

FORAMINIFERA BIOSTRATGRAPHIC AND PALEOENVIRONMENTAL ANALYSIS OF “X-1” WELL, ON THE WESTERN SECTOR OF THE NIGER DELTA BASIN, NIGERIA

ABSTRACT

A foraminiferal biostratigraphic and paleoenvironmental study was conducted on ditch-cutting samples from well X-1 (1870–1320 m), located in the western sector of the Niger Delta Basin, southern Nigeria. The objectives were to determine the stratigraphic age, depositional paleoenvironments, sequence-stratigraphic framework, and preliminary petroleum potential of the penetrated interval. A total of 48 ditch-cutting samples were analyzed using standard lithologic (visual and microscopic) and micropaleontological preparation techniques. Lithostratigraphic analysis identified four sub-lithofacies units (X1–X4) characterized by alternating sand and shale, a typical feature of the Agbada Formation. Foraminiferal analysis revealed moderate abundance and diversity of planktonic, calcareous benthic, and agglutinated benthic forms. A total of 60 foraminiferal species were identified, comprising 21 planktonic species (42%) and 39 benthic species (58%). The co-occurrence of key taxa including *Globigerinoides obliquus*, *Globorotalia acostaensis*, *Globigerinoides obliquus extremus*, and *Cyclammina cf. minima* enabled recognition of two planktonic foraminiferal zones: *Globorotalia acostaensis* Zone (N16) and a composite *Globorotalia humerosa* / *G. margaritae margaritae* / *G. margaritae evoluta* Zone (N17–N19). A composite benthic foraminiferal zone spanning *Marginulina costata* Zone (NNDF 04), *Cyclammina minima* Zone (NNDF 05), *Haplophragmoides narivaensis* Zone (NNDF 06), and *Ammobaculites agglutinans* / *Florius costiferum* Zone (NNDF 07) was erected, in accordance with the standard Niger Delta chronostratigraphic framework (Adegoke et al., 2017). Biostratigraphic results indicate that the studied interval penetrates sediments of Late Miocene to earliest Early Pliocene age. Paleoenvironmental interpretation, based on biofacies and lithofacies integration, identified four paleodepositional/paleobathymetric settings: coastal delta plain, inner neritic, middle neritic, and outer neritic. Sequence-stratigraphic analysis delineated a major maximum flooding surface (MFS) at 1390 m (~5.0 Ma), separating a transgressive systems tract (TST) below from a highstand systems tract (HST) above. The moderately well-sorted sands and enclosing shales exhibit good potential as petroleum reservoir, source, and cap rocks, respectively.

Keywords: Foraminiferal biostratigraphic, paleoenvironment, lithologic analysis, Age determination, major bounding surfaces

INTRODUCTION

The Niger Delta Basin, situated in the Gulf of Guinea on the southern coast of Nigeria, is one of the world's most prolific hydrocarbon provinces. Formed as a passive-margin clastic wedge, it comprises three major diachronous lithostratigraphic units: the deep-marine Akata Formation (primarily source rocks), the paralic Agbada Formation (main reservoir interval with alternating sandstones and shales), and the continental Benin Formation (top seal and aquifer). The basin's depobelts prograde southwestward, with the coastal swamp depobelt (western sector) representing a key transitional zone between onshore and shallow offshore plays (Short

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and Stauble, 1967; Doust and Omatsola, 1990; Reijers, 2011). Hydrocarbon exploration in the Niger Delta has evolved from onshore and shallow-water Miocene–Eocene targets to deeper offshore frontiers, driven by Nigeria's reliance on petroleum revenues and the need for sustained discoveries (Adegoke et al., 2017).

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Foraminiferal biostratigraphy, integrated with lithostratigraphy and sequence-stratigraphic analysis, remains a cornerstone for age dating, paleoenvironmental reconstruction, and reservoir prediction in deltaic settings. Numerous studies have applied these techniques across the basin (e.g., Petters, 1982, 1995; Ozumba, 1999; Ajayi and Okosun, 2014; Asadu and Anintah, 2023), yet detailed foraminiferal records from the western sector's (Figure 1) coastal swamp depobelt remain limited, particularly for Late Miocene–Early Pliocene intervals of the Agbada Formation.

