Fossil Algae from the Paleogene sediments of Meghalaya:

Introduction:
Warm water dinoflagellates one of the most prominent biotic response in the marginal marine realm to the warming event known as the Paleocene – Eocene Thermal Maxima (PETM), earlier known as Late Paleocene Thermal Maxima (LPTM) or Initial Eocene Thermal Maxima (IETM). During this interval, deep water at the high latitudinal regions rapidly warmed up with considerable warming of oceanic surface waters in the equatorial regions.

The biotic response to this warming event was remarkably widespread and reflected globally, showing matching geochemical signatures in several marine and terrestrial records. The event seems to be the most dramatically reflected in the deep sea microfossil records by massive extinction of benthonic foraminifera.

Paleogene Dinoflagellates:
Dinoflagellates rapidly diversified in the Paleogene and are very important stratigraphically, especially in nearshore marine sediments. They provide an invaluable link between the critical marine animal fossil stratigraphic indicators and spore/pollen from land. A number of dinoflagellate cyst taxa terminate at or near the end of the Cretaceous, but many other taxa sail unabashedly across the boundary, and it is evident that the terminal cretaceous event was not as cruel to Dinoflagellates as to the Coccolithophoridae and many other organisms.

Review of fossil algal studies in Early Tertiary sediments in India:
Such a phase is normal and significant for any new group of fossils that serves to bring it in the main stream of subsequent biostratigraphic studies. This period is considered here as a phase of *Reconnaissance* and *Understanding*.


**Review of fossil algal studies in Early Tertiary sediments outside India:**


W.A.S. Sarjeant, 1981. restudied some dinoflagellate cyst holotypes in the University of Kiel collections. II. The Eocene holotypes of Barbara Klumpp (1953); with a revision of the genus *Cordosphaeridium* Eisenack, 1963.


L.A. Sirenko, N.V. Kondratyeva worked on the role of **Cyanophyta** in nature.
P.M. Tsarenko, O.N. Vinogradova, V.V. Stupina, S.P. Wasser, E. Nevo described diversity of algae in the continental part of Israel.

L.N. Bukhtiyarova reporting *Bacillariophyta* in biomonitoring of river ecosystems. Current state and prospects for their use.

Wan Maznah, Mashhor Mansor, Ho Sinn Chye recorded Periphyton biomass related to water pollution in Pinang River basin, Malaysia.

L.A. Medvedeva made a short note on taxonomic structure of the algoflora of Sikhote-Alin’sky Biosphere Reserve (Primorsky region, Russia).

N.P. Masyuk, G.G. Lilitskaya compared intraspecific variability of the rare species *Carteria abiscoensis* Skuja (*Chlamydomonadaceae, Chlorophyta*) in the flora of Ukraine.

A. Kadri Cetin recorded phytoplankton of Gölbasi Lake (Adiyaman, Turkey) and their seasonal variations.

O.I. Berchenko described a new representative of fossil algae (*Chlorophyta*) from the Paleozoic of Ukraine.

V.K. Orleansky, M.E. Raaben recorded modeling of actively ramifying columnar stromatolites.

D.V. Mikulich, G.D. Lukina, S.P. Lipovetskaya studied the chemical composition of storm flings in hypergaline reservoirs of Sivash Lake as a source for production of stabilizers.

E.V. Borisova described species composition of bacteria accompanying microalgae in culture.

Ecostratigraphic Study of Paleocene and Early Eocene Palynological Cyclicity in Northern South America, *Palaios*, February 1, 2000;
In 2003, V. Rull and V. Rull has made a contribution of quantitative ecological methods to the interpretation of stratigraphically homogenous pre-Quaternary sediments: A palynological example from the Oligocene of Venezuela. They deal with an Oligocene section that is stratigraphically homogeneous from both a lithological and palynological point of view. It has been impossible to subdivide it into discrete units, using either taxon-range analysis or assemblage-zone approach based on the relative abundance of palynomorphs.

Michael W. Rasser and Werner E. Piller recorded Crustose algal frameworks from the Eocene Alpine Foreland, Austria, 2003. Upper Eocene algal limestones of the Eastern Alpine Foreland in Austria contain three different types of crustose algal frameworks. These reveal several similarities with the present-day coralligene de plateau of the Mediterranean Sea, but the framework types differ in the crust-forming algal taxa, the sedimentary regime, and the environmental setting.

C.A. Jaramillo, G. Bayona, A. Pardo-Trujillo, M. Rueda, V. Torres, G. J. Harrington, and G. Mora, collaboratively recorded the palynology of the Cerrejon Formation (Upper Paleocene) of Northern Colombia, 2007. Coal palynofloras have fewer morphospecies, and a distinct and more homogeneous floral assemblage compared to assemblages from the intervening sisciclastic strata, suggesting that tropical swampy environments supported fewer plant species and had distinct vegetation adapted to permanently wet environments.

G. Doria, C. A. Jaramillo, and F. Herrera The origin and processes creating the high diversity of plant species in neotropical rain forests and their floristic composition and multistratified forest structure are still uncertain. Studied Menispermaceae from the Cerrejon Formation, middle to late Paleocene, Colombia in August 1, 2008. The origin and processes creating the high diversity of plant species in neotropical rain forests and their floristic composition and multistratified forest structure are still uncertain.

