Palynomorph Assemblage and Palaeoecological Interpretation of Ajali Sandstone in Western Anambra Basin of Nigeria

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ABSTRACT

The study presents the lithology, palynomorph assemblage and palaeoecological interpretation of outcrops of Ajali Sandstone in Ayogwiri, Fugar and Orame in the western Anambra basin of Nigeria. The outcrops were logged and sampled. The textures range from fine sand to pebbly sand in places. Thin clay beds were also observed occurring between the basal heterolithic and sandy beds. 24 samples from selective beds were taken for foraminifera micropaleontology and palynological analysis. All samples were found to be barren of foraminifera, thus precluding age determination, but yielded few palynomorphs. Terrestrial palynomorphs dominate in the three locations with few marine dinoflagellates and acritarch occurring in Orame. The inferred palaeoecology range from humid to tropical mangrove swamps with infiltration of fresh water and marine waters. Corroborating both lithology and palynology, the depositional environment is shallower at Ayogwiri and Fugar (marginal marine) and deeper in Orame (shallow marine).

Keywords: Palynomorph, Lithology, Palaeoecology, Mangrove swamp, Pollen, Spore, Dinoflagellates.

1.0 INTRODUCTION

The Ajali Sandstone is one of the Campanain –Maastrichtian Sedimentary fills of the Anambra basin. The Anambra basin became a depocenter after the Santonian tectonic activity that resulted to the folding and uplift of the Abakiliki Anticlinorium which was flanked to the right by the Anambra basin and to the left by the Afikpo basin. The first lithic fill of the Anambra basin is the transgresive marine Nkporo Group. The Nkporo Group includes the Nkporo Formation, the Owelli Sandstone and the Enugu Shale. The Mamu Formation of the Coal Measures Group conformably overlies the Nkporo Group. Overlying the Mamu Formation is the Ajali Sandstone. The Nsukka Formation is the Upper Coal Measure. These sediments form the sediments of the proto Niger Delta. (Umeji and Nwajide, 2007)

Simpson (1955) defined the Ajali Sandstone as "False bedded Sandstone" It consists of mainly fine grain, friable, subangular to subrounded Sandstone with few intercalations of siltstones and clays especially at the base. The unit stratotype of the Ajali Sandstone was examined by Reyment (1965)), and he observed that the formation lies between two parallic sequence and he suggested a continental origin. Hoque and Ezepue (1977) changed this line of thought by suggesting a fluvial-deltaic environment. Amajor (1987) subdivided the formation into two fining upward sequence, with each possessing three sub-facies in his facies analysis of the sandstone in Okigwe area. He postulated a fluvial-marine depositional environment because he observed marginal marine deposits at the base of the formation. Benerjee (1979) suggested that the Sandstone was deposited in a spectrum of environments ranging from marine through parallic to continental. Ladipo (1986a, b, and 1988b) using process interpretation of sedimentary structures and palaeocurrent analysis of the Sandstone suggested a tidally influenced regime, possibly a tidal shelf characterized by shoreline – parallel sand bodies with intercalations of mud. Outcrops of Ajali Sandstone extend from Fugar/Agenebode area in the west, towards Enugu/Udi area in the east and narrows southwards towards Okigwe area, thereby forming a characteristic ‘‘question mark’’ shape. The thickness ranges from over 350 to 450 m in places and thins southward to few tens of meters around Okigwe area (Hoque and Ezepue, 1977).

A lot have been written on the Ajali Sandstone. It is assumed that because it is basically a quartz arenite, it is barren of fossil content and its age determination has been arrived at based on its stratigraphic position in relation to the Mamu Shales and Nsukka Formation. This paper projects the palynomorph assemblage of the Ajali Formation outcropping in Ayogwiri, Fugar and Orame in the Western Anambra basin, to interprete the palaeoecology. Fossil pollen and spores, provide evidence about ancient paleoenvironments, often when other fossils are absent, and they are key tools in biostratigraphy, which will help in depositional environment consideration and probably age determination. Ayogwiri, Fugar and Orame are situated in Etsako West Local Government Area of Edo State. The area is covered by the Ajali Sandstone. Accessibility to and within the study area is fairly good. There are good network of tarred roads including Auch-Ibillo road, Auchi-Agenebode road among others. The Sandstone exposures in the area are along road cuts and in quarries (Fig 1.).

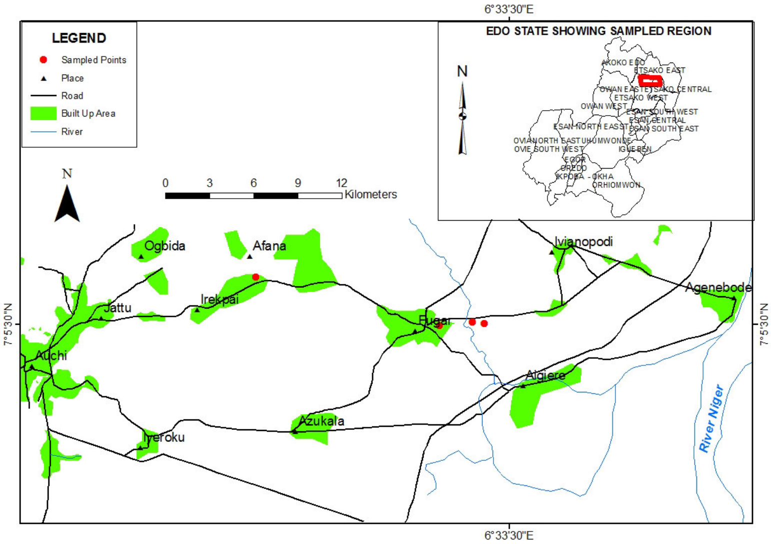


Fig 1: Location map showing sample points in Ayogwiri, Fugar and Orame.

