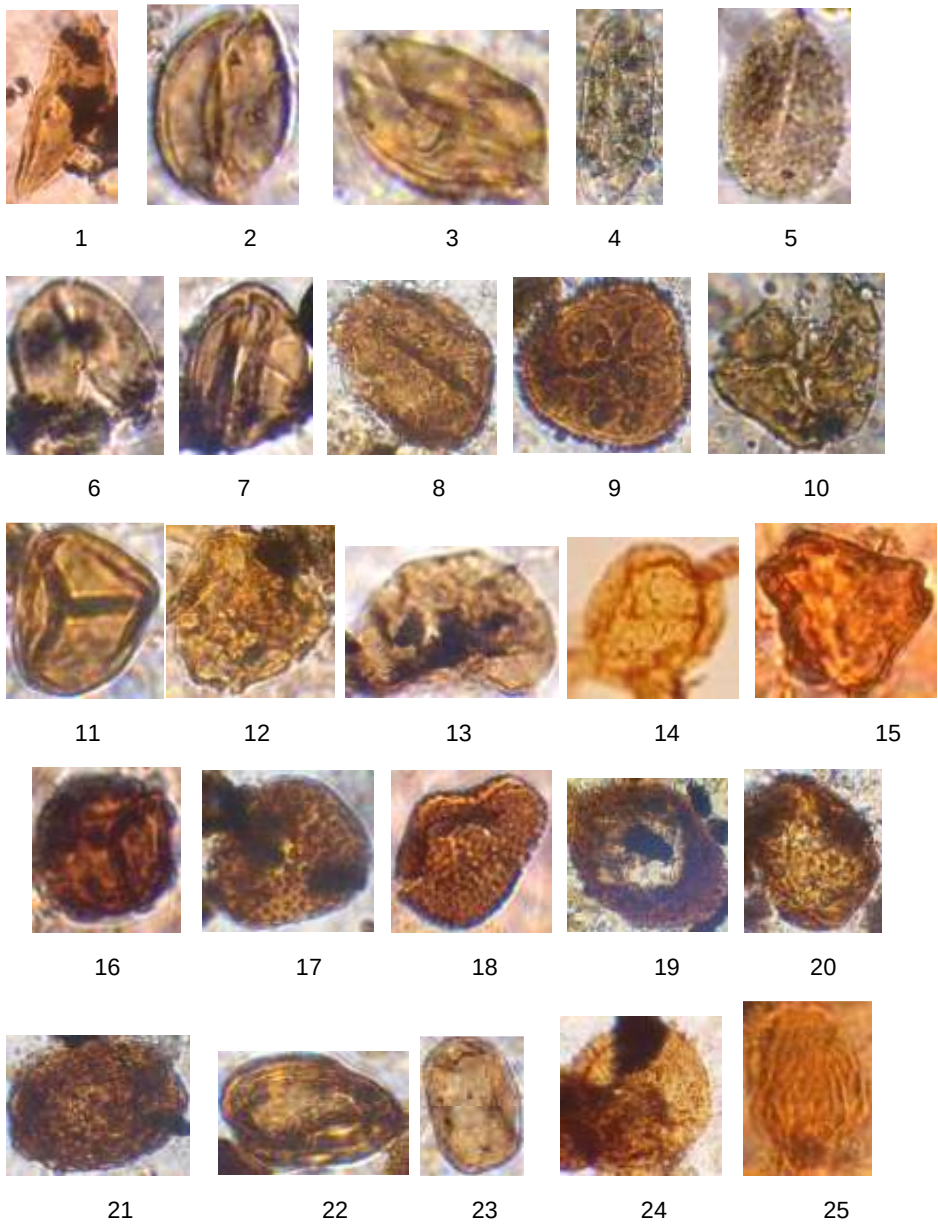
PLATE 1

- 1 Liliacidites sp
- 2-4 Monosulcites sp
- 5 Retimonocolpites sp
- 6-8 Monocolpites marginatus
- 9-11 Leiotriletes sp
- 12 Cyathidites sp
- 13 Laevigatosporites sp
- 14 Zlivisporites sp
- 15 Syncolporites sp
- 16 Distaverrusporites sp
- 17 Verrucosisporites sp
- 18 Foveotriletes margaritae
- 19-22 Milfordia sp
- 23 Inaperturopollenites sp
- 24 Mauritiidites crassibaculatus
- 25 Striatricolpites catatumbus



