Journal of the Nigerian Association of Mathematical Physics
Volume **23 (March, 2013), pp 229 – 238**

Determination of Depositional Parameters by the Analysis of Microfossils in Hydrocarbon Exploration and Production

[1]Alile, O.M., [1]Aigbogun, C.O., [1]Airen O.J., [1]Ikponmwen, M.O., and [2]Ezenwoye, I.T.
[1]Department of Physics,
University of Benin, Benin City, Nigeria.
[2]Department of Physics,
Covenant University, Canaan land, Ota, Nigeria

Abstract

A high resolution biostratigraphic study was carried out on one hundred and nine (109) ditch cutting samples retrieved from IDI-1 well, deep offshore Niger Delta, Nigeria. They were subjected to foraminifera and nannofossil analysis to determine their age, biozonation and paleoenvironment of deposition. The studied intervals range from 4811m – 5333m (16020ft - 17760ft) depth and sampled at 18m (60ft) interval. A tentative sequence stratigraphic framework for the studied sequences was established. Four major nannofossil zones were erected for this well. A major unconformity surface was identified. The environments of deposition of the sequence were interpreted. The dark coloured shale characterised the environment as fluctuating salinities and limited circulation, formed under anaerobic conditions. Four condensed sections were identified for the foraminiferal assemblages and four zones for the calcareous nannofossil as correlated to the Global Cycle Chart. The analysis was carried out adopting the use of the STRATABUG software. The tentative sequence stratigraphy obtained from the condensed section dated by the Maximum Flooding Surfaces confirms an early Paliocene to late Miocene age. This is associated with 5.0 Ma, 7.4 Ma, 8.6 Ma and 9.2 Ma.

Keywords: Biostratigraphy, exploration, production, hydrocarbon, early Paliocene, late Miocene.

1.0 Introduction

The research for hydrocarbons has been going on for many generations. As man advances in technology and population, so does his need for hydrocarbon is necessary. In the past, hydrocarbons were found from seepages or from random drilling due to guesses or observation of vegetative conditions. As time went on, exploration and production of hydrocarbons became much more complicated.

Biostratigraphy is defined as the separation and differentiation of rock units on the bases of assemblages of fossils they contain. It is an aspect of stratigraphy which deals with the sequential subdivision of rock strata on the bases of their fossil content. Biostratigraphy had its origins in the late eighteenth century, when William Smith, a civil engineer, deduced that the same strata invariably occurred in consistent sequences and included unique assemblages of fossils. Its establishment as a discrete field of study is considered to have followed from the mid-nineteenth century work of Albert Oppel on Jurassic strata. The term 'biostratigraphy' was used first by Dollo in 1910. Most of its current concepts had been formulated by the start of the twentieth century and have subsequently become more subtle [1]. It focuses on correlating and assigning relative ages of rock strata by using the fossil assemblages contained within them [2].

Usually the aim is correlation, demonstrating that a particular horizon in one geological section represents the same period of time as another horizon at some other sections. The fossils are useful because sediments of the same age can look completely different because of local variations in the sedimentary environment. For example, one section might have been made up of clays and marls while another has more chalky limestone, but if the fossil species recorded are similar, the two sediments are likely to have been laid down at the same time. Ammonites, graptolites, archeocyathids, and trilobites are index fossils that are widely used in biostratigraphy. Different fossils work well for sediments of different ages; trilobites, for example, are particularly useful for sediments of Cambrian age. To work well, the fossils used must be widespread geographically, so that they can occur in many different places. They must also be short lived as a species, so that the period of time during which they could be incorporated in the sediment is relatively narrow. The longer lived the species, the poorer the stratigraphic precision, so fossils that evolve rapidly, such as ammonites, are favoured over forms that evolve much more slowly, like nautiloids. Often biostratigraphic correlations are based on a fauna, not an individual species, as this allows greater

Corresponding author: ***Alile, O.M,*** E-mail: -, Tel. +234 8061624117/+234 8056731089

precision. Further, if only one species is present in a sample, it can mean that the strata were formed in the known fossil range of that organism; that the fossil range of the organism was incompletely known, and the strata extend the known fossil range [3]. For instance, the presence of the fossil Treptichnus pedum was used to define the base of the Cambrian period, but it has since been found in older strata.

