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Organic Sediment and Sedimentary Environment Using Palynomorphs from Bonny Coastal Area of Niger Delta

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Abstract— *Fifteen 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 paleoenvironmental changes in the study area. The results revealed diatoms species among benthic and planktonic life forms. The age of the well can be determined with the presence of some diagnostic palynomorph which include Aspitia nodulifer, Thalassiosira ferelinate, Thalassiosira oestriupii, Chactoceros, Nitzschi apaerenheildii and Actinocyclus undulotus, which is a diagnostic form of Miocene to Pliocene that indicated more energy than in present days. Palynofacies analysis identified types of kerogen: palynomorphs, and kerogen components in the sediments, followed by equipdimensional brown debris (60%), equipdimensionl black (20%), bladed black (15%), and palynomorphs (5% or less). We note here that the overwhelming amounts of degraded and comminuted phytoclasts cover up palynomorphs and other components on the slides. And their paleoenvionments ranges from swamp to fresh water and near shore marine sedimentary environment, under erosive conditions, unfavorable to the colonization of vegetation. The intermediate grey shale which 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, colonized by mangrove forest and alluvial palm forest. The lower organic-shale within depth 20-30cm and of the organic-shale much younger than depth 0-10cm, showed more agitated and erosive sedimentary conditions, however, with less energy than that of the middle part depth 10-20cm, indicated by higher abundance of Thalassioira ferelinate. The sedimentary environment allowed colonization by which persists on the coastal to swamp near shore to foreshore.*

I. INTRODUCTION

Palynology 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. Diatoms are abundant in aquatic environments, generally cosmopolitan in distribution, and have a fairly well-studied taxonomy and ecology. Paleoenvironmental studies in coastal environments have lagged behind, primarily because of the more dynamic nature and presumed invulnerability of coastal ecosystems. Coastal are characterized by variability in salinity, sediment deposition, water currents and residence time, turbidity zones, and unique biogeochemistry of sediments. There is often mixture and transport of sediments after initial deposition, and differential silicification and preservation of diatom valves and environmental problems in coastal areas. Thus the aim of this work is to carry out palynological and palynofacies analysis of the area. To interpret the depositional environment of the study area.

II. LOCATION OF STUDY AREA

The area of study is an oil well in Niger Delta Basin in Nigeria. The study area lies between Longitudes 4° 45.04′.03″N and 7°0014.08″E Latitude. Figure 1 Map Showing the Study Area.

III. 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 kilometers 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 km2 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 u 12 km (Murat, 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). 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).

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3.1: 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).

