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LITHOFACIES CHARACTERIZATION AND FORAMINIFERA BIOSTRATIGRAPHY OF SEDIMENTS PENETRATED BY WELL "P" WITHIN THE INTERVAL OF 285FT AND 10440FT OF THE GREATER UGHELLI DEPOBELT, NIGER DELTA BASIN, NIGERIA

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Abstract

Lithofacies characterization and foraminiferal biostratigraphic analyses were carried out on forty-four ditch cutting samples from the Greater Ughelli Depobelt, Niger Delta in order to determine the lithofacies zones, foraminifera biozonation, age and the depositional environment the sediments were formed. The lithofacies study identify four lithofacies types of sandstone, shaly sandstone, sandy shale and shale; and six-teen lithofacies zones of which four are homogenetic zones and twelve are heterogenetic zones. The foraminifera analysis was carried out on forty four (44) ditch cutting samples at different intervals between 7380ft to 10440ft allowed the recovery of one hundred and forty five (145) calcareous foraminifera, and ninety eight (98) agglutinated foraminifera. Two foraminifera zones of Lower N2-N3 and Upper N3-N4 were identified. The age of the sediments penetrated by the well using the age diagnostic markers range from Oligocene to Miocene epoch.

Keywords: *Lithofacies, depobelt, biozonation, calcareous foraminifera, agglutinated foraminifera*

INTRODUCTION

The Niger Delta Basin is one of the most prolific hydrocarbon provinces in the world, with a complex stratigraphic framework shaped by tectonics, eustasy, and sediment supply (Doust & Omatsola, 1990; Ekweozor & Daukoru, 1994; Kulke, 1995; Tuttle *et al.*, 1999). The collapsed of the continental margin at the site of the triple junction in the mid-Cretaceous times gave rise to the evolution of the Basin (Burke et al., 1971). Since the Cretaceous, sediment deposition in the basin has been continuous. Back in 1978, Evamy and his colleagues pointed out that the Niger Delta growth really depends on two things: how fast the sediments are builds up (they called that Rd) and how quickly the ground sinks (Rs).

When these two aren't in sync, you end up with distinct mega units of sediment, each with different size, shape and thickness. Its subsurface succession record a wide range of depositional environments that provide critical information for hydrocarbon exploration and basin evolution studies. Within the basin, the Greater Ughelli Depobelt represents a key structural and stratigraphic unit, characterized by thick successions of alternating sandstones and shales that serve as important reservoirs and seals (Itiowe and Lucas, 2020).

Lithofacies characterization provides a means of reconstructing depositional environments, identifying reservoir heterogeneities, and linking stratigraphic patterns to basin-fill dynamics. Complementary to this, foraminiferal biostratigraphy offers a powerful tool for dating and correlating sedimentary sequences, as well as for interpreting paleoenvironmental conditions (Itiowe *et al.*, 2020). Variations in foraminiferal assemblages and morphotypes often reflect shifts in sea level, sediment influx, and ecological changes, thereby serving as reliable indicators in stratigraphic analysis.

This study focuses on the lithofacies analysis and informal foraminiferal biostratigraphy of sediments penetrated by Well-P, within the interval of 285 ft to 11,400 ft in the Greater Ughelli Depobelt, Niger Delta Basin (Figure 1). The objective are to establish the lithofacies framework of the studied interval, identify the foraminifera biozones and the age using the biostratigraphic markers, and interpret the depositional environments.

