PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (12) 4105-4112 Dec. 2024

Investigation of the Foraminiferal Biostratigraphy of Well AMKP 2-11 in Shallow, Offshore Niger Delta Basin, Nigeria

***[1]NWACHUKWU, HGO; [2]UDOM, GJ; [2]CHIAZOR, FI; [1]ISIORJI, CC; [1]IKE, I; [1]AMADIKE, MP**

**[1]Department of Geology, School of Physical Sciences, Federal University of Technology Owerri, Imo State, Nigeria*
[2]Department of Geology, Faculty of Science, University of Port Harcourt, Choba, Nigeria

**Corresponding Author Email: helengloria222@gmail.com*
**ORCID ID: https://orcid.org/0000-0003-3449-4427*
**Tel: +2348065215809*

Co-Authors Email: godwin.udom@uniport.edu.ng; fortune.chiazor@uniport.edu.ng; christianchisom965@gmail.com; kenilascott4179@gmail.com; amadikeprecious2001@gmail.com

ABSTRACT: The objective of this paper was to investigate the foraminiferal biostratigraphy of well AMKP 2-11 (interval 3280m to 4629m), in shallow, offshore of the Niger Delta Basin, Nigeria using appropriate standard procedures with 135 ditch cutting samples analysed at 60m. 40 foram species were recovered including *Cylammina minima, C. cancellata, Saccamina complanata, Haplophragmoides narivaensis, H. compressa, H. obliquecameratus, Ammobaculites strathearnensis, Valvulina flexilis, Recurvoides deformis.* One foram biozone N17 was identified and characterised by top occurrences of *Cyclammina minima* and *Saccamina complanata* at 3390m and top occurrence of *Haplophragmoides narivaensis* at 4130m. The occurrence of *Haplophragmoides narivaensis*, *Globigerinoides extremus* and influx of agglutinated taxa in the studied section of the well enabled an inference of Late Miocene (Messinian) age. The paleoenvironment of deposition is identified as Upper Continental Shelf to Mid Continental Shelf environments based on the occurrence of the Inner Neritic biofacies such as *Lenticulina inornata*, *Heterolepa pseudoungeri* and *Ammobaculites* spp. as well as deep water middle to outer shelfal foraminiferal assemblages, such as *Cyclammina minima*, *Haplophragmoides compressa*, *Vavulina flexilis*, *Trochammina globigeriniformis*, *Uvigerina peregrina* of the Middle Neritic. Therefore, a Middle Neritic (Middle Continental Shelf) environment (40–100 m) was inferred due to the presence of very fine-grained clay signifying slow rate of deposition of taxa as well as distinctive benthonic foraminiferal assemblage: *Cyclammina minima*, *C. cancellata*, *Saccammina complanata*, *Uvigerina subperegrina*, *Vavulina flexilis*, *Karreriella siphonella.* This work provides detailed the biostratigraphic framework of the well section.

DOI: https://dx.doi.org/10.4314/jasem.v28i12.21

Cite this Article as: NWACHUKWU, H. G. O; UDOM, G. J; CHIAZOR, F. I; ISIORJI, C. C; IKE, I; AMADIKE, M. P. (2024). Investigation of the foraminiferal Biostratigraphy of Well AMKP 2-11 in Shallow, Offshore Niger Delta Basin, Nigeria. *J. Appl. Sci. Environ. Manage.* 28 (12) 4105-4112

Dates: Received: 22 October 2024; Revised: 20 November 2024; Accepted: 08 December 2024; Published: 18 December 2024

Keywords: Foraminifera; Biostratigraphy; Chronostratigraphic surfaces; Paleoenvironment; Biozone

The Niger Delta Basin, located in the Gulf of Guinea on the West African coast, is one of the world's most prolific hydrocarbon provinces, containing about 70% of the overall hydrocarbon reserves of subSaharan Africa and over 40 trillion cubic feet of natural gas. It was formed as the youngest of the three large sediment bodies that filled the aulacogen created after the separation of the African and South American plates.This basin majorly consists of three subsurface lithostratigraphic units—the marine Akata Shales, the paralic Agbada Formation, and the continental Benin Formation. These units generally corresponds to the

