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FORAMINIFERAL AND PALYNOLOGICAL BIOSTRATIGRAPHY OF STRATIGRAPHIC FORMATION, PORT HARCOURT-ENUGU EXPRESSWAY, ANAMBRA BASIN, NIGERIA

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ABSTRACT

The biostratigraphy of stratigraphic sections exposed along the Port Harcourt – Enugu Expressway was studied and some key evaluations were reached. The stratigraphic section is one of the Campanian – Maastrichtian successions of the Anambra Basin, Southeastern Nigeria. It is located between longitudes 7^{0}30' and 8^{0}00' East and latitudes 6^{0}26' and 6^{0}30' North. The lithologic units of the succession are basically shales with ironstone intercalation showing a likely marine depositional environment. The method of study involved the collection of sample to evaluate the final subsequent laboratory analysis of collected sample to evaluate observable features. From the laboratory analysis carried out, a lithological description of all samples collected depth by depth and was made with 2.0m HCI to check the presence or absence of calcareous forms. Palynomorphs assemblage yielded includes *Laevigatosporites oval us, Leptolepidites major, aporopollenites emenianori, Proteacidites sp., Spiniferites sp., Diphyes trianguflformis* Also from micropaleontological analysis made, *Haplophragmoides Impensus, Cibicides lobalulus, Bat hysiphon, Hormosina Irinitalensis, Kalarnopsis, Elphidium articulatum, A mmohaculitesiiephensoni, Spiropleclamona coslata, Nonionpompiloides, as well as Evolutinella ewongueensis, Buccicrenata herdhergi, Trochaminoides aff Amrnotium nkalagum, Trochamina aff Spiropleciamina. were recovered.* Their ages span from campanian to maastrichtian which coincides with the marine incursion in the Anambra Basin. These forms suggest a coastal swamp, tidal flat to estuarine, delta front to inner neritic environments of deposition.

INTRODUCTION

This project work was based on the Biostratigraphy of the outcrop in Enugu area in Anambra Basin, Nigeria..The Basin came into existence during the Santonian Orogeny. Prior to the Orogeny, it was a proto-basin covered by thin veneer of older sediments. (Reyment,1965). The Basin had several transgressive and regressive events which led to the continual deposition of sediment in it. (Whiteman, 1982).The study is aimed at determining age of sediments and their possible depositional environments using fossils as index.

LOCATION AND ACCESSIBILITY

The study area is located in Enugu, location is located between longitudes $7^{0}30'$ and $8^{0}00'$ East and latitudes $6^{0}26'$ and $6^{0}30'$ North on the left side of the Enugu-Port Harcourt expressway at Amagu-Ibite village is located on the left side of the Enugu-Port Harcourt expressway at Amagu-Ibite village. These outcrops can be reached either on foot or by car via road.

DRAINAGE AND TOPOGRAPHY

The study area is sparsely drained by major rivers except for a few water seepages formed by the milling activities of the indigenes and the Enugu State Coal Corporation. There also exists water seepages at the foot of the outcrops, but this is only prominent during the rainy season as they were absent during the dry season. The topography of southeastern Nigeria shows a particular prominent cuesta which stretches in a laterally inverted sigmoid from ldah, through lnugu to the right bank of the Cross River near Arochukwu. It forms the divide between the Cross River and the Anambra River drainage basins. Most of the exposures of the lithofacies comprising the Anambra sedimentary basin fill are exposed on the east-facing scarp of the cuesta.

OBJECTIVES

The objectives of this work include:

1. To give a concise geological description of the outcrops.
2. To determine the possible environment of deposition of the outcrop.
3. To ascertain the various geological formations encountered in the outcrops.
4. To determine the age of the outcrop sediments.