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This study presents a foraminiferal biostratigraphic and paleoenvironmental analysis of ditch-cutting samples from well X-1 (1870–1320 m), located in the western sector of the Niger Delta Basin, southern Nigeria. The primary objectives were to: (1) establish the stratigraphic age of the penetrated interval; (2) reconstruct depositional paleoenvironments and paleobathymetry; (3) define a sequence-stratigraphic framework; and (4) evaluate preliminary petroleum system elements.

A total of 48 ditch-cutting samples were examined using standard lithologic (visual and microscopic) and micropaleontological preparation methods. Lithostratigraphic analysis delineated four sub-lithofacies units (X1–X4) dominated by sand–shale alternations, characteristic of the Agbada Formation. Foraminiferal recovery showed moderate abundance and diversity of planktonic, calcareous benthic, and agglutinated benthic forms, yielding 60 species (21 planktonic [42%], 39 benthic [58%]). Key index taxa, including *Globigerinoides obliquus*, *Globorotalia acostaensis*, *Globigerinoides obliquus extremus*, and *Cyclamina cf. minima*, supported recognition of two planktonic zones: *Globorotalia acostaensis* Zone (N16) and a composite *Globorotalia humerosa* / *G. margaritae margaritae* / *G. margaritae evoluta* Zone (N17–N19). A composite benthic zone spanning *Marginulina costata* Zone (NNDF 04), *Cyclamina minima* Zone (NNDF 05), *Haplophragmoides narivaensis* Zone (NNDF 06), and *Ammobaculites agglutinans* / *Florius costiferum* Zone (NNDF 07) was established, aligned with the Niger Delta chronostratigraphic scheme (Adegoke et al., 2017).

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The integrated biostratigraphy dates the interval to Late Miocene to earliest Early Pliocene. Paleoenvironmental reconstruction, based on biofacies and lithofacies integration, identified four settings: coastal delta plain, inner neritic, middle neritic, and outer neritic. Sequence-stratigraphic interpretation delineated a major maximum flooding surface (MFS) at 1390 m (~5.0 Ma), separating a transgressive systems tract (TST) below from a highstand systems tract (HST) above. The moderately well-sorted sands and enclosing shales exhibit good potential as reservoir, source, and cap rocks, respectively.

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This work will contribute to refining the biostratigraphic and depositional framework of the western Niger Delta's Agbada Formation, supporting ongoing exploration in the coastal swamp depobelt.

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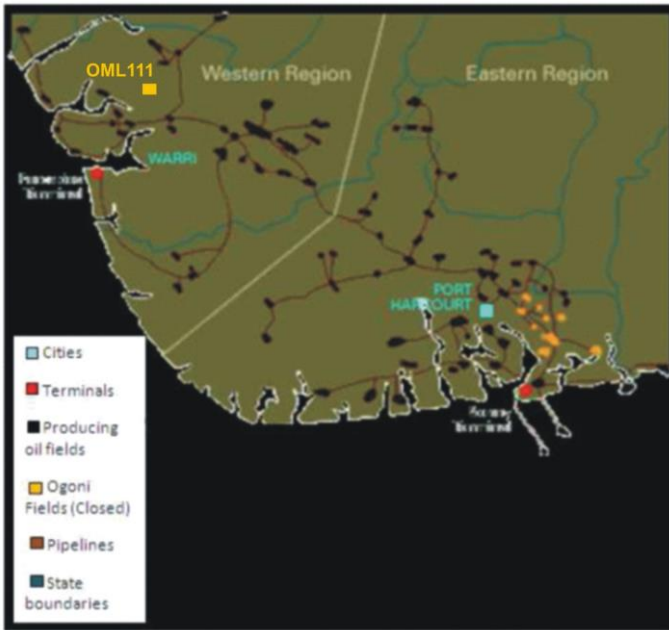


Figure 1: Location map of the Niger Delta showing “X-1 Well” (Modified from Imasuen *et al.*, 2011).

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The map lacks in latitudes and longitudes!

