British Journal of Earth Sciences Research, 11 (2),16-25, 2023
Print ISSN: 2055-0111 (Print),
Online ISSN: 2055-012X (Online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Foraminiferal Biostratigraphy of Well Ad, Western Niger Delta

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doi: https://doi.org/10.37745/bjesr.2013/vol11n21625 Published June 1 2023

Asadu A. N. and Oghotuoma O. B. (2023) Foraminiferal Biostratigraphy of Well Ad, Western Niger Delta, *British Journal of Earth Sciences Research*, 11 (2),16-25

ABSTRACT: *Micropaleontological analysis of sixty (62) ditch cuttings rock samples collected from interval, 7800 feet to 12,002 feet of well AD, located offshore western Niger Delta was carried out for the investigation of their age and paleodepositional environment. Standard methods and techniques of foraminiferal sample processing and analysis were followed to disaggregate the microfauna from the rock matrix. The studied interval is predominantly made up of 80 to 100 % sandstone, minor shale and siltstone with variable textural properties. Foraminifera study revealed well preserved and diverse species dominated by the calcareous benthic forms. A total of seventy-four (74) foraminiferal species were recovered among which fifty (52) two are calcareous benthic, six (6) are agglutinating forms while sixteen (16) are planktonic foraminifera. On the basis of the faunal assemblage, abundance and diversity of the important foraminiferal events, four (4) foraminiferal zones (Valvulineria spp, Brizalina mandoroveensis, Hanzawaia concentrica and Lenticulina inornata) were recognised and correlated with F300 and F500 to assign an early to middle Miocene age for the sediments. Paleoenvironmental deductions were based primarily on the richness and diversity of foraminiferal species categories. The presence or absence of planktonic foraminifera aided in deciphering open ocean environments. The dominant biofacies associations recorded within the studied section of Well-AD is the Ammonia beccarii biofacies defined by the rare to common occurrences of Ammonia beccarii, Bolivina scalpratamiocenica, Florilus atlanticus and Epistominella vitrea. Brizalina mandoroveensis species, Lenticulina inornata, Hanzawaia strattoni, Eponides eshira, Cribroelphidium galvestonensis and Hanzawaia concentrica were also in association. The Ammonia beccarii biofacies is indicative of the Shallow/Inner Neritic Paleoenvironment, while the Inner Neritic/Middle Neritic Setting is characterized by top occurrence of Valvulineria spp, a rich continuous occurrence of Epistominella vitrea. The paleoenvironment of the studied section of Well-AD is dominantly inner to middle neritic with concomitant minor incursion of outer neritic setting.*

KEYWORDS: foraminifera, neritic, age, Niger Delta, micropaleontology, paleoenvironment.

INTRODUCTION

Foraminifera are very useful in biostratigraphy both in the subdivision of rock strata into geologic age, paleobathymetry study of ancient ocean and in paleoenvironmental reconstruction of ancient and recent environments. The benthic foraminifera are mostly sessile and therefore very good environmental indicators. Different sedimentary rocks are deposited in a wide range of

environments that seem quite similar (Armstrong and Brasier (2005)). Due to several special qualities they possess as index fossils, foraminifera are used extensively. They are numerous, simple to identify, widely distributed geographically, and have a limited life span. For this study, a total of sixty (62) ditch cuttings samples were collected from interval, 7800 feet to 12,002 feet of well AD located offshore western Niger Delta (figure 1) for investigation of age and paleodepositional environment.

Geology of the Niger delta

The Niger Delta Province is an important geological region that contains vast reserves of hydrocarbons and other important mineral resources. It is located in the Gulf of Guinea and covers the whole Niger Delta Province. The Cenozoic Delta is located where a triple junction formed after the split of South America and Africa in the late Jurassic ((Short and Stauble, (1967), Murat,

