

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 (Discoater Kugeri zone) and NN6 Cyclicargolithus Floridanus zone), while the foraminiferal 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 foraminiferal 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 4⁰N and 6⁰N and Longitude 3⁰E and 9⁰E, 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.

Data recovered from several thousands of drilled wells in this basin have led to a considerable understanding of the stratigraphy and regional geology of the delta as published by numerous authors, few are documented here: Petroleum Sedimentology (Short and Stauble,1967; Weber, 1971; Weber and Daukoru, 1975) and biostratigraphy (Adegoke *et al*, 1971, 1976, Petter,1979, 1982; Seiglie *et al*, 1982, Ozumba 1995, 1997, 1999 and Fadiya,1988; Adeniran, 1997;Boboye and Fowora, (2007) Boboye and Adeleye, 2009;Alkali, *et al*, 2014; Oloto, *et al*, 2014; Obaje and Okosun (2014).

This study involves an integrative approach to biofacies study involving calcareous nannofossils and foraminiferal 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

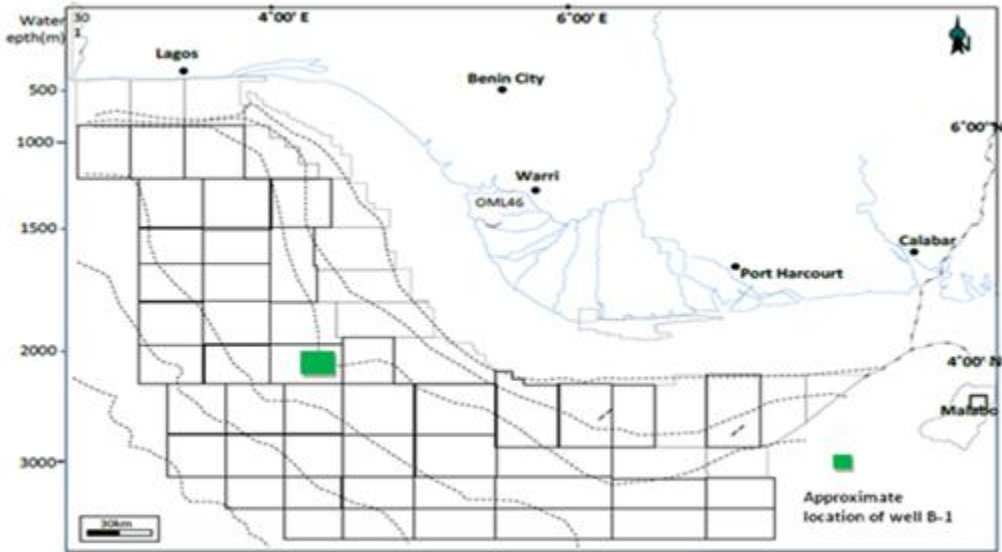


Fig 1. Map showing approximate location of well B-1, Niger Delta.

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;