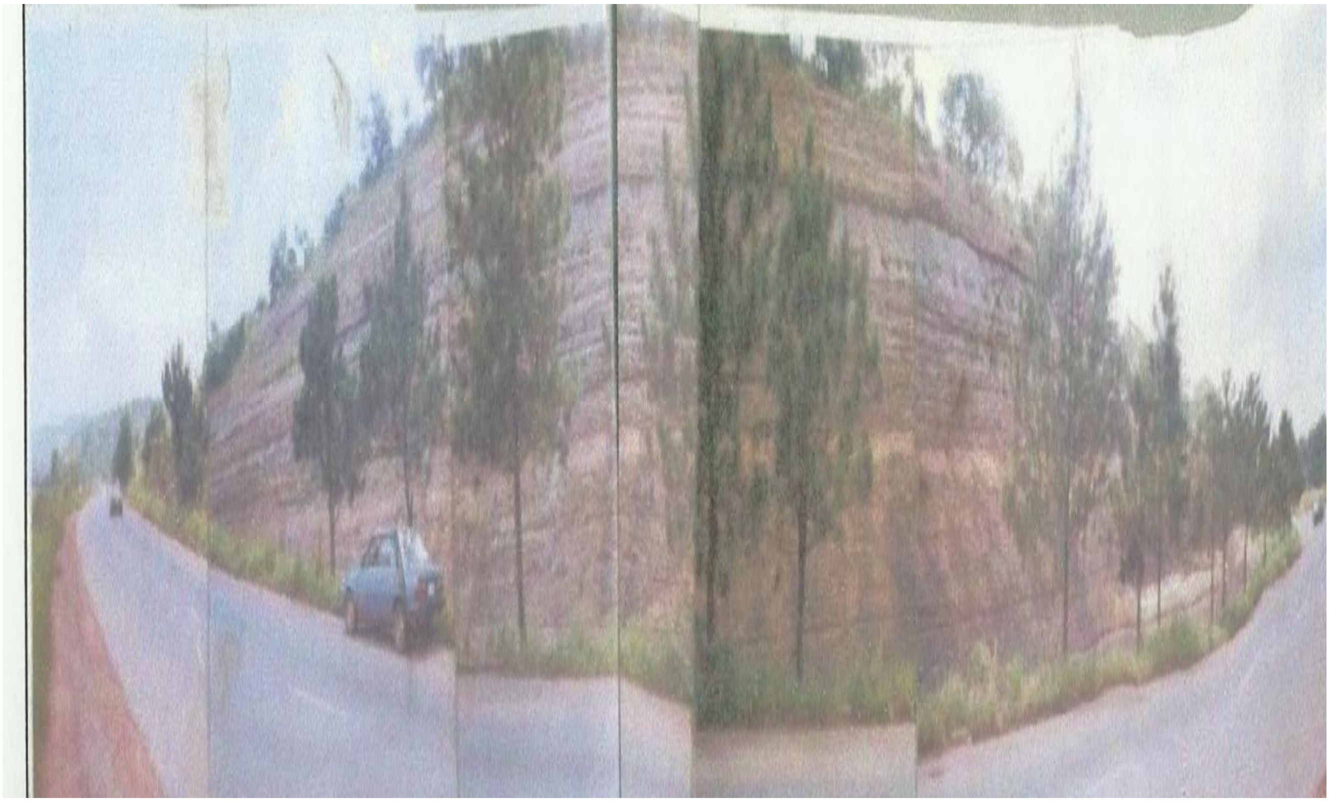

Figure 1: Location of the study Area

METHOD OF STUDY

The study involves collection of samples from outcrop in the field, were then analyzed in the laboratory to describe the lithologic characteristics and paleontological assemblages to obtain necessary data or results for interpretation

PROCEDURE AT OUTCROPS

On each of the outcrop locality, observations are noted systematically and recorded. The procedure is as follows:

1. Log of the section taking particular note of

   (a) Rock types — Plant and animal remains as well as ichnofossils are described.

   (b) Bed thickness

   (c) Textural features, colour, grain size (sphericity and roundness), sorting, and details on fabrics (preferred grain orientation, grain-matrix relation),

(d) Sedimentary structures including; Bedding planes: -scoured, sharp or transitional.

Bedding surfaces structures: - stratification (bedding and lamination) graded bedding, (normal or reverse), cross-bedding (planar, trough, hummocky, ripple), reactivation surfaces, pause planes, tidal bundles, massive bedding, deformed bedding, nodules, concretions and stylolytes. Trace fossils; trails, tracks, tunnels, burrows (whether vertical, horizontal or inclined).

(e) Other structural features e.g. Fractures (joints and faults).

2. Based on these observations, questions are addressed, the depositional environments can be inferred from the trend of the grain size, rock types and sedimentary structures, recurrent pattern of vertical lithological succession are observed and put into a sketch log and the result inspected.

3. The stacking pattern inferences; progradational, aggradational or retrogradational tendencies, sequence boundaries, maximum flooding surfaces, and transgressive surfaces of erosion tracts. The dominant control on sequence developments.

4. From the composition, texture, sedimentary structures, paleocurrent parameters and vertical profile, attempts are made to establish a qualitative assessment of the reservoir quality of the rocks and its lateral distribution.

5. Using the above data attempts on the reconstruction of the paleogeography is made.

6. Finally, the sandstone units are checked whether there are any hydrocarbon trapping configuration sections and if there are any productive problems are hydrocarbon -charged.

SAMPLING TECHNIQUE

The sampling method adopted in this research takes cognizance of the aim of the work. Samples were collected at different sections of the beds in each outcrop of the study area.