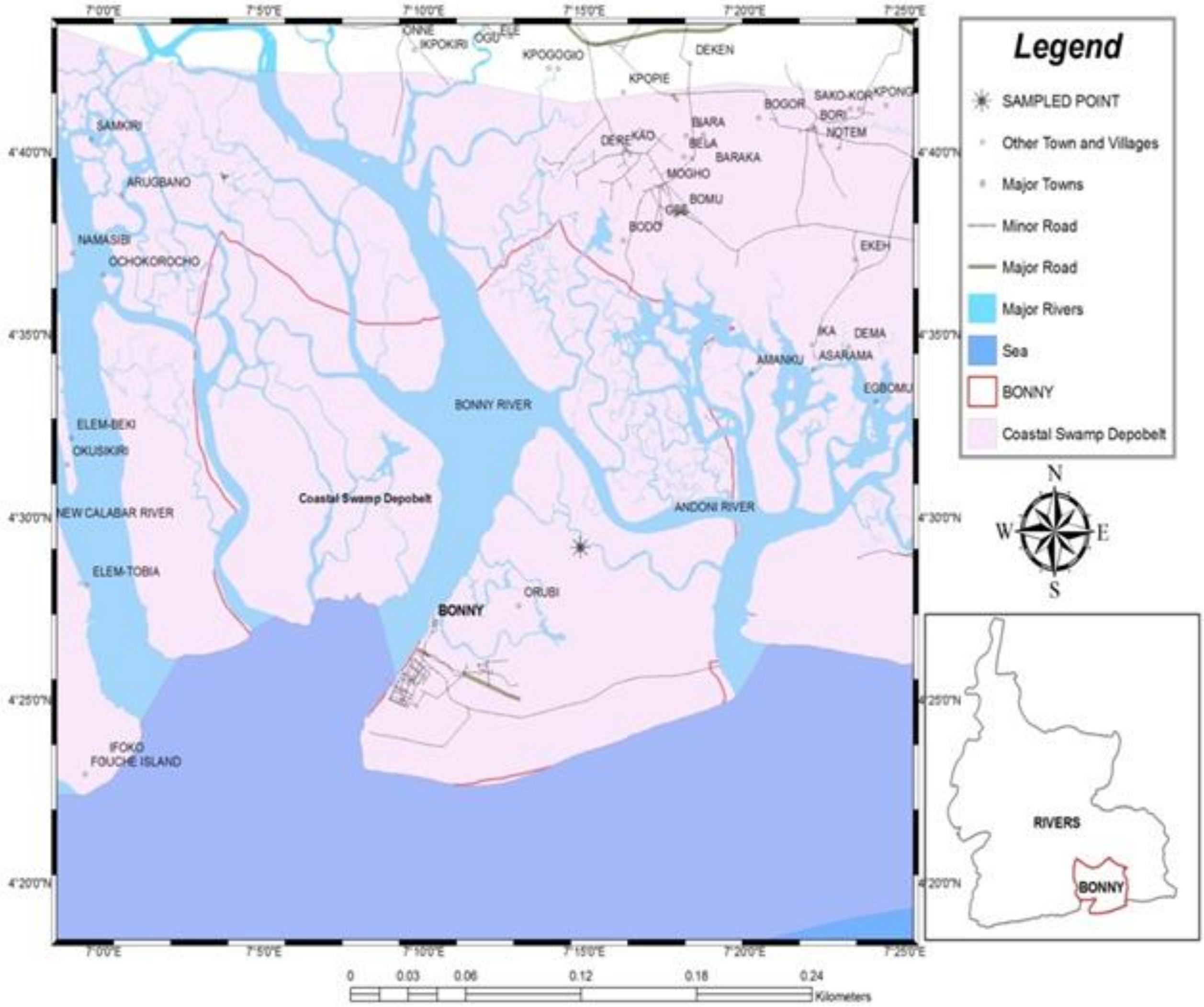

Figure 1: Map Showing the Study Area.

3.2: Akata Formation

The basal major time-transgressive litho logical 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).

3.3: 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 paralicclastics are the truly deltaic portion of the sequence and were deposited in a number of delta-front, delta-top set 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 deponents, and ranges in ages from Eocene to Pleistocene (Merki, 1972). Most exploration wells in the Niger Delta have

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bottomed in this lithofacies, which reaches a maximum thickness of more than 3000m (Doust and Omatsola, 1990).

IV. Methodology

Fourteen core samples were used for both palynological and sedimentological studies. Litho logic description of the samples was done by examining them under the binocular microscope by noting the textural characteristics such as color, grain size, shape (roundness), sorting, effect of ferruginization, and fossil content in terms of plant remains. Palynological slides were prepared by subjecting the samples to initial digestion by adding dilute hydrochloric acid into them in order to remove calcium carbonate ($CaCO3$) that might be present. This is followed by hydrofluoric acid (HF) digestion overnight for proper liberation of the organic macerals present in the samples. Recovered macerals from sieving with nylon sheet of 10µm in order to remove clay particles present is followed by oxidation, heavy liquid separation and mounting of the residue on glass slides with D. P. X. mountant, ready for palynological analysis. The method of preparation conforms to international standard. Taxa counts were made to determine the relative frequency of each species in each sample, after which the diagnostic species photographs were taken using Koolpix camera 6000 model.

V. Results and Discussion

The litho-description follows the standard method of describing samples as described in the methodology. Formal sedimentary analysis of the ditch cutting shows the shale unit is dark grey in colour and very fine grain in nature.

