Available online at www.elixirpublishers.com (Elixir International Journal)

Geology

Elixir Geology 108C (2017) 47593-47600

ISSN: 2229-712X

Foraminiferal Study of Koda–1 and Mar–1 Wells of Western Niger Delta Basin, Nigeria

Ojo, A.O[1], Adebayo, O.F[1], Aturamu, A.O[1] and Oguntuase, M. A[2]
[1]Department of Geology, Ekiti State University, Ado- Ekiti, Nigeria
[2]Department of Science Laboratory Technology, Geology Unit, Ekiti State University, Ado- Ekiti, Nigeria

ARTICLE INFO

Article history:
Received: 3 June 2017;
Received in revised form:
28 June 2017;
Accepted: 9 July 2017;

Keywords
Foraminifera,
Biozones,
Planktonic,
Benthonic.

ABSTRACT

A total of 60 composited ditch cutting samples from Koda-1 and Mar-1 wells from onshore and offshore areas of the western Niger Delta Basin were processed and analysed for the lithological, microfauna and microflora contents. Based on the microfaunal analysis, one informal planktonic foraminiferal namely *Orbulina universa* zone which corresponds to the N9 zone (Middle Miocene) and one informal benthonic biozone *Amphistegina radiata* zone with *Bolivina striatula, Spiroloculina antilarum, Quinqueloculina stelligera* and *Bulimina elongata* sub zones were established for Koda–1 well. An informal planktonic foraminiferal named *Globorotalia margaritae* zone which corresponds to N17-N19 (Late Miocene–Early Pliocene) was established for Mar-1 well while one informal benthonic *biozone Cibicides refulgens* zone with *Lagena cantenulata, Quinqueloculina costata, Nonionina orbicularis* and *Planulina wuellerstorfi* sub zones were established. The recovered benthonic foraminiferal assemblages and other microfauna accessories indicated that the sediments of the two wells were deposited in marginal to coastal marine (inner neritic, inner to middle neritic and middle neritic) environments. The paleotemperature of the sea was warm with normal salinity, based on the presence of tropical marine indicator species of *Orbulina universa*.

Introduction

Foraminiferal assemblages are used in this research to determine the faunal contents that are contained in the western part of the Niger Delta Basin. Foraminiferal study have become a very useful tool in the interpretation of paleoecology, paleobiogeography, correlation, stratigraphy and age determination of environment. Information obtained from such studies are important to the understanding of the economic potential of sedimentary basin (Ojo, 2000; Ojo and Salami, 2005; Adekeye et al, 2006). It is known that the distribution of any particular fossil assemblage in any stratigraphic section is controlled either by paleoecological factors or as a result of evolution (Dodd and Stenton, 1981). However, any change in fossil assemblages that correspond with a change in lithology is probably due to the environmental tolerance of the fossil species rather than to their evolution (Ojo, 2006). Thus, fossils serve as environmental indicators and are used to interpret ancient environments of deposition of sediments. This is because their distributions depend on the environmental conditions that existed at the time the organisms lived, died or were buried (Ojo, 2006).

A study of the lithology and fauna contents of some sediments in the basin was carried out using data from two exploratory wells to establish the age and foraminiferal assemblage contents to reconstruct the paleoenvironment of deposition and determine age. The two wells are Koda-1 and Mar-1 wells which lie within the western part of the Niger Delta Basin (Fig. 1)This study seek to contribute a better understanding of the sedimentology, biozones and paleoenvironment of the sedimentary strata in the western Niger Delta Basin area based on the recovered organic contents. It is hoped that the results obtained will be useful in addressing some of the paleoenvironmental problems in the Niger Delta Basin and by extension the Gulf of Guinea region.

Geology of the study area

The Tertiary Niger Delta Basin is situated along the southeastern part of the Gulf of Guinea on the west coast of Africa. It lies between Latitudes 4^0N and 6^0N and Longitudes 5^0E and 8^0E (Fig. 1). It is a large arcuate delta of the destructive wave-dominated type (Weber and Daukoru, 1975). The Basin has been delved into based on its origin and tectonic evolution, paleogeography, stratigraphy and structures. All these have played important roles to the generation and production of petroleum in the region. The stratigraphy of the Niger Delta is intimately related to its structure, the development of each being dependent on the interplay between sediment supply and subsidence rate.

Short and Stauble (1967) recognised the three subsurface diachronous units in the Niger Delta. The deltaic sequence is mainly a sequence of marine clays overlain by some paralic sediments which were capped by continental sands. The general stratigraphy of Niger Delta Basin is as follows: Akata, Agbada and Benin Formations.

