Diatomic Palynofacies and Depositional Environment in Part of Bonny Coastal Area of Niger Delta

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ABSTRACT:

Fourteen sedimentary cores were collected on the sedimentary shale deposits of Bonny area, in the Niger Delta region, where palynological analysis was performed to infer the history of the palynofacies and depositional environmental changes in the study area. The results revealed diatoms species among benthic and planktonic life forms. Correspondence analysis applied to relative abundance of diatoms and associated with sedimentary deposit. The age of the Well can be determined with the presence of some diagnostic palynomorph which include Aspitia nodulifer, Thalassiosira ferelinate, Thalassiosira oestriupii, Chactoceros, Nitzschia paerenheildii and Actinocyculus undulotus, which is a diagnostic form of Miocene to Pliocene that indicated more energy than in present days, originating a coastal swamp. And their paleoenvionments ranges from coastal swamp to fresh water and near shore marine sedimentary environment, under erosive conditions, unfavorable to the colonization of vegetation. The intermediate grey shale was observed only in the core showed the prevalence of planktonic diatoms, providing evidence of a deeper and calmer environment, located in a probably protected area, with intense sedimentation of shale particles with abundant plant remains.

KEY WORDS: *Palynology, Depositional, Environment*

1.0: INTRODUCTION

Pollen, spore and diatoms are particularly useful in these endeavors, not only because they are preserved in the sediment record, but because they have a short reproductive rate and respond quickly to changes in nutrient availability and water-quality conditions. Palynology and palynofacies offers powerful techniques with which to study historical changes due to human influences in depositional environments, including estuaries and coastal wetlands. Pollen, spore and diatoms are particularly useful in these endeavors, not only because they are preserved in the sediment record, but because they have a short reproductive rate and respond quickly to changes in nutrient availability and water-quality conditions. Coastal are characterized by variability in salinity, sediment deposition, water currents and residence time, turbidity zones, and unique biogeochemistry of sediments. Historically, there has been a lack of appreciation for the magnitude and severity of human impacts on coastal ecosystems, and of how important these ecosystems are to human society. The demand for resources and the wastes generated as human populations grow will continue to cause cultural, economic, aesthetic, and environmental problems in coastal areas.

1.1: GEOLOGY OF NIGER DELTA

The Niger Delta is situated on the Gulf of Guinea on the west coast of Central Africa, during the tertiary it built out into the Atlantic Ocean at the mouth of the Niger-Benue River System, and catchments area span about a million square kilometres of predominantly savannah-covered lowland (Merki, 1972). The Delta is one of the world's oil provenances with the sub-aerial portion covering about 75 000 km^2 and extending more than 300 km from apex to mouth (Short et al, 1967). The regressive wedge of clastic sediments which it comprises is thought to reach a maximum thickness of 12 km (Murat, 1972). Throughout the geological history of the delta, its structure and stratigraphy have been controlled by the interplay between rate of sediments supply and subsidence (Murat, 1972). Important influences on sedimentation rate have been ecstatic sea level changes and climatic variations, initial basement morphology and differential sediment loading on unstable shale (Whiteman, 1982). The delta sequence is extensively affected by synsedimentary and post sedimentary normal faults, the most important of which can be traced over considerable distance along strike (Merki, 1972).

Accumulation of marine sediments in the basin probably commenced in Albian time, after the opening of the South Atlantic Ocean between Africa and South America Continent. True delta development, however started only in the Late Paleocene/ Eocene, when sediments began to build up beyond troughs between basement horst blocks at the northern flank of the present delta area (Ogbe, 1982). Since then, a delta plain prograded southward on to oceanic crust gradually assuming a convex to the sea morphology (Doust and Omatsola, 1990).

1.2.: STRATIGRAPHY OF THE NIGER DELTA

The tertiary lithostratigraphic sequence of the Niger Delta consists in ascending order Akata, Agbada and Benin Formations which make up an overall massive clastic sequence of about 30000-39000ft (9000- 12000m) thick (Evamy et al, 1978).

1.3: AKATA FORMATION

The basal major time-transgressive lithological unit of the Niger Delta complex is the Akata Formation. It is composed mainly of marine shales but contains sandy and silty beds, which are thought to have been laid down as turbidites and continental slope channel fills above (Merki, 1972). The Akata Formation is characterized by a uniform shale development as evident in gamma ray and spontaneous potential logs (Merki, 1972). These pro-delta shales are grey to dark grey, medium-hard or soft at some places and sandy or silty. The shales are under-compacted and may contain lenses of abnormally high pressured siltstone or fine-grained sandstone (Merki, 1972). Furthermore, the Akata Formation is thought to be the main source for Niger Delta complex oil and gas. The Akata Formation may be continuous with the outcrops of the Imo Shale, but continuity between the two type sections which are of very different ages is not yet proved. The known age of the Akata Formation ranges from Eocene to Recent (Murat, 1972).

