A BIOFACIE STUDY OF AN OUTCROPPING UNIT AT IBII QUARRY SITE, AFIKPO BASIN, SOUTH EASTERN NIGERIA

SORONNADI-ONONIWU, G. C.[1], DIDEI, I. S[2]

[1,2]Department of Geology, Niger Delta University, Wilberforce Island, Yenagoa, Bayelsa State

ABSTRACT

A Biofacie study of an outcropping unit at the Ibii quarry site, Afikpo Basin, South Eastern Nigeria was carried out to determine the fossil assemblage of the samples in relation to its lithological variations in order to determine the age and paleoenvironment of deposition, using a total of ten samples obtained from the field. The samples were further subjected to lithological/Sedimentological and palynological analysis respectively. The results for the lithological/Sedimentological analysis which cuts across both processes of lithological description, lithofacie and wet sieve analysis showed that the samples were highly calcareous, and the lithofacie analysis showed the presence of authigenic minerals such as quartz, heavy minerals, muscovite, gypsum, and mica flakes respectively while the wet sieve analysis showed a high value of shale to sand ratio all of which further depicts a marginal marine to marine depositional environment. The palynological analysis yielded practically no Palynomorph to very scanty to low quantity of palynomorphs. The palynomorphs include; *Psilatricolporites sp, Laevigasporites discordatus, Diatom and Fungal spore.* Although the analysis yielded no environmentally significant Palynomorph, the presence of Diatom and fungal spore in most of the samples portray that the samples were probably deposited in a marine setting.

Keywords: Biofacie, Paleoenvironment, Fossil assemblage, Sedimentological and Palynological

INTRODUCTION

A century of geological studies have enabled a broad understanding of the geology of the Benue Trough. But it was only in the later part of the 20th century that a picture of the structural framework, within which the Benue Trough evolved, began to emerge. The controversies surrounding the tectonic evolution of the Benue Trough have been largely resolved, with the overwhelming evidence leaning towards the interpretation of the so called French school of structural Geologists which sees the Benue Trough as a collection of pull apart basins, related to transcurrent or strike-slip movement along deep-seated basement shear zones of Pan African origin reactivated as Oceanic transform faults (Benkhelil, 1982; 1989; Guiraud, 1993). This view is supported by field evidence in the Northern Benue Trough where the climate and the nature of the sedimentary units allow for classic geologic study. In the Southern Benue Trough, the fine grained nature of most of the units and the dense vegetation as a result of a wet tropical climate have hindered field studies and created a missing link in the proper explanation of the structural framework of the basin (Okonkwo, 2014).

According to King (1950), Farrington (1952), Nwachukwu (1972), Murat (1970), the Benue Trough originated as a failed arm at the time of the opening of the South Atlantic Ocean during the separation of the African plate and the South American Plate. Benue Trough is defined as an intercontinental Cretaceous basin about 1000km in length stretching NE-SW direction and resting unconformably upon the Precambrian basement. It is subdivided into the upper, middle and lower region, extending from the Niger delta to the Northeast Chad Basin.
The Lower Benue Trough comprises of the Abakaliki Anticlinorium, Afikpo Synclinorium to the east and Anambra basin to the west. The Afikpo Basin originated during the Santonian Orogeny in the Upper Cretaceous time, during the Santonian tectonism; older strata were folded, faulted, intruded and uplifted. The folding resulted into the formation of Afikpo Basin, the depressed Afikpo platform became a major depocenters after the deformation and uplift of the Benue Abakaliki Trough, thereby making it a Basin for the deposition of the Pre-Santonian and Post-Santonian sediments, Odigi, (2012). According to Ojoh, (1990) the lithic fill in the Afikpo Basin is considered a part of Anambra Basin. Although the lithic fill in the Afikpo syncline postdates to the Santonian folding event .There is therefore no justification for according the Afikpo Syncline the status of a Basin distinct from the Anambra Basin, Nwajide, (2013). PostSantonian sediments deposited in the Afikpo Basin include the outcropping unit at Ibii quarrysite for which the analysis of this work have been carried out on, the sediments involves varying lithology of highly calcareous shales and siltstone respectively. The Afikpo Basin has been a subject of discussion by many researchers Odigi, (2007), Umeji, (2010).Thus this project work as part of contributing to the wealth of research in the area, intends to determine the lithofacie variation within the basin, age and the depositional environment with case study of an outcropping unit at Ibii quarry site employing both lithological/Sedimentological and Biostratigraphical forms of analysis.

STUDY LOCATION

The study area as shown in Fig (1.1) lies within longitude N5^{0}56’55.83” and latitude E7^{0}57’11.1” respectively. The quarry site is located along a road into Ibii, the area has good road network and is easily accessible by main roads and minor roads including foot paths respectively. The major access roads (Fig 1.2) into the study area include the Abakaliki – Afikpo road, Okigwe- Afikpo road. It can also be accessible from Akpoha and through footpath from Uroro into Afikpo.

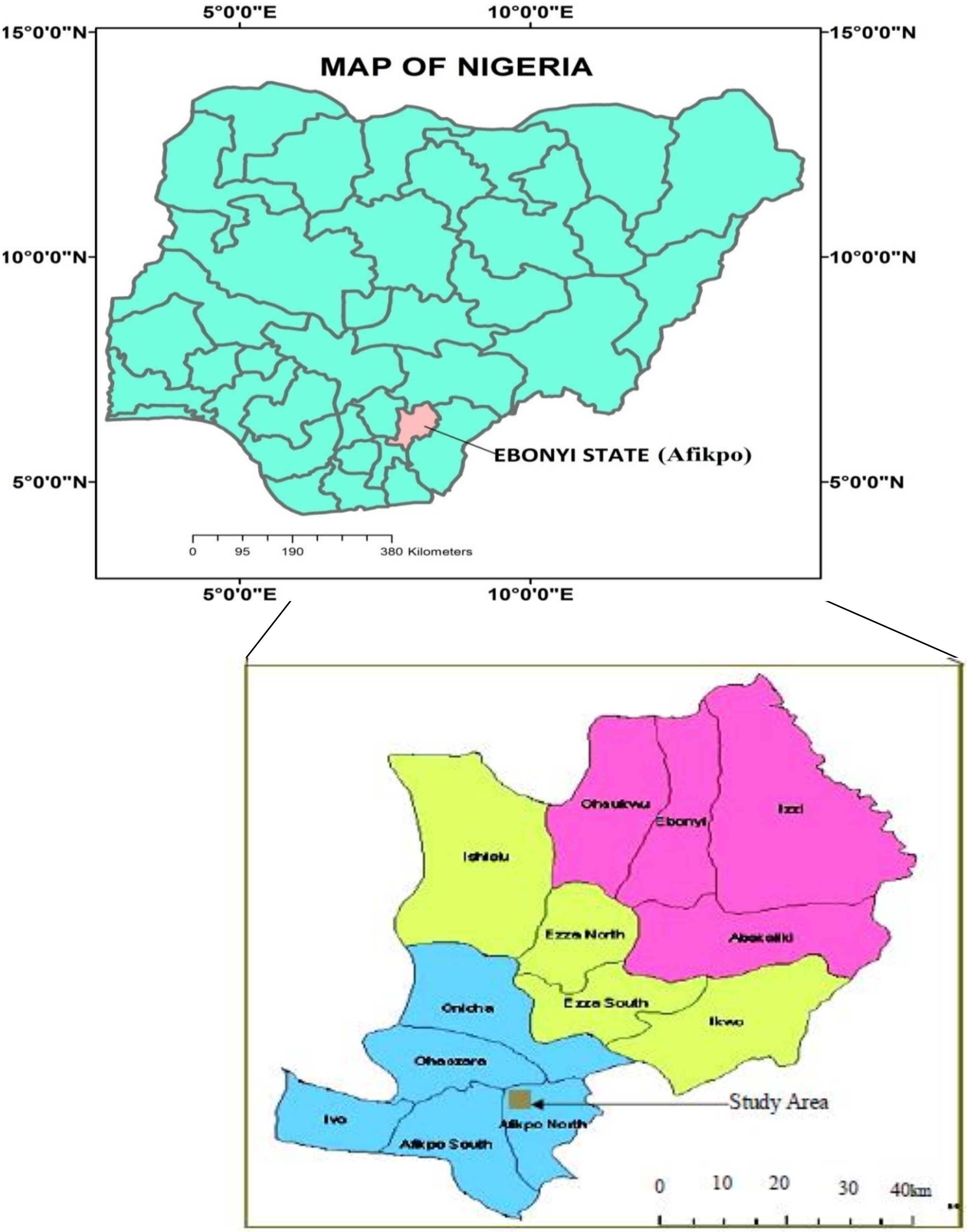

Fig 1: Map of Nigeria Showing Area of Study (Ogbonnaya, 2012)