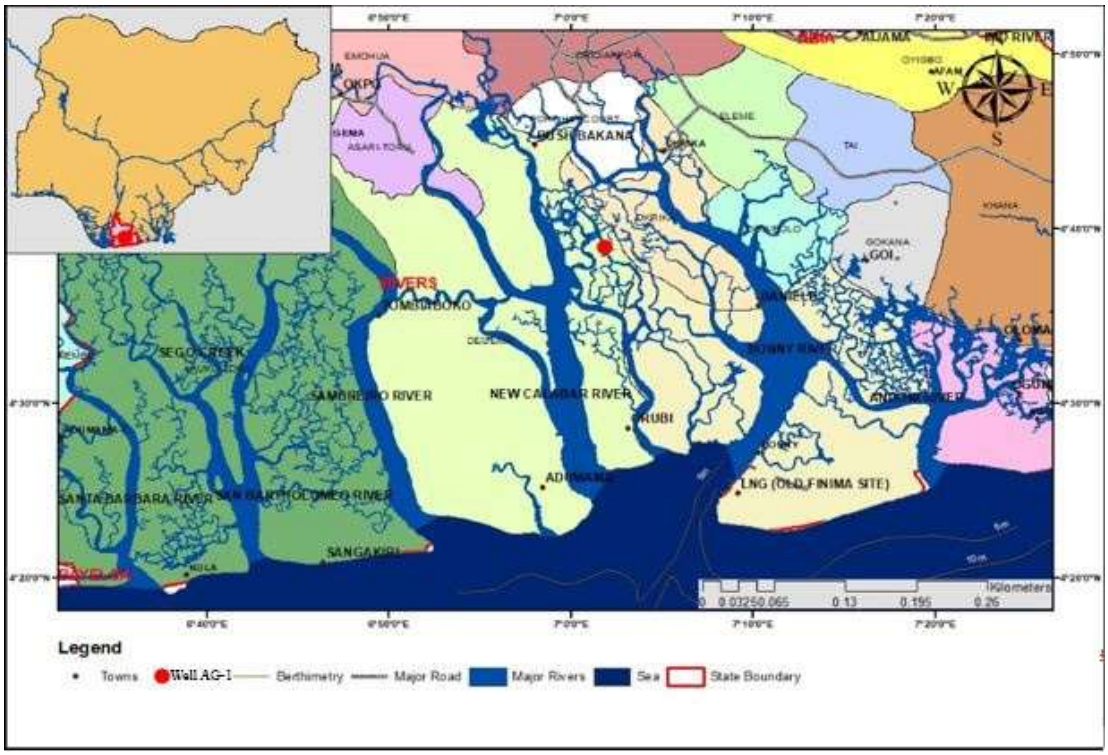

Figure 1: location map of the study area.

(1972), Avbovbo, (1978), Whiteman, (1982) Doust, and Omatsola, (1990)). The Niger Delta Province is a vast sedimentary basin that spans roughly 75,000 km2 in southern Nigeria. The Benin flanks the Anambra Basin, the Dahomey Basin, and the Gulf of Guinea are the northern, eastern, western, and southern boundaries of the basin.

Basin Stratigraphy

The Akata, Agbada, and Benin Formation are the three primary sedimentary units that make up the Niger Delta Province. Marine shale, sandstone, and siltstone that were deposited in a shallow marine environment make up the Akata Formation. Because of the Akata Formation's high organic

content, hydrocarbons like oil and gas have been formed. It is known for its high organic content, which has led to the formation of hydrocarbons such as oil and gas. It is the lowest unit in the Niger Delta Basin deposited during the Paleocene age. (Whiteman, 1982) estimated a thickness ranging from 2000ft to 20000ft for the formation. The Agbada formation overlies the Akata. It is made of non-marine sandstone and shale deposited in a deltaic environment when sea levels were high and the Niger Delta was surrounded by a shallow marine environment. The Agbada Formation is known for its high porosity and permeability, which makes it an ideal reservoir rock for hydrocarbons. The formation, which can be broken down into the basal part, the middle member, and the top member, is up to 3000 meters thick. The basal member consists of sandstone and siltstone with interbedded shale, while the middle member is predominantly composed of sandstone with interbedded shale and siltstone. The upper member consists of sandstone, siltstone, and shale. It is Eocene in age. The Benin formation which is the uppermost unit in the delta overlies the Agbada formation. The continental sandstones and shale deposited in a fluvial setting make up the Benin Formation. Although the Benin Formation is not well known for having large amounts of hydrocarbon reserves, it does include significant aquifers that are used to supply groundwater. Sandstone dominates the formation, with sporadic strata of shale and siltstone. It is Oligocene in age (figure 2).