GEOLOGICAL SETTING

The Niger Delta Basin is a world-class clastic wedge formed at the intersection of the African and South American plates, representing a classic passive-margin delta system. It exhibits characteristics of an intermediate-class delta with mixed fluvio-deltaic, wave, and tidal influences, currently in a dynamic equilibrium between accommodation space and sediment supply (Chiaghanam *et al.*, 2011). The basin is subdivided into three major diachronous lithostratigraphic units from base to top: the Akata Formation, the Agbada Formation, and the Benin Formation (Figure 2), overlain by Quaternary deposits of varying types (Boboye and Fawora, 2007; Reijers, 2011).

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

- Akata Formation: the basal, predominantly marine shale sequence, approximately 600 m thick in many areas but thickening significantly basinward. It is overpressured in deeper sections and occurs at depths of 4–6 km onshore and 1–3 km offshore (Oti and Beka, 1995). Composed mainly of marine shales with minor turbidites, it serves as the primary hydrocarbon source rock in the basin due to its high organic content.

- Agbada Formation: the most extensively studied and hydrocarbon-productive unit, forming the paralic (delta-front to pro-delta) transition between the underlying Akata and overlying Benin formations. Its top is defined by the first occurrence of shales containing brackish to marine fauna, while the base corresponds to the deepest significant sandstone with plant remains and mica, coinciding with the top of the marine Akata shales. The formation reaches thicknesses of up to ~4500 m in the central depobelt (Oti and Beka, 1995) and is characterized by rhythmic alternations of sandstone and shale that constitute the principal petroleum reservoirs. Recent geophysical studies in the southeastern Niger Delta have further highlighted structural controls and geothermal implications within this interval (Ekpo et al., 2024b&c).
- Benin Formation: the uppermost, continental to coastal-plain clastic wedge, dominated by sands and sandstones (70–100% sand content) with minor shale intercalations (Ojo and Gbadamosi, 2013). Its top coincides with the present-day surface, and the base is marked by the highest shale bearing marine foraminifera (Short and Stauble, 1967). The formation is approximately 2000 m thick (Beka and Oti, 1995) and serves primarily as an aquifer and top seal in many fields.

The outcropping equivalents of these units are the Imo Shale (Akata equivalent), Ameki Group (Agbada equivalent), and Benin Sands (Benin equivalent), respectively. The basin's structural framework is dominated by growth faults, roll-over anticlines, and shale diapirism, which play critical roles in hydrocarbon trapping and migration. In the western sector (coastal swamp depobelt), these elements combine with progradational deltaic processes to create favorable conditions for stratigraphic and structural plays, as documented in regional studies (Ekpo et al., 2024a&d; Adegoke et al., 2017).