1.4: AGBADA FORMATION

The Agbada Formation is believed to be the hydrocarbon prospective sequence in the Niger Delta. It is represented by alteration of sands, silt and clays in various proportions and thicknesses, representing cyclic sequences of off lap units (Murat, 1972). These paralic clastics are the truly deltaic portion of the sequence and were deposited in a number of delta-front, delta-topset and fluvio-deltaic environments (Whiteman, 1982).The alternation of fine and coarse clastics provide multiple reservoir-seal couplets (Murat, 1972). As with the marine shale, the paralic sequence is present in all depobelts, and ranges in ages from Eocene to Pleistocene (Merki, 1972). Most exploration wells in the Niger Delta have bottomed in this lithofacies, which reaches a maximum thickness of more than 3000m (Doust and Omatsola, 1990).

1.5: BENIN FORMATION

The Benin Formation occurs throughout the whole Niger Delta from Benin-Onitsha in the north to beyond the present coastline. It constitutes the shallowest part of the sequence and is composed almost entirely of non-marine sand predominantly massive, highly porous fresh water-bearing sandstones with local thin shale interbed which are considered, braided-stream origin (Whiteman, 1982). The sand and sandstone of the Benin Formation are coarse grained, commonly very granular and pebbly to very fine grained. They were deposited in alluvial or upper coastal plain environments following a southward shift of deltaic deposition into a new depobelt (Whiteman, 1982).

1.6: AIM AND OBJECTIVES OF THE STUDY

The aim of this research work is to carry out palynofacies and paleoenvironmental analysis of samples obtained from some core in Bonny area of the Niger Delta.

1.7: LOCATION OF STUDY AREA

The area of study is an oil well in Niger Delta Basin in Nigeria. The study area lies between longitudes 3^{o}E and 9^{o}E, latitude 4^{o}E, and 52^{o}N. Figure 1.

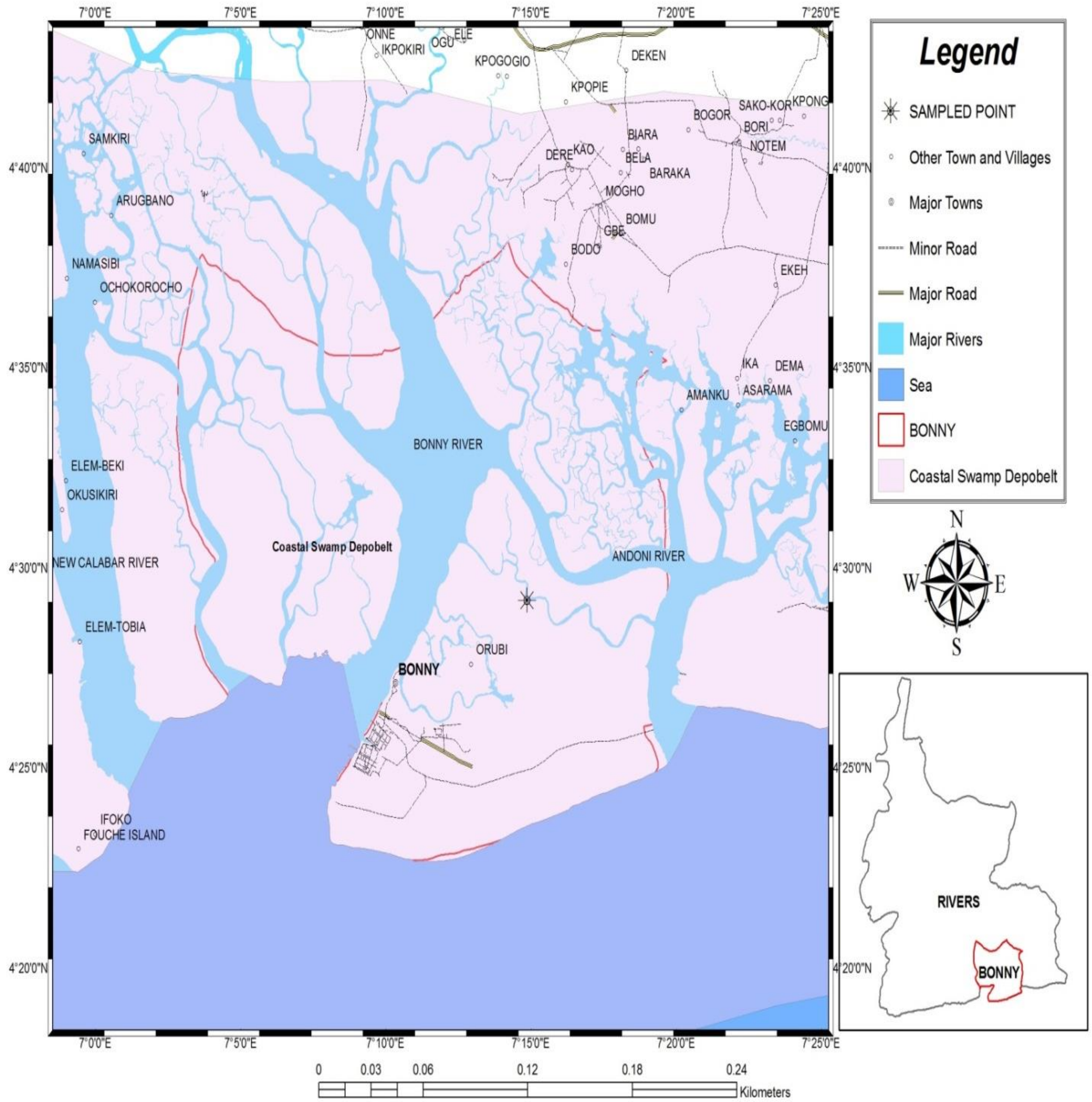


Figure.1: Map showing the study Area.

