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FORAMINIFERAL BIOZONATION OF "WELL K-27", GREATER UGHELLI DEPOBELT, NIGER DELTA BASIN, SOUTH EASTERN NIGERIA

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ABSTRACT

Ditch cutting samples collected from interval 2590 – 3300 metres in Well K-27, Greater Ughelli depobelt, Niger Delta were studied for their lithology and foraminiferal content with the aim of dating and subdivision of the sequences penetrated by the well into biozones. The samples were processed using standard foraminiferal processing methods involving sample disaggregation and washing through a 63 micron mesh sieve, drying and picking and subsequent analysis of the foraminifera and accessory fauna. Results showed that the well section penetrated the alternating sand and shale sequence of the Agbada Formation and yielded characteristic benthic foraminifera markers such as Hopkinsina bononiensis, Spiroplectammina wrightii, Uvigerinella sparsicostata, Lenticulina grandis and Bolivina imperatrix which corresponds to P18-P19, P20/N1, P21/N2 and P22/N3 foraminiferal zones and were used to assign an Early Oligocene to Late Oligocene and younger ages for the well. Four foraminiferal zones were identified viz: Globigerina selli/pseudohastigerina barbadoensis zone (P18-P19), Globigerina ampliapertura zone (P20/N1), Globorotalia opima opima zone (P21/N2) and Globigerina ciperoensis ciperoensis zone (P22/N3). These biozones can be useful in the dating and correlation of large rock units of same geologic age.

KEYWORDS: *Foraminifera, Oligocene, Biozone, Greater Ughelli depobelt, Niger Delta.*

1.0 INTRODUCTION

The Niger Delta is a clastic sedimentary basin located in the Gulf of Guinea and comprising of three stratigraphic units of different geologic characteristics. The paralic Agbada Formation is overlain by the continental Benin Formation and is prograding over the marine shales of the Akata Formation (Doust and Omatsola, 1990). The Niger Delta is a major hydrocarbon producing sedimentary basin in Nigeria which became prominent since early 1960's owing to the discovery of oil in commercial quantities in Oloibiri-1 well in 1956 (Reijers *et al.*, 1997;Ajaegwu *et al.*, 2012). Niger Delta lies between Latitudes 4° and 6° N and Longitudes 3° and 9° E in the southeastern part of Nigeria (Ojo *et al.*, 2009). (Fig.1).