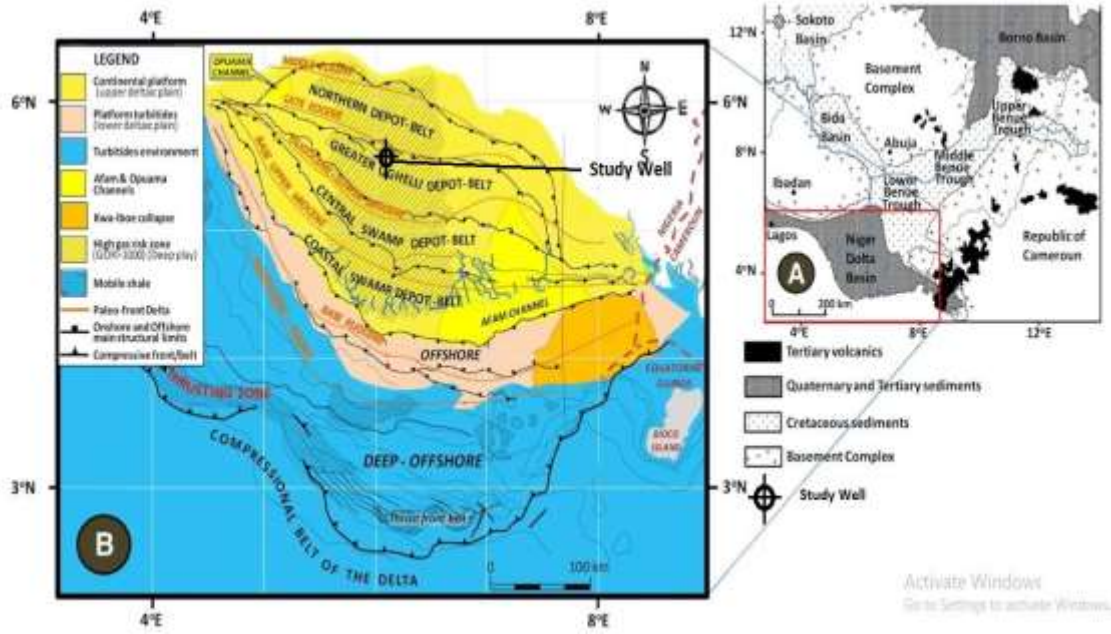

Figure 1: Map showing the study area (Modified after Ebong *et al.*, 2019)

Geology and stratigraphy of the Niger Delta

The stratigraphy of the Niger Delta is defined by a regressive sequence of Tertiary sediments that coarsen upward and display notable diachronism (Weber & Daukoru, 1975; Evamy *et al.*, 1978). This Cenozoic stratigraphic framework results from a dynamic interaction of diverse depositional settings (Frankly & Cordry, 1967; Short & Stauble, 1967; Weber, 1971; Avbovbo, 1978). Over the years, several researchers including Evamy *et al.* (1978), Ejedawe *et al.* (1984), Nwachukwu and Chukwura (1986), Haack *et al.* (2000), Reijers (2011), Itiowe *et al.* (2021, 2023), Ekone *et al.* (2025), Itiowe & Adetule (2026) have advanced our knowledge of the delta's subsurface stratigraphic units.

Recent research on foraminifera has been carried out in some parts of the world. Abu-Zied *et al.,* (2025) used planktonic foraminiferal biostratigraphy to establish a time-stratigraphic framework for the studied sections of the upper middle Eocene-lower Oligocene successions from Northern Saudi Arabia and modify the lithostratigraphy of Rashrashiyah Formation.

Shahin et al (2023 carried out a study on the Middle Eocene–early Miocene planktonic foraminiferal biostratigraphy at the N. El Faras-1X well in Western Desert, Egypt. They reconstructed sea-level curve that revealed two major transgressive–regressive cycles and the sequence stratigraphy study identified two transgressive–regressive (T–R) depositional sequences

The stratigraphy is commonly divided into three principal formations: the Akata, Agbada, and Benin Formations (Reijers, 2011) (see Figure 2). Positioned at the base of the Niger Delta stratigraphic column, the Akata Formation represents the earliest phase of the delta's outward growth and is composed predominantly of marine sediments. The lithological makeup primarily consists of dark gray shale and siltstone, enriched with both planktonic and benthonic foraminiferal assemblages (Itiowe *et al.*, 2020; Itiowe *et al.*, 2021). Chronologically, the Akata Formation ranges from the Paleocene epoch to the present (Doust & Omatsola, 1989). It gradually transitions upward into the overlying Agbada Formation, indicated by an increasing presence of plant debris, root traces, and mica flakes (Doust & Omatsola, 1989; Lucas *et al.*, 2020; Itiowe *et al.*, 2021).

The Agbada Formation is composed of interbedded sandstones, siltstones, and shales, typically arranged in repetitive sequences that range from several tens to hundreds of feet thick. These successions display progressive variations in grain size and bedding thickness upward. The sandstones vary from fine to coarse-grained and are generally moderately sorted (Itiowe & Lucas, 2020a; 2020b). Kaolinite is the principal clay mineral found in the formation, with secondary minerals such as illite, chlorite, and sepiolite also present (Itiowe *et al.*, 2023).

