FORAMINIFERAL BIOSTRATIGRAPHY OF Y-1 AND Z-1 WELLS, WESTERN SECTOR OF NIGER DELTA, NIGERIA

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Abstract

A foraminiferal biostratigraphic and paleoenvironmental study was carried out on 251 ditch-cutting samples from wells Y-1 (3220–1920 m) and Z-1 (5110–3680 m) in the coastal swamp depobelt (western sector) of the Niger Delta Basin. The study aimed to establish stratigraphic age, reconstruct depositional paleoenvironments, define a sequence-stratigraphic framework, and assess preliminary petroleum potential. Lithostratigraphic analysis delineated three sub-lithofacies units (Y1–Y3) in Y-1 and four units (Z1–Z4) in Z-1, characterized by rhythmic sand–shale alternations typical of the Agbada Formation. Foraminiferal assemblages show moderate to low abundance and diversity, dominated by benthic forms (calcareous and agglutinated/arenaceous); planktonic taxa occur in Y-1 but are absent in Z-1. In Y-1, two planktonic zones were identified: *Globorotalia humerosa* Zone (N17) and *Globorotalia margaritae* Zone (N18), whereas Z-1 yielded a composite benthic assemblage correlatable with the *Globigerinoides primordius–Catapsydrax dissimilis* interval (N4–N5). Benthic zonation indicates the *Cyclammina minima* Zone (NNDF 05) in Y-1 and the *Hanzawaia concentrica* Zone (NNDF 16) in Z-1, consistent with the Niger Delta chronostratigraphic framework. The studied intervals are dated Late Miocene–earliest Early Pliocene (Y-1) and Early Miocene (Z-1). Integrated biofacies and lithofacies analyses define four paleobathymetric settings: coastal delta plain, inner neritic, middle neritic, and outer neritic environments. Sequence-stratigraphic interpretation, constrained by the absence of wireline logs and seismic data, identified two major maximum flooding surfaces: MFS-Y at 3080 m (~6.0 Ma) in Y-1 and MFS-Z at 4290 m (~23.2 Ma) in Z-1, separating transgressive and highstand systems tracts. The Agbada intervals show promising petroleum potential, with reservoir-quality sands, effective marine shale source–seal pairs, and favorable trapping conditions.

Keywords*: Foraminiferal biostratigraphy, paleoenvironment, Agbada Formation, sequence stratigraphy, petroleum potential, Niger Delta*

Introduction

Niger Delta Basin is a prolific hydrocarbon province that belongs to the Gulf of Guinea situated along the south coast of Nigeria (latitudes 3 o - 6 o N, longitudes 5 o - 8 o E; Figure 1). This Tertiary clastic wedge has kept the economy of Nigeria alive in the past five decades with intensive exploration and production which was initially centered on onshore and shallow offshore Miocene-Eocene sequences. Improvements in both drilling and seismic technologies have since driven the activity to more offshore targets due to the necessity to maintain a supply of hydrocarbons in the face of dwindling reserves in the mature fields and the growing world energy consumption.

The stratigraphic succession of the basin includes three large diachronous units which are the bottom of sea Akata Formation (primary source rock), paralic Agbada Formation (alternating sandstones and shales, the main reservoir interval), and the top seal and aquifer Benin Formation. In the western sector and more so the coastal swamp depobelt, Agbada Formation has a lot of untapped potentials in which geoscientific approaches have to be combined whereby accurate age control, reconstruction of paleoenvironment, prediction of reservoir and evaluation of play fairway would be crucial. Lithostratigraphy and sequence-stratigraphic work, in conjunction with foraminiferal biostratigraphy, has been considered quite useful to these ends throughout the Niger Delta (e.g., Petters, 1982, 1984, 1995; Ozumba, 1999; Rotimi, 2012; Onyekaru et al., 2012; Chukwu et al., 2012; Ajayi and Okosun, 201 Although lots of previous research existed, in-depth multi-well foraminiferal research is still scarce in the western segment, especially in Early to late Miocene periods of the Agbada Formation.

The paper includes a foraminiferal biostratigraphic and paleoenvironmental study of ditch-cutting samples of wells Y-1 (32201920 m; 108 samples) and Z-1 (51103680 m; 143 samples), in the coastal swamp depobelt of the western Niger Delta (Figure 1). Its main tasks include: (1) identifying the stratigraphic age of penetrated intervals; (2) defining depositional paleoenvironment and paleobathymetry; (3) creating a sequence-stratigraphic framework; and (4) determining initial petroleum system components. The inquiry is based solely on the 251 samples of ditch-cutting samples given, and no access to seismic data or wireline logs. Such findings will be used to improve the chronostratigraphic and depositional context of the Agbada Formation in this underdeveloped part of the Niger Delta to aid in further hydrocarbon exploration in the region.