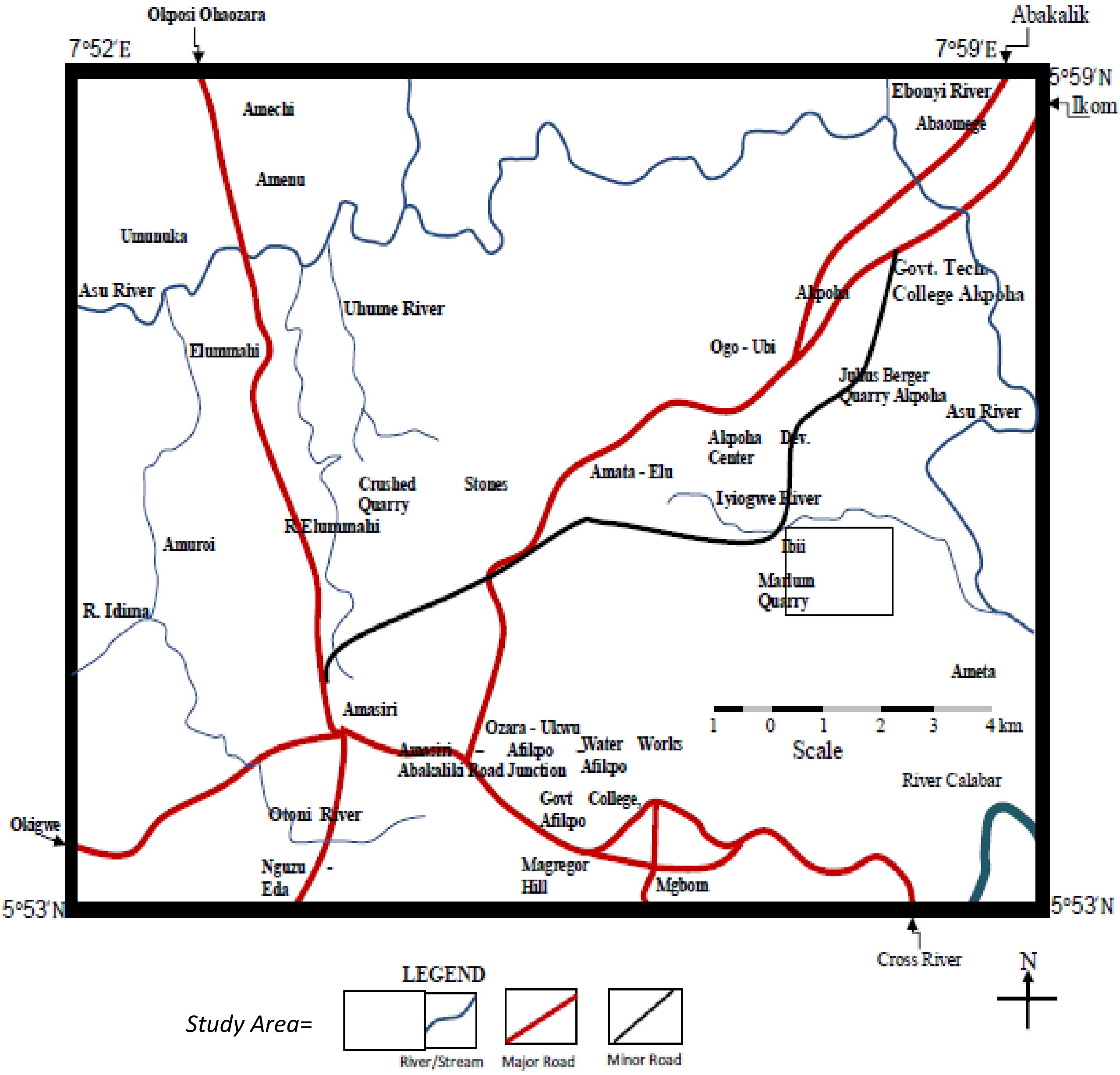

Fig 2: Accessibility map showing the location of the study area (Ogbonnaya,2012)

GEOMORPHOLOGY

The terrains of the study area are basically composed of an undulating alternation of high lands and low lands basically of hills and valleys.

The study area is generally an undulating alternation of high lands which is bounded by sandstone and lowland which is bounded by shale. The highlands which are mainly ridges and hills are basically composed of sandstone lithology, including some minor siltstones, mudstones, and clay which serve as cementing materials that binds the quartz grains in the sandstones together. Shale and siltstone usually underlie the lower areas (plains). Hence, on a regional scale Afikpo is considered a trough or a sub-basin but in terms of its local topography it is commonly undulating.

The highest elevation from the map is about 450ft while the lowest elevation is 50ft.

The Cross River is the largest river passing through the study area, it originates in Cameroon, it flows southwards through the study area to the Atlantic Ocean (Cross River Nigeria) the Amboina river is one of the major tributaries of the Cross River. If passes through the study area from north-south where it joins the Cross River. Its path seems to be controlled by NNW – SSE lineaments.

The Asu River is a west-East flowing tributary of Aboine River. Its flow direction is controlled by the alignment of the ridges and the river path is limited to one of the large shale swales through which the river meanders and forms a large flood plain before joining the Aboine River at Akpoha- these rivers though perennial, show a large variation between peak flow (usually at the end of the rainy season) and ebb flow (at the end of the dry season) where they are reduced to a bare trickle. Their banks provide in the dry season, very good exposures of the shale units otherwise hidden in other locations. Other minor smaller streams are also controlled by the ridge and swale topography giving a roughly trellis drainage pattern along with the Aboine and Asu river (Fig3).

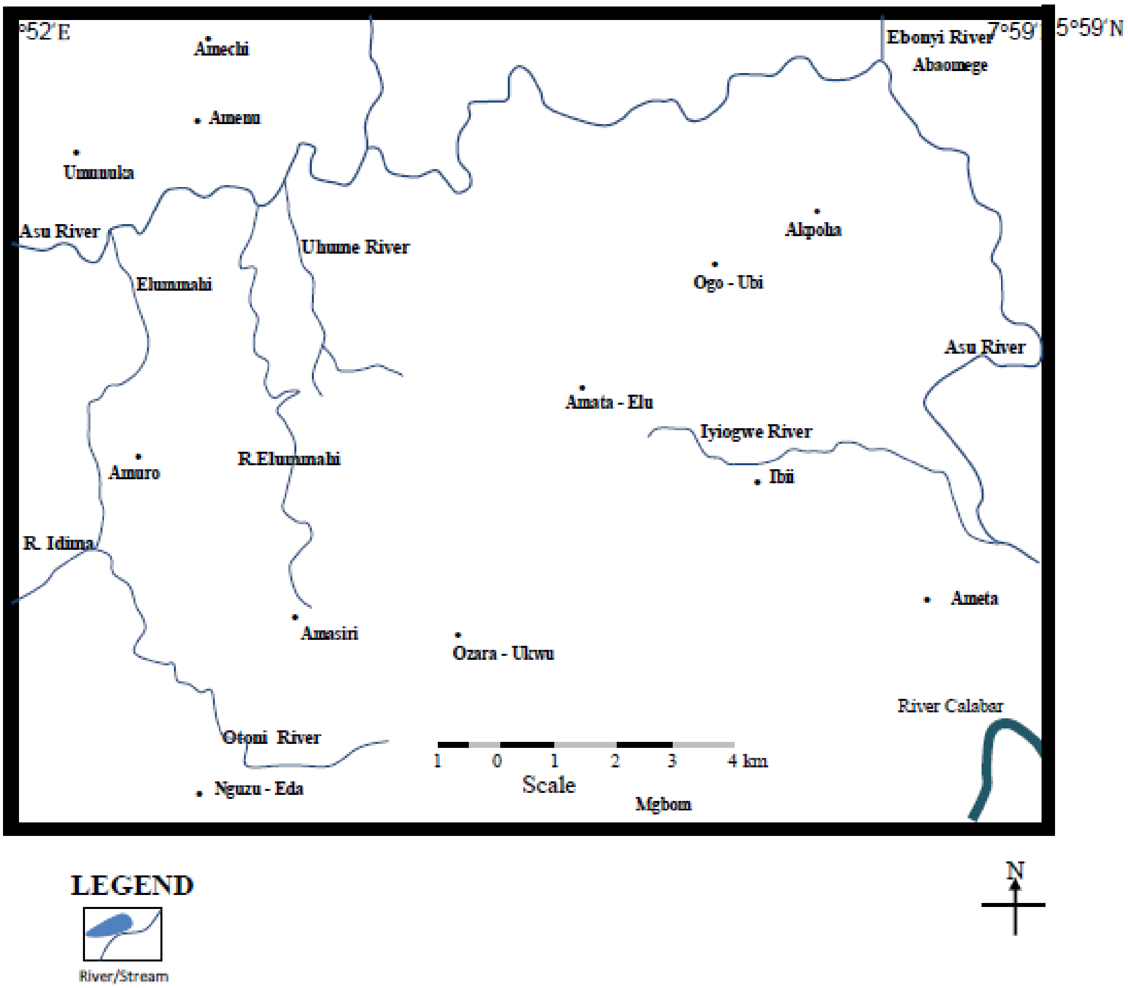

Fig 3: Drainage map of the study area showing the major rivers and their distributaries