Tele: +2348038544040
E-mail address: adeyinka.aturamu@eksu.edu.ng

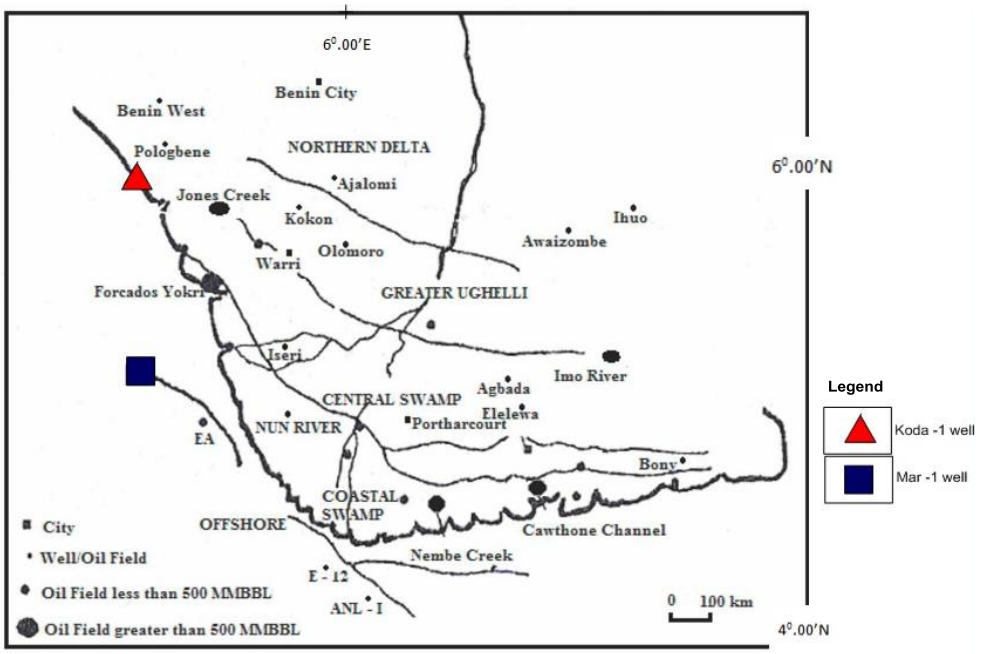

Fig. 1. Map of the Niger Delta Showing the Location of the Study wells (Koda-1 and Mar-1 wells)

The schematic cross section of the Niger Delta showing relationships of the three lithostratigraphic sequences to basement and the stratigraphic column of the three formations respectively is shown in (Fig. 2).

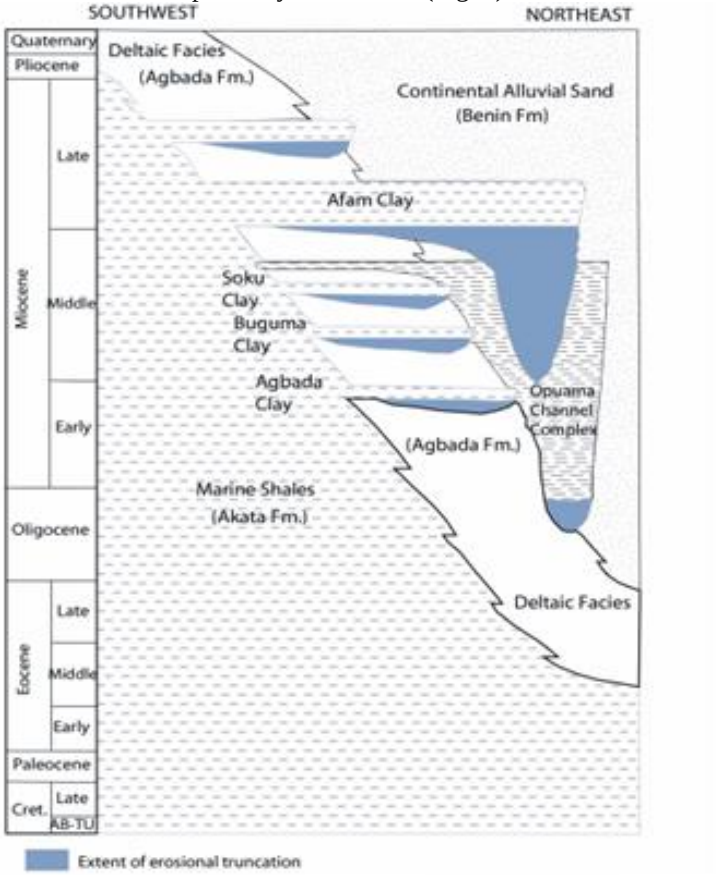

Fig. 2. Stratigraphic Column Showing the Major Formations of the Niger Delta (After Shannon and Naylon, 1989; Doust and Omatsola, 1990).

