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Research Article

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The Anomalous Disparity in the Occurrences of Planktonic Foraminifera and Calcareous Nannoplanktons in the Early – Middle Miocene of the Niger Delta: Its Implications in Paleoenvironmental Reconstruction

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Abstract Micropaleontological analysis was carried out on seven (7) wells spread across the Onshore and Offshore in the Central and Western parts of Niger Delta to investigate the anomalous disparity in the abundance and diversity of planktonic foraminifera as compared to their calcareous nannoplanktons counterparts in the Early to Middle Miocene times. Planktonic foraminifera and calcareous nannoplanktons generally co-habit in similar diverse and abundant trends in the tropical marine environments, especially in the Outer Neritic and Upper Bathyal realms; which is not the case in sections of the Early to Middle Miocene of the Delta. The observed disparity in their occurrences during this period is anomalous and can be primarily attributed to dissolution of non-resistant calcareous (calcite) components of their tests in under-saturated carbonate oceanic conditions. This de-populates the planktonic foraminiferal niche and the more resistant calcareous nannoplanktons. The resistance of these remnant groups to solution effects is attributable to a number of factors including the presence of aragonite skeletal elements, the protective organic sheath, low concentration of pores / apertures as well as the development of thickened tests with age. This anomaly usually leads to erroneous inferences of shallower paleo-bathymetric realms rather than effects of dissolution of the non-resistant carbonates. Thus, paleoenvironmental interpretations of the sediments deposited in Early – Middle Miocene of the study area should be attempted with the hindsight of this finding. With this knowledge, an integrated approach incorporating other datasets (core description, sedimentary facies, seismic facies, and palynofacies analyses) can be useful in overcoming this challenge.

Keywords Planktonic foraminifera, Calcareous nannoplanktons, Paleobathymetry, Paleoenvironmental reconstruction, Niger Delta

Introduction

Planktonic foraminifera and calcareous nannoplanktons generally co-habit in the open marine environment; where they usually occur in large numbers as a result of the nutrient supply and temperature of the surface water. These two groups of organisms, of biogenic origin are the most abundant in modern oceans and most commonly found in strata of Mesozoic and Cenozoic age [1].

These organisms constitute components of pelagic sediments which are usually made of suspended materials that float in the ocean; away from the shoreline. This ecological niche suits the floating mode of life adapted by these organisms and thus explains their influx and abundance in the open ocean environment. Their distribution is influenced by among other factors, the biogenic productivity of carbonate-forming organisms, productivity of siliceous organisms, water depth and the oceanic water circulation [2-3]. Another reason for the preference of this ecological niche by these pelagic groups is because it is in these warmer waters near the equator that the

highest productivity of biogenic materials occurs. In this region there is a continuous accumulation of calcareous and to a much lesser extent, siliceous biogenic materials. Thus, their accumulation is less intense in cooler regions or areas with lower nutrient supply [1]. The high productivity of carbonate-forming organisms also explains why calcium carbonate ($CaCO_3$) constitutes the major component of their tests: near the surface most ocean waters are close to saturation limits with respect to calcium carbonate. Therefore, plants and animals (including nannoplanktons and foraminifera) are able to precipitate either calcite or aragonite ($CaMgCO_3$) in their shells (tests) and skeletons.

The ecological niche of any organism is an excellent indication of its depositional environment. It is based on this premise that the preponderance of planktonic organisms such as planktonic foraminifera and coccoliths are used to infer open ocean paleoenvironmental conditions. However, the planktonic foraminifera are generally preferred in the paleobathymetric determinations because the ratio of the benthonic to the planktonic foraminifera usually provides an estimate of the bathymetry. This is applied in a semi-quantitative way in the Mesozoic and Cenozoic [1]. Generally, the abundance of benthic species decreases as water depth increases and vice versa for the planktonic foraminifera. Thus, while foraminifera can be used to estimate water depth, calcareous nannoplanktons on their own can only define the bathymetric realm.

It is in the light of the foregoing, therefore, that the anomalous disparity in the occurrences of these two calcareous planktonic groups as observed in the Early to Middle Miocene times of the Niger Delta is being brought to the fore; to avoid misleading paleoenvironmental interpretations by considering other data sets such as core description, sedimentary facies, seismic facies and palynofacies analyses.

This study was carried out based on data obtained from seven (7) wells from the onshore and offshore of the Niger Delta (Figure 1).