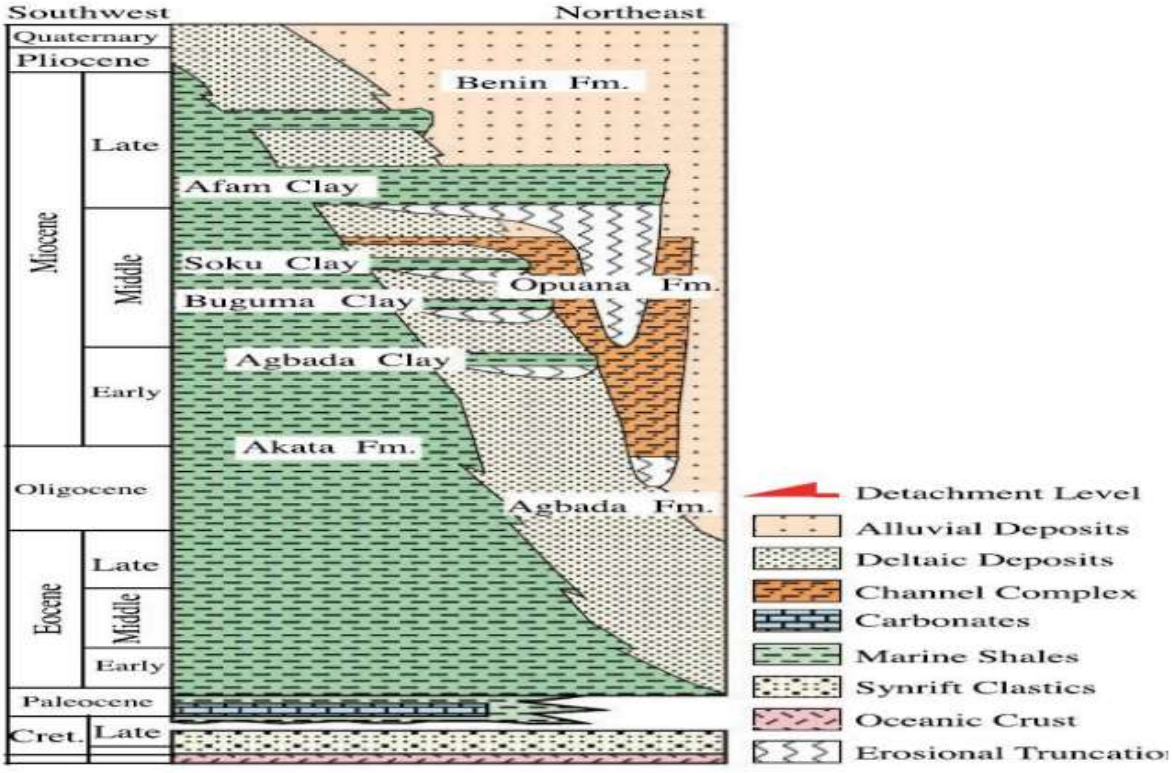

figure 2: Niger Delta Regional Stratigraphy

Previous research on Foraminifera: The basin's foraminiferal biostratigraphy has received a fair amount of documentation. The biostratigraphy and tectonic context of the Cretaceous and Cenozoic sediments in Nigeria were examined by Reyment in 1965. He provided a thorough description of the age characterisation and environment of deposition for both mega and

microfossils, including foraminifera, ostracods, gastropods, pelecepods, pollen, and spores. Fayose (1970) postulated ten biostratigraphic units after analyzing the foraminiferal biostratigraphy of the Afowo-1 borehole in the Dahomey Basin. When Adegoke et al. (1971) examined 36 offshore bottom samples from the Gulf of Guinea for the presence of planktonic foaminiferal species, they discovered 22 species, with *Globigerinoides ruber, Globigerinoides trilobus, Globoquadrina dutertrei,* and *Globorotalia menardii* dominating the list.