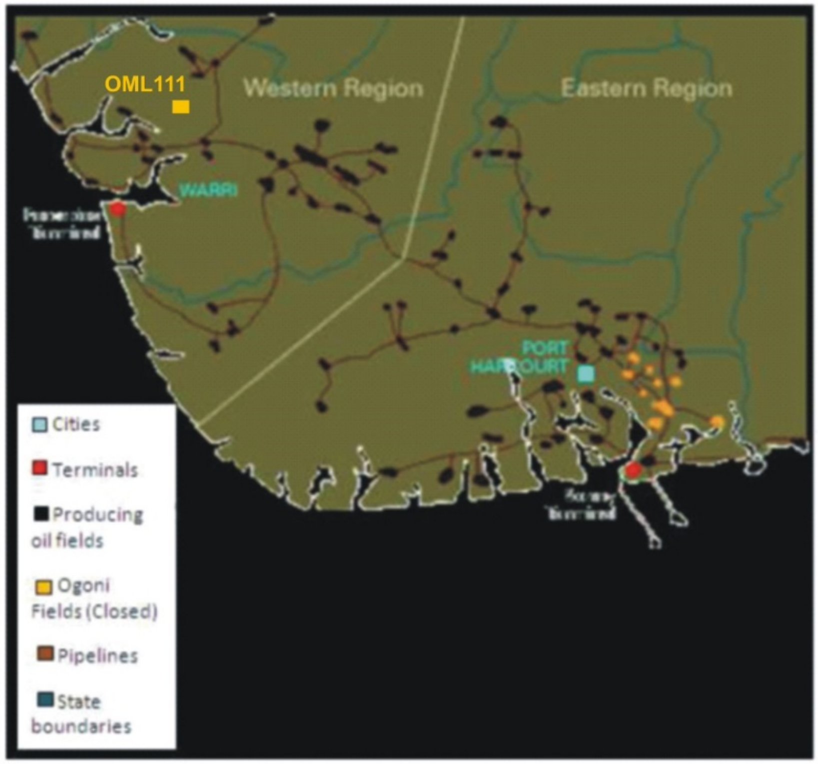


Figure 1: Location map of the Niger Delta showing Y-1 and Z-1 Wells (Modified from Imasuen, *et al.*, 2011).

Geological Setting

The Niger Delta Basin is a global clastic wedge which is created at the convergence of the African and the South American plates, one which is a classic passive-margin delta system. It has the features of an intermediate-type delta consisting of a combination of fluvio-deltaic, wave, and tidal processes, and which is in a dynamic balance between the accommodation

space and sediment supply (Chiaghanam et al., 2011). The basin is further separated into three major diachronous lithostratigraphic units in ascending order of the Akata Formation, the Agbada Formation and the Benin Formation (Figure 2), which are covered by Quaternary deposits of diverse types (Boboye and Fawora, 2007; Reijers, 2011).

According to Adegoke et al. (2017), these subsurface units consist of:

a. Akata Formation: the bottom, mainly marine shale formation, which is about 600 m thick in most places, but which becomes considerably elevated basin ward. It is over pressed in more depths and at the depths of 4 to 6 km onshore and 1 to 3 km offshore (Oti and Beka, 1995). It is primarily a marine shale rock which contains a small amount of turbidities and is the main source of the hydrocarbon rock in the basin because it is rich in organic components.

b. Agbada Formation: the most widespread and the most hydrocarbon-bearing unit, comprising the paralic (delta- front to pro-delta) transition between the underlying Akata and overlying Benin formations. The first appearance of shale of brackish or marine fauna marks its upper edge, and the lowest important sandstone with remains of plants and mica marks its bottom, and coincides with the upper limit of the marine Akata shale. The formation is up to 4500 m in thickness in the central depobelt (Oti and Beka, 1995) and is typified by rhythmic sandstone and shale alternations that make up the major petroleum reservoirs. The geophysical investigation into the southeastern Niger Delta in the recent past has also indicated structural constraints and geothermal consequences in this period (Ekpo, et al., 2024 b & c).

c. Benin Formation: the topmost, continental to coastal-plain clastic wedge, and is characterized by sands and sandstones (70 -100 percent sand content) with minor shale intercalations (Ojo and Gbadamosi, 2013). Its highest point is the current surface, and the lowest point is where the highest bearing marine foraminifera shale is located (Short and Stauble, 1967). It is about 2000 m thick (Beka and Oti, 1995) and it is a major source of water as well as a top seal in most fields.

d.

These units have outcropping equivalents that are Imo Shale (Akata equivalent), Ameki Group (Agbada equivalent), and Benin Sands (Benin equivalent), respectively. Growth faults, roll-over anticlines and shale diapirism are the structural frameworks that dominate in the basin and play very important key roles in the trapping and migration of hydrocarbons. These factors form positive stratigraphic and structural plays, which are reported in the study of the region (Ekpo et al., 2024a&d; Adegoke et al., 2017). The combination of these factors and progradational deltaic processes in the western sector (coastal swamp depobelt) leads to the favorable conditions of stratigraphic and structural plays.