The Benin Formation represents the uppermost unit of the Niger Delta stratigraphy and is mainly composed of sand-sized to boulder-sized sediments. The grains range from subangular to well-rounded and show moderate to good sorting. Kanayo *et al.,* (2020) carried out depositional environment and morphometric analysis of River Sediments of the Benin Formation at Nihi area and they concluded that the pebbles were deposited in a fluvial environment with influence from high -low marine conditions. In addition to sand, the formation contains clay lenses, root traces, fragments of wood, and occasional coal deposits. Although the lack of fossil content complicates precise age determination, the Formation is generally considered to span from the Oligocene to Recent (Itiowe & Lucas, 2020a; 2020b).

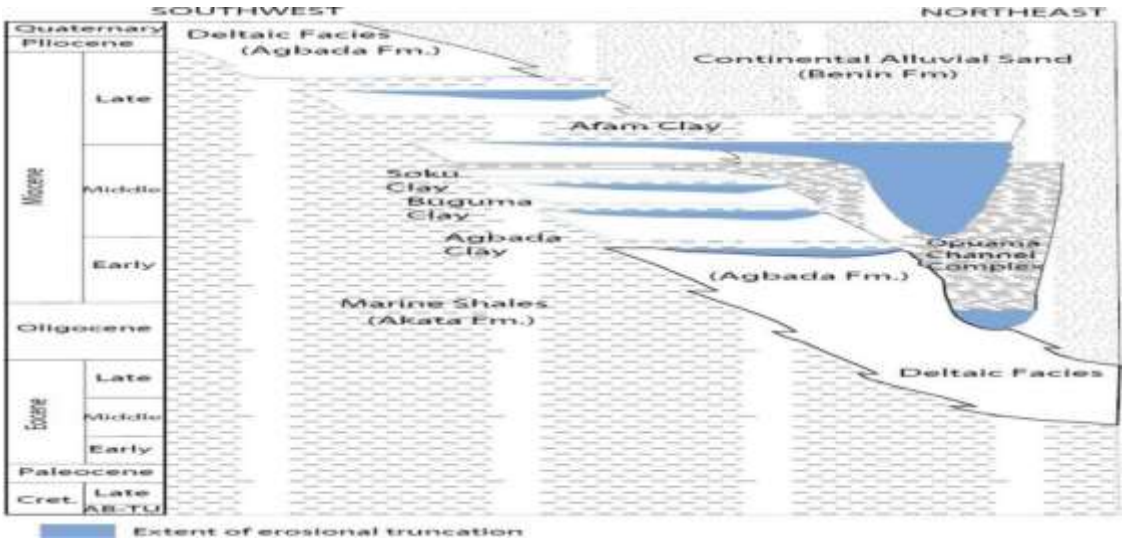

Figure 2: Stratigraphic column displaying Formations of the Niger Delta Basin (after Doust and Omatsola, 1990).

Methodology

Forty six (46) ditch cutting samples from shaly and sandy shale intervals (7380-11415ft) were analysed for foraminiferal slide preparation. The number of ditch cutting samples used for the foraminifera study was based on the number of suitable samples that were available. The process involved:

Sedimentological description

For the sedimentological grain size analysis, twenty (20) grams of each ditch cutting sample were collected and processed in the laboratory using both wet and dry sieve methods. The wet sieving was carried out with a 63 µm mesh sieve, during which the samples were washed under running water to eliminate clay particles. A mild detergent was also applied to remove drilling mud. The materials that passed through the sieve were considered the clay and silt sized fraction, while the retained portions were considered to be the sand sizes. The retained portions were dried on a hot plate at low temperature.

Subsequently, the dried samples were subjected to dry sieve analysis using mesh sizes of 63 µm, 250 µm, and 500 µm, corresponding to fine, medium, and coarse sand, respectively. The retained fractions from each sieve were carefully weighed. The percentage of the clay, silt, fine, medium and coarse sand were calculated. Binocular microscope was used to carry out the sedimentological description.

RESULTS AND DISCUSSION

Lithofacies characterization

Lithofacies analysis for Well "P" was conducted on one hundred and twenty-one (121) ditch cutting samples recovered from depths ranging between 285 feet and 11,400 feet. The examination enabled the subdivision of the succession into sixteen (16) lithofacies zones, comprising four (4) homogenetic and twelve (12) heterogenetic zones. Within the well, four (4) principal lithofacies types of sandstone, shaly sandstone, sandy shale, and shale were recognized. In addition, mineralogical constituents identified include quartz, iron oxide, pyrite, carbonate, and mica flake (Figure 3).