2.0 PREVIOUS STUDIES

Benkhelil, 1986; Amajor, 1987, Adediran et al., 1991 suggested a continental and fluvio-deltaic setting as a regressive phase of a short-lived Maastrichtian transregression. The sediments were derived from westerly areas of the Abakaliki anticlinorium and the granitic basement units of Oban and Adamawa massifs. Nwajide and Reijers, 2004 is of the view that two major transgressions in the Late Campanian and Paleocene separated by two regressions in the Maastrichtian-Datian and Eocene age, respectively affected the Anambra basins, thus depositing the Nkporo Group, Mamu Formation, Ajali Sandstone and the Nsukka Formation in the Campanian-Maastrichtian. However, Ladipo (1986a) using sedimentary structures and the presence of trace fossils (*Ophiomorpha and Skolithos*) suggested a tidal shallow marine depositional environment for the Mamu Formation and the overlying Ajali Sandstone, as part of a continued Maastrichtian transgression, which commenced in the Late Campanian and lasted until the Paleocene.

Akpofure and Etu-Efeotor (2013a) using data from field outcrop logging, biostratigraphy and granulometric analysis inferred fluvial and shallow marine environments with very strong and extensive tidal influences based on several internal sedimentary structures such as the herringbone stratification, epsilon beds, flaser beddings, mud drapes; biostratigraphic analysis and textural parameters.

3.0 REGIONAL SETTING

The Benue Trough of south eastern Nigeria is the failed arm of the triple junction formed as the South American plate separated from the Africa plate in the Cretaceous. The Benue Trough is subdivided into the Upper, Middle and Lower Benue Trough. The Anambra basin is one of the basins that occur in the Lower Benue Trough. The Anambra basin was a platform thinly draped by older Albian sediments before the Santonian active tectonic phase. The Cretaceous stratigraphy of the Lower Benue Trough is representated by sediments deposited by three main marine depositional cycles: The Albian – Cenomanian, the Turonian – Coniacian and Campanian – Maastrichtian (Reyment, 1965). The Santonian was heralded by an active tectonic event which led to the uplift, folding and widespread erosion of pre-Santonian sediments that formed the Abakiliki anticlinorium and the Anambra basin to the west and Afikpo basin to the left of the Anticlinorium.

The first transgressive sediments in the Albian are represented by the Asu River Group. The regressive phase deposited the Odukpani Formation in the Cenomanian. The Turonian is represented by the Ezeaku Formation while Agwu Formation was laid down in the Coniacian. The Nkporo Group, Mamu Formation, Ajali sandstone and Nsukka Formation represent the third trangressive – regressive phase sediments in the Cretaceous (Kogbe, 1976)

4.0 METHOD OF STUDY

The study involved lithological logging and sampling of selective beds. Biostratigraphic studies, using 24 samples from the Sandstone was undertaken to determine its fossil assemblage. The samples were discriminated for foraminiferal micropaleotologic and palynologic studies and prepared according to the standard maceration technique. Hydrochloric and hydrofluoric acid were used to remove carbonates and silicates. Also, samples were treated first with warm 36% HCL and then cold HCL to remove fluoride gel. Half of the samples were separated for foraminiferal micropaleotological preparation, and the organic content was separated and thoroughly washed with distilled water. The organic matter was oxidized with nitric acid (HNO3) and thoroughly washed before neutralizing the acid with potassium hydroxide (KOH) and washed thoroughly with distilled water and then alcohol, before the slides were prepared. The other half for the palynofacies, was then sieved with 10 – 20µ sieves prior to washing with alcohol. The residues were preserved by adding a drop of glycerol/glycerin to each of the properly labeled phials. Microscopic slides were prepared by placing a small quantity of glycerin jelly in the center of a clean slide and a small quantity of organic residue was added and warmed. The mixture was spread out evenly and covered with a cover slip and labeled.

5.0 LITHOSTRATIGRAPHY

Outcrops of Ajali Sandstone outcropping in Ayogwiri, Fugar and Orame were logged and described.

5.1 Lithologic Description Of Ajali Sandstone In Ayogwiri

The outcrop logging of the Sandstone in Ayogwiri was at a quarry site in the village (by the old police station) with a georeference of 07° 7.230' N and 06° 24.217'E though, the entire area is overlain by the Sandstone. The Ajali Sands are quarried for various uses. About eight beds can be noticed here separated by thin beds of mud and with various geological structural imprints. (Fig 2)

