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Paleontologic Studies of Arochukwu and Obotme Areas, Afikpo Basin Southeastern Nigeria

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Abstract

This research is focussed on foraminiferal species recovered from Arochukwu area in the Afikpo Basin Southeast, Nigeria. Sixteen samples from Akama, Asaga, Amanangwu, Okobo, Agbagwu and Ututu were collected and processed for their foraminiferal contents. Standard methods as used in Paleontologic studies have been applied to samples recovered from the study area. Age diagnostic forms allowed for dating of the samples. A total of 74 species of foraminifera have been identified from the clays, shaly limestone and limestone units in the study area, the age range of the identified forms is Campanian to Eocene and correspond to Mamu and Nsukka Formations. A late Maastrichtian - Palaeocene age is assigned based on the following benthonic and foraminifera assemblages such as *Bolivina explicita*, *Haplophragmoides talakaoense*, *Haplophragmoides sahariense*, *Haplophragmoides hausa*, *Praebulimina laddi*, *Ammobaculites amabensis*, *Ammobaculites coprolithiformis*, *Cibicides harperi*, *Gavelinella guineana*, *Anomalinoidea midwayensis*, *Bolivina afra*, *Bolivina sp.*, *Eponides pseudoelevatus*, *Haplophragmoides sahelense*, *Osangularia sp.*, *Planulina nacatochensis*, *Reophax minuta*, *Spiroplectammina semicomplanata*, *Textularia Biafrae*, *Eponides psuedoelevatus*, *Trachommina sp.*, *Valvulineria jacksonensis*, *Textularia hockleyensis* and diagnostic planktonic foraminifera such as *Heterohelix globulosa*, *Heterohelix striata*, *Planorotalites compressa*, *Globotruncana sp.*, *Morozovella aequa*, *Morozovella conicotruncana* and *Globigerina fringa*. This agrees with earlier works that benthonic foraminifera predominate in sediments in the Anambra, Afikpo and Niger Delta basins. The distribution of the age diagnostic foraminiferal assemblages suggests the forms correspond to the late Maastrichtian – Palaeocene, the Mamu and Nsukka Formations in the Afikpo Basin. The abundance and diversity of the benthonic foraminifera are indicative of shallow marine to transitional environment of deposition. The presence coral fragments, ostracods and gastropods support a littoral-inner neritic depositional environment.

Keywords: Afikpo Basin; Foraminifera; Benthonic; Planktonic; Assemblages

Introduction

Fossils assemblages of planktic and benthic foraminifera provide evidence for age determination, correlation, depositional environment, reconstruction the record of events in geologic history, climate and using the evidence from sedimentary rocks and their contained fossils in the study area. The ranges of depositional environment typical of the Lower Benue Trough of which the Afikpo Basin is part of are marine, continental, and transitional represented by the Nkporo, Mamu, Ajali, Nsukka, Imo, Ameki Formations, Nanka Sands and the Benin Formation. The study area is within the Afikpo Basin covers parts of Arochukwu Local Government Areas of Abia State- Southeastern Nigeria and located within longitudes 7°44' - 8°03' E and latitudes 5°15' - 5°28'N. The study area is found within the Afikpo Syncline in the Lower Benue Trough of Nigeria (Figure 1). The aim was to determine their age, stratigraphic relationship to the regional geological framework and depositional environment. The objective of this research was to use detailed lithostratigraphic and Paleontologic analysis to establish lithostratigraphic sequence and age of the study area.

Materials and Methods

The methodologies applied for this research are fieldwork and laboratory analysis.