The sampling involves the use of the hammer and an iron rod to hit out a block of the rock and stored in a sample bag made of calico cloth. This sample bag is labeled for the sample location and sample number in which it represents. A piece of paper with this same inscription along with the field description of the rock sample and bed, the physical description of the locality.

The sampling was done to establish a chronological order, which the beds occur, structural features like unconformities, faults and folds are described. Samples were taken below and above planes of non-continuity to determine period of non-deposition and/or erosion. Samples were collected from beds that dip, they were laterally collected in order to determine the lateral variations for the different beds. Sampling was also done to carry out a systematic correlation of beds across the outcrops and to determine the various geological formations described by the Anambra basin, their contacts, their type and the distinct sedimentary structures.

PARTICLE SIZE DISTRIBUTION

Particle size distribution is one of the geotechnical index properties used to classify the rock samples in this study. (Table 1). This was done in a sieve analysis test.

Basically, a particle size distribution test yields information on size group of a sample's solid particles relative proportions of the sizes.

Mechanical analysis using wet and dry sieving is usually employed. In either case, oven dried samples of soil is weighed and passed through a batch or stack of sieves. The weights retained on each sieve are recorded, and the percentage of the total sample passing each of the sieves is calculated. These particle size limits of coarse materials are classified using the Wentworth scale.

Dry sieving was employed when less than 5% of the soil passed the No. 153pm sieve, i.e. if the clay fraction is very small. In this case, the soil is simply oven dried and then passed through a set of sieves.

When the sample contains significant amount of fine particles (5%) with its weight known, it is washed with water through sieve No. 200 or No. 153pm sieve to get rid of the fine material, and sieved. Here sieve analysis first involves washing with water through the No. 200 (0.075mm) sieve before drying the fraction retained on the 0.075mm sieve. This procedure is adopted to ensure greater accuracy in the determination of the proportion of fines.

PARTICLE SIZE ANALYSIS

The following is a severely abridged version of the test procedures: -

(i) Oven drying of a known quantity of sample.

(ii) Record its dry mss. Next pulverizing of the sample is done to separate into individual grain sizes if they are not loose. Care is taken not to break the particles into smaller sizes.

(iii) Arrange a set of sieves with a pan at the bottom. Record the weight of each empty sieve; this is done because each sieve has its own mass different from the other.

(iv) The sample of known weight is emptied in the topmost sieve in the set, covered with a lid and placing the set in a shaker to vibrate for about ten minutes.

(v) The individual sieves are weighted with their retained particles. With the knowledge of the mass of each sieve, it is easy to know the mass retained on each. The results are recorded on a data sheet.

(vi) The curves and graphs of the particle size distribution are plotted on graph papers.

The percentage passing is also referred to as percentage finer than or summation percentage.

SAMPLE NUMBER	MASS OF SAMPLE	DIAMETER	MASS RETAINED	MASS PASSING	% RETAINED	% PASSING
L2-S11	50g	53µm	0.3	49.7	0.6	99.4
	50g	153µm	10.0	39.7	20.0	79.4
	50g	300µm	22.2	17.5	44.4	35.0
L2-S2	50g	53µm	0.0	50.0	0.0	100.0
	50g	153µm	21.0	29.0	42.0	58.0
	50g	300µm	16.9	12.1	33.8	24.2
L2-S3	50g	53µm	0.0	50.0	0.0	100.0
	50g	153µm	19.6	30.4	39.2	60.8
	50g	300µm	13.5	16.9	27.0	33.8
L2-S4	50g	53µm	0.0	50.0	0.0	100.0
	50g	153µm	7.2	42.8	14.4	85.6
	50g	300µm	29.5	13.3	59.0	26.6
L2-S5	50g	53µm	0.0	50.0	0.0	100.0
	50g	153µm	29.9	20.1	59.8	40.2
	50g	300µm	8.0	12.1	16.0	24.2
L2-S6	50g	53µm	0.3	49.7	0.0	99.4
	50g	153µm	34.5	15.2	96.0	30.4
	50g	300µm	9.4	5.8	18.8	11.6
L2-S7	50g	53µm	2.4	47.6	4.8	95.2
	50g	153µm	29.2	18/4	58.4	36.8
	50g	300µm	12.0	6.4	24.0	12.8
L2-S9	50g	53µm	2.3	47.7	4.6	95.4
	50g	153µm	9.0	38.7	18.0	77.4
	50g	300µm	14.2	24.5	28.4	49.0
L2-S10	50g	53µm	3.4	46.6	6.8	93.2

Table 1: Particle size distribution table

BIOSTRATIGRAPHY

Samples for each depth were pulverized and 10g weighed into enamel container. The samples were mixed with water and treated with 2g Sodium bicarbonate (Na_2CO_3) and brought to boil at about 200◦C for some minutes. Samples were turned into plastic containers and allowed to cool. Cooled samples were washed using a set of sieves Set of sieves 90, 75 & 53μm respectively in a jet of water. Residues from each sieve was collected and dried.. The dried samples were examined using paleontological microscope at varying magnifications and the fossils were picked and morphological examinations were then carried out on species with aid nomenclature. Species were also counted and recorded. Table 2.

