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Sedimentological and Palynological Approach for Determining the Depositional Environment of the Outcropping Surma Group Mudrocks in the Sitakund Anticline, Chittagong-Tripura Fold Belt, Bangladesh

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Abstract

Sitakund anticlinal structure exposes about 1.5 km of Surma group sediments and has been chosen for a comprehensive study of the mudrocks depositional environment based on sedimentological and palynological evidences. Five mudrock facies have been identified in this region. They are Mudstone Dominated, Sand/Silt Streaked Shale, Fissile Shale, Laminated Shale and Lenticular Bedded Shale. The palynological assemblages from these samples have been analyzed qualitatively, and a variety of pollen, spores, algae and fungi identified. The pollen and spores have been attributed to parent plants located at the immediate and more regional surrounding areas during the deposition of these sediments. Palynological assemblages incorporates ample of Palmae grains such as spores in the Palmipollenites and Proxaperites and predominance of pteridophytic spores. The occurrences and abundances of these pollens indicate that the deposition of the Surma mudrocks took place at the proximity of the shore level. Coastal fluvial environment is also triumphed after the previous depositional event which is apparent by the occurrence of palynomorphs of pteridophytes, angiosperms and algal origin.

Keywords: Sedimentology, Palynology, Depositional environment, Surma group, Mudrcoks, Sitakund anticline.

I. Introduction

The mudrocks occur interbedded with sandstone in a repetitive and monotonous succession and the latter forms one of the thickest Neogene stratigraphic unit - the Surma Group (> 3 km). The depositional environments of the Neogene Mudrocks are generally considered as shallow marine to deltaic environment that at late Neogene progressively changes to fluvial system. The purpose of the present study is to reform the depositional environment of the Surma group Mudrocks from sediment logical and palynological data. A number of workers did extensive work on Neogene succession. Main purpose of the study is to describe Neogene succession in terms of formation lithology, facies association, age determination etc. Davis et.al[1] compared the modern, tidally dominated shelf and detail sedimentary facies withthe late Miocene sediments, Sitakund anticlin. He identified some facies in Sitakund anticline that combine to record shallow, tidally influenced shelf depositional exposure where evidence of intertidal deposits are also present. Palynological approaches can be used for studying most sedimentary environments since the preservation of palynomorphs is usually good, because palynomorph occur throughout the Phanerozoic, and because palynological assemblages include several proxies or tracers that can be analyzed simultaneously. They permit assessment on the source of organic matter and reconstruction of productivity and hydrographical conditions. Palynological assemblages are useful for various applications dealing with environmental issues such as productivity, eutrophication and climate changes. They led to application dealing with the biostratigraphy and paleogeography of the Paleozoic to recent. This study presents an overview of the palynological content of sediments from Sitakund anticline to reconstruct the sedimentary depositional environment.

II. Geologic Settings

It is believed that the youngest structural segment of the western flank of the Indo-Burman ranges is Chittagong Tripura Fold Belt (CTFB) formedowing to the collision of Indian and Burmese plates. It is characterized by N-S trending hills made up of sedimentary piles ranging in age from Miocene to Recent (Alam et al[2]). Sitakund, Kailastila, Lalmai, and some other anticlinal structures comprise the west zone of the folded belt (Shamsuddin and Abdullah[3]). It is proven that the Indian plate had moved from south to north, while Burmese plate had relocated from east to west. Main east-west horizontal compression in the region has produced due to this relative movement. In the eastern part, the magnitude of the compressional force was greater than in the west. This tectonic force was the main driving mechanism behind the formation of the NNW-SSE fold belt and thrusts of the CTFB as well as the Sitakund hill range. The Miocene Surma Group is subdivided into two units: 1) The Bhuban and 2) Boka Bil formations (Holtrop and Keizer[4]; Hiller and Elahi[5]; Khan et al[6]), both of which extend throughout the Bengal basin. The Surma Group was deposited in transitional delta–front settings and comprises progradational sequences (Alam[7]). The Surma Group is unconformably overlain by the upper Miocene to Pliocene Tipam Group.