2.0 MATERIAL AND METHODS

Methodology entails the procedures and materials used in carrying out a researcher analysis. Various stages were adopted in this project starting with sample collection, sample preparation to sample analysis.

(ii) Laboratory Method At the laboratory a detailed lithologic description of the various sample were described, each sample was tested with dilute hydrochloric acid. The degree of reaction of the samples with the acid was noted and expressed as calcareous, when there is effervescence and non-calcareous when there is no reaction with the acid. The steps of laboratory analysis are explained below.

(a) Palynological Sample Preparation

Two to three grams of the samples were broken to a grain size of 4mm, and transferred to a plastic breaker cup. The beakers were then labeled according to the depth of the samples. All the samples were then treated with commercial grade hydrofluoric acid. The essence of these was to separate the fossils from the rock debris. Most of the calcareous samples showed effervescence. The length of time needed for the samples to digest varies depending on the quantity of silt and sand. But once the initial heat of reaction had been dissipated, hydrofluoric acid concentration was increased. The samples were displaced in a water bath and stirred, with plastic rods twice a day for the period of maceration. The effect of the acid was neutralized by decanting and settling method. The residual rock particle and megafossils were separated from the finer disaggregated material by passing them through a mesh of 106µm and 200µm. The filtrate was thoroughly washed with water using the 10µm mesh nylon sieve. The subsequent residue was swirled on a 24cm diameter watch glass. The lager residual was discarded while the final top material was boiled for a few seconds in water to which a few drops of concentrated hydrochloric acid were added. The residual was again washed in the 10µm mesh nylon sieve and stained with safranin- O in a mild alkaline medium stored in small glass centrifuge tubes and labeled.

(b) Slide preparation

The stained specimen above is further diluted and washed out with water and the finished residual transferred into a tube with two drops of diluted solution of glue is added. A few of the residual is pipetted out on a clean dry cover slip, allowed to dry on a hot plate. Canada balsam is smeared on a slid on a hot plate at 1000C. When warmed enough, the dried cover slip was stuck to the slide, pressed uniformly to avoid air bubble and allowed to dry. The prepared slide is cleaned, labeled correctly and properly stored after cooling.

(c) Examination of sample

It involves the preliminary examination of the prepared material followed by a quantitative listing of the pollen and spore flora. Secondly, a quantitative determination of the dominant palynomorphs present. In carrying out the first step, the essence is to yield or provide information as to the reliability of the sample. If the sample is reliable, the most useful information normally gained is a record of the total composition of the flora. This will give clue as to the knowledge of the range in time of specific taxa, floral origin, evolution and the nature of facies and the climate at the time of deposition. Whereas, quantitative determination provides information on the dominate palynomorphs, based on absolute figures, percentages or both. In determining the relative abundance, identification and counting was continued until all the samples were exhausted under high as well as low, power microscope and results recorded. Depths where palynomorphs were encountered are analyzed and identified, whereas certain depths were scanty and most were barren or sample not seen.

3.0 Results and Discussion

The results of this research work are presented in Figures 3.1 to 3.2 and Plate 1- 14

