Journal of Science Research and Reviews
PRINT ISSN: 1595-9074
E-ISSN: 1595-8329
DOI: https://doi.org/10.70882/josrar.2025.v2i5.128
Homepage: https://josrar.esrgngr.org
Original Research Article

Foraminiferal Biostratigraphy and Paleoenvironment of Ovia-1 Well, Northern Depobelt of Niger Delta Basin, Nigeria

***Salisu, Mukhtar, Yandoka, Babangida M. S. and Raheem, Mudashir O.**

Department of Geology, Bayero University Kano, Nigeria.
*Corresponding Author's email: salisumukhtar325@gmail.com

KEYWORDS
Age determination,
Biozonation,
Paleodepositional environment.

ABSTRACT
The Ovia-1 well located in the Northern Depobelt, Niger Delta Basin was investigated based on Gamma Ray log, Lithostratigraphy, foraminifera and nanno fossil biostratigraphy. This is aimed to determine biostratigraphic distribution, age and paleodepositional environment of the studied intervals. Based on the foraminfera, the marker species identified are *Quinqueloculina microcostata, Amphistegina lessonii, Heterostegina sp, Lenticulina inornata, ex gr. costiferum, Heterolepa* pseudoungeriana, Hanzawaia stratoni, Spirosigmoilina oligocaenica, and Cibicorbis inflata. Twelve (12) biozones identified are N15 – N14 (middle Miocene middle Miocene 12.26 – 13.12Ma), (N13 – N12/N11 middle Miocene 13.12 – 13.68Ma) N9 – N10/N11 middle Miocene 14.20 – 15.6Ma) (N4 - P22 early Miocene 20.94 –23.2Ma) (P17-P18 early Oligocene 33.0 – 36.50Ma) (P14 middle Eocene 36.50 – 43.2Ma) P12 middle Eocene 41.0 – 43.2Ma) (P4 late Paleocene 56.8 – 57.3Ma) (P1 – M18 early Paleocene 64.6 – 65.0Ma respectively). The paleoecological interpretation, based on the identified plantic foraminiferal species, indicates Inner Neritic to Outer Neritic zones. Lithostratigraphic criteria including Gamma Ray log responses and sand/shale ratios supported by paleobathymetric data indicate that the Ovia-1 have well, have two broad lithofacies units -the Marine Paralic and the Marine Units, which are ascribed to the Agbada Formation, Lithological analysis revealed alternating layers of shale, and sand, reflecting different paleoenvironmental conditions during deposition. The age of the well was established as Middle to Late Miocene, based on the bioevents of key marker species. Additionally, the limited presence of calcareous benthic and planktonic foraminifera supports the interpretation of a shallow marine depositional setting.

CITATION
Salisu, M., Yandoka, B. M. S., & Raheem, M. O. (2025). Foraminiferal Biostratigraphy and Paleoenvironment of Ovia-1 Well, Northern Depobelt of Niger Delta Basin, Nigeria. *Journal of Science Research and Reviews*, *2*(5), 162-174. https://doi.org/10.70882/josrar.2025.v2i5.128

INTRODUCTION

Petroleum has long served as a vital energy resource and a major driver of economic development in both industrialized and developing nations. The Niger Delta Basin is of significant economic importance due to its rich hydrocarbon resources, which form the cornerstone of Nigeria's economy. Geologically, the basin is of Tertiary age and is located predominantly in the Gulf of Guinea, southwest of the Benue Trough. It represents the most

prominent Cenozoic deltaic system along the South Atlantic margin (Doust & Omatsola, 1990).

The basin's favorable combination of source rocks, diverse lithologies, structural traps, and an appropriate thermal history make it highly conducive for hydrocarbon generation, accumulation, and preservation (Evamy et al., 1978). Since the Eocene, the Niger Delta has undergone a southwestward progradation, forming a series of depobelts that mark successive phases of deltaic development. The delta comprises a clastic sediment wedge up to 12 km thick, covering approximately 75,000 km^2 across southern Nigeria and into the offshore Gulf of Guinea. This sedimentary complex contains the 12th largest known accumulation of recoverable hydrocarbons globally, with proven reserves exceeding 34 billion barrels of oil and 93 trillion cubic feet of natural gas (Tuttle et al., 1999). The Niger Delta Province is characterized by a single petroleum system: the Tertiary Niger Delta (Akata–Agbada) Petroleum System (USGS, 1999).

This study presents the results of biostratigraphy (foraminiferal and calcareous nannofossil) lithostratigraphy, Gamma logs and paleoenvironmental analyses conducted on the interval between 3,405 and 10,640 feet in the Ovia-1 Well, located within the Northern Depobelt of the Niger Delta. Based on the International Stratigraphic Guide (Hedberg, 1976) and the observed stratigraphic ranges of planktonic foraminifera, Thes research focused on the chronological framework and stratigraphic subdivision of the sequences penetrated by the Ovia-1 Well. This was achieved using the globally recognized planktonic foraminiferal zonation scheme developed by Blow (1969, 1979), alongside a zonal interpretation based on benthic foraminiferal assemblages recovered from the well. The environmental interpretation of the well will employ a combination of the sedimentological description of the ditch cuttings and environmental diagnostic benthic foraminiferal specie

Geological setting

The studied wells are located within the Northern Depobelt Niger Delta Basin. The study area contains an extensive wedge of Cretaceous to recent sediments. The basin has been of much geological interest as it serves as a source of hydrocarbon exploration. The Niger delta is situated in the Gulf of Guinea on the margin of West Africa. It is one of the largest regressive deltas in the world that has prograded southwestwards forming depobelts that represent the most active portion of the delta at each stage of its development evolution (Doust and Omatsola, 1990).. The Niger Delta is bounded by the Cameroon volcanic line to the east, the Dahomey basin to the west, and the 4000-m (13,100-ft) bathymetric contour (Corredor et al., 2005). The Delta is a classical shale tectonic province (Wu and Bally, 2000), whose shape and internal structure are controlled by fracture zones along the oceanic crust, denoted as trenches and ridges (Corredor et al., 2005). The Niger Delta sits at a failed arm of a rift triple junction, located at the southern end of the Benue Trough, in which the rifting ended in the Late Cretaceous (Lehner and De Ruiter, 1977).