III. Materials and Methods

Extensive field work has been done in Sitakund structure in order to get basic geological data in different exposures of mudrocks. Sediment samples were taken from freshly cleaned surfaces at stratigraphic intervals that varied with the type and thickness of sediment. Further, samples were prepared in laboratory for the extraction of pollen. Rock samples were cleaned thoroughly before treatment to ensure that samples were completely free from any extraneous matter. Sample preparation includes the disintegration of bulk rock fragments to maximize the surface area in contact with the acid. The pulverized samples were then slowly treated with 10% concentrated HCl in separate beakers tagged with sample ID. Samples were stirred two times every day with a glass rod and were kept in this condition for two days. After that, 10% concentrated HNO3 added to the samples and preserved for two days to recover pollen easily. Carbonates were removed by treating the samples with dilute HCI, whereas silica and other minerals with HNO3. Then it was sieved to separate the large particles.

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Large-mesh (160 µm) metal screens are used to remove coarse mineral and plant debris from the sample. Water added to the beakers and poured until all contents were removed. Water-bearing macerated residue was mixed with a few drops of polyvinyl alcohol and was spread uniformly over the cover glass with the help of a glass rod. The cover glass was dried in oven for about 30 min and was then mounted in Canada balsam. Slides prepared out of the productive samples were examined under the microscope for qualitative assessment. Photographs were taken under 20*/0.40 and 10*/0.25 Polarization field with the help of Nikon DSLR camera. Distinguishable morphotypes were identified and were described on the basis of their affinity to specific depositional environment.

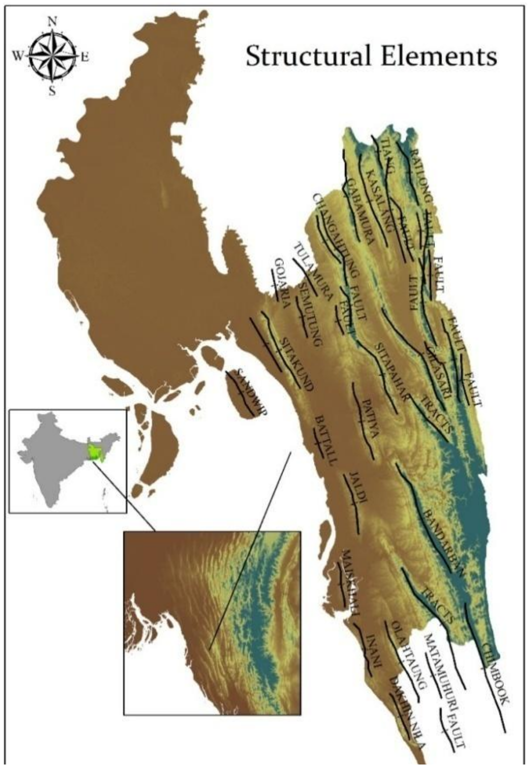


Fig. 1. Map showing the structural elements of the study area and adjacent region.

IV. Results and Discussion

All the outcrops studied in the axial region of the Sitakund structure, shale is abundant. The following five facies could be identified within the shale dominated sequence on the basis of internal sedimentary structure.

1) Mudstone Dominated (Facies F_{ms})

Shale is dominantly laminated ranging from well-developed laminae to poorly developed laminae. It is highly fissile to brittle.Continuous sedimentation of clays from suspensionare noted by the facies. Color of shale in this facies ranges from grey to bluish grey and some pale red. The parallel laminatedclay-rich subfacies contain 0.5-mm-thick sand and silt partings that are continuous for several meters flanked by centimeter thick clay layers. Occasional mudstones have been observed in shale dominant intervals at several sections. Shale is typically present in the labanakhya and Khaiyachara section mostly in the axial region of the northern section. The Labanakhaya chara shale in the axial part is highly fissile and breaks down into small elongated chips when dehydrated but some shale from axial region are paper thin laminated and well cleaved.