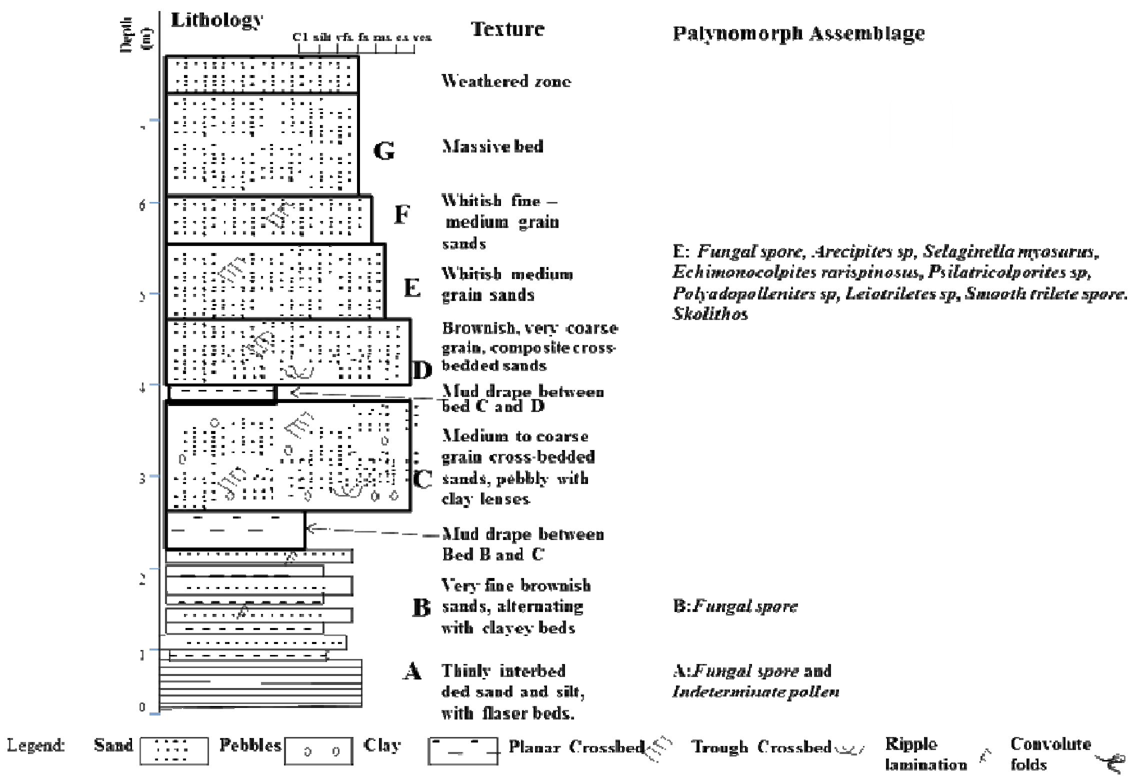


Fig. 2: Stratalog of Ajali Sandstone at Ayogwiri (Quarry site at old police station)

The layers in bed A are near horizontal and are made of thin laminated beds of fine sands and silt with flaser bedding and grayish clay lenses. It is about 37cm thick. Bed B which is about 216cm thick is heterolithic and is made up of near horizontal layers of beds. Bed B exhibits cyclic sedimentation of fine sands which are brown in colour and clay beds at intervals. Bed B is capped by a clay bed of about 6cm thick which was deposited when current energy was nonexistent or very minimal. This is followed by bed C with medium to coarse grained sands, pebbles in places. The sands are whitish, with large planar crossbeds and friable. Clay lenses were also seen in places. The bed is about 153cm thick; it is also capped by a mud drape that is about 6cm thick. The base contains pebbles. Bed D is a composite bed with planar and trough crossbeds. The horizontal bed dips about 4^o and strike 58NW while the cross beds strike 121NE. The entire bed is about 118cm. it is also capped by a mud drape that is about 6cm thick.

Bed E is about 68cm thick and with large planar crossbeds. It is made up of whitish medium to coarse grain sands, very small to large pebbles. *Skolithos* and liesangang structures occur in places.

Bed F is also of high energy with large planar crossbeds and is about 58cm thick. It is composed of fine to medium grain sands which are white in colour. Bed G overlies bed F and it has fine to medium grain sands that are white. It is about 12cm thick. It is massive without crossbeds. The weathered zone lies above bed G, it is about 130cm thick and it is highly lateritic and most part of it is now ironstone.

5.2 Lithologic Description Of Ajali Sandstone In Fugar

Deposition of the Ajali Sandstone in Fugar took place in form of packets or bundles of curved inclined beds of short lateral extent. The location of outcrop logging in Fugar is along a road cut on Auchi – Fugar- Agenebode road (by abandoned "419 building"). It is about 30 km from Ayogwiri where the Sandstone is exposed at a georeference of 07^o 05.448'N and 006^o 30.943'E. At this location, several bundles of large inclined crossbeds known as epsilon beds formed from the lateral migration of pointbars were noticed (Fig. 3). The bundle planes are erosion surfaces. The thickness of each bed of the epsilon bundles ranges from 2cm to 5cm, with average of about 3.4cm with laminations within them. The number of such beds in a bundle ranges from 24 to 28. These beds are traversed by gravity fault planes, which strike NW-SE directions with dips of 6^o. The planes have been mineralized.

The height of the Sandstone at this exposure is about 12.5m. From the bottom to about 7.2m, there are several packets of epsilon beds. Epsilon bed A is about 27cm and has light brown fine grain sands. Epsilon beds B and C both have 117cm and 170cm height, respectively. The sands are fine grain. The epsilon beds D, E and F have medium to coarse grain sands and have thickness of 160cm, 130cm and 110cm respectively. The epsilon beds are overlain by bed G. The surface separating bed G from the epsilon bundles is an erosion surface lagged with pebbles. Bed G is also ripple laminated and about 80cm in height. It is overlain by bed H that is about 110cm high and has large planar crossbeds as a result of increased energy. The sands are also pebbly. Bed I overlies bed H; it is about 150cm thick. The grains in bed I are fine to medium size. The sands in bed J are also fine to medium-grained. Bed J is about 120cm thick. Beds G, H and J are near horizontal beds with about 18^0 dip towards SE. The Sandstone is highly weathered above bed J.

