



International Research Journal of Interdisciplinary & Multidisciplinary Studies (IRJIMS)

A Peer-Reviewed Monthly Research Journal

ISSN: 2394-7969 (Online), ISSN: 2394-7950 (Print)

Volume-II, Issue-II, March 2016, Page No. 58-64

Published by: Scholar Publications, Karimganj, Assam, India, 788711

Website: <http://www.irjims.com>

Biostratigraphical and Paleoenvironmental Analysis Enugu Area Anambra Basin Nigeria

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Abstract

Biostratigraphical analyses of outcrops around Enugu area using rock samples collected at different intervals yielded a total of 59 agglutinated foraminiferal species. Arenaceous forms encountered include species as 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 GAB AM34. Palynomorphs assemblage yielded includes Lae'vigatosporites oval us, Leptolepidites major, Hex aporopollenites emenianori, Proteacidites sp., Spiniferites sp., Diphyes trianguliformis. These indicate near shore sediments deposited in marine shelf zone, not reached by tidal influence. These sediments were laid down in shallow marine environments. The ages of the outcrop range from Campanian to Maastrichtian.

(I) Introduction: The roughly triangular Anambra basin in South Central Nigeria covers about 40,000 sqkm. The southern boundary coincides with the northern boundary of the Niger Delta basin and Anambra basin, is its main precursors. The basin extends northwards beyond the lower Benue River.

The area is plateau country, especially in the north and the east where oolitic ironstone capped hills extend from around the Niger-Benue confluence to Egeneja in the Bassa Nge area of Kogi state. The southeastern part of the Anambra basin is a part of the scarp lands of southern Nigeria. The north-south trending Enugu cuesta or escarpment forms the major watershed between the lower Niger drainage system to the west, and the Cross River and Imo River drainage systems to the east. It is essentially a ridge stretching in a sigmoid curve form for over 500km from Idah on the Niger River to Arochukwu on the Cross River.

The Abakaliki area has over a considerable span of geological time undergone several vertical movements. Before the formation of the Benue trough the region had a positive topography in crystalline basement rocks. During the Santonian tectonic event the sediments were folded, and the area was uplifted. During the Campanian to Eocene, weathering and denudation processes created second cycle sediments that were transported westward to the Anambra basin. The Abakaliki area remained topographically positive until about the end of the Eocene when it underwent inversion and it once again became depressed, though never below sea

(A) Location and Accessibility: The study area is located in Enugu area, within the southern part of Nigeria between longitudes 7°30' and 8°00' East and latitudes 6°26' and 6°30' North. The accessibility is good. The study location is located by the right side of the Enugu-Port Harcourt expressway junction. These outcrops can be reached either on foot or by car via road.

(B) Aim and Objectives: The aim and objectives of this study is to understand and document the fossil assemblages that are characteristic of the study area, have an understanding of the lithostratigraphic framework of the study area, understand the correct sedimentary boundaries using its fossil assemblages and use the fossil assemblages and the stratigraphy of the outcrop to deduce the age and possible paleoenvironments of deposition..

(C) Review of Biostratigraphy: In Nigeria, there would appear to be a definite lower Maastrichtian ammonite assemblage with *Libyoceras*, *Sphenodiscus*, *Bostiyochoceras*, *Cirroceras* and this occurs in the Nkporo shale and lowest Mamu Formation. *Sphenodiscus* appears again in the uppermost part of the Nigerian Maastrichtian succession, the Nsukka Formation in its extension into Mid-Western Nigeria.

Anofia aro Reymont, *Fragum subperohliguum* (Reidcl), *Veniella undata* (Conrad) (occur up to the top of the Nsukka Formation), *Venericardia crossensis* Reymont, *Pseudocucullaea lens solgar*, *Trigonarca angolensis* Rennie, *Plicatula ferryi* Coquand, *Ageia plenodonta* Reidel, *Inoceramus bantu* (Heinz), *Inoceramus coxi* Reymont, (Nsukka Formation only). Apart from the two species noted, all forms occur in the lower Maastrichtian, in, southeastern Nigeria. Boreholes in coastal Western Nigeria, where the Nkporo Shale have yielded *Cirroceras* sp., *Volutomorpha* sp., unidentified muricids, *Plicatula ibo* Reymont, and unidentified fish teeth.