Fieldwork

Detailed fieldwork was undertaken in the study area. The approach used was to document and describe what was seen in the outcrops in detail to avoid a return to repeat the fieldwork in addition to methods modified from [1-3]. Equipment used during the field mapping exercise include compass/clinometers, Geographic Positioning System (GPS), measuring tapes, strong sample bags and sacks

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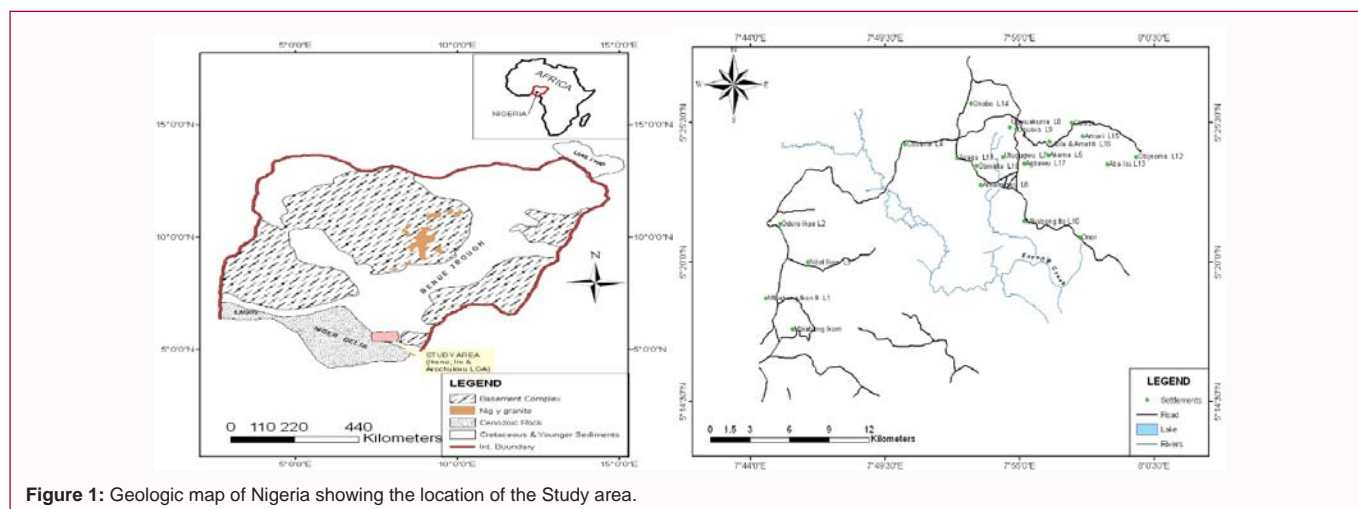


Figure 1: Geologic map of Nigeria showing the location of the Study area.

Table 1: Correlation Chart for Early Cretaceous-Tertiary Strata (Post Santonian sediments) in Southern Nigeria.

Age	Abakaliki/Anambra Basin	Afikpo Basin	Study Area
Oligocene	Ogwashi-Asaba Formation	Ogwashi-Asaba Formation	Coastal Plain Sands
Eocene	Ameki/Nanka Formation	Ameki Formation	
Palaeocene	Imo Formation Nsukka Formation	Imo Formation Nsukka Formation	Nsukka Formation
Maastrichtian	Ajali Formation Mamu Formation	Ajali Formation Mamu Formation	Ajali Formation Mamu Formation
Campanian	Nkporo/Owelli Formation	Nkporo Shale/ Afikpo Sandstone	Nkporo Shale
Santonian			
Coniacian	Agbani Sandstone/Agwu Shale	Non-Deposition (Erosion)	
Turonian	Eze-Aku Group	Eze-Aku Group Amaseri Sandstone	
Cenomanian Albian	Asu River Group	Asu River Group	Basement Complex
Aptian Bananian Hauterivian	Unnamed Units	Basement Complex	
Precambrian	Basement Complex		

properly labelled, celloctapes, field notebook, camera, protective clothing and strong boots in addition topographic map indicating the position of the study area (Ikot Ekpene sheet 322 on a scale 1: 50,000). The outcrops identified were examined for bedding contacts, bed thickness variation, sedimentary and biogenic structures as well as syn- and post- depositional structures (Table 1).