Juliana Kohler and Andreas Clausing recorded taxonomy and palaeoecology of dinoflagellate cysts from Upper Oligocene freshwater sediments of Lake Enspel, Westerwald area, Germany. Freshwater dinoflagellates play an important role as primary producers in the lacustrine environment. A new species of dinoflagellates, Cleistosphaeridium lacustre, is described from Upper Oligocene sediments of palaeo-lake Enspel. They are associated with other phytoplankton, such as diatoms, chrysophytes, green algae and benthic cyanobacteria. Mass
occurrences of this species are interpreted as algal blooms and may partly reflect seasonal successions. This phenomenon was controlled by volcanic activities in the depositional area, which led to an increase in nutrient supply.

Clifford W. Morden and Alison R. Sherwood continued evolutionary surprises among dinoflagellates, Honolulu. It is well established that chloroplasts in green and red algae are derived from a primary endosymbiotic event between a cyanobacterium and a eukaryotic organism ~1 billion years ago. Although these two groups account for many of the world's photosynthetic species, most other major taxonomic groups of photosynthetic organisms (stramenopiles—including diatoms, phaeophytes, chrysophytes—and haptophytes) have plastids derived from a photosynthetic eukaryote implying a secondary endosymbiosis. The dinoflagellates have more complicated associations believed to be derived from tertiary endosymbioses involving the engulfment of a secondary endosymbiont. Each endosymbiotic event has characteristic structural changes associated with it, the most notable of which is the addition of two membranes surrounding the plastid (the inner representing the cell membrane of the engulfed organism and the outer representing the phagocytosis vacuole membrane). Dinoflagellates, although believed to be tertiary endosymbionts, have only 3 membranes surrounding their plastids, suggesting that the acquisition of too many membranes may be functionally unstable and can cause some to be lost.

Valenti Rull described Middle Eocene mangroves and vegetation changes in the Maracaibo Basin, Venezuela. The floristic composition of middle Eocene mangroves was very different from those of the Oligocene to Recent. An important, probably worldwide, evolutionary change occurred during the late middle Eocene and the late Eocene in these communities. Pollen taxa botanically related to known and extant mangrove elements seem scarce for this time span. *Pelliciera* and *Nypa* dominated mangroves; *Brevitricolpites variabilis*, which has been considered the dominant taxon of the early and middle Eocene mangroves in nearby areas. The succession of coastal vegetation, linked to sea-level changes, could be reconstructed from these assemblages. The trends constitute a palyno-cycle which began and ended with a low sea-level plant community dominated by unknown stands represented by *E. trianguliformis* and interpreted low paleosalinities; intermediate high sea-level vegetation is represented by mangroves and interpreted high paleosalinities.
Scope of the present study:

During the course of palynological investigation of the Paleogene sediments of Meghalaya, presences of algal remains have been observed. These include the dinocysts, acritarch and other algal remains. Systematic and taxonomic studies of these organic remains have been attempted. This assemblage includes both fresh water and marine forms. A general survey of the distribution pattern of these microorganisms in relation to the spore – pollen content indicates the importance of the findings in stratigraphic and environmental parameters.
**Systematic list of dispersed algal remains:**

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| Genus- | *Solisphaeridium* Staplin, Jansonius & Pocock, 1965 |
| Species | *Solisphaeridium debilispinum* Wall, 1962 |

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PLATE- I

1. *Hystrichosphaeridium mineralosum*
2. *Wetzeliella* (Apectodinium) *quinquelata*
3. *Spiniferitites dentatus*
4. *Hystrichosphaeridium sp.a*
5. *Concentricystis rubina.*
6. *Deflendrea spinulosa*
7. *Hystrichosphaeridium perplexum.*
8. Fragments of Dinoflagellate cyst
9. Fragments of Dinoflagellate cyst
10. *Hystrichosphaeridium sp. cf. H. cornigerum*
11. *Cleistosphaeridium sp.*
12. *Hystrichosphaeridium sp.e*
13. *Hystrichosphaeridium sp.c*
14. *Baltisphaeridium sp.*
15. *S. ramosus var. ramosus*
16. *Hystrichosphaeridium sp.b*
17. *Hystrichosphaeridium sp.d*
18. *Achomosphaera cf. sagena*
19. *Spiniferites ramosus var. ramosus*
20. *Oligosphaeridium pulcherrium*
21. *Baltisphaeridium sp.*
22. *Hystrichosphaeridium cambayense*
PLATE - II

1. *Palaeocystodinium microgranulatum*
2. *Kenleyia lophophora*
3. *Canningia crassicingulata*
4. *Godavariella venkatachalae*
5. *Oligosphaeridium pulcherrium*
6. *Palaeocystodinium microgranulatum*
7. *Canningia crassicingulata*
8. *Dinocyst Type 2*
9. *Dinocyst Type 2*
10. *Apteodinium granulatum*
11. *Heterolaucacysta*
12. *Kenleyia lophophora*
13. *Ceratiopsis leptoderma*
14. *Ceratiopsis leptoderma*
15. *Godavariella venkatachalae*
PLATE - III