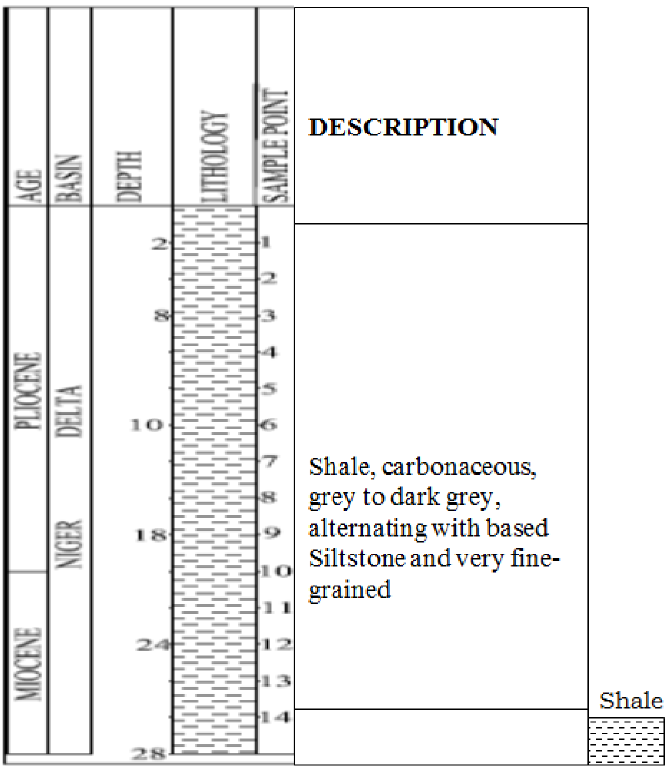

Figure 2: Lithology Description of the Study Area.

TABLE.1: Showing The Palynofacie Analysis

Depth (cm)	Sample point	Equidimensional black %	Equidimensional brown %	Bladed shape %	Cellular debris %	Granular %	Micro fossils %
2	1	20	50	25	-	-	5
4	2	38	50	10	-	-	2
6	3	38	50	10	-	-	2
8	4	25	45	25	5	-	-
10	5	30	30	30	-	-	10
12	6	39	50	10	-	-	1
14	7	30	60	5	-	-	5
16	8	-	-	-	-	-	100
18	9	50	40	5	-	-	5
20	10	10	70	10	-	-	10
22	11	60	30	10	-	-	-
24	12	20	70	10	-	-	-
26	13	25	60	5	-	-	10
28	14	25	65	-	-	-	10

