
FORAMINIFERA AND AGE CHARACTERIZATION OF WELL X, ONSHORE NIGER DELTA, NIGERIA

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ABSTRACT

Micropaleontological analysis was carried out on one hundred and ninety-two (192) ditch cutting rock samples from interval, 5480 feet to 11256 feet of well-x, located between Longitude 0 3'47.677"E and latitude 0 2'30.506"N, onshore Niger Delta, The aim of the study was to erect biozonation model of foraminifera and use it to characterize the age of the sediments penetrated by the well section studied. The sedimentological sample investigation involved wet and dry sieve analysis using 63 micrometer mesh size, 250 micrometer mesh size and 500 micrometer mesh size while the micropaleontology samples was prepared through wet sieve analysis with sodium hexametaphosphate as a deflocculant and analyzed for foraminifera following the taxonomic classification of Loeblich and Tappan (2015) method for foraminifera analysis. The sedimentological description of the ditch cutting rock samples provided data for sand / shale ratio, sorting and gradational profile of the study well and show that the sediment under study penetrated the Paralic Agbada Formation. Micropalaeontological analysis result indicated that some intervals yielded a rich recovery of foraminiferal assemblage while other intervals were either completely barren or recorded few occurrences of foraminifera. A total number of Ninety-three (93) well preserved foraminiferal species were identified. Calcareous benthonics accounted for about 35% of the total recovery while the agglutinated benthonics constituted about 42% and the planktonic species made up the remaining 23%. Three biozone (Haplophragmoides sp, Valvulina flexilis / Haplophragmoides compressa and Globigerinoides ruber/ Alveolophragmium crassum) were recognised and compared with, ?N19/20, N18 - N19/20 and N17 of Blow (1979) zonation scheme respectively to assign early Pliocene to Late Miocene age for the rock succession studied.

Keywords: Foraminifera, micropaleontology, Age, Biozonation, Niger Delta, Sedimentology.

Introduction:

In biostratigraphic studies, foraminifera have been highly valued in age characterization as different types have revealed evolutionary bursts at different times in the geologic record. Since the discovery of hydrocarbon in Niger Delta which has placed the basin at an advantage, foraminifera have been exploited as marker fossil in age recognition as exploration of the hydrocarbon continues in the propitious basin. The studied well is located within the marginal marine fringes of the Niger delta between Longitude 0°3'47.677"E and latitude 0°2'30.506"N (Figure 1). The aim of this study was to identify and classify different species of foraminifera as well as their abundance and diversities; erect a biozonation model and compare with Blow, (1979) zonation scheme in order to characterize the age of the sediments penetrated by the well x, interval studied.

Previous studies: By coordinating the foraminiferal zonation schemes of all the member companies of the Stratigraphic Committee of the Niger delta, Adegoke et al. (2017) calibrated a foraminifera biozonation scheme of the Niger delta concessions. The wells penetrating the Paleocene to Pleistocene epochs, spanning both onshore and shallow-offshore depobelts of the Niger delta, were utilized for the chronostratigraphic compilation. They also noted that the Niger Delta's foraminiferal biofacies were affected by both the shallow, warm tropical Surface Waters and the deeper, cooler South Atlantic Central Water mass. Murray (2014) asserts that several low-latitude larger foraminifera, such as *Amphistegina* spp. and *Heterostegina* spp., as well as cold-water indicator planktonics, such as *Globorotalia inflata*, are typical characteristics of the Neogene deeper biofacies of the Niger delta and are crucial for comprehending its chronostratigraphy and depositional environment. Ozumba and Amajor (1999) presented the necessary evolutionary relationships of these benthonic foraminifera genera (*Lenticulina*, *Bolivina/Brizalina*, *Nonion/Florilus*, *Hanzawaia*, *Epistominella*, *Eponides berthelotianus/Ammonia beccarii*, and *Uvigerina*) in the Niger delta, for an understanding of their biochronologic and biostratigraphic relevance as the main marker foraminiferal species in the Niger delta. Foraminiferal biostratigraphy has been extensively studied and applied all over the world for the past eight decades. This was made feasible by Bolli (1957), Blow (1979), and Be et al. (1980) who provided more, in-depth taxonomic documentation of planktonic foraminifera in the low latitude Caribbean as well as descriptions of the biology of contemporary planktonic foraminifera. Ozumba (2011), Loeblich and Tappan (2015) and numerous other studies carried out in various regions of the world have released excellent monographs on the evolutionary trend and paleogeographic distributions, exploited the differences in their test compositions and morphologies in the taxonomic description of the foraminiferal species used in this study.