1. Lejennea ampla
2. Gonyaulacysta hadra
3. Gonyaulacysta hadra
4. Palaeocystidinium punctatum
5. Lejuenea tricuspidium
6. Heteraulacacysta campanula
7. Palaeocystodinium punctatum
8. Ceratiopsis leptoderma
9. Scriniodinium crystallinum
10. Dinogymnium sp
11. Dinocyst Type 5
12. Rhaetogonyaulax
13. Palaeocystodinium microgranulatum
14. Palaeocystodinium microgranulatum
15. Pareodinia imbatodinensis
16. Carpodinium granulatum
PLATE - IV

1. Baltisphaeridium sp
2. Fibrocystic variables
3. Hystrichosphaeridium sp.b
4. Baltisphaeridium sp
5. Oligosphaeridium asterigerum
6. Hystrichosphaeridium sp.c
7. Cordospheridium sp
8. Canningia crassicingulata
9. Lingulodinium machaerophorum
10. Oligosphaeridium diloculum
11. Hystrichosphaeridium lateraliprocessum
12. Prolixosphaeridium elongatum
13. Spinifertites ramosus var ramosus
15. Glaphrocysta retintexta
PLATE - V

1. *Carpodinium granulatum*
2. Dinocyst Type 2
3. *Paleoperidinium pyrophorum*
4. *Dinogymnium sp.*
5. *D. acuminatum*
6. *Rhaetogonyaulax rhaetica*
7. *Saeptodinium sp.*
8. *Ceratiopsis leptoderma*
9. *Rhaetogonyaulax*
10. *Canningia crassicingulata*
11. Dinocyst Type 2
12. *Kalyptea indica*
13. *Palaeoperidinium pyrophorum*
14. *Palaeocystodinium sacbratum*
15. *Godavariella venkatachala*
PLATE - VI

1. Prolixosphaeridium bifidum
2. Baltisphaeridium sp
3. Canningia crassicingulata
4. Baltisphaeridium sp
5. Solisphaeridium debilispinum.
7. Cleistosphaeridium
8. Spinifertites sp.
9. Dinocyst Type 1
10. Hystrichosphaeridium sp. cf. cornigerum
11. Concentricystis circularis
12. Hystrichosphaeridium tubeliferum
13. Dinocyst Type 4
14. Noricysta fimbriata
15. Dinocyst Type 3
16. Heibergella sp.
17. Cribroperidinium edwardsii
18. Gonyaulax sp.
19. Deflandrea spinulosa.
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*Family: Gonyaulacystaceae (Sarjeant & Downie 1967) Gorka 1970*

*Family: Apteodiniaceae Eisenack 1961*
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**Family: Exochosphaeridiaceae Sarjeant & Downie**

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**Family: Cordosphaeridiaceae Sarjeant and Downie 1974**

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**Division: (III) Prasinophyta**

**Order - Pterospermales**

**Family: Tasmanitaceae**

**Genus** - *Concentricystis* Rossignol, 1962

**Species** - *Concentricystis rubina* Rossignol
**Taxonomic Description:**

Incertae sedis

Division - Acritarcha Evitt 1963
Subgroup - Acanthomorphicite Downie, Evitt & Sarjeant 1963
Type Specie - *Baltisphaeridium longispinosum* (Eisenack), Eisenack, 1958

*Baltisphaeridium sp a*
(Pl- I, Fig-14, 21); (Pl-VI, Figs- 2, 4)

Description - Shell ovoid to spherical, wall 0.5-1µm thick, surface covered with long, simple thread like processes, tips capitate or bifid, sometimes pointed. Surface unornamented. Archaeopyle not seen.

Remarks - This specimen resembles best with *B. fimbriatum* (White) Sarjeant (1959)

Present occurrence - Langpar Formation.

*Baltisphaeridium sp b*
(Pl-IV; Figs-1, 4)

Description – Vesicle circular, size ranges 28-32 µm, pylome appears to be present towards the centre and polygonal in shape, spine like processes coarsely distributed, radiating from the centre towards the periphery, spine solid, straight and long with broad base and gradually pointed at ends.

Present occurrence - Langpar Formation.
Genus *Solisphaeridium* Staplin, Jansonius & Pocock, 1965
Type species-*Solisphaeridium apodasmion* Wicander & Loeblich, 1974
*Solisphaeridium debilispinum* Wall. 1962
(Pl-VI, Fig-5)

Description- Vesicle mostly circular, size ranges upto 30-32 μm, processes long, distributed evenly throughout the body, straight or curved, broader at the base, cyst equatorially folded.

Present occurrence- Langpar Formation.