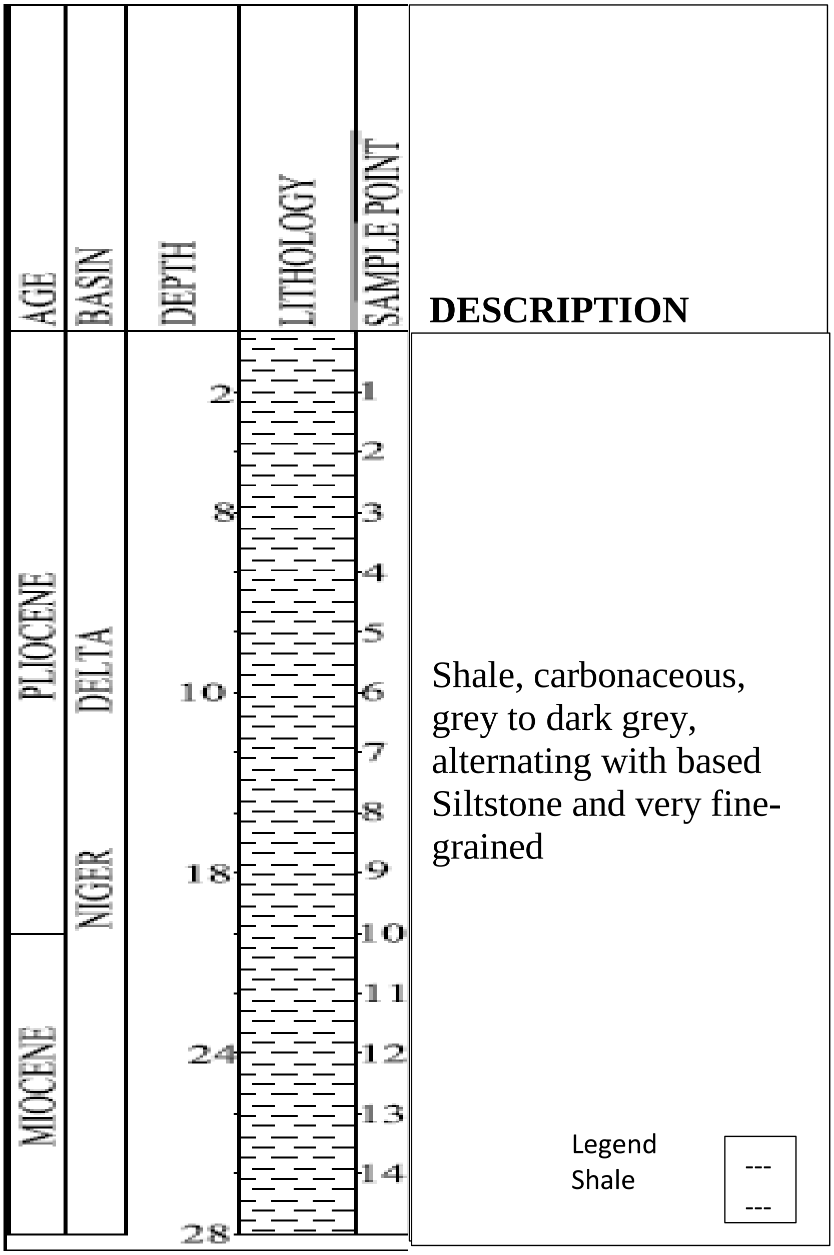


Figure.3.1: Lithology Description of the study area.

3.1: Palynofacie Interpretation

From the trend of the Palynofacie analysis that was carried out, it is obvious that sediment from marine environment of the younger sediments yielded the data from figure 3.2. The analysis shows the percentages distribution of palynofacie.

From sample 1-7 marks a decrease in equipdimensionl black with an increase abundant in equipdimensional brown debris and also a little deposit of bladed black, also the presence of cellular debris, and micro fossils found within these depths on a small scale which is associated with organic matter helped in the paleoenvironmental interpretation of the study area. The presence of diatom within these depth include *Aspitia nodulifer*, *Thalassiosira lineate*, *Thalassiosira lentiginosa*, and *Nitzschia paerenheildii*, at sample point 5 shows the presence of

Deamonorps, *Laevigatosporites*, *Pachylermites* and *Ephedripites sp*. The presence of fungal probably further confirms a swamp depositional environment. The dominance of diatom, pollen and spore, in addition to the presence of abundant plant debris, probably indicate a swamp environment. In sample 8, with the depth of 16cm are devoid of plant debris but are rich in diatom which include *Aspitia nodulifer*, *Thalassiosira ferelinate*, *Thalassiosira oestriupii*, and *Actinocyculus undulotus*, which is associated with pollen and spore *Daemenorops sparsiflorus*, *Dityophyliidites harisii*, *Tricolporopollenites rizophorous* and *Canthriumidites reticulatus.* Mostly they are found in a marine environment and could be near to foreshore.

In sample 9-14 within depth 18-24cm mark decrease in equidimentional black with an increase in percentage of equidimentional black debris and a very low percentage of bladed black shape debris but with a fluctuation of microfossils in sample 10 and 13. The minor presence of diatom, pollen and spore which include *Chactoceros*, *Aspitia nodulifer*, *Aspeitia tubularus* and *Thalassiosira lineate*. The pollen and spore, in addition to the presence of abundant plant debris, probably indicate a swamp environment. The common species include *Longapertites marginatus*,*cycadopites sp* and *Glaeiehemidites senonicus* and the presence of fungal probably further confirms a swamp depositional environment.

