An Integrated Study: Biofacies Analyses of Sediments of Well B -1, Offshore, Niger Delta.

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Abstract- Biofacies analysis of twenty five samples from well B-1, offshore Niger Delta, based on the nannofossil and foraminiferal content were carried out. The aim was to identify the biozones, determine the age and reconstruct paleoenvironment of the sediments. From the diagnostic taxa recovered two biozones were recognized for the nannofossil NN7 (Discocyst Kugeri zone) and NN6 Cyclicargolithus Floridanus zone), while the foraminferal zone identified include N13-N12 and N11, both Calcareous nannofossil and Foraminiferal analysis indicate middle Miocene. A proximal to distal inner neritic (6440 – 6860ft), middle – outer neritic (6860 - 7640ft), shallow inner neritic (7760 – 9140ft) and middle – outer neritic (9290 – 10340ft) paleoenvironment was recognized for the study intervals. Paleoenvironmental deductions were based primarily on benthic foraminferal assemblage and abundance and diversity of species. Presence or absence of planktic foraminifera and calcareous nannofossils also helped in deciphering Open Ocean.

Indexed Terms- Biofacies, Foraminifera, Nannofossils, Paleoenvironments, Niger delta.

I. INTRODUCTION

The Niger Delta is an oil province of Nigeria located on the West Africa continental margin popularly called the Gulf of Guinea. The Niger Delta lies between Latitude 4°N and 6°N and Longitude 3°E and 9°E, in the South-South geo-political region of Nigeria.

The Cenozoic Niger Delta is situated at the intersection of the Benue Trough and therefore the South Atlantic Ocean where a triple junction development during the separation of South America and Africa in the late Jurassic (Obaje et al, 2013). It is one of the important hydrocarbon resources Sedimentary basins formed by the rift faulting of the Nigeria Precambrian rock. It started to evolve in Eocene period, and deposition is still ongoing offshore.


This study involves an integrative approach to biofacies study involving calcareous nannofossils and foramineral studies carried out on B-1 well located within the offshore in Niger Delta Basin. The aim of the study is towards identifying the biozonations, determining the age and reconstructing the paleoenvironment of the study intervals.

1.1 Location of B - I well

The area under study is located in the western offshore Niger delta within OML 118. The basin lies between longitude 3˚E and 9˚E and latitude 4˚E and 5˚2’N (Figure 1).

II. MATERIALS AND METHODOLOGY

Ditch cutting samples were obtained from an Oil producing company in Nigeria. Twenty-five samples of depth intervals of 6440ft -10340ft, well B-1 were processed and analyzed for lithofacies and fossil
content. Lithologic characteristics of the studied samples were carefully noted and documented based on the observed textural/compositional characteristics, while the Calcareous nannofossil and Foraminifera used standard preparatory techniques. After nannofossil and foraminiferal slides were identified under microscope with respective literatures and catalogues, the following were adopted: standard nannofossil zonation according to the scheme of Martini, 1971; Okada and Bukry, 1980; Perch-Nielsen, 1979;

Figure 2: Lithofacies section of well B-1

Okada and Bukry, 1980 and Perch - Nielsen, 1983; ages in Ma were based on Berggren et al, 1995 and for nannofossils while foraminifera were identified following classification of Leoblich and Tappan, 1987; Bolli and Sanders, 1985. The identified taxa for both Nannofossils and Foraminiferal are displayed in Appendices 1 and 2 respectively.

III. RESULTS AND INTERPRETATIONS

3.1 Lithofacies
The lithofacies description of the study interval shows percentage composition of sands and shales. The most dominant lithofacies unit was shales, alternated by few units of sands (Figure 2). The well may have penetrated the Akata formation of the Niger delta that showed thicker units of shale/mudstone.

3.2 Calcareous Nannofossil Biostratigraphy

The result of the analysis shows that the analysed interval is generally characterized by sparse to barren occurrences of nannofossils with many dissolved/unidentified nannofossils. This high degree of dissolution/paucity of forms within this studied interval is believed to result from local environmental conditions. However, depths 7160ft, 7340ft, 7640ft, 8660ft and 8840ft were characterized by fairly abundant and diverse nannofossils. The marker species among these nannofossil taxa were used to identify the zone and age of the studied interval.