Materials and Methods of Study

One hundred and forty five (145) ditch cutting samples from Koda-1 well and three hundred and fifty-two (352) ditch cutting samples from Mar-1 well, were processed and analysed for lithologic composition and foraminiferal contents using standard micropaleontological techniques.

Koda-1 well samples were collected from depth interval 945–2265m while Mar-1 well samples were from depth 488–2484m. The samples from both wells were composited at intervals of 18m. Twenty four (24) composited samples from Koda-1 well were selected at an interval of 18m while thirty six (36) composited samples from Mar-1 well were selected at an interval of 18m. A

total of sixty (60) composited samples were processed for both wells. A semi-quantitative analysis which involves chart construction (use of pie charts and line graphs) was applied.

Processing Procedures

Each of the ditch cutting samples was poured into a labelled beaker and was soaked with 10% hydrogen peroxide (H_2O_2) solution for 48 hours. Each sample was washed and wet sieved under a jet of tap water using set of sieves: 150µm, 75µm, 63µm placed over one another until the filtrate was clean. The washed samples were carefully transferred into labelled dishes where they were dried in open air. After drying, the residues were spread into a picking tray and the foraminifera content were carefully picked under the microscope. Classification of Loeblich and Tappan (1988) was followed in addition to the identification of foraminifera and other microfossils using the measures proposed by Fayose (1970).

Results and Discussion

Lithologically, the studied section of Koda-1 well consists of alternation of shaly sandstone/sandy shale and sandstones while Mar-1 well is composed of sandstones, alternation of shaly sandstone/sandyshale (figs. 3 and 4). The recovered foraminifera were employed to study the biostratigraphy of Koda-1 and Mar-1 wells. The analysed sample from the wells yielded few planktonics but very abundant benthonics. Relevant literature materials such as Cushman (1933, 1969), Loeblich and Tappan (1988), Bolli and Saunders (1985), World Foraminifera Catalogue (2000) were used for the identification of the foraminifera.

The planktonics recovered were mainly *Orbulina universa, Globorotalia margaritae, Globorotalia sp* and Globigerina *bulloides.* The *benthonics* recovered are *Cibicides refulgens; Amphistegina radiata; Lenticulina atlantica; Siphogenerina striata; Planulina wuellerstorfi, Spiroloculina antilarum, Lagena cantenulata; Nonionina orbicularis; Bulimina elongata; Bolivina striatula; Textularia luculenta; Quinqueloculina seminulum; Q. stelligera; Q. costata and Q.alata.*

Unidentified moulds/casts, faecal pellets (black and brown) wood and shell fragments, micro gastropods, Ostracod and corals were also recovered in the well apart from the foraminifera.

The photomicrographs of these foraminifera listed above are shown in plates 1 and 2.

Foraminiferal Assemblage of Koda–1 and Mar–1 Wells

This was deduced from the microfaunal distribution chart of the well. The diversity in the foraminifera assemblage of the well is the number of different species at each depth. The analyzed samples of Koda–1 and Mar–1 wells yielded fairly rich foraminifera assemblages which are mostly benthonic foraminifera. A total of seven (7) genera and nine (9) species of foraminifera were recovered from Koda–1 well, of which six (6) genera belong to the benthonics and planktonic is only one. The foraminiferal distribution charts are shown in figures 5 and 6. Foraminifera Planktonics (FOP) is one (with a percentage abundance of 5.46%), Foraminifera Benthonic Calcareous (FOBC) are six (6) (with a percentage abundance of 94.54%). A total of thirteen (13) genera and seventeen species of foraminifera were recovered from Mar–1 well of which ten (10) belong to the benthonics and planktonics is three (3). FOP has a percentage abundance of 3.24%, FOBC has a percentage abundance of 96.51% and Foraminifera Benthonic Arenaceous (FOBA) has a percentage abundance of 0.25%. The ratio of planktonics to benthonics in Koda–1 well is 6:94 while in Mar–1 well is 3:97. This is represented in a pie chart in figures 7 and 8. The foraminifera assemblage is moderately diversified most especially the benthonics. The planktonics are few and are mainly of genera *Globorotalia, Globigerina and Orbulina* which are well known to characterize tropical fauna province. Semi-quantitatively, the recovered species of planktonic and benthonic foraminifera were plotted in a chart as shown in figures 9 and 10.