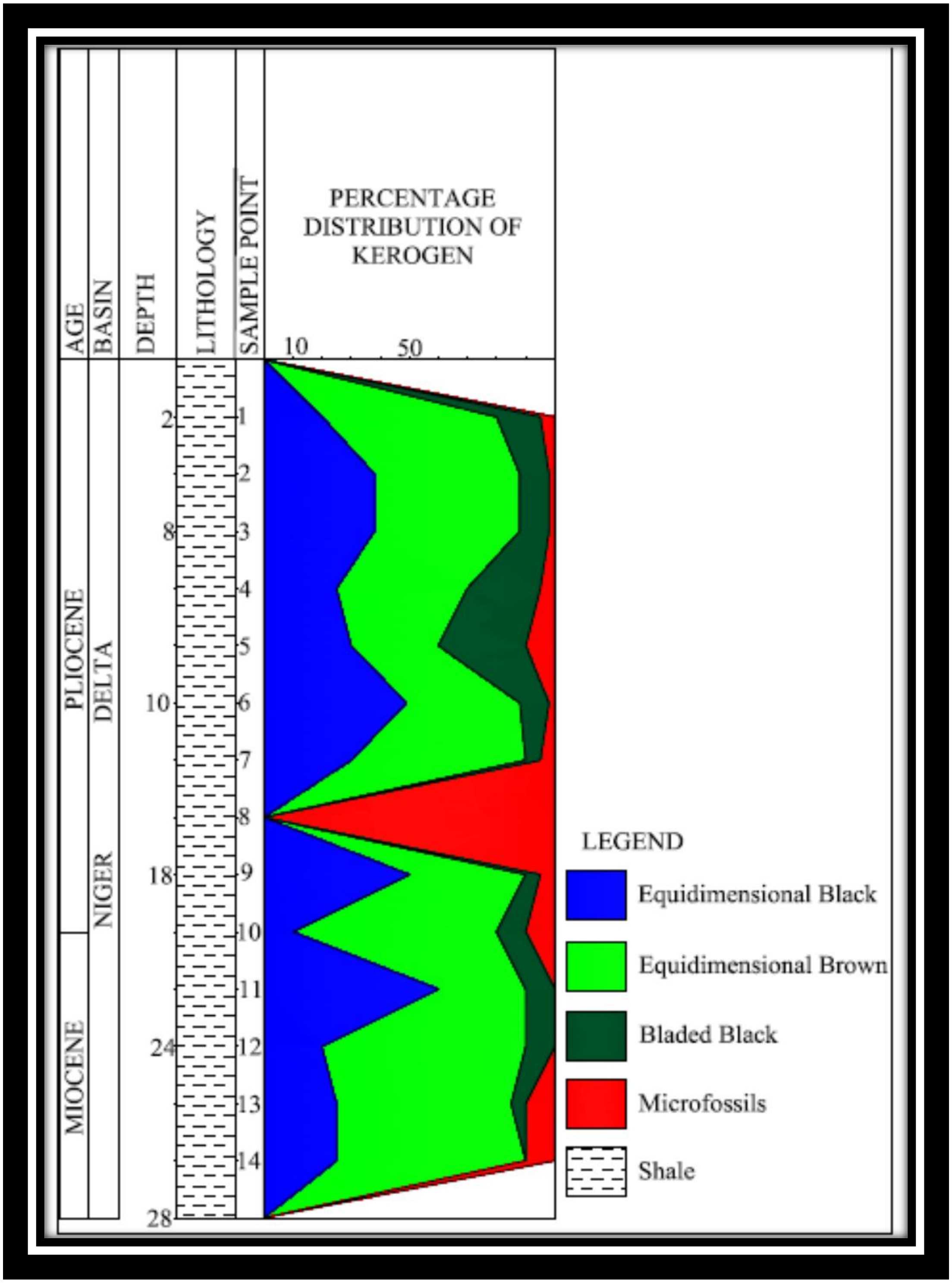


Figure.3.2: Percentage Distributions of Kerogen within the Study Area.

3.2: Paleoenvironment of Deposition

The sharp boundary between sediment layers support the hypothesis that sediment on the subsurface of all fourteen cores is derived from recent coastal sediment. The distribution of sediments were typically from 2 to 14cm, whereas non-storm sediments were around 16cm.

Reduction of organic matter is a characteristic of coastal to swamp sediments due to the winnowing or loss of plant material from turbulent storm surge (Jackson et al., 1995). Though higher in sediment for only a few sample intervals exhibited a larger increase in shale content and lacked consistency within the observed deposition layer, contrary to results found in other depth where shale layers were used as evidence for sedimentation (Donnelly et al., 2001; Liu and Fearn, 2000b), in this study of Delta plain sedimentation in Bonny. Since the likely sources of redistribution within the marsh system itself (including tributaries and marsh lakes) and all these locations are dominated by fine-grained sediments (Beall, 1968; Draut et al., 2005), the lack of distinct shale layers is not altogether surprising. In addition, Draut et al. (2005) describes post-storm deposition for the intercontinental shelf as shale-mud couplets resulting from decreasing intensity of the storm. Shale-mud layers characteristic of this pattern can be identified in several 14 cores and may explain a few of the six samples with greater than 25% shale content. The 2cm depth sampling interval may be insufficient (too thick) to identify this pattern for all coastal to swamp sediments in all cores, the absence of a defined return to pre-storm sediments at the surface and the documentation of sedimentation in nearby monitoring sites suggest that deposition is likely reflected in this top layer. The range chart data in fig 3.1 to 3.2 also support the conclusion that surface sediments were deposited from recent storms. The high organic matter and low microfossils content of the cores, combined with the location, suggest a dominance of organic matter for recent non-storm accretion. The contrast between organic matter accretion and storm sedimentation provide a clear record on the percentage distribution. Increases in percentage distribution data also indicate event-derived sedimentation, with sediments having up to two times the deposit of non-storm sediments. These locations also have between 25 and 50% of their vertical distribution. Sample 8 is also dominated by non-organic matter accretion, but with fewer diatom deposits. Diatom microfossil assemblages found in recent deposited sediments are different from sediments found deeper within the sediment core. Diatom assemblages of sediments from the different locations are more similar to each other and are composed primarily of *Aspitia nodulifer, Thalassiosira ferelinate, Thalassiosira oestriupii, Chactoceros, Nitzschia paerenheildii* and *Actinocyculus undulotus.* A diatom paleoindicator of historic sediments would be the most valuable at coastal to swamp with less than 20% organic matter (high mineral composition) and at depths greater than 28 cm since organic matter decomposition increases, likely making sediments more difficult to sedimentary profiles.