Niger Delta stratigraphy: The stratigraphy of the Niger Delta is composed of three diachronous stratigraphic units, including the Akata, Agbada, and Benin formations. Numerous researchers, including Short and Stauble (1967), Reijers (2011), Doust and Omatsola (1989), Avbovbo (1978), and others, have extensively researched these formations. These formations exhibit an overall coarsening-upward progradational clastic wedge that was deposited under marine, deltaic, and river conditions respectively (Short and Stauble, 1967; Weber, 1967; Weber and Daukoru, 1975). These prograding depositional facies can be divided primarily by their sand-to-shale ratios and their age ranges from Eocene to Recent.

The Akata formation: The Akata Formation is the oldest sedimentary unit in the delta that overlies the basement rock. It is composed of over-pressured marine shales, sand-covered turbidites, and consistently dark-gray channel fills. It spans the Late Eocene through the Recent Period. In deep-water, these turbidites can serve as reservoirs. According to Doust and

Omatsola (1989), Whiteman (1982), and Corredor et al. (2005), the Akata formation's sedimentary thickness ranges from 2000 to 7000 meters. The Akata formation, which is characterized by its richness in organic matter, is assumed to be the source of the hydrocarbon in the Delta (figure 2).

The Agbada Formation: The Niger Delta's main petroleum-bearing unit is the Agbada formation. It is a sequence of sandstone and shale-dominated paralic to marine-coastal and fluvial-marine deposits that overlies the Akata Formation (Pochat et al., 2004). According to Corredor et al. (2005), the Agbada Formation can be divided into the Upper, middle, and lower units. Sand makes roughly 60% to 40% of the top unit. 50% to 30% of the middle unit is made of sand while the lower unit, under-compacted shales are interbedded with 20% sand. It is composed of more than 3500 m (11,500 ft) deep paralic siliciclastics, which constitute the actual deltaic segment of the delta.

Benin Formation: The Benin Formation is made up of Late Eocene to Recent alluvial and upper coastal plain deposits that can be up to 2000 m (6600 ft) deep ((Avbovbo, 1978), Aigbedion (2011) and Ajaegwu et al. (2012)). The majority of the formation is composed of sand, gravel, and back-swamp deposits. The Benin Formation, the youngest of the three formations in the Niger delta, overlies the Agbada Formation and is dated between the Oligocene and Recent epochs. This is the water bearing formation in the Niger Delta province (figure 2).