(Ogbonnaya, 2012)

The study area is characterized by a warm tropical climate with relatively high temperatures of about 27^0c on the average, basically two seasons dominate the area – the rainy or wet season that last from March – November in the south and from May to October in the north . And the dry season that occupies the rest of the year. The rainy season has two periods of maximum rainfalls that measures an average of about 1500mm-2000mm (Fig 4) annually (Inyang, 1978) separated by short drier period in August (the August break). Relative humidity in the study area is generally high and ranges between 60% and 95% during the rainy season and fall below 60% during the dry season (Monanu, 1978).

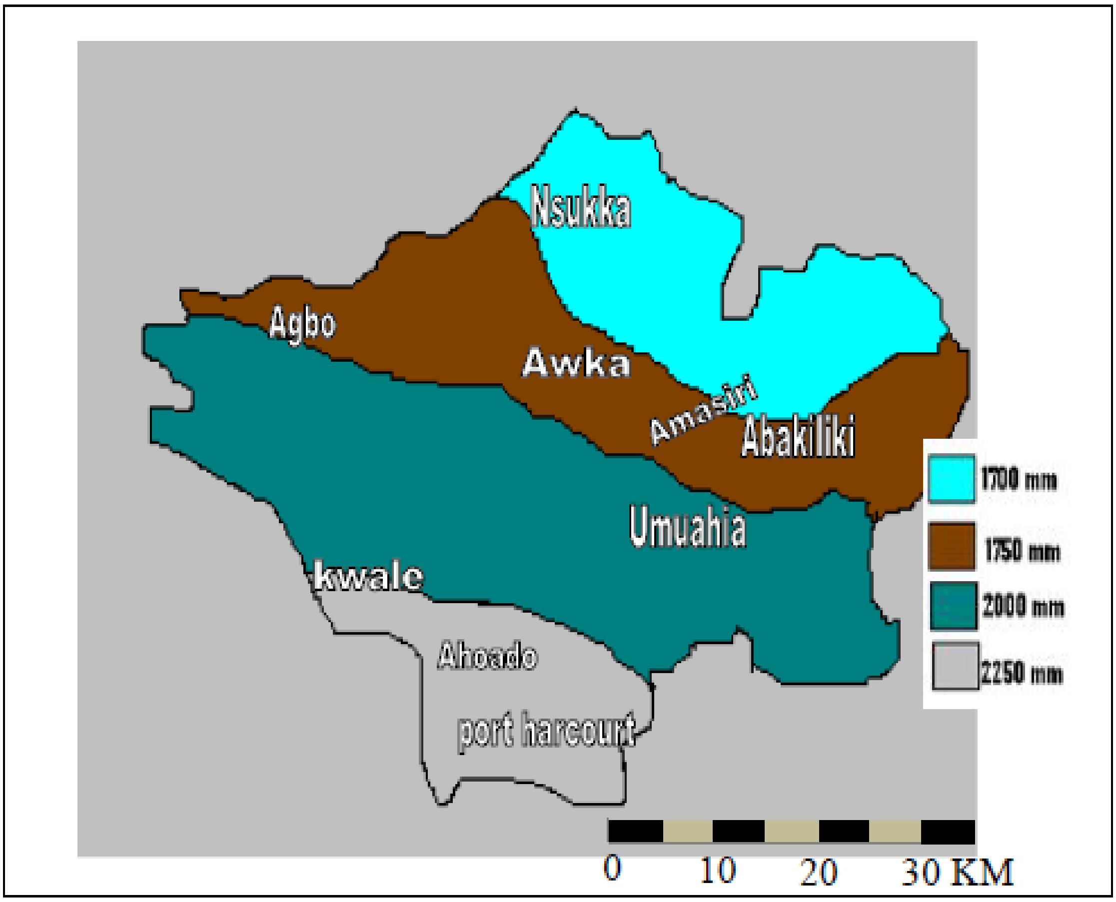

Fig 4: Map of South-Eastern Nigeria showing Climatic condition with respect to the annual rainfall of the study area (Inyang, 1978)

REGIONAL GEOLOGY OF THE STUDY AREA

The study area lies within the Benue Trough, According to King (1950), Farrington (1952), Nwachukwu (1972) and Murat (1970) it is noted that the Benue Trough originated as a failed arm at the time of the opening of the South Atlantic Ocean during the separation of the African plate and the South American plate. Benue Trough is defined as an intracontinental Cretaceous basin about 1000km in length stretching in NE-SW direction and resting unconformably upon the Precambrian basement. Based on the Benue Trough corresponding geological and geomorphological partitioning, it is subdivided into the upper, middle and lower region. The lower which is the southern Benue Trough, is the southwestern part of the Benue depression (Carter et al, 1963: Reyment, 1965). It comprises of the Abakaliki Anticlinorium, Afikpo Synclinorium to the east and the Anambra Basin to the west.

A review of the tectonic framework of the inland sedimentary basin of Nigeria has demonstrated that the Benue Trough system was indeed a rejuvenation of existing basement features, wrench movements along these faults resulting in blocks faulting and formation of several sedimentary basins.

The Benue Trough is a unique rift feature on the African continent in that it occupies an intercontinental position, and has a thick compressionally folded Cretaceous supracrustal fill. (Cratchley and Jones, 1965). The Benue Trough has a lateral extent of about 250km in the south and includes the Anambra Basin, the Abakaliki Anticlinorium and the Afikpo Syncline.