4.0: SUMMARY AND CONCLUSION

Diatoms are an important primary producer and are prevalent in the sediments, plants, and water column of coastal swamp. They are widely used to assess aquatic environmental conditions due to their species-specific correspondence to water characteristics. They have the potential to provide a significant ecological indicator of current coastal wetland condition and a tool for examining past environmental change. However the number of samples and the breadth of the conditions sampled must be sufficient to isolate the full tolerance and range of a significant number of species. Despite the ubiquitous nature and valuable applications, there are very few studies that examine the relationships between the complex community structure of diatoms and environmental factors influencing their distribution and abundance in coastal swamp of the Bonny area. The age of the well can be determined with the presence of some diagnostic palynomorph which include *Aspitia nodulifer, Thalassiosira ferelinate, Thalassiosira oestriupii, Chactoceros, Nitzschia paerenheildii* and *Actinocyculus undulotus*,which is a diagnostic form of

Miocene to Pliocene. These deposits are of economic benefit being used in filters, paints, toothpaste, and many other applications.

EXPLANATION TO PLATE 1

Fig 1-3 kerogen retrieved from Bonny consists of 30% equidimensional black debris, 60% equidimensional brown debris, 5% bladed shape debris and 5% microfossils.

4-23 Palnomorphs retrieved from fig 4-23

4, 5,and 16. Actinocyclus lingen

6, 8, 7, 10, 11, 17, 18, and 19 Thalassiosira ferelineate

9. Canthriumiditees reticulatus

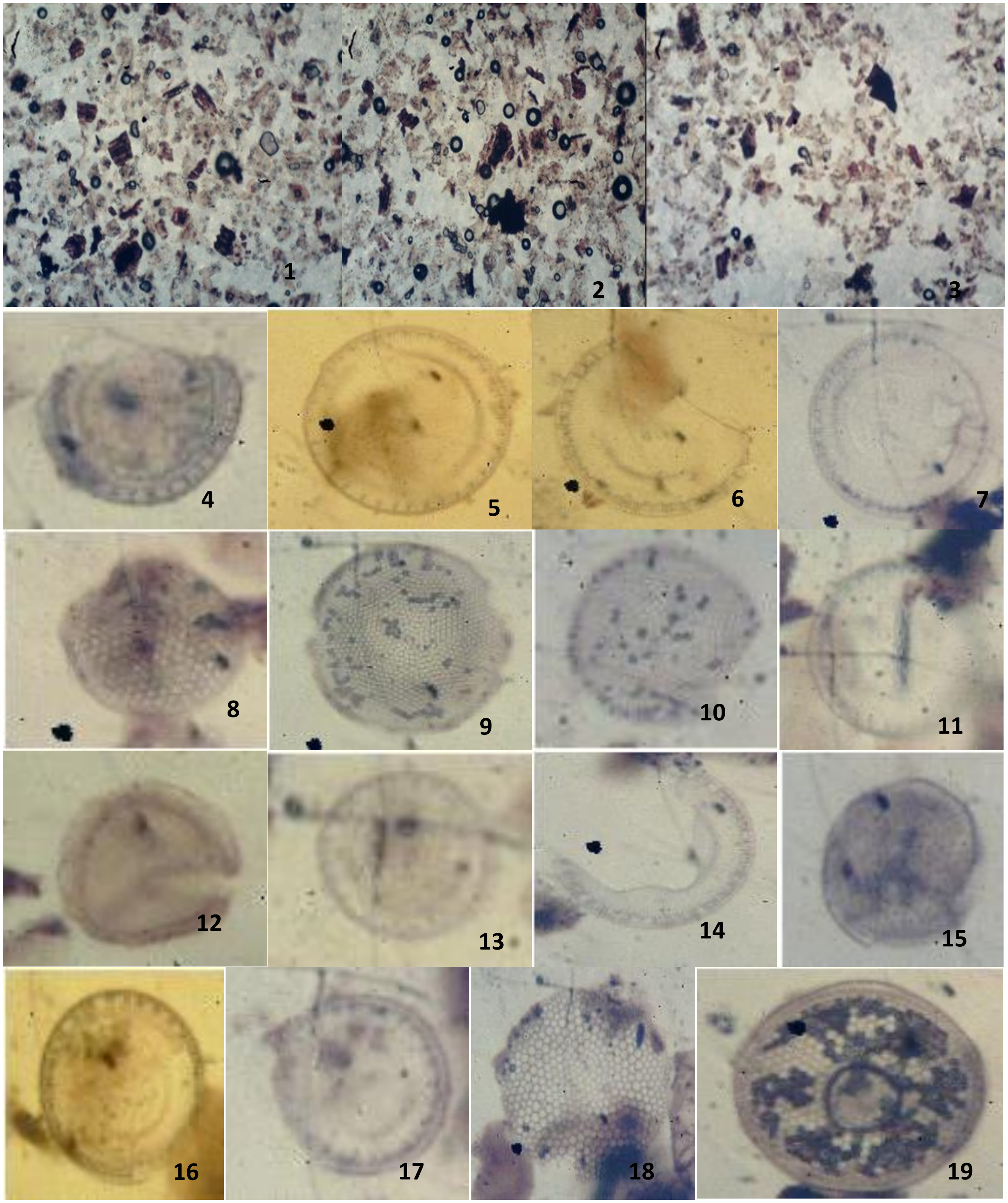
11. Triporopollenites rizophorus

12. Dityophyllidites harisii

13 and 15. Azpeitia nodulifer

14. Daemonorops sparsiflorus

PLATE 1



EXPLANATION TO PLATE 2

Fig 1-4 Palynomorphs retrieved from fig 1-4

1. Daemonorops sparsiflorus

4. Thalassiosira ferelineate

2 and 3 Thalassiosirs lineata

Fig 5-6 Kerogen retrieved from Bonny consists of 50% equidimensional black debris, 40% equidimensional brown debris 5% bladed black and 5% microfossils.

Fig 7-18 Palynomorphs retrieved from fig 7-18

9 and 7. Fungal spore

11, 13, 14, 17 and 18. Thalassiosira ferelineate

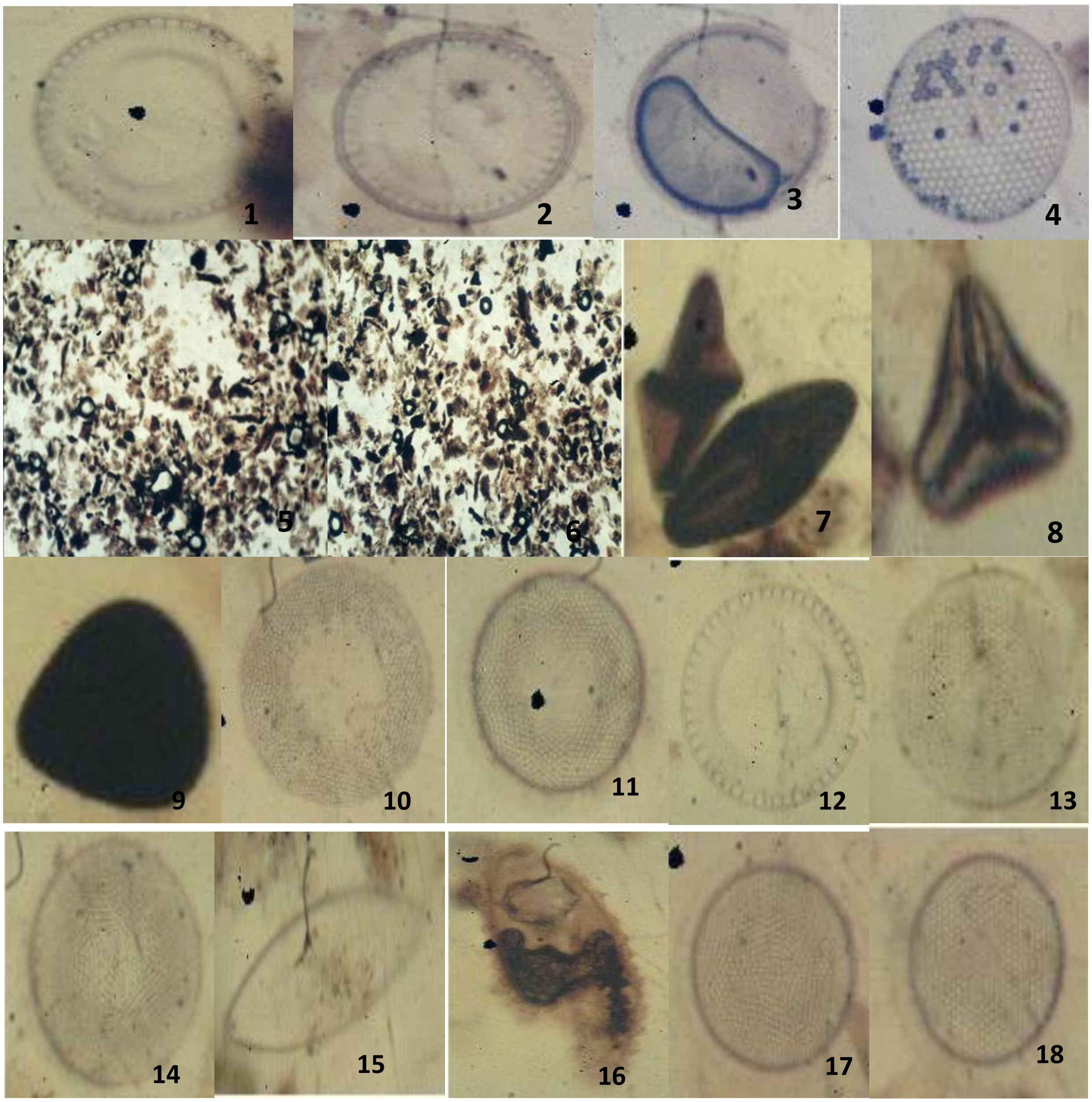
8. Glaeiehemidites senonicus

15 and 16. Cycadopites

10 Thalassiosira eccentric

12 Thalassiosirs lineata

PLATE 2



EXPLANATION TO PLATE 3

Fig 1-3 Kerogen retrieved from Bonny consists of 20% equidimensional black debris, 50% equidimensional brown debris, 55% bladed shape debris and 5% microfossils.