Foraminiferal biofacies:

Foraminiferal biofacies models derived from investigation of recent deltas furnish the most empirical and actualistic method for identi1'ing ancient analogies. To achieve this, it is germane to review the foraminiferal assemblages, which characterize the various sub-environments in modem tropical elastic deltas. Various biofacies styled after physiographic or bathymetric features (e.g. marsh, lagoonal, estuarine, inner neritic, middle neritic, bathyal, abyssal), with their diagnostic foraminiferal assemblages are objectively defined. Phieger adopted a similar physiographic rather than microfaunal nomenclature for the Mississippi Delta where he applied terms such as open gulf. sound, estuary and marsh to his geographical ecologic foraminiferal biofacies.

Open shelf pro-delta environments are usually very densely populated by foraminifera. In this environment fossil preservation is at its best.

A common problem in the foraminiferal biofacies interpretation of ancient sediments is the fact that the ecological preferences of extinct species are not known. One worker circumvented this problem by defining his biofacies on the basis of foraminifera genera, rather than species.

This approach can be augmented by applying the paleontological concepts of homeomorphy. Fossil species that exhibit close morphologic resemblance with living forms are there considered homeomorphs or even ancestors to living counterparts..

In describing foraminiferal tests, the following outline is offered; general appearance, chambers, sutures, wall, apertures, and colour.

General appearance includes relative size, proportions, characters of the periphery, changes in plan of development, condition of attachment.

Sutures include amount of depression or elevation, clearness, amount of limbation, if any, changes in various parts or sides of the tests, direction, straight or if curved, the relative amount of curvature, relations to the ornamentations. Wall description include relative thickness, material of which composed, kind and relative amount of cement, finest of the interior, relative size of perforations, if a perforated form, ornamentation, especially changes in different stages of development or in different parts of the wall. Aperture includes changes of position of different stages of development, relation to peculiar structures or modification of the chamber, development of the neck or lip, and ornamentation directly connected with the aperture itself.

Colour description usually includes whether black or white or other colour but is usually not evident in fossil forms, although occasionally of decided importance.

Certain maximum and minimum temperature affect the survival of species as well as its reproduction and repopulation generally, this is one of the important environment

Oxygen deficiency accounts for high organic productivity at the sea surface leading to anaerobic bacterial blooms in the seafloor. Oxygen or Aerated conditions Favours the secretion of calcium carbonate, while low oxygen concentrations reduce the ability of Foraminifera to secrete calcium carbonate, thus anaerobic assemblages are typified by small thin shelled unornamented calcareous or agglutinated assemblage of low diversity as discoursed by Mode (1991)

FORAMONIFERA							PALYNOMORPH									
							POLLEN				SPORE					
Ammodiscus angustus	Ammodiscus aff macilentus	Glomospira diffundens	Glomospira irregularis	Silicosigmoilina sp.	Spiroplectammina navarroana	Karrerulina GAB K17	Proteacidites sp.	Echitriporites sp.	Auriculiidites reticulatus	Praedapollis sp.	Cingulatisporites ovatus	Foveotriletes sp.	Cyathidites australis	Gleichenidites senonicus	Zlivisporis blanensis	Foveotriletes margaritae
								3	2	1				1	1	1
		28	7				1	1				2	1	2	1	
								1			2	3				
								1			2	2				

LOCATION IV SECTION 2

FORAMONIFERA								PALYNOMORPH															
								POLLEN							SPORE								
Ammodiscus angustus	Ammodiscus aff macilentus	Glomospira diffundens	Glomospira irregularis	Silicosigmoilina sp.	Spiroplectammina navarroana	Karrerulina GAB K17		Buttibia adrevii	Echtriporites trianguliformis	Aiiriculidites reticulaus	Retibrevicolporites abodoensis	Retidiiporotes magadalensis	Hexaporopollenites emenilon		Zlivisporis blanensis	Ariachaesporites	Proteacidites sp.	Gleichenidites seciricus		Cyathidites australis	Cyathidites minor	Cingulatisporites sp.	Foveotriletes sp.
	12	13			12																		
		92			114																		
8																							
4			13																				
		36		112																			
			42																				
								1	3	1					1	3	1	1		2			75
				88					2	3	2	1	1							1	1		
									5		1					1	1					5	3
168																							
				1	18	6																	