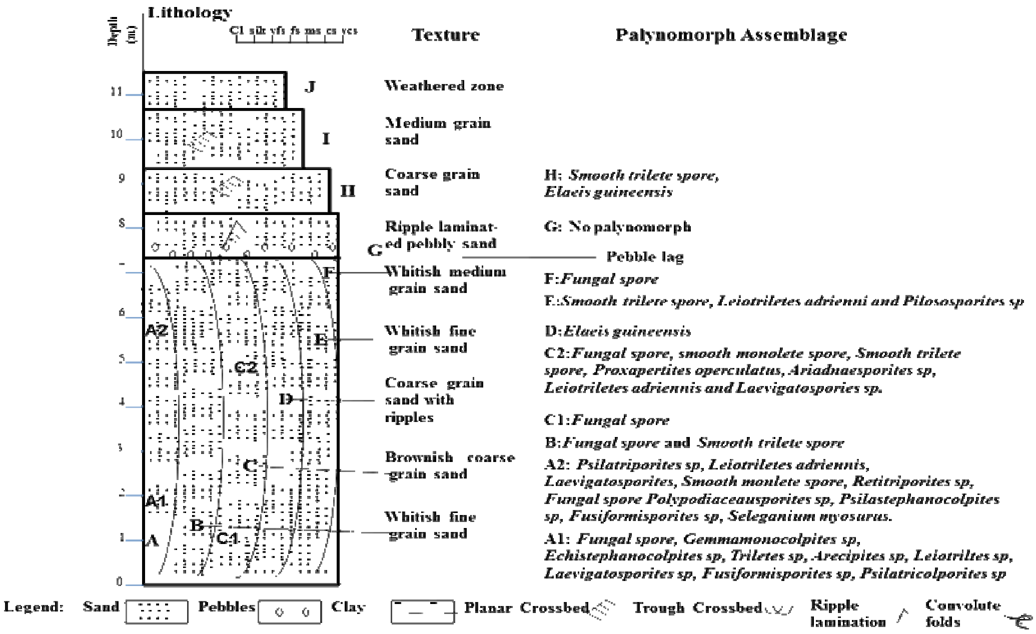


Fig 3: Stratalog of Ajali Sandstone at abandoned 419 building, Fugar

5.3 Lithologic Description Of Ajali Sandstone In Orame 1

Just before Orame village along Agenibode road, at a point with a georeference of 07o 05.576'N and 06o 32.593', the Ajali Sandstone is massively exposed along the road cut. The sand body is as high as 13.05 m. The beds occur as near horizontal crossbeds. Fifteen of such beds occur with the last severely weathered, the height of each bed is indicated in the strata log (Fig. 4).

Five depositional sequences are represented in Orame 1. The first two beds A and B separated by thin mud layer each have cyclic sedimentation with the deposition of thin sand and clay beds and granules in places. They are both heterolithic. Bed B is overlain by a thick clay bed of about 23cm. The clay bed is thin laminated. Above the clay bed, we have beds C and D. Bed C is massive and structure less with medium grain sands while bed D has convolute deformational folds with light brown medium - coarse grains.

Above this, we have the second fining up sequence of beds which begins with Bed E. Bed E is a massive bed with no cross stratification. The sands of both beds E and F are white medium grains but bed F has large planar beds. Bed G is white in colour with fine grain sands with granules in places. It also has large planar crossbeds. The second fining up sequence is capped by bed G. Bed H has convolute deformational folds and it begins the third fining up sequence. The third sequence also deposited beds I and J with large planar crossbeds. Bed H is fine to medium grain with pebbles and white in colour. Bed I is medium to coarse grain and light brown in colour. Above bed I are beds J and K which are fine grain sands.

5.4 Lithologic Description Of Ajali Sandstone In Orame 2

Orame 2 is 120m from Orame 1 and on the opposite side of the road to Agenibode. It is on 07^o 05.568' N and 006^o 32.159'E. The exposed section here is about 6m in height and four distinctive beds were mapped (Fig. 5). Bed A is about 113cm thick and is made up of fine ripple laminated sands. The plane between bed A and B shows the presence of trace fossils *Ophiomorphia*. Bed B is about 170cm and overlies bed A, the grains are fine. The bed shows soft deformational structures: Convolute and recumbent folds. Part of bed B exhibits bioturbation. Bed C has planar crossbeds and is a non horizontal bed, which is about 140cm in some places and less in others. Above C is bed D with very distinct slump structures with deformation of deposits associated with faulting. The fault plane is veined.