Fossil assemblages were traditionally used to designate the duration of periods. Since a large change in fauna was required to make early stratigraphers create a new period, most of the periods we recognized today are terminated by a major extinction event or faunal turnover. By the 1950s, confusion had arisen over the use of geological terms referring to strata and to time. Biostratigraphical classification aims at organizing rock strata systematically into named units based upon the content and distribution of fossils. All rocks possesses lithostratigraphical and chronostratigraphical features. However, as considerable tracts of the Earth's rocks are devoid of fossils, they lack biostratigraphical character. Furthermore, biostratigraphical units are different from other stratigraphical units because they are based on varied, separated remains scattered in uneven quantities within rocks [1]. The fundamental biostratigraphical unit is a *biozones*—the general term for any kind of unit used in calibration and correlation. Fossils that are diagnostic of biozones do not occur everywhere that relevant rocks are found. The areas of distribution of fossils vary; some are limited, others extensive. Widely distributed, abundant, and easily recognizable remains of former living organisms that occur over a narrow span of geological time are called *index fossils*. These fossils are normally of species, the narrowest major classificatory grouping of organisms, and basic to biostratigraphical investigations. However, other members of the taxonomic hierarchy are also used for biostratigraphical purposes. A taxon (plural *taxa*) refers to any biological category, whatever its classificatory rank, and is a widely used biostratigraphical term. The lateral limits of a biozones are determined by the distribution of the taxa by which it is defined; its vertical limits by the persistence of these taxa over time [1]. Surfaces of biostratigraphical change or distinctive character (zone boundaries) are called *biohorizons*. Horizons (biohorizons) are increasingly recognized in modern stratigraphical practice. If a number of biozones possess common features they may be grouped into *superzones*. Biozones may be divided into *subzones* to demonstrate finer detail. Division of subzones into *zonules* is the ultimate expression of such patterns.

Four main formal types of biozones can be designated. An *assemblage-zone* is characterized by certain association of fossil taxa. Its biohorizons delimit this characteristic assemblage. Boundaries can be defined either by eye, or by computerized numerical methods (such as cluster analysis, ordination, and principal components analysis) in order to avoid human bias. A constituent taxon may be distributed beyond the boundaries of an assemblage-zone. The written definition of a zone is by the scientific (Latin) names of two or more of the principal taxa of which it is composed; for example, *Betula–Pinus–Corylus* pollen assemblage-zone [1]. A *stratotype* (i.e. reference stratal section) should also be designated in order that the zone can be identified at other sites. Assemblage-zones are of most use for local correlation, and their constituent taxa can provide important information on past environmental conditions. A *range-zone* is a body of strata that represents the horizontal and vertical range of a specified taxon. An *acme-zone* is characterized by the maximum development, abundance or frequency of occurrence of a taxon but not its entire range. An *interval-zone* occurs between two clearly defined biostratigraphical horizons. It may include nothing diagnostic biostratigraphically, and is normally named after a characteristic of one of its boundaries, such as the appearance or disappearance of a taxon [4].

2.0 The Geology Of Study Area

A high resolution biostratigraphic study was carried out on one hundred and nine (109) ditch cutting samples retrieved from well-3, deep offshore Niger Delta, Nigeria. They were subjected to foraminifera and nannofossil analysis to determine their age, biozonation and paleoenvironment of deposition. The studied intervals range from 16020 - 17760 ft depth and sampled at 60 foot interval. A tentative sequence stratigraphic framework for the studied sequences was established. The Niger Delta area is an oil producing area of Nigeria, also known as the Niger Delta Basin. The Niger Delta basin lies between longitudes 3ºE and 9ºE and latitudes 4ºE and 5º2'N.

The total sedimentary prism, an area of 140,000km (75,000 km2) has a stratigraphic thickness of about 12km and is composed of an overall regressive clastic sequence that reaches a maximum thickness of 29,500 to 39,400 ft. The delta developed with a balance between sedimentation rates and subsidence. The resulting sedimentation patterns appear to have been influenced by the structural configuration and tectonics of the basement. A lot of work has been concentrated on the Niger Delta basin since its discovery as a petroliferous basin in the 1950's, by Shell BP.

The Niger Delta basin is further subdivided into three formations; Pro-delta shales of the Akata Formation (Palaeocene to Recent), Deltaic and paralic facies of the Agbada Formation (Eocene to Recent) and Fluviatile facies of the Benin Formation (Oligocene-Recent). In cross-section, it is a large arcuate sediment wedge and constructive wave-dominated delta. The onshore portion of the Niger Delta area is delineated by the geology of southern Nigeria and southwestern Cameroon. Stable mega-tectonic frames flank the boundaries of the Niger delta basin. These include Benin and Calabar flanks at the northwestern and eastern boundaries of the delta respectively. The Anambra basin and Abakaliki mark the northern boundary of the delta. The Gulf of Guinea borders the Niger Delta basin in the south. Subsequent to its discovery as a petroleum-laden basin, the onshore areas of the Niger Delta were extensively explored for oil and gas. Currently, offshore areas are been explored and exploited for hydrocarbon. The development of geophysical technologies has assisted greatly in deepwater drilling and other exploration techniques, which have proved useful in the search for oil and gas. The joint uses of these

techniques with biostratigraphy, well log, reservoir sequence stratigraphy and so on, have contributed greatly to hydrocarbon exploration in the Niger Delta basin.