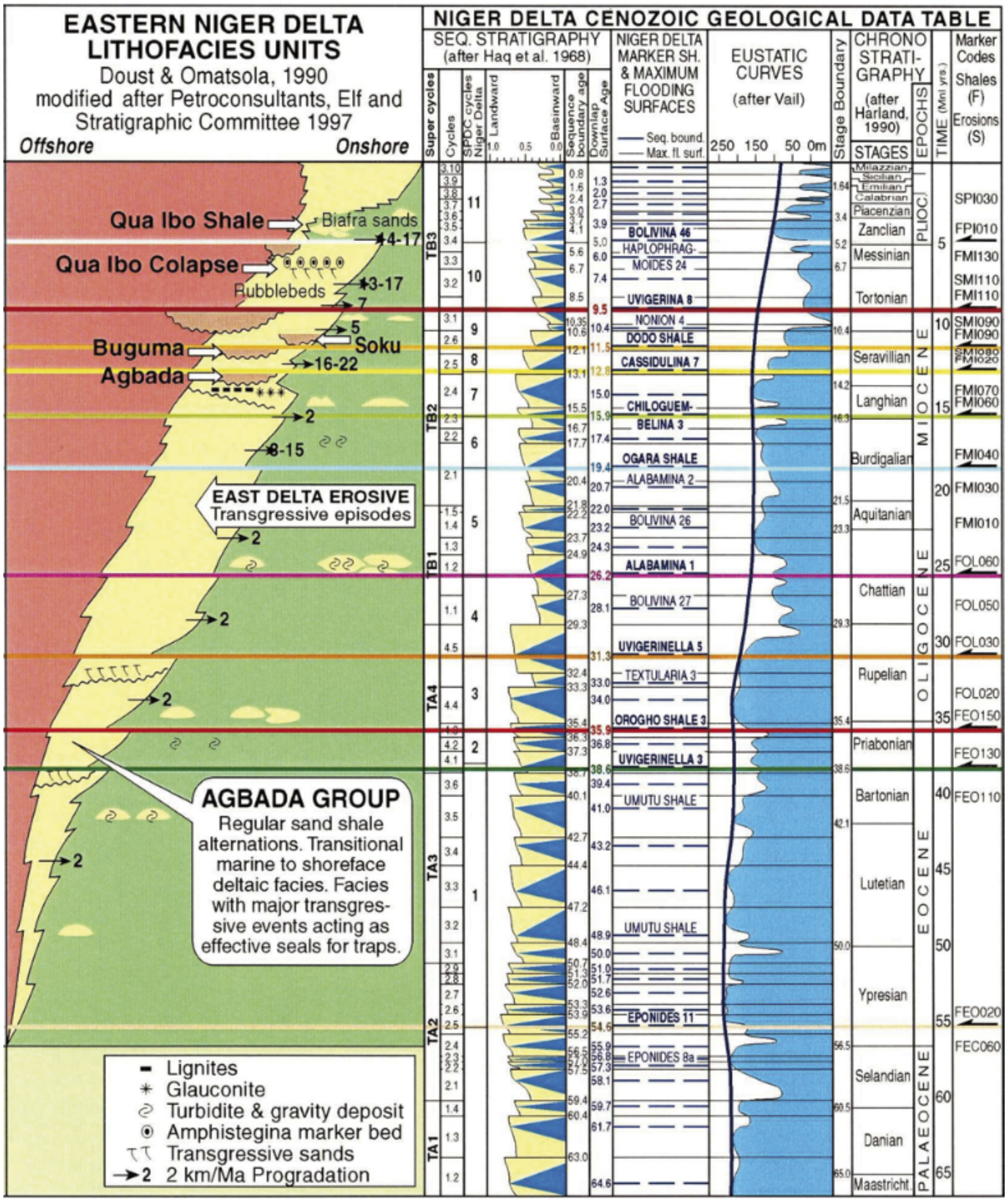


Figure 2: Stratigraphic data sheet (eastern Niger Delta) of the Niger Delta. (from Reijers, 2011)

Materials and Methods

An operating oil company provided ditch-cutting samples in wells Y-1 (32201920 m), and Z-1 (51103680 m) as part of the coastal swamp depobelt of the western Niger Delta Basin. Two hundred and fifty-one samples were taken at 10 m intervals to make integrated lithologic and foraminiferal biostratigraphic analysis (108 samples of Y-1 and 143 samples of Z-1).

Lithologic Analysis

Lithostratigraphic description was conducted using macroscopic (visual) and microscopic examination. Each sample was assessed for grain size, sorting, roundness, angularity, colour, sedimentary structures (where discernible), and accessory minerals (e.g., pyrite, carbonaceous matter, ferruginous material, mica, and shell fragments). Observations were recorded systematically to define lithofacies units and infer depositional characteristics.

i. **Sample Organization:** Samples were put in order of depth and labelled separately.

ii. **Initial Cleaning and Drying:** The cuttings were rinsed with water to remove the drilling mud after which they were air-dried without washing.

iii. **Disaggregation**: Each dried sample (20 g) was put in a clean sample plate that was wetted in the solution of anhydrous sodium carbonate and water and left overnight to disaggregate.

iv. **Washing and Sieving:** The disaggregated residues were washed with running tap water through a 63 μm mesh sieve to remove fines, clay, and silt fractions. The residue left behind (>63 μm) was dried in an oven on a hotplate with a set temperature not greater than 20 ^{o} C so that the foraminiferal tests would not be subjected to any thermal changes.

v. **Size Fractionation and Examination**: Dried residues were dry-sieved into three sizes: coarse (>500 μm), medium (250500 μm), and fine (63250 μm). The fractions were checked individually in a picking tray in reflected light with a binocular stereomicroscope (Zeiss model). A fine sable-hair brush (size N0000) was used to pick the specimens.

Foraminiferal Biostratigraphic Analysis

The preparation and analysis of the samples were conducted using standard micropale ontological procedures for ditch cuttings (Bolli and Saunders, 1985; Petters, 1995; Adegoke et al., 2017). The steps involved in the procedure were as follows:

vi. **Zonation and Identification**: Direct comparison of foraminiferal taxa with published illustrations and descriptions in Bolli and Saunders (1985), Petters (1995), Adegoke et al, (2017), and other sources was used to identify them. Planktonic and benthic (calcareousand agglutinated) were recorded. The alpha-numeric system of Blow (1969) and variants in Bolli and Saunders (1985) and Adegoke et al. (2017) was adopted as the system of zonation by biostratigraphy, with zones being defined mostly based on the age-diagnostic planktonic taxa (where it occurs) and complemented by associated benthic assemblages typical of the Niger Delta.

All analyses occurred in the micropaleontology lab of the Department of Geology, Akwa Ibom State University. Because of the characteristics of ditch-cutting samples, no quantitative measures of abundance (e.g. the number of specimens per gram) were determined; presence/absence, relative abundance, and diversity trends were used to interpret biostratigraphic and paleoenvironmental information.

Results and Discussion

Lithologic Description

Lithostratigraphic analysis of ditch-cutting samples of wells Y-1 (3220 1920 m 1400 m thick) and Z-1 (5110 3680 m 1430 m thick) indicated the existence of very similar lithologic characteristics with intercalated sandstones/sands and shale, which are characteristic of the Agbada Formation. There were no wire line logs and only visual and microscopic interpretation of cuttings.

Sands/sandstones are mainly fine to coarse -grained, clean, moderately to well-sorted and angular to sub rounded and locally ferruginous. Shale layers appear light to dark grey and brownish grey, and they vary from fissile to moderately hard, and they have accessory minerals such as pyrite, carbonaceous matter, and ferruginous material. Shales also contain shell fragments (gastropod, pelecypod, scaphopod, ostracod and indeterminate) in Z-1.