Division- Pyrrhophyta
Class- Dinophyceae Fritsch 1927
Order-Peridiniales Schiitt 1896
Family- Dinogyminiaceae Sarjeant & Downie 1974
Genus- *Dinogymnium* Evitt, Clarke & Verdier, 1967
Type species-*D. acuminatum* E. C. & V., 1967

*Dinogymnium sp.*
(Pl-V; Fig-4)

Description- Autoblast ovoidal, with a small opening at the apex. Antapical end characteristically prolonged into a smooth tapering, blunt -tipped horn .Epitract smaller than hypotract. A low numbers of longitudinal ribs are developed, both on epitract and hypotract; their length is variable and arrangement irregular. Elsewhere the epiphragm is smooth. Cingulum well-developed on the ventral surface but not obvious on the dorsal surface. Sulcus indistinct on the epitract but well developed on the hypotract, extending posterior up to the point from which the horn originates.

Present occurrence- Gumaghat and Mahadeo Formation.

*Dinogymnium acuminatum* Evit, Clarke, & Dowie, 1974, Verdier, 1967
Description - Autoblast biconical in shape, apical end showing a small opening, antapex having a blunt termination. Longitudinal folds well developed, extending from poles to cingulum. Phragma otherwise smooth. Cingulum indicated by a subequatorial depression bounded by thick ridges, moderately helicoids. Sulcus not seen, owing to lateral cyst flattering.

Remarks - The single specimen illustrated and described here is very similar to the specimen described by Evitt (1967), except that the granulose ornamentation of its autoblast is not as prominent as in the type material.

Present occurrence - Gumaghat and Mahadeo Formation.


Description - Shell oval, side convex, one pole broadly rounded, another pole conical, epitheca and hypotheca more or less equal, cingulum wide, deep equatorially placed, longitudinal ribs prominent, many in number, present in both theca, surface granulat, archaeopyle apical.

Remark - It possesses all the essential character of *D. acuminatum* Evit et al. but in differ in having one pole rounded.

Present occurrence - Mahadeo Formation.

Family - Pareodiniaceae Gocht 1957
Syn. Netrelytraceae Sarjeant & Downie 1966

*Pareodinia* Deflandre 1947

(Pl-III, Fig - 10)
Description: Proximate ovoid to polygonal peridiniacean cysts, may have apical horn and rarely one or two apical horns; may have enclosing kalyptra; paratubulation weak. Part of pseudoceratioid lineage.

Age- Upper Triassic to Middle Miocene.

Genus- *Pareodinia* Deflandre, emend. Gocht, 1970
Type species- *Pareodinia ceratophora* Deflandre, emend. Gocht, 1970
*Pareodinia imbatodinensis* (Vozzhennikova) Lentin and Williams, 1977
(Pl-III, Fig-15)

Remarks: The concept of the genus *Pareodinia* has been changing since it was proposed by Deflandre (1947), and this genus has gone through several emendations. Wiggins (1975) discussed the morphology of this genus in detail, and emended it

In the present study, the concept of *Pareodinia* as proposed by Stover and Evitt (1978) is followed. The proposal of Davey (1982) to keep *Imbatodinium* as an independent genus is not acceptable at present, because of the uncertainty of the archaeopyle type in the genus *Imbatodinium*.

Age- Upper Triassic to Middle Miocene.

Type Species- *Heibergella asymetrica* Bujak & Fisher
Genus- *Heibergella aculeate* Bujak and Fisher
(Pl-VI, Fig –16)

Description - Apparently single – walled cysts. Epitract of triangular to subtriangular outline. Hypotrac of ovoidal or symmetrical or asymmetrical trapezoidal outline. Small, distinct, apical horn always present and presence of one or two antapical horns sometimes suggested by small lobes and relatively long spines. Cingulum – circular or slightly laevo-rotary, delimited by two rows of proximally united spines. Sulcal position marked by depression near cingulum on
hypotrac and sometimes on epitrac. Sulcus also occasionally bordered by two rows of spines. Remainder of wall bearing dense cover of spines of similar to those of cingular borders, these bearing evexate, bifid, bifurcate or rarely acmuminate or baculate and either isolated or proximally united by low crests in fielded arrangement. Arrangement possibly of paratubullr significance on occasional specimens. Archaeopyle anterior intercalary, formed by loss by two or sometimes three plates.

**Age-** Upper Triassic to Middle Miocene.

**Genus-** *Kalyptea* Cookson & Eisenack, 1960  
**Type species-** *Kalyptea diceras* Cookson & Eisenack, 1960  
*K.indica* Jain & Maheshwari  
(Pl-V, Fig.12)

**Description-** Cyst ellipsoidal, thin-walled, single-layered, folds frequent, surface finely granulate, apical and antapical horns well developed; apical horn longer and broader than antapical horn, gradually tapering, tip rounded; antapical horn usually short, narrow, pointed. Central part of cyst inflated –elongate. Kalyptra and apical structures totally absent. Archaeopyle intercalary.

**Comparison-** Twenty –five specimens belonging to *Kalyptea indica* Jain & Maheshwari sp. Nov. have been studied. The species compares with *K. diceras* Cookson & Eisenack, 1960 in having unequal horns and thin and finely granulate cyst wall but differs in having inflated elongated central part and no kalyptra. The rhombic shape of *K. glabra* (Cookson & Eisenack) Wiggins, 1975 easily distinguishes it from *K. indica*.