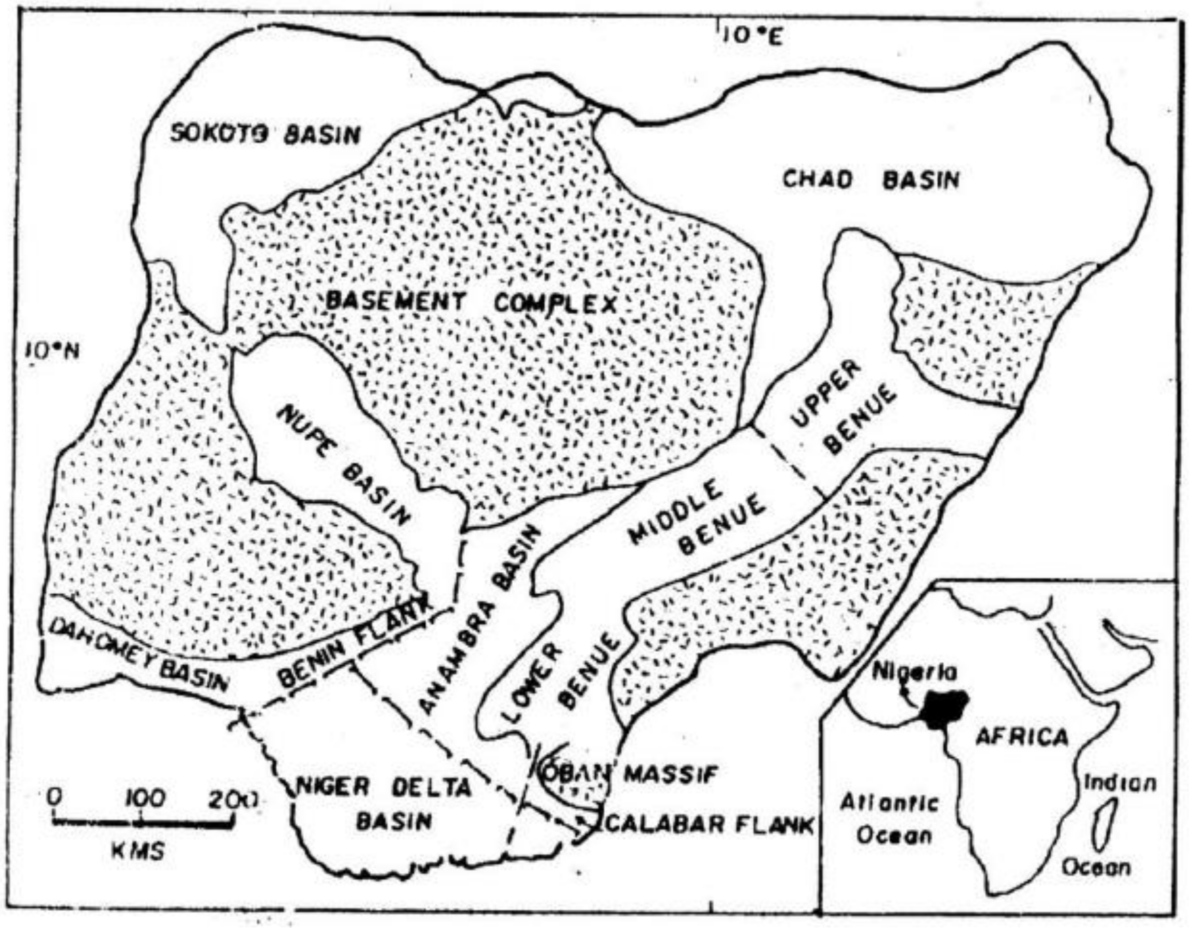

Fig.5: Map of Nigeria showing the location of the Benue Trough (Basin) and South-Eastern sedimentary basins (Odigi, 2007)

TECTONICS AND BASIN EVOLUTION OF THE STUDY AREA

The formation of the Southern Nigerian sedimentary basin followed the breakup of the South American and African continents in the Early Cretaceous (Murat, 1972, Burke, 1996). Various lines of geomorphologic, structural and paleontologic evidence have been presented to support a rift model (king, 1950, Bullard et al, 1965; Reyment, 1969; Burke et al 1971; 1972, Fairhead and Green, 1989; Benkhelil. 1989).

The Createaceous tectono-sedimentary evolutions of the Afikpo domains are presented through six stages.

1. The first stage involved the breakup of Afro- Brazilian plate at the triple junction.
2. Benue Trough developed as a graben between the on-shore of oceanic fracture zones.
3. The third stage encompassed the formation of Benue Trough as a rifted depression in response to a regional stress field due to active or passive lithospheric extension.
4. The fourth stage involved minor folding in parts of the trough (Late Cenomenian); renewed transgression and regression and the deposition of the late Cenomenian – Conician rocks (Eze-Aku Group).
5. The fifth stage involved compressionally folding tectonic inversion, faulting and alkaline–sub alkaline magmatism (including volcanic sills, dykes, Eziator microdiorites, Afikpo dolerites, Ugep microdiorites and dolerites – microgabbros). The folding resulted to the formation of Afikpo Basin. The deformed and uplifted (Benue- Abakaliki) Trough became a positive element to shed sediments; the depressed platforms became the major depocenters. In environments ranging from marine to paralic to fluvial, about 400m post-Santonian sediments where deposited in the Afikpo Basin. These post-Santonian proto- Niger Delta deposits were formed between Campanian – Maastrichtian.
6. The sixth stage was characterized by tectonic inversion, deformation, faulting and magmatism of post-Santonian sediments including the Afikpo microgabbros marking the termination of Cretaceous sedimentation and the evolution of the Cenozoic Niger Delta (Odigi, 2007).

LOCAL GEOLOGY OF THE STUDY AREA

The study area which is the Afikpo Basin is a component part of the lower Benue Trough and is a linear, intracrationic, graben basin, trending NE-SW its origin is associated with the separation of the African and south American continents in the Early Cretaceous.

The study area consist highly undulating alternations of sandstone ridges and shale low lands, trending in a NE-SW direction. However, according to Odigi, (2007). The Afikpo Basin is composed of three main Cretaceous lithostratigraphic units namely: Asu River group, the Eze-Aku group and the post Santonian proto-Niger Delta successions.

ASU RIVER GROUP: This is a major stratigraphic unit in the area, it is composed of a sequence of marine shales occupying the base of the Afikpo basin. It possesses a thickness of about 3000m, embedded with shale and micaceous sandstone and contains radiolarian echinoids, pelecypods and gastropods Omoboriowo et al, (2012). The Asu River group represents deposits of the first transgressive – regressive marine depositional cycle in the area (Petters, 1980). The Age is Albian. The geology of the different lithostratigraphic facies of the Asu River Group in the study area is highlighted below (Ukaegbu and Akpabio, 2009).

- **Amenu Shale:** Amenu Shale is the oldest lithologic unit of the Asu River Group in the study area. Its contact with the younger Amenu Sandstone is very sharp, and the shale is fissile, and dark-bluish grey or pure grey in colour.
- **Amenu Sandstone:** Amenu Sandstone conformably overlies the Amenu Shale. The contact between this unit and the underlying older Amenu Shale is sharp, grading through coquina and back to shale.

- **Amauro Sandstone:** The Amauro Sandstone member is within the Amenu Shale unit. It maintains the same mineralogical composition and textural characteristics with the host and older Amenu Sandstone.
- **Amauro Shale:** Amauro Shale is the youngest unit of the Asu River Group, and it is unconformably overlain by the oldest Eze-Aku unit; Amate-Elu Sandstone member. The shale is fissile and grey in colour except that it assumes reddish-brown to dirty-brown colours when weathered.

EZE-AKU GROUP: The Eze-Aku group consist of shales, limestone and sandstone ridges, the beds of the Eze-Aku group overlying the Asu River group has its strike ranging from 40^0 E to 45^0 E and dip ranging from 20^0 – 68^0. The sandstone bodies are in parallel to enlongate features. The Eze-Aku beds represent the second transgressive depositional cycle that occurred during the upper Cretaceous (Murat, 1972). The geology of the different lithostratigraphic facies of the Asu River Group in the study area is highlighted below (Ukaegbu and Akpabio, 2009).

- **Amate-Elu Sandstone:** This is the oldest lithologic unit of the Eze-Aku Formation that unconformably overlies the Amauro Shale of the Asu River Group, in the study area.
- **Amate-Elu Shale:** This is the blue-black fissile and laminated shale conformably overlying the older Amate-Elu Sandstone. Weathered components of this shale lack fissility and are brown or yellow or red in colour. The contact between this shale unit and the Amate-Elu Sandstone is gradational.
- **Amasiri Sandstone:** This unit extends from Amasiri to Ugwu Okporo through Amate-Elu to Asu River. It overlies conformably the Amate-Elu Shale, and the contact between the two units is gradational.

- **Amasiri Shale:** Amasiri Shale is fissile and conformably overlies the Amasiri Sandstone. It is blue-black when fresh and yellow to reddish-brown when weathered. The two units maintain gradational contacts.
- **Akpoha Sandstone:** This is a highly indurated lens within the Amasiri Shale. The maximum height is 75m with thickness of the beds ranging from 90 cm to 210 cm. Fresh surfaces show dark-grey to grey colours but dirty brown when weathered.
- **Okpo-Ezi Sandstone:** Okpo-Ezi Sandstone unconformably overlies the Amasiri Shale with the contact between the two gradational from coquina to silty shale to siltstone then to sandstone.
- **Iyi-Ogwe Shale**: This unit unconformably overlies the Okpo-Ezi sandstone. Intraformational unconformity exists within the Eze-Aku Formation marked by basal conglomerate that separates the top of Okpo-Ezi sandstone and the base of Iyi-Ogwe Shale.
- **Ibii Sandstone**: This sandstone unit conformably overlies the Iyi-Ogwe Shale and both follow the same NE-SW trend. It is structurally massive and laterally extensive, covering about 250m.
- **Uroro Shale**: This is the youngest unit of the Eze-Aku Formation in the study area. It directly conformably overlies the Ibii Sandstone, and trends NE-SW. The shale is grey when fresh but turns dirty brown to dark-brown on weathering

PROTO-NIGER DELTA SUCCESSIONS: The regressive phase which marked the end of the Turonian was terminated by a third sedimentation cycle of the Campanian – Maastrichtian transgression which led to the deposition of the postsantonian Campanian –

Maastrichtian) proto Niger Delta sequences in the broad and gentle depression of the Afikpo Basin. These beds is composed of alluvial, fluvial to shallow marine conglomerates and sanstones, mudstones and shales which show a NE-SW trend, all of which overlie the Eze-Aku strata unconformably. Following the southwestward shift of the depositional axis in southern Benue Trough, the paralic Nkporo Formation, Mamu, Ajali and Nsukka Formations were deposited in the subsiding Afikpo Basin. The late Campanian Nkporo Formation consists of basal alluvial sediments and conglomerates overlain by alternation of sandstones, siltstones, shales, mudstones and coal beds.