Laboratory method

Twenty-six (26) representative samples of shales, limestones, and clays were analyzed for their microfossil content. The simple washing soda method was used in preparing for foraminiferal analysis; this method is useful for loose sediments. Two spoonful of sodium bicarbonate was added to already desegregate samples in water placed in aluminium pans and allowed to boil. The resulting liquid could simmer until the rock showed no further sign of breaking down. The samples were washed through sieve mesh of 300, 200 and 53 with a gentle jet of water. Each prepared sample labelled A, B and C scanned on a picking tray, picked onto Franke slides and analyzed using a Zeiss binocular paleontological microscope.

Results and Discussions

Results

A total of seventy-four species of foraminifera was identified comprising planktonic and benthonic foraminifera in addition to ostracods, gastropods and pelecypods. These species identified were

Table 2: Paleontologic data for Location 1 – Akama.

Depth (m)	Lithology	Diversity	Abundance	Benthic Count	Planktic Count
2.2	Shale	18	115	17	1
0.3	Shale	19	220	15	4
22.5	Shale	27	1367	24	3
0.6	Shale	12	422	8	4
Total		76	2124	64	12

used for dating and interpretation of environment of deposition of the sedimentary rocks in the study area. The results show that the benthonic foraminifera predominate in all samples analysed except for few samples that are barren. The age range of the forms identified is Campanian – Palaeocene corresponding to Nsukka and Mamu Formations (Tables 2–7 and Plate 1). No attempt was made at description of the forms identified because many workers have already described these forms in their works [4,5].

Biofacies description

Location 1: Akama-Arochukwu

2.20: Shale, brownish to grey. The following forms were recovered *Ammobaculities Amabensis*, *Anomalinoidea midwayensis*, *Textularia hockleyensis*, *T. biafrae*, *Miliammina petila*, *Reophax minuta*, *Haplophragmoides Sahariense*, *H. Saheliense*, *H. talakaoense*,

Table 3: Paleontologic data for Location 1 – Akama.

Depth (m)	Lithology	Diversity	Abundance	Diversity %	Abundance %
2.2	Shale	18	115	23.68	5.41
0.3	Shale	19	220	25	10.34
22.5	Shale	27	1367	35.53	64.36
0.6	Shale	12	422	15.79	19.87
Total		76	2124	100	100

Table 4: Paleontologic data for Location 1 – Akama.

Depth (m)	Lithology	Benthic Count	Planktic Count	Benthic %	Planktic %
2.2	Shale	18	115	94.1	5.9
0.3	Shale	19	220	71.4	28.6
22.5	Shale	27	1367	89.9	11.1
0.6	Shale	12	422	66.7	33.3
Total		76	2124		

Table 5: Paleontologic data for Location 2 – Amanangwu-Arochukwu.

Depth (m)	Lithology	Diversity	Abundance	Benthic Count	Planktic Count
0.91	Sand	0	0	0	0
3.66	Shale	3	135	3	0
2.63	Shale	5	61	5	0
2.31	Shale	5	786	5	0
0.91	Shale	3	310	5	0
12.2	Sand	0	0	0	0
Total		16	1292		

Bolivina sp., *B. afra*, *Trachommina sp.*, *Osangularia sp.*, and *Planulina nacatochensis*. In addition to ostracods and shell fragments. This bed is dated Mid to Late Maastrichtian and the environment of deposition is middle neritic.

0.30: Shale, grey to black. The following forms were recovered *Ammobaculites Amabensis*, *Haplophragmoides nigeriense*, *H. talakaoense*, *Trachommina dutsuna*, *H. Sahariense*, *Textularia hockleyensis*, *Bolivina sp* and *Gavelinella guineana*. This bed is dated Mid Maastrichtian to late Palaeocene and the environment of deposition is middle neritic.