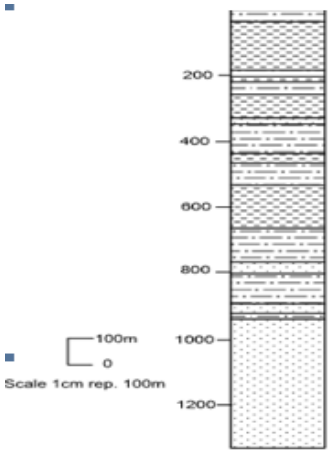

Fig 3.Lithologic Log of koda-1 Well, Western Niger Delta

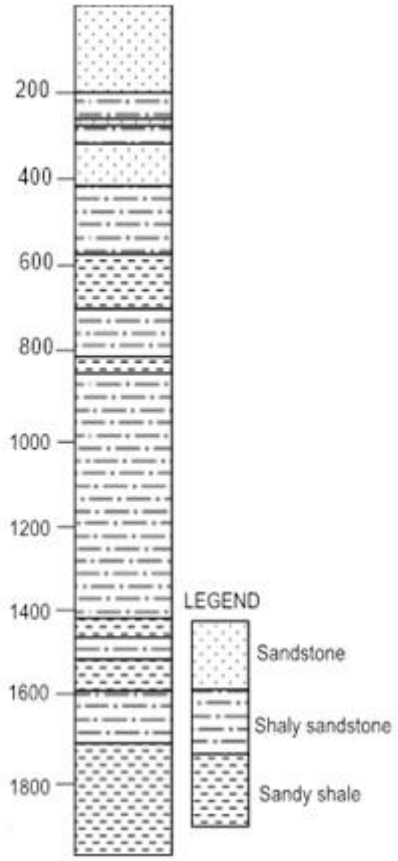

Fig 4. Lithologic Log of Mar-1 Well Western Niger Delta

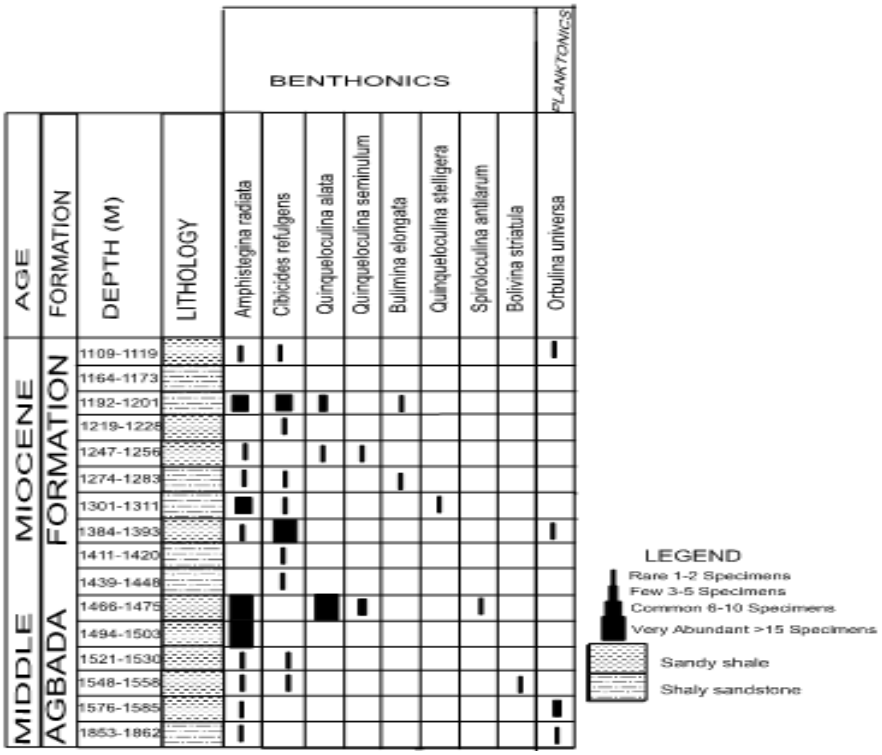

Fig 5. Foraminiferal Distribution of Koda-1Well.