**Remarks-** Morgan (1975) has reported similar single layered cysts as *Fusiformacysta* from the Lower Cretaceous of Australia, having precingular archaeopyle. The species *F. salasii* is believed by Morgan (1975) to be a non-marine dinoflagellate cyst.

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Family-PaleoPeridiniaceae Vozzhennikova ex Sarjeant 1967
Genus- *Palaeoperidinium* Deflandre ex Sarjeant 1967
Species- *Palaeoperidinium pyrophorum* Deflndre ex Sajeant 1967
(Pl-V, Fig-3)

**Description**- Proximate peridiniaceae cysts, ovoid to polygonal, may have apical and two antapical horns; archaeopyle epicystal or transapical.

**Age**- Paleocene.

Genus-*Saeptodinium* Harris 1973
Species- *Saeptodinium hansonianum* Evitt 1974
(Pl-V, Fig-7)

**Description**- Proximate peridiniaceae cysts, ovoid to polygonal, may have apical and two antapical horns; archaeopyle epicystal or transapical.

**Age**- Upper Oligocene.

Family- Hexagoniferaceae Sarjeant and Downie ex Vozzhennikova 1967
Genus- *Noricysta* sp.

Type species- *Noricysta fimbriata* Bujak and Fisher

*Noricysta fimbriata* Bujak and Fisher n. sp.
(Pl-VI, Fig.14)

**Description** - Double walled cysts, endophragm typically compressed dorsoventrally and oval to subrhomboidal in outline. Periphragm granular to sometimes sparsely spinose, in contact with endophragm, except where crests are formed. Crests, which are mainly developed around periphery of epitract and at antapex, are distally indented and forms ribs perpendicular to endophragm. Cingulum circular or laevo-rotary, delimited by two low, thin crests. Sulcus
poorly defined if at all. Archaeopyle formed by removal of all of epitrac except for pericingular zone.

Comments: It is uncertain whether the operculum in *Noricysta* includes an anterior intercalary plate series.

**Family- Deilandraceae (Eisenack 1951) Bujak & Davis 1983**

**Genus- Ceratiopsis Vozzhennikova 1963**

*Ceratiopsis leptoderma* Vozzhennikova 1963

(Pl-II, Figs.13, 14) (Pl-III,Fig -8) (Pl-V, Fig- 8)

**Description:** The archaeopyle type in the Indian specimen is the broad hexa-2a type of Lentin & Williams 1976, both peripyle and endopyle being distinct & the operculum free. The endophragm is smooth; the periphragm bears striations running from near the apex to antapex, continuous or discontinuous. The striations are more prominent on the hypotrac than the epitrac. A few reach the antapical horns equally strong & continue up to their tips. These are more like periphragm folds. Similar folds extend into the apical horn. The cingulum is distinction both surfaces & a little offset ventrally; the anteroposterior separation between its two ends is less than its width. The sulcus is broad, not very distinct & restricted to the hypotrac.

**Present occurrence** – Mahadeo and Langpar Formation.

**Genus- Deflandrea (Eisen. 1938) Will. & Downie 1966**

*Deflandrea sp.*

(Pl-I, Fig-6); (Pl-VI, Fig –19)

**Description:** Cavate peridiniacean cysts, ovoid to polygonal, may have apical horn, one or two antaocial and one or two lateral horns; Paratabulation weak, archaeopyle with operculum of one or more pieces.

**Age** –Upper Triassic to Middle Miocene.
Genus- *Godavariella* Mehrotra & Serjeant 1987

**Type species-** *Godavariella venkatachalae* Mehrotra & Serjeant 1987

*Godavariella venkatachalae* sp.nov.

(Pl-II, Figs.-4, 15); (Pl-V, Fig-15)

**Description-** Proximate, acrove cyst, cingulotabulate to cryptabulate, with an ellipsoidal central body (almost lensoid in ambitus), a long apical horn and an equally long antapical horn. Below the tip of the apical horn there is often a horizontal septum defining a small apicular cap; this cap may be detached from the horn. the antapical horn bears a prominent to reduced lateral outgrowth or spur. The distal extremity of the antapical horn may be pointed and may sometimes also bear an apicular cap, much like that of the apical horn. Small spinose outgrowths may be developed along the margins of both horns. Periphragm thinner and light-coloured than the endophragm, the two layers being largely appressed and separate only in the horns, the epistomia typically plug not only the horn bases, but also the entire horn cavities. Phragma smooth to shagreenate, lacking parasutural features. A cingulum may be faintly suggested, but the sulcus is not indicated. Archaeopyle intercalary, type I, according with the attenuated hexa-2a type of Lennin & Williams 1976.

**Remarks-** *Godavariella* is closely comparable to *Palaeocystodium* Alberti, 1961, in shape and size and archaeopyle type, but differs in being acrocavate and in having a lateral extension from the antapical horn. *Godavariella* resembles *Andalusiella* Riegel, 1974, emend.Riegel & Sarjeant, 1982, being acrove and in its unusual phragma texture, but differs from that genus in lacking a second antapical horn and being without any extensive simulation of a paratubulation by creatureae. However, these genera are evidently closely related. *Godavariella* is intermediate between *Palaocystodinium* and *Andalusiella*, the very different character of the very different character of the phragma in typical species of *Palaocystodinium*.

