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Article

Palaeoecological Aspects of Nannoplankton Assemblages of AS-2 Well, Niger Delta

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Abstract

Certain nannoplankton species are sensitive to surface water conditions hence, they are proxy for palaeocological studies. This study analyzed biostratigraphy and inferred paleoecologic preferences of major nannofossil species of ditch cutting samples from well AS-2, Niger delta. The relative fluctuation and changes in abundance of the nannoplankton allowed the following deductions in the study interval: Two major biozones, NP21 and NP20 of late Eocene (Priabonian) and early Oligocene (Rupelian). Higher abundances of *Reticulofenestra* spp (49%) compared to the total taxa recovered, including *Cyclicargolithus spp*, *Coccolithus spp* and *Chiasmolithus spp* were characterized as cool water, eutrophic conditions while *Sphenolithus* spp, *Helicosphaera* spp, *Pontosphaera spp* were characterize as warmer water more Oligotrophic species. The total increase in abundance of cooler-water indicators over the warm-water forms within the study intervals suggest a prevailing environmental condition describing cooler water trends, eutrophic and upwelling ones with nutrient rich conditions during the Oligocene period than in the Eocene.

Keywords: Nannoplankton, Biostratigraphy, Paleoecology, Oligotrophic, Niger Delta.

1. Introduction

The term "Nannoplankton" was defined by [1] as small plankton, that will pass through the mesh of the phytoplankton net of 63microns. Calcareous nannofossils have been identified as one of the most abundant phytoplankton group in the marine realm with enormous effect to changes that occur in the oceanographic terrain. This phytoplankton group has progressively become tremendously useful in solving Biostratigraphic [2] palaeocologic, palaeoceanographic, palaeoclimatic and even palaeoenvironmental problems [3 -8].

Nannoplanktons are known for their distinct, pronounced and quick response to changes to temperature, light, availability of nutrients, salinity, primary productivity and other parameters in the world oceans, all these have extensively been studied in many basins *around the world*. Thus, more efforts in research is necessary towards understanding the Mesozoic and Cenozoic marine systems and interactions as evidenced by nannofossils [3],[8-10] for classical aspects of palaeocologic and palaeoceanographic interpretations even in the global and local basins.

Some vital reasons for calcareous nannofossils importance as explained by many authors include: they are one of the most abundant phytoplankton species of the marine realm; the distribution patterns of nannoplanktons species give clues to stratigraphic and oceanographic information; they are most abundant in marine sediments and show many evolutionary changes [11], and several individual taxon studied have ecologic affinity for different environments.

Review of available literature has shown that the Paleogene sections of the Niger Delta ar yet to be studied in much detail as their Neogene and Pleistocene counterparts [12], [13], [14], and [15]. The studied interval which penetrates the Eocene – Oligocene is investigated for some dominate taxa of nannoplankton in sediments for their palaeocological aspects. This present study is aimed at establishing the biozonation, age and the palaecological affinity of some selected nannoplanktons recovered from the studied section in Niger Delta, and along with published catalogues identify those with significant information to bridge the information gap palaeocologically in the Nigerian local oceanographic settings. The information established will contribute conclusively that different calcareous nannofossil assemblages can be used to characterize the different palaeocological preference in sections of the Niger Delta and the data can be applied in the recognition and interpretation of past oceanic conditions. The popular Niger Delta basin has been the major source of hydrocarbon exploration since 1957, *and* today *it* is named the Africa's leading oil province, penetrating more than 5,000 wells. The exploration activity has since shifted to the offshore part of the Niger Delta hence, more revelation by research into the oceanic setting of the different Era, period; stages will be helpful for the relatively new exploration and exploitation activities in the basin.

1.1 Location of the study area

The study area is an onshore well AS-2 (coded name) from Greater Ughelli depobelt, Niger Delta (Fig. 1). The basin is located in the Niger Delta basin which lies between longitudes 3ºE and 9ºE and latitudes 4ºE and 5º2'N.

