

Early to Middle Miocene Foraminiferal Biostratigraphy of Well03, Shallow Offshore, Niger Delta, Nigeria

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Abstract

Ditch-cutting samples obtained from well-03, shallow offshore, Niger Delta, Nigeria were analyzed for foraminifera to establish age, biozonations and paleoenvironments of deposition. 20 g of each of 112 cuttings were subjected to a processing technique for their foraminifera content using kerosene, biofacies data generated were inputted into strata bug software to produce foraminiferal distribution chart. Lithologically, the studied sequences were composed of greyish shales, siltstones and mudstones with intercalation of sandstones. A fairly diverse foraminiferal assemblage was recovered. Also, three planktic foraminiferal biozones comprising *Globorotalia peripheroacuta* zones, *Orbulina universa*, and an undiagnostic zones were established based on the distribution of the index taxa. The establishment of these zones aided the assignment of the early Miocene - middle Miocene age range to the studied section. The environment of deposition of the strata ranged from inner neritic to outer neritic based on the occurrence of *Quinqueloculina inornata*, *Ammonia becarrii*, *Lenticulina inornata*, *Eponides eshira*, *Brizalina mandoroveensis* and *Uvigerina sparsicostata* species

1.0 Introduction

The Niger Delta basin belongs to the most important hydrocarbon province of Nigeria in West Africa, it is situated between longitudes 3° E and 9° E and latitudes 4° N and 7° N (Figure 1) and is known to be holding roughly 34 billion barrels of oil in addition to its enormous gas resource. Exploration activities commenced in the late 50s following the first spotting of commercial quantities of petroleum in the basin. Several studies on the stratigraphy of the basin have been carried out by both multinational oil companies and other authors to explain the geology of the basin [1],[2],[3],[4] However, much of the findings in the basin have been kept secret by the oil companies for proprietary reasons. Looking at the intricate stratigraphic nature of the basin occasioned by the presence of many synsedimentary faulting and related structural elements [2], the need for careful biostratigraphic correlations from well to well cannot be over-emphasised [5].

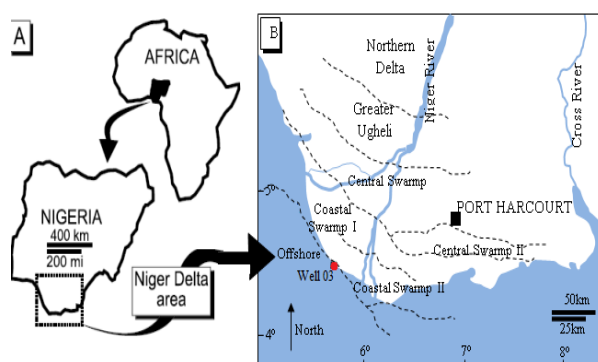


Figure 1: A. Location of Niger Delta along the west coast of Central Africa B. Location of Well-03, shallow offshore

Several workers have utilized foraminifera and other microfossils to study the

biostratigraphy of the Niger Delta region. The Niger Delta Neogene (N) 8-N 9 planktic zone of the early to middle Miocene age was described based on the presence of *Praeorbulina glomerosa*, *Globorotalia obesa*, *Globigerinoides immaturus*, *Orbulina universa* and a suite of benthic foraminiferal assemblages; *Bolivina miocenica*, *Bolivina beyrichi*, *Saccamina complanata* and *Cyclamina minima* [6],[7].

Also, the Neogene boundaries have been determined by [8],[9] based on the occurrence of planktonic foraminiferal and established zones such as *Globorotalia margaritae* Zone (N18), *Globigerinoides obliquus extrenules-sphaeroidinellopsis seminulina* Zone (N17), *Globorotalia acostaensis* Zone (N16) which were utilized in assigning ages to corresponding maximum flooding surfaces and sequence boundaries.

The rich presence of the benthic foraminifera has permitted the description of the neritic environments that are affected by the progradational pattern of deposition in the basin [10],[11]. This study was carried out to determine the age and depositional environment of strata penetrated in well-03 shallow offshore Niger Delta.