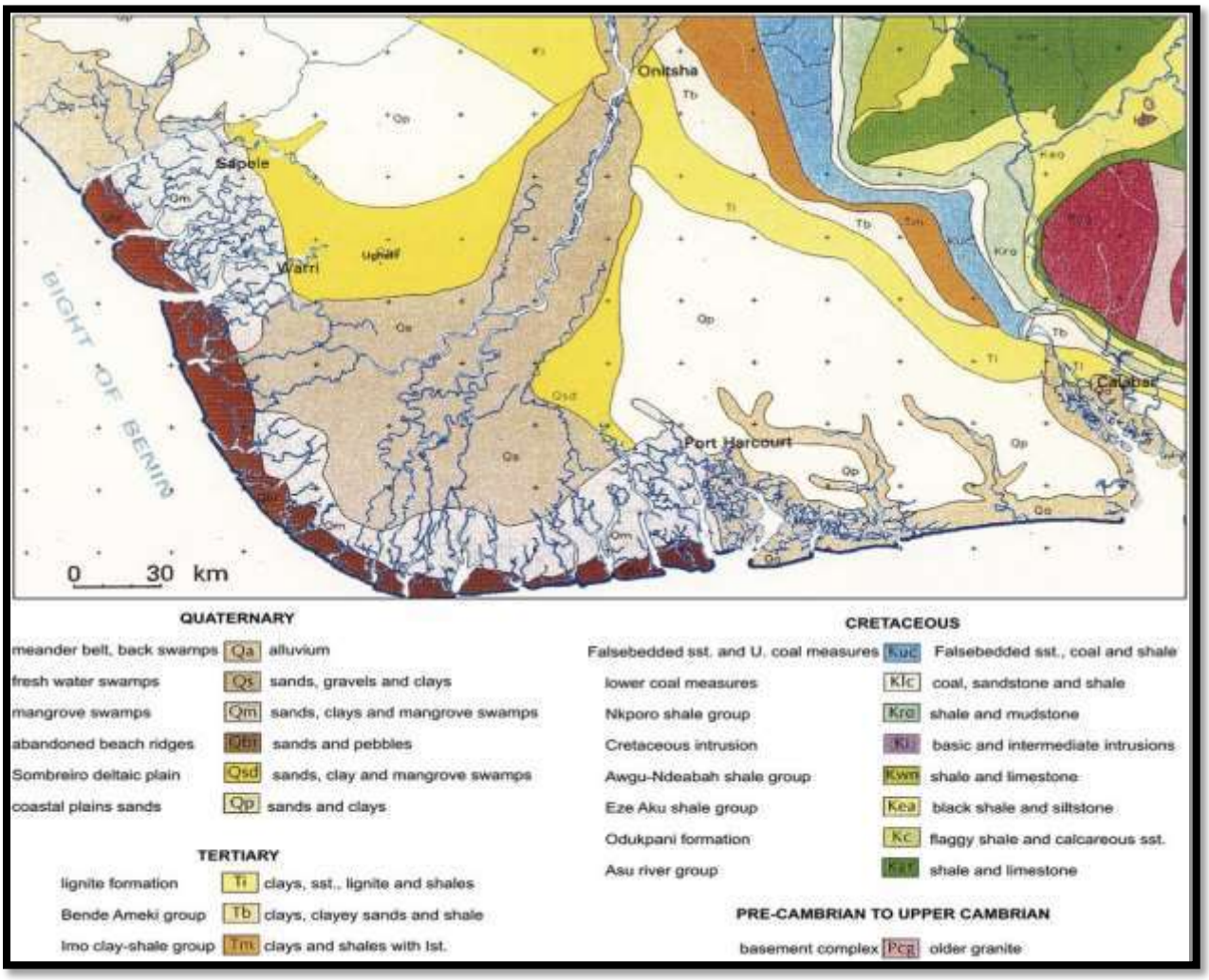

Figure 1: Geological Map of the Niger Delta and surroundings (After Reijers 2011)

The basic unit of biostratigraphy is the biozone, often just referred to as the zone in older literatures. Biozones are stratigraphical units defined on the basis of their guide fossil content (Armstrong and Brasier 2005). Biozones may be recognized on local or regional scales and they are very important in the exploration realm, especially for basin wide and large scale unit correlations (Giwa *et al.*, 2005).

Niger Delta basin has been the subject of several foraminifera biozonation studies. Some of the notable biozonation studies carried out in the Niger delta include the work of Petters (1979), who established two biostratigraphic zones (the upper *Globorotalia tumida* biozone which was dated Pliocene age and the lower *Globorotalia opima-nana* zone dated Oligocene age respectively) in Parabe-1 Well in the Western Niger Delta. Ozumba and Amajor (1999) defined six foraminiferal zones (*Globigerina* cf *ciperoensis* Zone, *Nonion centrosulcatum/Chiloguembelina victoria* Zone, *Eponides eshira* Zone, *Uvigerina sparsicostata* Zone, *Spirosigmoilina oligoceanica* Zone, and *Florilus ex. gr. costiferum* Zone) dated middle to late Miocene from five wells located in the coastal and central swamp

