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Palynological Analysis of Ajaka Outcrops in the Northern Kogi District of Kogi State, Nigeria

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Abstract: **The palynological analysis and paelodepositional environment of the Ajaka area were analysed using a detailed study of outcrops and a borehole section. Results show that two major lithostratigraphic units outcrop in the area; dominantly conglomerate unit which can be subdivided into the paraconglomerate and the orthoconglomerate subunits, and the massive sandstone unit. The massive sandstone facies consists of fine-to-coarse grained massive sandstone. The sand grains are angular to subrounded and poorly to moderately sorted. This facies is interpreted to have formed as a result of transport and deposition by short-lived mass flows. The palynological analysis, indicate the presence of Retidiporites miniporatus, Hexaporotricolpites emelianova and Buttinia andreevi, which all are indicative of the Maastrichtian age bracket in the geological time scale. This evidence thus suggests that the outcrops of Ajaka and environs are Maastrichtian in age.**

Keywords: **palynological Analysis, Maastrichtian age, Anambra Basin, Palynomorphs.**

1. INTRODUCTION

Structural settings:

As recognized by Murat (1972), the megatectonic setting in the southern domain of the Benue Trough was a longitudinally faulted crust whose eastern half subsided preferentially to become the Abakaliki sub-basin (or the southern Benue Trough). The western fragment remained a stable platform up to the Santonian. Thus the subsided eastern part become an important depocentre relative to the platform which received only a veneer of clastic and chemical sediments. Following the Santonian folding and uplift, the main depocentre in the southern Benue Trough, i.e. the Abakaliki area, became flexurally inverted, displacing the depocentre to the west and northwest. This created the Anambra Basin.

Ojoh (1990) had noted that basin subsidence in the southern Benue Trough was spasmodic, being a high rate in pre-Albian time, low in the lower Cenomanian, and very high in the Turonian, which was related to the Important phase of platform subsidence. This is thought to be the actual time of initiation of the Anambra Basin creation, a process that gained momentum in the Coniacian and climaxed during the Santonian thermotectonic event. Thus the localized subsidence on the western reach of the southern Benue Trough and the continued sea level rise into the Coniacian, led to the installation of the Anambra Basin (Ojoh, 1990). It should be noted however, that sedimentation started as far back as Turonian or even earlier on the shallowly submerged Anambra Platform. The rate of westward migration of the depo axis was of the order of 10 km/My or 1 cm/ year, and gradually effected the tectonic inversion between the Abakaliki region and the Anambra Basin.

As already stated, the sediment-filled depression in the Afikpo area is considered a part of the Anambra Basin. The area was involved in the tectonic inversion that produced the depocentre to the west of the Abakaliki Anticlinorium. Sedimentation in that area, which is centred to the south of southeast of Abakaliki, is dated to have commenced in the Santonian into the Campanian, using the palynofloral *Syncolporites lisamae* subtiles and *Auriculdites* sp. (Ojoh, 1990).

In the southern Nigeria stack the Anambra Basin is sandwiched between the Benue Trough and the Niger Delta. The main implication of this is that, after the Santonian thermotectonic event, there must have been a thermal decay, i.e a detumescent stage that produced a sag on which at least part of the Anambra Basin became superimposed. In the same manner, the establishment of the Niger Delta sedimentary regimen from the Paleocene must have taken advantage of continued thermal sag. According to Mckenzie (1978), there is usually a distinct thermal sag stage involved in post-rift basin formation in response to the cooling and contraction of the lithosphere and the asthenosphere that were thermally perturbed during the earlier rifting process. The isostatic response to such cooling is a flextural subsidence of the crust, such that magnetism would rapidly decrease and then cease altogether, such as developed along the western margins of the Benue