Basinward these sequences laterally changes to deltaic and tidal channel deposits. The table below further shows the two major lithological units typical of the Afikpo Basin namely the Eze-Aku formation and the Asu river group which generally exhibits a NE-SW directional trend (Reyment, 1965).

Table 1. Showing the stratigraphic sequence of the Afikpo Basin (Ukaegbu and Akpabio, 2009).

AGE	LITHOSTRATIGRAPHIC UNITS		
	Group	Formation	Member
Turonian		Eze-Aku	Ururo Shale
			Ibii Sandstone
			Iyi-Ogwe Shale
			Okpo-Ezi Sandstone
			Akpoha Sandstone Amaseri Shale
			Amaseri Sandstone
			Amate-Elu Shale
			Amate-Elu Sandstone
Albian	Asu River	Amauro Shale	
		Amauro Sandstone	
		Amenu Sandstone	
		Amenu Shale	

Table 2: Stratigraphic succession of the lower Benue Trough (Odigi, 2007)

STAGES & EPOCHS		LOWER BENUE	MIDDLE BENUE		UPPER BENUE		LOWER BENUE TROUGH
		ANAMBRA BASIN	LAFIA AREA	BASHAR AREA	GOMBE AREA	LAU AREA	AFIKPO BASIN
TERTIARY		Ameki Fm.					Ameki Fm.
	Eocene						
	Paleocene	Imo Shale	Volcanics	Kerri Kerri Fm	Kerri Kerri Fm	Volcanics	Imo Fm
MAESTRICHTIAN		Nsukka Fm.		Gombe Sandstone	Gombe Sandstone	Lamja Sandstone	Nsukka Fm.
		Ajali Sandstone					Ajali Fm.
		Mamu Formation	Lafia Formation				Mamu Fm.
CENOMIAN	Campanian	Enugu Shale		Unnamed Marine	Pindiga Formation	Numanha Shale	Nkporo Fm
	Santonain					Sekule Formation	
	Coniacian	Awgu Formation	Awgu Formation			Dukul Formation	Eze Aku Group
TURONIAN	Upper	Eze Aku Shale		Zurak Formation	Yolde Formation	Yolde Formation	
	Lower		Eze Aku Fm.	Muri Sandstone	Bima Sandstone	Bima Sandstone	
CENOMANIAN		Odukpani Fm.	Keana Formation	Keana Fm			
ALBIAN	Upper	Asu River Group	Asu Awe Formation	Pre-Bima Sediment	Pre-Bima Sediment	Pre-Bima Sediment	Asu River Group
PRECAMBRIAN		Basement Complex					Basement
		HOQUE (1977)	OFFODILE (1976)	AYOOLA (1978)	CARTER ET AL (1963), CRATCHELY & JONES (1965)		ODIGI, 2007

Regionally, the mapped area is within the southern end of the Benue Trough, the oldest sedimentary rocks in Nigeria are in this Trough and they are of lower Cretaceous age. The Cretaceous stratigraphic record of southern Benue Trough particularly the Afikpo Basin is represented by sediments deposited by three main marine depositional cycles: Albian-Cenomanian, Turonian-Santonian and Campano-Maastrichtian.

MATERIALS AND METHOD

The study involves the collection of samples in the field, which were then analysed in the laboratory to describe the lithological characteristics, sedimentology and paleontological assemblages in order to obtain necessary and quality data results for interpretations.

Part of the field study involved the field descriptions of the samples.field description of the samples were carried out based on lithology, texture, beds, sedimentary structures, palaeocurrent data and fossil content

Thus the field description carried is in line with measurements of individual beds for which samples were collected, enabled the creation of a graphic log of the sequence as shown below.

Samples were collected in an outcropping unit at the Ibii quarry site, Afikpo Basin of South Eastern Nigeria. The studied outcrop is composed of a succession of shale and interbeds of siltstones respectively.

A total of ten (10) samples were collected carefully using shovels and geologic hammers in other to obtain fresh samples. collection was made in increasing depth using the measuring tape for measurements owing to the occurrence of shale and siltstone beds, the collected samples were then put into a nylon/polythene sample bag all labelled accordingly using the masking tape to avoid contaminants and for ease of identification. a digital camera was used in taking scaled photographs of the outcrop as shown below, writing materials such as pen, pencil and field notebook were used to record field measurements respectively.

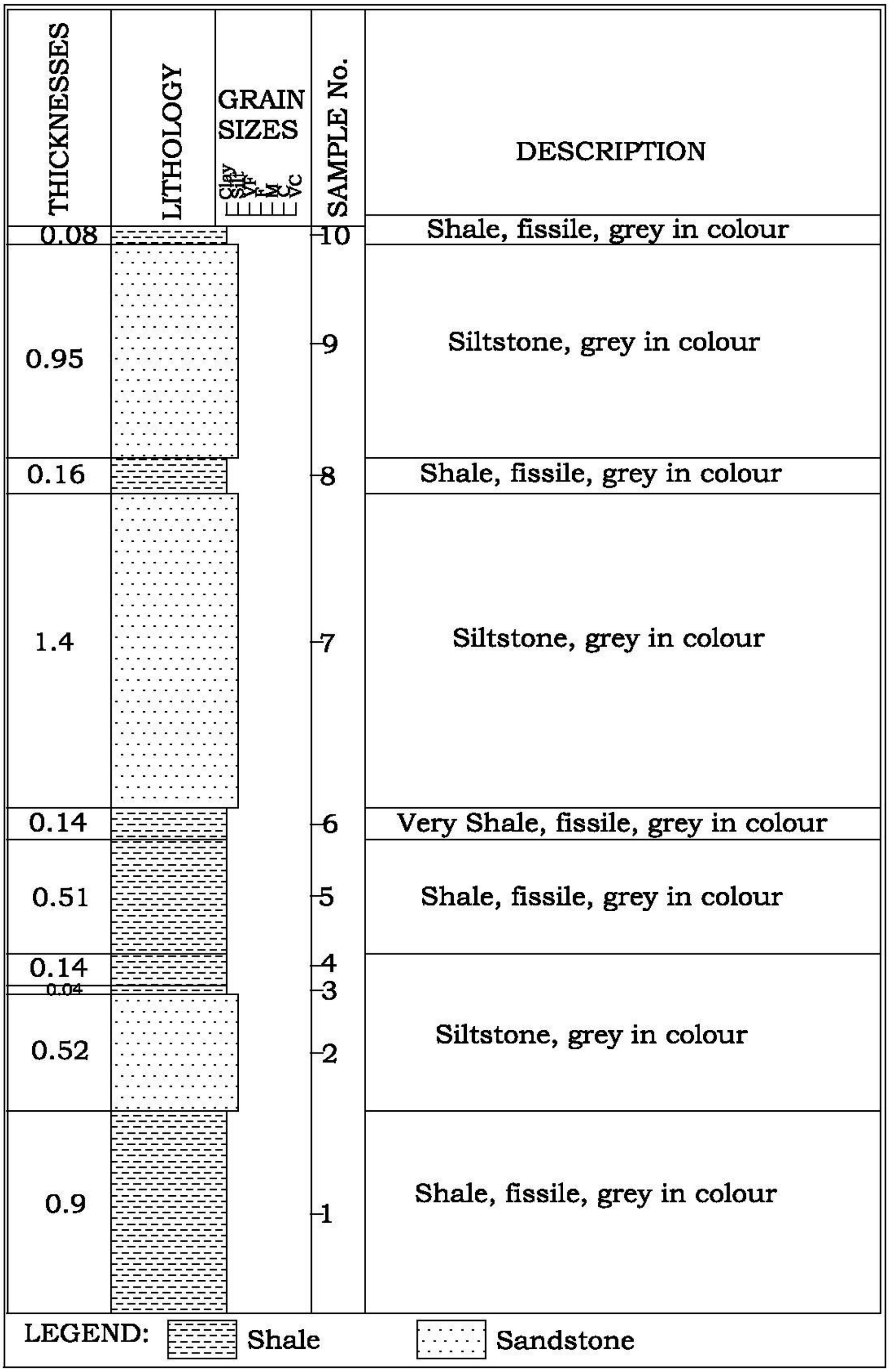

Fig 6: Showing Graphic Log of The Studied Outcrop

Fig 7: showing an outcropping unit of shale and siltstone interbeds at the Ibii quarry site, in the Afikpo Basin South Eastern Nigeria.

Fig 8: showing an outcropping unit of shale and siltstone interbeds at the Ibii quarry site in the Afikpo Basin, South Eastern Nigeria.

The samples collected from the field were subjected to three aspects of laboratory analysis which includes; lithological/Sedimentological analysis, lithofacie analysis and palynological respectively.