**Present occurrence-** Langpar Formation

Genus- *Lejeunia* Gerlach 1961
**Lejeunia ampla** Harland 1973  
(Pl-III, Fig-1)

*Description* – Shell proximate, rhomboidal, single apical horn, acute, two antapical horn, one slightly larger than other, archaeopyle apical, surface granulate.

*Present occurrence* - Mahadeo and Langpar Formation.

**Lejeunia tricuspidatum** (Wetzel 1933) Harland 1973  
(Pl-III, Fig-5)

*Description* – Shell pentagonal, wider than length, equatorial cingulum conspicuous, epitheca and hypotheca equal in size, single apical horn, acute apex; two antapical horn having acute ends, archaeopyle triangular, precingular surface finely granulate.

*Present occurrence* - Gumaghat, Mahadeo, Langpar Formation.

**Genus** *Palaeocystodinium* Alberti 1961

*Palaeocystodinium microgranulatum*  
(Pl-II, Fig-1); (Pl-III, Fig-13, 14); (Pl-V, Fig-13)

*Description* – Test elongate to spindle shaped, sometimes globular with convex lateral sides. Horns two, one at each end, tapering; periphragm microgranulate, horns spongy, endophragm smooth, in close contact with periphragm, leaving very small pericoel below horn bases; capsule ellipsoidal. Archaeopyle penta-to hexagonal below apical horn. No evidence of furrows except for periphragmal folds.

*Present occurrence* - Langpar Formation.

*Palaeocystodinium punctatum* Jain and Millepied 1971  
(Pl-III, Fig-4, 7)
Description- Shell spindle shaped, large, two horns, and one apical another antapical, apical horn terminated into a dentate end, archaeopyle trapezoidal, situated below the apical horn, surface puntate.

Present occurrence – Mahadeo and Langpar Formation.

*Palaeocystodinium sacbratum* Jain, Sah and Singh 1973
(Pl-II, Fig.-6); (Pl-V, Fig.-14)

Description- Shell spindle shaped, large, two appendages, one on each end, horn tapered at the end, periphragm slightly scabrate, archaeopyle intercalary, trapezoidal.

Present occurrence- Langpar formation.

Family- Shublikodiniaceae Wiggins 1973
Genus-*Rhaetogonyaulax* sp Sarjeant, 1966
*Rhaetogonyaulax* sp.
(Pl-V, Fig.-6,9); (Pl-III, Fig-12)

Description- Proximate, gonyaulaccean cysts, ovoidal subequal epicyst and hypocyst, paratubulation occur. Here archaeopyle is formed by removal of a number of intercalary plates. Specimen with single displaced opercular plate.

Present occurrence- Langpar Formation.

Family- Gonyaulacystaceae (Sarjeant & Downie 1967) Gorka 1970
Genus-*Gonyaulacysta* Deflandre emend. Sarjeant, 1966
*Gonyaulacysta* sp. Deflandre 1964 emend. Sarjeant, 1966
Description - Cyst proximate, epicavate, of moderate size. Ambitus subpolygonal, with a broadly conical apical base from which arises a small horn. Epitract slightly longer than the hypotrac; epitract roughly conical, hypotrac having the form of an inverted dome. The flanks of both epitract and hypotrac are convex, those of the hypotrac more pronouncedly so. Paratubulation marked by crests of moderate height, denticulate, bearing low, acuminate to somewhat blunt spines. Cingulum strongly offset, its two ends differing in anteroposterior position by nearly one and a half of its maximum width. Sulcus sigmoidal, quite broad, clearly divided into paraplates. One anterior, two or three median and one posterior sulcal paraplate is poorly marked. The posterior ventral paraplate is quite distinct, having quadrate shape. Archaeopyle single-plate precingular.

Present occurrence - Gumaghat and Mahadeo Formation.

*Gonyaulacysta hadra* Serjeant 1966

Description - Shell subspheroidal, apical horn tapering, antapical horn short, cingulum spiral, periphragm thin, endophrag thicker, surface granulate or reticulate.

Present occurrence - Gumaghat and Mahadeo Formation.

*Carpodinium granulatum* Cookson & Eisenack 1962

Description - Proximate gonyaulacacean cysts; ovoid to polygonal; posterior intercalary, posterior ventral sulcal and a possible additional posterior circle of paraplates may occur.

Age - Middle Jurassic to Quaternary.
**Cribrorperidinium edwardsii** Neale & Sarjeant 1962  
(Pl-VI, Fig.17)

**Shape**- cyst spherical with along apical horn.

**Wall relationship**- Cyst wall perforate with parasutural ridges that are with serrate or spinulate crest at places especially in apical and antapical regions.

**Paratubulation**- Indicated by parasutural ridges gonyaulacean. Exact paratubulation formula could not be ascertained due to lack of specimens.

**Archaeopyle**- Precingular.

**Family**- Apteodiniaceae Eisenack 1961  
**Genus**- *Apteodinium* Eisenack 1958  
*Apteodinium granulatum*  
(Pl-II, Fig-10)

**Description**- Proximate gonyaulaccean cysts; ovoid to subpolygonal; paracingulum may be weakly indicated; paratubulation absent or indistinct.