**Corresponding Author Email: helengloria222@gmail.com*
**ORCID ID: https://orcid.org/0000-0003-3449-4427*
**Tel: +2348065215809*

source rock, reservoir rock and aquiferous zone in the Niger Delta petroleum system. The best studied of these is the petroliferous Agbada Formation with its varied lithofacies ranging from reservoir sands through heteroliths to mudrock seal facies. (Adegoke *et al.*, 2017). The Niger Delta Depo Belts, of which the Shallow Offshore depobelt is one, was formed to accommodate sediments induced by the southward progradation of the Niger Delta. Tectonic activities and structural instability contributed to observable lateral facies variations in the study area. The complex stratigraphy of the Niger Delta Basin, influenced by various geological processes including deltaic progradation, marine transgressions, and tectonic activities, makes it a prime target for detailed stratigraphic and paleontological investigations. Among the various methodologies employed for understanding the Niger Delta stratigraphy, foraminiferal studies stands out due to its potential for providing paleoenvironmental information and sedimentary processes, contributing to a better understanding of the basin's geological history and evolution (Martini,1971; Bolli *et al*.,1985). Forams are among the earliest, most abundant, diverse and important fossils, because they are particularly useful in the oil industry to age-date and correlate marine sedimentary rocks. In the Niger Delta Basin, the diverse and well-preserved foraminiferal assemblages allow for detailed environmental reconstructions and age determinations. Foraminifera are single-celled protists, comprising a large group. They first occured as simple tubes of sand in the Cambrian. Later more complex tubes and coils appeared, even developing chambers in the Ordovician. In the Silurian, secreted calcium carbonate types appeared; these diversified into many different shapes and kinds. Some 60-80,000 species have been described from Cambrian through Recent age sediments. About 4,000 species are alive today. Of these, only 40 are planktonic, the rest are benthic. Some even live on other forams! The biostratigraphic utility of the foraminifera is enhanced by their rapid evolutionary rates and distinct morphological characteristics, which allow for precise species-level identifications and correlations (Culver and Rawson, 2000). Planktonic foraminifera, which inhabit the upper water column, provide valuable information on global oceanographic conditions and are crucial for correlating marine sequences across different basins. Benthic foraminifera live on or within the seafloor sediments and offer insights into past environmental conditions, including water depth, oxygen levels, and substrate type. The foraminifera data can aid in the interpretation of depositional environments and sedimentary processes, contributing to a better understanding of the basin's geological history and evolution (Martini, 1971; Bolli *et al.*, 1985). Therefore, the objective of this paper is to investigate the foraminiferal biostratigraphy of well AMKP 2-11 (interval 3280m to 4629m), in shallow, offshore of the Niger Delta Basin, Nigeria

MATERIALS AND METHODS

Description of Study Area: The study well is within the maritime boundary of Nigeria, in the Gulf of Guinea. The period of study is the Cenozoic, with particular emphasis on the stratigraphic intervals encountered in well AMKP 2-11. The research involves foraminifera data gathering and analysis. The biostratigraphic data was used to identify marker species, key biozones, and biostratigraphic boundaries (Bown and Young, 1998; Bolli *et al*.,1985). Therefore, the objective of the study is to investigate the foraminiferal biostratigraphy of well AMKP 2-11 (interval 3280m to 4629m), in shallow, offshore of the Niger Delta Basin, Nigeria.

Ditch cutting samples recovered at 10m interval and mud log was available for this research. Well AMKP 2 - 11 was drilled by Total Energies limited while all analyses were carried out at the Paleontology Laboratory of the University of Port Harcourt following these steps.