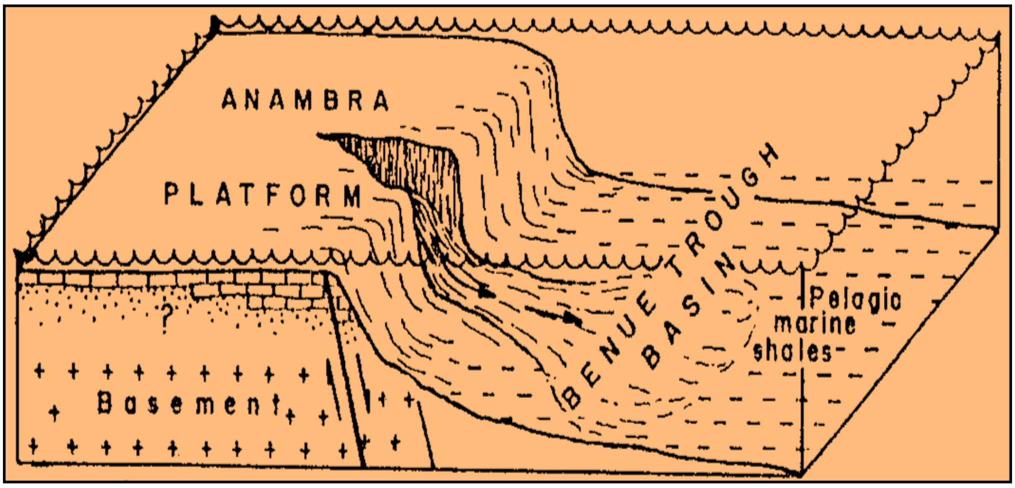

Fig 1: Conceptual model of the relationship between the Anambra platform and the Benue Trough in the Albian to Santonian (after Oti,1990)

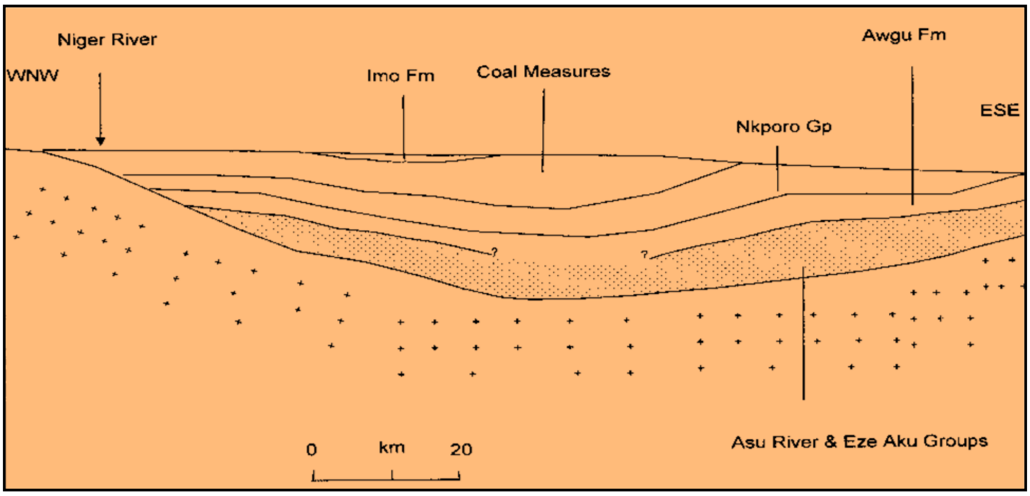

Fig 2: A WNW-ESE section the Anambra Basin fill as a broad shallow synclinal succession overlying the units of the southern Benue Trough (after Benkhelil, 1988).

Stratigraphic settings:

The Anambra basin which is in the southern Benue trough, being that the trough itself is a continental large scale intra-plate tectonic range structure, which is part of the mid-African rift system initiated in the latest Jurassic to early cretaceous and it is related to the opening of central and south Atlantic ocean (Murat, 1972). The southern Benue trough comprises the tectonically inverted Abakaliki anticlinorium, Afikpo and Anambra basin flanking the anticlinorium to the east and west respectively.

The development and evolution of the tectonics, of Anambra basin, and the stratigraphic setting of the study area will be better appreciated by reviewing developments in the depositional area since early cretaceous structural unit of the southeastern Nigeria as represented by Murat, 1972.