depobelts in the western Niger Delta. Chukwu *et al.* (2012) in their study of Oloibiri-1 well located in the eastern Niger delta also subdivided the strata penetrated by the well into biostratigraphic zones (the *Praeorbulina glomerosa* Zone and a taxon range zone of *Poritextularia panamensis*) which were dated Miocene in age. Okosun *et al.* (2012) while studying the strata penetrated by the wells in Akata field, onshore southeastern Niger delta established four planktic zones (*Globorotalia continuosa* zone, *Globorotalia mayeri* zone, *Praeorbulina glomerosa* and *Globorotalia peripheroroacuta* zone) and benthic zones (*Spirosigmoilina oligocaenica, Uvigerina sparsicostata, Eponides eshira/ Brizalina mandorovensis, Brizalina mandorovensis/Eponides eshira* and *Poritextularia panamensis zones*) which were dated Miocene in age. Fadiya *et al.* (2014) while studying foraminifera biostratigraphy and paleoenvironment of sediments from well AM-2, Niger delta established four informal benthonic foraminferal zones - *Altistoma tenuis* zone, *Eponides africana* zone, *Uvigerina peregrina/Lenticulina grandis* zone and *Bolivina ihuoensis/Hopkinsina hourqi* zone corresponding to the P12, P13/P14, P15 and P16 and younger planktic foraminiferal zones. Four major condensed sections were identified and dated 35.9 Ma, 36.8 Ma, 38.0 Ma and 39.4 Ma. In a similar study, Ajayi and Okosun (2014) identified three planktic foraminifera zones viz: *Globorotalia margaritae margaritae subzone (N18), Globigerinoides obliquus extremus - Sphaeroidinellopsis seninulina zone (N17), and Globorotalia acostaensis acostaensis* zone (N16), dated Late Miocene to Early Pliocene age from four wells drilled in the deep offshore area of the Niger Delta.