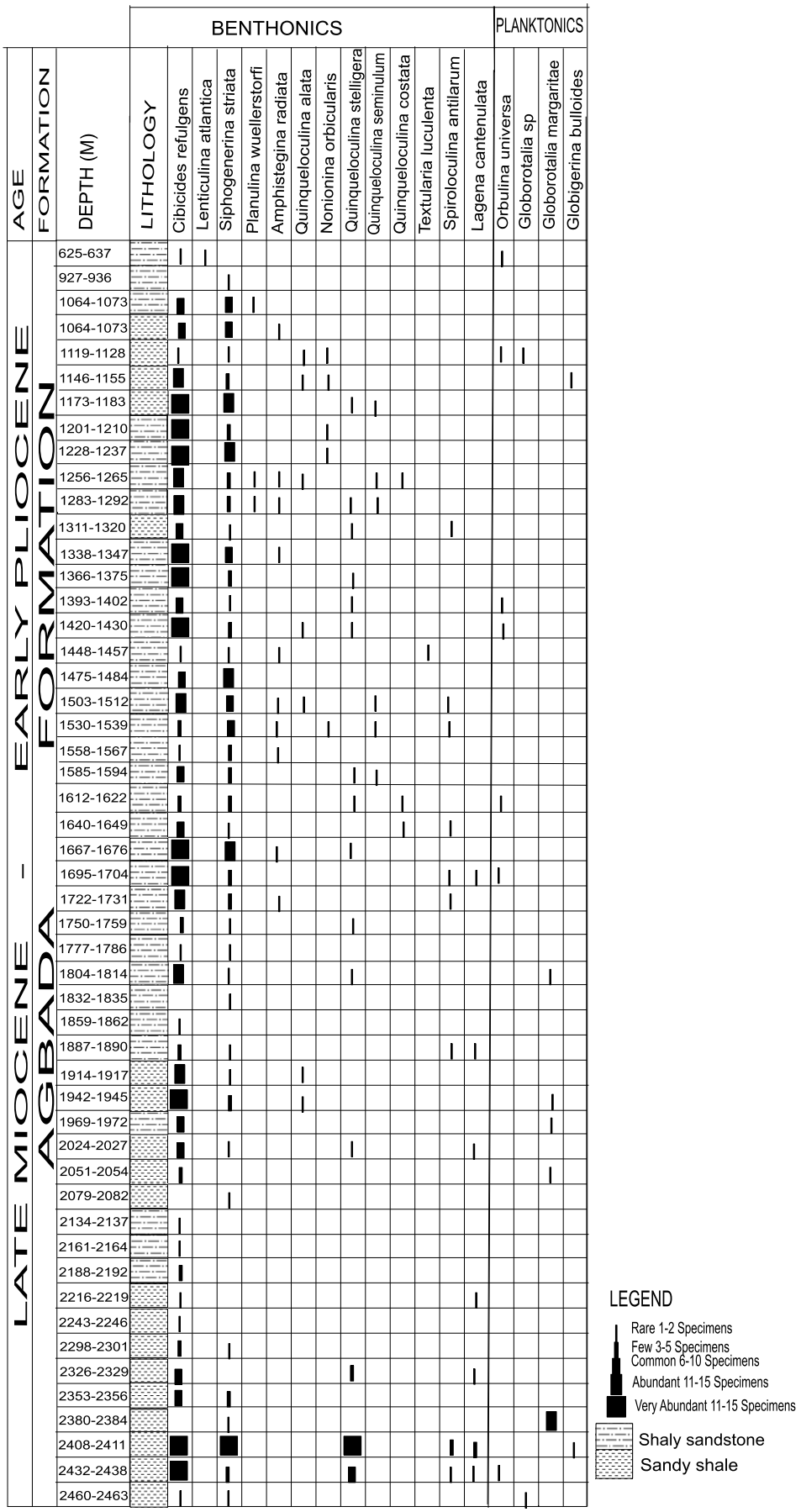

Fig. 6: Foraminiferal Distribution Chart in Mar-1 well

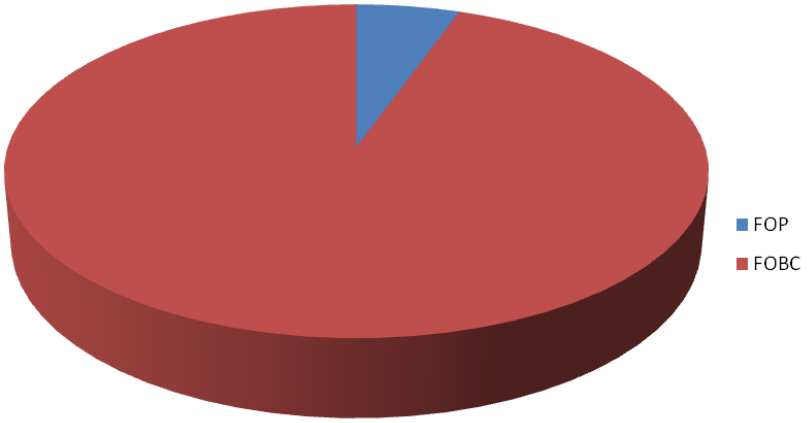

Fig. 7.Pie Chart Showing the Composition of Foraminifera in Koda-1 well

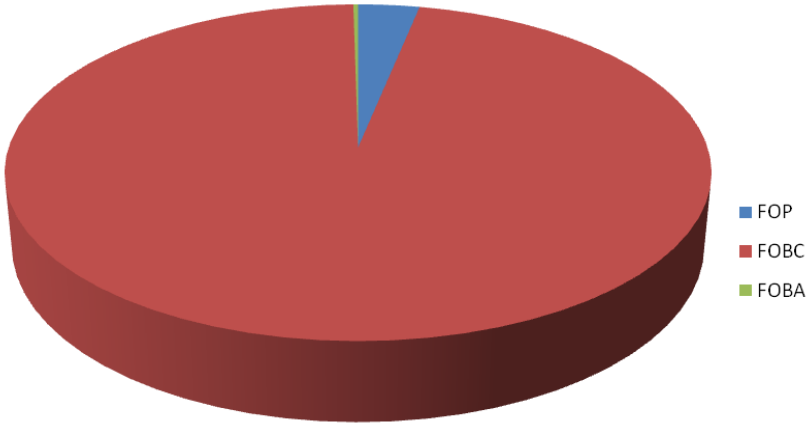

Fig. 8. Pie Chart Showing the Composition of Foraminifera in Mar-1 well

FOP = Foraminifera Planktonic
FOBC = Foraminifera Benthonic Calcareous
FOBA = Foraminifera Benthonic Arenaceous

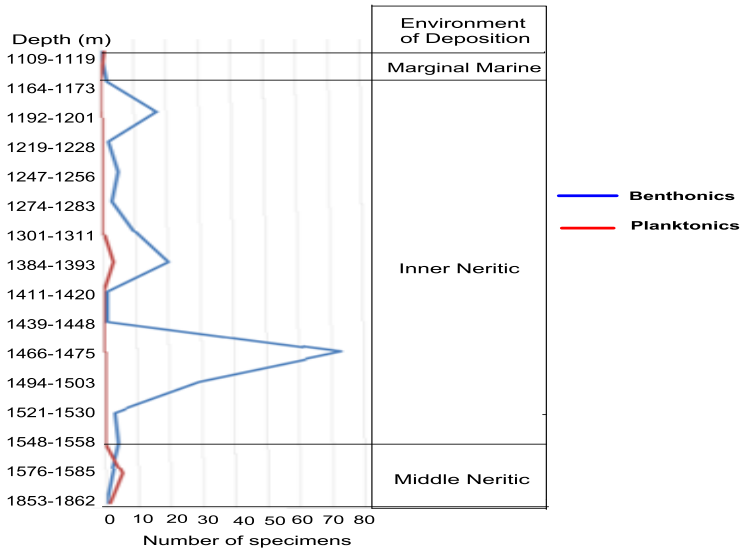

Fig.9. Planktonics and Benthonics ratios in Koda-1 well, western Niger Delta Basin.

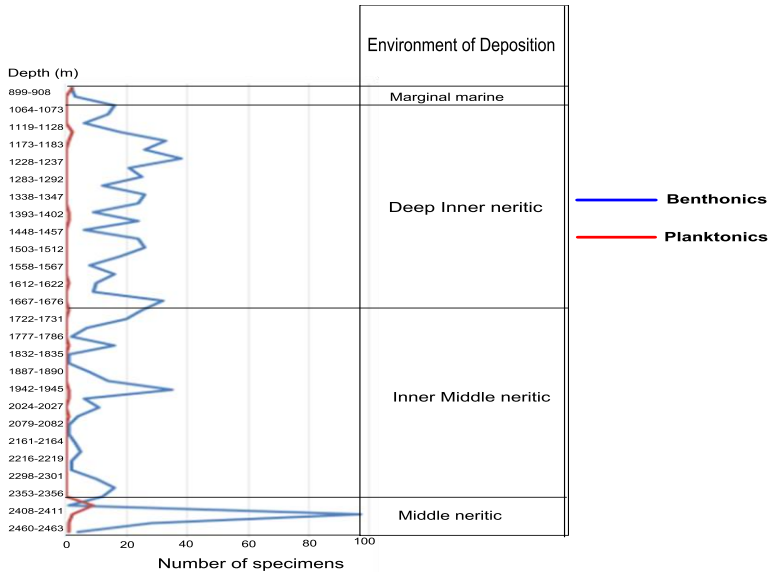

Fig.10. Planktonics and Benthonics ratios in Mar-1 well, western Niger Delta Basin.

Results and Discussions

The lithologic assessment of the ditch cutting samples from Koda-1 and Mar-1 wells confirms the fact that the ditch cutting samples belong to Agbada Formation, which a sequence of sandstones alternating with shales/mudstones with sands predominating in the upper section (Obaje, 2011). The studied sequences of Koda-1 and Mar-1 wells are in consonance with Obaje (2011). The lower part of Mar-1 well is composed of alternation of sandy shale/shaly sandstone but the lower part of Koda-1 well is predominantly sandstones while the upper part is composed of alternation of sandy shale/shaly sandstone. The coarsening and fining upward sequences observed in Koda-1and Mar-1 respectively is attributed to the signature of intermittent subsidence coupled with sedimentation in the basin.

Planktonics and benthonics foraminfera recovered showed moderate diversity with high individual species.