Table 1: The lithostratigraphic units of the Anambra Basin (after Nwajide 1990)

Age	Basin	Stratigraphic Units						
Thanetian	Niger Delta	Imo Formation						
Danian								
Maastrichtan	Anambra Basin	Coal Measures	Nsukka Fm					
			Ajalli Fm					
			Mamu Fm					
Campanian		Nkporo Fm	Nkporo Shale	Enugu Fm	Owelli Ss	Afikpo Ss	Otobi Ss	Lafia Ss
Santonian	Southern Benue Trough	Awgu Fm						

2. DESCRIPTION OF STUDY AREA

The study area lies between latitude N 07^0 10^1, N 07^0 17^1 and longitude E 006^0 42^1 and E 006^0 50^1. It covers Emachi, Ibochi Ofeke, Itobo, Ojiapata, and Okpo Iyokolo.

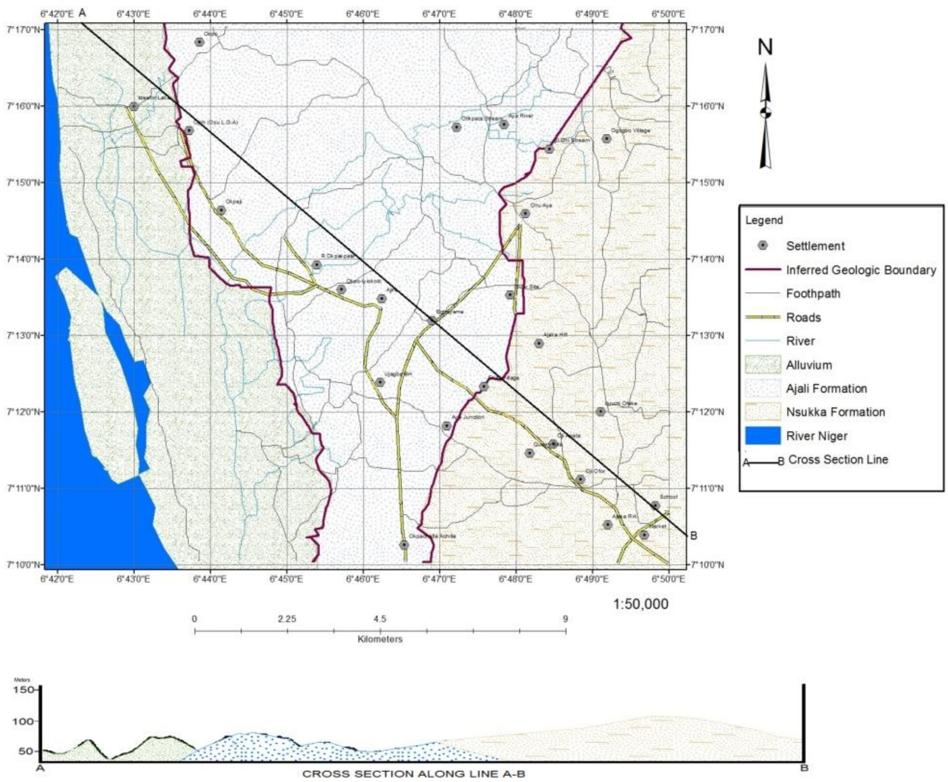

Fig 3: Map of the study area (Modified from sheet 267)

The dominant physiographic features of the Anambra Basin area are the cuesta topography and the presence of segments of the arterial Niger-Benue drainage system. Other topographic features include inselbergs, plateaus, and rolling plains. The cuesta is a ca. 500km long asymmetrical ridge whose crest describes a laterally inverted sigmoid and can be traced northwards from Idah on the left bank of River Niger. The topography of the study area is undulating. The land rises from about 300 and 930 meters above sea level in the uplands.

The predominant topographic feature found in the study area is the Ajaka hill, which have the highest elevation of 850-930 meters. Rocks of varying susceptibility to erosion occur in the area. The resistant rocks are seen around Ajaka and Okpeji area. While the rocks that are susceptible to erosion are seen basically around Okpo-iyiokolo and Egbayeme area.