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Epoch/Period</th>
<th>Age (Ma)</th>
<th>Zones (Martini 1971)</th>
<th>Significant Nannofossil datums</th>
</tr>
</thead>
<tbody>
<tr>
<td>6440</td>
<td>First sample analyzed</td>
<td>-</td>
<td>Indeterminate</td>
<td>Interval characterized by barren to rare nannofossils</td>
</tr>
<tr>
<td>6440 - 7160</td>
<td>Indeterminate</td>
<td>-</td>
<td>Indeterminate</td>
<td>?Top Discoaster kugleri</td>
</tr>
<tr>
<td>7160 - 7760</td>
<td>Middle Miocene</td>
<td>13.1</td>
<td>NN7-NN6</td>
<td>Base Cyclicargolithus floridanu</td>
</tr>
<tr>
<td>7760 - 10340</td>
<td>?Middle Miocene</td>
<td>-</td>
<td>NN6 &amp; ?older</td>
<td>Interval characterized by barren to rare nannofossils</td>
</tr>
<tr>
<td>10340</td>
<td>Last sample analyzed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Calcareous nannofossil in well B-1

The analyzed interval is dated middle Miocene based on the presence of some of the index nannofossil taxa within the NN7 and NN6 zones of Martini (1971). The important nannofossils that characterized this interval include the followings: *Helicosphaera carteri*, *Discoaster kugleri*, *Calcisculus macintyrei*, *Reticulofenestra pseudoumbilicus*, *Sphenolithus moriformis*, *Discoaster intercalaris*, *Reticulofenestra haqii* and *Cyclicargolithus floridanu*. The recognized sections in the analyzed interval are given below (Table 1) while some the identified forms arepresented in Figure 3.

Stratigraphic Interval: 6440 – 7160ft
Age: Indeterminate
Zone: Indeterminate
Top: Probably shallower than first sample analysed
Base: ?Top Discoaster kugleri

Remarks: Interval characterized by barren to rare nannofossil, Nannofossils recorded include lone occurrence of *Helicosphaera carteri*

Stratigraphic Interval: 7160 – 7760ft
Age: Middle Miocene
Nannofossils Zone: NN7- NN6
Top: ?Top Discoaster kugleri
Base: Base Cyclicargolithus floridanu

Remarks: Interval marked by significant increase in recovery of nannofossils, Important nannofossils that characterized this interval include *Helicosphaera carteri*, *Discoaster kugleri*, *Calcisculus macintyrei*, *Reticulofenestra pseudoumbilicus*, *Sphenolithus moriformis*, *Discoaster intercalaris*, *Pemma basquensis*, *Reticulofenestra haqii* and *Cyclicargolithus floridanu*.

The abundance and diversity of nannofossil observed at 7160ft could be relics of a condensed section associated with the 13.4Ma Maximum Flooding Surface. The assumed top of *Discoaster kugleri* (13.1Ma) recorded at depth 7160ft also confirmed this event.
Stratigraphic Interval: 7760 – 10340ft
Age: ? Middle Miocene
Nannofossils Zone: NN6 & ? Older
Top: Base Cyclicargolithus floridanus
Base: Placed at TD (10340ft)
Remarks: The upper part 9140-9440ft of this zonal interval is characterized by rare nannofossils which are non-age diagnostic while the lower part (9440-10,340ft) is completely barren of nannofossils. The presence of Middle Miocene age cannot be confirmed in the predominantly barren basal part of the well.

Assigned zone/age are based on the stratigraphic position below the positively recognized middle Miocene NN7-NN6 above.

3.3 Foraminiferal Biostratigraphy
Fairly rich abundant and diverse foraminiferal assemblages were recorded. The upper interval (6440-6740ft) recorded sparse to barren foraminiferal species, Interval 6860-9740ft dominated by calcareous benthic and planktic species. The lower interval (9590-10340ft) showed moderate recovery, dominated by arenaceous benthic foraminiferal species.