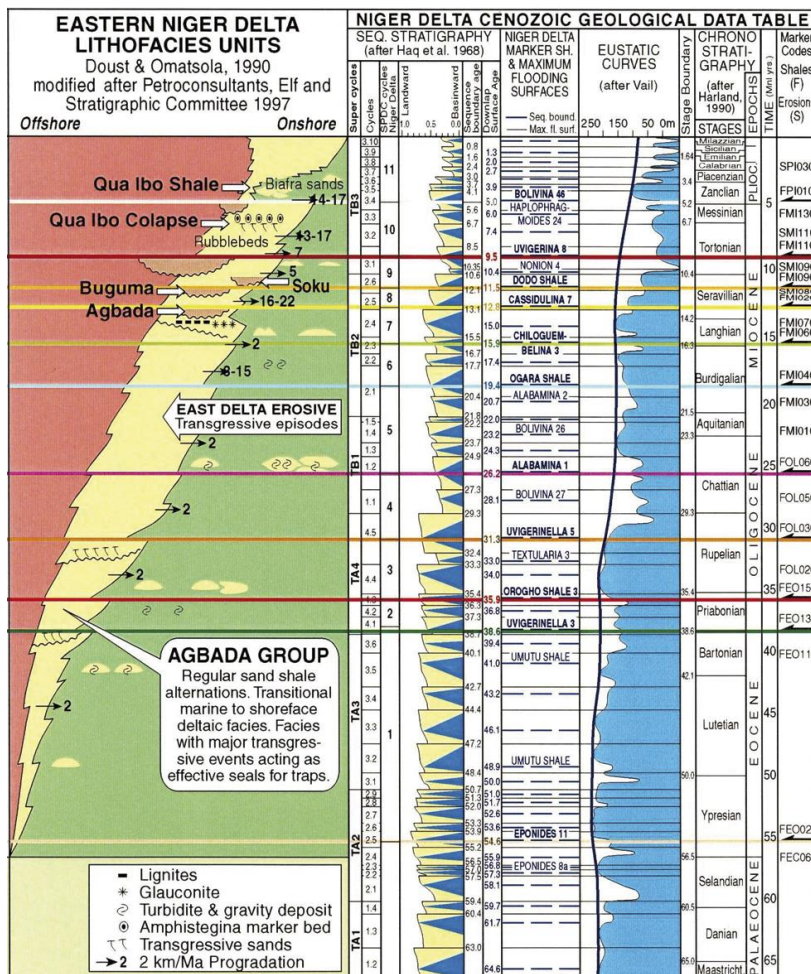


Figure 2: Stratigraphic data sheet (eastern Niger Delta) of the Niger Delta. (from Reijers, 2011)

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MATERIALS AND METHODS

Ditch-cutting samples from well X-1 (depth interval 1870–1320 m) were provided by an operating oil company in the Niger Delta. A total of 48 samples were collected at regular 10 m intervals for integrated lithologic and foraminiferal biostratigraphic analysis.

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Lithologic Analysis

Lithostratigraphic description was performed using both macroscopic (visual inspection) and microscopic techniques. Each sample was examined for textural characteristics (grain size, sorting, roundness, and angularity), colour,

sedimentary structures (where visible), and accessory minerals (e.g., pyrite, carbonaceous matter, ferruginous material, mica, and shell fragments). Observations were recorded systematically to delineate lithofacies units and infer depositional characteristics.

Foraminiferal Biostratigraphic Analysis

Sample preparation and analysis followed standard micropaleontological procedures for ditch cuttings (e.g., Bolli and Saunders, 1985; Petters, 1995; Adegoke et al., 2017). The workflow was as follows:

1. Sample Layout and Labelling

Samples were arranged sequentially by depth and clearly labelled.

2. Disaggregation

Unwashed ditch cuttings were rinsed with water to remove drilling mud, then air-dried. A standard 20 g subsample of each dried sample was placed in a clean sample plate, soaked in a solution of anhydrous sodium carbonate and water, and left to disaggregate overnight.

3. Washing and Sieving

Disaggregated residues were washed under running tap water over a 63 μm mesh sieve to remove clay and silt fractions. The retained residue ($>63 \mu\text{m}$) was oven-dried on a hotplate at a controlled temperature not exceeding 20° C to prevent thermal damage to foraminiferal tests.

4. Size Fractionation and Examination

Dried residues were dry-sieved into three main size fractions: coarse ($>500 \mu\text{m}$), medium (250–500 μm), and fine (63–250 μm). Each fraction was examined separately in a picking tray under reflected light using a binocular stereomicroscope (Zeiss model). Specimens were picked using a fine sable-hair brush (size N0000).

5. Identification and Documentation

Foraminiferal taxa were identified by direct comparison with published illustrations and descriptions from key references, including Bolli and Saunders (1985), Petters (1995), Adegoke et al. (2017), and other relevant regional and global monographs. Both planktonic and benthic (calcareous and agglutinated) forms were recorded. Species-level identifications were prioritized for biostratigraphic index taxa, while generic or higher-level assignments were used where preservation was poor.

All analyses were conducted at the micropaleontology laboratory of the Department of Geology, Akwa Ibom State University. No quantitative abundance data (e.g., specimens per gram) were calculated beyond total counts and qualitative abundance/diversity assessments, due to the nature of ditch-cutting samples and the focus on biostratigraphic zonation and paleoenvironmental reconstruction.

RESULT AND INTERPRETATION

Lithostratigraphy of “ X-1”- Well

Lithostratigraphic interpretation of well X-1 (1870–1320 m) was based exclusively on ditch-cutting samples, as no wireline logs were available. Four sub-lithofacies units (X1–X4) were delineated (Table 1), with a total analyzed thickness of 550 m.