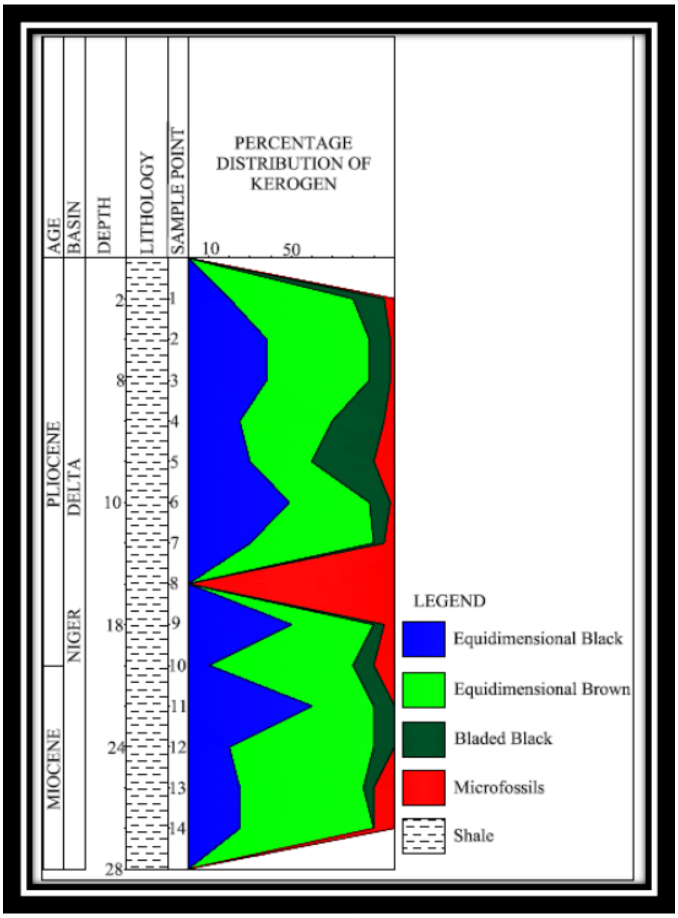

Figure 3: Percentage Distributions of Kerogen within the Study Area.

5.2: Palynofacie Interpretation

From the trend of the Palynofacies analysis that was carried out, it is obvious that sediment from marine