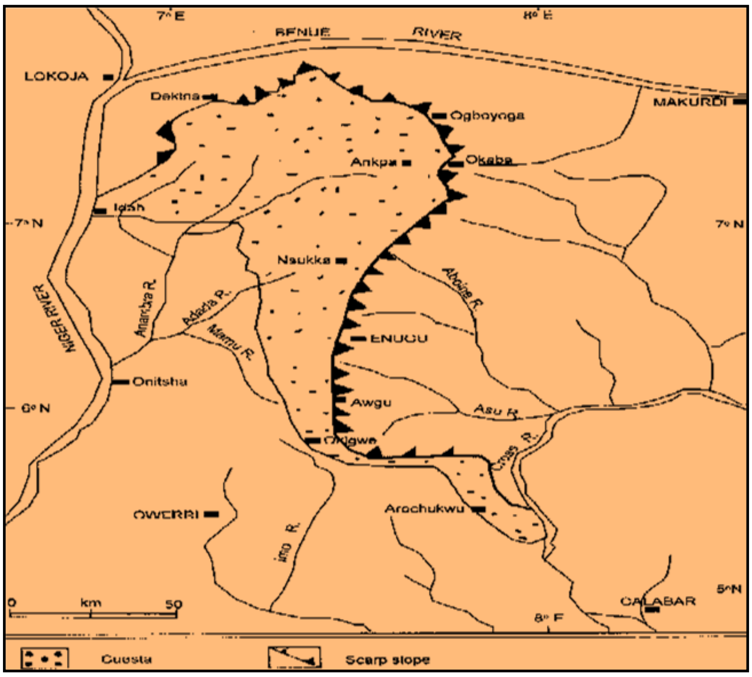

Fig 4: The cuesta topography of south-eastern Nigeria (after Umeji, 1980)

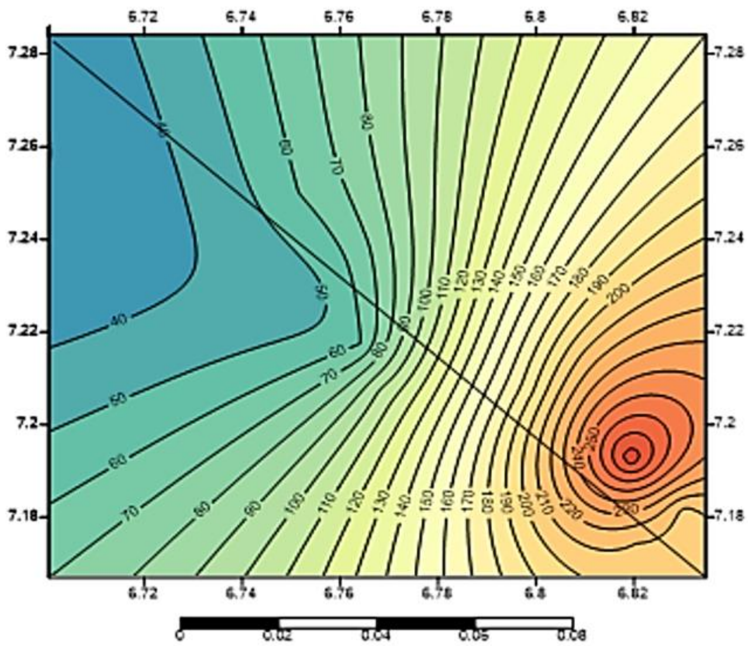

Fig 5: The Contour Map of the study area (Nzewi, 2016)

The drainage of the study area is controlled by its topography. It is drained by River Aya, Iyi-ohi, oyogbo and otikapata. The drainage system in the study area is characterized by dendritic drainage pattern

The drainage density on terrains underlain by the Ajali sandstone in the study area is generally low. This may be due to the ease of infiltration that greatly reduces overland flow. Another perspective is that the water table is generally low, because of the absence of impermeable Formation to restrain downward flow. Again due to ease and great depth of infiltration, such that springs are rare, and rivers are therefore relatively rarely generated.