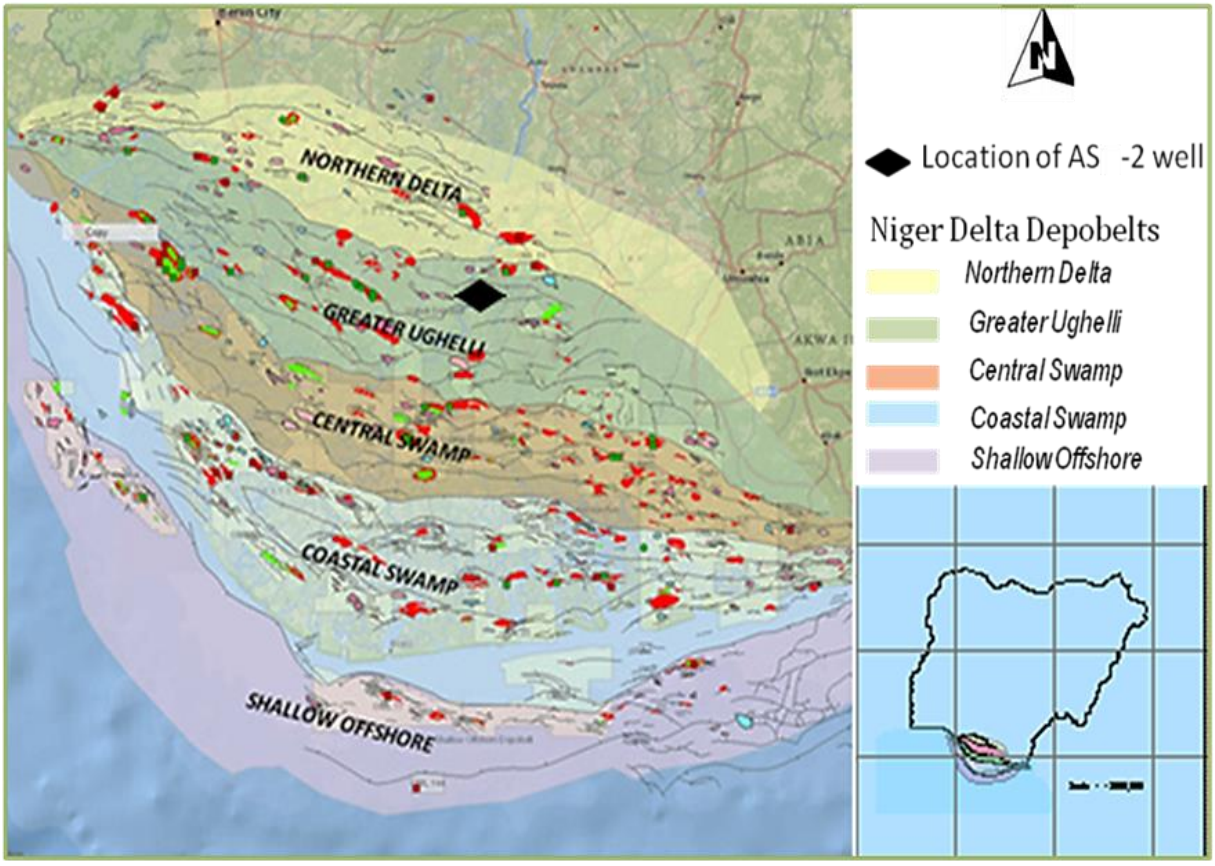

Figure 1: Depobelts of the Niger Delta and Location of study well (modified from [16]).

1.2 Outline Geology and Stratigraphy of Niger Delta

The Niger Delta is situated on the Gulf of Guinea at the West coast of Central Africa. The Niger-Delta is termed as the world's largest and also with sub aerial portion covered by about 75 000km² and extending more than 300km from apex to mouth, and the clastic sediments regressive wedge reaches

about 12km of maximum thickness [17]. The basin is as a result of the opening of the South Atlantic Ocean between Africa and South America continents. Development started in the late Paleocene and Eocene, these time sediments began to build out beyond troughs between basement horst blocks at the northern flank of the present day delta area and since then the delta plain has prograded southwards onto oceanic crust and also gradually assuming a convex to the sea morphology [17]. The rate of sediment supply and subsidence had controlled the structure and stratigraphy in the delta. Three formation names are globally used [18 -19] in the oil industry these three lithofacies are usually referred to as Akata. Agbada and Benin formations. Akata Formation (marine shales) is the basal unit, composed of shales, silts and clays. The approximate thickness of this sequence may be 7000m. Marine shales form the base of the sequence in each depobelts and range from paleocene and Holocene in age (Fig 2). The Agbada Formation (paralic clastics): It forms the hydrocarbon prospective sequence in the Niger delta. It is represented by an alternation of sands, clays and silts in various proportions and thickness, representing cyclic sequence of offlap units. These paralic clastics are truly deltaic sequence and were deposited in a number of delta front, delta topset and fluvio-deltaic environment [17]. The alternation of coarse and fine sediment provides multiple reservoir-seal couplets. The paralic marine shale sequence is present in all depobelts, and ranges in age from the Eocene to Pleistocene (Fig 2). Benin Formation (continental sands): It is the shallowest part of the sequence and is composed entirely of non-marine sands. It was deposited in alluvial environment by a southward shift of deltaic deposition into a new depobelt. The oldest continental sands are probably Oligocene, but they lack fauna and are impossible to date directly. They become thinner at offshore and disappear near the continental shelf edge (Fig 2).