Petters (1979), identified *Globorotalia opima nana, Globorotalia opima opima,* and *Globorotali foshi peripheroacuta* zones and utilized them to define the late Oligocene to early Miocene and Pliocene ages, respectively in Parabe-1. Petters (1982, 1983) studied the benthonic foraminiferal biostratigraphy of the Gulf of Guinea and Central West Africa, respectively, and identified nine planktonic foraminiferal zones and five benthonic foraminiferal zones. Fadiya (1999) carried out integrated studies on foraminifera and calcareous nannofossil biostratigraphy analysis of Opolo – 5 and Opolo – 9 Wells, offshore, western Niger Delta. He identified two informal planktic foraminifera zones (*Globigerinoides obliquus and G. ruber*) that corresponded to the N17 -N19 of Blow (1969) and assigned a Late Miocene to Early Pliocene age to the studied sequence of both wells. According to Okosun and Alkali (2012), the Paleocene benthic foraminiferal found in the Eastern Dahomey basin, exhibits a high affinity for the midway Formation of the Gulf coastal plain in North America and established that the Paleocene benthic foraminifera of Tunisia and Libya share some species which is similar to the assemblage in Sokoto Basin. Akinsile et al (2016) identified seventy-eight species of foraminifera in the SILE-Well, offshore Dahomey basin, with 45 species benthics and 19 species planktics.

METHOD OF STUDY

The sedimentological analysis was based on the ditch cutting and the well log available for this research. The processes and techniques used in research institutes and the oil industry at large as well as the standard (published and unpublished) methods and techniques were used to prepare all samples. Procedure followed include:

Logging and Composition of Samples:
Composition and logging of samples were carried out sequentially in batches

Pre-treatment of operations:
Labels for each sample plates were prepared. Clean sample plates were laid out, and the hot plate inside the fume cupboard was placed out.

Samples Treatment 1: Dry and weighing
25g of samples was placed into a plate and corresponding labels were attached, then, the samples were placed securely on the hot plate. Hot plate was regulated to temperature of about 8000C for about 2-3 hours. Sample plate were removed and allowed to cool. Then dried samples were weighed.

Samples Treatment 2: Soaking and Decanting
Samples were soaked in kerosene, left overnight to disaggregate. Kerosene was then decanted from the sample, topped with water and left to stand for 5 hours.

Sample Treatment 3: Sieving and Drying
Sieves were passed in blues methyl (for easy identification of any intruding contaminants). Samples were washed with water through four sieves 500, 250, 150, 63, microns sieves, and the four fractions were dried and transferred into four different bags/phials, labeled accordingly, and placed in one plastic bag. Packaged samples were later transferred for analysis and interpretation using reflected light microscope.

The sixty-two (62) ditch cutting rock samples processed from well AD (Interval: 7800-12002) feet were subjected to micropaleontological examination. Wherever possible, the recovered foraminifera were identified down to the species level using standardized manuals, such as the Central West African Cretaceous to Tertiary Benthic Foraminifera and Stratigraphy (Peters, 1982), Gulf of Guinea Planktonic Foraminifera Biochronology and Geological history of the South Atlantic (Peters, 1983), Oligocene to Holocene low latitude Planktonic Foraminifera.

RESULTS AND DISCUSSIONS

Lithostratigraphy: **S**ediments from 7800ft to 9635ft vary in lithology, grainsize, colour, shape, accessory minerals with sandstone accounting for 60 to 100% of the sediments, shale for 5 to 25%, siltstone for 5 to 10%, and mudstone for 5 to 10%. the grain size range from very fine to coarse sediment, and the grain quality of the sediment ranges from very poorly sorted to well sorted grains. They might be white, grey, brown, or dark in colour. Additionally, the shape might be either well-rounded or angular. Accessory minerals are carbonaceous detritus, with little pyrite content. Sandstone makes up the entire lithology between 9730 feet and 10600 feet. They range in size from very fine to medium to coarse grains, unconsolidated and well-sorted, angular to sub rounded in shape and white or light grey in colour. Carbonaceous materials are found only below 10475 feet depth. From depth 10602ft – 12002, lithology varies from 15%-100% sandstone, 2%-80% shale, 0%-10% mudstone and 0%-5% silt, sizes range from fine-grained to coarse-grained, colour varies from white to grey, fissile to sub-fissile and ferruginous with fair amounts of carbonaceous and gypsum at some horizons. These sediment characteristics typifies fluvial deposition.