Table 2: Foraminifera/ Palynomorphs Distribution Table

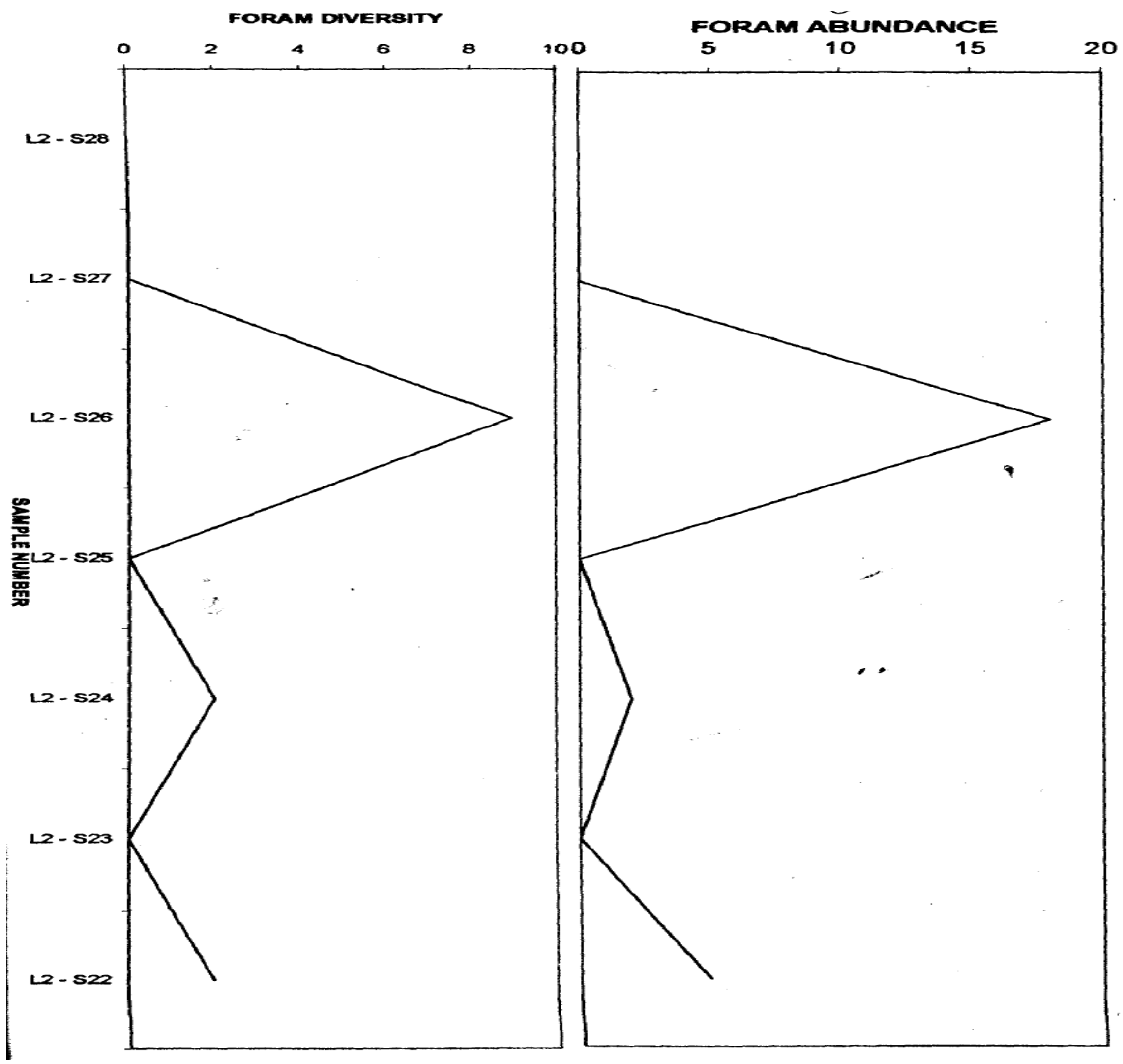

Table 2: Foraminifera/ Diversity/abundance Graph

Pollen And Spores Biofacies:

Palynomorphs include both plant and animal structures that range in size from about 5pmμm. They are composed of sporopollenin (carotinoid-like polymer found in the outer wall of pollen grains, spores, diniflagdllates and acritarchs), chitin or related compounds that are highly resistant to most forms of decay other than oxidation. The polysaccharide coating of microforaminiferal linings, scoledonts and the spores and hyphae of certain fungi. Highly resistant to forms of determination other than oxidation. Some other marine forms or freshwater organisms microfossils with siliceous, calcareous, phosphatic, or cellulose walls are sometimes classified as “palynomorphs” even they do not survive routine pollen-extraction procedures. Foraminifera can also be classified as palynomorphs (they have calcareous tests and acid resistant chitinous wall linings which are not destroyed by Palynological sample preparation methods).