The stratigraphy of the Tertiary Niger Delta is divided into three formations, representing prograding depositional environments (Short and Stauble, 1965}. These formations were deposited in the continental, transitional and marine environments, respectively; together they form a thick, overall progradational passive-margin wedge (Corredor et al., 2005). The Akata Formation is composed mainly of marine shales believed to be the main source rock within the basin. The Agbada Formation is made up of alternating sandstone, siltstone and shale sequences and represents the actual deltaic portion of the sequence that forms the primary reservoirs in the Niger Delta (Corredor et al., 2005).. The Agbada Formation is overlain by the Benin Formation, which is composed of continental deposits, including alluvial and upper coastal-plain deposits (Avbovbo, 1978). A stratigraphic section showing the three formations in the Niger Delta is shown in Figure 2. The Ovia-1 Well is an exploratory Well drilled in the Northwestern flank, Northern Depo-belt of the Niger Delta. The Well was drilled to a total depth of 10,640ft

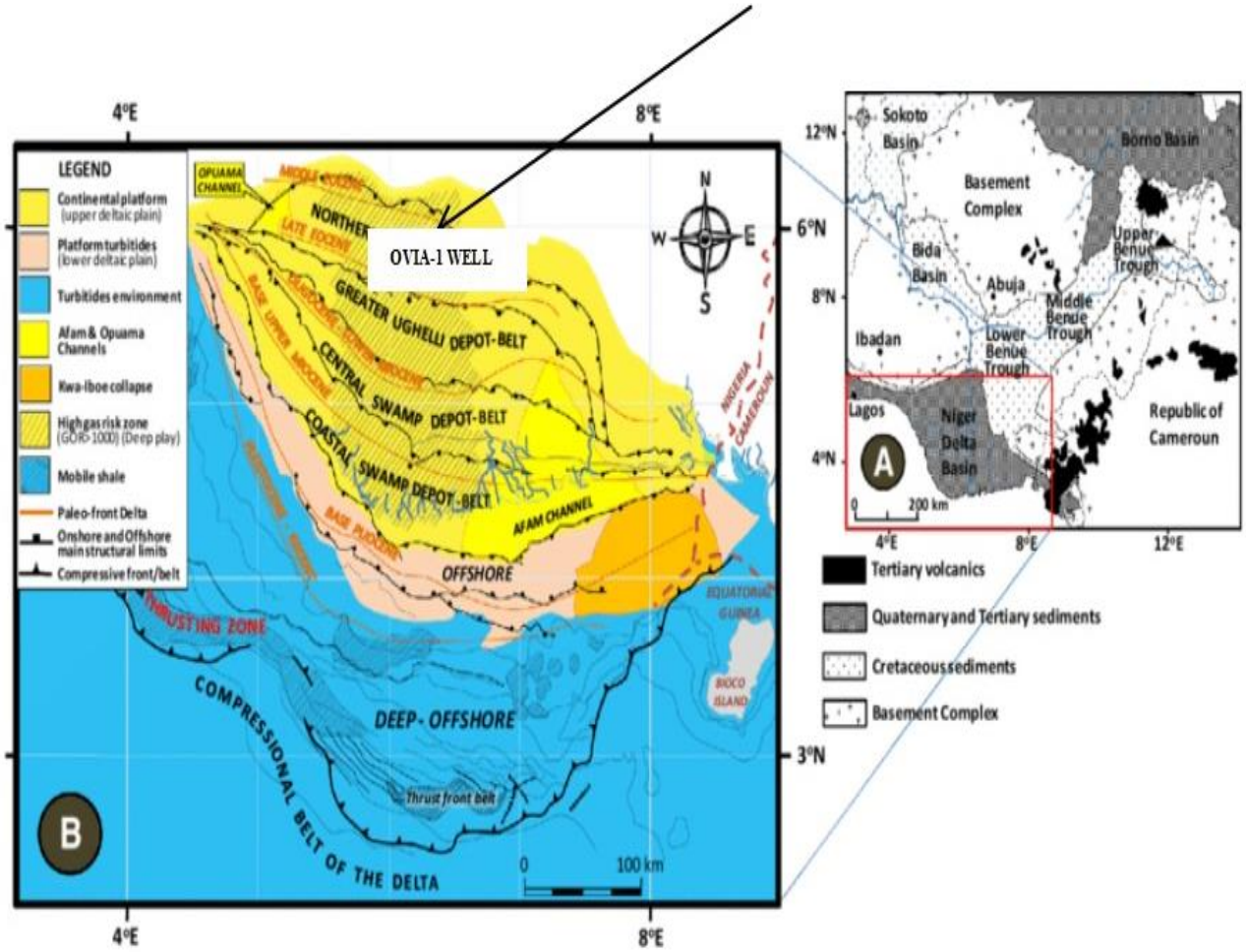

Figure 1: Geological map of Nigeria indicating the location of the Ovia-1 well in the Niger Delta Basin (a) (modified after Ebong et al., 2007) and sectional map of the Niger Delta depobelts with their structural boundaries (b) (adapted from Doust and Omatsola, 1990).

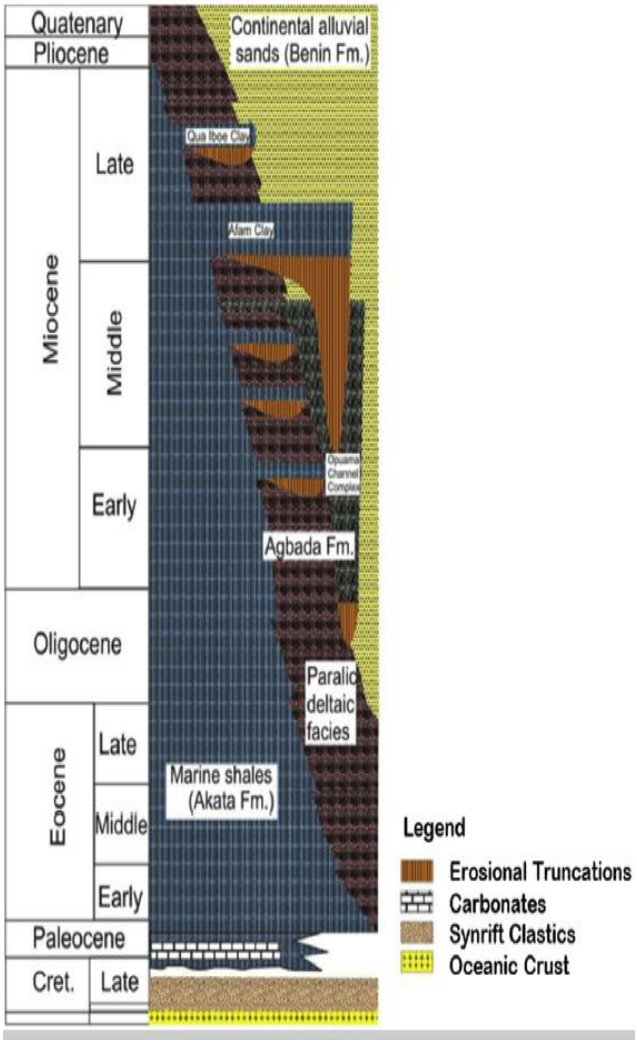

Figure 2: Simplified diagram illustrating the regional stratigraphy of the Niger Delta (modified from Corredor et al., 2005).