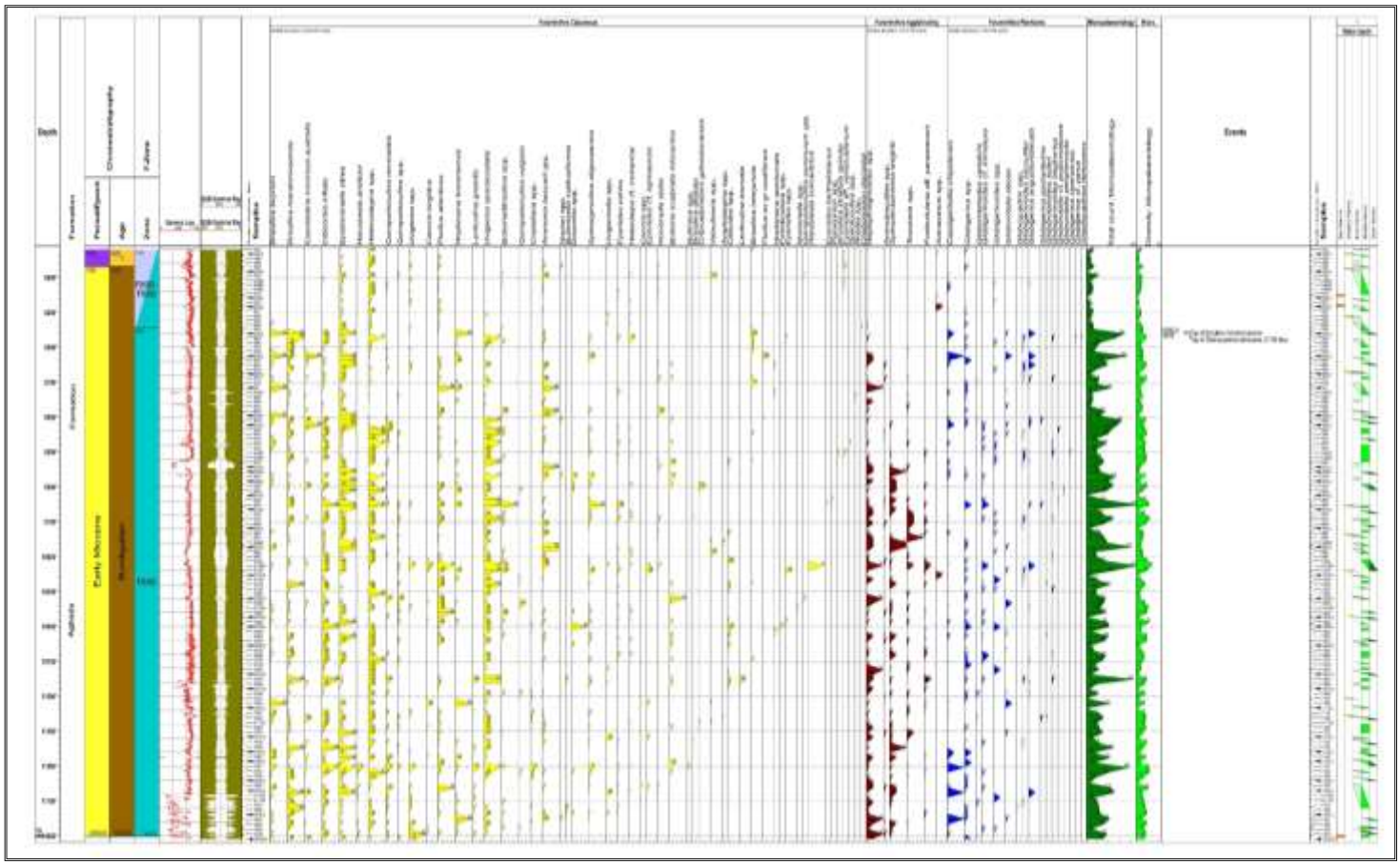

Figure 3: Foraminifera Distribution Chart of Well Ad

Micropaleontology

Foraminifera assemblage over the interval provided for analysis is generally rich and diverse. Foraminifera species recorded consist of Foraminifera Calcareous, Foraminifera Agglutinating and Foraminifera Planktonic species with calcareous benthonics dominating the assemblage wth rare occurrences of the planktonics and agglutinating forms (figure 3). A total of seventy-four (74) foraminiferal species were recovered among which fifty two are calcareous benthonics, six (6) are agglutinating forms while sixteen (16) are planktonic foraminifera. On the basis of the faunal asemblage, abundance and diversity of the important foraminiferal events, four (4) foraminiferal zones (*Valvulineria* spp, *Brizalina mandoroveensis, Hanzawaia concentrica* and *Lenticulina inornata)* were recognised. Due to the sparse population of the planktonics, the four zones are benthonics. These zones were correlated with the exisiting foraminiferal zones of the Niger delta (F300 and F500) to assign an early to middle Miocene age for the sediments.