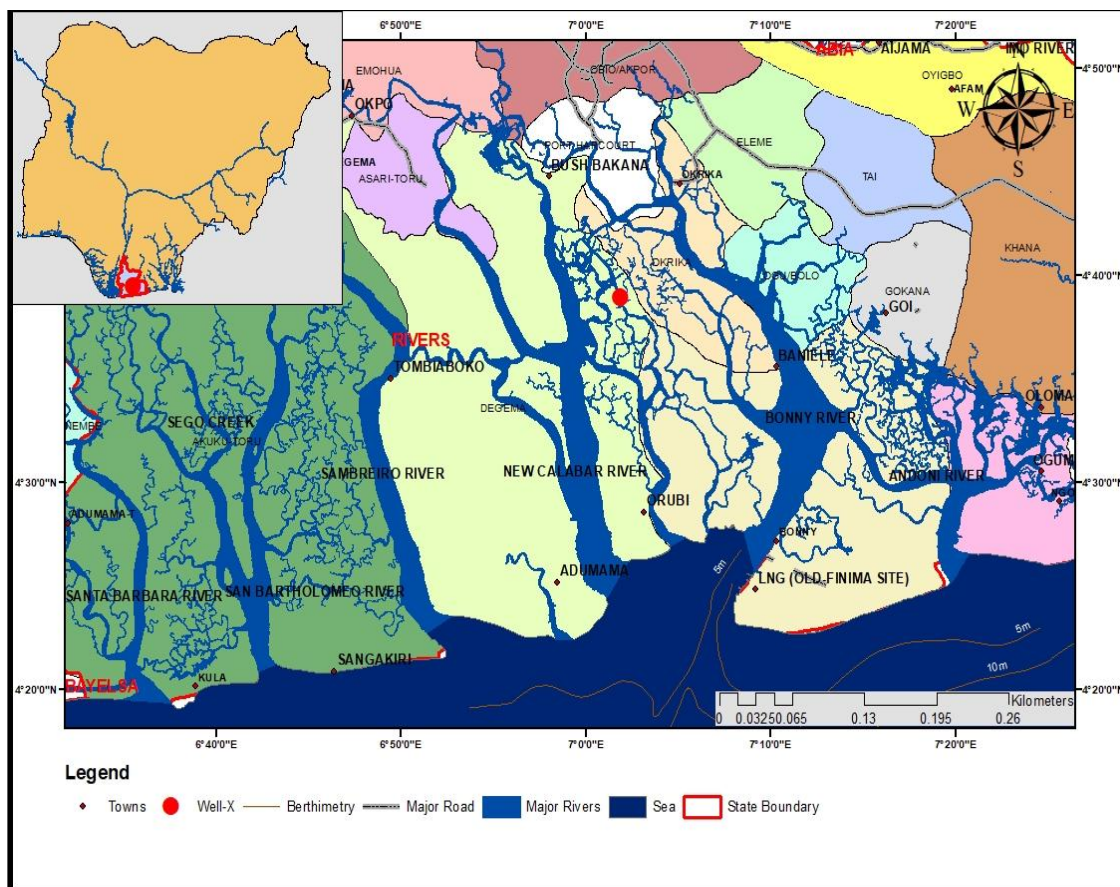


Figure 1: Location map of the well-x, onshore Niger delta (Generated from ArcGI)

Methodology:

Nature and Source of Data.

The ditch cutting rock sample and the gamma ray log were the primary data provided for this investigation. Sedimentology (Sieve analysis) and micropaleontology were used in the analysis to determine the distribution, abundance and diversity of foraminiferal bio-events as well as the gradation pattern, sand/shale ratio, and lithologic description of the ditch cutting rock samples. The lithologic data was used to interpret the sedimentary formations penetrated by well-x, while from the micropaleontological perspective, index fossils (marker species), significant bioevents, and biohorizons that served as the foundation for the biostratigraphic synthesis were identified, populated in strataBugs v2.0 for spatial display for proper data trawl.

Sedimentological Sample Analysis:

30 grams each of the ditch cutting rock samples was taken to the lab for sedimentological sample grain size assessment. Wet and dry sieve analyses were used to estimate the particle size. The wet sieve analysis was performed using a 63 m mesh sieve size. The samples were thoroughly cleaned by being washed under a running water to remove clay. During wet sieving, liquid detergents were employed to remove drilling mud-related oil stains. Following wet sieve analysis, the sample's weight loss corresponded to the clay fractions, and the retained samples was dried on a hot plate using low heat. The dried samples were sieved through a set of sieves with mesh sizes of 63, 250, and 500 micrometers, which respectively represent fine, medium, and coarse sand. Each retained sample was then weighed. The wet-sieve analytical result was tallied, converted to percentages, entered into the StrataBUGs software, and plotted as the ratio of sand to shale by depth and gradational profile of the investigated interval.