In this research, the main aim here is to identify the microfossils in the rock units. The practical value of microfossils in the oil industry is enhanced by their small sizes, which allows them to escape destruction by the drilling bit and their abundance and widespread geographical distribution in sediments of all ages. Biostratigraphy plays a critical role in the building of geologic model for hydrocarbon exploration and in the drilling operations that test those models. The history of life on earth has been one of such creatures that different layers of the sedimentary rocks contain different fossils. When drilling a well into the subsurface earth in search of hydrocarbon, we encounter different fossils in a predictable sequence below the point in time where the organism became extinct.

3.0 Microfossils used in Exploration and Production (E&P)

Rock samples from wells are often limited to ditch cuttings, but may also be sidewall samples or cores. These are then washed and prepared for picking of fossil forms in the samples and interpretation. As used in the oil industry, three biostratigraphic disciplines are involved, they are micropaleontology, nannopaleontology and palaeontology. The separate disciplines have arisen due to differences in the size and chemical composition, which imposes the need for specific preparatory and analytical procedures.

4.0 Research Methodology

Samples were collected from well-3, upto a total of one hundred and nine (109) ditch cutting samples retrieved from well-3, deep offshore Niger Delta, Nigeria. They were subjected to foraminifera analysis for proper identification of hydrocarbon. The studied intervals ranges from 4811m – 5333m (16020ft - 17760ft) depth and sampled at 18m (60ft) interval. The disaggregated sample was washed vigorously in water and processed residue picked of microfossils and presented for dating and paleoenvironmental deductions.

For the grain size, using tap water, wet sieve approximately 4 gms of sediment through a 63-µm sieve to break up clumps and separate the mud and clay-size portions from the rest of the sample. If percentage of carbon is to be analyzed, wet sieving should be done with buffered, deionised water. Sodium metaphosphate ($NaPO_x$ concentration 180 mg/l) can be used as the buffer. Weigh empty beakers prior to wet sieving so the weights of the <63-µm particles and the rest of the sample can be determined after drying at 40^{o}C - 50^{o}C in an oven. The part of the sample > 63 µm should be weighed and then dry sieved for 15 minutes on an electric shaker to determine the following size fractions: >2mm, 1mm - 2mm, 0.500mm -1mm, 0.250mm - 0.500mm, 0.125mm - 0.250mm, 0.0625mm - 0.125mm, and <0.063mm (pan). Record the weights before sieving and weights of each sieve catch. Combine the weight of the pan fraction with the mud removed by wet sieving to determine the total mud fraction. Grain-size analysis is not required to calculate the FORAM Index. However, it is useful to determine if FORAM Index values are influenced by grain size, as well as for additional data analyses

For enumeration of foraminifera taxa, the 1-g portion of the sample should be washed with fresh water over a 63-µm mesh sieve to remove mud-size sediments, and then dried on filter paper at 40^{o}C - 50^{o}C until the sample is thoroughly dry. The dried sample should be disaggregated if necessary, thoroughly mixed, and poured into a mound on a clean, smooth surface. With a fine spatula, a small scoop of the sample (approximately 0.01 gm) is removed from the center of the mound and weighed to the nearest milligram. The weighed subsample is sprinkled over a gridded picking tray and examined using a stereomicroscope. All foraminiferas in readily identifiable condition (i.e., heavily worn and reworked specimens are excluded) are picked onto a cardboard micropaleontological slide, and a preliminary count is made. If the specimens picked are approximately 150 – 200 in number, then the subsample is sufficient. If fewer specimens were picked in the first portion, then a second portion is removed from the mound, weighed, and picked. This process can be repeated until a picked assemblage of 150 - 200 specimens is obtained or until the entire grams of sample are picked.

Sample procedures for micropaleontology processing and nannofossil processing were carried out with all the necessary apparatus and reagents in place. Both the water based mud and oil based mud were considered. The centrifuge process and analysis were done. Adequate sample preparations at various stages are carried out. The STRATABUG software was used in the interpretation of data. The soil samples treatment for paleontology, sedimentology and micropaleontology and the bagging administration were carried out in the Chemistry and Physics laboratories of Covenant University, Canaan land Ota, Nigeria. On the analysis, the following was done.

- Examining each slide under a transmitted ray stereomicroscope.
- Identifying fossils to species using type slides, album and literature.
- Recording name of fossil and number of each species present in the analysis sheet
- Transferring analysis sheet and slides to the Nannopalaeontology.