2) Sand/Silt Streaked Shale (Facies F_{ss})

The facies is frequently observed in the axial region together with the laminated shale. Parallel laminated clays intermeddled with millimeter-thick sand or silt partings, and laminated clays interbedded with millimeter-centimeter thick sand or silt lensesaccomplished the facis. The sand/silt streaks are recognized by color variance and their grittiness, the shale is bluish grey to grey whereas the streaks are yellow to yellowish brown in color. The streaks are very thin usually a few grains to 2mm in thickness and they are commonly discontinuous, rarely being continuous for over a meter.

3) Lenticular Bedded Shale (Facies F_{lb})

The lenticular laminated facies consists of unremitting clay layers, very nearly 1–2 cm thick, occasionally separated by approximately 0.5-cm silt or sand lenses, creating lenticular bedding. The sand lenses contain current ripple sets, showing both unidirectional and bi-directional current directions. It is another widely-distributed shale dominant facies identifiedall the way through the Neogene shale. In the axial region of Barabkund temple roadcut section, the facies generally observed along with laminated shale and mudstone. Lenticles are usually regular and sometimes irregular. Internally, the lenticles are frequently cross laminated showing micro cross laminations that are usually unidirectional, but sometime bi-directional cross-lamination in vertically adjacent lenses are also seen. Very small scale mud drapes are also observed within the cross-lamination. Lenses are sometime continuous with several of them connected together. As much as 6cm long lens could be found with maximum amplitude of 1.2 cm.

4) Fisile Shale (Facies F_{fs})

Fissility in shales appears directly related to the parallel orientation of mineral grains in the rock fabric. In Barabkund temple and jeorgory Chara section, some outcrops of fissile shale were examined. Fissility of Sitakund mudrocks increases along a gradient of decreasing bioturbation. In some outcrops, mudrocks are characterized by lack of fissility due to the randomized fabric produced by bioturbation, whereas some mudrock outcrops exhibit good fissility due to the lack of biogenic reworking and the preservation of an originally horizontal particle arrangement.

5) Laminated Shale (Facies F_{ls})

Laminations in Sitakund anticline are thin to moderately thick up to 0.8cm in thickness. Such laminations resulted due to the differences in grain size of the clasts in different laminae. It also resulted from the changes in the organic content and oxidation conditions at the site of deposition of the different layers. Lamination of silt, silty clay and shale are abundant in the study area.

The mudstone dominated facies F_{ms} records continuous sedimentation of clays from suspension. Even though the massive bodies of the clay could be formed due to bioturbation extinguishing any pre-existing fabric, no sign of such fabric was observed in any of this facies.

Fig. 2. Facies identified during fieldwork. a) Mudstone at the Microwave road-cut section and b) Sand/Silt-streaked shale facies near Barabkund in Sitakund structure.

Fig. 3. Facies observed in stream-cut sections. a)Highly Fissile (splinter) Shale near Georjory chara and b) Lenticular-bedded facies near Balukhali chara in Sitakund anticline.

This facies take placegenerally in a shelf environment starved of sand/silt grade sediment, distal, deeper shelf area is also be possible environment. Sand/Silt streaked parallel laminated Shale facies $\mathbf{F_{ss}}$accounts laterally continuous clay layers settled from suspension, intercalated with millimeter-thick sand and silt partings.That was the time when current velocity or sediment supply allowed influx of coarser sediment into this area.

The lenticular laminated facies $\mathbf{F_{lb}}$is composed ofvery fine clay layers along with mm–cm thick sand and silt lenses.These were formed during both dominant and subordinate current periods. Isolated sand lenses either consequence from the further erosion of ripples or deposition from a sediment-poor current. Parallel and lenticular laminated units, inferring mud-dominated shelf deposition with fluctuating sand/silt grade sediment supply, current velocities and retrogressive flows.

The fissile shale facies $\mathbf{F_{fs}}$ was deposited from clay suspension by the slow settling of clay platelets at very low depositional energy. Bioturbation during compaction, and weathering during and after uplift fashioned the fissility in this area. The laminated shale facies $\mathbf{F_{ls}}$showsthe deposition of laterally continuous clay layers from suspension, with alternating current velocity or sediment supply permitted influx of coarser sediment within relatively low energy, subtidal shelf environments.