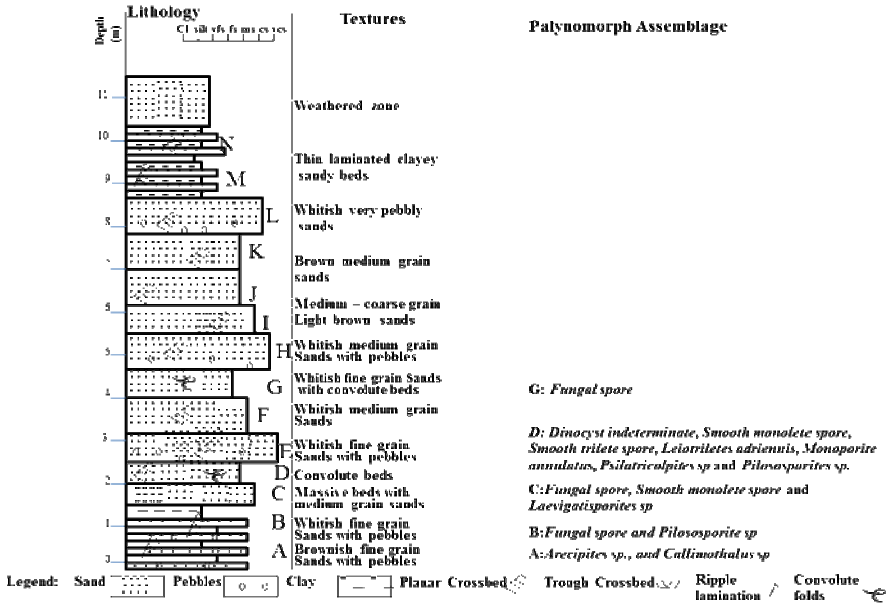


Fig. 4: Stratalog of Ajali Sandstone along road cut in Orame 1

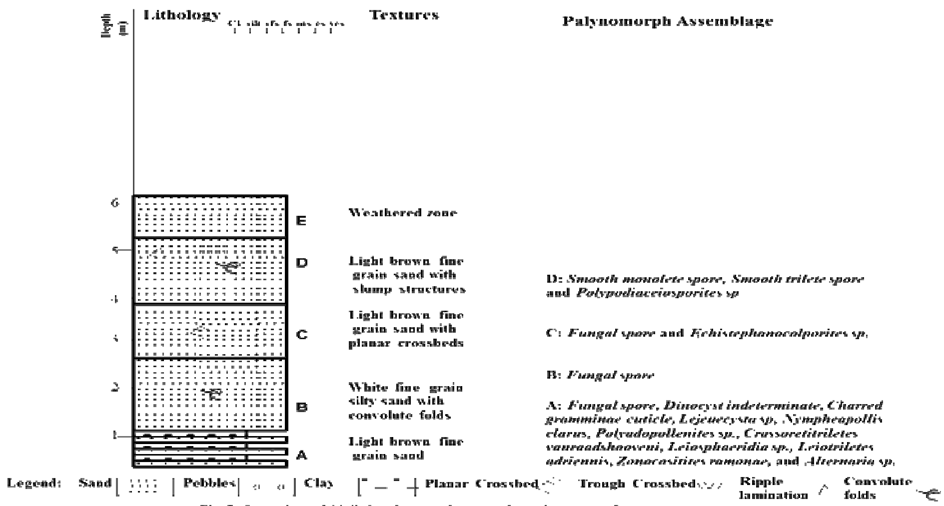


Fig 5: Stratalog of Ajali Sandstone along road cut in orame 2

6. 0 PALYNOLOGY AND PALAEOECOLIGICAL INTERPRETATION

Continental Indicators

Fresh Water/Forest

Retitriporate sp., Ariadnaesporite sp., Retritricolporite sp., Echitricolporite sp., Retistephanocolporites sp. Selaginella myosurus, Psilatricolpites sp

Mangrove /Swamp

Proxapertites operculatus, Leiotrilete adriennis, Zonocostitites ramonae

Coastal Savannah

Charred graminae cuticle, Monoporites annulatus

Humid marshy swamp

Crassoretitriletes vanraadshooveni, Laevigatosporites sp

Montane

Elaeis guineensis, Nympheopollis clarus

Undifferentiated

Polypodiaceoisporites sp., Multicellites sp., Fusiformisporites sp., Pilososporite sp., Polyadopollenites sp Arecipites sp., Echimonocolpites rarispinosus, Callimothalus sp

Fungal Spore – swamp

Marine Indicators

Dinoflagellates

Dinocyst Indeterminate, Lejeunecysta sp

Acritarch

Leiosphaeridia sp

Fossil pollen and spores, provide evidence about ancient palaeoenvironments, often when other fossils are absent, and they are key tools in biostratigraphy. Pollen analysis involves the quantitative examination of spores and pollen at successive horizons through a core, particularly in bog, marsh, lake or delta sediments. This method yields remarkable information on regional changes in vegetation through time, especially in Quaternary sediments where the parent plants are well known, though similar techniques have been used

with success in older deposits such as Carboniferous coals. Samples from the studied area were barren of foraminifera but yielded few palynomorphs which were analysed. Samples were collected from selective beds of the Sandstone in the different locations.

6.1 Ayogwiri

Palynomorphs are sparse in Ayogwiri especially at the base, bed A, with only a specimen each of *Fungal spore* and *Indeterminate pollen*. The sample is devoid of dinoflagellates. Also, sample from bed B is almost barren of palynomorphs, only a single specimen *Fungal spore* was recovered and no dinoflagellate cysts were recovered. Therefore, no comprehensive environmental interpretations are made on samples from beds A and B because of low palynomorph counts, but the presence of Fungal spore suggests a swampy environment for both. Bed E presents more diversified palynomorphs which consists of the following palynomorphs: *Fungal spore, Arecipites sp, Selaginella myosurus, Echimonocolpites rarispinosus, Psilatricolporites sp, Polyadopollenites sp, Leiotriletes adriennis, Smooth trilete spore. Skolithos* were also observed in this bed. The pollen and spore assemblage is composed of 7 species with a *Fungal spore*, no dinocysts and a trace fossil. There is practically no dominant species. The palynological assemblage contain Pollen 60%, Spores 20%, Fungal spores 20%. The sample consists of 30% fresh water pollen, 20% swamp pollen and 10% mangrove pollen. The occurrence of *Leiotrilete adriennis* and *Fungal spores* suggest a mangrove swamp environment in a coastal plain to a delta front with fresh water infiltration as indicated by *Selaginella myosurus, Psilatricolporites sp, and Polyadopollenites sp*. The presence of *Skolithos,* palynomorph assemblage and the lithology, indicate a marginal marine environment.

6.2 Fugar

The palynomorph assemblage in Fugar yielded no dinoflagellate, but there was the predominance of *Trilete spores*. Also, Pollen and Fugal spores were recovered in significant numerical counts. The Epsilon beds range from Bed A to F.