5.0 Results And Discussion

The result is as presented in tabular form. These were obtained from the analysis of soil samples treatment for palaeontology, sedimentology and micropaleontology.

Table 1: Result from depth ranges of 4811m – 4991m (16020ft – 16620ft)

DEPTH (ft)	ENVIRONMENT	QUANTITY	SPECIES
16020 - 16080	IN	i. 3 ii. 2 iii. 6	i. Haplophragmoides SP ii. Trochammina SP iii. Arenaceous indet
16080 - 16140	IN	i. 1 ii. 1 iii. 1	i. Cornuspira SP ii. Cyclammina SP iii. Haplophragmoides SP
16140 - 16200	CD	i. 1	i.Arenaceous indet
16260 - 16320	IN	i. 1 ii. 2	i. Haplophragmoides SP iii. Trochammina SP
16320 - 16380	IN	i. 1 ii. 3	i. Cyclammina Cancellata ii. Arenaceous indet
16380 - 16440	IN	i. 1 ii. 1 iii. 1	i.Cornuspira SP ii.Haplophragmoides SP iii.Arenaceous indet
16440 - 16500	SHALLOW IN	i. 5	i. Haplophragmoides SP
16500 - 16560	IN	i. 2 ii. 3 iii. 1	i. Trochammina Globigerinifo ii. Haplophragmoides SP iii. Trochammina SP
16560 - 16620	IN	i. 1 ii. 3	i. Saccammina Complanata ii. Haplophragmoides SP

Table 2: Result from depth range of 4991m – 5153m (16620ft – 17160ft).

DEPTH (ft)	ENVIRONMENT	QUANTITY	SPECIES
16620 - 16680	SHALLOW IN	i. 2	i. Haplophragmoides SP
16680 - 16740	CD	i. 1 ii. 3	i.Haplophragmoides SP ii.Arenaceous indet
16740 - 16800	CD	i. 2	i.Arenaceous indet
16800 - 16860	CD	i. 3	i. Arenaceous indet
16860 - 16920	CD	i. 2 ii. 4	i. Trochimmina SP ii. Arenaceous indet
16920 - 16980	CD	i. 2	i.Haplophragmoides SP
16980 - 17040	CD	i. 2	i. Arenaceous indet
17040 - 17100	CD	i. 1	i. Haplophragmoides SP
17100 - 17160	CD	i. 1	i. Haplophragmoides SP

Table 3: Result from depth range of 5153m – 5333m (17160ft – 17760ft).

DEPTH (ft)	ENVIRONMENT	QUANTITY	SPECIES
17160 - 17220	CD	i. 1 ii. 3	i. Haplophragmoides SP ii. Arenaceous indet
17220 - 17280	CD	i. 1 ii. 4	i. Haplophragmoides SP ii. Arenaceous indet
17280 - 17340	CD	i. 3	i.Arenaceous indet
17340 - 17400	IN	i. 1 ii. 2 iii. 1 iv. 1	i. Gastropod ii. Cibicidoides Pachyderma iii.Grobotalia SP iv.Bulimina SP
17400 - 17460	MN	i. 1 ii. 3 iii. 1 iv. 6 v. 2 vi. 1 vii. 2 viii. 1 ix. 1	i. Cyclammina Cancellata ii. Lenticulina Inornata iii.Gastropod iv.Cibicidoides Pachyderma v.Oridorsalis Umbonatus vi.Globorotalia Continuosa vii.Planktic indet viii.Globorotalia SP ix.Haplophragmoides SP
17460 - 17520	MN	i. 2 ii. 6 iii. 1	i.Haplophragmoides SP ii.Cibicidoides Pachyderma iii.Globorotalia Continuosa
17520 - 17580	MN	i. 3 ii. 4 iii. 10 iv. 2 v. 1 vi. 1 vii. 1	i.Lentriculina Inornata ii.Haplophragmoides SP iii.Cibicidoides Pachyderma iv.Globorotalia Continuosa v.Fissurina SP vi.Globigerinoides Obliquus vii.Karreriela Siphonella
17580 - 17640	MN	i. 2 ii. 1 iii. 6 iv. 7 v. 1 vi. 2 vii. 1 viii. 1	i.Lenticulina Inornata ii.Oridorsalis Umbonatus iii.Cibicidoides Pachyderma iv.Haplophragmoides SP v.Cyclammina Minima vi.Planulina Wuellerstorfi vii.Globorotalia Obesa viii.Uvigerina Sparsicstata
17700 - 17760	MN	i. 1 ii. 1 iii. 3 iv. 1 v. 3 vi. 1	i.Globigerinoides ii.Trochammina SP iii.Cibicidoides Pachyderma iv.Bulimina SP v.Haplophragmoides SP vi.Planktic indet

5.1 FORAMINIFERA

Twenty eight ditch cutting samples composited at18m (60ft) over interval 4811m – 5333m (16020ft – 17760ft) of IDI-1 well were processed and analysed for their foraminifera and accessory micro faunal contents (Tables 1, 2 and 3). Twenty four species were recovered in this study, six of these are planktics, seven are calcareous benthics while the remaining eleven are arenaceous benthics. The only accessory micro faunal recorded within the interval is the Gastropod.