Palynological evidences:

The Surma group of Bangladesh consists of recovered palynotaxa of 24 species belonging to 20 genera belonging to:

Algae: Spiniferites sp,
Fungi: Temporina globate, Lycopodiumsporites palaeocenicus;
Pteridophyta:Lygodiumsporites eocenicus , Corrugatisporites formosus, Cyathidites minor, Lygodiumsporites eocaenus, Leptolepidites tertiarus, Psilophaera plicata

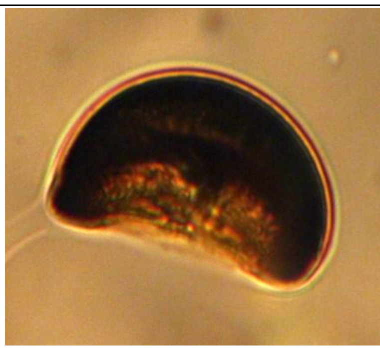
Angiosperme:Palmidites maximus, Proxaperites microreticulatus, Palmipollenites subtilis, Monosulcites *rectangulatus, Liliscidites microreticulatus, Bangladeshopollenites barishalensis, Proxaperites microreticulatu,s Couperipollis rarispinosus, Inaperturopollenites sp., Abiespollenites cognatus*

Table 1. Shows the identified pollens from Surma Group of sediments

Plate 1	Plate 2
1. Lycopodiumsporites palaeocenicus	**1. *Palmipollenites subtilissp.***
2. Palmidites plicatus	**2. *Palmidites assamicus***
3. Palmidites maximus	**3. *Liliacidites microreticulatus***
4. Lygodiumsporites eocenicus	**4. *Psilophaera plicata***
5 Liliacidites microreticulatus	***5. Spiniferites sp***
6. Bangladeshopollenites barishalensis	***6. Abiespollenites cognatus***
7. Corrugatisporites formosus	***7.Temporina globate***
8. Proxaperites microreticulatus	***8. Abiespollenites cognatus***
9. Cyathidites minor	***9. Psilosphaera plicata***
10. Couperipollis rarispinosus	**10. *Psilophaera plicata***
11. Lygodiumsporites eocaenus	***11. Inaperturopollenites***
12. Leptolepidites tertiarus	***12. Psilosphaera plicata***