MATERIALS AND METHODS

The materials used for this study are ditch cutting samples and wireline logs of the Ovia-1 well. These samples were packed in small labeled polythene bags bearing the name of the well and the depth of sampling. They were arranged serially in a wooden tray in the laboratory for lithologic description and processing for foraminiferal recovery. Three hundred and sixty -three (363) ditch cutting samples were collected between 3,405 ft and 10,640 ft of the Ovia-1 well, with samples at 30 ft intervals provided for biostratigraphic analyses (foraminifera). For the foraminiferal sample preparation, the logging and composition of each sample were laid out sequentially in batches. Labels were prepared for each sample, and clean sample plates were laid out. A hot plate was placed inside a fume cupboard. The samples were treated in various forms, including drying, weighing, soaking, and decanting, followed by transfer to sieving and drying. Approximately 20 g of each sample was soaked with kerosene inside a clean, dry aluminum bowl and left for 24 hours to disaggregate as completely as possible. The disaggregated materials were washed through a 63 µm sieve to remove coagulated particles. The fine residues were placed on filter papers to drain before being transferred to an oven to dry at 40°C. The dried samples were then sieved through 250 µm, 125 µm, and 63 µm sieves for ease of picking. The samples were then picked using a size 00 brush under a binocular stereo microscope. All the picked specimens were mounted on micropaleontological slides and subsequently quantitatively analyzed.

RESULTS AND DISCUSSION

Presentation of the Result

Lithostratigraphy

Lithostratigraphic criteria including Gamma Ray log responses and sand/shale ratios supported by paleobathymetric data indicate that the Ovia-1 well, have two broad lithofacies units –the Marine Paralic and the Marine Units, which are ascribed to the Agbada Formation as shown in Table 1.

Table 1: Lithostratigraphic table Showing the lithofacies and paleoenvironment of the Ovia 1 well based on this study

Interval (feet)	Formation	Lithofacies Unit	Diagnostic Criteria
3405 – 4400		Upper Paralic	- Sand/shale ratio of approximately 45:55. - Frequent sand-shale alternations. - Association largely with shallow marine fauna.
4400 – 6130		Marine-Paralic	- Sand/shale ratio of approximately 30:70. - Relatively thin sand/silt units intercalated with thicker mudstone/shale units. - Association with shallow marine and coastal fauna.
	Agbada		
6130 – 7240		Lower Paralic	- Sand/shale ratio of approximately 55:45. - Frequent alternation of sands and mudstones / shales. - Association with shallow marine and coastal fauna.
7240 – 10640		Marine	- Sand/shale ratio of approximately 20:80. - Generally thin sand/silt units intercalated with much thicker mudstone/shale units. - Association with moderately deep to shallow marine fauna.

Foraminiferal Biostratigraphy

Foraminiferal recoveries were moderate to good, in the studied samples Calcareous benthic foraminiferal species dominated the assemblage while the arenaceous species were rare in the entire studied interval. Planktic species were sparse and where recorded, were poorly preserved. Planktic foraminiferal species were generally rare in this Well. Zonation on the basis of planktic species could not be well established but were inferred using the endemic benthic, foraminiferal marker species whose stratigraphic distributions have been well established in the Niger Delta and have been calibrated with the planktic foraminifera.

The distribution, abundance and diversity chart of the recovered foraminifera together with the foraminiferal zones recognized and are presented as Figure (5, 6 and table 2, 3 and 4),

Important foraminifera bioevents considered includes; First Downhole Occurrence (FDO) of chronostratigraphically significant plankton/benthic foraminifera species, Last Downhole Occurrence (LDO) of plankton/benthic foraminifera marker species and Foraminifera abundance and diversity peaks dated with foraminifera marker species whose stratigraphic ranges are well established in the Niger delta and worldwide.

Table 2: Foraminiferal Calcareous Assemblage carried out based on this study

Foraminiferal Calcareous Assemblage (FOBC)	*Total Count*
Heterolepa crebbsi	*30*
Heterolepa pseudoungeriana	*44*
Cibicorbis inflate	*43*
Uvigerina (8) Subperegrina	*26*
Lenticulina inornata	*61*
Quiqueloculina microstate	*51*
Bulimina sp	*39*
Spirosigmolina oligocaenica	*30*
Valvulineria sp	*23*
Nodosaria sp	*20*
Heterostegina sp	*43*
Quinqueloculina sp	*26*
Amphistegina lessonii	*25*
Hanzawaia strattoni	*17*
Nonion sp	*10*
Brizalina interjuncta	*21*
Eponides cf eshira	*16*
Florilus ex. gr costiferum	*20*
Bolivina dertonesis	*29*
Bulimina aculeate	*18*
Uvigerina sp	*58*

Uvigerina sparsicostata	*16*
Frondicularia sp	*2*
Lenticulina cf .grandis	*11*
Ouinaqueloculina seminulum	*10*
Total species count	*669*

Table 3: Agglutinated foraminifera count based on this study

Foraminifera Agglutinating (FOBA)	***Species count***
Haplophragmoides sp	*2*
Haplophragmoieds excavate	*1*
Bathysiphon sp	*1*
Arenaceous indeterminate	*1*
Poritextularia panamensis	*2*
Spiroplectammina wrightii	*1*
Ammobaculites agglutinas	*1*
Total species count =	*9*