Table 1: Lithofacies units in well Y-1 (Agbada Formation)

Depth (m)	Lithofacies	Dominant Lithology	Key Characteristics
3220–3080	Y1	100% sand monoliths	Fine- to medium-grained, moderately sorted, ferruginous
3080–2920	Y2	100% shale with traces of sand	Light to gray-brown, fissile, carbonaceous, pyrite
2920–1920	Y3	Equal proportion marine sand/shale	Fine- to coarse-grained sand intercalated with fissile shale

Table 2: Lithofacies units in well Z-1 (Agbada Formation)

Depth (m)	Lithofacies	Dominant Lithology	Key Characteristics
5110–4940	Z1	90% sand/sandstone, 10% shale	Fine- to coarse-grained, moderately sorted, ferruginous
4940–4070	Z2	Predominantly light to gray-brown fissile shale with minor sand/ sandstone and siltstone	Fissile, moderately hard; shell fragments (gastropod, pelecypod, ostracod)
4070–3850	Z3	100% sand	Clean, fine- to medium-grained, subrounded
3850–3680	Z4	80% shale, 20% sand/siltstone	Fissile shale dominant; minor siltstone, pyrite

The cyclic fining/upward successions in both wells are superimposed in a larger coarsening/upward succession in both wells, however, repeating transgressive/regressive pulses and general progression of the Niger Delta system over geological time. The sand shale repetition is clear evidence of the paralic Agbada Formation penetration.

Foraminiferal Biostratigraphy

It was found that micropaleontological analysis of 251 ditch-cutting samples (108 of Y-1, 143 of Z-1) at 10 m depth intervals showed a low to moderate abundance and diversity of foraminifers in both wells and a number of barren intervals. Accessory macrofauna consisted of gastropods, ostracods and indeterminate shell fragments (Figures 3 and 4 - biostratigraphic charts of abundance and diversity trend).

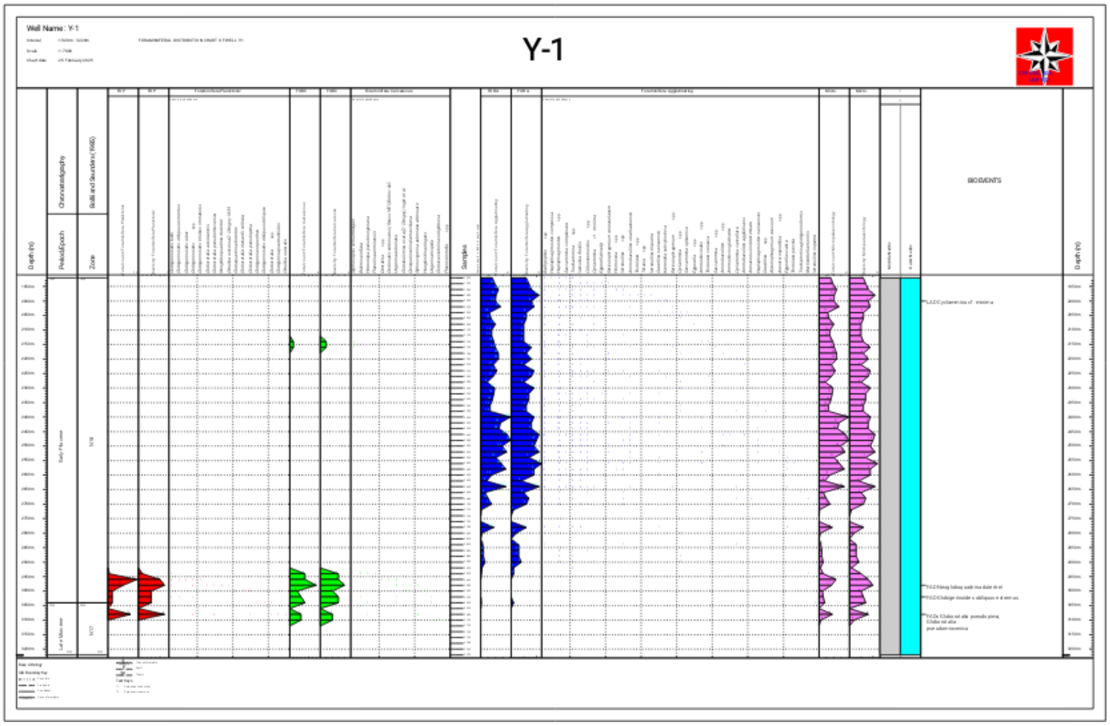


Figure 3: Foraminfera biostratigraphic chart showing abundance and diversity of analyzed forms from Y-1”- well

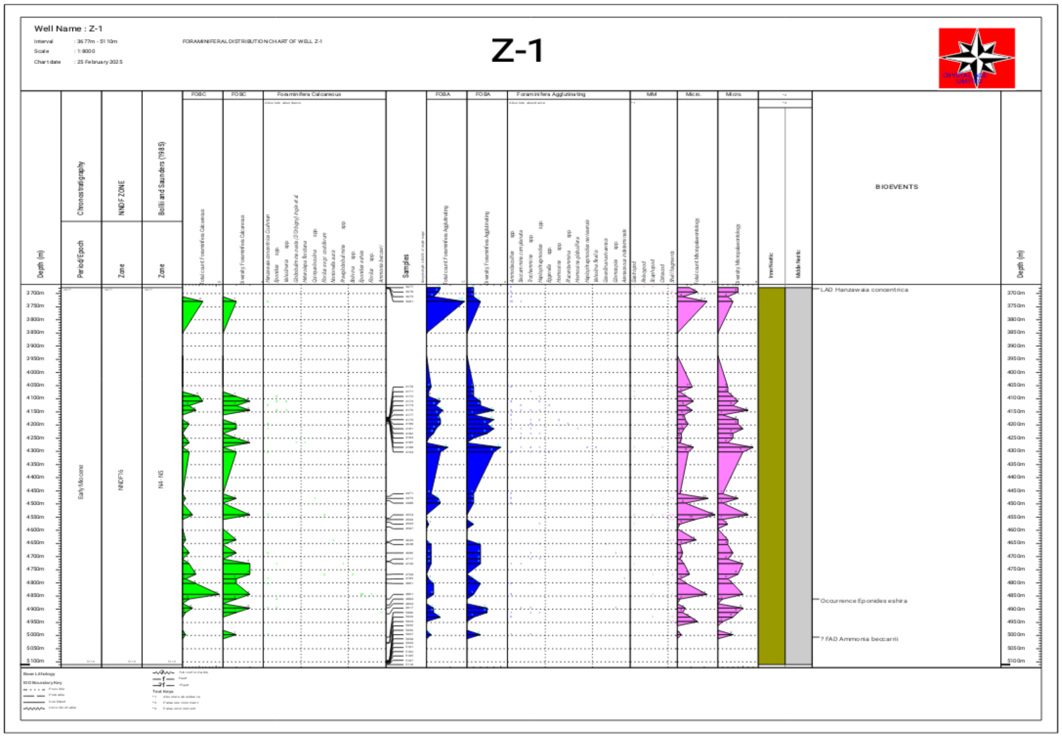


Figure 4: Foraminfera biostratigraphic chart showing abundance and diversity of analyzed forms from Z-1"- wellto 01.