2.0 Materials and methods

2.1 Materials

One hundred and twelve ditch-cutting samples for foraminiferal analysis were retrieved from well-03 Shallow Offshore, Niger Delta Basin, Nigeria within the range of 6000 - 12420 ft at 60 ft intervals.

Detailed identification of forms separated from the samples (to species level where possible) was made of all taxa encountered in each slide using binocular microscope.

The photomicrographs of some of the microfossils were taken (Plate 1 and 2) and the data from the slides and others were plotted on foraminiferal distribution charts on a scale of 1:5000 using Strata bug biostratigraphic software (Figure 2).

2.2 Methods

Twenty grams of each sample were processed for their foraminiferal content using the standard preparation techniques. The weighed samples were soaked in kerosene and left overnight to disaggregate, followed by soaking in a detergent solution overnight. The disaggregated samples were then washed-sieved under running tap water over a 63 μm mesh sieve. The washed residues were then dried over a hot electric plate and sieved (when cooled) into three main size fractions, namely: coarse, medium and fine (250, 150 and 63 μm meshes). Each fraction was examined under a binocular microscope. Foraminifera identification was made to genus and species levels where possible using the taxonomic scheme of [12], and foraminiferal paleo bathymetric work on significant benthic foraminifera [13].

The revised Cenozoic chronostratigraphic scheme of [14], was utilized along with the deep-water benthonic foraminiferal species within the Niger Delta. The zones recognized were discussed and correlated to planktonic zones [14],[15]. The zonal names

used in the study conform to the foraminiferal zonal scheme developed by the stratigraphic committee of the Niger Delta

3.0 Results and Discussion

Twenty-five (25) species of planktics, 48 species of calcareous benthics and 7 species of arenaceous benthics forms were recovered. Age significant assemblages of planktic and diagnostic paleoenvironmental benthic forms were utilised for the interpretations. Some photomicrographs taken and presented in plates 1 and 2. The identified foraminifera are presented in a distribution chart (Figure 2) and important bio-events recognised was used to decipher zonal boundaries and the assignment of age (Figure 3). Three planktic foraminiferal zones delineated and correlated with worldwide zones were discussed:

3.1 *Orbulina universa* Zone

Stratigraphic interval: 9860 - 10800 ft.

Age -Middle Miocene

Definition: The zone extends from LDO *Orbulina universa* at 10800 ft. to the Last downhole occurrence (LDO) of *Globorotalia fohsi peripheroacuta* datum at 9860 ft. The zone is also characterized by the LDO of *Lenticulina inornata* and *Florilus atlanticus* at 9860 ft. This zone is considered to be part of the 16.0 Ma mfs condensed section. This zone also correlates with the upper N9 foraminiferal zone of zone of [15].

3.2 *Globorotalia fohsi peripheroacuta* Zone

Stratigraphic interval: 7125 - 9860 ft.

Definition: The zone is defined by the LDO of *Globorotalia fohsi peripheroacuta* at 9860 ft. and FDO of *G.scitulla* at 7125 ft. The zone is characterized by FDO of *Cassigerinella continua* and FDO *Brizalina interjuncta* at 7120 ft. The zone is considered to be part of the 14.8 Ma mfs condensed section. The zone correlates with the N10 foraminiferal zone of [15].

3.3 Undiagnostic Zone

Stratigraphic interval: 10800 - 12420 ft.

Age - Early Miocene

Definition: The zone extends from 10800 ft to the base of the interval studied at 12420

ft. The zone is bounded at the top by the LDO of *Orbulina universa* at 10800 ft and is characterized by the LDO of *Globigerinoides immaturas*, *Globigerinoides ruber*, *Globigerinoides saculifera* 11520 ft. This zone was assigned early Miocene, even though zonal diagnostic forms such as *Praeorbulina glomerosa*, *Paragloborotalia peripheroronda*, *Praeorbulina sicana*, *Globigerina bisphericus* were not recovered from sediments, however as the zone which directly underlies a definite *Orbulina* Horizon which defined the beginning of middle Miocene and the end of early Miocene. This zone also correlates with the upper N8 foraminiferal zone of zone of [15].