The subdivision of a well sequence into units which are correlatable through assigning ages and erection of biozones is enhanced through detailed biozonation studies. Most of the important hydrocarbon reservoirs in the Niger Delta are found in the paralic Agbada Formation (Short and Stauble, 1967). These reservoirs are often situated in structurally and stratigraphic complex zones (Evamy *et al.* 1978). Biozonation of well sequences is important especially for understanding the stratigraphy of the well. A detailed biozonation of well sequences is very important for stratigraphic characterization of the reservoirs and planning new exploration fronts. This work is therefore aimed at dating and subdivision of the sedimentary sequences penetrated by Well K-27 in the Greater Ughelli depobelt (Fig. 2) into biozones, using globally recognized planktic foraminferal zonation schemes of Blow (1969, 1979) in combination with existing benthic foraminiferal zonation schemes (Petters, 1979; 1983) and associated foraminiferal assemblages.

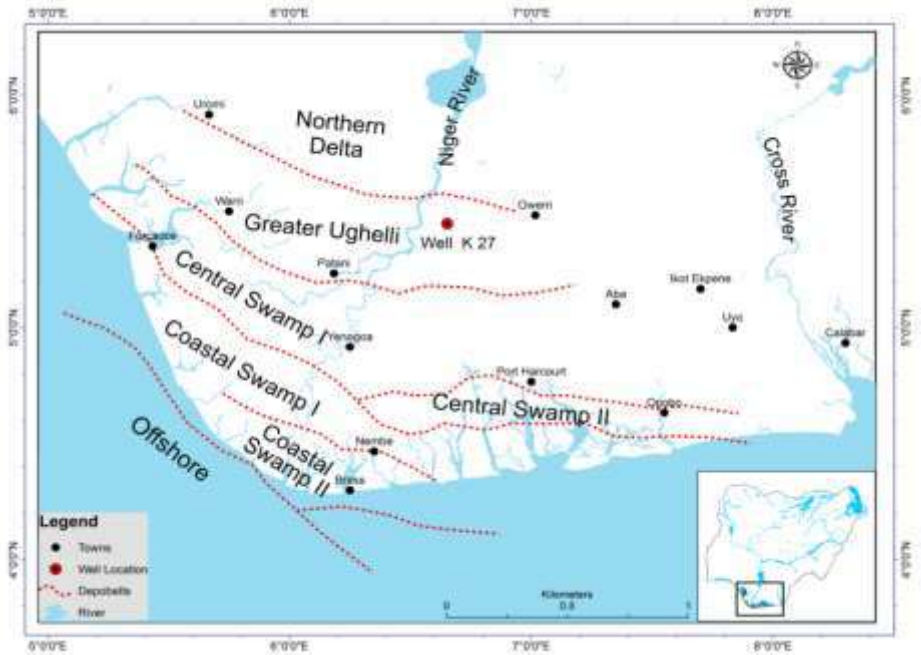

Figure 2: Map of Niger Delta Depobelts showing the location of well "K27".

2.0 REGIONAL GEOLOGIC SETTING

The Niger Delta is situated at the southern end of the Benue trough, corresponding to a failed arm of a rift triple junction, in which the rifting ended in the Late Cretaceous (Lehner and De Ruiter, 1977). Margin failure after the rifting ceased was caused by gravity gliding above basinward-dipping detachments and gravity spreading of a sedimentary wedge with a seaward-dipping bathymetric surface (Corredor *et al.,* 2005). Deformation during this period was driven by upper slope and shelf deposition, which maintains the bathymetric slope and the resulting gravity potential (Corredor *et al*., 2005). Well sections through the Niger Delta generally display three vertical lithostratigraphic subdivisions; an upper delta lithofacies; a middle delta front lithofacies and a lower pro-delta lithofacies (Reijers, 1996). These lithostratigraphic units correspond respectively with the Benin Formation (Oligocene-Recent), Agbada Formation (Eocene-Recent) and Akata Formation (Paleocene-Recent) of Short and Stauble (1967). The Akata Formation is composed mainly of marine shales, with sandy and silty beds which are thought to have been laid down as turbidites and continental slope channel fills. It is estimated that the formation is up to 7,000 metres thick (Doust and Omatsola, 1990). The Agbada Formation is the major petroleum-bearing unit in the Niger Delta. The formation consists mostly of shoreface and channel sands with minor shales in the upper part, and alternation of sands and shales in equal proportion in the lower part. The thickness of the formation is over 3, 700 metres. The Benin Formation is up to 280meters thick, but may be about 2,100 metres in the region of maximum subsidence (Whiteman, 1982) and consists of continental sands and gravels (Tuttle *et al*., 1999). A stratigraphic section showing the three formations of the Niger Delta is presented in Fig.3.