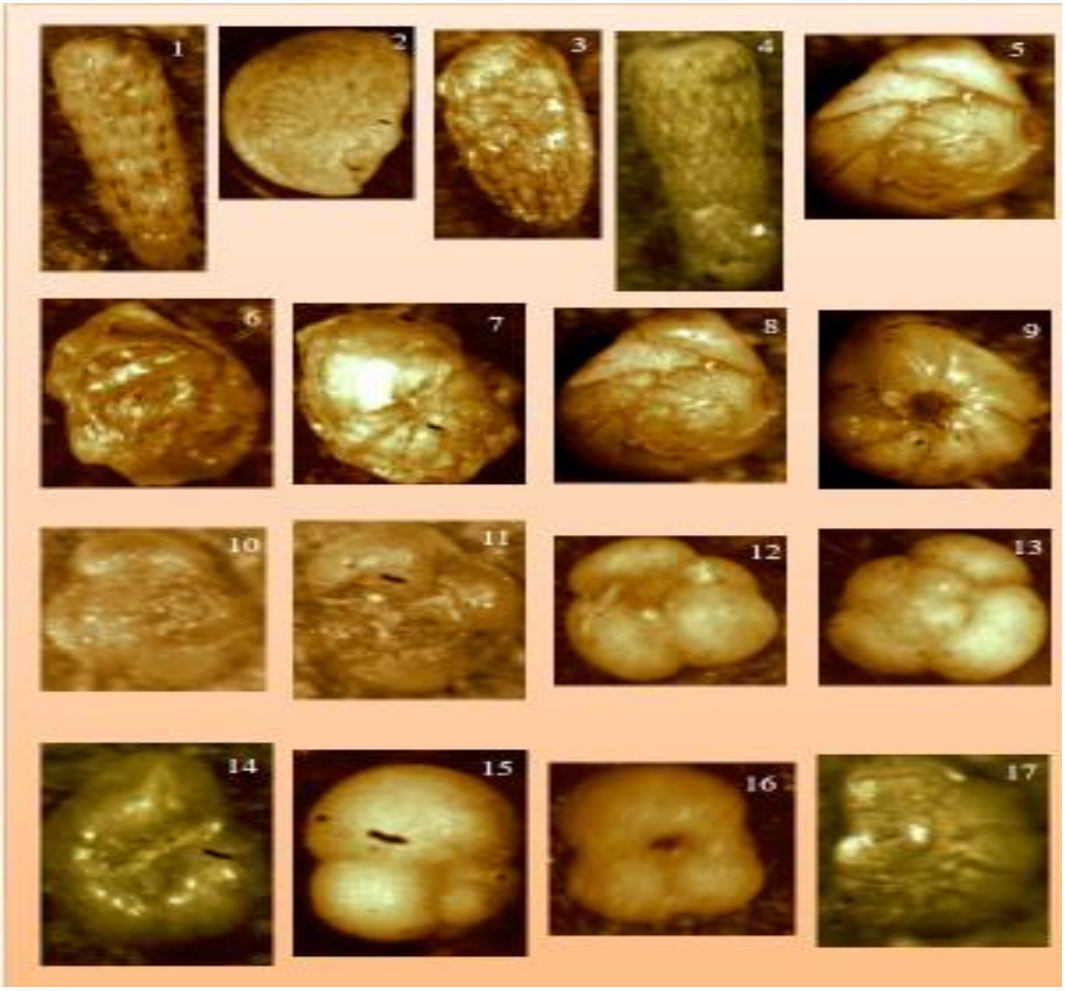

Figure 3: Photomicrograph of foraminiferal species showing1. *Bolivina afra* (8620-8680ft), 2. *Amphistegina lessonii* (3820-3880ft), 3. *Brizalina mandoroveensis* (6280-6340ft), *4. Bolivina afra* (8860-8920ft) 5. *Eponides eshira* (spiral side) (6280-6340ft) 6. *Eponides eshira* (spiral side) (6280-6340ft) 7. *Eponides eshira* (umbilical side) (6280-6340ft) 8. *Eponides eshira* (spiral sl side) (5980-6040ft.) *9. Eponides eshira* (umbilical side) (5980-6040ft) 10. *Globotruncana aegyptiaca* (spiral side) (9580-9640ft) 11. *Globotruncana aegyptiaca* (umbilical side) (9580-9640ft), 12. *Globoquadrina altispira* (umbilical side) (5920-5980ft) 13. *Globoquadrina altispira* (spiral side) (5920-5980ft) 14. *Gavelinel.la gune =-ana* (umbilical side) (9400-9460ft) 15. *Globigerinoides pimordius* (5980-6040ft) *16.Globigerinoides subquadratus* (5980-6040ft),17. *Gavelinella guineana* (spiral side) (9400-9460ft) spiral slide ide).