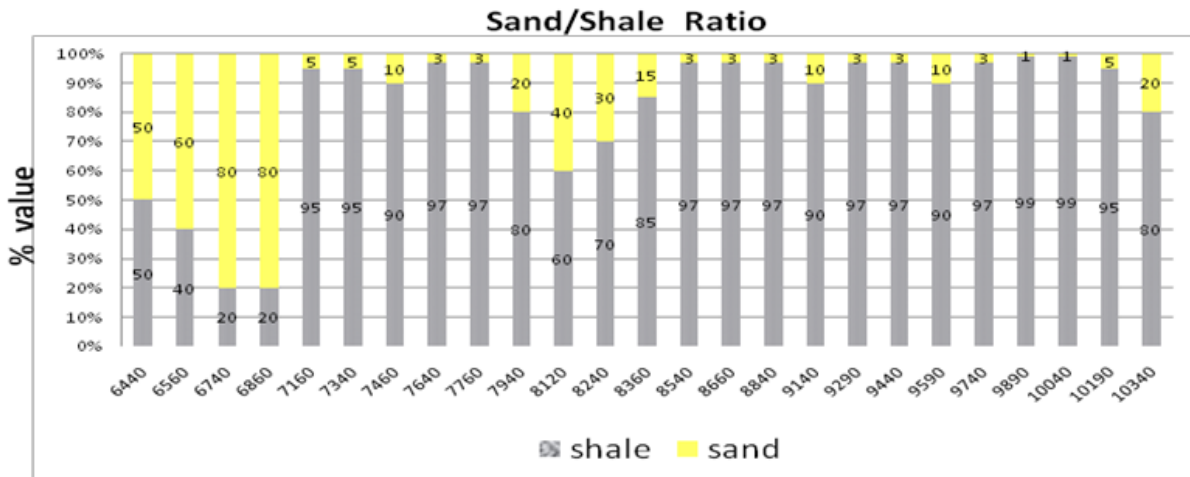


Figure 2: Lithofacies section of well B-1

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.

Calcareous Nannofossil Biostratigraphic summary of well B-1 (First Downhole Occurrence of stratigraphically important Calcareous Nannofossils)				
Depth (ft)	Epoch/Period	Age (Ma)	Zones (Martini 1971)	Signifiant Nannofossil datums
6440	<i>First sample analyzed</i>			
6440 - 7160	Indeterminate	-	Indeterminate	Interval characterized by barren to rare nannofossils
7160 - 7760	Middle Miocene	13.1	NN7-NN6	?Top <i>Discoaster kugleri</i> Base <i>Cyclicargolithus floridanus</i>
7760 - 10340	?Middle Miocene	-	NN6 & ?older	Interval characterized by barren to rare nannofossils
10340	<i>Last sample analyzed</i>			

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 Martiti (1971). The important nannofossils that characterized this interval include the followings: *Helicosphaera carteri*, *Discoater kugleri*, *Calcidiscus macintyreii*, *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 are represented 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 floridanus*

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

The abundance and diversity of nannofossil observed at 7160ft could be relicts 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

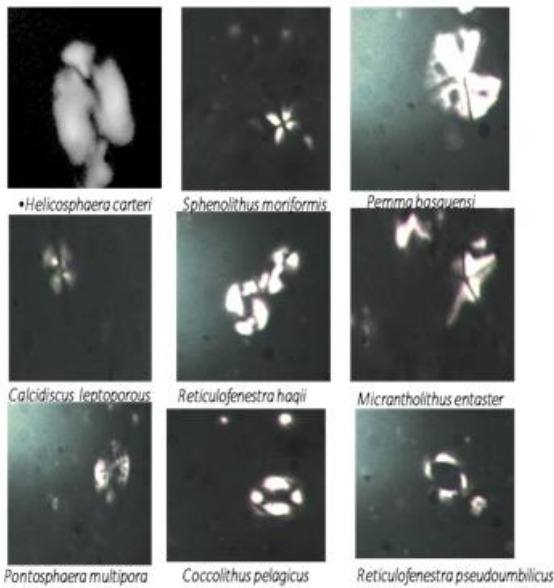


Figure 3: Nannofossils sp. from Well B-1

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 *Gligerinoides subquaratus*, *Globorotalia continuosa*, *Globorotalia mayeri*, , *Orbulina universa*, *Cassigerinella chipollensis*, *Globorotalia fohsi*, and *Globorotalia menardii* A Associated benthic marker species recovered include *Uvigerina subperegrina*, *Spirosigmolina oligocaenica* 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 12.8Ma to 15.0Ma and straddling the *Globigerinoides ruber*(N13)and *Globorotalia fohsilobata* (N11) planktic zone of Bolli and Saunders (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).