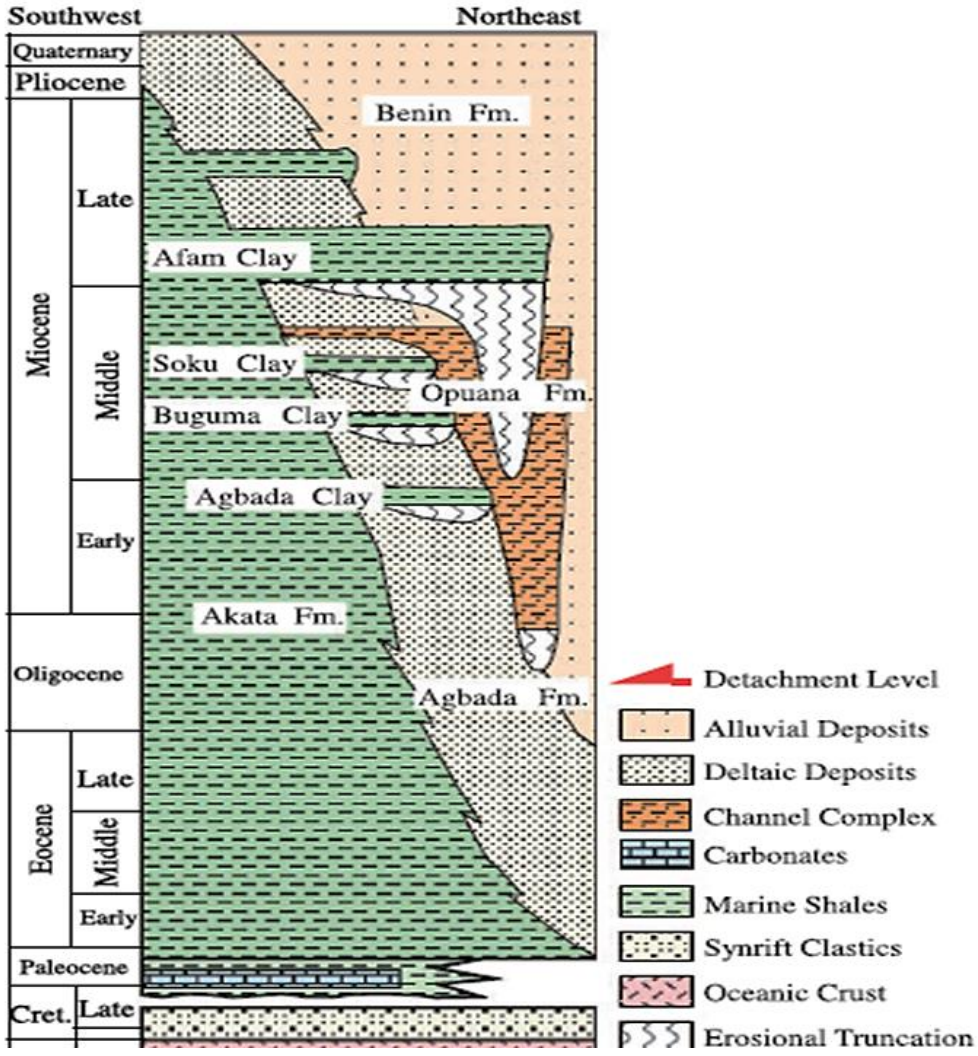

Figure 2: Column of the three stratigraphic formations of Niger Delta (Modified from [17]).

2. Methods

Data used in this study include gamma ray log and ditch cuttings samples from the interval of 10510 - 13790ft from well AS-2 of Greater Ughelli depobelt, Niger Delta. Detailed analysis and interpretation of the gamma ray log in combination with petrographic studies for lithologic description and analyses for nannofossil contents were carried out on the ditch cuttings samples. These results were integrated to generate the various interpretations observed in the study area.