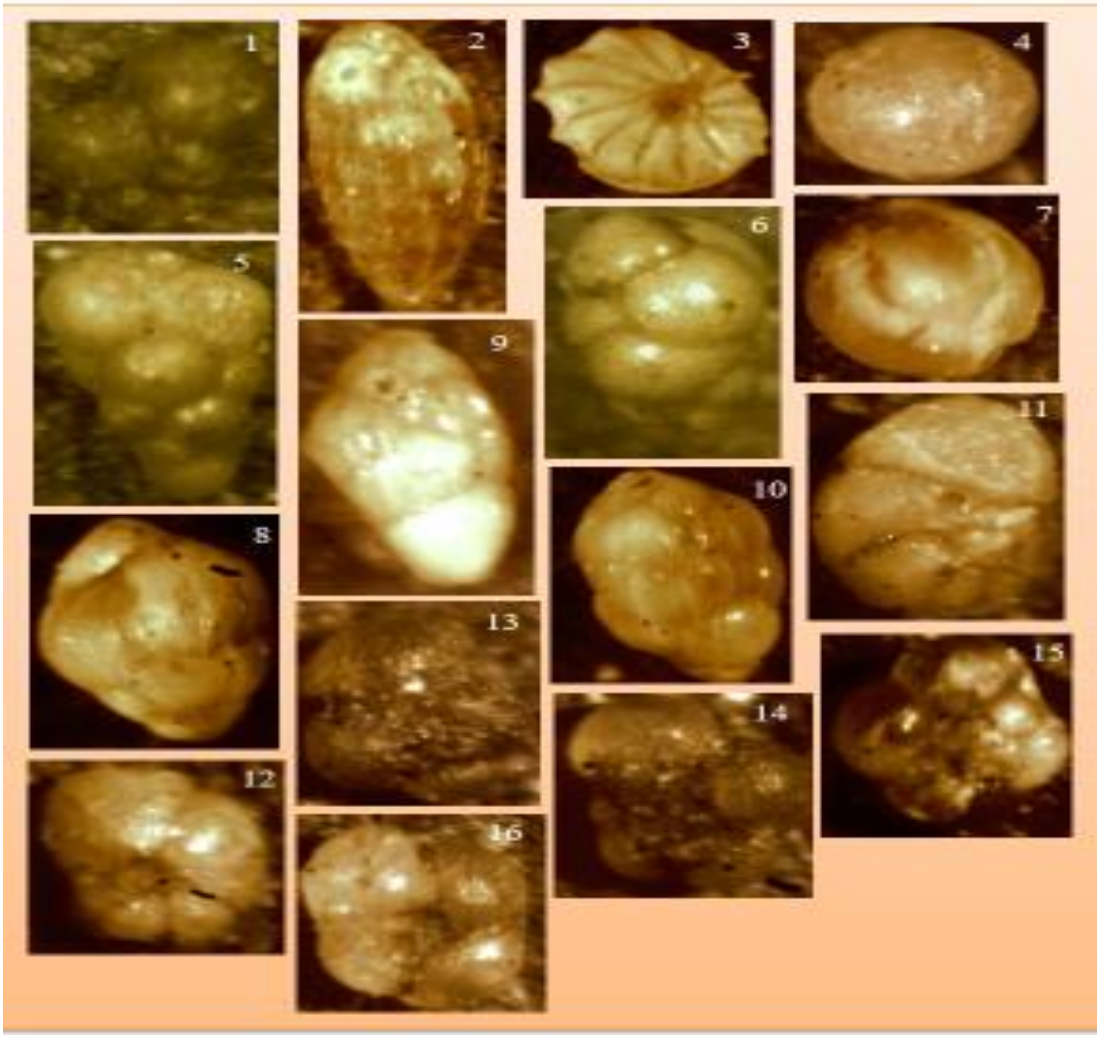

Figure 4: *Foraminiferal Photomicrograph showing 1. Heterohelix reussi* (9640-9700ft) 2. *Hopkinsina hourqi* (7480—7540ft) 3. *Lentiulina grandis* (7480—7540ft) 4. *Orbulina universa* (4120-4180ft) 5. *Praebulimia fang* (8920-8980ft) 6. *Praebulimia prolixa* (8920-8980ft) *7. Spirosigmoilina oligocaenica* (3700-3760ft) 8. *Uvigerina gallowayi* (8020-8080ft) 9. *Uvigerina sparsicostata* (6040-6100ft) *10. Uvigerina sparsicostata* (5980-6040ft) *11. Eponides pseudoelevatus* (spiral side) (8200-8260ft) *12. Eponides pseudoelevatus* (umbilical side) (8200-8260ft) 13. *Hedbergella holmdelensis* (spiral side) (8680-8740ft) 14. *Hedbergella holmdelensis* (umbilical side) (8680-8740ft) 15. *Hedbergella monmouthensis* (spiral side) (8680-8740ft) 16. *Hedbergella monmouthensis* (umbilical side) (8680-8740ft)

The results of the analysis indicate that the study interval (3,405–10,640ft.) of the Ovia-1 Well was deposited during the middle Miocene to? late Campanian epoch, of estimated numerical age of 13.5Ma to ? 69.75Ma straddling the N15 to M18 & Older planktic zones [2,, 3, 4] (figure 5.

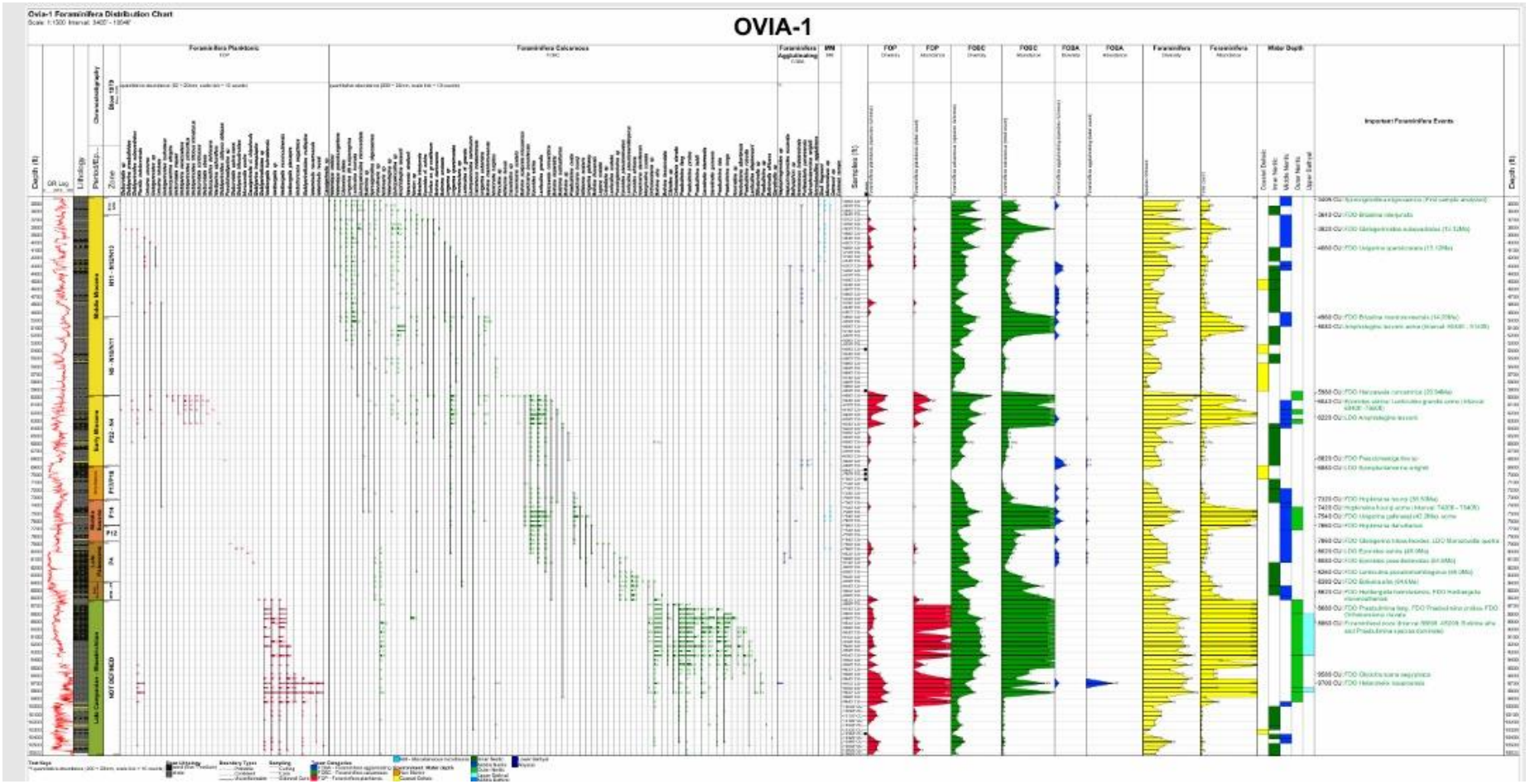

Figure 5: Foraminifera Distribution Chart of Ovial 1 well carried out based on this study

Discussion

Lithostratigraphy and paleoenviroment

Lithologic characteristics and the paleoenvironmental interpretations of the analyzed section are discussed within the framework of the identified lithofacies units as follows:

The Upper Paralic Unit (3,405 – 4,400 Feet)

This unit presents frequent sand/shale alternations and a sand/shale ratio of approximately 45/55. The sands are slightly calcareous, predominantly milky white to glassy, predominantly fine-grained, occasionally medium to coarse-grained and slightly pebbly, moderately to well sorted, occasionally poorly sorted, and sub-angular to sub-rounded. The mudstones/shales are greyish to brownish to occasionally reddish brown, blocky and hard. The unit is characterized by regular occurrences of ferruginous materials and shell fragments, fairly regular occurrence of mica flakes over the basal section, and sporadic occurrences of pyrite.