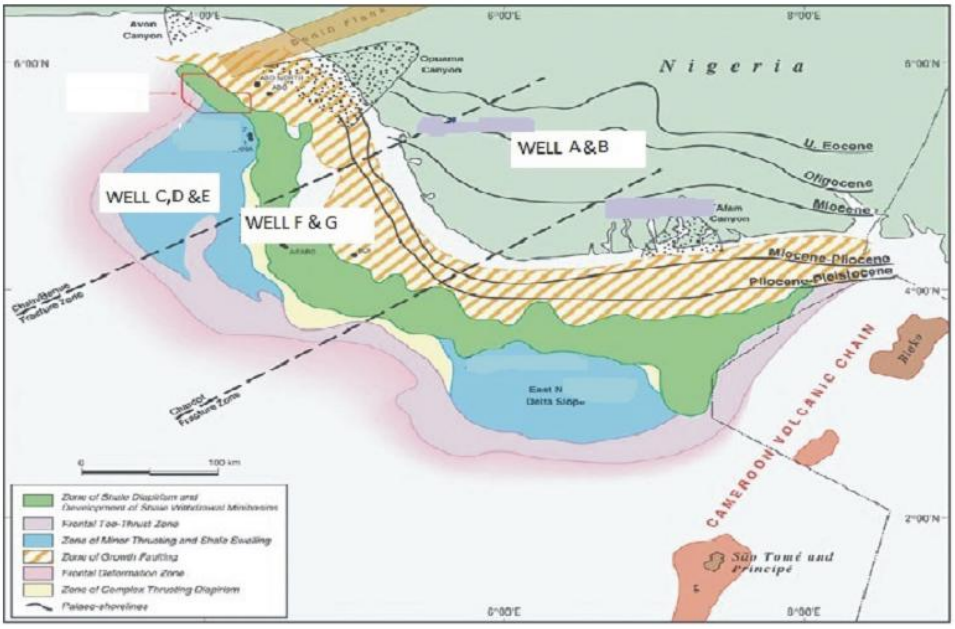

Figure 1: Location map showing the Study wells

Materials and Methods

The importance of using standard operating procedures in Paleontological sample preparation cannot be over-emphasized as this underlies the quality of results from the analyses of the samples. Standard operating procedures incorporating measures to curb contamination were used in the extraction of the foraminifera. Washing was done in a water/liquid soap medium using a 53 micron sieve to avoid the loss of the very small species. The washed samples were dried in an oven at a temperature of about 500° F and subsequently separated into three size fragments (coarse, medium and fine) and packed into three well-labelled sample bags. Samples were thereafter picked and subsequently analysed.

Similarly, standard operating procedures were applied in extracting the nannoplanktons: the rock sample was crushed and poured into a test tube, water was then added and the mixture was stirred vigorously with a glass rod. The sample was allowed to stand for 10 seconds and thereafter a small quantity of the suspension was collected using a pipette and smeared evenly on a glass cover slip which was allowed to dry. This was subsequently mounted on a properly labelled glass slide using a transparent adhesive and allowed to dry. Thereafter, the slides were analysed. After foraminiferal and nannoplankton analyses, the data were electronically generated using the STRATABUGS software and presented graphically and subsequently interpreted.

Results

Well A (Onshore)

A reasonable influx of calcareous nannoplanktons was recorded in intervals 3770 – 4610ft (Early Miocene) where planktonic foraminifera were completely absent. The paleobathymetry of the interval was interpreted to be Non – marine without taking into consideration the possible dissolution of the planktonic foraminifera.

Well B (Onshore)

The planktonic groups display a mirror image pattern in terms of their occurrences; alternating barren and fossiliferous sections in the upper (12,005- 13,955ft) part. However, there is a remarkable contrast in the lower (13,955 – 15,555ft) section, where the nannoplanktons persisted while the planktonic foraminifera were completely absent. Their absence is a direct consequence of the high susceptibility of their tests to solution effects.

The low counts of these plankton groups are a reflection of the relatively shallow paleobathymetric (Inner – Middle Neritic) setting of this well section. It is of remarkable significance that the persistent occurrence of the nannoplanktons is an indication of their resistance to solution effects.

Well C (Offshore)

The mirror image pattern displayed by the two planktonic groups; alternating barren and fossiliferous sections in intervals 12,900 – 14,800ft (Early – Middle Miocene) was used to appropriately infer the Inner - Middle Neritic paleobathymetric setting of the interval.

Well D (Offshore)

The absence/very rare occurrences of planktonic foraminifera were associated with the persistent occurrences of nannoplanktons in intervals 13,500 – 17,150ft (Early – Middle Miocene) of this well. The paleobathymetry is potentially deeper than that postulated for the singular reason that the absence of planktonic foraminifera was misconstrued to mean their non-occurrence.