Micropaleontology Sample Preparation

30 grams of the samples were weighed and transferred to the Pyrex beaker and heated on a hot plate to burn off organic components. In order to deflocculate the clays, a few grains of anhydrous sodium hexametaphosphate were added to the samples while they were on the hot plate, topped with water, mixed, and left to boil for a few minutes. The samples were allowed to cool before being thoroughly cleaned with distilled water with 63 sieve mesh under a running water to remove all of the clays and sodium hexametaphosphate. The residue was carefully and gently placed into enamel plate and heated on a low heat on the hot plate. The dried samples were divided into fine, medium, and coarse grain sizes using 63, 250, and 500 mesh sieve diameters for easy assessment.

The result of the micropaleontology and sedimentological descriptions of the ditch cutting rock samples were applied to lithostratigraphic delineation, biozonation and age characterization of the studied interval of well-x.

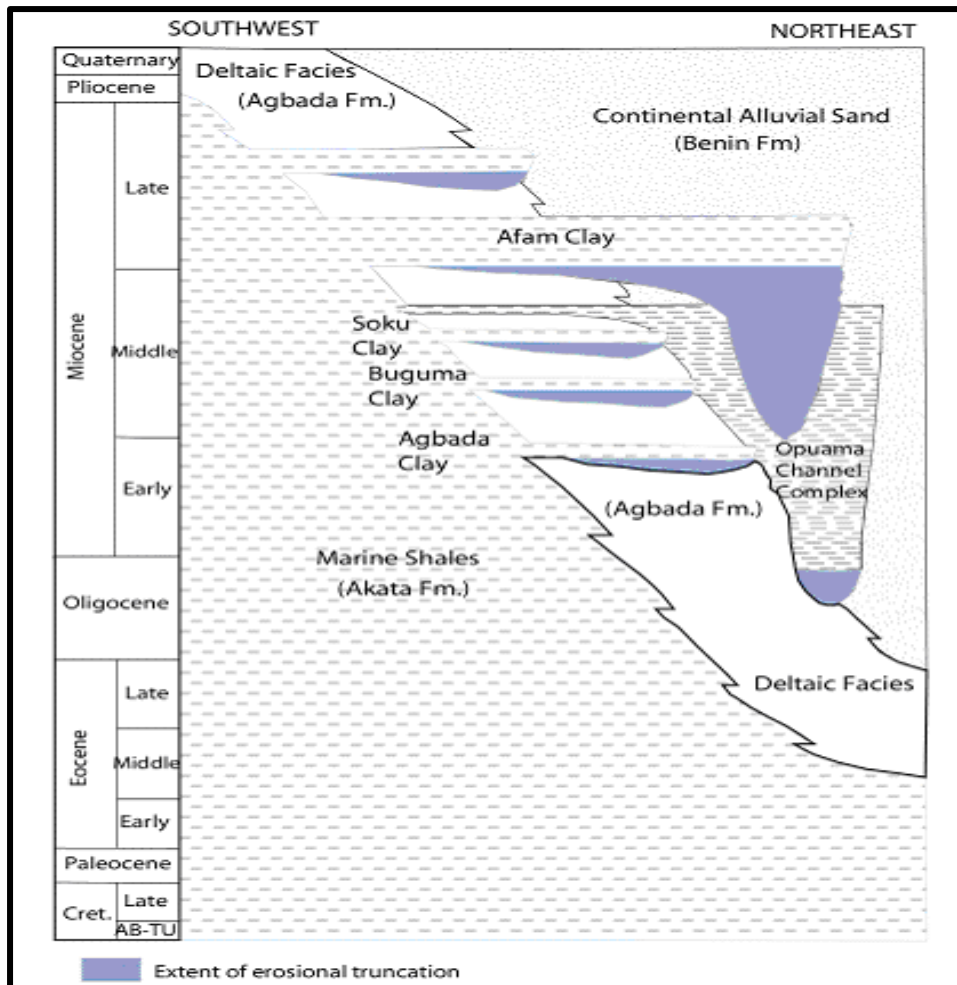


Figure 2: Lithostratigraphy of the Niger Delta (after Doust and Omatsola, 1989).