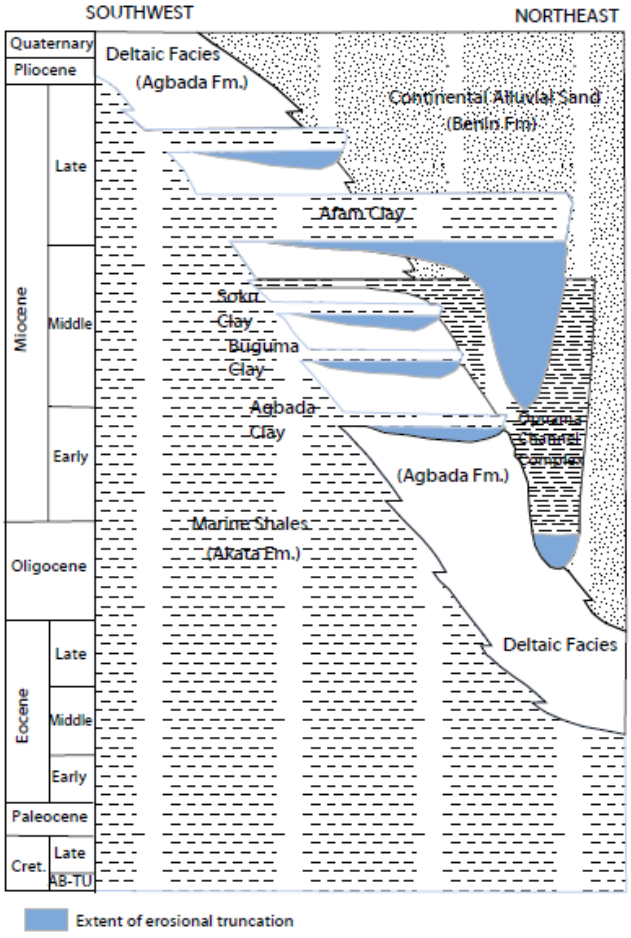

Figure 3: Stratigraphic section showing the three formations of the Niger Delta (Adapted from Tuttle *et al*., 1999).

3.0 MATERIALS AND METHODS

A total of seventy one (71) ditch cutting samples collected from interval 2590 – 3300 metres of Well K-27, Greater Ughelli depobelt, Niger Delta were used for this study. The location of the well is as shown in Figure 1. The ditch cuttings obtained were processed for their foraminifera and other microfaunal accessories using standard foraminiferal processing methods. About twenty (20) grams of each sample was soaked overnight (24 hours) with anhydrous sodium carbonate and water in a sample jar. Disaggregated samples were wet-sieved through a clean 63μ sieve under gentle running water from the tap. The entire trapped residue were dried at 50° C and sieved into three fractions (coarse, medium and fine) to allow for easy picking of the foraminifera and other microfauna. The foraminfera and other microfauna were carefully picked out of the residue with the help of a binocular microscope and transferred into foraminiferal slides for identification. The foraminifera recovered were identified to genus and specie levels where possible using the taxonomic schemes of Loeblich and Tappan (1964), Bolli and Saunders (1985), Petters (1982; 1995) and other relevant foraminifera literatures. The foraminiferal data was inputted into Strata- Bugs (Biostratigraphy Data Management software) to prepare the foraminiferal distribution chart. The residue left after picking the foraminifera samples were used for lithological analysis by examining each interval under a binocular microscope. The lithologic description involved examination of grain size, sorting and grain constituents. 10% dilute hydrochloric acid was used on some of the samples to infer the presence or absence of calcareous minerals and species remains.

4.0 RESULTS

4.1 LITHOLOGIC DESCRIPTION

Lithologic description involved detailed description of seventy one (71) ditch cutting samples from well K-27 (interval 2590m-3300m). The studied well is characterized by fine-coarse grained, moderately sorted, subangular to subrounded, carbonaceous and ferruginized sands/sandstone with minor siltstone and intercalations of dark grey, subfissile to fissile, hard to moderately hard calcareous and micromicaceous shale. Based on lithologic description the lithostratigraphy of the well was established as presented in Table 1.

Table 1: Depth and related lithofacies of sediments in Well K-27

Depth (m)	Lithofacies	Facies	Lithostratigraphy
2590-2630	This facies is composed of sand unit with intercalations of siltstone. This facies is barren of forminifera.	**A**	**AGBADA FORMATION**
2630-2850	This facies is predominantly composed of shale. It is rich in foraminifera assemblage	**B**	
2850-3250	This facies is composed of sandstone and shale in equal parts. This facies is poor in foraminifera assemblage	**C**	
3250-3200	This facies is mainly composed of shale but little intercalations of sandstone and siltstone. This facies is rich in foraminifera	**D**	
3200-3300	This facies consist predominantly of sand/shale intercalation with a siltstone unit. It is basically devoid of foraminifera	**E**	

4.2 FORAMINIFERA RECOVERY

The foraminifera assemblage recovered from ditch cuttings of well K-27 was relatively high throughout the well section except for some barren areas especially at the top and bottom of the well and also at intervals 2970m-2940m and 3030m-3050m respectively (Fig. 4). A total count of two thousand three hundred and ninety three (2,993) foraminifera specimens were identified. Part of this number, two thousand three hundred and seventy five (2,375) were benthics representing 99.25% of the total number of foraminiferal species while the planktonic foraminifera were 16 (sixteen) constituting 0.25% (Fig 5a and 5b).