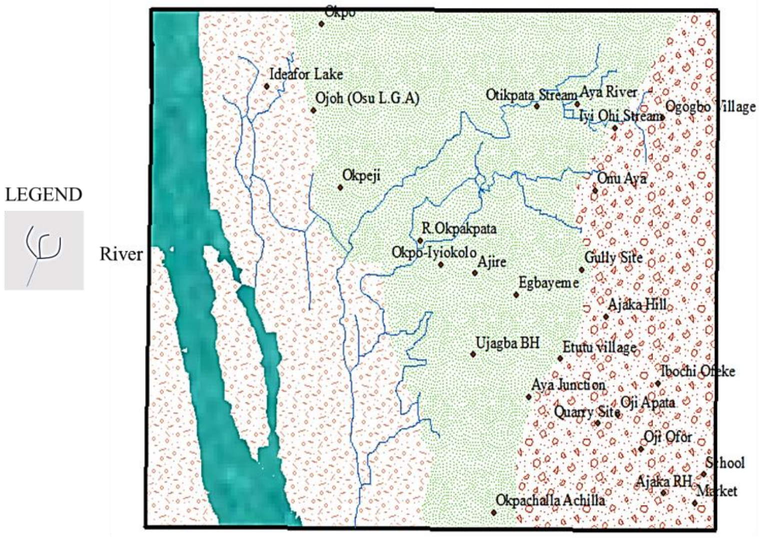

Fig 6: The drainage map of the study area. (Modified from sheet 267)

The study area lies within a zone of tropical climate characterized by two main seasons; the rainy and dry season. And has an annual rainfall of between 1,100mm and 1,300mm. The rainy season lasts from April to October. The dry season, which lasts from November to March, is very dusty and cold as a result of the northeasterly winds, which brings in the harmattan. The temperature of the study area varies in magnitude according to the period of the year; The minimum and maximum temperatures average 25^0c and 32^0c respectively. . The daily mean humidity varies from 40% to 92%; it is generally high during the early hours of the day (Egboka, 1993).

3. METHODOLOGY

Shale samples were collected from a borehole section for palynological analysis from different depth. Whose litholog have been shown in my outcrop description. Below is the procedure for the preparation of the sample.

NB: BH/1, BH/2 and BH/3. Are used in naming the depth where the samples are collected from

Borehole lithology:

Location: the borehole site is located Ujagba village, Idah- Lokoja road. Which have the coordinate of Lat N $07^0 12.454^1$ Long E $006^0 46.162^1$

Elevation: 95m.

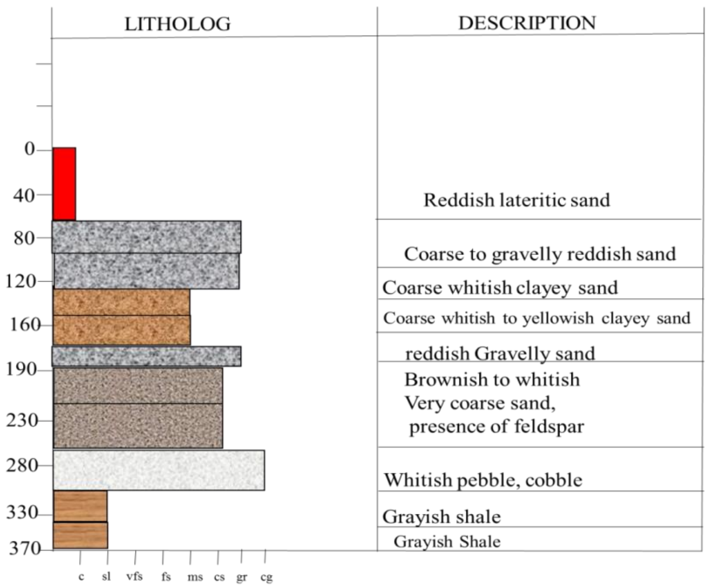

Fig 7: The litholog of the borehole section at Ujagba village

Sample Preparation Method – Palynology:

1. **Dissolution of Carbonates**: The samples are subjected to treatment with Hydrochloric acid (HCl) to remove any carbonate. The samples are then thoroughly washed with distilled water after decanting the HCl.
2. **Dissolution of Silicates:** The next procedure is the addition of Hydrofluoric acid (HF) to the samples to dissolve the silicates. The samples are stirred at regular intervals with a plastic or nickel rod and then left overnight in the fume cupboard. Samples are thoroughly washed with distilled water after decanting the HF.
3. **Removal of Fluoride Gels:** The samples are then treated first with warm 36% HCl, and then cold HCl to remove fluoride gels. The samples are then thoroughly washed with distilled water.
4. **Separation of Organic Content**: The next procedure is to wash with 0.5% HCl and then transfer the samples into small 15cc. centrifuge tubes. The 0.5% HCl is decanted after centrifuging and the Zinc bromide (s. g. 2.2) is added and properly stirred with glass rod. After centrifuging, the floating top part consisting of organic material is gently decanted into another tube. The organic material is gently decanted into another tube. The organic material is then thoroughly washed with distilled water.
5. **Oxidation of Organic Matter**: The organic residue is now transferred into porcelain basins, and concentrated Nitric acid (HNO_3) very gently added. It is warmed for a few minutes and stirred properly with a glass rod. It is centrifuged, and the Nitric acid decanted, and the residue thoroughly washed with distilled water.
6. **Neutralisation of Acids**: Warm Potassium hydroxide (KOH) is added to the residues and allowed to stand for about 5 minutes. It is centrifuged and the KOH decanted. The residue is washed about 2 or 3 times with distilled water in order to ensure that all KOH is washed out. The residue is finally washed twice with alcohol.
7. **Preservation of Residue**: The residues are preserved by adding a drop of glycerol/glycerin to each of the properly labeled phials. They may also be stored in water.
8. **Preparation of Microscopic Slides:** A small quantity of glycerin jelly is put in the center of a clean slide and a small quantity of organic residue is added and warmed. The mixture is spread out evenly, and covered with a cover slip, and the slide is then labeled

4. RESULTS AND INTERPRETATION.

Table 2: The Palynomorphs of the BH/1

Spores (terrestrial species)	Pollen (terrestrial species)	Dinoflagellate cysts (marine species)
Zlivisporis blanensis 3	*Psilamonocolpites sp 1*	*Acrostichum aurem 6*
Ariadnaesporites longispinosus 3	*Retimonocolpite sp 1*	
Foveotriletes sp 4	*Retitricolpite sp 2*	
Verrucosisporite sp 6	*Psilatricolpites 1*	
Leiotriletes sp 4	*Retidiporites miniporatus 1*	
Mauritiidites crassibaculatus 1	*Ephedripites sp 1*	
Leiotriletes adriennis 2	*Cyathidities sp 1*	
Auriculiidites reticulatus 2	*Proxapertites sp 1*	
Cicatricosisporite sp 1	*Proteacidites miniporatus 2*	

Table 3: The palynomorphs of the BH/2

Spores (terrestrial species)	Pollen (terrestrial species)	Dinoflagellate cysts (marine species)
Ariadnaesporites longispinosus 2	*Longapertites marignatus 2*	*Acrostichum aurem 9*
Verrucosisporites sp 9	*Longapertites sp 1*	
Leiotrilletes adriennis 3	*Periretisyncolpites sp 1*	
Auriculiidites sp 1	*Retidiporites miniporatus 3*	
Laevigatosporites sp 4		
Leiotriletes sp 2		
Ariadnaesporites spinous 1		
Cingulatisporites ornatus 1		

Table 4: The palynomorphs of BH/3

Spores (terrestrial species)	Pollen (terrestrial species)	Dinoflagellate cycts (marine species)
Ariadnaesporite sp 3	*Longapertities sp 2*	*Buttinia andreevi 1*
Ariadnaesporite longispinous 3	*Retidiporites miniporatus 9*	
Leiotriletes adriennis 9	*Retidiporites magdalenensis 1*	
Verrucosisporites sp 12	*Retridiporites sp 1*	
Mauritiidites crassibaculatus 1	*Polydopollenites microreticulatus 1*	
Zlivisporis blanensis 1	*Periretisyncolpites sp 2*	
Mauritiidites sp 2	*Hexaporotricolpites emelianova 1*	
Laevigatosporites sp 3		