Foraminiferal biozonation:

Interval 7800ft – 8380 feet
Valvulineria spp Zone: F9300/F9500
Age: early-middle Miocene
Stage: Burdigalian/Langhian

The top of this Foraminifera Zone was delineated at 7800 feet with the top occurrence of *Valvulineriaspp, Brizalina m*andoroveensis, *a rich continuous occurrence of, Epistominella vitrea, Heterostegina* spp, and a little occurrence of agglutinating benthonic foraminifera such as

Arenaceous spp. Interval between 7800ft - 8380ft consist of composite zone comprising of upper F9500 and lower F9300.

Interval 8380ft – 9480 feet (Inner Neritic Setting)
Brizalina Mandoroveensis Zone: *F9300*
Age: Early Miocene
Stage: Burdigalian
The top of this Foraminifera Zone was delineated at 8380 feet with the top rich occurrence of *Brizalina mandoroveensis.* The faunal assemblage is characterised by co-occurrences of abundantly rich calcareous such as *Brizalinabeyrichi, Brizalinamandoroveensis, Cassidulina norcrossi australis, Ammonia beccarii*, and moderate agglutinating benthonic foraminifera *Haplophragmoides spp. Spiroplectammina wrightii, Textularia* spp. Planktonic species were fair to moderately high as represented by *Cassigerinella chipolensis, Globigerina spp. Globigerina angustiumblicata.* This interval is interpreted to have penetrated Early Miocene (Burdigalian) F9300 zone.

Interval 9480ft – 10720 feet
Hanzawaia concentrica Zone: F9300
Age: Early Miocene
Stage: Burdigalian
The top of this Foraminifera Zone was delineated at 9480ft with the top occurrence *of Cribroelphidium galvestonensis* and *Hanzawaia concentrica.* The faunal assemblage is characterized by co-occurrences of abundantly rich calcareous benthics, *Uvigerina sparsicostata, Epistominella vitrea, Heterostegina* spp. and fair to moderately high agglutinating benthonic foraminifera such as *Haplophragmoides* sp*p. Spiroplectammina wrightii, Textularia* spp. Planktonic species were fairly recorded such *as Globigerinoides cf. immatura, Globigerinoides* spp and *Globorotalia obesa.* This interval is interpreted to have penetrated Early Miocene (Burdigalian) F9300 zone.

Interval 10720 feet – 12002 feet
Lenticulina inornata Zone: F9300
Age: Early Miocene
Stage: Burdigalian
The top of this Foraminifera Zone was delineated at 10720 feet with fair to little occurrence of *Lenticulina inornata, Hanzawaia strattoni, Eponides eshira, Heterolepa cf. mckannai, Cancrisspp, Eponides cf. iojimaensis, Nonionella stella, Bolivina scalprata miocenica, Bulimina* and fair to little agglutinating benthonic foraminifera such as *Poritextularia aff. Panamensis,*
Planktonic species were characterized as fairly to little occurrences such as *Globorotaloides variabilis, Globigerina pachyderma, Globorotaloidess uteri, Globigerinoides bispherica. T*his interval is interpreted to have penetrated Early Miocene (Burdigalian) F9300 zone.

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TABLE 1: FORAMINIFERA BIOSTRATIGRAPHIC SUMMARY OF WELL-AD

Depth Interval (ft)	Foram Zones (SPDC)	Ages	Stages	Foraminiferal Events / Remarks
7800 – 8380	**F9500/F9300**	**Middle Miocene/ Early Miocene**	**Langhian/ Burdigalian**	- top occurrence *Valvulineriaspp,* - *Epistominellavitrea, Heterostegina spp.*
8380 – 9480	**F9300**	**Early Miocene**	**Burdigalian**	Top rich occurrence of *Brizalinamandoroveensis*
9480 – 10720	**F9300**	**Early Miocene**	**Burdigalian**	- Top occurrence *of Cribroelphidiumgalvestonensis*and *Hanzawaiaconcentrica.*
10720– 12002	**F9300**	**Early Miocene**	**Burdigalian**	- Top little occurrence of *Lenticulinainornata,*