Quantitative count

In Well P, forty six (46) ditch cutting samples were collected from depths of 7380-11415 feet and processed using standard foraminifera biostratigraphy preparation technique. Analysis of the samples yielded one hundred and forty five (145) calcareous foraminifera forms and ninety eight (98) agglutinated foraminifera forms (Table 1). Photomicrographs of some of the recovered foraminifera are shown in Figure (4). The calcareous foraminifera recovered are: *Eponides eshira, Heterolepa pseudoungeriana, Lenticulina inornata, Florilus atlanticus, Calcareous indeterminate, Hanzawaia concentrica, Lenticulina grandis, Altistonia sp., Cristellaria sp., Altistonia scalaris, Nonion sp. 4, Valvulineria sp., Bolivina impertix, Hopkinsina bononiensis, Poritextularia panamensis, Bolivina dertonensis, Nonionella turgidus*. While the agglutinated foraminifera recovered are: *Spirosigmoilina oligocaenica, Eggerella scabra, Haplophragmoides sp., Reophax sp., Haplophragmoides narivaensis, Arenaceous indeterminate, Bathysiphon sp., Spiroplectammina wrighti*, and *Alveolophragmium crassum*.

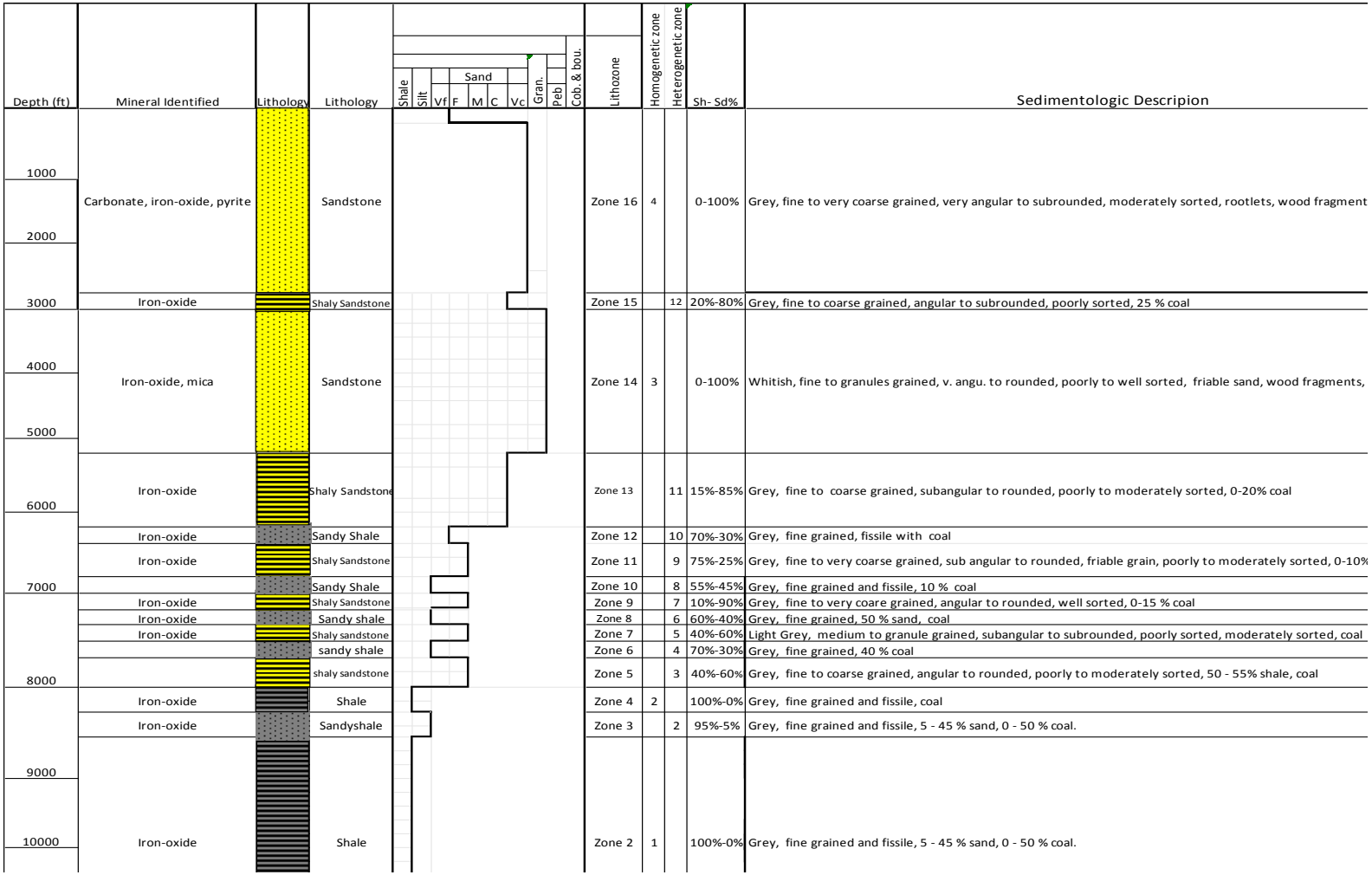

Figure 3: Lithofacies description of the sediments in Well P

Table 1: Quantitative count of calcareous and agglutinated foraminifera

	Calcareous Foraminifera																Agglutinated foraminifera								
Depth (ft.)	*Eponides esaira*	*Heterolepa pseudoungeriana*	*Lenticulina inornata*	*Calcareous indeterminate*	*Florilus atlanticus*	*Hanzawaia concentrica*	*Altistonia sp.*	*Lenticulina grandis*	*Cristellaria sp.*	*Altistonia scalaris*	*Nonion sp. 4*	*Bolivina impertix*	*Valvulineria sp.*	*Hopkinsina bononiensis*	*Bolivina dertonensis*	*Nonionella turgidus*	*Eggerella scabra*	*Spirosigmoilina oligocaenica*	*Haplophragmoides sp.*	*Reophax sp.*	*Haplophragmoides narivaensis*	*Arenaceous indeterminate*	*Bathysiphon sp.*	*Spiroplectammina wrightii*	*Poritextularia panamensis*
7380																									
8355																									
8370																									
8385																									
8400																									
8415																									
8430	1																								
8445																	4	5							
8460		1	1																1	2					
8475	2			2	5														1						
8505																		2							
8540	3																		3						
8635						2												13							
8650							2	1																	
8685																			1						
8700	1		1															2							
8715						1												1	1						
8730																		1							
8745	1																	2			2				
8760	2							3									1	1							
8775			2																						
8790						1												2							
8985								1										3	1						
9050	3		1			1													1						
9100	3		1																						
9285	1			4					2									13	1						
9315																	1								
9375			1																						
10200								1																	
10320									1	2	1														
10335			1									3	2												
10350																		2							
10380																		1							
10395							1				3								1	2					
10410	1		8									2							1	1		2			
10425	10											1						3					3		
10440	4		3						1										1				1		
10455		3	1															2			1				
10515		1	3																						
10545	1		1									1													
10560																						1		2	
10575																									
11000	1	3									1		2	3											
11370	11		1								3			2	1									1	
11385	1													1		3		4				1			1
11415	2		1						1												1		1		
Total																145									98