22.50: Shale, dark grey to black and fossiliferous. Forms recovered include *Ammobaculites sp.*, *A. Amabensis*, *A. coprolithiformis*, *Anomalinoidea midwayensis*, *Haplophragmoides sp.*, *H. nigeriense*, *H. talakaoense*, *H. Sahariense*, *Trachommina sp.*, *T. dutsuna*, *Bolivina sp.*, *B. afra*, *Planulina nacatochensis*, *Textularia hockleyensis*, *T. biafrae*, *Gavelinella guineana*, *Spiroplectammina sp.*, *S. semicomplanata*, *Heterohelix globulosa*, *Globotruncana sp.*, *Bulimina sp.*, *Cibicides harperi*, *Eponides reymont*, *E. pseudoelevatus*, *Valvulinera jacksonensis*, *Nonionella cummunis* in addition to shell fragments and coral fragments. This bed is dated Mid Maastrichtian to late Palaeocene and the environment of deposition is shallow inner to outer neritic.

0.60: Clay, reddish and highly fossiliferous. Forms recovered include *Eponides pseudoelevatus*, *Heterohelix globulosa*, *Gavelinella guineana*, *Anomalinoidea midwayensis*, *Haplophragmoides sp.*, *Anomalinoidea midwayensis*, *Haplophragmoides talakaoense*, *Bolivina afra*, *Siphogeneroides cretacea*, *Textularia sagttida*, *Globotruncana linneiana*, *Millammina Petila*, *Dentalina sp.*, and *Hedbergella sp.* In

Table 6: Paleontologic data for Location 2 – Amanangwu-Arochukwu.

Depth (m)	Lithology	Diversity	Abundance	Diversity %	Abundance %
0.91	Sand	0	0	0	0
3.66	Shale	3	135	18.75	10.45
2.63	Shale	5	61	31.25	4.72
2.31	Shale	5	786	531.25	60.84
0.91	Shale	3	310	18.75	7.74
12.2	Sand	0	0	0	0
Total		16	1292		100

Table 7: Paleontologic data for Location 2 – Amanangwu-Arochukwu.

Depth (m)	Lithology	Benthic Count	Planktic Count	Benthic %	Planktic %
0.91	Sand	0	0	0	0
3.66	Shale	3	0	100	0
2.63	Shale	5	0	100	0
2.31	Shale	5	0	100	0
0.91	Shale	5	0	100	0
12.2	Sand	0	0	0	0
Total		16	1292		100

addition to coral reef fragments and pelecypoda. This bed is dated Mid Maastrichtian to late Palaeocene and the environment of deposition is middle to outer neritic.

Location 2: Amanangwu-Arochukwu)

0.91: Very fine to fine grained, lateritic.

3.66: Pebbly ironstone and sandstone fragment angular to sub-round in a clayey matrix. The clay the following foraminiferal species *Haplophragmoides talakaoense*, *Textularia hockleyensis* and *Bolivina explicita* were recovered. This bed is dated late Maastrichtian based on the forams recovered and the environment of deposition is middle neritic.

2.63: Clay, lateritic with reddish to whitish patches. The clay yielded the following forams *Bolivina explicita*, *Haplophragmoides hausa*, *Cibicides sp.*, *Praebulimina laddi* and *Textularia hockleyensis*. This bed is dated Late Maastrichtian based on the recovered forams and the environment of deposition is middle neritic.

2.31: Shale, grey to blackish and highly fossiliferous. The following forams were recovered includes *Bolivina explicita*, *Haplophragmoides sp.*, *H. talakaoense*, *H. sahariense* and *Trochammina sp.* This bed is dated Maastrichtian – Palaeocene based on the diagnostic forams such as *Bolivina explicita*, *H. talakaoense* and *H. sahariense*. The environment of deposition is upper bathyal.

0.91: Shale, reddish and highly fossiliferous. Forams recovered, include *Bolivina explicita*, *Haplophragmoides sp* and *H. talakaoense*.

12.2: Very fine to fine grained whitish sands with pinkish to reddish stains.