RESULTS AND DISCUSSION

The results generated from the study carried out were tabulated to ensure clarity and easy reading respectively

LITHOSTRATIGRAPHY

Lithostratigraphy is a subdivision or an element of stratigraphy that deals with the identification, characterization and nomenclature of the rocks of the earth based on their lithology and their stratigraphic relation. Sedimentological characteristics utilized in the study include; Lithology, texture, colour, mineralogy, fossil content and environmentally sensitive index minerals and accessories. Chemical test was carried out in order to determine the presence of calcareous forms by using dilute Hcl, thus on application of dilute Hcl, a high degree of effervescence was obtained showing the samples were highly calcareous (Table 3).
The result showed that the samples from base to the top consist of an intercalation of shale and siltstone (Fig 9) grading from light grey to dark grey in colour.

Table 3: Showing Lithological Description

Sample no	Depth (m)	Description	Remark
1	0.9	Shale, grey in colour, fine grained and fissile	Highly calcareous
2	1.42	Siltstone, grey in colour and fine grained	Highly calcareous
3	1.46	Shale, grey in colour, fine grained and fissile	Highly calcareous
4	1.56	Shale, grey in colour, fine grained and fissile	Highly calcareous
5	2.07	Shale, grey in colour, fined grained and fissile	Highly calcareous
6	2.21	Shale, grey in colour, fine grained and fissile	Highly calcareous
7	3.61	Siltstone, grey in colour, fine grained	Highly calcareous
8	3.77	Shale, grey in colour, fine grained and fissile	Highly calcareous
9	4.52	Siltstone, grey in colour, fine grained.	Highly calcareous
10	4.60	Shale, grey in colour, fine grained and fissile	Highly calcareous

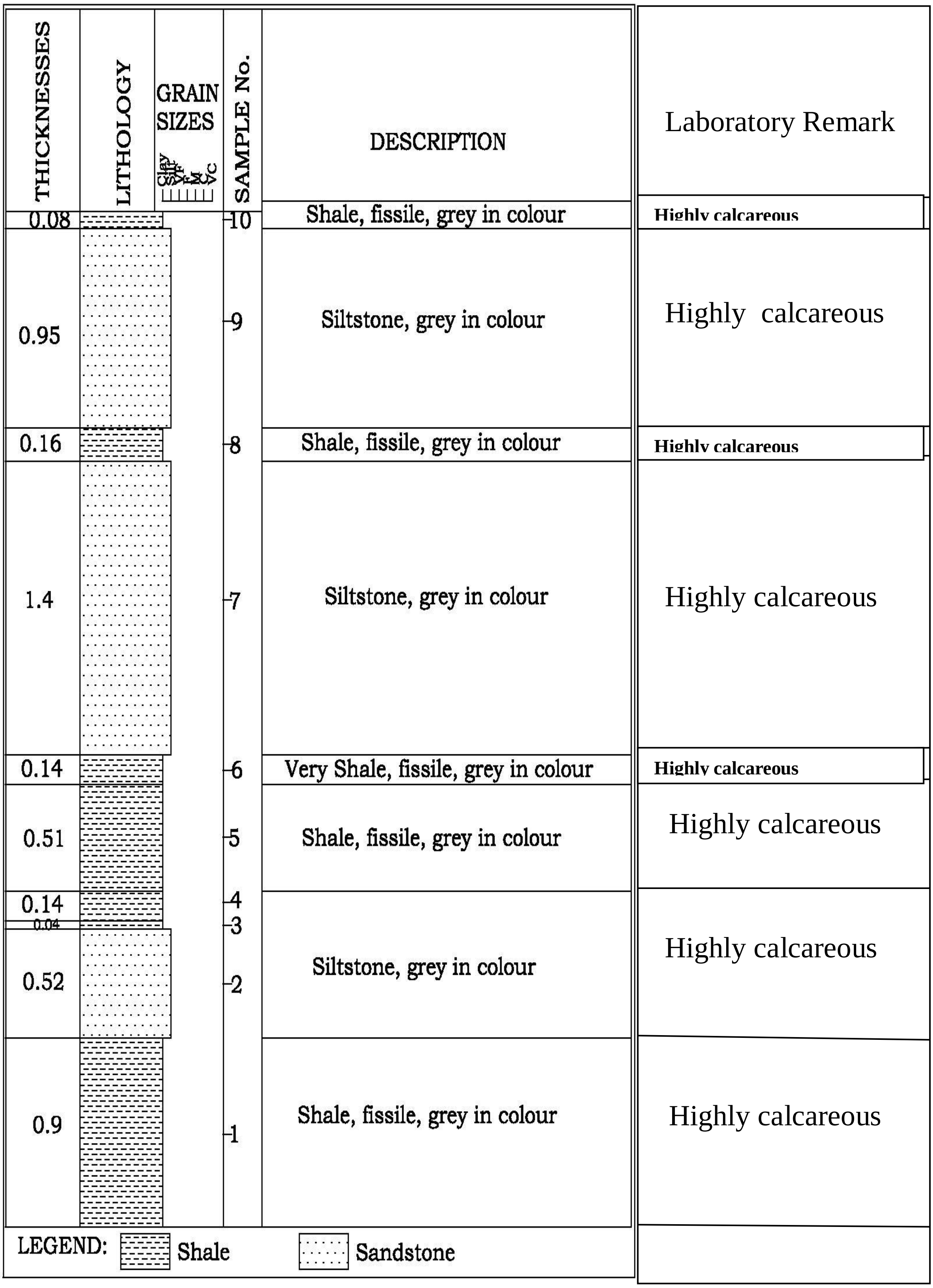

Fig 9: Showing graphic log and Laboratory Description of the Samples

LITHOFACIE ANALYSIS

Table 4: Showing Lithofacie Percentage Analysis

Sample no	Quartz	Rock fragments	Muscovite	Heavy mineral	Gypsum	Ferruginized fragments	Mica flake
1	15	55	15	10		5	
2	10	30	10	40			10
3	70	5	10		5	10	
4	65	10	15	5		5	
5	45	5	5	15	5	20	5
6	70	5	10	5	5	5	
7	60	10	10	20	20		
8	65	10	15	5	5	5	
9	70	5	10	10	10		
10	65		10	10	10	5	

The result generated from lithofacie analysis as show above (Table 4) was then used to plot for the lithofacie analysis against the depth of which samples were collected as shown in (Fig 10). Thus the plot shows a high occurrence of authigenic minerals such as quartz increasing from the base to the top which further suggest environment of deposition to be likely near shore or shore face which is typical of a shallow marine environment. The occurrence of other authigenic minerals such as gypsum, heavy minerals, and mica flakes further supports this interpretation.