The micro faunal distribution chart which displays the stratigraphic distribution of foraminiferal species, the foraminiferal abundance and diversity histograms and the pale bathymetric data is as presented in Figure 2.

5.3 Foraminiferal Zonation

The recorded taxa were used to erect a biostratigraphic zonation for the IDI-1 well based on the zonation scheme of [8] and [9]. The delineated zones are as described below

5.3.1 Interval: 5243m – 5333m (17460ft – 17760ft), Zone: N14 and Older, Top: Placed at the top occurrence of Globorotalia Continuosa, Base: Deeper than last analysed sample, Age: Middle Miocene.

This interval is characterized by fairly abundant occurrence of foraminiferal. The zone is delineated based on the presence of Globorotalia Continuosa and Globorotalia obesa within the interval. Globorotalia Obesa ranges between the planktic zone N15 and N5 while Globorotalia Continuosa ranges between the planktic zone N14 and N6. On the basis of the co-occurrence of these taxa, the interval is not younger than zone N14 but may be older. Other recorded foraminiferal fauna in the interval include Globorotalia spp, Globigerinoides Obliquus. Globigerina Quadrilobatus, Cibicidoides Pachyderma, Lenticulina Inornata, Oridosalis Umbonatus, Planulina Wuellerstorfi and Uvigerina Sparsicostata, Haplophragmoides spp, Karreriella Siphonella and Cyclammina cf (Table 3).

5.3.2 Interval: 4811m – 5243m (16020ft – 17460 ft), Zone: Indeterminate, Top: Shallow than first analysed sample, Base: Placed at the observed top occurrence of Globorotalia Continuosa, Age: Middle Miocene.

This interval is characterized by the paucity of planktic foraminifera species which preclude the assignment of a definite planktic zone to the interval. Calcareous benthic foraminiferal are also rare within the interval. However a few to common occurrence of calcareous benthic are found within the interval. These include Haplophragmoides spp, Trochanmmina spp, Cornuspira spp, Cyclammina Cancellata, Sacammina complanata and Trochammina Globigeriniformis (Table 1, 2 & 3).

The inability to get a refined zonation necessitated the Calcareous nannofossil analysis of the IDI-1 well section so as to refine the age of the studied section of the well.

5.4 Calcareous Nannofossils

A total of twenty eight ditches cutting from interval 4811m – 5333m (16020ft - 17760ft) of the IDI-1 well were prepared and analysed for nannofossil at 60ft interval.

The analysis revealed a fairly diverse and abundant population of calcareous nannofossil within intervals 5171m – 5333m (17720ft – 17760ft) while the upper section 4811m – 5171m (16020ft – 17220ft) was barren of calcareous nannofossil. The observed floral assemblage within interval 5171m – 5333m (17220ft – 17760ft) (Table 1, 2 & 3) facilitated precise zonal delineation and recognition of dated events using the zonation scheme of [5] and [6] respectively. The condensed section was correlated to the global cycle chart of [7]. The analysed section of the IDI-1 well has been dated Middle Miocene (NN4 – NN5 zones) age. The stratigraphic distribution of the recorded taxa is shown in Figure 2.

5.4.1 Calcareous Nannofossil Biozonation

The zonation scheme of [5] was employed for the zonation of the IDI-1 well for calcareous nannofossil biozonation and this is briefly discussed as follow:

5.4.2 Interval: 5243m – 5333m (17460ft – 17760ft), Zone: NN4, Top: Placed at the observed co-occurrence of Siphenolithus heteromorphus and Helicosphaera ampliaperta. Base: Deeper than the last analysed sample, Age: Middle Miocene.
This interval is characterised by fairly abundant and diverse nannofossil assemblage. The co-occurrence of Sphenolithus heteromorphus and Helicosphaera ampliaperta at depth 5243m (17460ft) is an indication that the well section is not younger than the Middle Miocene zone NN4 at this depth. Other nannofossil taxa recorded within the interval include Discoaster deflandrei, Reticulofenestra pseudoumbilius, Cyclicargolithus floridanus, Pontosphaera multipora and Reticulofenestra haqii. The presence of Helicosphaera ampliaperta at depth 5243m (17460ft) indicated that the well section is not younger than 14.91Ma at this depth. The observed floral increase over interval 5243m – 5333m (17460ft – 17760ft) (Table 3) is therefore believed to represent a condensed section associated with the 15.0Ma Maximum Flooding surfaces of [7].