Micropaleontology Sample Analysis

All the fractions were sparsely but evenly spread on a sample picking tray, the recognised foraminifera were picked with a picking brush and transferred to a foraminifera slide, and attached with Tragacanth adhesive for microscopic examination. A standard handbook, such as Oligocene to Holocene Planktonic Foraminifera, was used to identify the recovered foraminifera to species level as much as possible and to record their abundances per field of view. (Bolli and Saunders, 1985; incorporating Blow, 1969 and 1979), SPDC's Catalogue of Benthonic Foraminifera and TOTAL's *Principaux Foraminifères observés dans les séries deltaïques du Néogène*. The taxonomic division adhered to Loeblich and Tappan (2015)'s guidelines. The detected foraminifera were all divided into benthonic and planktonic forms, tallied, entered into stratabug software, and plotted on charts to show the total number of occurrences of each species, overall diversity, and abundance down the well x.

RESULTS AND DISCUSSION

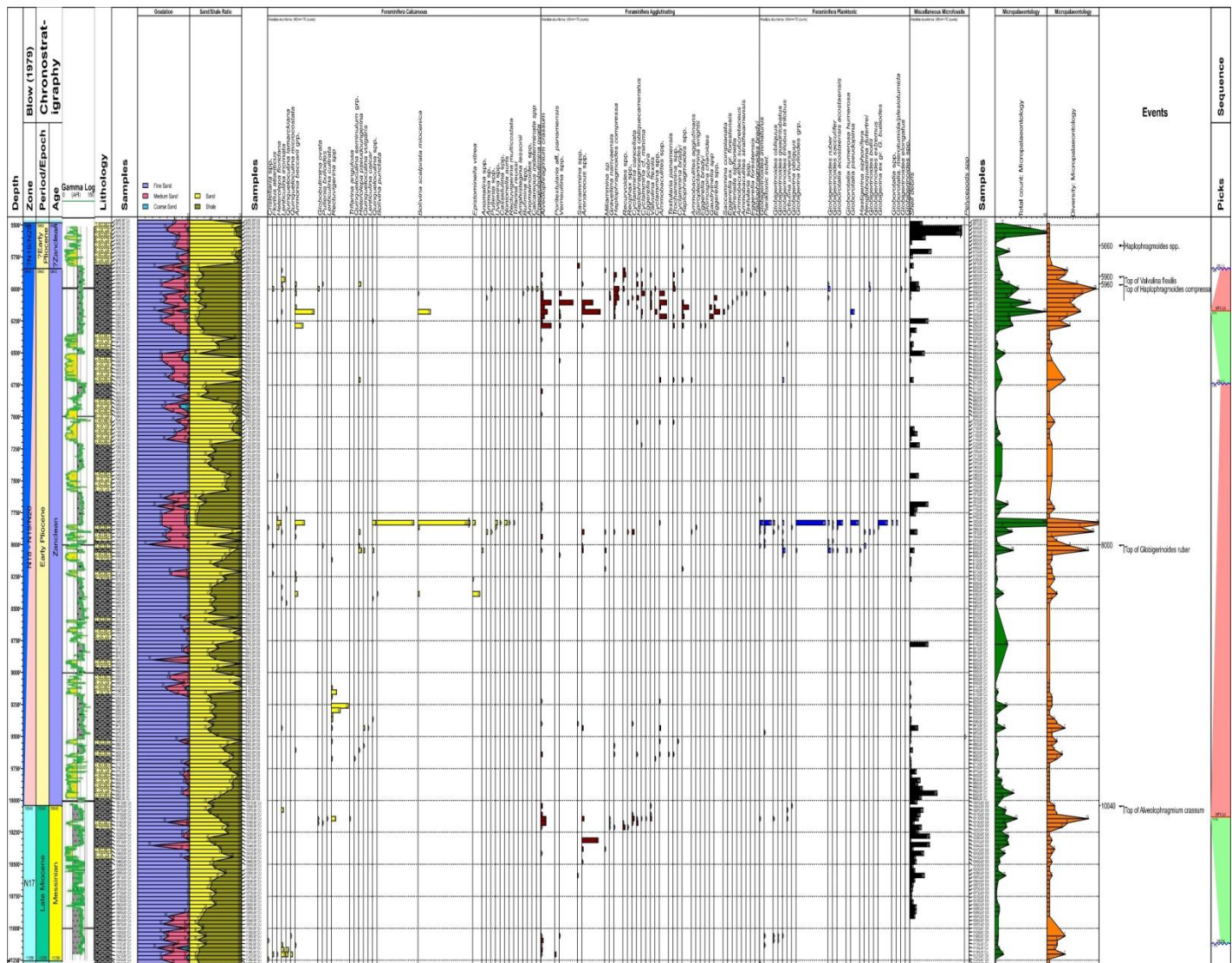


Figure 3: summary of grain size distribution, sand /shale ratio, foraminiferal distribution and biozonation of well x

Results

Data for the sand/shale ratio, sorting, or gradational profile of the research well were obtained from the sedimentological description of the ditch cutting rock samples (Figure 3) and show that the sediments of well x, penetrated the paralic Agbada Formation. A total of ninety-three (93) distinct foraminiferal species were identified (Figure 3 and Plate 1). About 35% of these species were calcareous benthonics, 42% were agglutinated benthonics, and the remaining 23% were planktonic species. Result of the micropalaeontological analysis show that intervals between 5840 and 7070 feet, 7790 and 8480 feet, 9050 and 10610 feet, and 11060 and 11256 feet produced moderately rich assemblages of planktonic, calcareous, and agglutinated benthonic foraminifera, while intervals between 5480 and 5840 feet, 7070 and 7790 feet, 8460 and 9050 feet, and 10610 and 11060 feet, foraminiferal occurrences were scarce or barren.

Discussions:

Biozonation and Age

Three (3) Foraminifera Zones namely: ?N19/20, N18 - N19/20 and N17 were delineated in the well sequence studied. The zones are summarized in (Table 1) and described as follows:

Foraminifera Zone 1: *Haplophragmoides* sp
Blow, (1979) zone ?N19/20
Interval: 5540 – 5840ft
Age/Stage: ?Early Pliocene (?Zanclian)

This interval is characterized by non-recovery of foraminifera except for lone occurrence of non-age diagnostic species of *Haplophragmoides* at 5660ft. However, on the basis of superposition relationship with respect to the underlying Early Pliocene (Zanclian) N18 – N19/20 Zone, this interval could have possibly penetrated ?Early Pliocene (?Zanclian) ?N19/20 Zone.

Foraminifera Zone 2: *Valvulina flexilis* / *Haplophragmoides compressa*
Blow, (1979) zone N18 – N19/N20
Interval: 5840 – 10040ft
Age/Stage: Early Pliocene (Zanclian)

This interval is characterized by First Downhole Occurrence (FDO) of *Valvulina flexilis* at 5900ft, First Downhole Occurrence (FDO) of *Haplophragmoides compressa* at 5960ft and Last Downhole Occurrence (LDO) of *Globigerinoides ruber* at 8000ft.

The top of this Foraminifera Zone was tentatively delineated at 5840ft where the influx of foraminifera is initiated while the base is marked by the Last Downhole Occurrence (LDO) of *Globigerinoides ruber* known to occur within the N18 Zone of Blow, (1979). The Zone is characterized by First Downhole Occurrence (FDO) of two agglutinated benthonic foraminifera namely; *Valvulina flexilis* and *Haplophragmoides compressa* at 5900 and 5960ft respectively.

The faunal assemblage is characterized by the co-occurrences of moderate to abundantly rich calcareous and agglutinated benthonic foraminifera including *Bolivina scalprata miocenica*, *Ammonia beccarii*, *Heterolepa floridana*, *Epistominella vitrea*, *Lenticulina inornata*, *Haplophragmoides compressa*, *Alveolopragmium cf crassum*, *Cyclammina cf minima*, *Valvulina flexilis*, *Gravellina narivaensis*, *Eggerella bradyi*, and species of *Rectuvigerina*, *Verneulina*, *Haplophragmoides*, *Cyclammina*, *Recurvoides*, *Ammobaculites* and *Gaudryinella*. Planktonic species were fair to moderately high as represented by *Globorotalia pseudopima*, *Globorotalia acostaensis*, *Globigerinoides ruber*, *Globigerinoides bolli*, *Globigerinoides sacculiferus*, *Globigerinoides obliquus*, *Globigerina bulloides*, *Globigerina ex gr. G. bulloides*, *Neogloboquadrina dutertrei* and *Orbulina universa*. This interval is interpreted to have penetrated Early Pliocene (Zanclian) N18 - N19/N20 ages.