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environment of the younger sediments yielded the data from Figure 4.2. 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 confirm a swamp depositional environment.

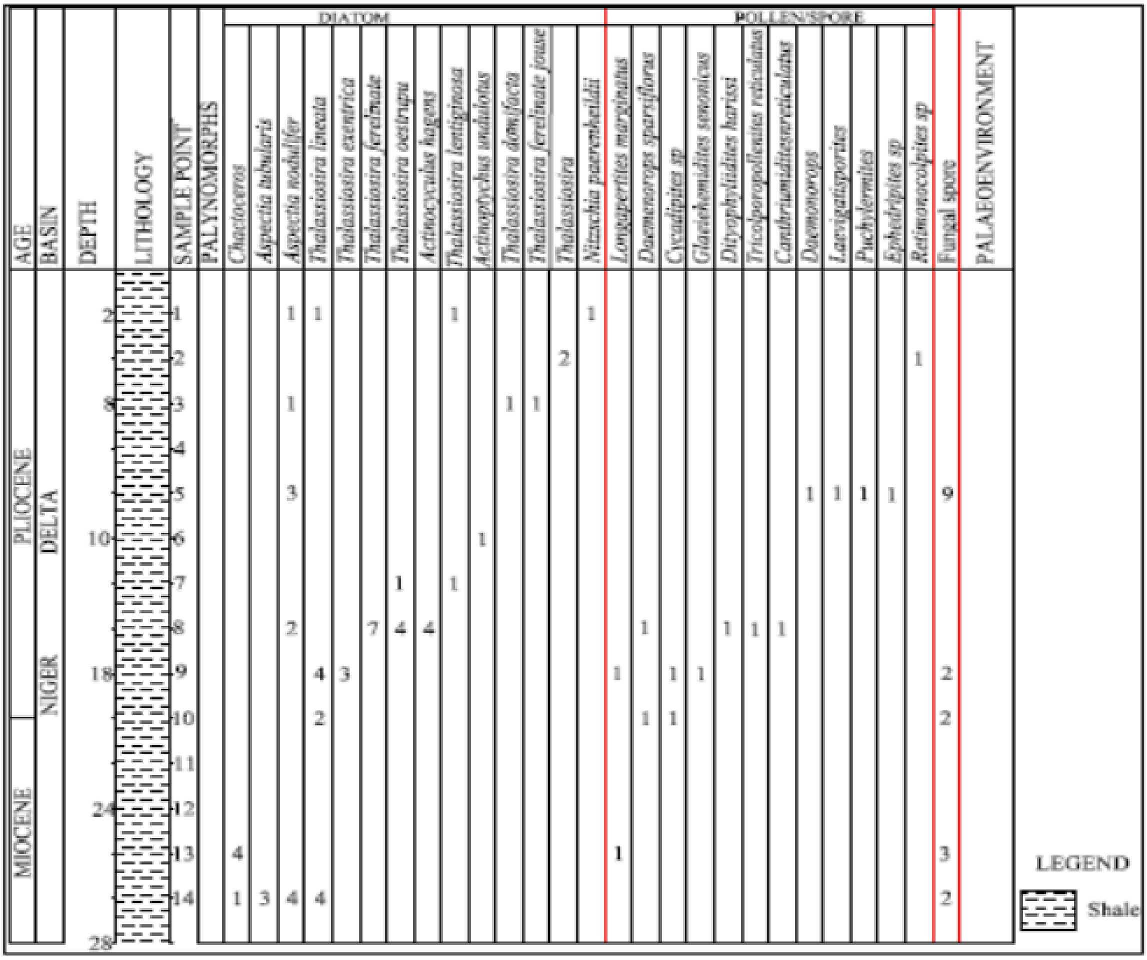
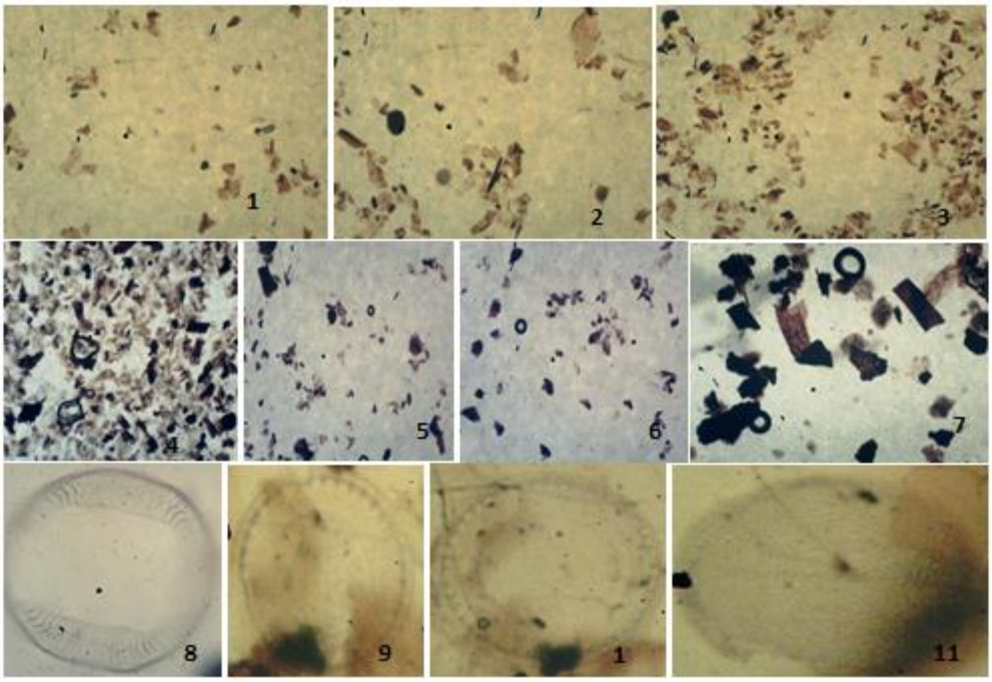