5.4.3 Interval: 4811m – 5243m (16020ft – 17460ft), Zone: NN5, Top: Shallower than the last analysed sample, Base: Placed at the observed co-occurrence of Sphenolithus heteromorphus and Helicosphaera ampliaperta, Age: Middle Miocene.
This interval is characterized by paucity of nannofossil at the lowermost part while the upper interval 4811m – 5171m (16020ft – 17220ft) is barren of nannofossil. The interval has been assigned to zone NN5 based on its stratigraphic position above the positively recognized NN4 zone below. Nannofossils presented in scattered occurrences include Discoaster deflandrei, Reticulofenestra pseudoumbilicus and Helicosphaera carteri (Table 1, 2 & 3).

5.5 Paleoenvironment

The analysed section of IDI-1 well (Figure 1) is composed entirely of shale lithology. Integration of this with the observed benthic foraminiferal species revealed that the lowermost interval 5243m – 5333m (17460ft – 17760ft) (Table 3) of the well was deposited in a fully marine setting ranging from the middle neritic environment to the outer neritic environment. This is due the Oridosalis umbobatus, Cibicidoides pachyderma and karreriella siphonella. This is further supported by the occurrence of some planktic species within the interval.
The upper interval 4811m – 5243m (16020ft – 17460ft) (Table 1, 2 & 3) is dominated by arenaceous benthic foraminifera characteristic of the inner neritic to the middle neritic environment with the quantity of these taxa taken into consideration. These include Haplophragmoides spp, Trochammina spp, Cyclammina Cancellata, Saccammina complanata and Trochammina Globigeriniformis. The details of these are as shown in the enclosed biostratigraphic chart (Figure 2).