The Nkporo shale also contains the well preserved crab, *Archeopus senegalensis* Remy? fish teeth, and occasional fragments of bryozoans. Echinoids also occur. In Western Nigeria at least, the Nkporo Shale contains Danian microfossils in its uppermost beds. In Eastern Nigeria, the uppermost beds of the Nsukka Formation contain planktonic Palaeocene foraminifers.

In a local equivalent of the Nkporo Shale, termed Enugu shale, the plant fossils (Seward, 1924) *Acrostichites* sp. *Lanzaeanus* (visiani), *Salvinia Formosa* Heer and *Typhacites latissimus* were collected. An exposure in the Afo River, near Fha Amufu, yielded

Libyoceras afikpoense. Reymont Maastrichtian microfossils have been found in calcareous parts of the Afikpo Sandstone; these include *Bairdia* and *Siphogenerinoides clavata* Chen Kl. Meji. And there are many gastropods and pelecypods.

The Limestones, which occur towards the top of the Nsukka Formation, contain oyster shells, and *Veniella undata* (Conrad). A section in the Obeze River, east of Ifon, discloses friable shales, micaceous sandstones and a brown sandstone with *Sphenodiscus studeri* Reymont, as well as casts of pelecypods and gastropods. Minute clay pockets contain *Afrobolivina afra* Reymont. It contains the ostracods *Bythonyopsis* sp., *Cytherella* sp., *Buntonia* (*Protobuntonia*) *ioruba* Reymont, *Cytherella kunradensis* Van Veen, *Buntonia* (*Buntonia*) *crassicostata* Reymont. *Brachycythere* sp. (Reymont, 1960).

The value of *Afrobolivina afra* to the oil micropalaeontologist will therefore be appreciated as it is to be found in great quantities in marine Cretaceous sediments (Nkporo shale) and therefore provides a ready way of picking up the Maastrichtian.

(II) Method of Study: The research procedure involves first carrying out a literature study on the works carried out on the study area by previous workers, after this, a field study is carried out on the study area with a visit to the field to assess the outcrops (their height, accessibility and location), the research continues with a final field trip. This field trip involves the sampling of stratigraphic units encountered. There is a field description of the samples, which include the colour, particle size, ichnofossils and rock type. This description also involves the topography and vegetation around each study area. These samples are taken to the laboratory for further detailed biostratigraphic studies. Results got from these studies are used to plot charts and graphs from where inferences are drawn.

Samples Slides Preparation: After Samples collection, these samples are taken to the laboratory and a detailed physical description is done about them . By breaking out a piece of the sample and applying a few drops of Hydrochloric acid on the sample, effervescence implies it is calcareous but if no effervescence, it means they are non-calcareous.

Fifty grams of each sample is weighed out, put in aluminum plate, water is added, potassium permanganate salt is added and then covered, and this mixture is put on a hot plate at 40F and allowed to boil. The mixture is brought out and washed in a stack of three sieves comprising 53µm; 153µm and 300µm mesh sizes with ordinary water. The various residues that remain in each of the sieves are taken out, dried and the various weights determined in a weighing machine. The various proportions of the different sand, silt and clay proportions weighed. These residues, which contain rock minerals and the fossils, are studied for the purpose of a detailed qualitative and quantitative micropaleontologic taxonomy.

(III) Results and Interpretation:

(A) 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.