Depth to depth sedimentological analysis was carried out on a total of one hundred and thirty-five (135) samples from Well AMKP 2 - 11 (interval 3280m - 4630m). The samples were spread on a flat surface smooth crucible and examined using a hand lens to identify the grain sizes, sorting, colour, presence of rootlets and other plant remains, mica flakes, pyrites, shell fragments and other physical components. 0.2M of hydrochloric acid (HCl) was then applied to the samples to determine the presence of calcareous material within the samples. Samples that showed effervescence were termed calcareous while the ones that did not show effervescence were termed non-calcareous or mildly calcareous, as the case may be. This sedimentological analysis was necessary to describe the dorminant lithology.

Procedure: The ditch cutting samples were composited at 60m interval for processing and analyses following standard foraminiferal processing techniques. The unwashed samples were initially rinsed in distilled water to remove drilling mud and then dried over a hot plate. A standard weight (20g) of each dried sample was soaked for 4 hours in kerosene, followed by water soaking overnight. The disaggregated sample was then washed under a shower of water over a 63-µm mesh sieve. The

washed residue was then dried over a hot plate and sieved through 500 mm, 250 mm, 180 mm and 125 mm (coarse, medium,fine and very fine) fractions and labeled accordingly prior to picking.

During picking very rich samples were usually subjected to splitting with the split factor recorded. All biotas including foraminifera, ostracods, shell fragments seen, were picked, counted and recorded. The complete micropaleontological data acquired was computerized using the StrataBugs software. Statistical barcharts and plots of the species count, abundance, and diversity were made from which candidate Maximum Flooding Surfaces (MFSs) were selected. The available mud logs of the wells were used to support the findings. Recovered foraminifera were identified to species level where possible, using standard manuals such as the Central West African Cretaceous - Tertiary Benthic Foraminifera and Stratigraphy (Petters, 1982), Gulf of Guinea Planktonic Foraminiferal Biochronology and Geological history of the South Atlantic (Petters, 1983), Oligocene to Holocene low latitude Planktonic Foraminifera (Bolli and Saunders, 1985; incorporating Blow,1969 and 1979), SPDC's Catalogue of Benthonic Foraminifera, TOTAL's *Principaux Foraminiferes observes dan les series deltaiques du Neogene* as well as *Principaux Foraminiferes observes dan les series deltaiques du Paleogene.* Faunal associations including benthonics, planktonics, benthonic/planktonic ratios (normalized) agglutinated/calcareous foraminiferal ratios, etc. were also plotted on charts.