Fig 4-7 Palynomorphs retrieved from fig 1-3

4, Nitzschia paerenhoidii

5, Thalassiosira lentiginosa

6, Thalassiosira lineate

7, Azpectia nodulifer

Fig 8-10 kerogen retrieved from Bonny kerogen consists of 38% equidimensional black debris, 50% equidimensional brown debris, 10% bladed shape debris and 5% microfossils.

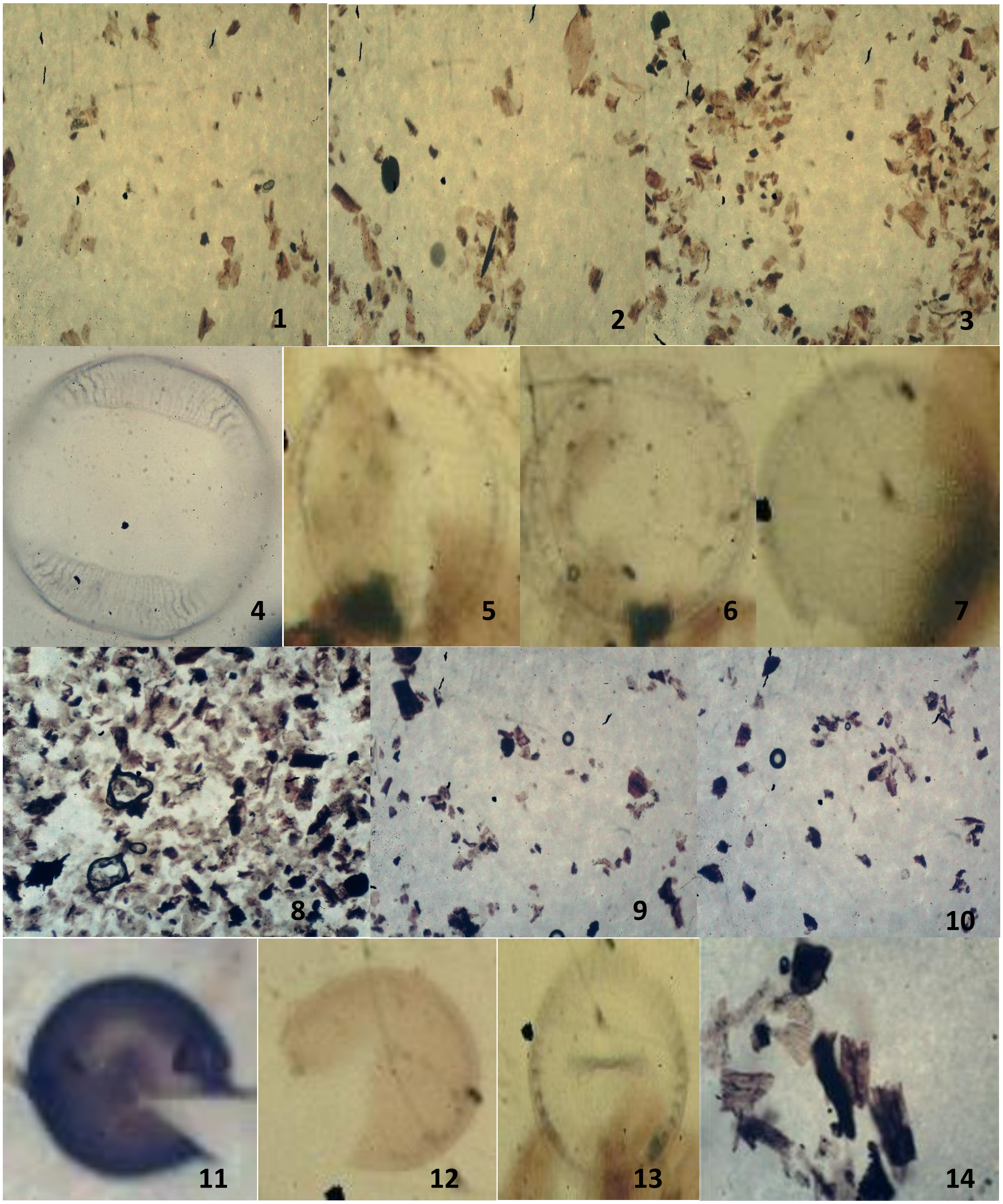
Fig 11-13. Palynomorphs retrieved from fig 11-13

11, Retimonocolpites sp

12 and 13, Thalassiosira

Fig 14 kerogen retrieved from Bonny consists of 38% equidimensional black

PLATE 3



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