**Age**- Upper Jurassic to Quaternary.

**Genus**- *Kenleyia* Cookson & Eisenack  
*Kenleyia lophophora*  
(Pl-II, Fig-2, 12)

**Description**- Gonyaulaccean cysts proximate; ovoid to subpolygonal; paracingulum may be weakly indicated; paratubulation absent.
**Age**—Upper Jurassic to Quaternary

**Genus**- *Wetzeliella* Williams & Downie

*Wetzeliella (Apectodinium) quinquelata* (Williams & Downie) **stat.nov.**
(Pl-I, Fig-2)

**Description**—Cyst pentagonal to round pentagonal in outline, compressed dorsoventrally. Wall layers thin, smooth and generally fairly closely adpressed although some specimens show a degree of contraction of the endophragm; which always reflects the pentagonal outline of the cyst. Pericoels most prominent at the position of the apical, lateral and antapical horns although the apical horn may or may not be developed. The lateral and antapical horns prominent and there is an asymmetrical development of the antapical horns, to the extent in some forms that it appears that only one antapical horn is present.

Processes variable in length, made up of periphragm, hollow, erect to sinuous, slender to tapering having distal tip that are evexate, bulbos or open with aculeate or patulate margins. In some forms the spines may be long and branched. Differentiation in process length also apparent such that the processes are smaller around the ambitus that on mid-ventral or mid-dorsal area of the cyst. Processes appear randomly distributed but some may be sutural bordering the cingulum. The cingulum trace, deciphered from process alignment, appears to be planar and not indented.

**Age**—Upper Jurassic to Quaternary

**Family**- Canningiaceae Sarjeant & Downie emend. Sarjeant & Downie.

**Genus**- *Cannigia* Cookson & Eisenack 1960

**Type species**—*Cannigia reticulata* Cookson & Eisenack 1960

*Cannigia crassicingulata* **sp. n.**
(Pl-II, Fig-3, 7);(Pl-IV, Fig-8);(Pl-V, Fig-10);(Pl-VI, Fig-3)

**Description**—Rounded egg shaped, without horns. Autophragm rigid, psilate, slightly thicker in a broad cingular belt. Archaeopyle apical with a zigzag margin, outlining the presence of six
precingular paraplates; parasulcal notch usually present. Operculum not observed. No other traces of paratubulation visible.

Comparison - This species is assigned to *Canningia* on accounts of its general shape and apical archaeopyle. It differs from *Canningia minor* Cookson & Hughes 1964 by the thickened cingular region and psilate autophragmlt resembles *Fromea amphora* Cookson & Eisenack 1958, but it is smaller and develops an apical archaeopyle.

**Age** - Upper Triassic to Lower Oligocene.

**Family**- Heteraulacacystaceae. Drugg & Loeblich Jr. 1967

*Heterolaulacacysta campanula*

(Pl-II, Fig-11); (Pl-III, Fig -6)

**Description**- Ovoid to polygonal gonyaulacaceaen cysts paratubulation occurs. Epicystal archaeopyle.

**Age** - Lower Eocene to Upper Oligocene.

**Family**- Hystrichodiniaceae Deflandre 1936

**Type species**- *Achomosphaera ramulifera* (Deflandre) Evitt 1963

**Genus**- *Achomosphaera* Evitt 1963

*Achomosphaera globata*  Sah, Kar and Singh 1969

(Pl-IV, Fig-14)

**Description**- Cyst almost sphaeroidal, processes long 15-19μm, thin, dichotomously branched, archaeopyle precingular, surface minutely punctuate.

**Present occurrence** - Langpar and Cherra Sandstone formation.

*Achomosphaera cf. sagena* Davey & Williams, 1966
Description- Cyst proximochorate, ovoid, paratubulation indistinct, processes long, spine long, spine long, sometimes bifurcated at the apex, situated along the margin of the plates, cingulum distinct, and archaeopyle indistinct.

Remarks- Present specimens possess almost all morphological features similar to *A. sagena*. Except distinct bifurcate or trifurcate extremities of the processes and moderately thick wall of central body with finer reticulation, these features may be treated the extent of variation.

Present occurrence- Bhutan Sub-group in Mizoram, India.

Genus- *Spiniferites* Mantell emend. Sarjeant, 1970
Type species- *Spiniferites ramosus* (Ehrenberg) Mantell, 1854

*Spiniferites sp.*
(Pl-VI, Fig -8)
Description - Vesicle large, membranous, nontabulated with apical large archaeopyle, processes sparse, bi or trifurcated at tips.

Present occurrence- Langpar Formation.

*Spiniferites ramosus* subsp. *ramosus* (Ehrenberg) Lentin & Williams, 1973
(Pl-I, Figs15, 19); (Pl-IV, Fig -13)

Description- Cyst spheroidal, chorate, processes long, many, slender, branched at distal end, cingulum faint, periphragm thin, surface smooth or granulose, archaeopyle precingular, more or less triangular.