In Koda-1 well; only one informal planktonic zone and one informal benthonic biozone with three subzones have been established. The planktonic zone is *Orbulina universa* zone corresponding to the N9 zone of Blow (1969, 1979); Berggren et al., (1995). The *benthonic biozone* is *Amphistegina radiata with Bolivina striatula*, *Spiroloculina antilarum/Quinqueloculina stelligera*, and *Bulimina elongata* as subzones. In Mar-1 well; only one informal planktonic and one informal benthonic biozone with four subzones have been established. The planktonic zone is *Globorotalia margaritae* zone corresponding to the N17–N19 zone of Blow (1969, 1979); Berggren et al., (1995). The *benthonic biozone* is *Cibicides refulgens/Siphogenerina striata* with *Lagena cantenulata*, *Quinqueloculina costata*, *Nonionina orbicularis* and *Planulina wuellerstorfi/Lenticulina atlantica* as subzones. A Middle Miocene (N9) has been assigned to the studied sediments of Koda–1 well while for Mar-1 well, Late Miocene–Early Pliocene (N17-N19) has been inferred for the sediments. The recovered benthonics indicate a shallow marine environment and they are the most abundant, constituting over 75% of the total foraminifera recovered. The benthonics and planktonics zones correlate with Murray (1973) where he used the abundance of benthonic foraminiferal assemblages in the interpretation of paleoenvironments using Fisher alpha index; In Ogbe (1982), benthonics dominated the assemblages of the biostratigraphy of the Niger Delta; In Ojo (1984), benthonics dominated the assemblage of the recovered foraminifera of central Niger Delta. The rarity of planktonics shows is an indication of a stressful environment.

The two wells are dominated variously by porcellaneous and calcareous hyaline species and rare/devoid of arenaceous (agglutinated) species. This assemblage results from transportation and redistribution of abandoned tests, that in life are mostly attached forms inhabiting a wave agitated, near-shore environment. King et al., (1989) posited that an assemblage composed of rare agglutinants (such as *Textularia*) with abundant calcareous cement indicates deposition above carbon compensation depth (CCD). This was observed in Mar-1 well, there is the rare occurrence of *Textularia luculenta* (agglutinant) and dominance of calcareous forms. Also, the dominance of calcareous forms over arenaceous forms in both wells is similar to the work of Obaje and Okosun (2013b) where the dominance of calcareous forms over arenaceous forms in the study of Tomboy Field, offshore western Niger Delta was reported.

In addition, the percentage ratios of foraminifera benthic calcareous to foraminifera benthic arenaceous (FOBC:FOBA) 96.51:0.25 indicate shallow marine paleoenvironment where clastic dilution usually lead to the destruction of the delicate shells of the planktonics. The dominance of calcareous benthonics is also an indication of depth lower than 4,500m according to Mitterer.

The foraminifera assemblages have been dominated variously by *Cibicides refulgens/Amphistegina radiata* in Koda-1 well while in Mar-1 well the assemblage has been dominated by *Cibicides refulgens/Siphogenerina striata*. *Cibicides refulgens* has been studied by Aleksander S. P. and Delaca T. E. (1987) to be a conspicuous and abundant component of the epifaunal community living on the values of the free–swimming Antarctic scallop, *Adamussium colbecki*. This foraminifer possess a combination of morphological and physiological adaptations, unique among benthic calcareous, which enhance its ability to acquire nutrients in an otherwise oligotrophic and seasonal environment.

Conclusion

The foraminiferal biostratigraphy indicate the dominance of an assemblage of calcareous forms over agglutinated forms. The two wells reasonably show similarities in lithology and faunal contents. The foraminifera of the wells are moderately diversified,

most especially the benthonics but the ratio of planktonics to benthonics show that the paucity of planktonics must have been as a result of the sediments being deposited in a shallow marine environment. This has contributed to the knowledge and understanding of the nature of Neogene deep offshore sediments in terms of their foraminiferal biostratigraphy.

Acknowledgement

The authors wish to express their gratitude for the technical assistance of Dr. O. L. Ademilua and Mr Ajayi C. A. from the Department of Geology, Ekiti State University, Ekiti State.

References

Adekeye, O.A., Akande, S. O., Erdtman, B. D., Samuel, O. J. and Hetenyi, M. (2006): Hydrocarbon Potential Assessment of the Upper Cretaceous-Lower Tertiary Sequence in the Dahomey Basin Southwestern Nigeria. *NAPE Bulletin*. 19(1):50-60.

Aleksander, S. P. and Delaca, T. E. (1987): Feeding adaptations of the foraminiferan *Cibicides refulgens* living epizoically and parasitically on the Antarctic scallop *Adamussium colbecki*. Biological Bulletin 173: 136-159. http://dx.doi.org/10.2307/1541868.