2.1 Nannoplankton Preparation and Analysis

The sample cuttings were prepared for calcareous nannofossils contents using standard preparatory techniques. A small portion of the sediments about 5g of the sample was gently crushed in a mortar and dispersed in distilled water in a glass. It was dried at 50˚C and mounted on a glass slide with the Norland adhesive mounting medium. Species were identified using relevant catalogues and materials. Quantitative measures were employed to get the total number of individual taxa, percentage of relative abundance, diversity from each sample. Taxa recovered from this study were grouped to enable palaeocological deductions. paleoecological affinities of known published palaecological preferences of some selected nannofossil species were considered and correlated with present work.

3. Results and Discussion

3.1 Lithostratigraphic description

Based on the gamma ray log and petrographic study of the cuttings within the study intervals (10510-13790ft), the lithology constitutes sandstones, shale/Mudstone, sandy mudstone, shaly sand and argillaceous sandstone units. The shale units occur in significant thicker section at the upper part of the well (Fig. 3), which suggests a more marine and lower part a paralic depositional setting. The sands ranged from fine to medium grains, sub-angular to rounded while the shales were mostly grey to dark grey in colour.

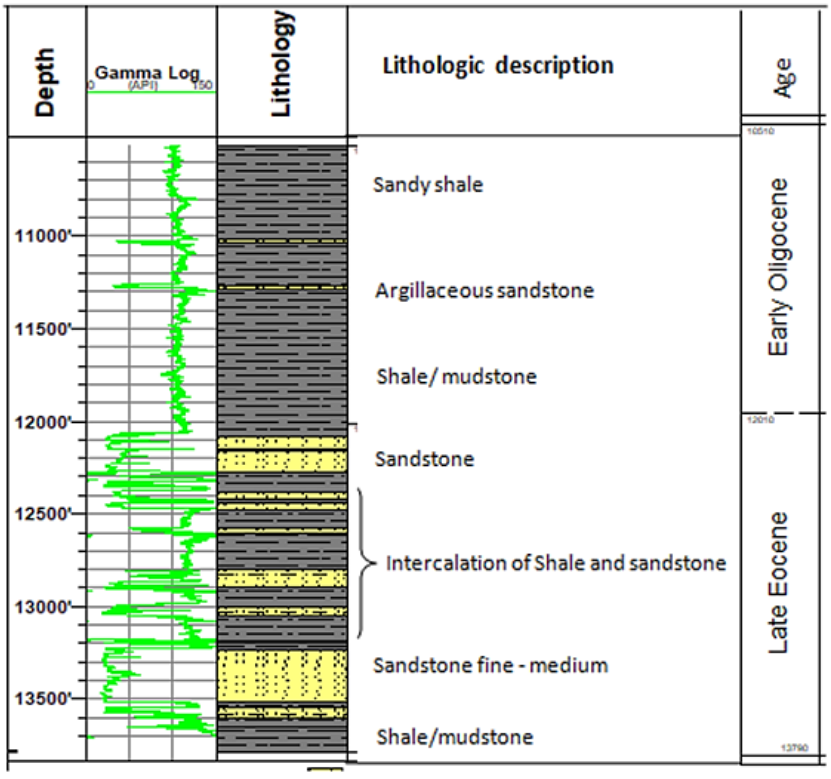

Figure 3. Lithologic section of well AS-2, Niger delta.

3.2 Abundance, diversity and Species richness of Calcareous nannoplankton

The abundance presentation of semi quantitative abundance values showed thus: 0 - (absent); 1 species - (present); 1-2 species- (rare); 2-5 species- (common); 5-15 species (abundant) and super abundant (> 15 species), this explains the distribution pattern of the recoverable taxa (Figure 4, and the selected species illustrated in Fig. 5. Nannoplankton assemblages recovered show very poor to scanty preservation at the lower part of the study interval (see distribution chart Fig. 4), while towards the upper second half of the interval preservation was relatively common to abundant. Their abundance increased and preservation became better in samples of the early Oligocene than their counterparts from the late Eocene.