Some of the age-diagnostic species recorded include Gigerinoides subquaratus, Globorotalia continuosa, Globorotalia mayeri, Orbulina universa, Cassigerinella chipollensis, Globorotalia fohsi, and Globorotalia menardii. A Associated benthic marker species recovered include Uvigerina subperegrina, Spirosigmaolina oligoecena and Florilus ex. gr constiferum (Nonion sp. 6. A foraminiferal distribution, abundance and diversity chart of the recovered forms together with the foraminiferal zones recognized are presented.

The foraminiferal zonation of well B-1 was guided by the works of Blow (1969, 1979) while the numerical ages (Ma) were based on the works of Berggren (1995).

Important foraminiferal bioevents considered include:
- First Downhole Occurrence (FDO) of chronostratigraphically significant planktic/benthic foraminiferal species.
- Last Downhole Occurrence (LDO) of planktic/benthic foraminiferal marker species.
- Foraminiferal abundance and diversity peaks dated with foraminiferal markers species whose stratigraphic ranges are well established in the Niger Delta and worldwide.

The results of the analysis indicate that the studied interval (6440-10,340ft) was deposited during the middle Miocene epoch, of estimated numerical age of 12.8 Ma to 15.0 Ma and straddling the Globigerinoides ruber (N13) and Globorotalia fohsilobata (N11) planktic zone of Bolli and Suanders (1985) and Blow 1969,1979 (Table 2).

Index species among the recovered foraminiferal assemblages have been used in dating and zoning the intervals. Details are given below:

Interval: 6440 – 6860ft
Planktic zone: Indeterminate
Age: ? Middle Miocene
Remarks: The top of this zonal interval is placed at 6440ft (Top of analyzed interval).
The base is marked at 6860ft by the FDO of *Globigerinoides subquadratus*. The age of this zonal interval is based on its stratigraphic position.

Features:
6440–6740ft: Samples within this interval are characterized by sparse to barren foraminiferal species. The sparse microfauna recovered are entirely devoid of any significant bioevents.

The following species were recorded *Globigerinoides immatus*, *Globorotalia sp*, *Bolivinascal pratamiocenica*, *Saccammina complanata* and *Bolivina sp* (some representative species in figure 4).

Interval: 6860 – 9590ft
Planktic zone: N13-N12
Age: Middle Miocene (13.4 - 15.02Ma)

Remarks: The top of this zonal interval is marked by the FDO of *Globigerinoides subquadratus* at 6860ft. The base is marked at 9590ft by the occurrence of *Globorotalia fohsihoi*.

Features: Interval is characterized by moderate abundance and diversity of planktic and benthic foraminiferal species. The following events were recorded within this interval and also confirmed the middle Miocene age assignment.

FDO – First Down hole Occurrence.
- FDO of *Globorotalia continuosa* at 6860ft
- FDO of *Globigerinoides subquadratus* at 6860ft
- FDO’s of benthic foraminifera *Spirosigmaolina oligocaenica* and *Uvigerina subperegrina* at 7160ft also placed this interval within N13-N12 zone of middle Miocene age.
- The co-occurrences of *Globorotalia mayeri*, *Cassigerinella chipollensis*, *Orbulina universa*, *Globorotalia obese Sphaeroidinellopsis disjuncta*, *Globorotalia menardii A*, *Globorotalia continuosa* also confirm the middle Miocene age.
- Associated benthic foraminiferal marker species such as *Florilus ex gr. costiferum (Nonion sp. 6)*, *Uvigerina subperegrina*, *Cassidulina neocarinata* and *Ammobaculites agglutinansr* were recorded within this interval.
- A peak of foraminiferal abundance and diversity observed at 7160 represent a Condensed section and is associated with 13.4Ma Maximum Flooding Surface, The FDO of *Globigerinoides subquadratus* (13.1Ma) recorded within this Condensed Section also confirm this event.

Interval: 9590 – 10340ft
Planktic zone: N11
Age: Middle Miocene (15.0 Ma)

Remarks: The top of this zonal interval is defined by the FDO of *Globorotalia fohsihoi* at 9590ft. The lower boundary is tentatively placed at 10,340ft, the terminal depth of this studied interval.