Environmental indications: The general palynological criteria used for environmental diagnosis (i:e the degree of marine influence) are shown in Table 5

Table 5: The general palynological indicators of degree of marine influence (Leckie *et al.*, 1990)

Environment	Descriptions
1. Continental	Palynoflora composed exclusively of land derived microspores and pollen.
2. Slightly brackish	Slight introduction of saline water in essentially fresh-water environment, e.g, coastal lakes with outletsto the sea, inlets, upper estuaries, and interdistributary channels, littoral. Contains rare specimens of ceratioid dinoflagellates (eg. *Nyktericycta*, *Vesperopsis* and *Balmula*) and a few acritarchs. Land derived spores and pollen abundant
3. Brackish	Marginal marine conditions found in bays, estuaries, lagoons and barrier associated backwaters. Increase in saline water. Dinoflagellate species diversity low. Certain species of ceratoid or peridinioid dino-flagellates (eg, *Palaeoperidinium cretaceum, Luxadinium primulum)* appear in abundance. Assemblage often monospecific. Land derived spores and pollen abundant.
4. Nearshore marine	Inner neritic environment. Shallow marine, dinoflagellate diversity higher due to increased salinity but assemblage still dominated by land derived spores and pollen grains.
5. Open marine	Outer neritic environment. Close to the margin of the shelf. Fully saline water. Dinoflagellate diversity highest. Land-derived spores and pollen grains reduced in quantity. Assemblage dominated by dinoflagellates.

Table 6: Summary of the palynomorphs % frequency distribution and their paleo-environmental inferences

Sample no.	Palynomorphs % frequency			Paleo-salinity	Paleo-environment
	Spores	pollen	Marine species		
BH/1	**73%**	**34%**	**9%**	**Slightly brakish- water**	**Marginal marine probably (estuarine or lagoon)**
BH/2	**63%**	**21%**	**11%**	**Slightly brakish- water**	**Marginal marine probably (estuarine or lagoon)**
BH/3	**77%**	**45%**	**2%**	**Slightly brakish- water**	**Marginal marine probably (estuarine or lagoon)**

Brief Summary of Age Determination:

Three (3) samples were processed for their palynomorph content and analysed. These samples were subjected to standard palynological processing procedures. Palynomorph preservation was relatively good/fair. The samples yielded fairly rich to rich diverse assemblages of miospores.

The analysis indicates that these samples were predominantly of **Maastrichtian** (**Early – Middle Maastrichtian)** age. This age interpretation is based on the occurrences of ***Retidiporites miniporatus (Macrotyloma brevicaule),*** H***exaporotricolpites emelianova, and Buttinia andreevi*** which are restricted within Early to Middle Maastrichtian age.

Also supporting this interpretation are the presence of ***Ariadnaesporites spinosus***, ***Zlivisporis blanensis, Cingulatisporites ornatus, Ariadnaesporites longispinosus, Mauritiidites crassibaculatus, Verrucosisporites sp, Auriculiidites reticulatus*** , ***Retidiporites magdalenensis*** and ***Ariadnaesporites sp*** which made up the palynofloral assemblage within this age.