Well Y-1

The foraminiferal recovery was rather high in most of the section (a total of 987 specimens), with several barren basal sections (32203120 m). Generally, abundance and diversity decrease downwards. Of the total population:

- 53 planktonic specimens (5.37%)

- 944 benthic specimens (96.15%), of which agglutinated/arenaceous forms (905 specimens, 98% of benthic) outnumbered the calcareous forms (39 specimens, 2% of benthic).

Calcareous benthic communities were also rare, which may indicate high input of clastics, or local stressed environments in the Late Miocene (e.g. Messinian-related processes, but probably deltaic dilution is the dominant factor). It was found to have two planktonic zones (Blow, 1969; Adegoke et al., 2017).

- Globorotalia humerosa Zone (N17): 3220 - 3040 m (Late Miocene, upper Messinian). Low abundance/diversity:

Globorotalia menardii (~3010 m), *G. pseudopima* and *G. pseudomiocenica* (~3080 m), *Globigerinoides obliquus extremus* (~3030 m).

- Zone (N18): *Globorotalia margaritae*: 30401920 m (most recent Late Miocene, oldest Early Pliocene). Greater abundance/diversity; arenaceous control; event: LAD *Cyclammina cf.* minima slightly after 2200 m.

Benthic zone: Cyclammina minima Zone (NNDF 05) - youngest Late Miocene benthic zone in the Niger Delta; with abundant agglutinated forms (*Haplophragmoides compressa, Valvulina flexilis, Trochammina spp., Textularia spp., Cribrostomoides spp.*) and almost no planktonics / calcareous benthics in the upper parts.

Well Z-1

Recovery was low (191 benthic specimens total) but diversity moderate. No planktonic foraminifera were recovered, likely due to preferential preservation or deltaic environmental stress. Calcareous benthic taxa (90 specimens, 45.45%) were dominated by rotaliids (85 specimens, 94.44%); agglutinated/arenaceous forms (108 specimens, 55.55%) outnumbered calcareous. Key taxa: *Hanzawaia concentrica, Eponides eshira, Ammonia beccarii, Saccammina complanata, Trochammina spp., Eggerella spp., Haplophragmoides spp..*

No planktonic zonation was possible; benthic markers inferred a composite equivalent to *Globigerinoides primordius–Catapsydrax dissimilis* (N4–N5). Key events: FAD *Ammonia beccarii* ~4910 m, lowest occurrence *Eponides eshira* ~4850 m, single occurrence *Gravellina narvansis* ~4650 m, FDO/LAD *H. concentrica* ~3740 m.

Benthic zone: Hanzawaia concentrica Zone (NNDF 16) – oldest Neogene benthic zone in the Niger Delta; top marked by *FDO H. concentrica* ~3740 m; absence of younger markers *(Cyclammina cf. minima, Uvigerina subperegrina, Eggerella scabra*) confirms pre-Middle Miocene age.
Systematic paleontological descriptions were omitted, as comprehensive taxonomic treatments are available in Adegoke et al. (2017) and earlier references.

Paleoenvironmental Analysis

Paleoenvironment interpretation was based on the lithofacies and biofacies criteria: abundance/diversity pattern of species, assemblage of foraminiferas, planktonic/benthic (P/B) ratio (Culver, 1988), calcareous/arenaceous benthic ratio (Allen, 1965, 1970): it conformed to Murray (2014) and local studies. Data in primary form were biostratigraphic charts (Figures 3 and 4), although, in some periods, they were not entirely paleoenvironmental due to poor recovery. Four paleobathymetric settings were identified:

i. Non-Marine Delta Plain Coastal.

Intervals: Y-1 (3220–3110 m); Z-1 (5110–5050 m, 4050–3850 m).

Dominated by clean sands, fine- to coarse-grained and containing carbonaceous matter.

Totally sterile as to foraminifera due to high-energy, terrigenous-predominant deposition.

ii. Inner Neritic (Upper Shelf, ~0–50 m)

Intervals: Y-1 (~2900–2650 m, 2300–2350 m); Z-1 (4950–4850 m, 4800–4200 m, ~3850–3800 m).

Sand is heavy to medium and then all the way to shale. Poor abundance/diversity; poor Y-1/B ratio (P only); poor calcareous/arenaceous ratio. These are: *Ammonia beccarii, Florilus costiferum, Heterolepa pseudoungeriana, Heterolepa floridana, Textularia spp., Quinqueloculina lamarckiana.* In proximity to the nearshore, the shoreface is very terrigenous.

iii. Middle Neritic (Mid-Shelf, ~50–100 m)

Intervals: Y-1 (~2600–2550 m, 2300–2150 m, 2100–1920 m); Z-1 (~4850–4800 m).

With few or no sand, and chiefly shale/silt and local glauconite. Increase in the abundance/ diversity; rising calcareous benthic fraction. *Cyclamannia minima Cyclamanna minima Ammodiscus glabratus Haplophragmoides compressa Valvulina flexilis Bolivina spp. Trochammina globigeriniformis Globobulimina ovata Eponides eshira*. Less influx of the continents in the middle holomarine environment.

iv. Outer Neritic (Lower Shelf, ~100–200 m)

Intervals: Y-1 (~2550–2350 m, 2150–2100 m); Z-1 (~5050–5000 m, 3750–3680 m).