Features: 9590 – 10340ft: Interval is characterized by moderate foraminiferal assemblage dominated by arenaceous benthic species, Occurrence of...
Globorotalia fohsifohsi at 9590ft suggests a middle Miocene N11 zone at this depth. The arenaceous species that characterized this interval include Ammoscalaris pseudospiralis, Glomospira charoides, Valvulina flexilis, Ammobaculites agglutinans, Saccammina complanata, Karrerella subcylindrica, Alveolohragmum crassum, Haplophragmoides narivaensis and Bathysiphon sp. The dominance of arenaceous species within this zonal interval also confirms a Middle Miocene age.

3.4 Paleoenvironmental Deductions
Integration of biofacies (foraminifera and calcareous nannofossils) and lithofacies characteristics have enhanced the deductions of varying depositional environments over the studied interval. Biofacies and paleoenvironmental deductions were based primarily on benthic foraminiferal assemblage and abundance and diversity of species.

6440-6860ft, Proximal to Distal Inner Neritic
The presence of few foraminiferal species consisting of rare calcareous benthic and rare to absence of planktics and nannofossils indicate deposition in a shallow water. Foraminiferal assemblage is characterized by Saccammina complanata, Bolivinascal pratamiocenica, and Bolivina sp suggesting sediments deposition fluctuating between proximal to distal Inner Neritic.

6860-7640ft, Middle to Outer Neritic
This interval is characterized by a gradual increase in the abundance and diversity of planktic and benthic foraminiferal species and a corresponding increase in recovery of calcareous nannofossil. The co-occurrences of planktic foraminiferal species and calcareous nannofossils within this interval suggest deposition in open marine settings.

The paleowater depth gradually increased to deeper water fluctuating between Middle Neritic to Outer
Neritic. Foraminiferal assemblage consists of *Pullenia bulloides*, *Uvigerina subperegrina*, *Hanzawaia mantaensis*, *Heterolepa pseudoungeriana*, *Stilostomella monilis*, *Dentalina leguminiformis*, *Heterolepa crebbsi*, *Marginulina costata*, *Hoeglundina elegans*, *Gyroidinoides neosoldanii*, *Bulimina costata* and *Siphouvigerina auberiana attenuate*

This foraminiferal biofacies suggests sediment deposition in Middle to Outer Neritic setting

7760–9140ft, Inner Neritic

Inner Neritic foraminiferal species thrived within this depositional unit. The foraminiferal species recorded include *Spirosigmolina oligocaenica*, *Cassidulina neocarinata*, *Bolvina sp.*, *Eggerella scabra*, *Alveolophragmium crissum*, *Trochammina sp.*, *Florilus ex. gr. Costiferum* and *Nodosaria sp.*

The rare to sparse planktic foraminiferal species and calcareous nannofossils recorded within this interval suggest deposition within a photic realm of Open marine condition

9290–10340ft, Middle to Outer Neritic

A gradual increase in abundance and diversity of foraminiferal fauna with a corresponding increase in paleobathymetry dominated by Middle to Outer Neritic biofacies characterized this interval. The interval is also dominated by deep water arenaceous species.

Calcareous benthic foraminiferal species consists of *Heterolepa pseudoungeriana*, *Globocassidulina subglobosa*, *Uvigerina subperegrina*, and *Stilostomella sp.* Arenaceous assemblage recorded include *Valvulina flexilis*, *Cyclammina cf. minima*, *Alveolophragmium crissum*, *Ammoscalaris pseudospiralis*, *Glomospirag ordialis*, *Haplophragmoides compressa*, *Karreriella subcylindrica*, *Trochammina proteus*, *Ammobaculites agglutinans*, and *Haplophragmoides narivaensis*

The occurrence of planktic foraminiferal species within this interval also suggests deposition in the open marine setting. The above foraminiferal assemblage suggests deposition in the Middle to Outer Neritic.

CONCLUSION

The analyzed interval is generally characterized by sparse to barren occurrence of nannofossils with many dissolved unidentified nannofossils; however few depth were characterized to be fairly abundant and diverse nannofossils. The marker species among these nannofossil taxa were for zonation and date the studied interval. On the other hand the Foraminiferal analysis show fairly rich and diverse assemblages dominated by calcareous benthic & planktic species, moderate recovery arenaceous benthic foraminiferal species, the results of the analysis indicates that the studied interval (6440–10340ft) was deposited during the middle Miocene epoch, of estimated numerical age of 12.8Ma to 15.0Ma. The paleoenvironment is more of open marine as deduced from the characteristics of the foraminifera recovered, the lithofacies with dominant thick shally units in a way also confirmed the open marine paleoenvironment.