Table 1: Depth and related lithofacies of sediments in “ X” –1 Well

Depth (m)	Lithofacies	Dominant Lithology	Key Characteristics
1870–1780	X1	Predominantly sand with traces of siltstone	Fine- to medium-grained, angular to subrounded, moderately sorted; ferruginous material
1780–1610	X2	Light to gray-brownish fissile shale with minor sand/sandstone	Fissile to non-fissile, moderately hard; carbonaceous matter, pyrite
1610–1420	X3	100% sand with traces of siltstone	Fine- to coarse-grained, moderately to poorly sorted
1420–1320	X4	Predominantly light to gray-brownish fissile shale monoliths with minor sand/siltstone	Fissile, moderately hard; shell fragments (gastropod), pyrite

The dominant lithologies are sandstones and sand with subordinate shale and siltstone intercalations. Sand grains are predominantly fine-grained, occasionally medium- to coarse-grained, angular to subrounded, and moderately to poorly sorted, with ferruginous material in places. Shale intervals range from dark gray to brownish gray (occasionally light gray), are fissile to non-fissile, and moderately hard. Accessory components include pyrite, carbonaceous matter, ferruginous material, and minor shell fragments (gastropod).

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The sandstone/shale ratio increases upward, producing an overall coarsening-upward succession. Alternating sand and shale is characteristic of the paralic Agbada Formation, and the upward increase in sand proportion reflects progressive progradation (seaward advancement) of the Niger Delta depositional system during the studied interval.

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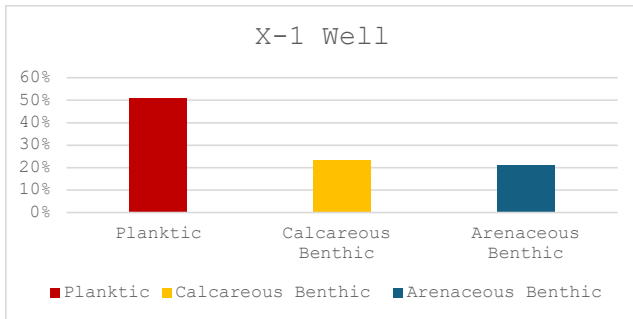
Foraminiferal Biostratigraphy

Foraminiferal analysis was performed on 48 ditch-cutting samples collected at 10 m intervals. Twenty-two samples were barren (1870–1800 m and 1650–1430 m), while the remaining intervals yielded moderate to low abundance and diversity of planktonic and benthic foraminifera (Figure 3 – biostratigraphic chart showing abundance and diversity trends).

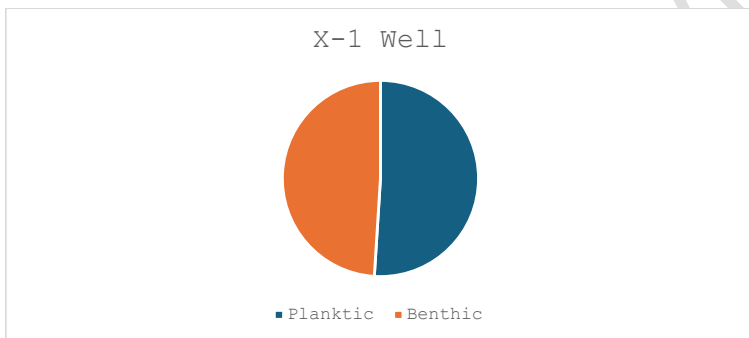
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A total of 223 foraminiferal specimens were recovered, representing 60 species: 21 planktonic species (42% of species; 119 specimens, 51.07% of population) and 39 benthic species (58% of species; 104 specimens, 48.93% of population). Among benthic forms, 16 were calcareous (42% of benthic species) and 13

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4a



4b

Figure4: The distribution of foraminifera analyzed forms from "X-1"- well as presented in: (a) bar chart showing foraminiferal types (b) pie chart for benthic and planktics

Table 2: Key foraminifera events used in "X-1" well

S/N	EVENT	DEPTH (M)
1	LAD <i>Globigerinoides obliquus</i>	1390
2	LAD <i>Cyclammina cf. minima</i> and <i>Eggerella scabra</i>	1420
3	FAD <i>Globigerinoides obliquus extremus</i>	1720
4	FAD <i>Globorotalia acostaensis</i> (~9.79 Ma)	1780