Preceded by shale/mudstone (88 98% shale); usually includes pyrite and mica. Peak/richness of Y- 1 (maximum planktonics); none in Z- 1. Indicators: *Bathysiphon spp., Globocassidulina subglobosa, Praeglobobulina spp., Uvigerina auberiana, Globocassidulina subglobosa, Planulina ariminensis, Karreriella subcylindrica* and *Cyclammina minima.distal* offshore/open marine environment; calcareous superiority to arenaceous during the periods of fossiliferous intervals. Delta progradation (delta deepening events) is present and Y-1 is more marine dominant than

Z-1.

Sequence Stratigraphy

The interpolation of the lithology and biostratigraphic data (abundance/diversity trend) was used to interpret the sequences-stratigraphy. Wireline logs and seismic profiles were not available to give complete analysis such as parasequence stacking pattern.

The wells possessed one large bounding surface, referred to as the maximum flooding surfaces (MFS) which is characterized as the highest point of the foraminiferal abundance /diversity, condensed sections of shale and fining-upward successes.

Table 4: Delineated maximum flooding surfaces in wells Y-1 and Z-1

Chronostratigraphic Surface	Depth (m)	Age (Ma) (Haq, et al., 1988)	Well	SPDC Foraminiferal Zonation (1999)
MFS-Y	3080	6.0	Y-1	Top of F9600
MFS-Z	4290	23.2	Z-1	F7800

Both MFSs mark maximum landward facies shifts, deepest paleowater depths, and highest foraminiferal abundance/diversity (planktonic, calcareous benthic, and arenaceous forms). They correlate with regional Niger Delta flooding events (Adegoke et al., 2017).

Systems Tracts

Due to data limitations, low stand systems tracts were not identified. Two systems tracts were delineated in each well:

- Well Y-1

- Transgressive Systems Tract (TST): 3220–3080 m. Older, shale-rich interval with fining/deepening-upward trend; minor basal sand. Biofacies show upward increase in marine taxa (middle to lower neritic). Top is MFS-Y (3080 m, ~6.0 Ma), within upper N17 Zone.

- Highstand Systems Tract (HST): 3080–1920 m. Younger interval; shale base with upward sand/shale intercalation. Dominated by calcareous and arenaceous benthic assemblages (pockets of planktonics higher up); inner to middle neritic paleobathymetry. Top not defined (ends at 1920 m).

- Well Z-1

- Transgressive Systems Tract (TST): 5110–4290 m. Basal interval (820 m thick); fining- to deepening-upward; predominantly shale. Middle to outer neritic biofacies. Top is MFS-Z (4290 m, ~23.2 Ma).

- Highstand Systems Tract (HST): 4290–3680 m. Cyclic calcareous/arenaceous benthic trends; falls within N5-equivalent zonation. Top at 3680 m (analyzed limit).

Petroleum Potential

A sequence stratigraphy is one of the tools that are successful in forecasting the distribution of possible reservoirs, seal and source rocks in deltaic basins (Adegoke, 2012). The agbada Formation contains the elements of the petroleum system in the wells Y-1 and Z-1 which are encouraging in the the following wells:

- Reservoir Potential

The good reservoir quality is TST and HST Clean, fine to medium-grained, moderately sorted, subrounded sands. Its potential terrains are approximately 3070-3020 m in Y -1, and 4680-4430 m in Z-1 - assumed to comprise of high-net to gross potential of marine-influenced delta-front or beachfront.

- Source Rock Potential

Intra-formational source potential is also availed by marine shales (in TSTs) and condensed sections (in MFSs) (3080 m in Y-1; 4290 m in Z-1). Such outer-neritic biofacies scales are suggestive of low-energy;

PLATE 1

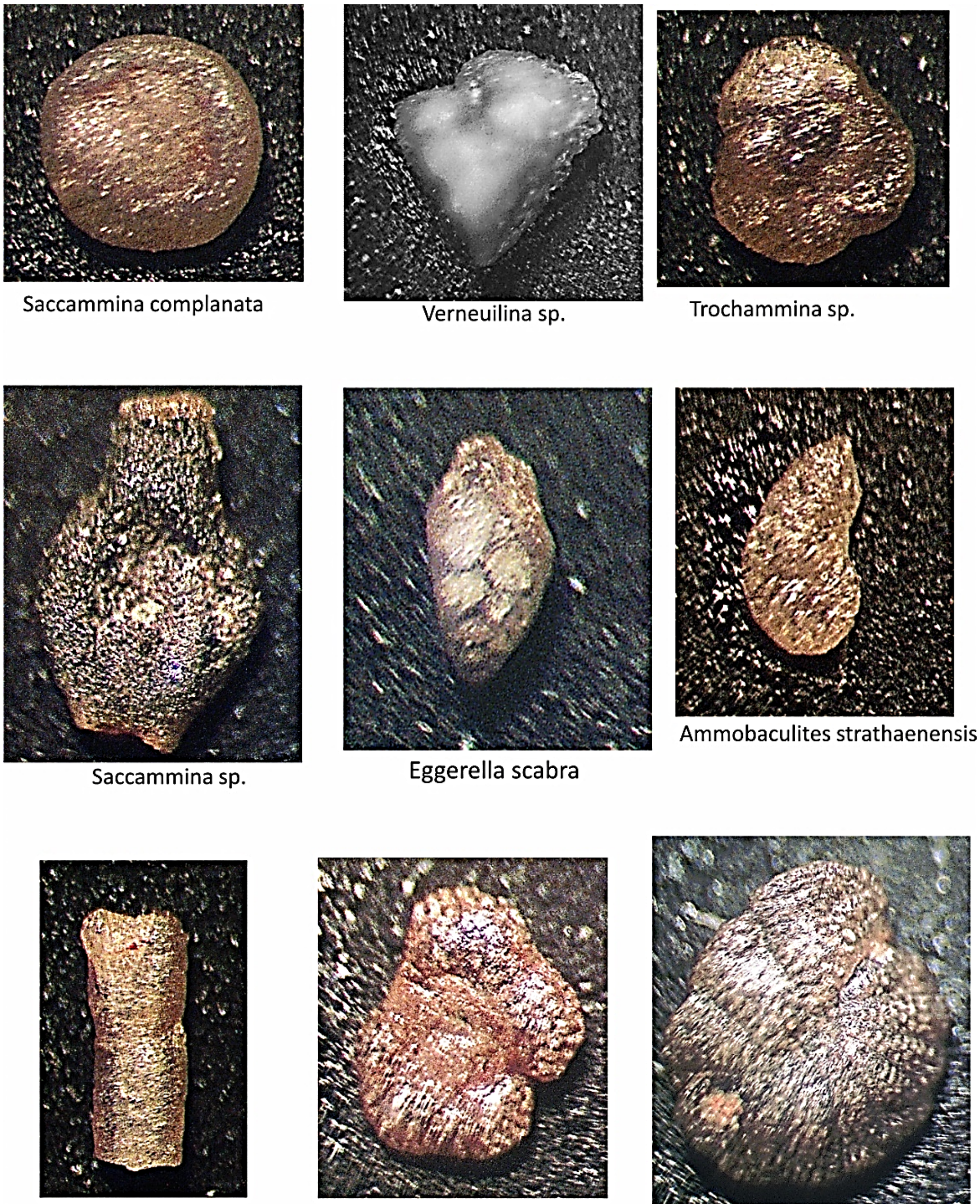
organic-preserving environments and regional equivalents are suggestive of Type II -III kerogen.