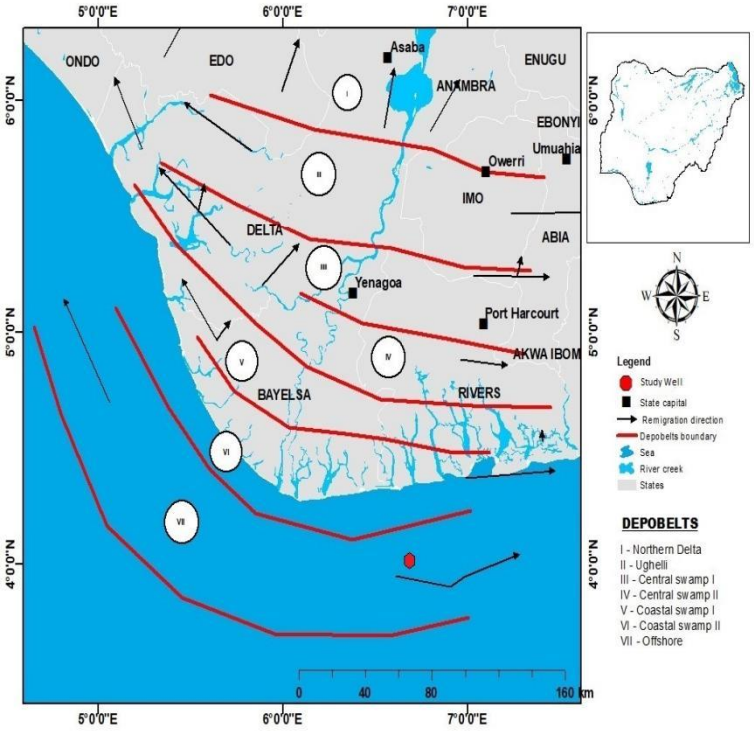

Fig. 1: Location Map of Study Area

RESULTS AND DISCUSSIONS

A comprehensive sample description showed a predominance of dark gray to smoky white/ light gray, non- calcareous to calcareous shale especially towards the base of the sampled section. Specifically, the top depth, interval of 3280m to 3710m were dominated by gray, non-calcareous shale with mildly calcareous depths in between. Interval 3710m to 3980m was characterized by light gray, non-calcareous shale; interval 3980m to 4230m continues as gray, non- calcareous shale; 4230m to 4380m was dominated by light gray/smoky white, non-calcareous shale and interval 4380m to 4630m (TD) consisted mainly of milky white/smoky white, non-calcareous/mildly calcareous shale with gray, non-calcareous, fissile shale in between (Table 1).

Foraminifera Biostratigraphy: A total of forty (40) foram species were recovered from the well. The foraminifera result showed that the foram species and occurrence increased steadily downhole from the foremost sample point at 3310m with *Haplophragmoides obliquecameratus* recording the highest singular occurrence of 19 at the last sample

depth of 4130m. Well AMKP 2-11 comprised of Top occurrence of *Cyclammina minima* and *Saccamina complanata* at 3390m and Top occurrence of *Haplophragmoides narivaensis* at 4130m. Table 2 presents the encountered foraminifera species at different depths.

Table 1: Lithostratigraphic description of Well AMKP 2-11

Depth (m)	Lithology	Lithostratigraphy
3280 - 3710	Gray, non- calcareous /mildly calcareous shale	Agbada Formation
3710 - 3980	Light gray, non- calcareous shale	
3980 - 4230	Gray, non- calcareous shale	
4230 - 4380	Light gray/ smoky white, non- calcareous shale	
46 4380 - 4630	Dark gray, non-calcareous/mildly calcareous shale	

Table 2: Encountered foraminifera in Well AMKP 2-11

S/No	Species	Depth (m)	Plate number
1	*Cyclammina cancellata*	3330	Plate 1, No 1a, 1b
2	*Glomospira gordialis*	3330	Plate 1, No 2c
3	*Cyclammina sp*	*3330*	
4	*Gravellina sp*	3330	
5	*Recurvoides sp*	3330	Plate 1, No 4f, 4g
6	*Cibicides sp*	3330	Plate 1, No 3d, 3e
7	*Cyclammina minima*	3390	
8	*Rectuvigerina sp*	3390	
9	*Saccammina complanata*	3390	
10	*Recurvoides deformis*	3390	
11	*Haplophragmoides compressa*	3390	
12	*Globigerinoides obliquus*	3390	Plate 1, No 5h
13	*Virgulina sp*	3450	
14	*Valvulina flexilis*	3450	
15	*Ammobaculites strathearnensis*	3450	
16	*Textularia panamensis*	3510	
17	*Trochammina sp*	3510	
18	*Trochammina globigeriniformis*	3510	
19	*Heterolepa pseudoungerina*	3570	
20	*Uvigerina mantaensis*	3950	
21	*Uvigerina peregrina*	4010	
22	*Textulariella barretti*	4010	
23	*Haplophragmoides obliquecameratus*	4070	
24	*Karreriella gaudryinoides*	4070	
25	*Karreriella bradyi*	4070	
26	*Karreriella siphonella*	4130	
27	*Haplophragmoides narivaensis*	4130	
28	*Bathysiphon sp*	4130	
29	*Trifarina angulosa*	4130	
30	*Lenticulina inornata*	4130	
31	*Heterolepa mckannai*	4130	
32	*Gyroidinoides neosoldanii*	4130	
33	*Epistominella vitrea*	4130	
34	*Globobulimina sp*	4130	
35	Globigerinoides sacculifer	4130	
36	*Globigerinoides ruber*	4130	
37	*Globigerinoides trilobus*	4130	
38	*Globorotalia sp.*	4130	
39	*Globorotalia plesiotumida*	4130	
40	*Orbulina universa*	4130	