Table3: Planktic foraminifera microzone of "X-1" well

Interval (m)	Microzone	Age	Depth Interval (m)
1	<i>Globorotalia humerosa</i> /G. <i>margaritae margaritae</i> / G. <i>margaritae evoluta</i> (N17–N19)	Mid Late Miocene – earliest Early Pliocene (Late Tortonian–Zanclean)	1720–1320
2	<i>Globorotalia acostaensis</i> (N16)	Late Miocene (Mid-Tortonian)	1870–1720

Planktonic Zones

- Globorotalia acostaensis Zone (N16): 1870–1720 m (early Late Miocene, Tortonian). Lowest abundance/diversity; basal interval barren. Dominant planktonics: Globigerinoides bollii, G. trilobus immaturus, Globigerina bulloides. Highest calcareous benthic abundance/diversity in this zone (Lagena spp., Oridorsalis umbonatus, Uvigerina auberiana, Heterolepa pseudoungeriana). FAD G. acostaensis at 1780 m (~9.79 Ma) and presence of Globorotalia tumida confirm Late Miocene age (Berggren et al., 1995).

- Composite Globorotalia humerosa / G. margaritae margaritae / G. margaritae evoluta Zone (N17–N19): 1720–1320 m (late Late Miocene – earliest Early Pliocene). Higher abundance/diversity. Key taxa: Globigerinoides obliquus extremus (FAD 1720 m), Neogloboquadrina dutertrei, Globorotalia plesitiumida. Absence of key separators (G. margaritae primitiva, Sphaeroidinellopsis disjuncta) justifies composite zoning. LAD Cyclammina cf. minima and regional markers confirm N17–N19 equivalence (Adegoke et al., 2017). Correlates with Upper F9700 Zone.

Benthic Zones

A composite benthic zone was erected, spanning NNDF 07 to NNDF 04 (Adegoke et al., 2017):

- NNDF 07 (*Ammobaculites agglutinans* / *Florius costiferum*): Base of well (1870 m); arenaceous dominance.

- NNDF 06 (*Haplophragmoides narivaensis*): Arenaceous/calcareous transition; base ~7.72 Ma.

- NNDF 05 (*Cyclammina minima*): FDO C. cf. minima ~1450–1420 m; top regular occurrence of *Valvulina flexilis*, *Quinqueloculina lamarckiana*, *Heterolepa pseudoungeriana*.

- NNDF 04 (*Marginulina costata*): Uppermost; FDO C. minima ~1400 m; correlates with upper N18–lowermost N19.

Systematic paleontological descriptions were not undertaken, as comprehensive taxonomic treatments are available in Adegoke et al. (2017) and earlier works.

PALEOENVIRONMENTAL ANALYSIS

Paleoenvironmental interpretations integrate lithofacies, foraminiferal abundance/diversity, planktonic/benthic (P/B) ratio, calcareous/arenaceous benthic ratio, and key indicator taxa (following Culver, 1988; Murray, 2014; and Niger Delta studies).

Four paleobathymetric settings were recognised:

1. Coastal Delta / Non-Marine (Coastal Plain)

Intervals: 1870–1800 m and 1600–1450 m (barren of foraminifera).

Dominated by fine- to coarse-grained sand/sandstone with ferruginous and carbonaceous material. High-energy, proximal deltaic setting; absence of foraminifera due to destruction or dilution by terrigenous input.

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

Intervals: ~1800–1750 m and 1650–1600 m.

Fine- to medium-grained clean sands with increasing shale. Low foraminiferal abundance/diversity; low P/B ratio; calcareous/arenaceous benthic ratio low. Indicators: *Heterolepa pseudoungeriana*, *Quinqueloculina lamarckiana*, *Criboelphidium gunteri*. Proximal offshore/nearshore setting with terrigenous influence.

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

Interval: ~1750–1700 m.

Predominantly shale/silt with reduced sand (shale:sand ~7:3). Progressive increase in foraminiferal abundance/diversity; higher P/B and calcareous benthic ratios. Indicators: *Cyclammina minima*, *Valvulina flexilis*, *Uvigerina* spp., *Eponides eshira*. Intermediate holomarine setting with reduced continental influx.

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

Interval: 1450–1370 m (peak near 1390 m).