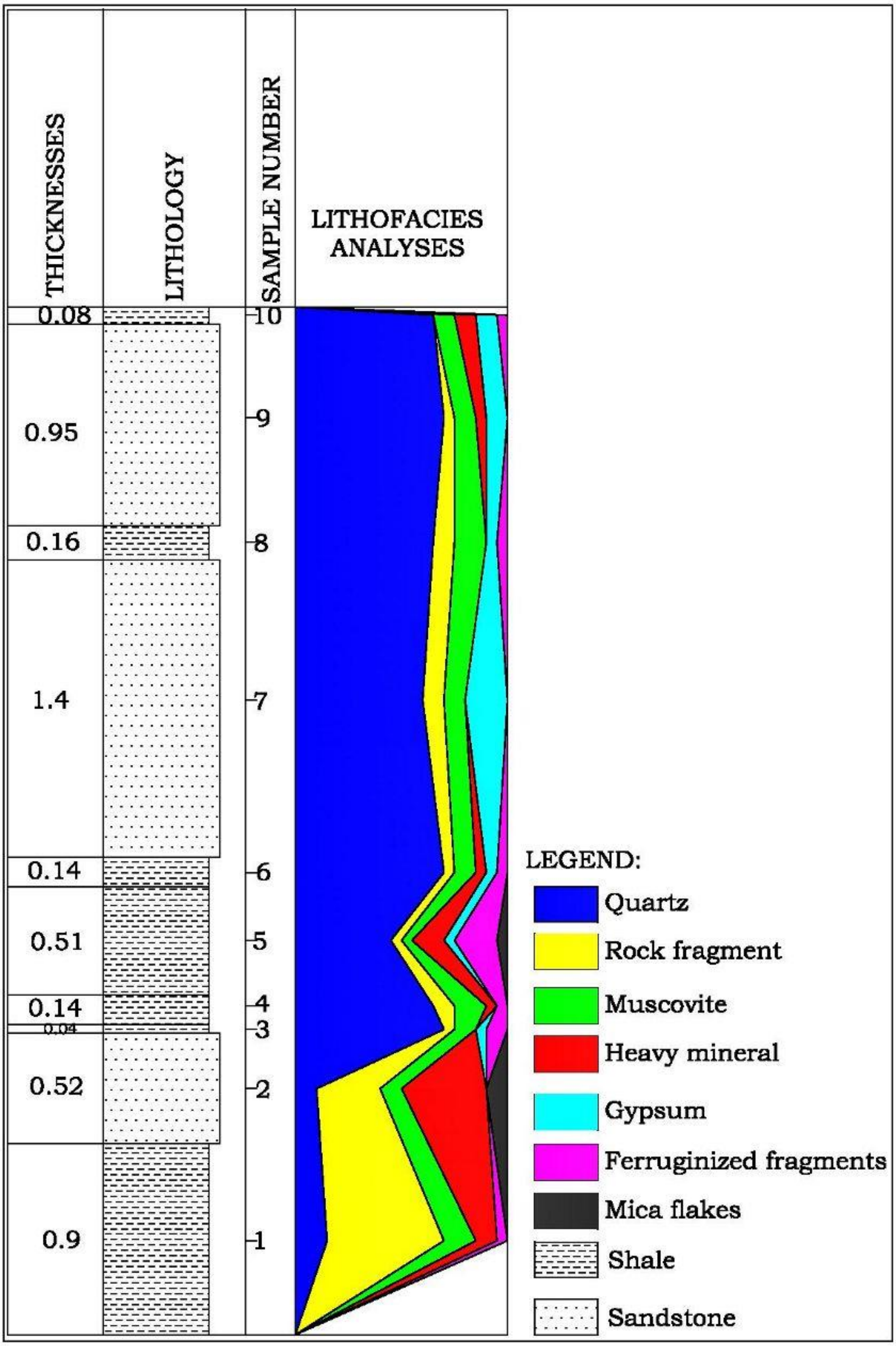

Fig 10: Showing lithofacie analysis plot of the studied area

INTERPRETATION OF THE LITHOFACIE ANALYSIS TABLE 4.

SAMPLE 1

Sample 1 consists of 55% rock fragments,15% quartz,15% muscovite,10% heavy minerals and 5% ferruginized fragments.

SAMPLE 2

Sample 2, is composed of40% heavy minerals, 30% rock minerals,10% quartz,10% muscovite and 10% micah flask.

SAMPLE 3

Sample 3 is composed of 70% quartz, 10% muscovite,10% ferruginized fragments, 5% rock fragment and 5% gypsum.

SAMPLE 4

Sample 4 consist of 65%quartz, 15% muscovite, 10% rock fragment, 5% heavy minerals and 5% ferruginized fragment.

SAMPLE 5

This sample is composed of 45% quartz, 20% ferruginized fragment, 15% heavy minerals, 5% rock fragments, 5% muscovite and 5% gypsum.

SAMPLE 6

This sample contains 70% quartz, 10% muscovite, 5% rock fragments, 5% heavy minerals, 5% gypsum and 5% ferruginized fragment.

SAMPLE 7

This sample is composed of 60% quartz, 20% gypsum, 10% rock fragment and 10% muscovite.

SAMPLE 8

This sample is composed of 65% quartz, 15% muscovite, 10% rock fragments, 5% gypsum and 55 ferruginized fragment.

SAMPLE 9

This sample consists of 70% quartz, 10%muscovite, 10% gypsum, 5%rock fragments and 55% heavy minerals.

SAMPLE 10

This sample is composed of 65% quartz, 10%muscovite, 10% heavy minerals, 10% gypsum and 5% ferruginized fragment.

SAND/SHALE RATIO

The wet-sieve analysis that was carried out on each of the (10) samples yielded the following:

Table 5: showing the weight retained and weight lost from wet-sieve analysis.

Sample no	Total weight (grams)	Weight retained sand (grams)	% sand retained	Shale weight lost	% lost.
1	5	1.9	38	3.1	62
2	5	3.9	78	1.1	22
3	5	1.6	32	3.4	68
4	5	1.8	36	3.2	64
5	5	1.9	38	3.1	62
6	5	1.9	38	3.1	62
7	5	3.1	62	1.9	38
8	5	2.1	42	2.9	58
9	5	2.9	58	2.1	42
10	5	2.1	42	2.9	58

The result generated from wet-sieve analysis as shown above was then used to plot a sand/shale ratio log shown below (Fig 11), and it can be inferred from the plot with respect to the high value of shale to sand ratio, that the environment of deposition is indicative of a an inner neritic and delta front environment all of which depict a marine environment.

SAND/SHALE RATIO LOG PLOT AGAINST DEPTH

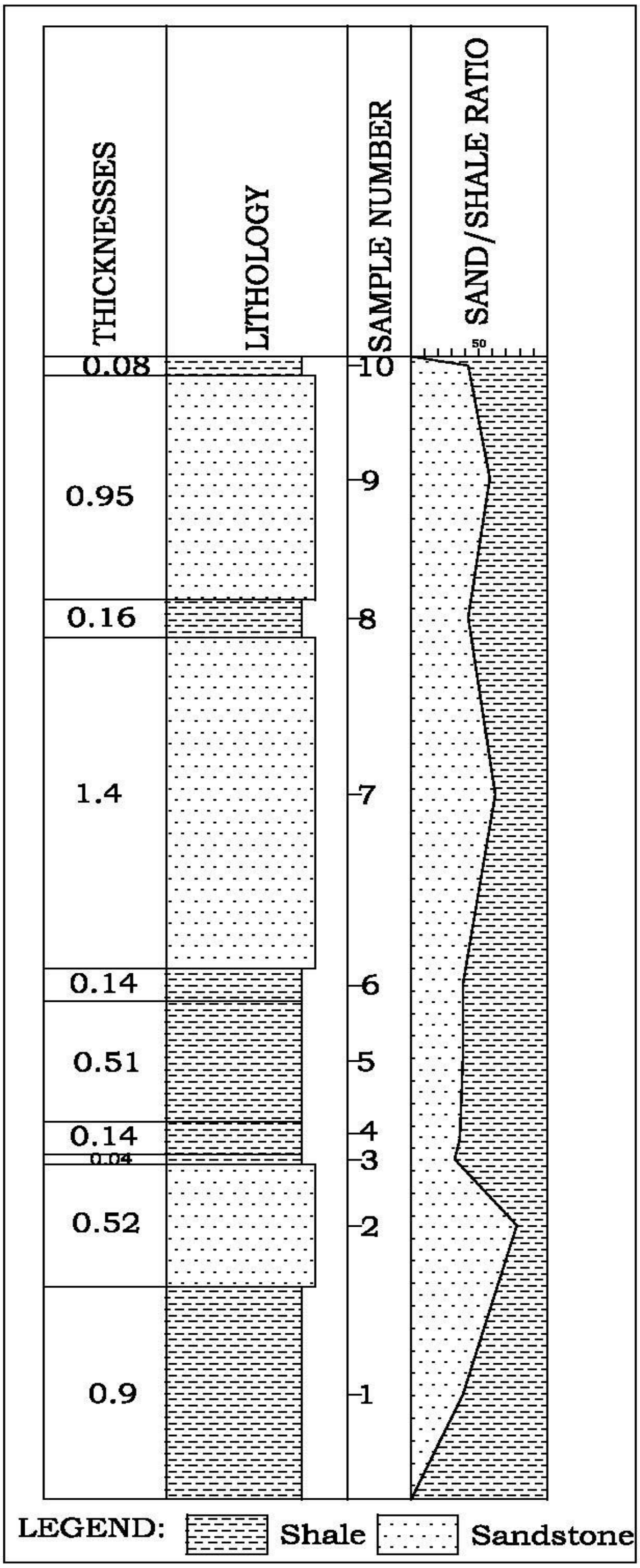

Fig 11: Showing Sand/Shale Ratio Plot

BIOSTRATIGRAPHY

Biostratigraphy is also a subdivision or an element of stratigraphy that deals with the characteristics and identification of rocks based on their fossil content in relation to stratigraphy. The biostratigraphy of the studied outcrop is therefore based on the fossil assemblage recovered from the laboratory analysis.

The samples were subjected to palynological analysis which yielded practically no palynomorphs to very scanty and low quantity of palynomorphs.