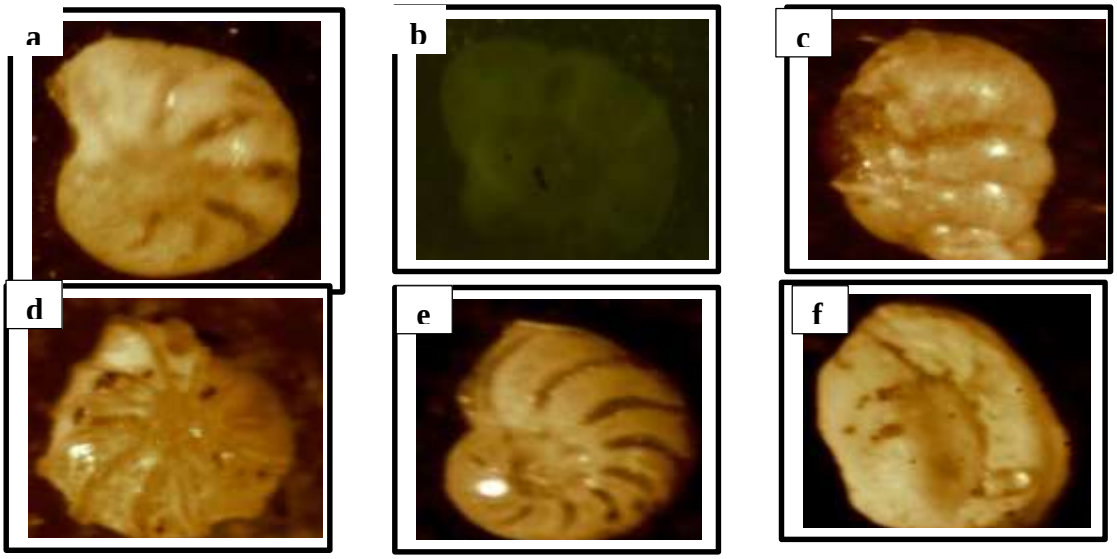

Figure 4: Photomicrograph of some of the recovered palynomorphs recovered from Well P: (a) *Cibicorbis inflata* (b) *Eponides eshira* (c) *Hopkinsina bononiensis* (d) *Lenticulina grandis* (e) *Florilus atlanticus* (f) *Spirosigmoilina oligocaenica*

Foraminifera bio-zonation and age

Ditch cutting samples obtained at various intervals from the well was processed using standard micropaleontological (foraminiferal) preparation technique and subsequently analyzed. Detailed examination of the prepared slides yielded quantitative counts of both calcareous and agglutinated foraminifera. From these results, foraminiferal distribution charts were constructed, incorporating the biozonation and chronological framework of the wells. The biozonation and age determinations were established using the First Appearance Datum (Last Downhole Occurrence) and the Last Appearance Datum (First Downhole Occurrence) of age-diagnostic foraminiferal species (zonal markers) recognized within the well sections.

Planktic foraminifera species are largely absent in the studied well. The absence of planktics, along with the generally poor recovery of foraminifera, is likely attributable to prevailing environmental conditions. A distribution and diversity chart of the recovered foraminifera species, as well as the identified biozones, is presented in the accompanying in Figure 5 and table 6.

Result from the analysis indicate that the entire studied interval (7,380 – 11,415 ft) was deposited between the Early Oligocene and Early Miocene epochs, corresponding to an estimated numerical age range of 35.9 Ma to 17.4 Ma. This interval falls within the *Spiroplectammina wrightii–Bolivina impertix* Zone (Lower N2 – Lower N3) and the *Eponides berthelotianus–Hanzawaia concentric*a Zones (Upper N3–N4) as defined by Bolli and Saunders (1985) and Blow (1969, 1979).

Stratigraphic Interval: 10350ft – 11370ft
Zone: Lower: N2 - N3
Age: Early to Late Oligocene

The upper boundary of this zone was defined by the FDO of *Bolivina impertix* at 10335ft. The lower limit is placed at the LDO of *spiroplectammina wrightii* at depth (11370ft). The interval is also characterized by the co-occurrences of the following calcareous foraminiferal species viz: *Eponides eshira, Lenticulina inornata, Altistonia sp., Cristellaria sp., Nonion sp. 4, Valvulineria sp., Bolivina impertix, Poritextularia panamensis, Bolivina dertonensis,* and *Nonionella turgidus;* and the following agglutinated foraminifera species: *Spirosigmoilina oligocaenica, Haplophragmoides sp., Reophax sp. Haplophragmoides narivaensis Arenaceous indeterminateBathysiphon sp., Spiroplectammina wrightii* and *Alveolophragmium crassum* which is consistent with Early to Late Oligocene age.

Stratigraphic Interval: 8715ft – 10335ft
Zone: Upper N3- N4
Age: Early Miocene

The upper limit of this zone was defined by the FDO of *Hanzawaia concentrica* at 8715ft, while the lower limit was placed at the FDO of *Bolivina impertix* at 10335ft. The First Downhole Occurrence of *Hanzawaia concentrica* at 8715ft suggests Early Miocene at this depth. The co-occurrences of the following foraminifera assemblages viz:

Heterolepa pseudoungeriana, Lenticulina inornata, Hanzawaia concentrica, Lenticulina grandis, Altistonia sp., Cristellaria sp., Altistonia scalaris, Nonion sp. 4, Spirosigmoilina oligocaenica, Eggerella scabra Haplophragmoides sp,. And Haplophragmoides narivaensis over this zone are consistent with the Early Miocene age.