Dominantly shale/mudstone (shale:sand 88–98%); pyrite and mica common. Highest foraminiferal abundance/diversity; peak P/B ratio; calcareous dominance. Indicators: *Globorotalia* spp., *Globigerina* spp., *Neogloboquadrina* spp., *Cyclammina minima*, *Uvigerina auberiana*, *Globocassidulina subglobosa*. Distal offshore/open marine setting.

The succession reflects overall retrogradation (deepening) punctuated by progradational pulses, consistent with Agbada Formation deltaic evolution.

SEQUENCE STRATIGRAPHY

Sequence-stratigraphic interpretation of well X-1 (1870–1320 m) was based on the integration of lithologic descriptions (ditch cuttings) and biostratigraphic data (foraminiferal abundance, diversity, and key bioevents). A comprehensive sequence-stratigraphic analysis, including detailed parasequence stacking patterns (progradational, retrogradational, or aggradational), was not possible due to the absence of wireline logs and seismic profiles. Consequently, only a limited framework could be established, focusing on the identification of one major bounding surface and two systems tracts.

Maximum Flooding Surface (MFS)

A single maximum flooding surface (MFS-X) was confidently identified at 1390 m (~5.0 Ma), based on the following integrated evidence (Table 4):

- Peak foraminiferal abundance and diversity (planktonic, calcareous benthic, and arenaceous forms)
- Highest occurrence of the planktonic taxon *Globigerinoides* spp. (lower part of N19 Zone)
- Lithologic shift to dominantly shale/mudstone with minor silt (fining-upward succession)
- Condensed section indicative of maximum landward shoreline position and deepest paleowater depth

This MFS correlates with the regionally significant Top F9700 Foraminifera Zone in the Niger Delta chronostratigraphic framework (Adegoke et al., 2017), which is widely recognized as a major Late Miocene–earliest Pliocene flooding event (~5.0–5.5 Ma).

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Table 4: Delineated systems tracts and key surfaces in well X-1

System Tract	Depth Interval (m)	Key Surface / Depth (m)	Age (Ma)	Epoch	Foraminiferal Zone
HST	1390–1320	MFS-X @ 1390	~5.0	Late Miocene–Early Pliocene	Top of F9700
TST	1870–1390	MFS-X @ 1390	~5.0	Late Miocene–Early Pliocene	N16 to N17–N19

Systems Tracts

Due to data limitations, full characterization of lowstand systems tract (LST) was not possible.

Two systems tracts were delineated:

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- Transgressive Systems Tract (TST)

Interval: 1870–1390 m

This basal and thicker interval represents the older systems tract. It is characterized by a fining- and deepening-upward succession, with increasing shale content upward and evidence of marine transgressive pulses (shale–sand intercalations). Foraminiferal biofacies indicate deposition from coastal to outer neritic environments. The top of the TST is marked by a condensed section at the MFS-X (1390 m, ~5.0 Ma), which separates it from the overlying HST. The base of the TST was not penetrated, as 1870 m represents the lowest analyzed depth.

- Highstand Systems Tract (HST)

Interval: 1390–1320 m

This younger and thinner interval overlies the TST. It is dominated by shale with subordinate sand and siltstone pockets. Foraminiferal assemblages show continued co-occurrence of planktonic, calcareous benthic, and arenaceous forms, consistent with middle to outer neritic conditions. The base of the HST is the MFS-X (1390 m); the top could not be defined, as 1320 m is the upper limit of the analyzed interval.

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PETROLEUM POTENTIAL

Sequence-stratigraphic analysis provides a powerful framework for predicting reservoir distribution, seal integrity, and source-rock potential in deltaic settings (Adegoke, 2012). In well X-1, the identified systems tracts and MFS offer favorable elements for a working petroleum system within the Agbada Formation.

- Reservoir Potential

Clean, fine- to medium-grained, moderately to well-sorted, subrounded to rounded sandstones within the transgressive systems tract (particularly the interval 1780–1720 m) represent the primary reservoir target. These sands are interpreted as marine-influenced delta-front or shoreface deposits with good lateral continuity potential. Under appropriate burial and diagenetic conditions, they are expected to exhibit excellent porosity and permeability, similar to proven Agbada reservoirs in the western Niger Delta.