The Marine-Paralic Unit (4,400 – 6,130 Feet)

This unit is predominantly shaly with few thin sand/silt bodies interbedded. It presents a sand/shale ratio of approximately 30/70. The sands are predominantly milky white to glassy, fine to medium-grained, occasionally coarse-grained, dominantly poorly sorted, occasionally moderately-sorted, and sub-angular to sub-rounded. The mudstones/shales are greyish to brownish, occasionally reddish brown, predominantly blocky, occasionally flaggy to platy and hard. The accessory minerals suite recorded over the unit comprises regular occurrence of ferruginous materials, fairly regular occurrences of carbonaceous detritus, shell fragments, mica flakes, and very rare occurrences of pyrite and glauconite pellets. Foraminiferal recovery over this lithofacies fluctuates between Coastal deltaic through Inner Neritic to Middle Neritic. Inner to Middle Neritic dominate the sediments depositional environment. The different depositional environments are presented in table1.

The Lower Paralic Unit (6,130 – 7,240 Feet)

This unit exhibits a sand/shale ratio of approximately 55/45. The unit shows frequent sand/shale alternations and a general thickening-downward sand profile. The sands are milky white to glassy, predominantly medium to very coarse-grained and pebbly, poorly sorted and sub-angular to sub-rounded. The mudstones/shales are greyish to brownish, platy to blocky and moderately hard. Micropaleontologically, this interval is characterized by moderate recoveries of foraminiferal and nannofossil species suggesting sediment deposition within the open marine setting.

The Marine Unit (7,240 – 10,640 Feet)

This unit is predominantly shaly with few intercalated thin sand/silt bodies. It exhibits a sand/shale ratio of approximately 20/80. The sands are milky white to glassy, predominantly fine to coarse-grained, poorly sorted and sub-angular to sub-rounded. The mudstones/shales are greyish to brownish, occasionally dark grey to black and dark brown, predominantly platy to blocky and moderately hard. Regular occurrences of pyrite, fairly regular occurrences of ferruginous materials and occasional carbonaceous detritus occurrences characterize the unit. Foraminiferal assemblage over this marine lithofacies was characterized by moderate to high abundance and diversity. Nannofossil also recorded moderate species suggesting deposition in the open marine setting.

The foraminiferal recovery over this marine lithofacies fluctuates between Inner Neritic to Middle Neritic. However, Outer Neritic to Upper Bathyal thrived between the intervals 8,680 – 9,520ft. The different depositional environments are presented in table1.

Table 4: Summary showing Lithostratigraphic Units & Paleoenvironmental Interpretations

Unit Name	Depth Interval (ft)	Lithologic Characteristics	Interpretation of Depositional Environment	Foraminiferal Assemblages / Paleoenvironment
Upper Paralic Unit	3,405 – 4,400	Frequent sand/shale alternations; sand ~45%—calcareous, fine to coarse, well to moderate sorting; mudstones greyish/brownish blocky; shell fragments, ferruginous materials, mica flakes, pyrite	Coastal to shallow-water (inner neritic); barrier bar / river-mouth bar, distributary channel sands (based on funnel/bell GR motifs)	Inner Neritic (species like *Quinqueloculina microcostata*, *Amphistegina lessonii*, etc.)
Marine-Paralic Unit	4,400 – 6,130	sand ~30%; poorly sorted sands; shales greyish/brownish, blocky	Low-energy coastal to shallow marine; delta-front sands & prodelta mudstones; barrier bars,	Fluctuating Coastal deltaic → Inner Neritic → Middle Neritic;

		to platy; ferruginous materials, carbonaceous	distributary channels, overbank deposits	dominance of Inner to Middle Neritic
Lower Paralic Unit	6,130 – 7,240	Sand ~55%; more sand-rich, thickening downward; medium to very coarse, pebbly, poorly sorted; mudstones greyish/brownish; pyrite, ferruginous materials, mica, carbonaceous detritus, glauconite	Coastal to shallow-water, possibly subaerial exposure; distributary channel sands	Aggregate foraminiferal and nannofossil counts moderate; Inner Neritic to Outer Neritic
Marine Unit	7,240 – 10,640	Sand ~20%; dominated by shales—platy to blocky, dark grey/brown; pyrite, ferruginous materials, some carbonaceous detritus materials, some carbonaceous detritus	Low-energy, below wave base; intermittent bursts of energy—likely marine bay	Low-energy, below wave base; intermittent bursts of energy—likely marine bay

Biostratigraphy and age determination

Foraminiferal Biozonation

Spirosigmoilina oligocaenica Zone

Stratigraphic Interval: 3,405 – 3,640ft

The zone is defined by the the first down hole occurrence *Brizalina mandoroveensis* , and *Brizalina mandoroveensis* at the at 3,640ft marked the base of this zone and the Last Down Hole Occurrence (LDO) of at the top and other Important foraminiferal species within this zonal interval includes: *Quinqueloculina microcostata, Amphistegina lessonii, Heterostegina sp, Lenticulina inornata, Florilus ex gr. costiferum, Heterolepa pseudoungeriana, Hanzawaia stratoni, Spirosigmoilina oligocaenica,* and *Cibicorbis inflata*. Interval characterized by high occurrence of *Brizalina interjuncta* suggesting middle Miocene age (N13-N12/N11, The peak of foraminiferal abundance and diversity recorded at interval 3,760 – 3,880ft is associated with 13.15Ma Maximum Flooding Surface the age this zone was based on Continuous occurrence of *Spirosigmoilina oligocaenica* from the first sample analyzed (3,405ft) An erosional surface/unconformity at approximately 5,980ft is suggested. This may be responsible for the absence of N8 to N5 zones which should normally be present below this interval.

Hanzawaia concentrica sp,

Stratigraphic Interval: 5,980 –6,880ft

This zone is identify by the *Hanzawaia concentrica* sp at 5,980ft .The lower limit of this zone usually marks by the FDO *Brizalina imperatrix* and *Bolivina tenuicostata* were not recorded, the FDO *Spiroplectammina wrightii* at 6,880ft marked the lower limit of this zone suggesting an unconformity/ a fault at this depth, The upper boundary of this zone is defined by the FDO *Hanzawaia concentrica* at 5,980ft, The planktic assemblage that characterized this zonal interval include *Globigerinoides primordius, Globorotalia mayeri, Globorotalia continuosa, Globoquadrina altispira, Globoquadrina dehiscens* and *Globigerinoides immaturus , however* The peak of foraminiferal abundance and diversity recorded at interval 5,980 – 6,400ft is associated with 21.30Ma . This event is confirmed by the FDO *Hanzawaia concentrica* (20.9Ma) at 5980ft.