Foraminifera Zone: *Globigerinoides ruber*/ *Alveolopragmium crassum*
Blow, (1979) zone N17
Interval: 10040 – 11256ft
Age/Stage: Late Miocene (Messinian)

This interval is characterized by First Downhole Occurrence (FDO) of *Alveolophragmium crassum* at 10040ft with rich co-occurrences of agglutinated benthonic taxa such as *Alveolophragmium crassum*, *Eggerella scabra*, *Valvulina flexilis*, *Cyclammina cf minima*, *Haplopragmoides compressa*, *Haplopragmoides obliquicameratus*, *Cyclammina cancellata* and *Gravellina narivaensis* at 10100ft.

The top of this foraminifera zone coincides with the base of the preceding zone marked by the Last Downhole Occurrence (LDO) of *Globigerinoides ruber* at 8000ft while the base of the Zone is tentatively marked by the last sample studied in the well sequence at 11256ft. The Zone is characterized by the First Downhole Occurrence (FDO) of *Alveolophragmium crassum* at 10040ft.

Table 1: The biozonation summary of the studied interval of well-x.

Depth Interval (ft)	Foram Zones (Blow, 1979) & STRATCOM (2002)	Ages	Stages	Foraminiferal Events / Remarks
5540 - 5840	?N19/20	?Early Pliocene	?Zanclian	- Interval almost completely barren of Foraminifera except for lone occurrence of <i>Haplopragmoides</i> spp. at 5660ft
5840 – 10040	N18 - N19/20	Early Pliocene	Zanclian	- FDO of <i>Valvulina flexilis</i> at 5900ft - FDO of <i>Haplopragmoides compressa</i> at 5960ft - FDO of <i>Globigerinoides ruber</i> at 8000ft
10040- 11256	N17	Late Miocene	Messinian	- FDO of <i>Alveolophragmium crassum</i> at 10040ft - Rich co-occurrence of arenaceous benthonic taxa: <i>Alveolophragmium crassum</i> , <i>Valvulina flexilis</i> , <i>Eggerella scabra</i> , <i>Cyclammina cf minima</i> , <i>Haplopragmoides obliquicameratus</i> , <i>Cyclamminacancellata</i> and <i>Gravellinanarivaensis</i> at 10100ft

The foraminifera Zone is further characterized by the rich co-occurrences of agglutinated benthonic taxa such as, *Alveolophragmium crassum*, *Valvulina flexilis*, *Eggerella scabra*, *Cyclammina cancellata*, *Haplopragmoides compressa*, *Haplopragmoides obliquicameratus*, and *Gravellina narivaensis* within the Zone, especially at 10100ft. The rich co-occurrences of the above recorded agglutinated taxa are known to be associated with

the end of Messinian period in Late Miocene age (STRATCOM, 2002).

The Zone faunal assemblage is dominated by moderately high agglutinated foraminifera co-occurring with rare to fairly rich calcareous benthonic and planktonic foraminifera. The agglutinated forms include *Alveolophragmium crassum*, *Alveolophragmium cf crassum*, *Haplophragmoides compressa*, *Haplophragmoides obliquicameratus*, *Valvulina flexilis*, *Cyclammina bradyi*, *Eggerella scabra*, *Textularia panamensis*, *Gravellina narivaensis*, *Cyclammina cf minima*, *Cyclammina cancellata* and *Poritextularia panamensis*. The recorded calcareous benthonics include rare *Lenticulina inornata*, *Ammonia beccarii*, *Globobulimina ovata*, *Quinqueloculina lamarckiana*, *Quinqueloculina vulgaris* and *Rectuvigerina spp.* The planktonic foraminifera were very rare including *Globigerinoides immaturus*, *Globigerinoides trilobus*, *Globigerinoides quadrilobatus* and *Orbulina universa*. This interval is interpreted to have penetrated sediments of Late Miocene (Messinian) age marked by N17 zone.