Paleoenvironmental Analysis

Foraminifera are primarily associated with marine environments; therefore, their occurrence within sediments provides strong evidence of deposition in a marine setting. Owing to their widespread distribution across diverse stratigraphic intervals, they serve as more reliable proxies for reconstructing paleoenvironments than most other groups of microfossils (Bandy, 1960; Peters and Simoneit, 1982). A wide range of microscopic fossils are adapted to life in the oceanic settings, where they occupy different ecological niches. Their occurrence in sediments can therefore shed light on the water-depth ranges they once inhabited. Ocean basins are commonly divided into depth-related zones, a framework outlined by Loeblich and Tappan (1964).

An in-depth reconstruction of the paleoenvironment was carried out by combining sedimentological observation with foraminiferal-based paleobathymetric analysis across the examined well intervals. Sedimentological data were derived from the study of ditch cutting samples, whereas the paleobathymetric interpretation of foraminifera relied on several micropaleontological criteria. These included the recognition of foraminiferal taxa that serve as environmental indicators along with considerations of assemblage structure, species amount and species richness (Adegoke et al., 1976; Murray, 1991).

Stratigraphic Interval: 10335ft – 11370ft

The basal interval 10335ft – 11370ft consist of shale and sandy shale units. The depositional environment recorded fairly high amount of foraminifera abundance and diversity. The presence of paleobathymetric indicators such as *Eponides eshira, Lenticulina inornata, Altistonia sp., Cristellaria sp., Nonion sp. 4, Valvulineria sp., Bolivina impertix, Poritextularia panamensis, Bolivina dertonensis, and Nonionella turgidus. And the following agglutinated foraminifera species: Spirosigmoilina oligocaenica, Haplophragmoides sp., Reophax sp. Haplophragmoides narivaensis, Arenaceous indeterminate, Bathysiphon sp., Spiroplectammina wrighti* and *Alveolophragmium crassum* is an indicator of shallow marine to deep marine environment. The presence of *Rhephax* and *Spiroplectammina wrightii* is an indication of oxygen deficient environment (Adegoke et al., 1976, Murray, 1991).

Stratigraphic Interval: 8715ft – 10335ft

This interval consists of shale to sandy-shale units. The foraminifera recovery in this zone are scanty.

The prescence of the following paleobathymetric indicators: *Florilus atlanticus, Hanzawaia concentrica, Heterolepa pseudoungeriana, Spirosigmoilina oligocaenica, Lenticulina inornata, Lenticulina grandis, Cristellaria sp., Eggerella scabra* The present of these foraminifera indicate shallow marine to outer shelf-slope. The presence of *Lenticulina inornata, Lenticulina inornata* suggest a more oxygen deficient setting (Murray, 1991, Bandy, 1967).

Stratigraphic Interval: 8400ft - 8700ft

The following foraminifera: *Eponides eshira, Heterolepa pseudoungeriana, Lenticulina inornata, Calcareous indeterminate is an indication of inner shelf to continental slope environment.* The presence of *Eponides esaira* indicates stable salinity (Murray, 1991).

Stratigraphic Interval: 7380ft - 8400ft

This zone has shaly sandstone and sandy shale interval, which is an indication of transitional environment. There is an absent of fossils in this zone.