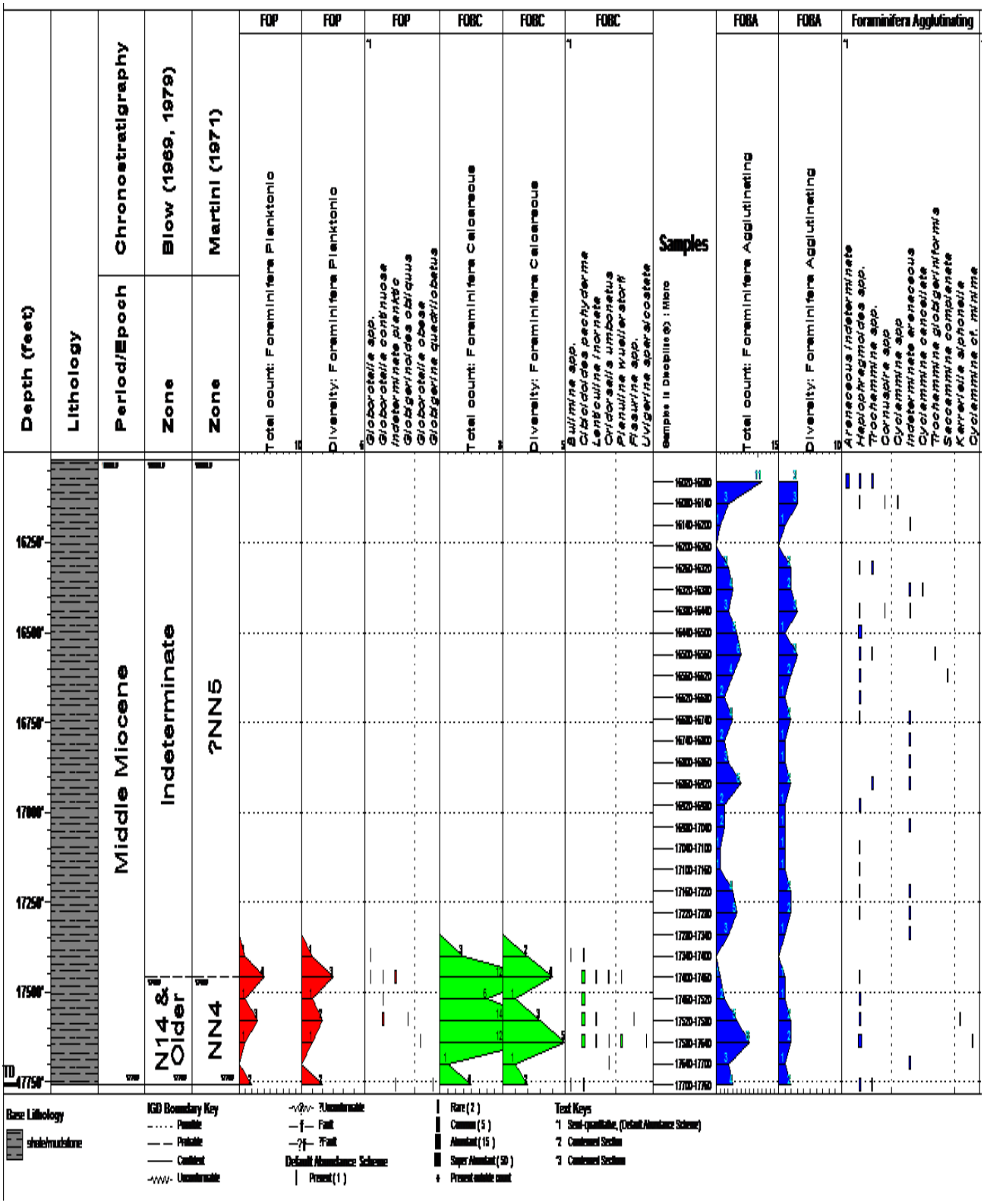

Figure 1: Foraminifera and Calcareous Nannofossils Distribution Chart of IDI – 1 Well