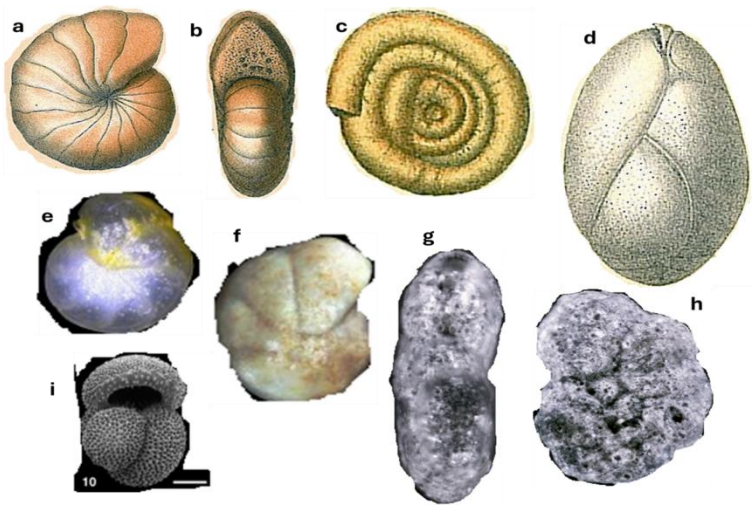

Plate 1: Photomicrographs of some encountered foraminifera
1.a. *Cyclammina cancellate;* 1 b. *Cyclammina cancellate;* 2 c. *Glomospira gordialis;* 3 d. *Cibicides sp, ;* 3 e. *Cibicides sp,* 4 f. *Recurvoides sp, ;*4 g. *Recurvoides sp,;* 5 h. *Globigerinoides obliquus*

Biozones and Age Determination
Interval: 3330 - 4130m
Foram Zone: N17
Age: Late Miocene (Messinian)
Interval characterised by:
- Top occurrences of *Cyclammina minima* and *Saccamina complanata* at 3390m
- Top occurrence of *Haplophragmoides narivaensis* at 4130m

Foraminiferal data from Well AMKP 2-11 identifies chronostratigraphic surfaces encountered to be Top occurrences of *Cyclammina minima and Saccamina complanata* at 3390m and Top occurrence of *Haplophragmoides narivaensis* at 4130m, all within the N17 zone. The Late Miocene (Messinian) age was assigned to this zone due to diagnostic agglutinated benthic assemblage defining a Late Miocene (Messinian) age observed in this well section, including *Cylammina minima, Cylammina. cancellata, Saccamina complanata, Haplophragmoides narivaensis, Haplophragmoides compressa, Haplophragmoides obliquecameratus, Ammobaculites strathearnensis, Valvulina flexilis, Recurvoides deformis, Karreriella gaudryinoides, Karreriella. siphonella* and *Trochammina globigeriniformis,* etc. A few calcareous benthics associated with this assemblage include; *Uvigerina mantaensis, Uvigerina peregrina, Trifarina angulosa, Lenticulina inornata, Heterolepa pseudoungerina* and *Heterolepa. mckannai.* Few planktonic species such as *Globigerinoides obliquus, Globigerinoides sacculifer, Globigerinoides trilobus, Globigerinoides ruber* and *Globorotalia plesiotumida* were also observed in the studied interval. This peculiar influx of arenaceous taxa is typical of the Messinian event in the Niger Delta (Adegoke, *et al,* 2017). This event is known globally and is associated with a cooling that destroyed most taxa of calcareous composition. The Foraminifera Checklist (Fig. 2) presents a summary of the foraminifera recovered from the well, with the fossil count, foram diversity, abundance, age and biozones.