- Seal Potential

Top and intra formational seal of the TSTs and HSTs are also good especially over any potential sand packages.

- Trap Mechanisms

This growth-faulted depobelt will have stratigraphic (sand pinch-outs of shales), structural traps (growth faults, roll-over anticlines). This would be verified with trap geometry by correlation with offset wells. The various penetrated intervals of Y-1 and Z-1 are favorable of good initial penetration, and the MFS-related shales are augmenting source/seal capacity and TST/HST sands are giving targets to the reservoirs. The implication is that quantitative assessment (porosity, permeability, TOC, maturity), and a mix with seismic/log is necessary in order to further explore the west Niger Delta.



Saccammina complanata

Verneuilina sp.

Trochammina sp.

Saccammina sp.

Eggerella scabra

Ammobaculites strathaenensis

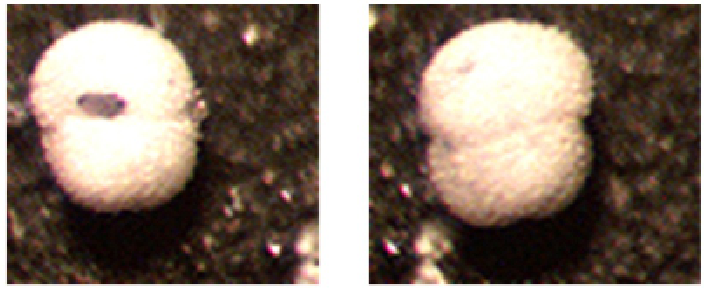
Bathysiphonsp.