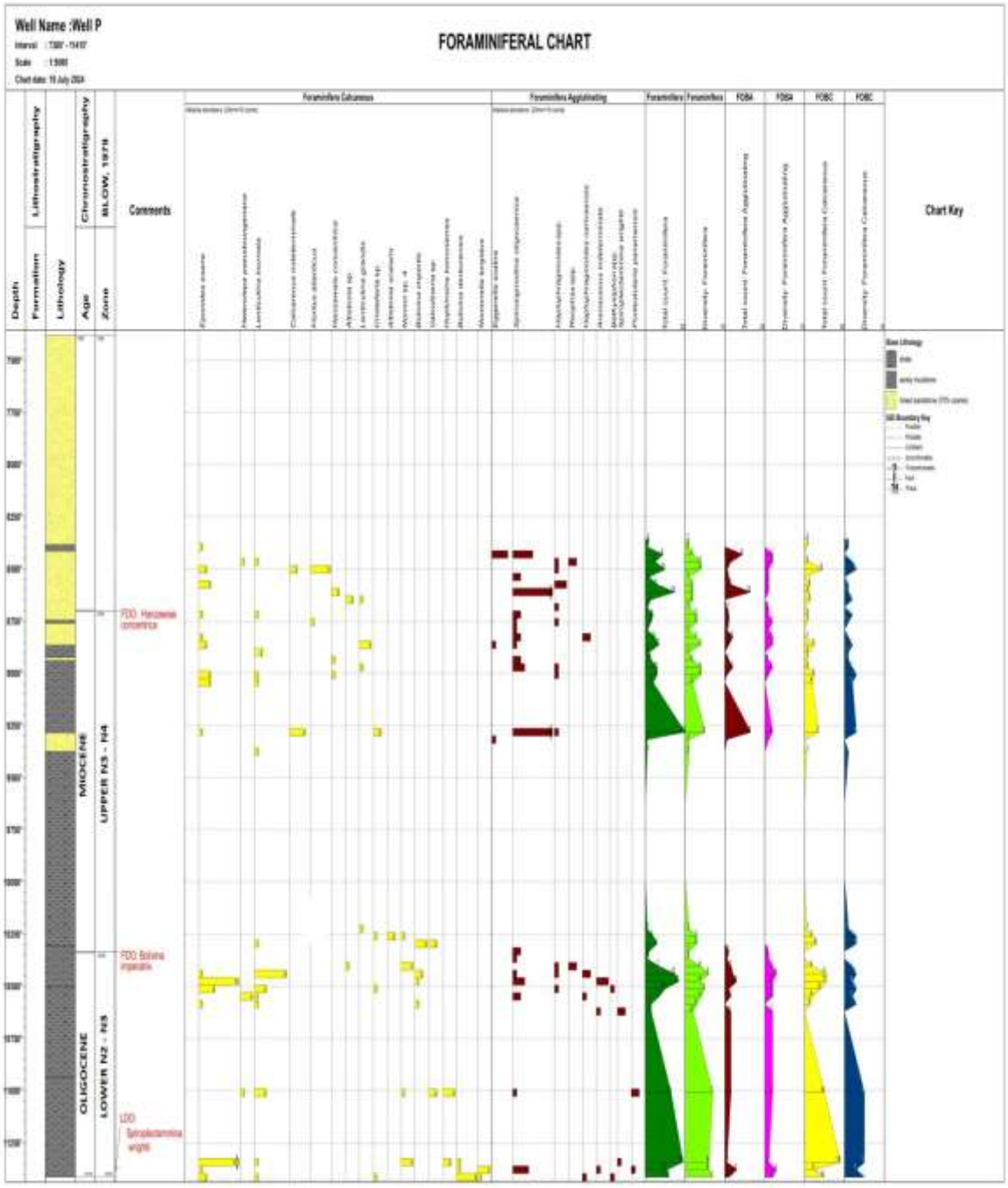

Figure 5: Showing foraminifera distribution chart for Well_P

| | Calcareous Foraminifera | | | | | | | | | | | | | | | | | Agglutinated foraminifera | | | | | | | | | | | | | | | | |

CONCLUSION

This study was carried out on one hundred and twenty two (122) ditch cutting samples fro, Well-M of the Greater Ughelli Depobelts, Niger Delta. Four lithofacies types of sandstone, shaly sandstone, sandy shale and shale were identified; and sixteen lithofacies zone of four homogenetic zones and twelve heterogenetic zones were identified.

Two foraminifera zones of Lower N2 - N3 and Upper N3 - N4 were delineated. The Lower N2 - N3 zones was identified with the help of the last downhole occurrence of *Spirosplectammina wrighti*i and the first downhole occurrence of *Bolivina impertix,* which delineates Oligocene epoch. while the Upper N3 - N4 zone was identified at the base with the first downhole occurrence of *Bolivina impertix* and the top with the First downhole occurrence of *Hanzawaia concentrica* which is an indicative of Miocene. Therefore, the age of the well is from Oligocene to Miocene epoch.

The integration of lithofacies information and paleobathymetric and the presence of specific environmentally indicative foraminiferal species, the depositional environment for the basal interval 10335ft – 11370ft is an indicator of shallow marine to deep marine environment, while the stratigraphic interval of 8635ft – 10335ft is an indicative of shallow marine to outer shelf-slope environment.

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