Foraminiferal Biostratigraphic summary of well B-1 (First Downhole Occurrence of stratigraphically important Foraminiferal species)				
Depth (ft)	Epoch/Period	Age (Ma)	Zones (Blow 1969, 1979)	Significant Foraminiferal datums
6440	<i>First sample analyzed</i>			
6440–6860	Indeterminate	-	Indeterminate	Interval characterized by barren to sparse foraminiferal species
6860-9590	Middle Miocene	13.4	N13 - N12	FDO <i>Globigerinoides subquadratus</i> at 6860ft FDO <i>Globorotalia continua</i> at 6860ft Co-occurrences of <i>Cassigerinella chipollensis</i> , <i>Globorotalia mayeri</i> , <i>Sphaeroidinellopsidis juncta</i> and <i>Globorotalia mayeri</i> <u>Benthic markers include</u> : <i>Spisigmoilina oligocaenica</i> , <i>Uvigerina subperegrina</i> , and <i>Florilus ex. gr. constiferum</i> (<i>Nonion</i> sp. 6)
9590-10340	Middle Miocene	15.0	N11	Occurrence of <i>Globorotalia fohsifohsi</i>
10340	<i>Last sample analyzed</i>			

Table 2: Foraminiferal Zones in well B-1

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 immaturus*, *Globorotalia* sp, *Bolivinasca pratamioecenica*, *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 *Globigerinoides subquadratus* at 6860ft. The base is marked at 9590ft by the occurrence of *Globorotalia fohsifohsi*.

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 continua* at 6860ft
- FDO of *Globigerinoides subquadratus* at 6860ft

- FDO’s of benthic foraminifera *Spirosigmoilina 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 obesa* *Sphaeroidinellopsidis juncta*, *Globorotalia menardii* A, *Globorotalia continua* 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 agglutinans* 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 N11 zone is defined by the FDO of *Globorotalia fohsifohsi* 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

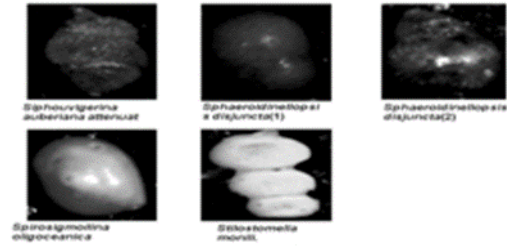
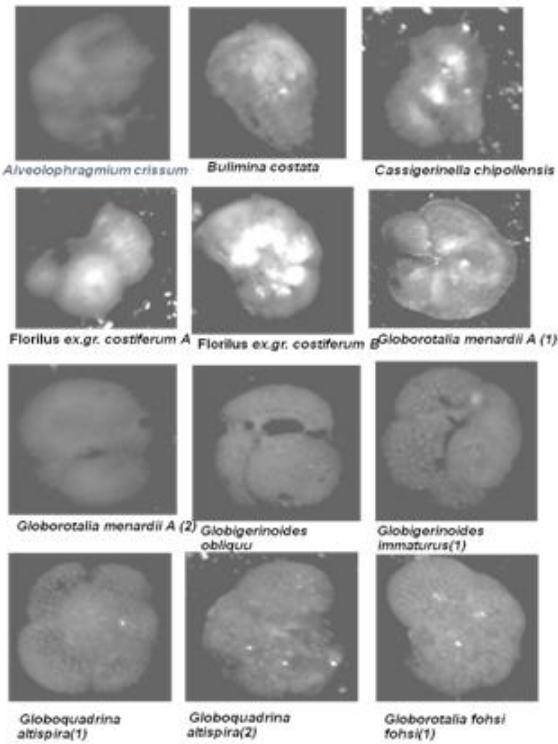


Figure 4: Foraminifera sp. from Well B-1

species that characterized this interval include *Ammoscalaris pseudospiralis*, *Glomospira charoides*, *Valvulina flexilis*, *Ammobaculites agglutinans*, *Saccammina complanata*, *Karrerella subcylindrica*, *Alveolophragmium 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 nanofossils) 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.