Interpretation

A Late Campanian – Late Palaeocene age is assigned to the sediments (shales and limestones) which comprise lithostratigraphic units in the study area that corresponds to Mamu Formation and Nsukka Formation and is based on the association of mainly benthic and few planktonic taxa such as *Ammobaculites sp.*, *A. amabensis*, *A. bauchensis*, *A. numanensis*, *A. coprolithiformis*, *Bulimina*



Plate 1: Some foraminifera, gastropods and ostracods recovered from the study area.

sp, *Bolivina* sp, *B. afra*, *B. explicita*, *Haplophragmoides* sp, *H. sahariense*, *H. sahelense*, *H. nigeriaense*, *H. talokaense*, *Nonionella insecta*, *Milliammina pindigensis*, *M. Petila*, *Valvulineria aegyptica*, *V. jacksonense*, *Anomalinoidea midwayensis*, *A. unboniferous*, *Margulina dorsata*, *Gavelinella guineana*, *Elphidiella africana*, *Planularia nacatochensis*, *Cibicides harperi*, *Morozovella aqua*, *M. acuta*, *Nonionella cummunis*, *Cibicides harperi*, *C. succedens*, *Eponides elevatus*, *E. Reymont*, *E. pseudoelevatus*, *Lenticulina midwayensis*, *Textularia hockleyensis*, *T. biafrea*, *Trachommina* sp, *T. dutsua*, *Spiroloculina* sp, *Spiroplectammina* sp, *S. semicomplanata*, *Heterohelix Striata*, *H. globosa*, *Osangularia* sp, *Globotruncana* sp, *G. linneiana* and *Reophax minuta* [4,6] (Plate 1). The environment of deposition is interpreted as Shallow inner Neritic to outer Neritic marine environment of deposition is based on the occurrence ostracods, pelecypods and gastropods along with foraminifera. The Nsukka Formation in the study area extends from Arochukwu area to Odoro Ikpe were it is overlain by Coastal Plain Sands which are not older than Palaeocene. This age agrees with earlier workers in this region [5,7-11] (Table 5).

Discussion

The benthonic forams provide a basis for paleodepth and environment of deposition. The benthonic foraminiferal assemblage in the study area comprises *Ammobaculites* sp, *A. amabensis*, *A. bauchensis*, *A. numanensis*, *A. coprolithiformis*, *Bulimina* sp, *Bolivina* sp, *B. afra*, *B. explicita*, *Haplophragmoides* sp, *H. sahariense*, *H. sahelense*, *H. nigeriaense*, *H. talokaense*, *Nonionella insecta*, *Milliammina pindigensis*, *M. Petila*, *Valvulineria aegyptica*, *V. jacksonense*, *Anomalinoidea midwayensis*, *A. unboniferous*, *Margulina dorsata*, *Gavelinella guineana*, *Elphidiella africana*, *Planularia nacatochensis*, *Cibicides harperi*, *Nonionella cummunis*, *Cibicides harperi*, *C. succedens*, *Eponides elevatus*, *E. Reymont*, *E. pseudoelevatus*, *Lenticulina midwayensis*, *Textularia hockleyensis*, *T. biafrea*, *Trachommina* sp, *T. dutsua*, *Spiroloculina* sp, *Spiroplectammina* sp and *S. semicomplanata*. Some benthonic genera present in the study area include *Ammobaculites*, *Textularia*, *Haplophragmoides*, *Osangularia*, *Reophax*, and *Trachommina*. *Ammobaculites* is an infaunal deposit

feeder that lives in muddy sediments with brackish to normal – marine salinities; from marsh to bathyal environment and is tolerant to low oxygen level. *Textularia* species inhabit normal marine environment ranging from lagoon to bathyal and live epitaurally on land substrates, muddy silts, and sand. *Trochammina* settles as an infaunal or epitaural deposits and plant feeder in a wide range of environment and water depth. It is also tolerant to low oxygen level. *Reophax* is mainly a marine genus, has also been reported from brackish lagoons and estuaries. *Osangularia* species live in modern oceans from outer neritic to bathyal environment with normal marine salinities and prefer muddy sediments, this suggest that the shale in the study area have been deposited in an outer shelf to bathyal environment [12-14]. The environment of deposition is interpreted as shallow inner neritic to outer neritic marine environment. In the present study, forty-nine (49) benthonic and planktonic foraminiferal species were identified from shale and limestone samples from Akama, Asaga, Amanangwu, Okobo Atani, Agbagwu and Ututu (Tables 2–7 and Plate 1). The planktonic foraminifera provide a basis for stratigraphic correlation with those established in other parts of Nigeria and serves as indirect link to worldwide chronostratigraphy [15-18]. They are mainly used in age dating; the association of planktonic foraminiferal assemblage in this study comprises *Morozovella aqua*, *M. acuta*, *Heterohelix Striata*, *H. globosa*, *Osangularia* sp, *Globotruncana* sp and *G. linneiana*. This association suggests Early Maastrichtian – Late Eocene as the age of this sediments and this corresponds to Nsukka and Mamu Formations [19-24].