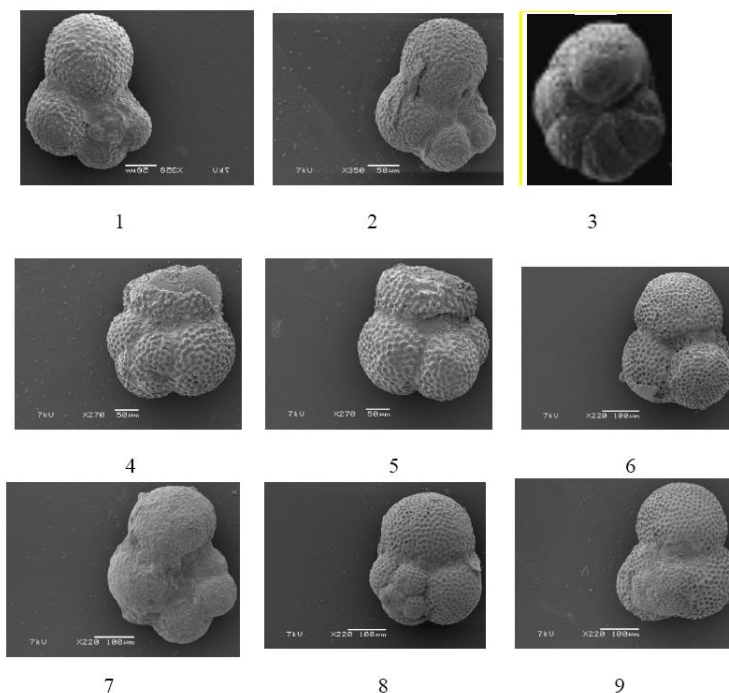


Plate 1: Planktic Foraminifera

Where:

- 1 -2 *Globorotalia obesa*, Bolli,
- 3 *Globorotalia fohsi peripheroacuta* Blow & Banner,
- 4 -5 *Globigerinoides bollii*, Blow,
- 6 *Globigerina quadrilobatus*, d'Orbigny,

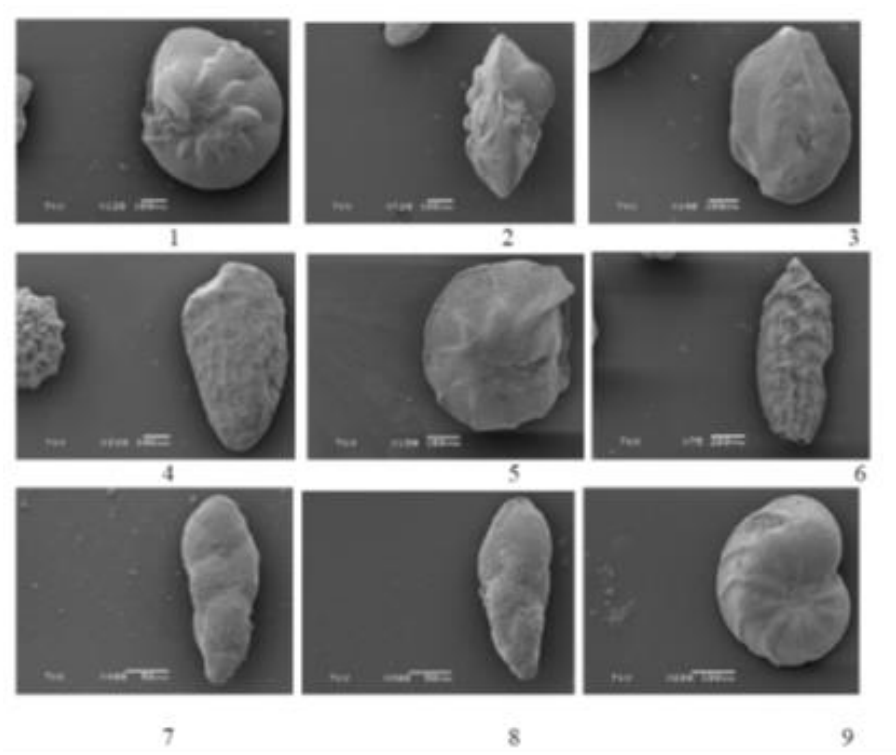
7 *Hastigerina* spp8-9 *Globigerinoides trilobustrilobus* Reuss,