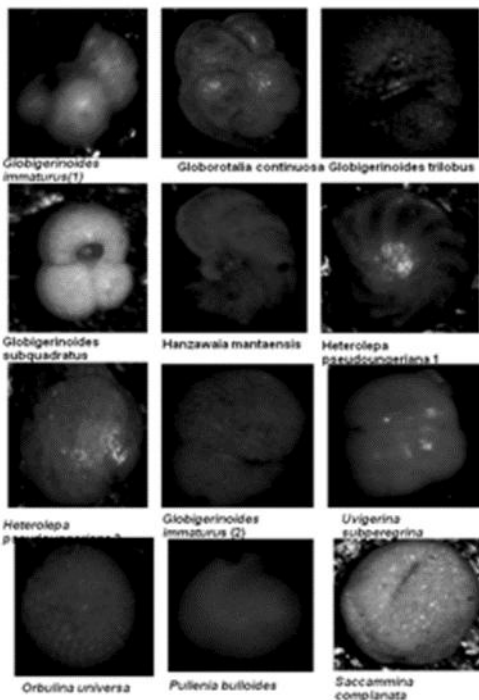
6440-6860ft, Proximal to Distal Inner Neritic

The presence of few foraminiferal species consisting of rare calcareous benthic and rare to absence of planktics and nanofossils indicate deposition in a shallow water. Foraminiferal assemblage is characterized by *Saccammina complanata*, *Bolivinasca 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 nanofossil. The co-occurrences of planktic foraminiferal species and calcareous nanofossils 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 *Spirosigmoilina oligocaenica*, *Cassidulina neocarinata*, *Bolivina 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*, *Karrieriella 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

Lists of Nannofossil Taxa Identified

Braarudosphaera bigelowii
Calcidiscus leptoporous
Calcidiscus macintyreii
Cocolithus formosus
Cyclicargolithus floridanus
Discoaster calcaris
Discoaster intercalaris
Discoaster kugleri
Discoaster intercalcaris
Helicosphaera carteri
Helicosphaera sp.
Micrantholithus entaster
Pemma basquensis
Pontosphaera multipora
Reticulofenestra haqii
Reticulofenestra pseudoumblicus
Sphenolithus abies
Sphenolithus moriformis

APPENDIX 2

Lists of Foraminifera Taxa Identified

Alveolophragmium crissum
Ammobaculites agglutinans
Ammoscalaris pseudospiralis
 Arenaceous indeterminate

Bathysiphon sp.
 Bolivina sp.
 Bolivina scalprata miocenica
 Buliminacostata
 Calcareous indeterminate
 Cassidulina sp
 Cassigerinellachi pollensis
 Cyclamina cf. minima
 Dentalina leguminiformis
 Eggerella scabra
 Eponides sp.
 Fissurina longirostris
 Fissurina marginata
 Florilus ex. gr. Costiferum
 (Nonion sp. 6)
 Globigerina nepenthes
 Globigerinoides immaturus
 Globigerinoidesbolli
 Globigerinoidesbullodeus
 Globigerinoides immaturus
 Globigerinoides obliquus
 Globigerinoides sp
 Globigerinoides subquadratus
 Globigerinoides trilobus
 Globigernoides immaturus
 Globocassidulina subglobosa
 Globoquadrina altispira
 Globoquadrina dehiscens
 Globorotalia sp
 Globorotalia continuosa
 Globorotalia fohsi
 Globorotalia mayeri
 Globorotalia menardiicultrata
 Globorotalia menardiimenardii
 Globorotalia obesa
 Globorotaliascutula
 Glomospiracharoides
 Glomospiragordialis
 Gyroidinasoldanii
 Gyroidinoidesneosoldanii
 Hanzawaiamantaensis

Haplophragmoides sp.
 Haplophragmoides compressa
 Haplophragmoides narivaensis
 Haplophragmoides sp
 Heterolepa crebbisi
 Heterolepa floridana
 Heterolepa pseudoungeriana
 Hoeglundina elegans
 Karreriellasub cylindrica
 Lenticulina inornata
 Marginulina costata
 Nodosaria sp.
 Orbulina universa
 Planktic indeterminate
 Pullenia bulloides
 Quinqueloculina sp.
 Reophax sp.
 Saccamina complanata
 Saccamina atlantica
 Siphouvigerinaauberiana attenuate
 Sphaeroidinellopsisseminulina
 Spirosigmoilina oligocaenica
 Stilostomella sp.
 Stilostomella monilis
 Trochammina sp.
 Trochammina proteus
 Uvigerina subperegrina
 Valvulina flexilis

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