Reticulophragmium venezuelana

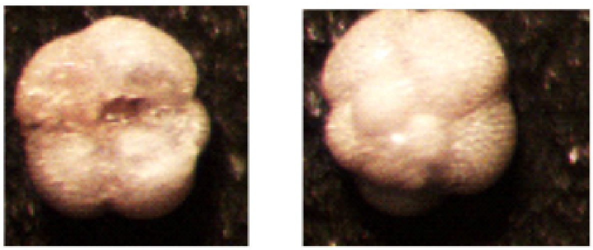
Cyclammina cancellata

PLATE 2

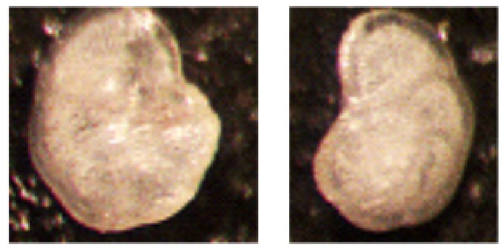
Globigerinoides trilobus immaturus



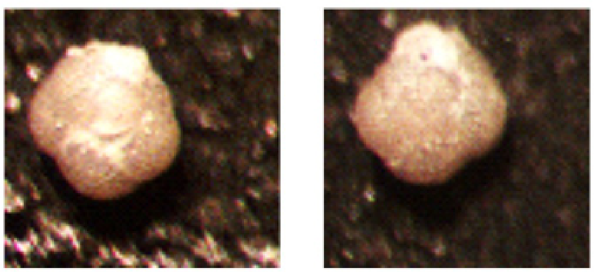
Globigerinoides bolli



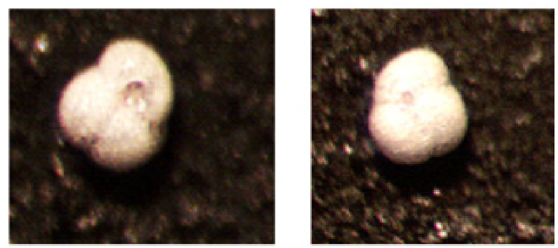
Globoquadrina dehiscens



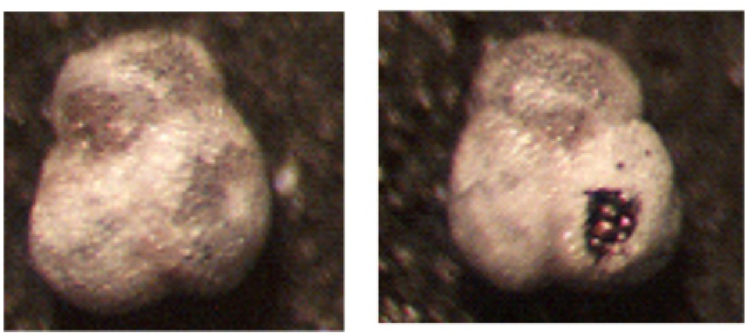
Globorotalia pseudomiocenica



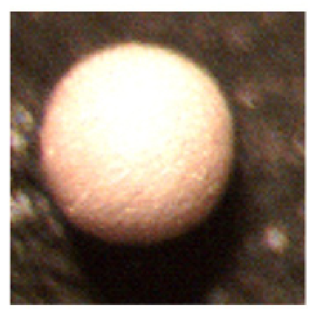
Globorotalia acostaensis



Globigerinoides obliquus extremus

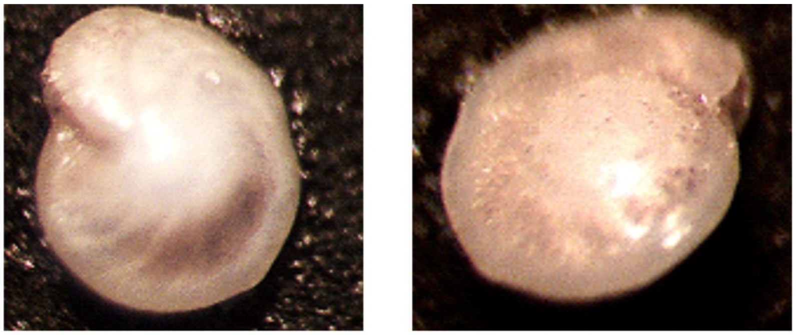


Globigerinoides obliquus obliquus



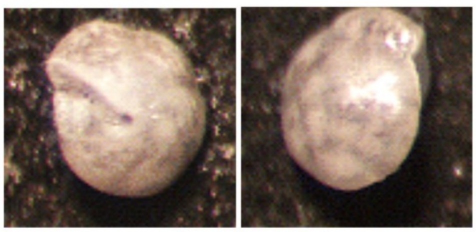
Orbulina universa

PLATE 3



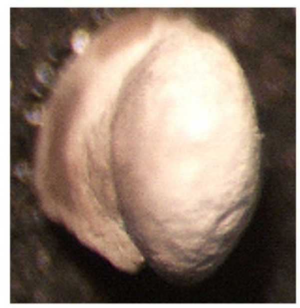
Heterolepa pseudoungeriana

Globocassidulina subglobosa



Oridosalis umbonatus

Dentalina sp.



Quinqueloculina lamarckiana

The Miospores present in Y-1 and Z-1 Wells

Conclusion

They have determined that Agbada Formation was penetrated by drilling the two wells as part of a biostratigraphic and paleoenvironmental study of the well Y-1 (3220-1920 m) and Z-1 (5110-3680 m) of the depobelt of the Niger Delta Basin coastal swamp (western sector). The Y-1 three units (Y1-Y3) sampled was rhythmic sandshale successions and the Z-1 four units (Z1-Z4) sampled was also rhythmic sandshale series, the point was that it is seen that it has overall cyclic readings of fining-upwards successions and progressive delta progradation.

The recovery of foraminifera was low to mediocre (987 in Y-1; 191 in benthic Z-1) and the latter were also recovered in planktonic form only in Y-1. They were supported by two planktonic zones known as Globorotalia humerosa Zone (N17) and Globorotalia margaritae Zone (N18) and benthic Cyclammina minima Zone (NNDF 05). Z-1 was barren of planktons to the level that it needed the benthic surrogacy and this led to a similar of Globigerinoides primordius-Catapsydrax dissimilis (N4-N5) and Hanzawiain Zone (NNDF 16). These areas date the periods to Late Miocene-earliest Early Pliocene (Y-1) and Early Miocene (Z-1), which is also in line with the chronostratinigraphic Niger Delta (Adegoke et al., 2017).

It was characterized by having a ratio of biofacies (absence /affluence) and lithofacies, paleoenvironmental reconstruction of four progressive paleobathymetric settings and coastal delta plain (barren high-energy sand), inner neritic (low-diversity nearshore sand), middle neritic (enhancing calcareous benthic proportion) and outer neritic (maximum abundance/diversity overriding planktonics in Y-1) settings. These occurrence that follow one another show that there was deltaic progradation in the sea.

The stratigraphic interpretation of the interpretation based on the unavailability of wireline logs and seismic themes was forced to work with two critical maximum flooding surfaces (MFS-Y at 3080 m [equivalent F7800]) and (MFS-Z at 4290 m [equivalent F7800]) on the Y-1 and Z-1 respectively. They are used to identify occurrence of transgressive systems tracts (TST) at the bottom and highstand systems tracts (HST) at the top and the notable marine flood events in the Agbada Formation.

The penetrated intervals are favourable in the initial petroleum prospectivity: the moderately well-sorted TST and HST sands are potential reservoir units, the condensed marine shales at the MFS levels are potential sources and seals, the stratigraphic/structural trapping mechanisms are most likely to be extensive to this growth-faulted depobelt system. The multi-well data complements the local data of exploration of Agbada depositional and petroleum system in western Niger Delta.

Recommendations

Acquire and merge the two wireline logs (gamma-ray, resistivity, sonic), and 3-D seismic data that will further eliminate the additional parasequence stacking pattern, resolve the sand-body shapes and determine the lateral continuity of potentially prospective reservoir intervals.

Perform quantitative petrophysical (porosity, permeability, net-to-gross), geochemical (TOC, Rock-Eval pyrolysis, vitrinite reflectance) analysis of core-or-sidewall samples of TST/HST sands and MFS shales in a bid to characterize quality of the reservoir, potential of source-rock and thermal maturity. Well correlation of the coastal swamp depobelt regionally to ascertain the trends of facies, pressure structure and trap structure, particularly in the points of the proposed MFS horizons.

Age control: foraminiferal data: Age control must be done with other biostratigraphic methods (e.g., calcareous nannofossils, palynomorphs) especially in Z-1 where there are no planktonics. Positioning and de-risk exploration in western Niger Delta: forward stratigraphic modelling and seismic attribute: Financial Undrilled reserves position.

Telegraph geophysical surveys (e.g. aeromagnetic, aerogravity surveys) that will additionally disrupt the basement structure, fault regime and thermal regime that have assisted in the migration and entrapment of the hydrocarbons in the study territory.

The research provides a solid background where exploration of Agbada hydrocarbon Formation of the western Niger Delta can be elevated and data-restricted solution can be monitored as one of the remedies in the establishment of foraminiferal biostratigraphy.

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