Paleoenvironmental Interpretation/ Paleobathymetry:
The paleoenvironmental interpretation was based on recent review of the Geology of the Niger Delta by Nwajide (2013) and the principle studies of the bathymetric ranges of recent foraminifera by Bandy et al. (1967), Bandy and Arnal (1957), Phleger (1960), Boltovskoy *et al.* (1980) and Murray (1991). The presence of diagnostic foraminifera biofacies enabled the interpretation into subenvironments. The studied marine shales units feature the Prodelta and Open Shelf Biofacies (Figure 3) with relatively high-benthonic foraminifera diversity and abundant planktonic species. The biofacies are characterized by the common occurrence of the Inner Neritic biofacies such as *Lenticulina inornata, Heterolepa pseudoungeriana, Ammobaculites* spp. (Adegoke *et al.*, 1976; Murray, 1991) as well as deep water, middle to outer shelfal foraminifera assemblages, such as *Cyclammina minima*, *Haplophragmoides*

compressa, *Vavulina flexilis*, *Trochammina globigeriniformis*, *Uvigerina peregrina* of the Middle Neritic signifying the Upper Continental Shelf to Mid Continental Shelf environments. There was probably an influx of Delta top biofacies characterised by arenaceous genera, such as *Ammobaculites strathearnensi*, *Textularia* spp., and *Haplophragmoides* spp. (Adegoke *et al.*, 1976) indicative of tidal creeks and estuaries deposits of the outer neritic environment of deposition (Adegoke and Stanley, 1972; Murray, 1991).