Pollen are preserved in Bogs, Lakes, Soils, and the Sea. They are resistant to decay with morphological characteristics specific to plant groups. They are produced in vast quantities and generally reflect the natural vegetation of a location and are produced by that have sexual reproduction.

Most pollen are not carried far from site, although some can travel very long distances, dispersal is a function of grain size, wind (direction speed) and precipitation as well as the plant habit (low vegetation, trees). Topography also matters in the distribution of pollen; mountain building episodes lead to the local appearance of montane species (usually associated with temperate climates) e.g. the bisaccate Podocarpus mitanjiarnus, which may be related to the Cameroon volcanism in the Late Neogene.

Another line of approach was used. Results of reflected and fluorescence light microscopy (coal petrology) to that of transmitted light (mierofacies, sediment petrology).

RESULTS AND INTERPRETATION

LITHOSTRATIGRAPHY:

The outcrop lithologic log presents the geology of the outcrops based on the rock types encountered and their relative thicknesses. The outcrop lithologic logs presented below.

SAMPLE NUMBER	DATE SAMPLED	LITHOLOGIC DESCRIPTION
L4-S1	11-12-2000	Shale, gray, even parallel laminae (0.1cm), black carbonaceous materials, intercalations of curved non parallel laminae (0.4cm), burrows (0.2cm), slightly weathered, platy indurated (hard), non calcareous.
L4-S2	11-12-2000	Shale, silty, gray with red ting, slightly weathered, faults across beddings, wavy parallel bedding (2.3cm), wavy parallel laminiae (0.3cm), platy and slabby, mottled, burrow casts (0.2cm wide) parallel to bedding, indurated (hard), non calcareous.
L4-S3	11-12-2000	ShaLe, silty, dark gray with intercalation of white siltstone, wavy parallel laminae (0.2cm-0.6cm), lens of coal (0.1cm wide, 2cm long), black carbonaceous materials, mottled, lenticular silt laminae, platty to flaggy, indurated (hard), non calcareous, few shiny specks.

L4-S4A	11-12-2000	Shale, dark gray, pral1el bedding (1.7cm), few black carbonaceous streaks, slabby, slightly mottled, few burrow casts, indurated (hard), non calcareous.
L4-S5	11-12-2000	Claystone, cream with red ting, mottled, structures completely destroyed, burrows (0.1cm wide), cracks, indurated (hard), non calcareous.
L4-S6	11-12-2000	Shale, dark gray, black carbonaceous materials, wavy parallel bedding (1.2cm), slabby, indurated (hard), non calcareous, few shiny streaks.
L4-S7	11-12-2000	Shale, dark gray, black carbonaceous materials, woody materials, curved non parallel bedding (1.8cm), slabby, few burrow cast, indurated hard), slightly weathered, non calcareous.
L4-S8	11-12-2000	Shale, dark gray, curved non parallel beddings 91.1cm0, black carbonaceous materials shiny specks, platy, indurated (hard), non calcareous, few brown carbonaceous material.
L4-S9	11-12-2000	Claystone, dark gray, curved non-parallel bedding (2.3cm0, black carbonaceous materials, shiny grains, platy, indurated 9hard), non calcareous, few burrows.
L4-S10	11-12-2000	Shale, dark gray, highly mottled, black carbonaceous material, burrows (0.2cm), wavy parallel bedding (1.2cm), few shiny streak particles, bioturbated, indurated (hard), non calcareous.
L4-S11	11-12-2000	Shale, dark gray, black carbonaceous materials, curved non-parallel bedding (1.4cm) platy, non calcareous, indurated (hard)
L4-S12	11-12-2000	Claystone, dark gray, black carbonaceous materials, wavy non-parallel bedding (1.7cm), indurated (hard), non-calcareous, shiny particles, brown carbonaceous materials, slabby.
L4-S13	11-12-2000	Shale, dark gray, even parallel laminae (0.9cm), burrows (0.1cm), black carbonaceous materials, indurated (hard), non calcareous.

L4-S14	11-12-2000	Claystone, dark gray, black carbonaceous materials, wavy parallel bedding (1.8cm), slabby, indurated (hard), non calcareous, few burrow casts (0.3cm)
L4-S15	11-12-2000	Claystone, dark gray, wavy non-parallel beding (1.8cm0, black and brown carbonaceous materials, burrows 90. 1cm wide), also some laminae (0.6cm), indurated (hard), non calcareous.
L4-S16	11-12-2000	Shale, dark gray, even parallel laminae (0.4cm), black carbonaceous materials, white lens materials (0.1cm wide, 1.2cm long), lenticular laminae, white materials remains are circular (0.2cm diameter), indurated (hard), non calcareous.