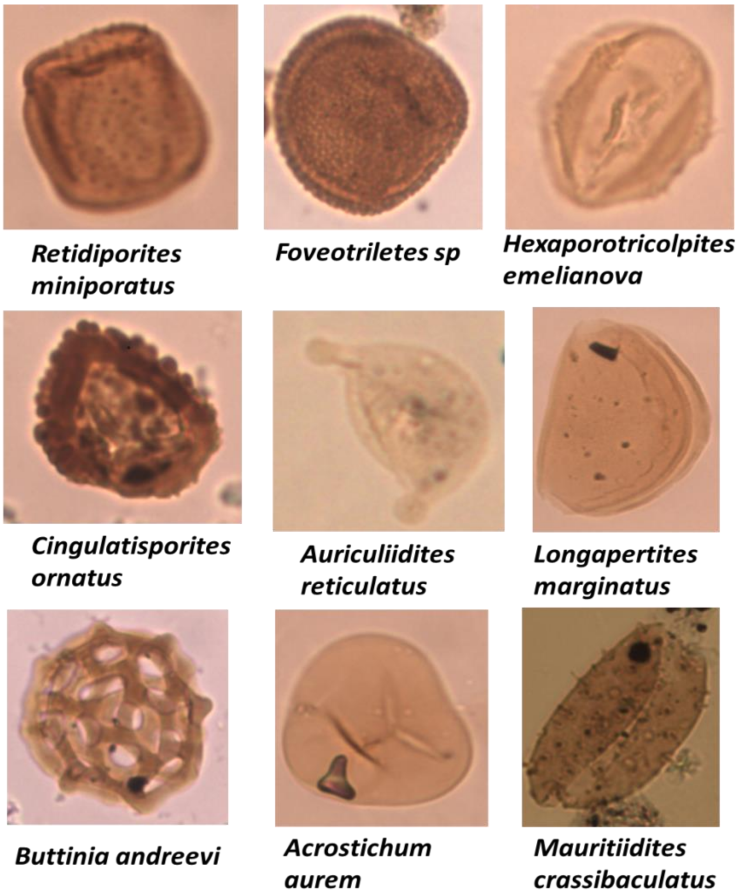

Fig 8a: Micrographs of some recovered palynomorphs from the analyzed samples.

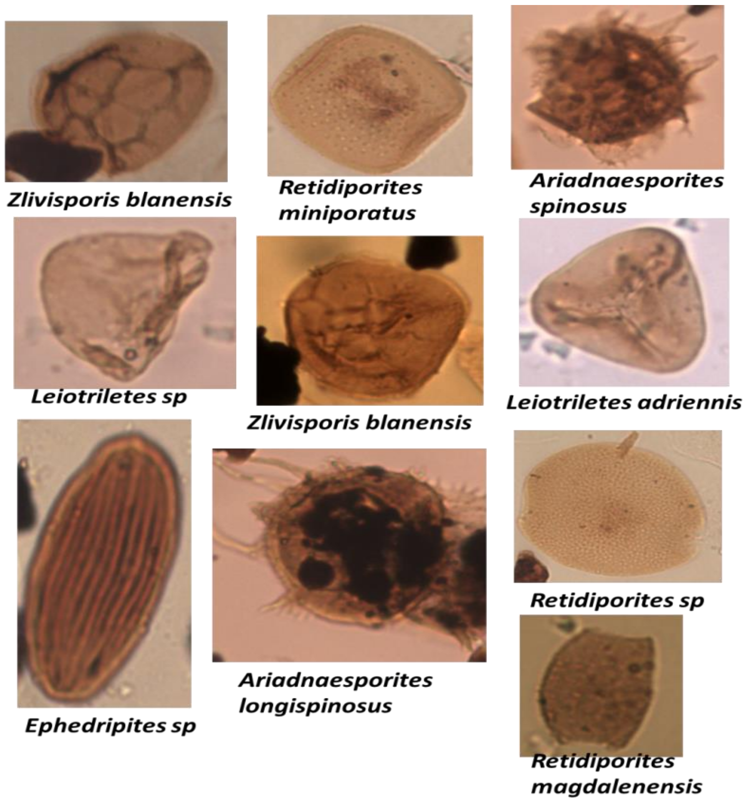

Fig 8b: Micrographs of some recovered palynomorphs from the analyzed samples

5. CONCLUSION

The palynological analysis and paelodepositional environment of the Ajaka area were analysed using a detailed study of outcrops. Results show that two major lithostratigraphic units outcrop in the area; dominantly conglomerate unit which can be subdivided into the paraconglomerate and the orthoconglomerate subunits, and the massive sandstone unit The massive sandstone facies consists of fine-to-coarse grained massive sandstone. The sand grains are angular to subrounded and poorly to moderately sorted. The palynological analysis, indicate the presence of Retidiporites miniporatus, Hexaporotricolpites emelianova and Buttinia andreevi, which all indicative of the Maastrichtian age bracket in the geological time scale. This evidence thus suggests that the outcrops of Ajaka and environs are Maastrichtian in age.

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