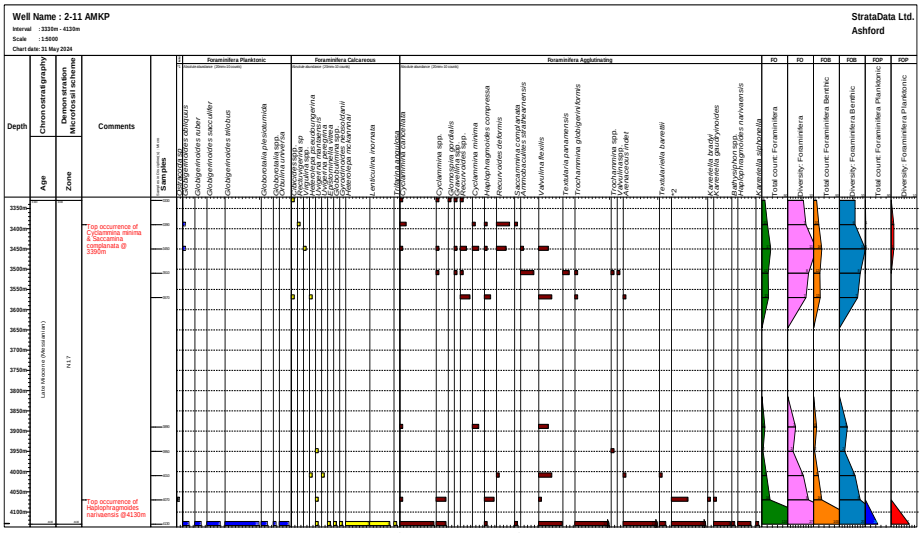

Fig. 2: Foraminifera checklist for Well AMKP 2-11

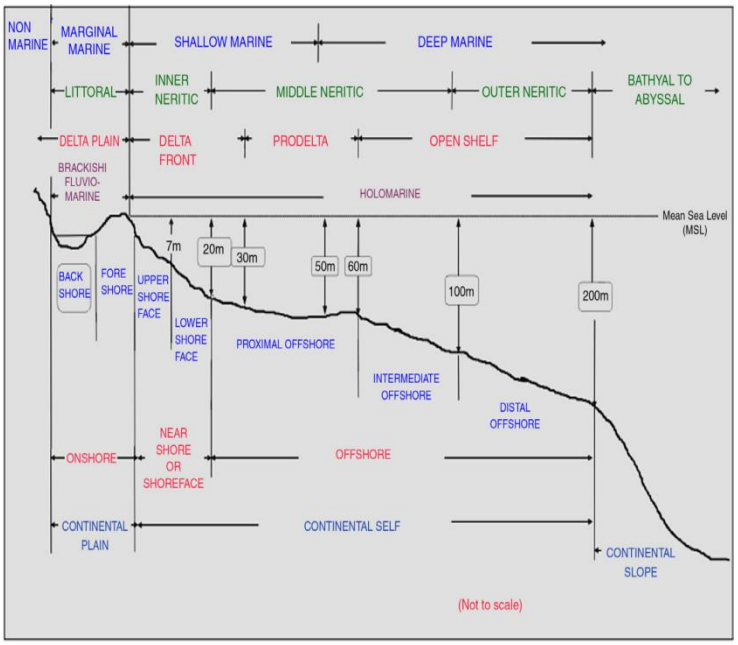

Fig. 3: Sketch showing the main sedimentary environments of the Niger Delta (Modified from Allen, 1965a,b, 1970).

Paleobathymetric interpretations were carried out by recognising bathymetric ranges and environments of significant benthonic foraminiferal species encountered in the study. Similar model that was applied for the reconstruction of the paleoenvironments of the ancient Niger Delta as well as the neighboring Gulf of Guinea marine realm (Asseez *et al*., 1974; Fayose, 1976; Debenay, 1990; Debenay and Basov,1993; Debenay and Redois,1997; Debenay *et al*., 1996) was equally applied throughout the Cenozoic Niger Delta. A Middle Neritic (Middle Continental Shelf) Environment (40–100 m) was

inferred due to the presence of very fine-grained clay signifying slow rate of deposition and the dominant taxa including *Haplophragmoides compressa*, *Uvigerina peregrina*, Also, influence from the Outer Neritic (Lower Continental Shelf) Environment biofacies (100–250 m) characterized by a distinctive benthonic foraminiferal assemblage including *Cyclammina minima*, *Cyclammina cancellata*, *Saccammina complanata*, *Uvigerina subperegrina*, *Vavulina flexilis*, *Karreriella siphonella*. Considering the dominant foram assemblages and typical depositional environment, the paleobathymetry vary between inner to middle neritic biofacies within the Agbada Formation.

Conclusion: The top and base of the studied section of Well AMKP 2-11 lie within the shale unit of the Agbada Formation in the Niger Delta Basin. The stratigraphic range of the fossil assemblages showed that the studied section lies within N17 zone. It was dated Late Miocene (Messinian) based on the occurrence of diagnostic foraminifera including *Cyclammina minima, C. cancellata, Saccamina complanata, Haplophragmoides narivaensis, H. compressa, H. obliquecameratus, Ammobaculites strathearnensis* and *Globigerinoides extremus.*

Declaration of Conflict of Interest: The authors declare no conflict of interest

Data Availability Statement: Data are available upon request from the first author or corresponding author or any of the other authors

REFERENCES

Adegoke, OS; Oyawoye, MO; Obaje, NG (1976). Geology of Nigeria. Elizabethan Publishing Company.

Adegoke, OS; Oyebamiji, AS; Edet, JJ; Osterloff, P L; Ulu, OK (2017). Cenozoic foraminifera and calcareous nannofossil biostratigraphy of the Niger Delta. *Elsev Incorp*. https://doi.org/10.1016/B978-0-12-812161-0.00002-8

Allen, JRL (1965a). Late Quaternary Niger Delta and Adjacent areas: sedimentary environments and lithofacies. *Am. Assoc. Petr. Geol. Bull.* 49 (5), 547–600.

Allen, JRL (1965b). A review of the origin and characteristics of recent alluvial sediments. *Sed. 5*, 89–191.