Botanical affinity

In order to interpret the probable paleo-environment during the sedimentation of the different lithological units, the systematic botanical affinity and its ecological considerations are discussed below: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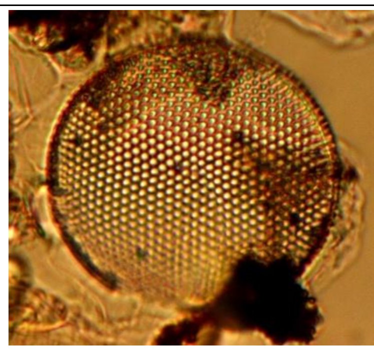
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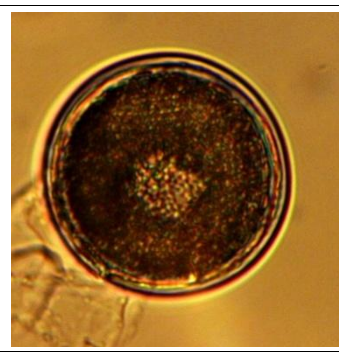
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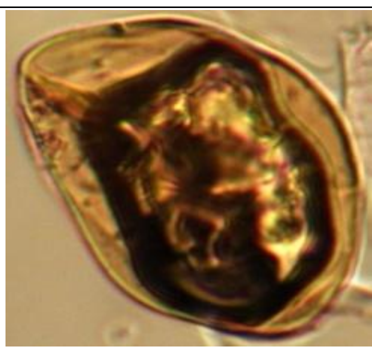
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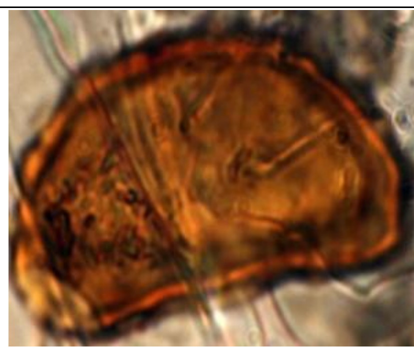
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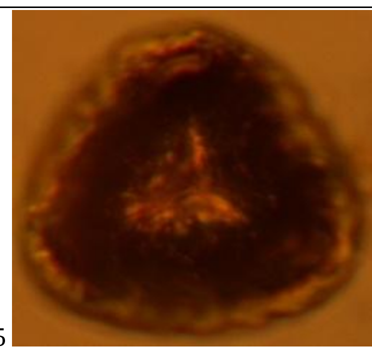
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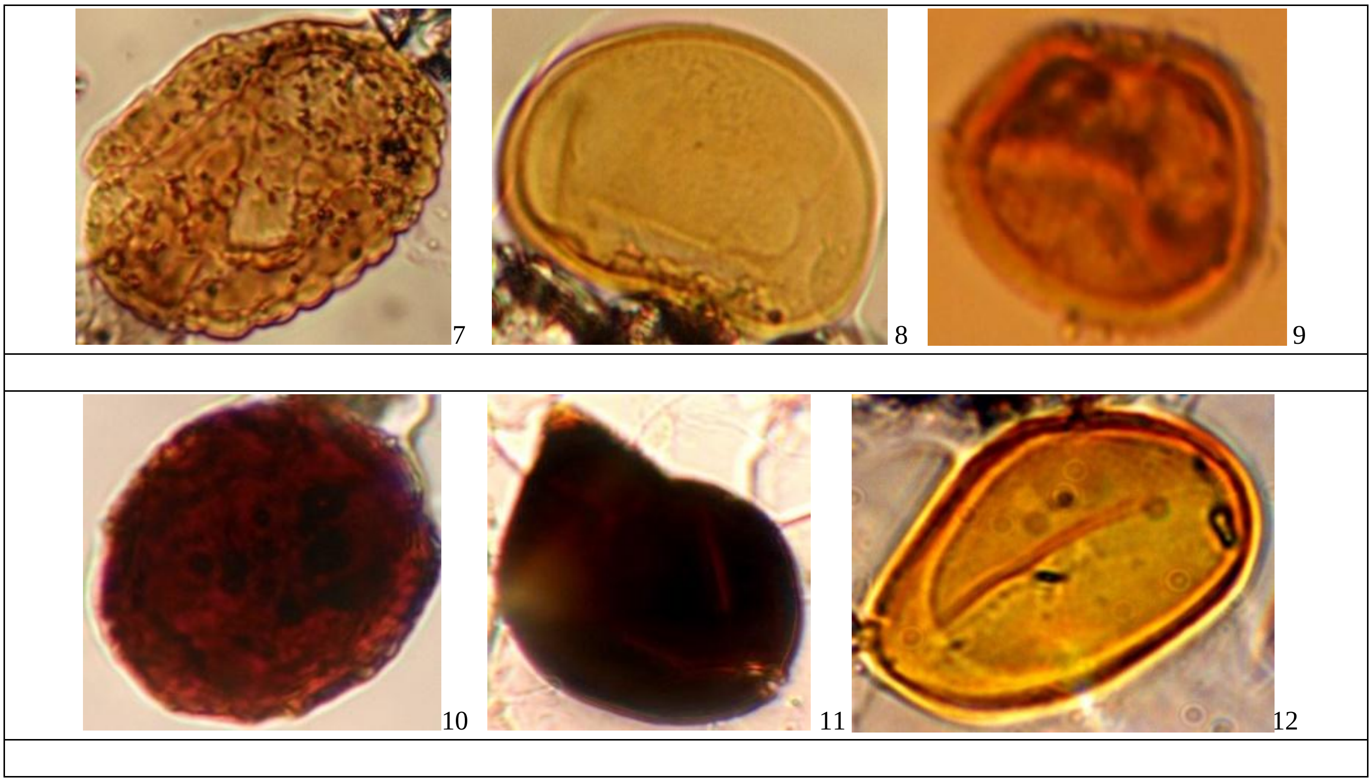
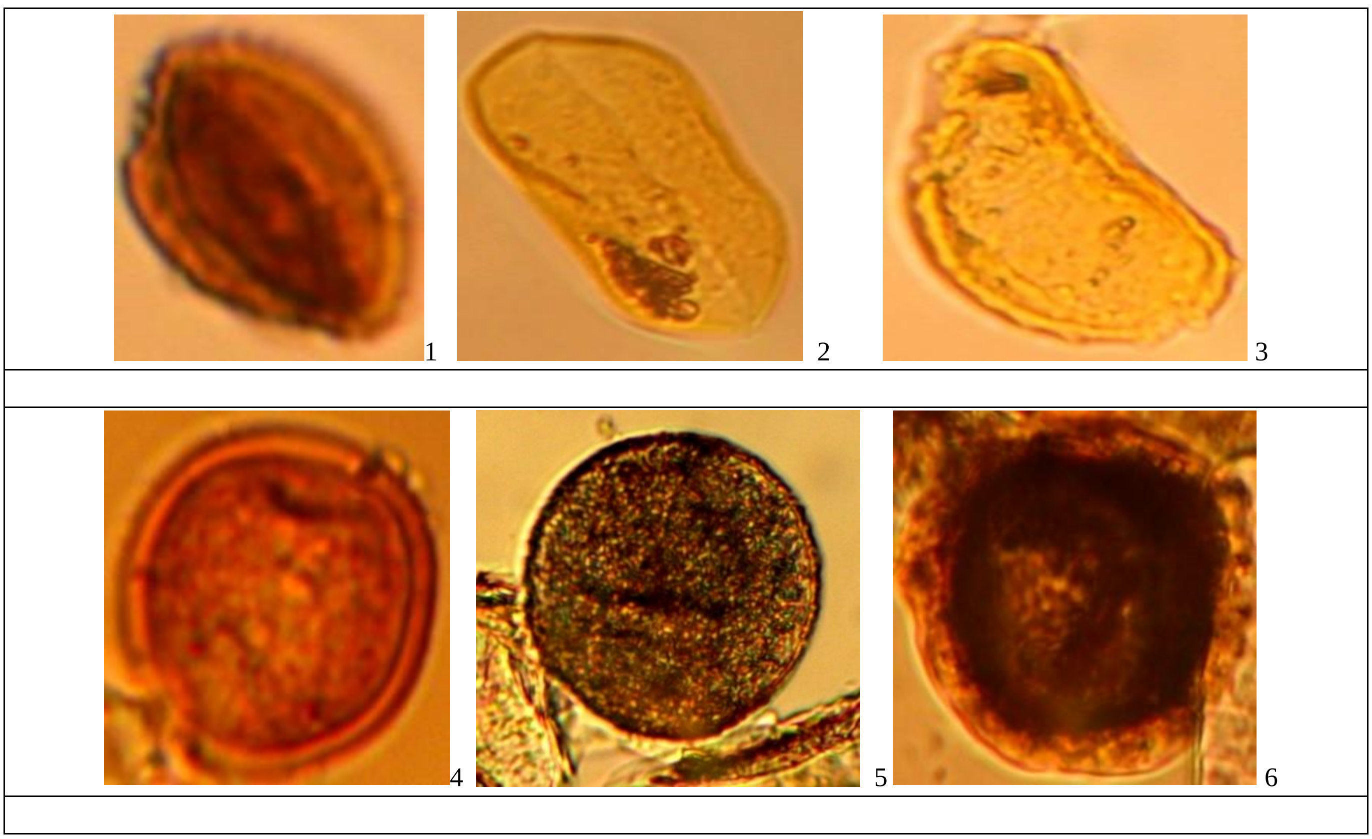