Table 3: Sample description table

INTERPRETATION

STUDY ON PARTICLE SIZE:

The particle size distribution graphs is presented for the sample technique due to the fact that the left and right blocks of the outcrop are separated by a fault plane. This prompted the need for this sampling technique so as to establish a stratigraphic correlation between the beds outcropping in the left and the right hand sides of the fault plane. From this outlook, the following observations are hereby made below.

Particle size distribution graph for the right side of the fault plane shows a rock type trend of silty shale because there were only silt and shale particle sizes and no sand sized particles. The general trend of the silt/shale ratio diminishes from about 5%: 95% at the base of the outcrop (sample 20) to about 2%: 98% at the top of the outcrop (sample 5) in section 2 of the outcrop. This trend is also same with the particle size distribution with the graph of particle size distribution for the left side of fault plane. The trend of the silt/shale ratio also diminishes from about 8%: 92% at the base of the outcrop to about 2%: 98% at the top of the outcrop.

Although the silt proportion is more evenly distributed between the three samples at the base of the hill in the left block of the outcrop, but the contrary is the case for earlier samples (samples 1, 2, 3, 11 and 4) in the right block of the fault plane, as the distribution of the given trend of ratio is uneven among the samples (sample 1,2,3,11 and 4A) in the right block of the fault plane, as the distribution of the given trend of ratio is uneven among the samples (samples 19,17,13,16,10,8 and A4) having more silt than samples 20, 18, 15,9,6 and 7 which have lesser proportions of silt sized particles.

This shows similarity between the rock types outcropping between the left and right blocks of the fault but the right block of the fault shows more outcropping bed than the left side of the fault. This trend shows the right up-thrown block and the left downthrown block.

FORAMINIFERA/PALYNOMORH STUDY:

The outcrop was sampled taking cognizance of a fault plane. The left block as well as the right block of the fault plane were sampled. 6 samples were collected from the left block of the fault plane — samples 1, 2, 3, 4A, 5 and 11 – (0.2m to 17.5m). These samples yielded faunal fossil assemblage of paleobathymetry of middle nertic marine environment. The gains are sub angular to sub rounded in shape. Mica flakes were present in the microscopic view of the washed samples. Only one sample taken from 6m height (sample 11) in the section 1 of the fault plane had foraminiferal species fossils. Fossils encountered include *Glomospiral diffundens*, *G. irregularis.* Fossil flora yielded include few *Cingulatisporites ovalus*, *Echitriporites sp., Foveotriletes sp., Auriculidites reticulates*, *Praedopolis sp*. *protaecidites sp*.

Section two sampling had more beds outcropping. Eight beds were sampled. 16. Samples were taken from the base of the outcrop to 40.3m height. The first 5 samples (samples 19, 20, 18, 17, 13) collected from 8.2m height to the 24.5m height in the right block of the fault plane, yielded sediments, paleobathymetry of outer neritic marine environment from the fossil assemblage (*Ammodiscus angustus*, *Silicosigmoilina aff macilentus*, *Spiroplectammina navarroana*, *Karrerulin*. The quartz grains are rounded and there were numerous pyite grains, also a few of the samples revealed few mica flakes. Foraminifera species encountered include *Karrerulina*, *Spiroplectammina navarroana* *Ammodiscus angustus* as well as *Silicosigmoilina sp*., which arespecics of foraminifera diagnostic of marine shelf inhabitants. 11 samples collected from 26.5m height to 28.3m showed quartz grains with angular to subangular shapes, there were also mica flakes seen in the microscopic study as well as foraminifera species of *Glomospira irregularis*, G. *diffundens*, *spiroplecammina navarroana*, *Silicosigmoilina sp* as well as. *Ammodiscus angustus* which are shelf dwelling foraminifera species. Floral fossils yielded include numemrous *Foveotriletes sp*. *Buttibia adrevii, Zlivisporis blanensis, Echitriporites trianguflformis*.

The floral fossils were very few arid' unevenly distributed throughout the outcrop studied as such there. This is so because the results of this study reveals only numerous foraminiferal fossils and as such infer a marine environment for the location studied.

CONCLUSION

The study location is a 22.5m high outcrop in Amagu Ibite on the left side of the road along Enugu/Port Harcourt expressway. This outcrop divided is into two blocks by a fault plane (normal fault). The right block has the first 8.2m to 24.4m is made up of outer neritic sediments paleobathymetry while in the last 26.5m to 40.4rn is of middle neritic paleobathymetry. The left block of the outcrop comprises sediment of middle neritic paleobathymetry. This outcrop has a 6m thick clay bed unconformably lying on it. This outcrop belongs to Enugu shales and is of Campanian-Maastrichtian age..