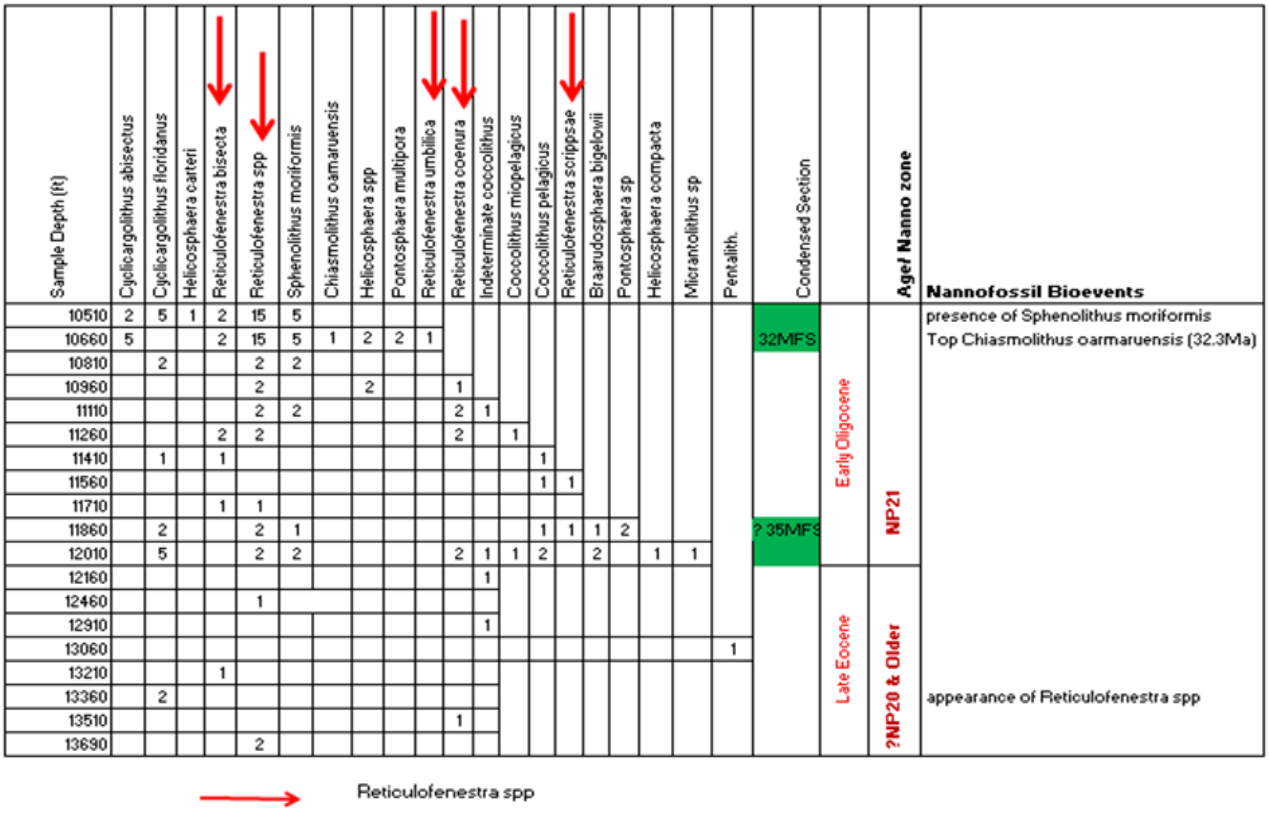

Figure 4: Nannofossil distribution of AS-2 well, Niger Delta.

From the sampled interval, 140 species belonging to 10 genera, were identified. The nannoplankton assemblage were dominated by Reticulofenestra both in abundance and diversity followed by Cyclicargolithus, Coccolithus, Sphenolithus, Helicosphaere and others as seen in Fig. 4 & 6.

Based on the percentage occurrence and composition of individual calcareous nannoplnkton in the well, Reticulofenestra group occurred most in more than half of the samples studied (Fig. 5). However, identification of some taxa could not go beyond the genus level for some forms: Reticulofenetra sp. Interminate coccolithus, Pontosphaera sp, Helicosphaera sp and Micrantolithus sp these phenomena could be as a result of poor preservation due to dissolution, hence may not contribute any diagnostic information in the intervals.

Those depths with maximum abundance and diversity of nannofossils reflect the zones of condensed sections representing 32Ma and? 35Ma assemblages based on the peak and bioevent that existed within the interval of 10510ft and 12010ft respectively, describing low rates of sedimentation within the period.