Berggren, W.A., Kent D.V., Swisher, C.C. and Aubry, M.P., (1995):A revised Cenozoic geochronology and chronostrat igraphy. SEPM. *Society for Sedimentary Geology, Special Publication.* 54. pp. 129-212.

Blow, W.H. (1969): Late Middle Eocene to Recent Planktic Foraminifera Biostratigraphy. *Proceedings, First Internation al Conference Planktonic Microfossils, Geneva,* 1967(1) pp. 199-422.

Blow, W.H. (1979): The Cenozoic Globigerinida. Leiden, E. J. Brill, ed.3, pg. 413.

Bolli, H.M. and Saunders, J.B. (1985): Oligocene to Holocene Low Latitude Planktic Foraminifera. Elizabeth Publishing Co., pp. 155-250.

Cushman, J. A. (1933): The Foraminifera of the Tropical Pacific Collections of the "Albatross" 1899-1900. Part 2: Lagenidae to Alveolophragminidae, Smithsonian Institute, *United State National Museum Bulletin*, vol.161 pp.19.

Cushman, J.A. (1969): Foraminifera: Their Classification and Economic Use 4th Edition. *Publication Havard University Press Massachusetts*; 605 pp.

De Monfort, (1808): Biology Bulletin. pp. 173:136-159 (August, 1987).

Dodd, J.R. and Stenton, R.J. (1981): Paleoecology, Concepts and Applications. New York, Wiley & Sons.

Doust, H. and Omatsola, M.E. (1990): The Niger Delta: hydrocarbon potential of a Major Tertiary Delta province. *Proceedings of KNGMG Symposium Coastal Lowland Geology and Geotechnology 1987, Dordrecht, Kliwer, pp*. 203–212.

Fayose, E.A. (1970): Stratigraphical paleontology of Afowo – 1 well, South Western Nigeria. Journal of Mining and Geology, Nigeria.5 (1, 2): pp. 1-97.

King, C.H. W., Bailey, C., and Burton, D. King (1989): Cretaceous of the North Sea – In: Jenkins, D. G., J. W.
Murray (eds), Stratigraphical Atlas of Fossil Foraminifera British.

Loeblich, A.R., and Tappan, H. (1988): Foraminiferal Genera and their Classification. Van Nostrand Rienhold Co., New York, pg. 97.

Mutterer,R.M.:Stability-www.utdallas.edu/pujana/oceans/calcium.html. Date assessed 29th May, 2017.

Murray, J.W. (1973): Distribution and ecology of living benthic foraminiferids. Crane, Russels & Co., New York, pg. 244.

Obaje,S.O.(2011):Sequence Stratigraphy and Biostratigraphy of XX-1 (Tomboy) Field, offshore Western Niger Delta, Nigeria. Unpublished Ph.D Geology dissertation, Federal University of Technology, Minna Nigeria, pgs. 254-573.

Obaje, S.O. and Okosun, E. A. (2013b): Paleoenvironmental Interpretation of Tomboy Field, Offshore Western Niger Delta, Nigeria. *International Journal of Science and Technology*. vol. 2 no 9, pp. 628–638.

Ogbe, F.G.A. (1982): The Biostratigraphy of the Niger Delta, Nigeria. *Journal of Mining and Geology, Nigeria* 18 (20): pp. 545-582.

Ojo, A.O. (1984): Microbiostratigraphical studies of Magna–1 well Niger delta. M.Sc Thesis, University of Ife, Ile–Ife. pgs. 34–42.

Ojo, A.O. (2000): Distribution of Foraminiferal in Magna-1 well sediments: Implications on age and paleoecology of western Niger Delta, Nigeria. J. Biol. Phys. Sci., 1 (1): 114-128.

Ojo,A.O.(2006): Foraminiferal Assemblage and Paleo environment of the Agbada Formation, Central Niger Delta,Nigeria.Journalof Applied and EnvironmentalSciences, vol. 2 No 1, pp 98-111.

Ojo, A.O. and Salami, M. B. (2005): Quantitative analysis of Neogene Foraminifera in the central Niger Delta. Ife J. Sci. 7(2):271-289.

Shannon, P.M. and Naylon, D. (1989): Petroleum basin studies. Graham and Trotman, pp. 206.

Short, K.C. and Stauble, A.J. (1967): Outline of the Geology of Nigeria Delta. *American Association of Petroleum Geologists Bulletin*. 51, 761–779.

Weber, K.J. and Daukoru, E.M., (1975): Petroleum geological aspects of the Niger Delta. *Journal of Mining and Geology,* 12, pp. 9-22.

World Foraminifera Catalogue (2000): www.catalogueoflife. org/col/details/database/id/157.