Figure 4: Range chart Distribution of Diatom, Pollen and Spore.

4.4: Paleoenvironment of Deposition

The presence of sharp boundary between sediment layers and increased 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. Reduced 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). (Oluwajana & Omoboriowo, 2012). (Soronnadi-Ononiwu, & Omoboriowo, 2012). Though higher in sediment, grain size 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 his 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 14cores and may explain a few of the 6 samples with greater than 25% shale content. The 2-cm 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 and fig 4. 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. The data from these studies can improve our understanding of the impacts of future climate change and sea-level rise on coastal wetlands, as well as provide essential data for predictive modeling of the impacts of future events of paleoenvironment deposition and climate scenarios.



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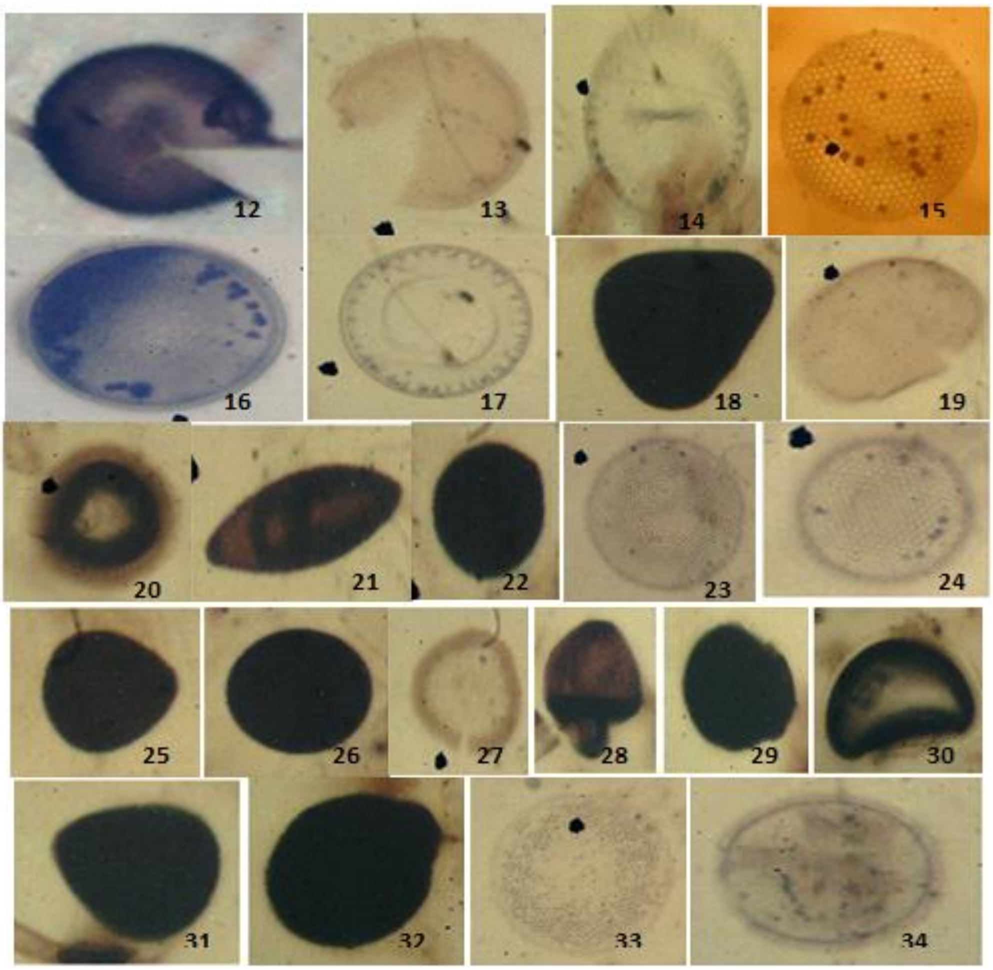

EXPLANATION TO PLATE 1

Fig 1-7: kerogen derived from the core coastal swamp samples kerogen consists of 20% equidimensional black debris, 50% equidimensional brown debris, 55% bladed shape debris and 5% microfossils.

Fig 8-34 microfossils

8. *Nitzschi apaerenhoidii*
9. *Thalassiosira lentiginosa*
11. *Thalassiosira lineate*
10. *Retimonocolpites sp*

12 and 13, *Thalassiosira*

15. *Thalassiosira ferelineate*
17. *Thalassiosira domifacta*

18,21,22,25,26,28,29,30 and 32 *Fungal spore*

19. *Epheddripites*
20. *Pachylermites sp*
31. *Coscinodiscus radiatus*

14,16,23, 24 and 33 *Azpectia nodulifer*

27. *Laevigatosporites*
31. *Daemonorops*
34. *Actinoptychus undulotus*

VI. 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. The silica walls of the diatom frustule do not decompose and are preserved in the sediment record, providing a record of past environmental conditions. Diatoms 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. Studies which compare sampling effort with its influence on gradient length and model predictive capacity could help clarify the number of samples and effort required to create effective transfer functions.

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