REFERENCES

1. **Agagu, O.K., Fayose, E. A. and Petters, S. W.,** 1985: Stratigraphy and Sedimentation in the Senomanian Anambra Basin of Eastern Nigeria, Nig. Journal Mining and Geol, Vol. 22, P. 25 — 30.
2. **Allen, G. P., 1991**: Principles of Siliciclastic Sequence Stratigraphy and Applications of Fluvial and Shelf Deposits. Queensland University of Technology Brisbane, Australia. p. 5 — 65, 99— 120.
3. **Banergee, I., 1979:** Analysis of Cross bedded Sequences, An Example from the Ajali Sandstone of Nigerian, Quaternary Journal Geol. Mm. Metal. Society India, Vol. 51, P. 69 — 81.
4. **Bizhleger, F. 1965:** Ecology and Distribution of Recent Foraminifera, The Johns Hokas Press, Baltimore.
5. **Bown, P. R., 1999** "Calcareous Nannofossil Biostratigraphy, Kluwer Academic Publishers, London. p. 55 - 100.
6. **Jean, L. V., and Bernadette, H. J. B., 1996:** Arenaceous Foraminifera from the Late Cretaccous Gabon Bull. Centres Rech. Explor-Prod. Elf Aquitaine Production. June.
7. **Kinglsey, O.O., 1990:** Stratigraphy, Basin Analysis and Palaeo-oceanography. Bulletin Centres Rech. Explor-Prod. Elf-Aquitaine. December 4.
8. **Kogbe, C.A., 1976:** Paleogeographic History of Nigeria from Albian Times, In, Geology of Nigeria (Edited). Elizabethan Publishers Co. Lagos. p. 227 — 259.
9. **Krawinkel, H, and Seyfried, 1996:** Sedimentologic, Palaeoecologic, Taphonomic and Ichnologic Criteria for High resolution Sequence Analysis: A Practical Guide for the Identification and Interpretation of Discontinuities in Shelf Deposits. Sedimentary Geology (Journ.) 102. p.79-110.
10. **Ladipo, K. O. et al, 2001:** Geological Field trip to the Anambra Basin and the Lokpanta Oil Shale. NAPE Conference Port Harcourt.
11. **Middlemis, F. A., 1975:** Introducing Geology Series, Fossils, Second Edition. A Thomas Murby Publication of George Allen & Unwin. p. 15—22, 52— 55.
12. **Mode, A. W., 1991:** Assemblages, Age and Palaeo-environment of the Nkporo Shale, Akanu Area, Ohahia, Southern Nigeria, Journal of Mm. and Geol, 27. P. 100— 121.
13. **Ogbemudia, A. S., 2001:** Biostratigraphy of Agbara — 17 Well in Niger Delta, Unpub. Seminar Thesis Submitted to Dat. of Geol., Faculty of Science, UNIPORT. p. 12 —25.
14. **Ojoh, K. O., 1990:** Cretaceous Geodynamic Evolution of the Southern Part of the Benue Trough (Nig.) in the Equatorial Damian of the South Atlantic. Stratigraphy, Basin Analysis and Paleo-oceanography, Bulletin Centres Rech. Explor-Prod. Elf— Aquitame.
15. **Oko, A. S., 2001:** The Geology and Geophysical Survey of Ovoko and Environs, Igbo-Eze South L.G.A.

Enugu State, Nig. Unpub. Seminar Presented to Dept. of Geol. and Mining, Enugu State University of Science and Tech. p. 20—25.

16. **Oloto, I. N., 1990:** Palynological Assemblage from the Danian of South Western Nigeria. Journal of the Acta Palaeoeotanica. Vol. 30(12).
17. **Oloto, I. N., 1994:** Nigerian Maastritchian to Miocene Dinoflagellate and Miospore Biozonation — A Summary. Journ of Min. and Geol. Vol. 30, Printed in Nigeria by NMBS. p. 61 73.
18. **Petters, S. W., 1978:** Maastritchian Paleocene Foraminifera from NW Nigeria and Their Paleogeography. Acta Paleontologica Polonica. Vol. 23, No. 2.
19. **Petters, S. W., 1979:** Maastritchian Arenaceous Foraminifera from North-Western Nigeria. Reprinted from Paleontology. Vol. 22, Part 4, November.
20. **Reijers, T. J. A., 1996:** Selected Chapters on Geology, "Sedimentary Geology, Sequence Stratigraphy, Three Case Studies, A Field Guide. SPDC Reprographic Services Warn, Nigeria.
21. **Tucker, M., 1988:** Techniques in Sedimentology. Edited. Blackwell Science Ltd. Osney Mead, Oxford. p. 5 — 62.