Allen, JRL(1970). Sediments of the modern Niger Delta: summary and review. In: Morgan, JP(Ed.), Deltaic Sedimentation, Modern and Ancient. *SEPM Special Publication.* No. 15, Pp. 138–151.

Asseez, LO; Reyment, RA; Fayose, EA (1974). Stratigraphy and micropaleontology of the Niger Delta. *J. Afr. Eart. Sci. 2*(1), 1-13.

Bandy, OL; Arnal, RE (1957). Distribution of recent foraminifera off the west coast of Central America. *Bull. Geol. Soc. Amer. 68*(4), 1155-1181.

Bandy, OL; Arnal, RE (1967). Distribution of foraminifera in the Gulf of Mexico. *Cushman Found. Foram. Res, 18*(2), 107-122.

Blow, WH (1979). The Cainozoic Globigerinida: A study of the morphology, taxonomy, evolutionary relationships, and stratigraphical distribution of some Globigerinida (mainly Globigerinacea) (Vol. 1–3). Brill, EJ.

Bolli, HM; Saunders, JB (1985). Oligocene to Holocene low latitude planktic foraminifera, in: Bolli, HM; Saunders, JB; Perch-Nielsen, K (eds), Plankton stratigraphy, Cambridge Univ. Press, vol. 1, 155-257.

Boltovskoy, E; Guissani, G; Watanabe, S; Wright, R (1980). Atlas of Benthic Foraminifera of the Southwest Atlantic. Dr. Junk, W, b.v. Publishers, The Hague.

Bown, PR;Young, JR (1998). Calcareous nannofossil biostratigraphy. Kluwer Academic Publishers.

Culver, SJ; Rawson, PF (2000). Biotic response to global change: The last 145 million years. Cambridge University Press.

Debenay, JP (1990). Recent benthic foraminifera of the Niger Delta: Distribution, diversity and ecology. Marine Micropaleontology, *16*(1-2), 39-61.

Debenay, JP; Basov, I (1993). Distribution of recent benthic foraminifera on the West African shelf and slope. A synthesis. Rev. *Paleobiol.* 12, 265–300.

Debenay, JP; Redois, F (1997). Recent Foraminifera of the northern continental shelf of Senegal. Rev. *Micropaleontol.* 40, 15–38.

Debenay, JP; Beck-Eichler, B; Fernandez-Gonzalez, M; Mathieu, P; Bonetti, C; Duleba, W (1996). Les foraminiferes paraliques des cotes d' Afrique et d' Amerique du sud, de part et d' autre de l'ocean l'Atlantique: comparison—discussion. Actes Colloques Angers 1994, 463–471.

Erba, E (1992). Middle Cretaceous calcareous nannofossil biostratigraphy and paleoceanography of the Western Atlantic Ocean (DSDP Sites 367 and 144). *Mar Micropaleon. 20*(1-2), 41-60.

Fayose, EA (1976) Stratigraphic and biostratigraphic studies of the Niger Delta. *J. Afr. Ear. Sci. 1*(1), 27-38.

Ibe, AC; Ajayi, S (2020). Coastal processes and sedimentation in the Niger Delta: Implications for the petroleum industry. *J. Coast. Res.* 36(2), 376-390. https://doi.org/10.2112/JCOASTRES-D-19-00063.1

Martini, E (1971). Standard Tertiary and Quaternary Calcareous Nannoplankton Zonation. Proceedings of the Second Planktonic Conference Roma, 739-785.

Murray, JW(1991). Ecology and palaeoecology of benthic foraminifera. *John Wiley & Sons*.

Nwajide, CS (2013). Geology of Nigeria's sedimentary basins. CSS Press. Lagos, Nigeria, p.565

Petters, SW(1983). Lithoral and Anoxic Facies in the Benue Trough. *Bull.Centr. Recherch. Explor.* Production ELF- Aquinntaine 7,361-365.

Phleger, FB (1960). Ecology and Distribution of Recent Foraminifera. The Johns Hopkins Press, Baltimore, MD, p.279.