Well E (Offshore)

Two patterns are observed in this well. The first pattern is a juxtaposition of the complete absence of planktonic foraminifera with the persistent occurrences of nannoplanktons in intervals 12,800 – 13,960ft (Middle Miocene) while the second pattern is the co-occurrences of both groups in intervals 15,000 – 15,620ft (Early – Middle Miocene). However, the calcareous nannoplanktons occur in greater numbers than their foraminiferal counterparts. The paleobathymetric setting of intervals 12,800 – 13,960ft is potentially deeper than the Outer Neritic postulated.

Well F (Offshore)

The total absence/very rare occurrence of planktonic foraminifera is associated with an influx of calcareous nannoplanktons in intervals 9880 – 10,210ft (Early Miocene). Again, the paleobathymetric setting in this interval is potentially deeper than the Middle Neritic postulated.

Well G (Offshore)

The absence/very rare occurrence of the planktonic foraminifera is juxtaposed with the persistent occurrence of their calcareous nannoplankton counterparts in intervals 10,140 – 11,895ft (Middle Miocene) of this well section. The complete absence of the planktonic foraminifera in intervals 10,140 – 10,380ft explains the misleading Shallow Inner – Inner Neritic paleobathymetric interpretation for this section.

Discussion

From the results, the common remnant planktonic foraminifera as seen in this study comprises of the *Globigerinoides trilobus group, Globigerinoides obliquus, Globigerina praebulloides, Globoquadrina altispira, Globoquadrina dehiscens, Globorotalia obesa and the Praeorbulina / Orbulina group* while the more resistant calcareous nannoplanktons include species of the *Discoaster, Coccolithus, Sphenolithus, Helicosphaera and Reticulofenestra* genera.

Generally, it is observed that the anomalous disparity is more distinct in the offshore wells than in the onshore wells.

Various studies have shown that the dominance of individual planktonic species within deep-sea sedimentary assemblages is primarily a function of the resistance of their calcareous tests to solution in the Calcium carbonate under-saturated deep ocean water. This is determined by the composition of the skeletal elements (calcite or aragonite), a low concentration of pores, the presence of a protective organic sheath and the development of thickened tests with age [4-6].

A total absence or rare occurrences of planktonic foraminifera was observed in this study showing a consistent disparity between them and their calcareous nannoplankton counterparts. This may be attributed to the dissolution of their tests which are less resistant to under saturated oceanic water conditions than the calcareous nannoplanktons. The calcareous nannoplanktons have been observed to be more solution resistant mostly due to their ability to accrete large amounts of secondary calcite over their entire surface thus developing more thickened tests. Early diagenesis resulting in in-situ dissolution and re-precipitation of skeletal calcite is responsible for the heavy secondary calcite overgrowths on calcareous nannofossil tests, especially the *Discoasters* and *Coccolithophorids* [7]. The *Discoasters* are the most common solution resistant taxa in low latitudes and the *Coccolithophorid* species are the most common solution resistant taxa in high latitudes. This in turn, results in the formation of a chalk unit sufficiently lithified to withstand compactive deformation during the subsequent loading of many hundreds of meters of clastic sediments. Planktonic foraminifera on the other hand, do not possess the large crystals which serve as the nuclei for secondary calcite overgrowth in the calcareous nannofossils [8], thus their susceptibility to dissolution.

Paleoenvironmental interpretations are primarily based on the paleobathymetric ranges of the benthic assemblages because they are depth dwellers. However, the occurrence of the planktonic foraminifera and nannoplanktons alongside the benthic group gives an indication of the depth of the marine realm penetrated. Therefore, in situations where this anomalous disparity is observed, the interpretations are bound to be incorrect; being inferred to be within shallower marine environments due to the rare occurrences or total absence of the planktonic foraminifera. However, considering the fact that calcareous nannoplanktons thrive mainly in the open marine indicating deeper settings, their abundance and diversity in the study area questions the wrongly inferred (shallower) paleobathymetry, which were based solely on the remnant planktonic foraminiferal assemblage(s).

Conclusion

Based on these observations, Paleoenvironmental interpretations of sediments deposited in the Early – Middle Miocene times in the Niger Delta should be approached cautiously; especially where the anomalous disparities are well pronounced.

An integral approach incorporating other relevant data sets such as core descriptions, sedimentary facies analysis, palynofacies analysis and seismic facies analysis would provide a broader and more reliable inference of the paleoenvironmental conditions within those times.

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