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- Source Rock Potential

Marine shales within the transgressive systems tract and the condensed section at the MFS (1390 m) provide good potential as intra-formational source rocks. The outer-neritic biofacies at and below the MFS indicate deposition under low-energy, oxygen-deficient conditions favorable for preservation of marine organic matter. Regionally, shales associated with ~5.0 Ma flooding events often contain Type II–III kerogen and contribute to hydrocarbon charge.

- Seal Potential

Thick, fissile marine shales in the upper TST and throughout the HST serve as effective top seals and intra-formational baffles. The shale-dominated interval capping the prospective TST sands (around 1720–1390 m) is particularly promising for stratigraphic trapping.

- Trap Mechanisms

Potential traps include stratigraphic pinch-outs of TST sands into sealing shales, as well as structural closures (growth faults and roll-over anticlines) typical of the coastal swamp depobelt. Correlation with offset wells would help confirm lateral continuity and trap geometry.

Overall, the penetrated interval in well X-1 demonstrates good preliminary petroleum prospectivity, with the 1780–1720 m sand package as the most attractive reservoir target and the MFS-related shales providing source and seal capacity. Quantitative evaluation (porosity, permeability, TOC, maturity) and integration with seismic and wireline data are recommended to de-risk and refine these prospects.

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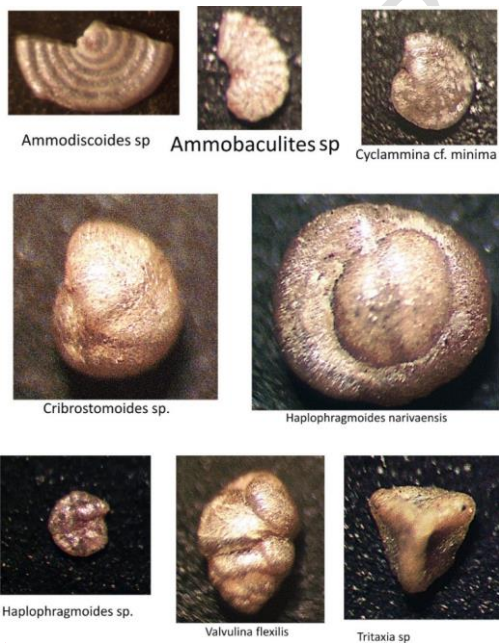


Fig: 5 The forms recovered in X-1 Well

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CONCLUSION

This foraminiferal biostratigraphic and paleoenvironmental study of well X-1 (1870–1320 m) in the western sector (coastal swamp depobelt) of the Niger Delta Basin demonstrates that the penetrated interval belongs to the Agbada Formation. The succession consists of alternating sandstones and shales arranged in four sub-lithofacies units (X1–X4), exhibiting an overall coarsening-upward trend indicative of delta progradation.

Foraminiferal analysis recovered moderate abundance and diversity, yielding 60 species (21 planktonic and 39 benthic). Integrated planktonic and benthic biozonation established two planktonic zones — *Globorotalia acostaensis* Zone (N16) and composite *Globorotalia humerosa* / *G. margaritae margaritae* / *G. margaritae evoluta* Zone (N17–N19) — and a composite benthic zone spanning NNDF 07 to NNDF 04. These zones collectively date the studied interval to Late Miocene to earliest Early Pliocene (Tortonian–Zanclean), correlating with the Upper F9700 Foraminiferal Zone in the Niger Delta chronostratigraphic framework.

Paleoenvironmental reconstruction identified four progressive paleobathymetric settings: coastal delta plain (barren high-energy sands), inner neritic (low-diversity nearshore sands), middle neritic (increasing calcareous benthic forms), and outer neritic (peak abundance/diversity with dominant planktonics and calcareous benthics). Sequence-stratigraphic interpretation, constrained by the absence of wireline logs and seismic data, delineated a major maximum flooding surface (MFS-X) at 1390 m (~5.0 Ma), separating a thick transgressive systems tract (TST: 1870–1390 m) below from a thin highstand systems tract (HST: 1390–1320 m) above. This MFS correlates regionally with the Top F9700 flooding event.

The interval exhibits good preliminary petroleum potential: clean, moderately well-sorted TST sands (notably 1780–1720 m) offer strong reservoir quality; condensed marine shales at and below the MFS provide source and seal capacity; and stratigraphic/structural trapping mechanisms are likely in this growth-faulted depobelt setting.

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