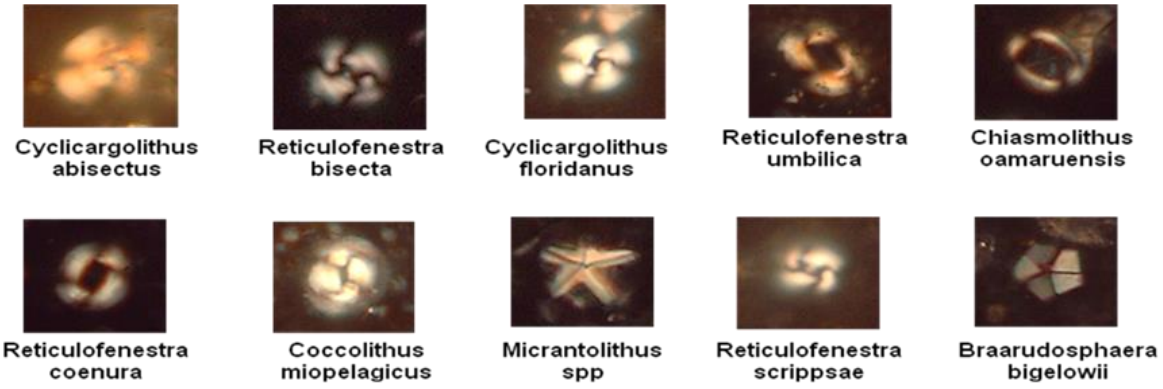

Figure 5: Some selected calcareous nannofossils in the studied section

3.3 Biozonation and age

Two major biozones, NP 21 and NP 20 of late Eocene and early Oligocene were identified using the globally recognized calcareous nannofossil zonation scheme of [20] and the Niger Delta Nannozones, (Figure 4). The last occurrence of *Reticulofenestra umbilica* and *Chiasmolithus oamaruensis* are zonal markers for the two biozones according to [20], it was suggested to be the boundary between early Oligocene and late Eocene. Different calcareous nannofossil species appeared in these zones.

Zonal Description

Nannofossil zone: Zone NP 21

Stratigraphic interval: 10510 - 12010 ft

Age: Early Oligocene (Rupelian)

Comments: It is marked by the last occurrence of *Reticulofenestra umbilica* and last occurrence of *Chiasmolithus oamaruensis* which are zonal marker for nannofossil of early Oligocene [20]. The zone is also marked by the first occurrence of *Cycliargolithus abisectus*, occurrence of *Coccolithus pelagicus* which is an age marker and also age determined by the appearance of *Helicosphaera Compacta*, Down-Hole appearance of *Cyclicargolithus floridanus* and *Sphenolithus moriformis* and last appearance of *Cyclicargolithus abisectus*.

Base: The base of this zone is marked by last depth occurrence of *Reticulofenestra umbilica* and also the first appearance of *Reticulofenestra umbilica* and also *Micrantolithus* spp.

Top: is marked by the last occurrence of *Helicosphaera* and also with the down-hole occurrence of *Cyclicargolithus floridanus*, *Reticulofenestra bisectus*, *Sphenolithus moriformis* and also the disappearance of *Chiasmolithus oamaruensis*.

Zonal Description

Nannofossil zone: ?NP 20 and Older

Stratigraphic interval: 12010 - 13790 ft

Age: Late Eocene (Priabonian)

Comments: The biozone was not determined due to the scarcity of calcareous nannofossil, this zone can be described with the obvious reduction of nannofossil abundance; it is the older zone in the studied well. It is marked by the first appearance of *Helicosphaera compacta* and *Micrantolithus* spp, is marked by the Down Hole occurrence of *Cyclicargolithus floridanus*. It was also suggested by the last occurrence of *Reticulofenestra Umbilica* and last occurrence of *Chiasmolithus oamaruensis* that appeared in the upper zone NP 21.

Base: The base of this zone is marked by the last appearance of *Reticulofenestra* spp. Nannofossil species are not abundant here.

3.4 Paleoecological preferences

The Paleoecological preferences of the taxa in the study interval were mainly interpreted from previous works of calcareous nannofossils with known paleoecological preferences documented in various literatures. The distribution pattern of calcareous nannofossils assemblages show fluctuations and changes towards sea surface temperature, salinity, and nutrient availability. A total of 140 taxa were identified and recorded; however, only few species or species groups are chosen for detailed paleoecological discussion. Species are grouped on the basis of taxonomic and paleoecological affinities in order to enhance a trend. Calcareous nannofossils examination in the present study interval indicate dominance of *Reticulofenestra spp* with percentage abundance of 49% compared to the total taxa. Followed by *Cyclicargolithus spp,* (percentage abundance of 17%), *Sphenolithus spp, (* percentage abundance of 12%*),* Coccolithus *spp,* (percentage abundance of 8 %), the taxa with an average percentage abundance of less than 5% were *Helicosphaera spp* 4% , *Pontosphaera spp* 3%, *Braarudosphaera spp* 2%, Chiasmolithus oamaruensis 1% (as seen in Fig. 6).