Magnification at X400

PLATE 1



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PLATE 2

- 1 Longapertites verneendenburgi
- 2 Periretisyncolpites sp
- 3-4 Longapertites marginatus
- 5 Trichotomosulcites sp
- 6-7 Stephanocolpites sp
- 8 Ulmoideipites krempii
- 9 Ctenolophonidites costatus
- 10 Spinizonocolpites baculatus
- 11 Syncolporites sp
- 12-14 Tricolpites sp
- 15 Triorites africaensis
- 16 Triporites sp
- 17 Triporites cf iverseni
- 18-19 Tricolporopollenites sp
- 20 Polyadopollenites sp
- 21 Constructipollenites ineffectus
- 22-24 Retidiporites magdalenensis
- 25 Monoporites annulatus

Magnification at X400

PLATE 2



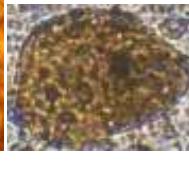
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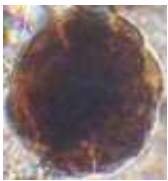
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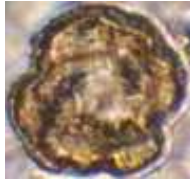
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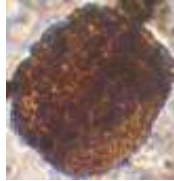
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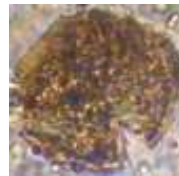
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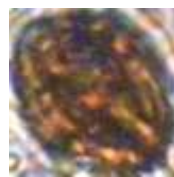
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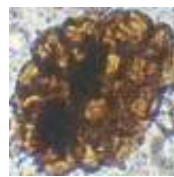
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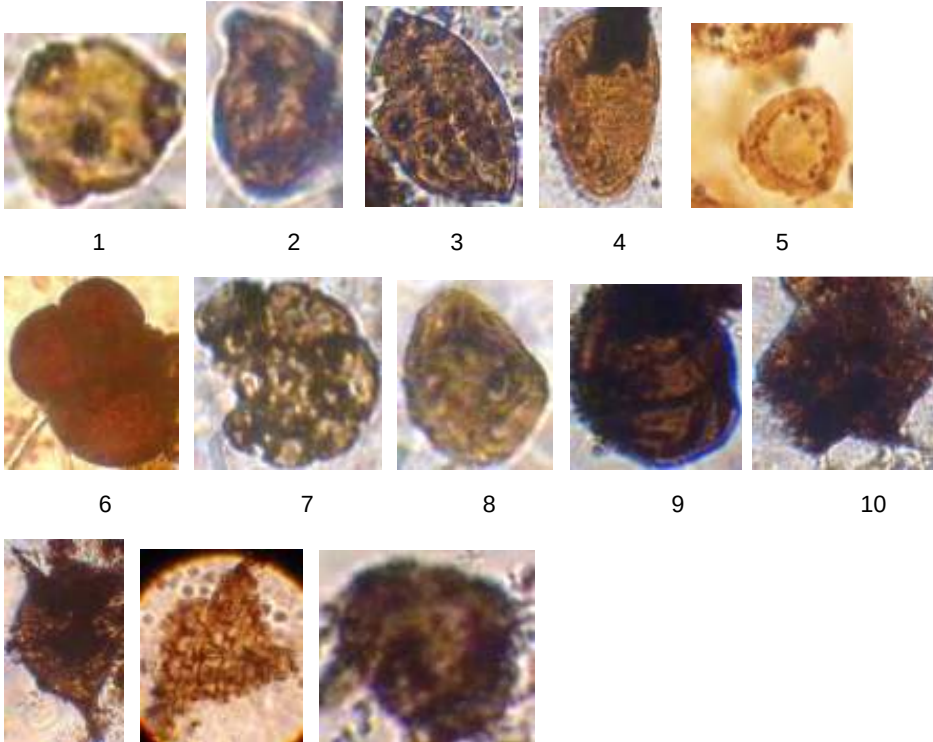
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Magnification at X400

PLATE 3



- 1 Retibrevitricolporites protrudens
2 Auriculiidites sp
3 Monosulcites sp
4 Longapertites microfoveolatus
5 Cingulatisporites ornatus
6-7 Microforaminiferal wall lining
8 Phelodinium bolonienae
9 Batiacasphaera sp
10 Senegalinium bicavatum
11 Andalusella polymorpha
12 Calcium oxalate crystal

Acknowledgements

The author is grateful to Palystat Limited for its endless support in making this research work a reality. He also appreciate the cooperation of Geological Survey Agency for providing ditch cutting samples used and granting permission to publish these findings.

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