Samples were collected from two point in bed A: A1 and A2. The palynomorph assemblage recovered from bed A1 consisted of *Fungal spore, Gemmamonocolpites sp, Echistephanocolpites sp, Triletes sp, Arecipites sp, Leiotriltes adriennis, Laevigatosporites sp, Fusiformisporites sp, Psilatricolporites sp.* The spores constitute 69.6%, the pollen content is 15.4% and the Fungal spore is 21.2%. The most dominant species is *Leiotrilete adriennis* with 42.4%, followed by *Fungal spore* with 21.2%. Mangrove pollens were 42.2%, Fresh water pollens were 3.0%, Humid swamp pollens were 6.1% and Fungal spore was 21.2%. This implies a mangrove swamp depositional environment, probably a coastal plain environment. The dominance of *Leiotrilete adriennis* indicates that it was derived from a restricted flora, in a mangrove swamp and reflects nearly in situ deposition. A more diverse assemblage was recovered from sample point A2. They are: *Psilatriporites sp, Leiotriletes* *adriennis, Laevigatosporites, Smooth monolete spore, Retitriporites sp, Fungal spore Polypodiaceausporites sp, Psilastephanocolpites sp, Fusiformisporites sp, Seleganium myosurus.* A total of 10 species were recovered. The spores formed 70.8% of the total assemblage, Pollen 12.5% and fungal spore formed 16.7%. *Leiotrilete adriennis* formed 50% of the aasemblage and Fungal spore formed 16.7%. Mangrove pollens constitute 50%, Fungal spores 16.7%, Fresh water pollens 12.5% and humid marshy swamp 4.16%. As in sample A1, The dominance of *Leiotrilete adriennis* implies nearness to environment of deposition and along with *Fungal spor,e* indicate a mangrove swamp. Also, the presence of *Laevigatosporites sp* implies a humid and marshy swamp. The lithology is fine grain sand. The palynomorph assemblage in bed B does not attain any numerical importance, being only two specimens: a *Fungal spore* and *Smooth trilete spore.* In bed C, sampling was done at two points: C1 and C2. At sample point C1, a specimen of *Fungal spore* was recovered, but at C2, a relatively, high species diversity with no clear dominant species were recovered, probably indicating transportation of sporomorph from upland region into the swamp region where they were fossilized. The assemblage include: *Fungal spore, smooth monolete spore, Smooth trilete spore, Proxapertites operculatus, Ariadnaesporites sp, Leiotriletes adriennis and Laevigatospories sp.* The presence of the palm pollen, *Proxapertites operculatus* implies that the prevailing climate was tropical. The presence of *Leiotriletes adriennis* and *Fungal spore* imply a swamp, while, *Laevigatosporite sp* indicate a humid cooling environment. Spores dominate with 62.5%, pollen content is 25% and Fungal spore is 12.5%. Samples from Bed D to H are almost barren and yielded little or no palynomorphs. One specimen of *Elaeis guineensis* was recovered from bed D. Also, a single specimen each of *Smooth trilete spore, Leiotriletes adriennis and Pilososporites sp* occur in bed E. Whereas, Bed F yielded a specimen of *Fungal spore* and practically no palynomorph was recovered from bed G. The low numerical count of palynomorph may be due to the absence of preservable parts or differential destruction of the palynomorphs and dinocyst at the strand lines. Bed H overlies bed G and it yielded *Smooth trilete spore, Elaeis guineensis, and Fungal spore.* Though, palynomorph numerical count is low, it is inferred due to the presence of *Elaeis guineesis* that probably, the deposits are transported from the montane area and deposited into the swamp environment before fossilization.

6.3 Orame 1

The palynomorph assemblage in Orame 1, consists of the dinoflagellates, pollens, spores and fungal spores, with the trilete spores *(Leiotrilete adriennis)* dominating. There are a total of fourteen beds observed, but samples were collected from beds A, B C, D and G. The sandstone contained some thin clay beds in the heterolithic and a thick clay bed between bed B and C.

Beds A and B are both heterolithic, bed A yielded *Arecipites sp., and Callimothalus sp*, while in bed B, we recovered *Fungal spore and Pilososporite sp.* The clay bed between bed B and C yielded *Fungal spore, Smooth monolete spore* and *Laevigatisporites sp.* The numerical count of the palynomorphs are low probably, due to absence of preservable parts or differential destruction of palynomorphs due to temporary exposure at the strand lines. The inferred environment is a cool mangrove swamp based on the presence of *Fungal spore* and *Laevigatisporites sp*. The palynomorph assemblage in bed D consists of *Dinocyst indeterminate, Smooth monolete spore, Smooth trilete spore, Leiotriletes adriennis, Monoporite annulatus, Psilatricolpites sp* and *Pilososporites sp.* The spores form 94.8%, dinoflagellates form 2.7% and pollens were 2.5%. No Fungal spore was recorded. The presence of a dinoflagellate in a spore dominated environment indicates infiltration of marine waters into a fresh water environment. *Monoporite annulatus* is a grass in the tropics found in coastal savannah, river valleys and montane areas. Whereas, *Leiotrilete adriennis* is a mangrove species and has a dominance of 53.9% which implies it was derived from a restricted flora and reflects a nearly in situ deposition. The depositional environment is inferred to be a mangrove forest with both fresh water and marine water infiltration, that is, a coastal plain and delta front. Samples were also collected from bed G and it yielded a specimen of *Fungal spore.*

6.4 Orame 2

There is high species diversity with no clear dominant species, probably indicating transportation of sporomorphs from upland region into the depositional environment where they are fossilized in Orame 2. The marine species consisted of dinoflagellates and Acritarch, while terrestrial species consisted of pollens, spores and fungal spores. There are a total of five beds – Bed A to Bed D and a weathered zone.

The plane between bed A and B shows the presence of trace fossils *Ophiomorphia*. The palynomorphs that occur in Bed A consist of *Fungal spore, Dinocyst indeterminate, Charred gramminae cuticle, Lejeuecysta sp, Nympheapollis clarus, Polyadopollenites sp., Crassoretitriletes vanraadshooveni, Leiosphaeridia sp., Leiotriletes adriennis, Zonocositites ramonae,* and *Alternaria sp.* Dinoflagellates/Acritarch form 26.6%, Fungal spores make up 20%, Pollen are 40% and Spores form 13.3% of palynomorph assemblage. The presence of *Zonocositites ramonae* and *Leiotriletes adriennis* and *Fungal spore* indicate a mangrove swamp. The presence of *Charred gramminae* is indicative of a coastal savannah, while *Nympheapollis clarus* indicate a montane environment. The marine species consists of *Dinocyst indeterminate, Lejeucysta sp* and *Leiosphaeridia sp*. which indicate marine waters incursion. Therefore, the depositional environment is a coastal environment which ranges from marginal marine to shallow marine with influences from both terrestrial and marine forces. Bed B exhibits bioturbation but it is almost barren of palynomorphs, only a specimen of *Fungal spore* occur in bed B. Bed C yielded single specimen each of *Fungal spore* and *Echistephanocolporites sp*. Samples from bed D also yielded single specimen each of *Smooth monolete spore, Smooth trilete spore* and *Polypodiaceiosporites sp.* The palynomorph assemblage is sparse but due to the presence of the fungal spore, a swamp environment is inferred.