Plate 2 : Benthic Foraminifera

- Legend:**
- 1-2 *Eponides eshira* de Klasz & Rerat
 - 3 *Spiroculina* spp
 - 4 *Brizalina Interjuncta* Cushman,
 - 5 *Cibicorbis inflata*
 - 6 *Brizalina mandoroveensis* Graham,de Klasz & Rerat
 - 7-8 *Hopkinsina bonionensis* Howe &Wollace,
 - 9 *Hanzawaia* spp

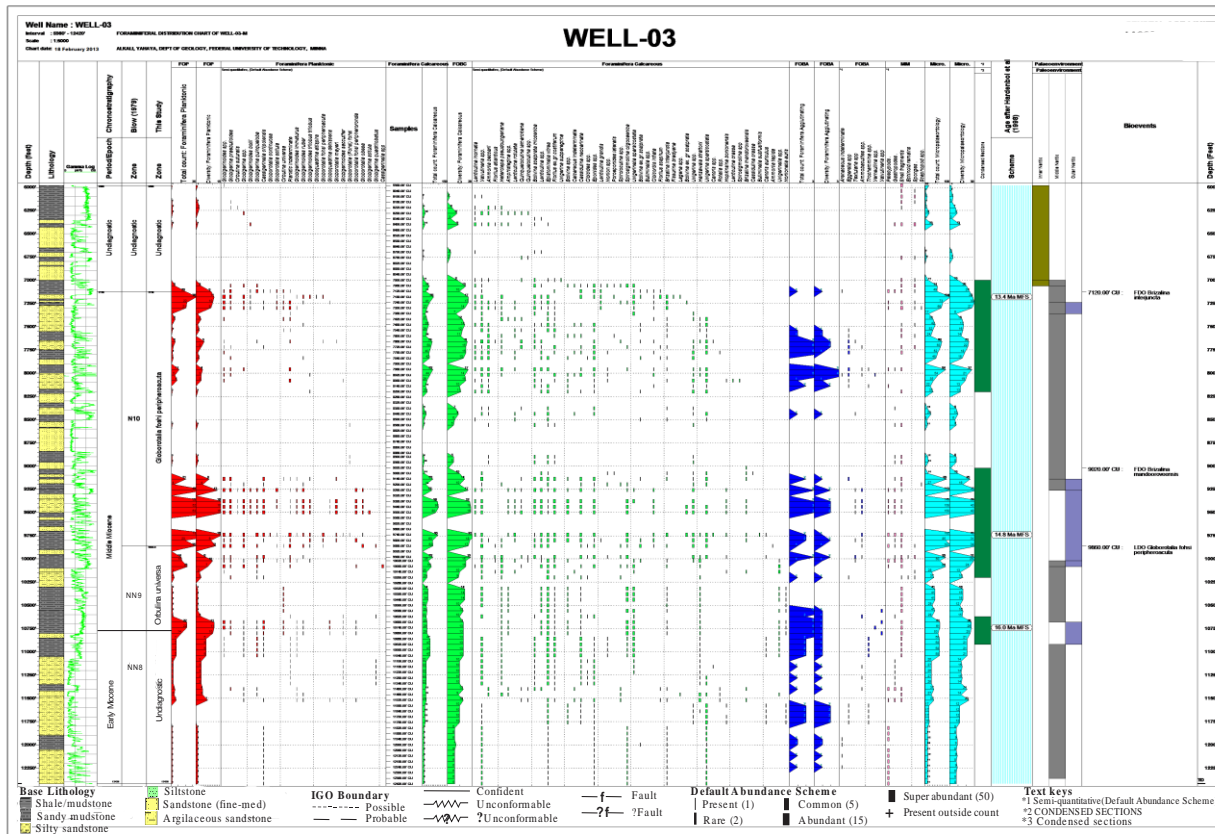


Figure 2: Foraminiferal distribution chart of Well 03, Deep Offshore, Niger Delt

Depth (ft)	Epoch/Period	Hardenbol <i>et. al.</i> (1998) Scheme	Blow (1979)	Berggren <i>et. al.</i> (1995)	This Study	Bioevents			
6000	Middle Miocene	13.4Ma	Undiagnosics	Undiagnosics	Undiagnosics				
7000			7125				Gibborotalia peripheroacuta	7120-FDO <i>Brizalina interjuncta</i> FDO <i>Cassigerinella continua</i> <i>G. scitula</i>	
8000			N10					M7	9020-FDO <i>Brizalina mandoroveensis</i>
9000			14.8Ma					9860	9860-LDO <i>Gibborotalia foshi peripheroacuta</i>
10000			N9					M6	10080 LDO <i>Lenticulina inornata</i> 10140 LDO <i>Florilus atlanticus</i>
11000	16.0Ma	N8	M5	Orbulina universa	10800 LDO <i>Orbulina universa</i>				
12420	Early Miocene				Undiagnostic	11520 LDO <i>Globigerinoides immatutus</i> LDO <i>Globigerinoides ruber</i> LDO <i>Globigerinoides sacculifer</i> LDO <i>Globobulimina deluscaensis</i>			

Figure 3: Foraminiferal Biozonations Recognized in Well 03

3.3 Palaeoenvironmental Interpretation

Foraminifera are of paramount significance in palaeoenvironmental studies of marine environments. Palaeoenvironmental indicators are marker species that give reliable and accurate information about past environments to earth scientists.

Dark shales occur as a result of anaerobic conditions. When marine transgression was at its peak entirely marine conditions were attained. Also, agglutinated foraminifera such as *Eggerella* spp, *Arenaceous* indet, *Haplophragmoides* spp, *Trochammina* spp, *Valvuneria* spp and *Ammobaculites* spp which have less demand for carbonate shell construction are most abundant in hyposaline conditions typical of shallow marine paralic environments [11] [16].