Hopkinsina hourqi sp,

Stratigraphic Interval: 7,320 –7,660ft

This zone is define by the *Morozovella quetra LDO* at 7,860ft characterized this interval. The upper boundary of this zone is defined by the FDO *Hopkinsina danvillensis* at 7,660ft, however The lower boundary of this zone is marked by the FDO *Globigerina triculinoides* at 7,860ft, this is equivalent to P12 as plantic zone Estimated Numerical age 41.0 – 43.2Ma and other important Associated foraminiferal species recorded within this interval include *Eponides eshira, Lenticulina grandis, Hopkinsinna bononiensis, Hanzawaia concentrica* and *Hopkinsina hourqi.*

Valvulineria martinezensiss sp,

Stratigraphic Interval: 7,860 –8,380ft

This zone is define by First Downhole Occurrence of *Globigerina triculinoides* at 7,860ft, the lower boundary of this zone is marked by the FDO *Bolivina afra* at 8,360ft and The upper boundary of this zone is defined by the FDO *Globigerina triculinoides* at7,860ft however Interval is characterized by planktic foraminifera *Globigerina opima nana, Globigerina triculinoides, Morozovella quetra, Cassigerinella chipollensis* and *Globigerina inequispira*. Other important *associated* benthic foraminiferal species recorded within this interval include *Eponides eshira,*

Lenticulina grandis, Hanzawaia concentrica, Uvigerina gallowayi, Brizalina ihuoensis and *Lagena costata*.

Bolivina afra sp zone,
Stratigraphic Interval: 8,380 –8,620ft
This zone is define by First Downhole Occurrence of *Bolivina afra* at 8,380ft. The lower boundary of this zone is marked by the FDO *Hedbergella holmdellensis* at 8,620ft however the upper boundary of this zone is defined by the FDO *Bolivina afra* at 8,380ft and other important *associated* foraminiferal species recorded within this interval include *Eponides pseudoelevatus, Lenticulina pseudomamillegerus, Eponides africana, Hopkinsina danvillensis, Bolivina afra, Orthokastenia sp,* and *Bolivina tenuicostata*

Hedbergella/ Praebulimina
Stratigraphic Interval : 8,620 –10,640ft
The zone is defined by the First Down Hole *Occurrence (FDO) of Hedbergella holmdellensis at 8,620ft and Globigerinoides sp at the base and the Last Down Hole LDO of Hedbergella holmdellensis at 8,620ft at the top. The interval is also characterized by the co-occurrences of the following planktic foraminifera: Globotrucana aegyptiaca, Hedbergella holmdellensis, Hedbergella monmouthensis, Heterohelix navareensis, Heterohelix planispira, Globigerinelloides multispina and Heterohelix reussi however the interval is characterized by the FDOs of Hedbergella holmdellensis (8,620ft.), Hedbergella monmouthensis (8,620ft.) Praebulimina fang (8,680ft.), Praebulimina prolixa (8,680ft.), Globotruncana aegyptiaca (9,580ft.) and Heterohelix navareensis (9,700ft) suggesting a Maastrichtian to Late Campanian age and other important Associated benthic foraminiferal species recorded within this interval include Bolivina afra, Praebulimina fang, P. longa, P. lata, P. laddi, P. prolixa, Gavelinella guneana, Gavelinella intermedia, Lenticulina stephensoni and Buliminella africana. And The peak of foraminiferal abundance and diversity recorded at interval 8,680 – 9,520ft is associated with ?69.75Ma Maximum Flooding Surface. This event is based on the FDO Bolivina afra at 8,380ft*

Age Determination
Middle Miocene
The upper boundary of this zone is placed at 3,640ft, based on FDO of *Brizalina interjuncta* The FDO *Brizalina mandoroveensis* at 4,960ft. marked the lower limit of this zone Interval characterized by high occurrence of *Brizalina interjuncta* suggesting middle Miocene age (N13-N12/N11) Interval is also characterized by the co-occurrences of *Lenticulina inornata, Amphistegina lessonii, Heterostegina sp, Heterolepa pseudoungeriana, Hanzawaia stratonii, Spirosigmoilina oligocaenica, Brizalina interjuncta, Cibicorbis inflata. Brizalina interjuncta, Uvigerina sparsicostata, Quinqueloculina microcostata,* and *Uvigerina subperegrina*.

Early Miocene
The upper limit is marked at 5,980 –6,880ft and the lower limit of this zone usually marks by the FDO Brizalina imperatrix and Bolivina tenuicostata were not recorded. The FDO Spiroplectammina wrightii at 6,880ft marked the lower limit of this zone suggesting an unconformity/ a fault at this depth. Interval is characterized by planktic foraminifera *Globigerina opima nana, Globigerina triculinoides, Morozovella quetra, Cassigerinella chipollensis* and *Globigerina inequispira,* Associated foraminiferal species recorded within this interval include *Eponides eshira, Lenticulina grandis, Uvigerina sparsicostata, Hanzawaia concentrica, Buliminella subfusiformis, Brizalina mandoroveensis, Brizalina interjuncta,* and *Altistoma tenuis*

Middle Eocene
The upper boundary of this zone is defined by the FDO *Hopkinsina hourqi* at 7,320ft. The FDO *Hopkinsina danvillensis* at 7,660ft marked the lower limit of this zone. Associated foraminiferal species recorded within this interval include *Lenticulina grandis, Hanzawaia concentrica, Eponides eshira, Hopkinsina bononiensis, Hopkinsina hourqi, Brizalina ihouensis, Uvigerina gallowayi* and *Altistoma scalaris* confirming the middle Eocene age

Late Paleocene
The upper boundary of this zone is defined by the FDO *Bolivina afra* at 8,380ft and The lower boundary of this zone is marked by the FDO *Bolivina afra* at 8,360ft, Interval is characterized by planktic foraminifera *Globigerina opima nana, Globigerina triculinoides, Morozovella quetra, Cassigerinella chipollensis* and *Globigerina inequispira* Associated benthic foraminiferal species recorded within this interval include *Eponides eshira, Lenticulina grandis, Hanzawaia concentrica, Uvigerina gallowayi, Brizalina ihuoensis* and *Lagena costata*

Maastrichtian - Late Campanian
The upper boundary of this zone is defined by the FDO *Hedbergella holmdellensis* at 8,620ft however The lower boundary of this zone is tentatively placed at depth 10,640ft, the terminal depth of the studied interval The interval is characterized by the FDOs of *Hedbergella holmdellensis* (8,620ft.), *Hedbergella monmouthensis* (8,620ft.) *Praebulimina fang* (8,680ft.), *Praebulimina prolixa* (8,680ft.), *Globotruncana aegyptiaca* (9,580ft.) and *Heterohelix navareensis* (9,700ft) suggesting a Maastrichtian to Late Campanian age. The interval is also characterized by the co-occurrences of the following planktic foraminifera: *Globotrucana aegyptiaca, Hedbergella holmdellensis, Hedbergella monmouthensis,*

Heterohelix navareensis, Heterohelix planispira, Globigerinelloides multispina and *Heterohelix reussi*.
And also associated benthic foraminiferal species recorded within this interval include *Bolivina afra, Praebulimina fang, P. longa, P. lata, P. laddi, P. prolixa, Gavelinella guneana, Gavelinella intermedia, Lenticulina stephensoni* and *Buliminella africana*.