Summary

The occurrence of benthonic and planktonic forms as *Ammobaculites* sp, *A. amabensis*, *A. bauchensis*, *A. numanensis*, *A. coprolithiformis*, *Bulimina* sp, *Bolivina* sp, *B. afra*, *B. explicita*, *Haplophragmoides* sp, *H. sahariense*, *H. sahelense*, *H. nigeriaense*, *H. talokaense*, *Nonionella insecta*, *Milliammina pindigensis*, *M. Petila*, *Valvulineria aegyptica*, *V. jacksonense*, *Anomalinoidea midwayensis*, *A. unboniferous*, *Margulina dorsata*, *Gavelinella guineana*, *Elphidiella africana*, *Planularia nacatochensis*, *Cibicides harperi*, *Morozovella aqua*, *M. acuta*, *Nonionella cummunis*, *Cibicides harperi*, *C. succedens*,

Eponides elevatus, *E. Reymont*, *E. pseudoelevatus*, *Lenticulina midwayensis*, *Textularia hockleyensis*, *T. biafrea*, *Trachommina* sp, *T. dutsua*, *Spiroloculina* sp, *Spiroplectammina* sp, *S. semicomplanata*, *Heterohelix Striata*, *H. globosa*, *Osangularia* sp, *Globotruncana* sp, *G. linneiana* and *Reophax minuta*. Suggest that the Akama, Asaga and Amuvi area of the study area is interpreted as late Maastrichtian-Palaeocene. A Mid- Maastrichtian- Late Eocene age is assigned to the shale units of the study area corresponds to Mamu and Nsukka Formations, based on this association of mainly benthic forams. The shale units from Akama, Asaga, Amanagwu, Okobo Atani and Agbagwu are dated Late Maastrichtian to Eocene this corresponds to Nsukka Formation while the shale unit from Ututu is dated Campanian-Maastrichtian and corresponds Mamu Formation. According, Campanian – Maastrichtian sediments have been dated based on foraminifera species recovered from five sedimentary basins of the Gulf of Guinea, Anambra Basin, Afikpo Syncline, Calabar Flank, Rio del Rey and Douala Basins such as *Bolivina afra*, *B. explicita*, *Ammobaculites coprolithiformis*, *Praebulimina exiqua*, and *Gabonita lata*. The association of planktonic and benthonic forams used in dating in this work is like those used by [4,25-27].

Conclusion

The co-occurrence of benthonic such as *Haplophragmoides telokaense*, *Haplophragmoides sahariense*, *Ammobaculites amabensis*, *Ammobaculites coprolithiformis*, *Cubicides harperi*, *Planulina nacatochensis*, *Anomalinoidea midwayensis*, *Bolivina afra* and *Heterohelix Striata*, *H. globosa*, *Globotruncana* sp and *G. linneiana*. Suggest that the shales and clays in the study area are not older than late Maastrichtian – Late Palaeocene age. Based on the foraminiferal data and Lithologic description in addition to gastropods, pelecypods, ostracods and fragments of corals, the environment of deposition is interpreted as shallow marine (shallow inner neritic to outer neritic). A Late Campanian to Late Palaeocene age has been assigned to the shales and limestone units in the study area (Arochukwu area) based on identified assemblages of foraminifera and corresponds to Nsukka, and Mamu Formations.

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