SUMMARY AND CONCLUSION

This study was carried out using ditch cutting rock samples from well-x. The rock samples comprised of one hundred and ninety-two (192) intervals sampled at 60ft and ranged from 5480ft to 11256ft. Well-x is located on Longitude 0°3'47.677"E and latitude 0°2'30.506"N, onshore Niger Delta. The data used in the study was generated through sedimentological and micropaleontological laboratory preparation and analysis of the ditch cutting rock samples. The sedimentology sample analysis involved wet and dry sieve analysis using 63 micrometer mesh size, 250 micrometer mesh size and 500 micrometer mesh size. The micropaleontology was prepared through wet sieve analysis with sodium hexametaphosphate as a deflocculant. The micropaleontology analysis and taxonomic classification followed the Loeblich and Tappan (2015) method for foraminifera analysis.

The sedimentological description of the ditch cutting rock samples provided data for sand / shale ratio, sorting or gradational profile of the study well and populated in charts. Micropaleontological analysis indicated that the following intervals 5840 to 7070 feet, 7790 to 8480 feet, 9050 to 10610feet and 11060 – 11256ft yielded moderately rich assemblages of planktonic, calcareous and agglutinated benthonic foraminifera; while intervals 5480 – 5840ft, 7070 - 7790ft, 8460 – 9050ft and 10610 – 11060ft were either completely barren or recorded few occurrences of foraminifera. Ninety-three (93) foraminiferal species were identified using standard manuals. Calcareous benthonics accounted for about 35% of these species while the agglutinated benthonics constituted about 42%. The planktonic species made up the remaining 23%.

The result of the micropaleontology and sedimentological descriptions of the ditch cutting rock samples were applied in biozonation and lithostratigraphic delineation respectively. Three (3) Foraminiferal Zones namely: *Haplophragmoides* sp, *Valvulina flexilis* / *Haplophragmoides compressa* and *Globigerinoides ruber*/ *Alveolophragmium crassum*) corresponding with, N19/20, N18 -N19/20 and N17 of Blow (1979) biozonation scheme were delineated and used to characterize the age of the well sequence from Late Miocene to Early Pliocene age. The study also showed that the sediments of the well-x (interval 5480 – 11,256ft) penetrated a section of the Agbada Formation.

Plate 1

- 1 *Glomospira charoides* (Magnification - 200µm)
- 2 *Globigerinoides immaturus* (Magnification - 200µm)
- 3 *Karreriella siphonella* (Magnification - 200µm).
- 4 *Valvulina flexilis* (Magnification - 200µm)
- 5 *Globigerina ex gr. G. bulliodes* (Magnification - 200µm)
- 6 *Pullenia bulloides* (Magnification- 200µm).
- 7 *Saccamina spp* (Magnification - 200µm).
- 8 *Globigerinoides obliquus* (Magnification - 200µm)
- 9 *Cyclammia cf. minima* (Magnification - 200µm)
- 10 *Cyclammia cancellata* (Magnification - 200µm).
- 11 *Globigerinoides ruber* (Magnification - 200µm)
- 12 *Ammobaculites strathearnensis* (Magnification - 200µm).
- 13 *Textularia spp*, (Magnification - 200µm).
- 14 *Globigerinoides quadrilobatus* (Magnification - 200µm).
- 15 *Globorotalia acostaensis acostaensis* (Magnification - 200µm)
- 16 *Textularia spp.* (Magnification - 200µm).
- 17 *Globorotalia humerosa humerosa* (Magnification - 200µm).
- 18 *Orbulina universa* (Magnification - 200µm)
- 19 *Globorotalia. merotumida/plesiotumida* (Magnification - 200µm)
- 20 *Cyclammia cancellata* (Magnification - 200µm).
- 21 *Florilus atlanticus* (Magnification – 200µm).

Plate 1



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