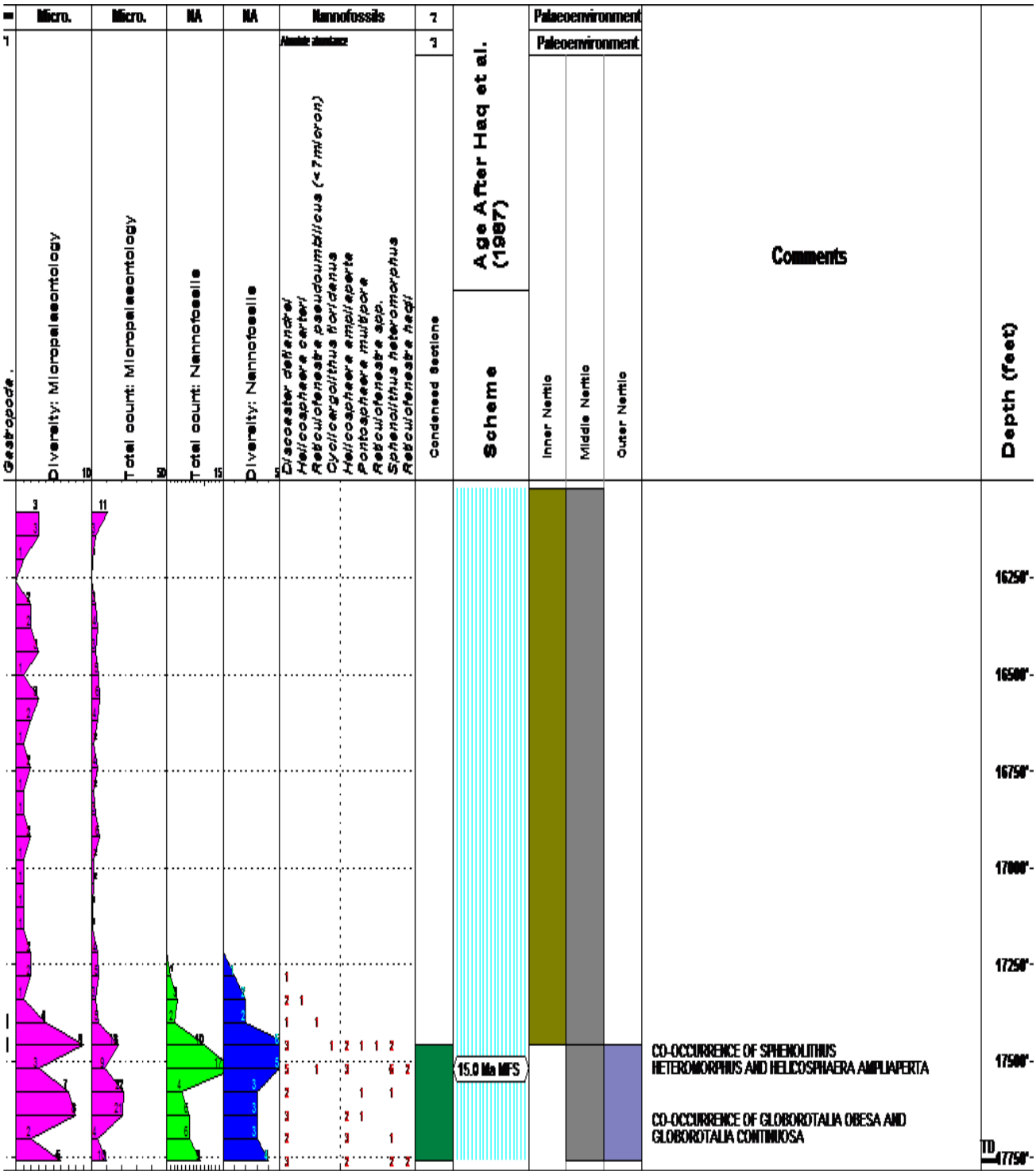

Figure 2: Biostratigraphic chart

6.0 Conclusion

A high resolution biostratigraphic study was carried out on one hundred and nine (109) ditch cutting samples retrieved from IDI-1 well, deep offshore Niger Delta, Nigeria. They were subjected to foraminifera and nannofossil analysis to determine their age, biozonation and paleoenvironment of deposition. The studied intervals range from 4811m – 5333m (16020ft - 17760ft) depth and sampled at 18m (60ft) interval. A tentative sequence stratigraphic framework for the studied sequences was established. A lithostratigraphic description of the ditch-cuttings revealed that the bulk of the lithofacies constitutes shale, which are grey to dark grey in colour, with intercalations of coarse - medium- and fine- grained sandstone beds. Major nannofossil zones include Discoaster deflandrei, Reticulofenestra pseudoumbilicus and Helicosphaera carteri were erected for this well based on the index taxa and fossil assemblage recorded. This interval is characterised by fairly abundant and diverse nannofossil assemblage.

The condensed section was correlated to the global cycle chart of [7]. The analysed section of the IDI-1 well has been dated Middle Miocene (NN4 –NN5 zones) age and the foraminifera description shows that interval is characterized by fairly abundant occurrence of foraminiferal. The zone is delineated based on the presence of Globorotalia Continuosa and Globorotalia obesa within the interval. Globorotalia Obesa ranges between the planktic zone N15 and N5 while Globorotalia Continuosa ranges between the planktic zone N14 and N6. On the basis of the co-occurrence of these taxa, the interval is not younger than zone N14 but older. As such, using two disciplines of biostratigraphy, the determination of the age, biozonation and paleoenvironment of deposition of the IDI-1 well were established.

References

[1]Hancock, P. L. and Skinner, B. J. (eds) 2000. *The Oxford Companion to The Earth*. x+1174 pp. Oxford, New York: Oxford University Press.

[2]Gehling, J.G. 2001: *Proterozoic Ediacara Member Within the Rawnsley Quartzite, South Australia.* Petroleum Abstracts, 30.

[3]Myrow, P.M., Hughes, N.C., Paulsen, T.S., Williams, I., Parcha, S.K., Thompson, K.R., Bowring, S.A., Peng, S.-C., and Ahluwalia, A.D., 2003, Integrated tectonostratigraphic analysis of the Himalaya and implications for its tectonic reconstruction. Earth and Planetary Science Letters, v. 212, 433-441.

[4]Hedberg, H. D., 1974, Basis for chronostratigraphic classification of the Precambrian: Precambrian Research, v. 1, p. 165-177. , Ed., 1976, International Stratigraphic Guide: New York, Wiley, 200 p.

[5]Martini, E., 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. In:Farinacci (eds), Proceedings II planktonic conference, Roma, 1970, 2: pp 739-785.

[6]Gradstein F.M., J.G.Ogg, A.G.Smith, F.P.Agterberg, W.Bleeker, R.A.Cooper, V.Davydov, P.Gibbard, L.Hinnov, M.R. House (†), L.Lourens, H-P.Luterbacher, J.McArthur, M.J.Melchin, L.J.Robb, J.Shergold, M.Villeneuve, B.R.Wardlaw, J.Ali, H.Brinkhuis, F.J.Hilgen, J.Hooker, R.J.Howarth, A.H.Knoll, J.Laskar, S.Monechi, J.Powell, K.A.Plumb, I.Raffi, U.Röhl, A.Sanfilippo, B.Schmitz, N.J.Shackleton, G.A.Shields, H.Strauss, J.Van Dam, J.Veizer, Th.van Kolfschoten, and D.Wilson. 2004: A Geologic Time Scale 2004. *Cambridge University Press*, ~ 500 p.

[7]Haq, B.U., Hardenbol, J., Vail, P.R., 1987. Chronology of fluctuatingsea levels since the Triassic. Science 235, 1156–1167.

[8]Blow, W.H., 1969. Late middle Eocene to Recent Planktonic foraminiferal biostratigraphy. *In* Bronnimann, P., and Renz, H.H. (Eds.), *Proc. 1st Int. Conf. Planktonic Microfossils Geneva,1967*: Leiden (E.J. Brill), 1:199 – 422.

[9]Blow, W.H., 1979. *The Cainozoic Globigerinida*: Leiden (E.J. Brill)