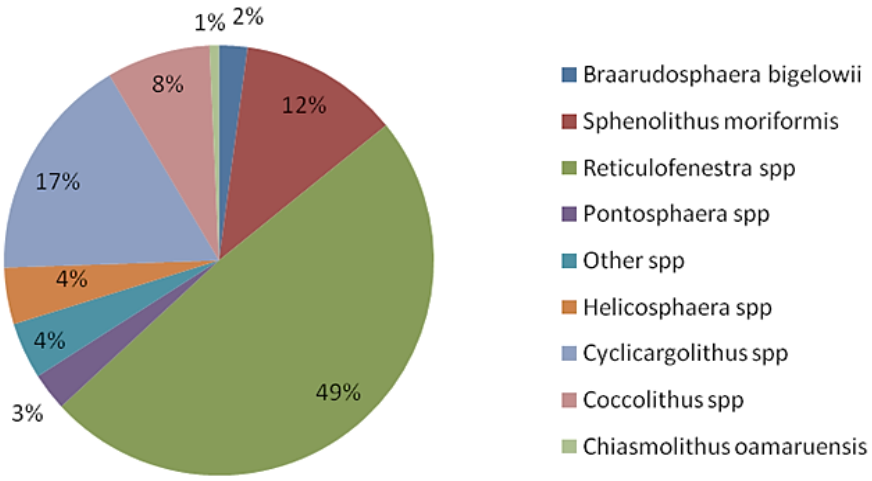

Figure 6: Pie chart of percentage occurrence of recovered taxa groups

3.5 Cool water Nannofossils Taxa

The following species Reticulofenestra *spp*, *Cyclicargolithus spp*, *Coccolithus spp* and *Chiasmolithus spp* have been characterized as cool water (Fig. 7), eutrophic nutrient rich species, and indicators of upwelling areas for this present study [5], [21-24].

Reticulofenestra *spp*

The *Reticulofenestra* group is the most predominant species (Fig. 4 & 6) in the study interval, consisting of *Reticulofenestra bisecta, Reticulofenestra scrippsae, Reticulofenestra umbilica, Reticulofenestra umbilica* and *Reticulofenestra* spp.

The average abundance of the group increased towards early Oligocene. According to [5], [21-22]; [24], this species is referred to cool water conditions. Their abundance suggest cool, more eutrophic and nutrient rich episode in the study which corresponds to the global event in the Oligocene.

Cyclicargolithus spp

This group consist of *Cyclicargolithus abiesctus* and *Cyclicargolithus floridanus.* They have been inferred as cool water species by [7], [24] and in this study, though ecological preference remains ambiguous by some authors [12]. They are the next in abundance in the study interval with 17% (Fig. 6) and because of their relationship in abundance with *Reticulofenestra* within the Oligocene (Fig. 7). The FO *Cyclicargolithus spp* appeared at depth 13360ft, disappeared and at the boundary of Eocene –

Oligocene reappeared again (Figure 4). The abundance of the group contributes to the cool water eutrophic environment.

Coccolithus spp

This group consist of Coccolithus *pelagicus and Coccolithus miopelagicus* making up 8% in percentage abundance of the total assemblage in the study (Fig. 6). Its first occurrence in this study appears in zone NP21 though very scanty occurrence. Presently, this species is considered as a typical cool water form [24], [26-27] and eutrophic upwelling zones [28], [29].

Chiasmolithus spp

Chiasmolithus group has only *Chiasmolithus* oamaruensis which appeared in the upper zone of NP2 (Figure 4). It is well established as a cold-water taxon in [4, 5,],[30-32] suggested that this taxon was adapted to eutrophic environments.