Details of the occurrence are shown in the table below, photographs of the occurring forms are shown in fig 1, 2, 3 and 4 all in the appendix and the result was used to plot abundance and diversity plot against depth (Fig 12)

Table 6: Showing Abundance And Diversity Distribution

Sample No	Taxom Name	Count
1	Diatom	1
	Fungal Spore	3
2	Diatom	1
	Fungal Spore	2
	Psilatricolporites Sp	1
3	Diatom	6
	Fungal Spore	1
4	Barren	Barren
5	Diatom	1
	With Amorphous Materials	
6	Barren	Barren
7	Diatom	3
8	Diatom	1
9	Diatom	2
	Fungal Spore	1
10	Diatom	6
	Fungal Spore	1
	Laevigatosporites Discordatus	1

Abundance and diversity distribution plot against depth

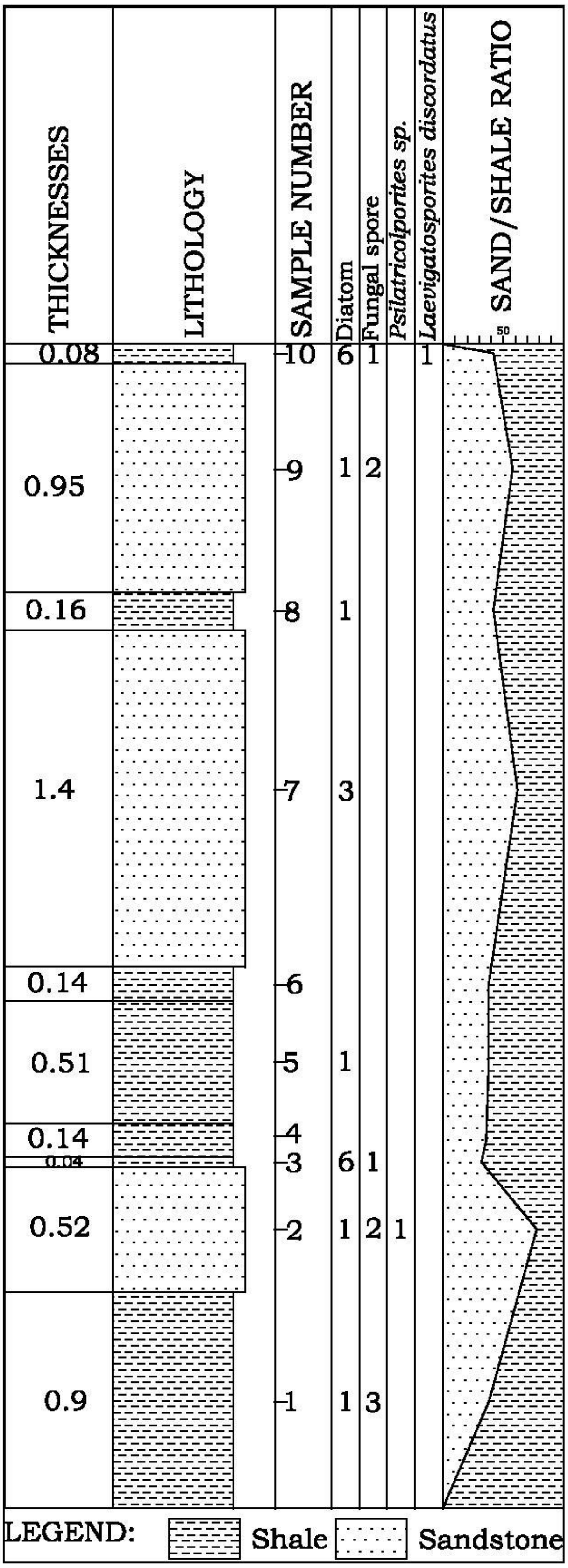

Fig 12: Showing the distribution chart

A distribution chart showing the distribution of the fossils against their depth of occurrence is made alongside with a graphic log and a sand/shale ratio plot of the studied outcrop. A total of four (4) species were encountered with Diatom dominating the chart both in abundance and in frequency further suggesting the environment of deposition to be marine.

PALEOENVIRONMENT

The aim of paleoenvironmental analysis is to reconstruct the biological, chemical and physical nature of the environment at the time of deposition, based on the rocks paleontological records information can be reconstructed for ancient depositional environments.

Thus from the biostratigraphic analysis that was carried out, no environmentally significant palynomorphs were recovered from the samples, however the occurrence of diatom fostules with fungal spores in most of the samples portray that the samples were probably deposited in a marine setting. The occurrence of amorphous material supports this interpretation.

AGE DETERMINATION

The samples involved yielded practically no palynomorphs to very scanty and low quantity of palynomorphs. Due to this paucity, the age of the samples could not be determined.

DISCUSSION.

From the lithofacie analysis carried out, it can be inferred that the sediments are of marine environment. Most of the environmental interpretations here are mainly based on the affinities of minerals which are useful in determining the depositional environments. Thus from samples 1-10 marks an increase in quartz with relative minimum scale fluctuations in samples 2 and 10, except for sample 5 which de crease is in outrageous amount compared to sample 2 and 10. Sample1-10 also marks a relative decrease in rock fragments, minor scale fluctuation in muscovite. A sample 1-2 marks increase in abundance of heavy minerals with no occurrence of gypsum and accessory compositions of ferruginized fragments and mica flakes. Sample 4-10 marks relative fluctuations of increase and decrease in muscovite as well as heavy minerals although samples 7 and 8 are entirely lacking of heavy minerals. Samples 5-10 mark an increase with minimum scale fluctuation in gypsum. Thus the occurrence of gypsum from samples 5-10 is an indication of shallow marine or lagoonal environment showing there was reduction or fall in sea level exposing its shoreline. The occurrence of authigenic minerals such as quartz, heavy minerals, gypsum, and mica flakes further suggest possible environment of deposition to be likely nearshore or shore face which in turn suggest continental shelf and shallow marine environment respectively. This interpretation is based on the assertion that authigenic minerals are the main constituents of marine sedimentation.

To further buttress this point is the occurrence of Diatom fostules in almost all the samples, which provides further evidence on the environment of deposition in attributes relating to shallow marine to marine environment, they live in all forms of sub-aquatic to aquatic environments within the confines of the photic zone. This interpretation follows the precept that the distribution of fossil assemblage in any stratigraphic section may be controlled by paleoecological factors, Hamza et al,, (2002). As such any significant change in fossil assemblage that corresponds with a relative change in lithology is probably due to the environmental tolerance of the fossil species. Therefore some fossils serve as environmental indicators and are used to interpret ancient environments of deposition.

Hence in general the rock fragments found within the lithofacie is indicative of the fact that volcanic rocks from high mountainous area have eroded and transported to the basin, which is also responsible for the abundance of quartz.

Further supporting the interpretation of depositional environment is the result generated from the wet sieve analysis, which depicts high value of shale to sand in the sand/shale ratio plot, indicating an inner neritic and delta front environment of deposition all of which are of marine environments

CONCLUSION

A Biofacie study of an outcropping unit at Ibii quarry site, Afikpo Basin, South Eastern Nigeria was carried out. The study involved both processes of field and laboratory analysis respectively. A total of ten samples were obtained and logged accordingly from the base and further used to produce a graphic log as shown in Fig (3.1).The samples were made up of fine grained siltstone and intercalation of shale. The samples were subjected to lithological/Sedimentological and palynological analysis respectively. The lithological description of the samples involves such physical characteristics as colour, grain size and rock type. The samples were tested with dilute HCL to determine sample calcareousness, those that showed effervescence were termed calcareous and those that did not show effervescence were termed non-calcareous .Furthermore the samples were subjected to Sedimentological (wet-sieve) analysis to evaluate for sand/shale ratio, the data generated from this analysis was used to plot a sand/shale ratio plot which showed a relatively high value of shale to sand further depicting a marginal marine to marine depositional environment. The samples were also subjected to lithofacie analysis which yielded and recorded occurrences of authigenic minerals such as quartz, heavy minerals, muscovite, gypsum and mica flakes which also depicts a marginal marine depositional environment; hence from this data a lithofacie plot was produced.

The samples after being subjected to palynological analysis yielded practically no palynomorph to very scanty and low quantity of palynomorphs, the palynomorphs include; *Psilatricolporite sp, Laevigasporites discordstus,* Diatom and Fungal spore. A fossil abundance and diversity chart was produced using the depth to depth occurrences accordingly. Although the analysis yielded no environmentally significant palynomorphs, the presence of Diatom and fungal spore in most of the samples portray that the samples were probably deposited in a marine setting, further supporting this interpretation is the occurrence of amorphous material.
Due to the paucity in the nature of the palynological analysis result the age of the samples could not be determined.

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APPENDIX

EXPLANATION TO PLATES

Fig 1 *Fungal spore*

Fig 2 *Diatom*

Fig 3 *Psilatricolporite sp*

Fig 4 laevigatoporites discordatus