Plate 1. Selected index Pollen recovered from Neogene mudrocks.



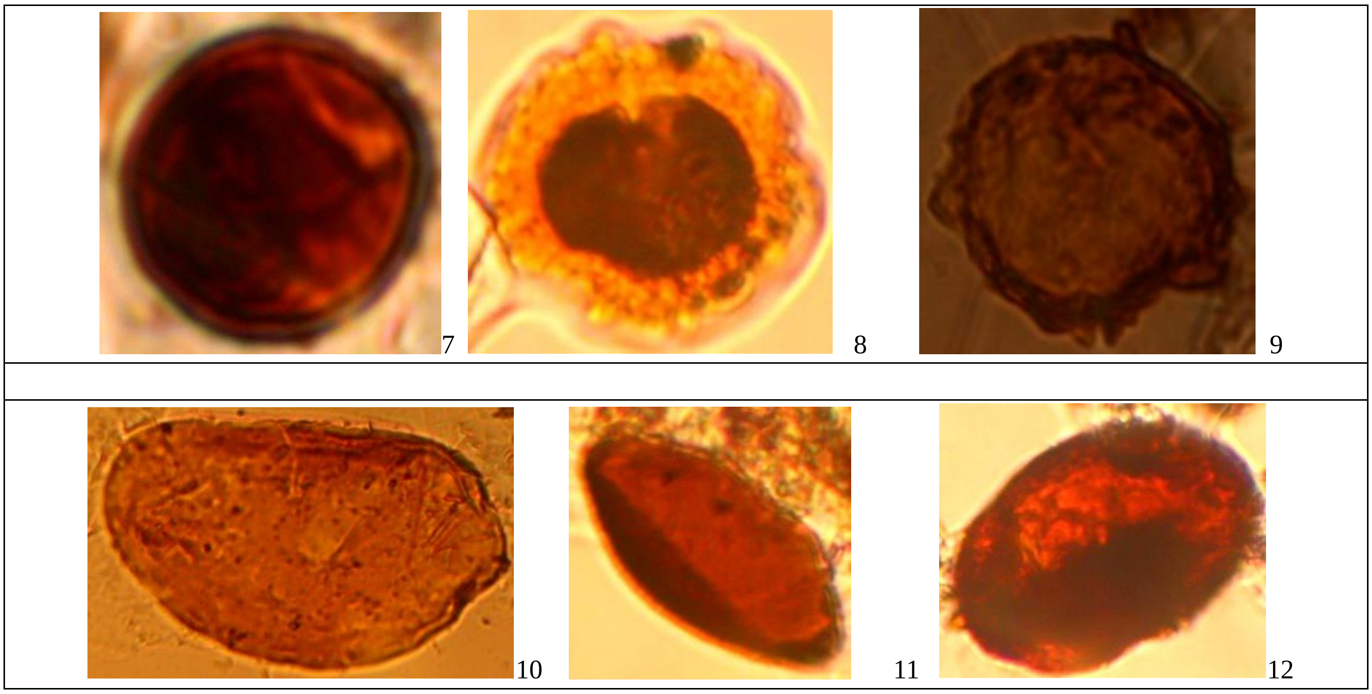


Plate 2. Selected index Pollen recovered from Neogene mudrocks

*Algae:*the group suggest brakish to marine environment of deposition.

Fungi: the fungal assemblage point out warm, humid climate with heavy precipitation.

*Pteridophyta:*the group suggest moist and shady place.

Angiosperme: the group indicate of continental element along the coastal margin.

VII. Conclusion

Facies analysis including the pattern of depositional bodies and contacts suggest that Surma group mudrocks were deposited in shelf environment. The abundant grains of Palmae such as spores in the Palmipollenites and Proxaperites and predominance of pteridophytic spores in the palynological assemblage point out the deposition of the Neogene mudrocks took place at the proximity of the shore level whereas in latter part a coastal fluvial environment prevailed which is evident by the occurrence of palynomorphs of pteridophytes, angiosperms and algal origin.

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