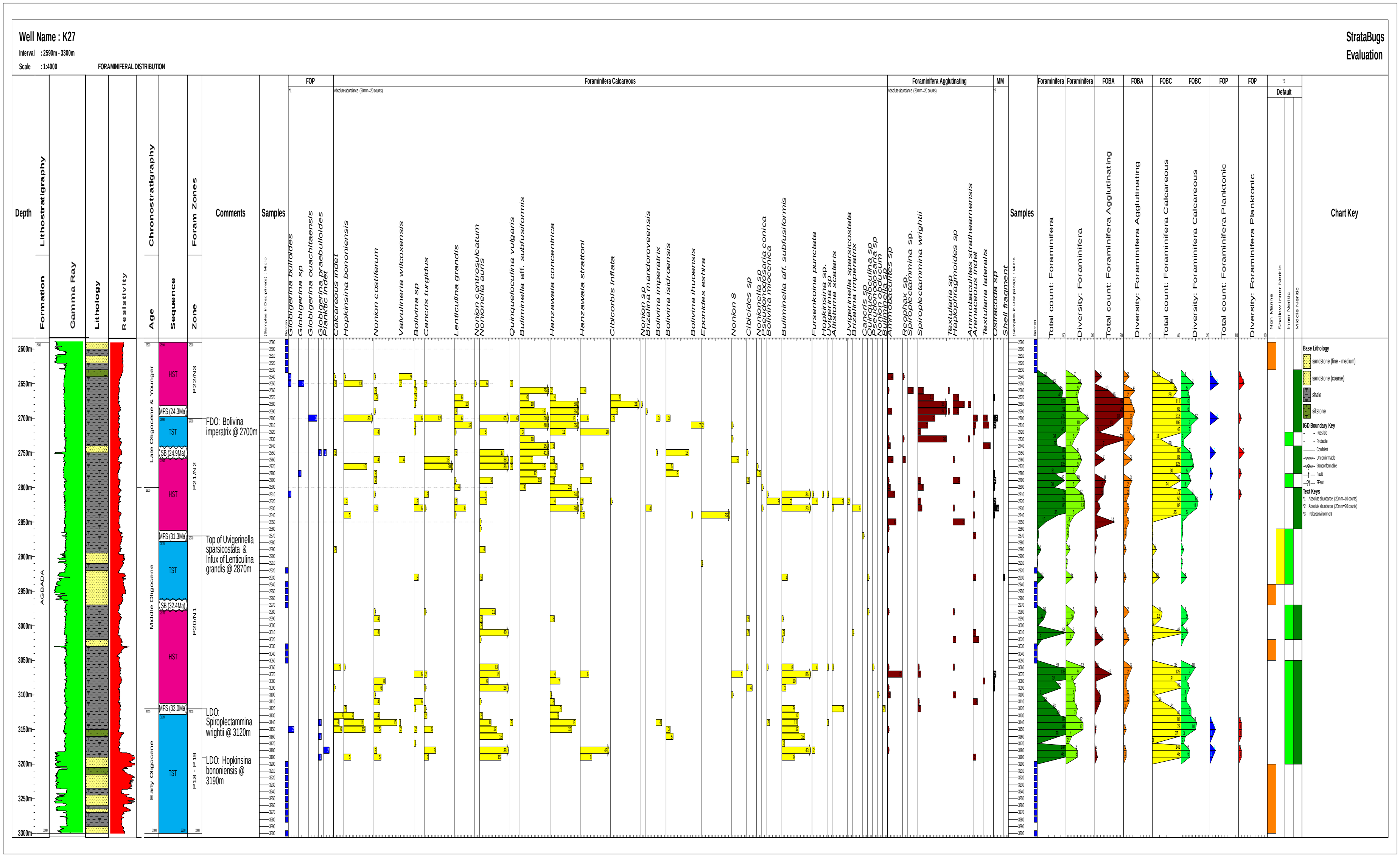

Figure 4: Biostratigraphic chart of well K-27

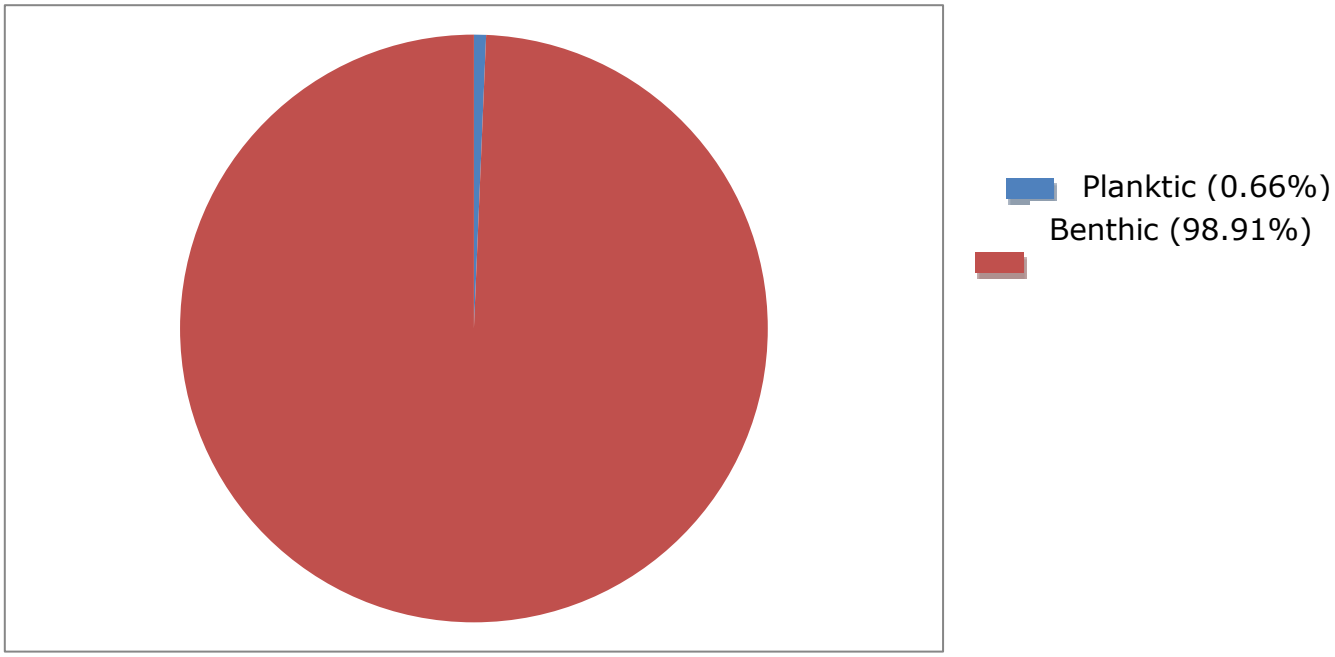

Figure 5a: Pie chart showing the Percentage of Planktic and Benthic foraminifera in Well K-27 well.