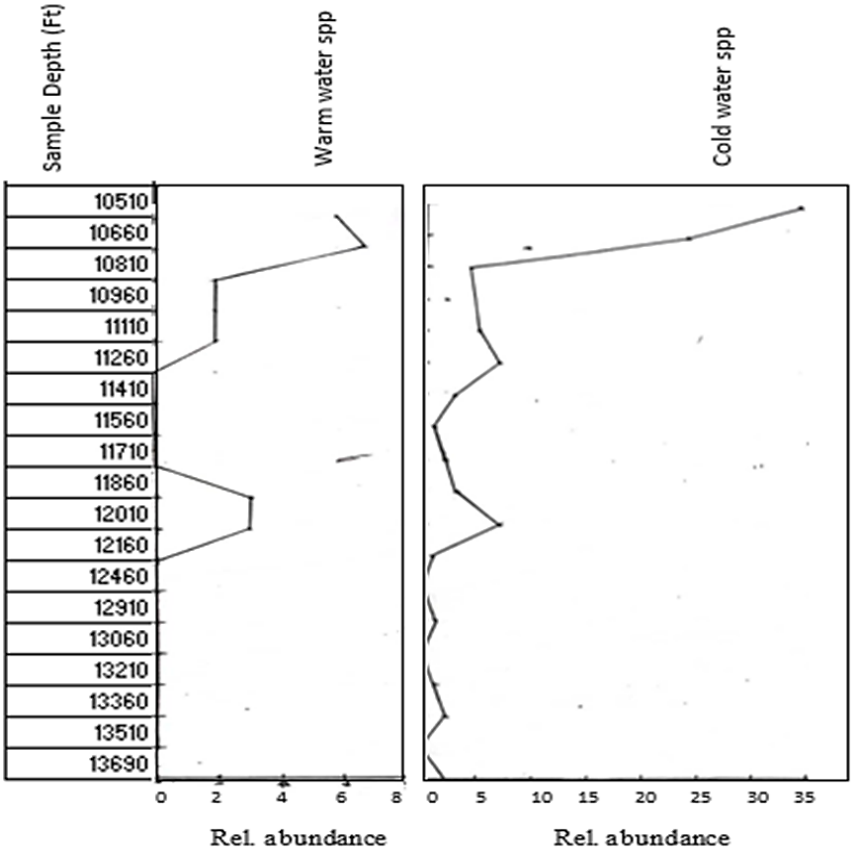

Figure 7: Relative abundance of ecologically significant nannofossils of Total warm and cold water species against depth and blue dashed line signifies the Eocene-Oligocene boundary

3.6 Warm water Nannofossils taxa

Sphenolithus spp, *Helicosphaers* spp, *Pontosphaera spp* are characterize as warm water (Fig. 7), oligotrophic species [3] and [33-37].

***Sphenolithus* spp**

Only *Sphenolithus moriformis* is present in this group from the study section. It has been characterized as oligotrophic warm water taxon by many authors [34, 35]. In this study the relative abundance is less compared to the *Reticulofenestra* which indicate cooler waters, hence the prevailing condition is suggestive of cooler- water and more eutrophic environment during this period.

Helicosphaera spp

This group consists of *Helicosphaera catrei* and *Helicosphaera compact [34] a*nd others which could not be identified beyond genus level (Fig. 4) due to poor preservation in the studied intervals. The presence of this group indicates hemiplegic - shelf environment, moderate nutrient and turbulence in the surface waters [38, 39].

Pontosphaera spp

Major examples of this group include *Pontosphaera multipora* and *Pontosphaera* spp (Fig. 4). This group indicate more common near shore and warm water conditions. These changes correlate with global sea level curves discussed by others [35].

4. Conclusions

This study examined palaeocological preferences of calcareous nannoplankton assemblages of AS-2 well in the Niger delta. The following observations were noted.

1. Quantitatively, the nannofossil assemblage recorded from Well AS-2, Niger Delta were scanty to moderately preserved, with 140 species belonging to 10 genera.
2. The assemblage belongs to the late Eocene – Oligocene or precisely dated as Priabonian – Rupelian, only two major nannofossil zones (NP21 and NP20) belonging to the early Oligocene to late Eocene age was identified using the standard zonation schemes of [20] and [40] for the studied interval of the well.
3. Presence of the following species *Reticulofenestra spp*, *Cyclicargolithus spp*, *Coccolithus spp* and *Chiasmolithus spp* have been characterized as cool water, eutrophic nutrient rich species, and indicators of upwelling zones for this present study.
4. Records of *Sphenolithus* spp, *Helicosphaers* spp, *Pontosphaera spp* are characterize as warm water, oligotrophic environments.
5. The prevailing environmental condition in accordance with the palaeocological preferences studied suggest cooler, more eutrophic condition for the studied section.

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