Table 1: Location Sample Description Table

Sample Number	Lithologic Description
L3-S1	Claystone, black, few scattered black carbonaceous materials, curved non-parallel bedding (1.5cm), slabby, indurated (hard), non-calcareous.
L3-S2	Claystone, black, slightly feruginized, few black carbonaceous bodies scattered indurated (hard), structureless, radial alignment of claystone around silt materials, burrow casts (0.3cm) (circular outline), bioturbated, lines of leaf-like fossil imprints, white siltstone grain inclusions, non-calcareous, slabby, bedded.
L3-S3	Shale, black, wavy parallel laminae (0.1cm-0.6cm), glassy transparent fossils (lens-like) like plant flower fossils (0.2cm to 0.9cm long), burrow casts (0.2cm), numerous carbonaceous materials, fissile, platy, non-calcareous, green colour on contact with HCL acid, non-calcareous, green stain with HCL acid.

L3-S4	Shale, black, bioturbation (0.1cmx0.7cm), laminae, brown carbonaceous material present, curved non-parallel laminae (0.2cm-0.3cm), burrow casts (0.1cm), indurated (hard), glassy streaks numerous, non-calcareous.
L3-S5	Siltstone, brown with red ting, weathered, slightly feruginized, vertical faults, parallel laminae (0.5cm-1.0cm), platy-flaggy, gritty, indurated (hard), non-calcareous materials, load casts.
L3-S6	Shale, gray, slightly bioturbated, burrows (with infillings), black carbonaceous materials, lenticular white (few), wavy parallel laminae (0.1cm-0.2cm) indurated (hard) slightly weathered, non-calcareous, burrow (hollow) (0.2cm)
L3-S7	Claystone, highly feruginized, red, heavy, parallel bedding (1.0cm), indurated (hard), non-calcareous, shiny transparent flakes on bedding surface (0.1cm) black carbonaceous specks also on bedding surface, yellowish stain reaction with HCL acid, slabby.
L3-S8	Shale, gray, black carbonaceous materials, bioturbated (burrow casts), non-calcareous, indurated (hard), wavy parallel laminae (0.2cm), platy, partially destroyed laminae.
L3-S9	Shale, gray, black and brown carbonaceous materials, bioturbation (burrow are 0.2 cm diameter), structure completely destroyed, indurated (hard), burrow casts (wavy), noncalcareous, green colour with HCl acid.
L3-S10	Shale, gray, black and brown carbonaceous materials, highly bioturbated, mottled, spherical inclusions of siltstone (1cm x 0.7cm), papery in some parts but structures completely destroyed in some parts, indurated (hard), non-calcareous.
L3-S11	Shale, gray, weathered, spherical concretions, heavy, with red ting, mottled, black and brown concretions, white lenticular structures, wavy parallel laminae (0.05cm-0.1cm), indurated (hard), non-calcareous, linear lens of black carbonaceous materials.
L3-S12	Shale, silty, gray, slightly weathered, with brown ting, brown and black carbonaceous materials (1cm x 0.4cm), shiny speck inclusions, burrows (1cm x 0.1cm), highly mottled, bioturbated, indurate (hard), white lenticular structures, laminae (0.2cm), structures are almost completely destroyed, black lenticular carbonaceous materials (0.1cm wide, 4.5cm long), non-calcareous.
L3-S13	Shale, gray, mottled, silty, parallel laminae (0.1cm) with white lenticular laminae (0.2cm), fissile weathered, numerous black carbonaceous materials, non-calcareous, indurated (hard)

(B) Micropaleontology: The encountered fossils as shown on plate 1 below are *Ammobaculites amabensis*, *Haplophragmoides sahelense*, *Spiroplectamina hausorum*, *Textularia gilbedina*, *Ammobaculites sp* and *Haplophragmoides sp*. The fossils as encountered in each sample and their numerical count in each sample. Together and distribution chart showing the distribution of the fossils against their depth of occurrence is made alongside with a graphic log of the studied outcrop. The distribution chart plotted from the discovered forms against their depth of occurrence using suitable scale as shown on table 2.