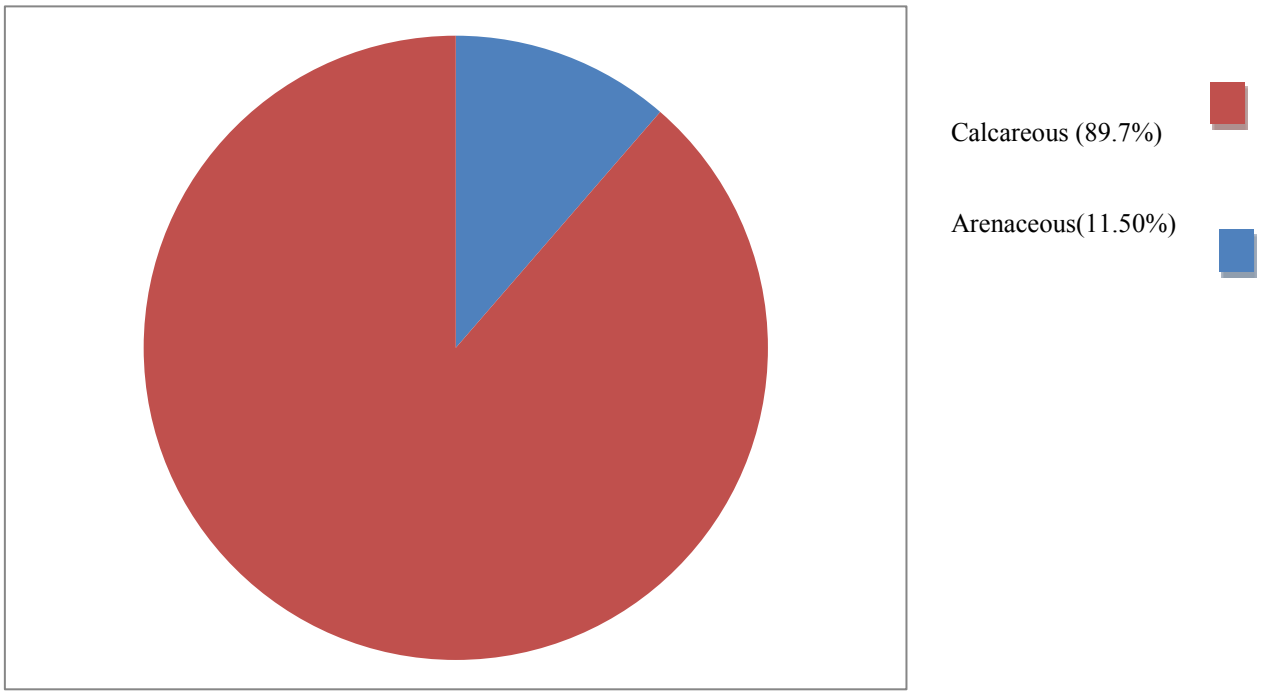

Figure 5b:Pie Chart showing Percentage of Calcareous and Arenaceous foraminifera in Well K-27 well.

Biozonation of the well section was made possible by the abundant occurrences of benthic foraminifera species as well as the presence of diagnostic index planktonic foraminiferal species. The procedures employed for the biozonation of the well section include the First and Last Appearance Datums (FAD and LAD) of chronostratigraphically significant planktic foraminiferal species and the First and Last Appaearance Datums of chronostratigraphically significant benthic foraminifera whose stratigraphic ranges have been established in the Niger Delta (Petters 1979, 1982; Chukwu *et al* 2012; Okosun *et al*

2012). Other procedures employed were the zonation of the well based on characteristic foraminifera assemblage of stratigraphically significant benthic foraminifera species that is well established (Petters 1982, 1995; Fadiya *et al.* 2014). The zones identified were subsequently compared to the standard planktic foraminiferal zonation scheme of Blow (1969, 1979).

Index foraminiferal taxa recovered from the studied section of well K-27 which were used in dating include: *Hopkinsina bononiensis, Spiroplectammina wrightii, Uvigerinella Sparsicostata, Lenticulina grandis and Bolivina imperatrix.* These forms were used to assign an Early Oligocene-Late Oligocene and younger ages to the studied section of the well. These index foraminifera taxa recovered were subsequently used to designate the following foraminifera zones: P18-P19, P20/N1, P21/N2 and P22/N3. Table 2, shows the key foraminiferal events used in the zonation of well K-27 while Table 3 shows foraminiferal biozones that were delineated in well k-27.

TABLE 2: KEY FORAMINIFERA EVENTS IN WELL K-27

S/N	FORAMINIFERAL EVENTS
1.	**FDO of *Hopkinsina bononiensis* @ 2640m**
2.	**FDO of *Bolivina imperatrix* @ 2700m**
3.	**Top of *Uvigerinella sparsicostata and influx of Lenticulina grandis* @ 2870**
4.	**LDO of *Spiroplectaminina wrightii* @ 3120m**
5.	**LDO of *Hopkinsina bononiensis* @ 3190m**

TABLE 3: FORAMINIFERAL BIOZONATION OF K-27 WELL

Interval (m)	Microzones/Events	Age
2590 -2700	***Globigerina ciperoensis ciperoensis* zone (P22/N3). FDO of *Hopkinisina bononiensis*@ 2640**	**Late Oligocene & younger**
2700 – 2870	***Globigerina opima opima zone* (P21/N2). Top of *Uvigerinella spersicostata* & *influx of Lenticulina grandis* @ 2870m**	**Late Oligocene and younger**
2870 – 3120	***Globigerina ampliapertura* zone (P20/N1). LDO of *Spiroplectamina wrightii* @ 3120m**	**Middle Oligocene**
3120 – 3300	***Globigerina selli/ Pseudohastigerina barbadoensis* zone (P18-P19) LDO of *Hopkinsina bononiensis* @ 3190m**	**Early Oligocene**

5.0 DISCUSSION

5.1 Foraminiferal Age and Biozonation

The section of the well analyzed (interval 2590-3300) yielded characteristic foraminifera markers such as *Hopkinsina bononiensis, Spiroplectammina wrightii, Uvigerinella sparsicostata, Lenticulina grandis and Bolivina imperatrix.* This recovered foraminiferal assemblages which correspond to P18-P19, P20/N1, P21/N2 and P22/N3 foraminiferal zones were used to assign an Early Oligocene-Late Oligocene and younger ages to the studied section of Well K-27 (Fig. 4). Further details on the delineated foraminiferal microzones are presented below.