6.5 Classification Of Palynomorphs

The sporomorphs in the Ajali Sandstone are classified according to the above scheme into Division I (Sporites) and Division II (Pollenites).

DIVISION 1 – SPORITES

Class Triletes

Ariadnaesporites sp, Leiotrleites adriennis, Smooth triletes spore, Foveotriletes sp, Crassoretitriletes vanraadshooveni, Polypodiaceoisporites sp, Psilatriletes

Class Monoletes

Smooth monolete spore, Fusiformisporites sp, Pilososporites sp, Laevigatosporite sp

DIVISION 11 – POLLENITES

Class Tricolporatae:

Psilatricolporites sp

Class Stephanocolporatae:

Retistephanocolporite sp, Echistephanocolporites sp

Class Monoporatae:

Monoporites annulatus

Class Triporatae:

Retitriporites sp

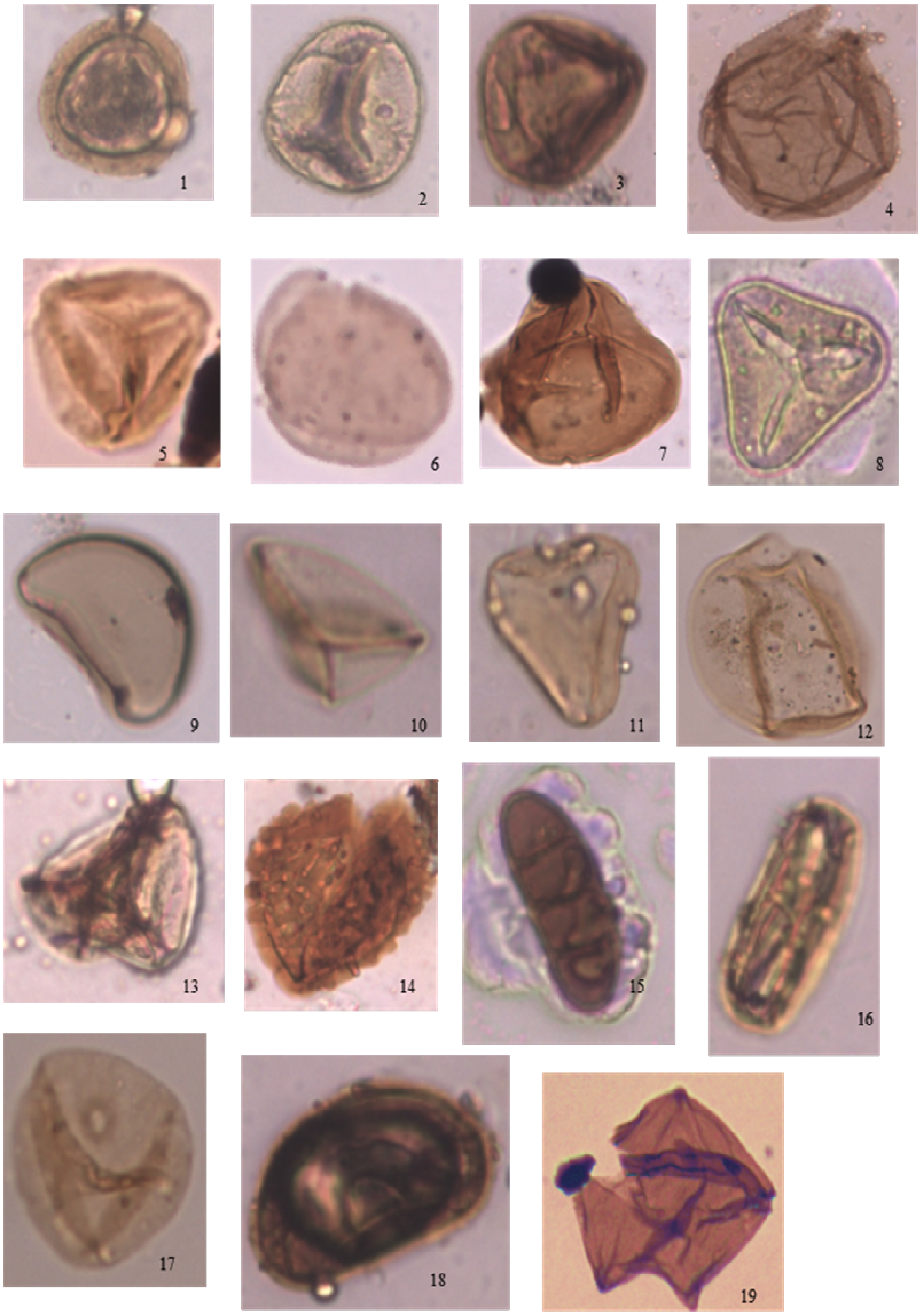
Class Monocolpatae:

Proxapertites Operculatus, Gemmamonocolpites sp, Echimonocolpites sp, *Polyadopollenites sp*

FUNGAL SPORE: Fungal spore, Fungal hyphae

MARINE INDICATORS include: **Dinoflagellates:** *Dinocyst indeterminate, Lejeunecysta sp,*