**Table 2: Foraminifera and palynomorphs distribution table
Interpretation of Particle Size Foraminifera/Palynomorph Study**

LOCATION III FORAMINIFERA / PALYNO M ORPH DISTRIBUTION TABLE																											
FORAMINIFERA										PALYNO M ORPHS																	
										POLLEN					SPORE												
<i>Ammobaculites aseweensis</i> n. sp.	<i>Bolivina Pseudoplicata</i>	<i>Buccirenata hedbergi</i>	<i>Bulliminea elegantissima</i>	<i>Haplophragmoides bradyi</i>	<i>Haplophragmoides impensus</i>	<i>Haplophragmoides kirki</i>	<i>Haplophragmoides sahelense</i> sp.	<i>Kalamopsis grzybowskii</i>	<i>Quinqueloculina arctica</i>	<i>Quinqueloculina seminulum</i>	<i>Quinqueloculina venusta</i>	<i>Recurvoides gr. Walteri</i>	<i>Spiroplectamina GAB AM34</i>	<i>Vereulina bearpawensis</i>	<i>Proteacidites</i> sp.	<i>Echirporites tranguiliformis</i>	<i>Spirosyncolpites brunii</i>	<i>Hexaporopollenites emelianori</i>	<i>Spirizonocolpites echinatus</i>	<i>Preadopolites africanus</i>	<i>Foveolites</i> sp.	<i>Cyathridites australis</i>	<i>Zlivisporis blanensis</i>	Fungal spore	<i>Laevigatosporites ovatus</i>	<i>Leptolepites major</i>	
S16																											
S15																											
S14																		1									
S13																											
S12																											
S11																											
S10																											
S9																											
S8			13		8						27					4	2			9						2	
S7										48						3							1			2	
S6																2	1			3		1	2				
S5																											
S4	98		43	1			56	140	3	4				18	42												
S3		5			1					17																	
S2																											
S1																					2					1	1

The particle size distribution shows the size distribution of silty shale in the sense that the silt/shale ratio is in the neighbourhood of 10%: 90%. This trend, although varies from 0.2m height to 11.6m height (sample 1 to sample 15), the sample with the most silt proportion is sample 14 taken from 10.8 height and this continues to 12.7m height, the sample with the least silt proportion were samples collected from around the foot of the hill (sample 1) with sample from 3m height (sample 4 and 6) and 4.8m height (sample 8) having outstanding proportions of silt of about 5%. Apart from these areas, the rest areas of the outcrop fall in the neighbourhood of 2% for silt ratio.

From the base of the outcrop comprises shale believed to be deposited in the middle neritic of the shelf. This is so because of presence of some mica flakes observed under microLocation III was sampled across once. The first three samples (sample 1, 2 and 3) yielded sediments seemingly deposited in an ancient outer neritic of a marine environment. This is from the base of the outcrop to

a height of 1.4m. Quartz grains here were rounded and there were pyrite grains present. Fossil assemblage included *Quinqueloculina seminulum* and *Bolivina pseudoplicata* as well as *Haplophragmoides bradyi* (Plate 7, Fig.4). These fossils were only encountered in the third sample. From the 2.9m height to the top of the outcrop (14.2m), there were 13 samples collected and they yielded fossil faunal assemblages of a paleobathymetry of middle neritic. The quartz grains were angular to subangular in shape and there were numerous mica flakes encountered. Profuse fossils of *Ammobaculites asseweensis*, *Haplophragmoides sahriliense* as well as *Quinqueloculina seminulum* were encountered among other foraminifera species fossils. Palynomorphs were as well scanty in the samples collected from this location. Floral fossils yielded include few *Foveotrilites sp.*, *Echtripurites frianguliformis*, *Spirosyncolpites brunii*, Fungal spore, *Leptokpiditus major*.

Based on the result got from measurements, calculations and analysis carried out on the samples collected for this study, the following conclusions are arrived at; the study location is a 20m high outcrop 500m from the first flyover along Enugu-Port Harcourt express way, Enugu junction. This outcrop belongs to the Enugu shales, 0.2m to 1.3m height of the outcrop has outer neritic paleobathymetry. 2.8m to 14.3m of the outcrop is of middle neritic paleobathymetry. The outcrop is of Maastrichtian age. 8m thick clay bed lies unconformably on top of the older bed.

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