The distribution of *Ammonia beccarii*, *Florilus costiferum*, *Eponides eshira*, *Brizalina interjuncta*, *Brizalina mandoroveensis*, *Uvigerina sparsicostata* within the studied interval closely approximates the paleoenvironments to range from inner neritic to outer neritic environments [16].

4.0 Conclusion

Lithological investigations of the intervals of well 03 revealed that the lithofacies is composed of grey to dark grey shales, silty mudstones and sandy mudstones with intercalations of coarse - medium - fine-grained sandstone beds. The interval yielded fairly rich and diverse assemblages of well-preserved planktonic and benthonic foraminifera.

Three biozones recognized were *Globorotalia fohsi peripheroacuta* zone, *Orbulina universa* zone and an undiagnostic zone corresponding to the established zones of N10, N9 and N8 respectively, indicating early to middle Miocene age. The dated intervals correlated to other worldwide zones can be correlated within Niger Delta basin and between other depositional basins.

The paleoenvironmental deductions of the studied sequence are interpreted as inner neritic to outer neritic based on the recovery of the marker species. The dark-coloured shales suggest environments with fluctuating salinities and limited circulation, formed under anaerobic conditions.

Declarations

Ethics approval and consent to participate: Not applicable

Consent for publication: Not applicable

Competing interest: The author declares that there is no competing interest

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Author's contribution: The author is the sole author and the whole idea of the research was conceived and carried out by the author.

Availability of Data Materials: 112 ditch cutting samples utilized for this study was provided by Nigerian Geological Survey Agency (NGSA), Kaduna

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