5.2 Foraminiferal zonation

Foram Microzone: P18-P19
Interval: 3120m- 3300m
Age: Early Oligocene
Key Microzone Events:
LDO of *Hopkinsina bononiensis* @ 3190m
LDO of *Spiroplectammina wrightii* @ 3120m

This microzone (P18-P19) is 180m thick. The lower part of this microzone is barren while the upper part has a high abundance and diversity of foraminifera. The calcareous benthic taxa include: *Hopkinsina bononiensis, Nonion costiferum, Nonionella auris, Hanzawaia concentrica and Hanzawaia strattoni.* The arenaceous forms are few, but include *Textularia lateralis* and *Ammobaculites* sp. The planktic forms include *Globigerina praebulloides* and planktic indet. The LDO of *Hopkinsina bononiensis* at 3190m was used to designate the Early Oligocene (Brouwer, 1977) while the LDO *Spiroplectammina wrightii* which occurred at 3120m was used to mark the top of this micro zone (Loeblich and Tappan, 1988).

Foram Microzone: P20/N1
Interval: 2870m-3120m
Age: Middle Oligocene
Key Microzone events:
Top of *Uvigerinelia spartiscostata* @ 2870m
Influx of *Lenticulina grandis* @ 2870m
LDO of *Spiroplectammina wrightii* @3120m

This microzone is 250m thick. It has a low abundance and diversity of foraminiferal taxa although the upper and lower parts have higher occurrences of foraminifera. The calcareous benthics here include: *Nonion costiferum, Lenticulina grandis, Uvigennella sparsicostata, Nonionella auris, Hanzawaia concentrica, Eponides eshira and Bolivina aff. subfusiformis.* The arenaceous benthics include *Ammobaculites sp, Textularia lateralis, Haplophragmoides sp.* and *Spiroplectammina wrightii.*

The top occurrence of *Uvigerinella sparsicostata* at 2870m is an indication of the penetration of Middle Oligocene age (Renz, 1948; Bolli and Saunders, 1985). The influx of *Lenticuluna grandis* at 2870m is also used as a marker for the Middle Oligocene (Bolli and Saunders, 1987; Cushman, 1921). The base of this zone corresponds to the LDO of *Spiroplectammina wrightii* (Bolli and Saunders 1987) at 3120m

Foram Microzone: P21/N2
Interval: 2700m- 2870m
Age: Late Oligocene & younger
Key microzone Events:

FDO of *Bolivina imperatrix* @ 2700m
Top occurrence of *Uvigerinella sparsicostata* and influx of *Lenticulina grandis* @ 2870m.

This interval is 170m thick. It has a high abundance and diversity of calcareous benthics which include *Hopkinsina bononiensis, Cancris turgidus, Hanzawaia concentrica, Buliminella aff subfusiformis, Nonionnella auris, Bolivina imperatrix, Lenticulina grandis, Hanzawaia strattoni, Cibicorbis inflata and Bolivina sp.* The arenaceous taxa include *Spiroplectammina wrightii Ammobaculites sp and Reophax sp.* The upper part of this microzone in well K-27 was barren and was not determined.

Foram microzone: P22/N3
Interval: 2590m-2700m
Ages: Late Oligocene & younger
Key microzone events:

FDO of *Hopkinsina bononiensis* @ 2640

This interval is 110m thick and characterized by high abundance and diversity of calcareous benthics: *Buliminella aff, subfusiformis, Hopkinsina bononiensis, Hanzawaia concentrica, Valvulineria wilcoxensis, Lenticulina grandis and Nonionella auris.* The arenaceous taxa encountered in this zone include *Spiroplectammina wrightii, Ammobaculites sp and Reophax sp.* The upper part of this microzone in well k-27 was barren of foraminifera and as such the top of the microzone is indeterminable in well K-27.

6.0 SUMMARY AND CONCLUSION

The analysed sequences of well K-27 (interval 2590m-3300m), Greater Ughelli depobelt Niger Delta penetrated the Agbada Formation. Planktonic foraminiferal recovery and fairly abundant and diverse benthic foraminifera assemblage recorded enabled the subdivision of the well section into the P18-P19, P20/N1, P21/N2 and P22/N3 foraminiferal biozones. These zones are found within the Early Oligocene-Late Oligocene and younger ages. The age assignment was confirmed by the co-occurrence of characteristic benthic foraminifera markers of the Niger Delta such as *Hopkinsina bononiensis, Spiroplectammina wrightii, Uvigerinella sparsicostata, Lenticulina grandis and Bolivina imperatrix* within the analyzed section of the well. Four foraminiferal zones Viz: *Globigerina selli/pseudohastigerina barbadoensis* zone (P18-P19), *Globigerina ampliapetura* zone (P20/N1), *Globorotalia opima opima* zone (P21/N2) and *Globigerina ciperoensis ciperoensis* zone (P22/N3) were erected for the analyzed section of the study well. The erected zones could be used for dating and correlation with other rock sequences across the world which are of similar age.

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