Acritarch: *Leiosphaeridia sp*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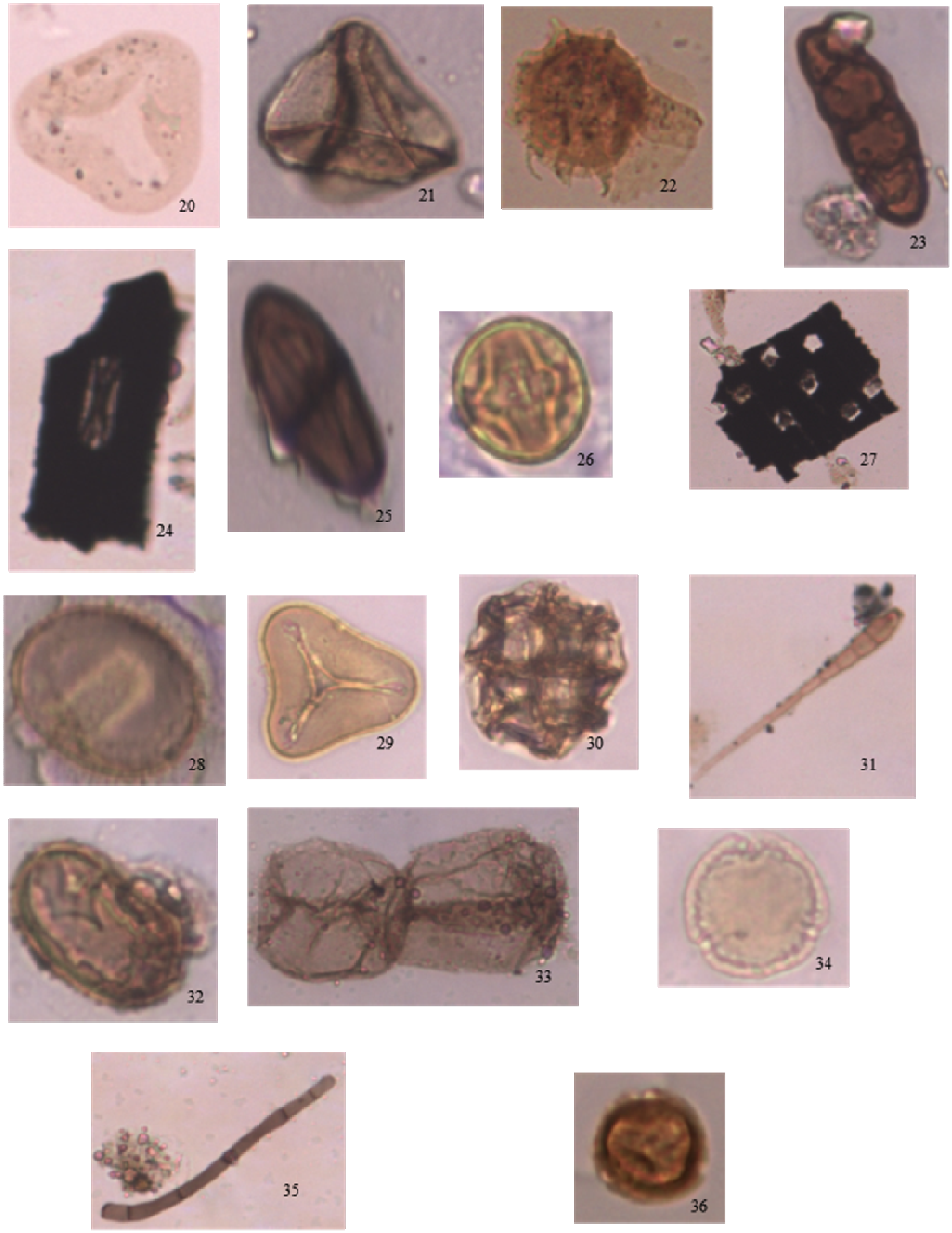
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Plates

1. *Selaginella myosrus*
2. *Triletes sp.*
3. *Polypodiaceoisporites sp*
4. *Leiosphaeridia sp*
5. *Polypodiaceiosporites sp*
6. *Proxapertites operculatus*
7. *Leiotriletes adriennis*
8. *Triletes sp*
9. *Laevigatosporites sp*
10 *Leiotriletes adriennis*
11. *Elaeis guineensis*
12 *Nympheapollis clarus*
13 *Leiotriletes sp*
14 *Crassoretitriletes vanraadshooveni*
15 *Multicellites*
16. *Retistephanocolporites sp*
17. *Monoporites annulatus*
18. *Laevigatosporites sp*
19. *Lejeunecysta sp*
20. *Elaeis guineesis*
21 *Leiotriletes sp*
22. *Ariadnaesporites sp*
23. *Multicellites sp*
24. *Charred graminea cuticle*
25. *Fusiformisporites sp*
26. *Psilatricolporites sp*
27. *Charred graminea cuticle*
28. *Pilososporites sp*
29. *Smooth trilete spore*
30. *Polyadopollenites sp*
31. *Alternaria sp*
32. *Pilososporites sp*
33. *Leiosphaeridia sp*
34. *Psilatricolporites sp*
35. *Fungal hyphae*
36. *Zonocostitites ramonae*

7.0 CONCLUSION

Terrigeneous species commonly increase during regression. The palynomorph in Ajali Sandstone in the studied area are mainly terrestrial with few marine species occurring in Orame 1 and 2. It shows that the environment in Ayogwiri and Fugar is shallower and it gets deeper into the ocean in the direction of Orame 1 and 2. The species are representative of a regression. Marine indicators are sparse in the sandstone. The palynomorph assemblage is mainly indicative of a mangrove swamp in tropical and as well as in humid or cooling environment. In conjunction with the lithology and sedimentary structures, which are mainly fine sand in places to coarse and pebbly sand in some others, an estuarine coastline is suggested and not a lagoon. The environment is marginal marine in Ayogwiri and Fugar and we are moving into shallow marine environment in Orame 1 and 2.

The findings support the short regressive phase in the Maastrichtian as postulated by Nwajide and Reijers, 2004; Benkhelil, 1986; Amajor, 1987, Adediran et al., 1991.

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