CONCLUSION

Integrated lithostratigraphy, Gamma Ray log, foraminiferal and anno fossils biostratigraphy of Northern Depobelt Niger Delta Basin penetrated by Ovia - 1 well yielded a total of (363) foraminifera fossil species made up of benthonic and planktic spp. The marker species identified are *Quinqueloculina microcostata, Amphistegina lessonii, Heterostegina sp, Lenticulina inornata, ex gr. costiferum, Heterolepa pseudoungeriana, Hanzawaia stratoni, Spirosigmoilina oligocaenica, and Cibicorbis inflata*. . Twelve (12) biozones identified are N15 – N14 (middle Miocene middle Miocene 12.26 – 13.12Ma), (N13 – N12/N11 middle Miocene 13.12 – 13.68Ma) N9 – N10/N11 middle Miocene 14.20 – 15.6Ma) (N4 - P22 early Miocene 20.94 –23.2Ma) (P17-P18 early Oligocene 33.0 – 36.50Ma) (P14 middle Eocene 36.50 – 43.2Ma) P12 middle Eocene 41.0 – 43.2Ma) (P4 late Paleocene 56.8 – 57.3Ma) (P1 – M18 early Paleocene 64.6 – 65.0Ma respectively). Lithostratigraphic criteria including Gamma Ray log responses and sand/shale ratios supported by paleobathymetric data indicate that the Ovia-1 have well, have two broad lithofacies units -the Marine Paralic and the Marine Units, which are ascribed to the Agbada Formation. Generally, foraminifera calcareous nannofossil recorded moderate to good recoveries of species to age date the study interval, on the basis of the recovered calcareous nannofossil and foraminifera chronostratigraphic marker species, the entire studied interval (3,405–10,640ft.) is conclusively dated middle Miocene for the youngest sediment and Upper Cretaeous (Maastrichtian – Late Campanian) for the oldest sediment of the Ovia-1 Well, Using the encountered benthonic foraminiferal fossil species, the paleo-ecology was determined; and it was revealed that the paleoenvironment of the section ranges from Inner Neritic to Outer Neritic Environment. Also, the lithological analysis revealed an intercalation of Shale, and Sand which indicates various paleoecological episodes that led to their deposition. The age of the well was inferred from the bioevents of the marker sppecies to be Middle Miocene to Late Miocene with the sparse occurrence of the Calcareous Benthic and the Planktic species suggesting a shallow marine environment.

ACKNOWLEDGEMENT

The authors are grateful to the members of staff of the Department of Geology, Bayero University, Kano (BUK) and Prof. Babangida Mohammed SYD for his support and encouragement during the course of this research work.

REFERENCES

Avbovbo, A. A. (1978). Tertiary lithostratigraphy of the Niger Delta. *AAPG Bulletin, 62*(2), 295–300. https://doi.org/10.1306/C1EA47C4-16C9-11D7-8645000102C1865D

Berggren, W. A., Kent, D. V., Swisher, C. C., & Aubry, M.-P. (1995). A revised Cenozoic geochronology and chronostratigraphy. In W. A. Berggren, D. V. Kent, M.-P. Aubry, & J. Hardenbol (Eds.), *Geochronology, time scales and global stratigraphic correlation* (SEPM Special Publication 54, pp. 129–212).

Berger, W. H., & Miller, K. G. (1988). The last 500,000 years: Glacial/interglacial cycles and planktonic foraminiferal biostratigraphy. *Marine Micropaleontology, 13*(1), 1–36. https://doi.org/10.1016/0377-8398(88)90003

Blow, W. H. (1969). Late Middle Eocene to Recent planktonic foraminiferal biostratigraphy. In P. Brönnimann & H. H. Renz (Eds.), *Proceedings of the First International Conference on Planktonic Microfossils, Geneva, 1967*, Vol. 1 (pp. 199–422). Leiden: E. J. Brill.

Blow, W. H. (1979). *The Cainozoic Globigerinida: A study of the morphology, taxonomy, evolutionary relationships and the stratigraphical distribution of some Globigerinida (mainly Globigerinacea).* Leiden: E. J. Brill.

Corredor, F., Shaw, J. H., & Bilotti, F. (2005). Structural styles in the deep-water fold and thrust belts of the Niger Delta. *AAPG Bulletin, 89*(6), 753–780.

Doust, H., & Omatsola, E. (1990). Niger Delta. In J. D. Edwards & P. A. Santogrossi (Eds.), *Divergent/Passive Margin Basins* (AAPG Memoir 48, pp. 201–238).

Ebong, E. D., Okosun, E. A., & Essien, N. U. (2007). Stratigraphy and depositional environments of the Eocene strata in the eastern Niger Delta, Nigeria. *Global Journal of Geological Sciences, 5*(2), 107–114.

Evamy, B. D., Haremboure, J., Kamerling, P., Knaap, W. A., Molloy, F. A., & Rowlands, P. H. (1978). Hydrocarbon habitat of Tertiary Niger Delta. *AAPG Bulletin, 62*(1), 1–39.

Hedberg, H. D. (1976). *International stratigraphic guide: A guide to stratigraphic classification, terminology, and procedure*. New York: John Wiley & Sons.

Lehner, P., & De Ruiter, P. A. C. (1977). Structural history of Atlantic margin of Africa. In A. E. M. Nairn, W. H. Kanes, &

F. G. Stehli (Eds.), *The Ocean Basins and Margins, Volume 1: The South Atlantic* (pp. 223–276). New York: Plenum Press.

Martini, E. (1971). Standard Tertiary and Quaternary planktonic foraminiferal zonation. In P. Brönnimann & H. H. Renz (Eds.), *Proceedings of the First International Conference on Planktonic Microfossils, Geneva, 1967*, Vol. 2 (pp. 739–785). Leiden: E. J. Brill.

Short, K. C., & Stauble, A. J. (1965). Outline of geology of Niger Delta. *AAPG Bulletin, 51*(5), 761–779.

Tuttle, M. L. W., Charpentier, R. R., & Brownfield, M. E. (1999). The Niger Delta Petroleum System: Niger Delta Province, Nigeria, Cameroon, and Equatorial Guinea, Africa. *U.S. Geological Survey Open-File Report 99-50-H*.

Wu, S., & Bally, A. W. (2000). *Slope tectonics: Comparisons and contrasts of structural styles of salt and shale tectonics of the northern Gulf of Mexico with shale tectonics of offshore Nigeria in the Gulf of Guinea*. In W. Mohriak & M. Talwani (Eds.), *Geophysical Monograph 115: Atlantic Rifts and Continental Margins* (pp. 151–172). American Geophysical Union.