Paleoenvironmental Analysis:

Micropaleontological traits have enhanced the deductions of varying depositional environments over the analyzed interval of Well–AD. Paleoenvironmental deductions were based primarily on the richness and diversity of foraminiferal categories such as planktonic species and benthonic species including calcareous and agglutinating benthonic species. Also, the Presence or absence of planktonic foraminifera aided in deciphering open ocean environments. The studied interval of Well-AD are dominated by calcareous benthic foraminifera with rare occurrences of agglutinating and planktonic forms. The dominant biofacies associations recorded within the studied section of Well-AD is the *Ammonia beccarii* Biofacies (Adegoke *et al*. 2017 defined by the rare to common occurrences of *Ammonia beccarii, Bolivina scalprata miocenica, Florilus atlanticus* and *Epistominella vitrea,* abundant recovery of *Brizalina mandoroveensis* species, *Lenticulina inornata, Hanzawaia strattoni, Eponides eshira, Cribroelphidium galvestonensis* and *Hanzawaia concentrica,* while the Inner Neritic/Middle Neritic Setting is characterized by top occurrence of *Valvulineria* spp, a rich continuous occurrence of *Epistominella vitrea, Heterostegina* spp, and a little occurrence of agglutinating benthonic foraminifera such as *Arenaceous* spp. *Nonionella stella,* and *Bolivina scalprata miocenica*. The paleoenvironment of the studied section of Well-AD is dominantly inner to middle neritic with concomitant minor incursion of outer neritic setting (figure 3).

SUMMARY/CONCLUSION

A total of sixty (62) ditch cutting samples were collected from interval, 7800 feet to 12,002 feet of well AD located offshore western Niger Delta to investigate age and paleodepositional environment. Standard methods and techniques of foraminiferal sample processing and analysis were followed. The studied interval is predominantly made up of 80 to 100 % sandstone, minor shale and siltstone with variable textural properties. The sandstone is generally white to grey, fine, medium to coarse grained, poorly to well sorted, angular to sub rounded wile the shale is fissile to non-fissile with carbonaceous detritus and gypsum at some horizons depicting fluvial deposition.
Foraminifera analysis revealed, well preserved, foraminiferal species with the calcareous benthonics dominating the assemblage with sparse population of the planktonic and agglutinating forms. A total of seventy-four (74) foraminiferal species were recovered among which fifty two are calcareous benthics, six (6) are agglutinating forms while sixteen (16) are planktonic foraminifera. On the basis of the faunal asemblage, abundance and diversity of the important foraminiferal events, four (4) foraminiferal zones (*Valvulineria* spp, *Brizalina mandoroveensis, Hanzawaia concentrica* and *Lenticulina inornata)* were recognised. Due to the sparse population of the planktonics, all the four zones are benthonics. These zones were correlated with the existing foraminiferal zones of the Niger delta (F300 and F500) to assign an early to middle Miocene age for the sediments. Paleoenvironmental deductions were based primarily on the richness and diversity of foraminiferal categories such as planktonic and benthonic (calcareous and agglutinating) species. Also, the Presence or absence of planktonic foraminifera aided in deciphering open ocean environments. The dominant biofacies associations recorded within the studied section of Well-AD is the *Ammonia beccarii* biofacies defined by the rare to common occurrences of *Ammonia beccarii, Bolivina scalpratamiocenica, Florilus atlanticus* and *Epistominella vitrea. Brizalina mandoroveensis* species, *Lenticulina inornata, Hanzawaia strattoni, Eponides eshira, Cribroelphidium galvestonensis* and *Hanzawaia concentrica were also recorded.* The *Ammonia beccarii* biofacies is indicative of the Shallow/Inner Neritic Paleoenvironment. *while* the Inner Neritic/Middle Neritic Setting is characterized by top occurrence of *Valvulineria* spp, a rich continuous occurrence of *Epistominella vitrea.* The paleoenvironment of the studied section of Well-AD is dominantly inner to middle neritic with concomitant minor incursion of outer neritic setting.
In conclusion, micropaleontological analysis of well AD, show that the rock succession were deposited in the inner to middle neritic setting with concomitant deepening to the outer neritic during the early to middle Miocene age.

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