APPENDIX 1

<table>
<thead>
<tr>
<th>Lists of Nannofossil Taxa Identified</th>
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<tbody>
<tr>
<td><em>Braarudosphaera bigelowii</em></td>
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<tr>
<td><em>Calcidiscus leptoporous</em></td>
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<tr>
<td><em>Calcidiscus macintyrei</em></td>
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<tr>
<td><em>Cocolithus formosus</em></td>
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<tr>
<td><em>Cyclicargolithus floridanus</em></td>
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<tr>
<td><em>Discoaster calcaris</em></td>
</tr>
<tr>
<td><em>Discoaster intercalaris</em></td>
</tr>
<tr>
<td><em>Discoaster kugleri</em></td>
</tr>
<tr>
<td><em>Discoaster intercalcaris</em></td>
</tr>
<tr>
<td><em>Helicosphaera carteri</em></td>
</tr>
<tr>
<td><em>Helicosphaera sp.</em></td>
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<tr>
<td><em>Micrantholithus entaster</em></td>
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<tr>
<td><em>Pemma basquensis</em></td>
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<tr>
<td><em>Pontosphaera multipora</em></td>
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<tr>
<td><em>Reticulofenestra haqii</em></td>
</tr>
<tr>
<td><em>Reticulofenestra pseudoumblicus</em></td>
</tr>
<tr>
<td><em>Sphenolithus abies</em></td>
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<tr>
<td><em>Sphenolithus moriformis</em></td>
</tr>
</tbody>
</table>

APPENDIX 2

<table>
<thead>
<tr>
<th>Lists of Foraminifera Taxa Identified</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Alveolophragmium crissum</em></td>
</tr>
<tr>
<td><em>Ammobaculites agglutinans</em></td>
</tr>
<tr>
<td><em>Ammoscalaris pseudospiralis</em></td>
</tr>
<tr>
<td>Arenaceous indeterminate</td>
</tr>
</tbody>
</table>
Bathysiphon sp.
Bolivina sp.
Bolivina scalprata miocenica
Buliminacostata
Calcareous indeterminate
Cassidulina sp
Cassigerinellachi pollensis
Cyclammina cf. minima
Dentalina leguminiformis
Eggerella scabra
Eponides sp.
Fissurina longirostris
Fissurina marginata
Florilus ex. gr. Costiferum
(Nonion sp. 6)
Globigerina nepenthes
Globigerinooides immaturus
Globigerinooides bolli
Globigerinooides bulloideus
Globigerinooides immaturus
Globigerinooides obliquus
Globigerinooides sp
Globigerinooides subquadratus
Globigerinooides trilobus
Globigerinooides immaturus
Globocassidulina subglobosa
Globoquadrina altispira
Globoquadrina dehiscens
Globorotalia sp
Globorotalia continuosa
Globorotalia fohsi
Globorotalia mayeri
Globorotalia menardiiculrata
Globorotalia menardiimenardii
Globorotalia obesa
Globorotaliasciitula
Glomospirchararoides
Glomospiragordialis
Gyroidinasoldanii
Gyroidinooidesneosoldanii
Hanzawaiamantaensis

Haplophragmoaides sp.
Haplophragmoaides compressa
Haplophragmoaides narivaensis
Haplophragmoaides sp
Heterolepa crebbsi
Heterolepa floridana
Heterolepa pseudoungeriana
Hoeglundina elegans
Karreriellatub cylindrica
Lenticulina inornata
Marginulina costata
Nodosaria sp.
Orbulina universa
Planktic indeterminate
Pullenia bulloides
Quinqueloculina sp.
Reophax sp.
Saccammina complanata
Saccammina atlantica
Siphouvierinaauberiania attenuate
Sphaeroidinellosissemunilina
Spiosigmoilina oligocaenica
Stilostomella sp.
Stilostomella monilis
Trocchammina sp.
Trocchammina proteus
Uvigerina subperegrina
Valvulina flexilis

REFERENCES