Present occurrence - Gumaghat, Mahadeo, Langpar, Cherrasandstone Formation.
Affinity - It has gonyaulaccean affinities with the gonyaulacoid lineage.

Present occurrence - Langpar Formation.

*Spiniferites dentatus* -
(Pl-I, Fig-3)

Description - Proximochorate gonyaulaccean cysts, ovoid to polygonal, may have apical horn or processes; parasutures with ridges to crests, bearing spines or processes, paratubulation occur.

Age - Upper Jurassic to Quaternary.

Genus - *Gonyaulax* Diesing 1866
Type species - *G. Spiniferae* (Claparede and Lachmann) Diesing 1866

*Gonyaulax sp.*
(Pl-VI, fig.18)

Description - Proximate cysts, spherical to ovoidal may appear rectangular if compressed. Two cyst walls are present, closely adpressed except where the periphragm makes up an apical horn with the development of a small apical pericoel. The cyst wall thick, ornamentation takes the form of granules, often large and elongate in plan and arranged uniformly on the periphragm. A true vermiculate appearance was not, seen in my specimen. The plate areas are defined by single or double raised sutures.

Age - Lower Eocene to Upper Oligocene.

Family - *Hystrichosphaeridiaceae* Evitt 1983
Genus - *Fibrocysta* Stover & Evitt 1978

*Fibrocysta variabilis* Mehrotra and Sarjeant 1987
(Pl-IV, Fig-2)
Description - Cyst Chorate, ellipsoidal, processes numerous, long, terminal bifid or trifid, archaeopyle precingular, surface punctate.

Present occurrence - Langpar Formation.

Genus - *Hystrichosphaeridium* (Deflandre, 1964) Davey and Williams 1966

*Hystrichosphaeridium cambayense* Verma and Dangwal, new species

(Pl-I, fig.22)

Description - Body spherical to somewhat angularly rounded, the angularity most probably attained during fossilization. Body wall well defined up to 3μm thick. Body densely granulate, processes rising from the body surface in groups or coalesced bundles situated at fair distances from each other. These groups of processes show a granulation similar to that seen on the body. Individual processes united simple or somewhat with slightly bifurcated tips.

Comparison: At first sight the most closely comparable species appear to be *H. inodes* Klumpp, but the details of *H. cambayense* are so widely different that they warrant its designation as a new species.

*Hystrichosphaeridium sp.* Cf. *H. cornigerum*

(Pl-I, Fig.-10); (Pl-VI, Fig.-10)

Description - Body originally spherical to oval, sometimes deformed during preservation, densely granulate. Body wall thin sometimes concealed. Body and processes light brown. Processes originating from all over the body at moderate distances from one another, mostly with pyramidal to broad bases. Each process extending outwards with a uniform thickness, rarely hair like, and as a rule furcating towards the tip into two three, or more branches. Processes hollow, mostly stiff.
Comparison—The individuals illustrated here are very similar to *H. cornigerum*, with which they are compared, but due to lack of better preserved specimens the exact identity can not be established.

*Hystrichosphaeridium lateraliprocessum* (sp. nov.) (Pl-IV, Fig.11)

Description Body oval, somewhat bluntly pointed, light brown. Body wall well defined, faintly reticulate. Processes almost equidistantly studded over the body, long, stout, solid, arising with a pyramidal base, very gradually tapering towards the end. Tips invariably branched into 2-5. Fine branches arranged in different patterns. Some processes characteristically show the lateral branching of the axis.

Comparison—No species known to the authors is directly comparable. The lateral branching of the processes warrants a separate designation as anew species.

*Hystrichosphaeridium mineralosum* subsp. *Jekhowaskyi* Verma and Dangwal, new species (Pl-I, Fig.-1)

Description — Body originally spherical, granulate, light brown in colour. Body wall is concealed. Processes of still lighter colour projecting densely from all over the body, hollow, stiff and thin (occasionally supple processes also seen). Tips of the processes slightly broadened, ending in flat or hollowed discs.

Comparison—The subspecies is essentially like *H. mineralosum* but differs from the typical subspecies in having in having processes almost uniform in diameter from base to tip. The tips end in small discoidal structures when complete, whereas the tips of *H. mineraosum* s. s. are hair like or digitate.

*Hystrichosphaeridium perplexum* Verma and Dangwal, new species (Pl-I, Fig-7)
Description - Body spherical to oblong, dark brown in colour. Body wall distinctly seen about 2μm thick, psilate to granulate, processes light colour, studded densely all over the body, long hollow, supple, flexous and characteristically tangled with one another into a confused interwoven mass. Tips mostly broken.

Comparison - It seems similar to *H. polytrichum* Valensi, but it processes are long, supple, filifrom and interwoven, whereas in *H. polytrichum* the processes are straight and bristle like, and not in the form of a confused interwoven mass.

*Hystrichosphaeridium sp.a.*

(Pl-I, Fig-4)

Description - Body spherical, light yellow. Body wall faintly discernible, finely granulate. Processes studded all over the body simple, hollow, stiff, hyaline, arising with a broader base gradually tapering towards the open tips.

Present Occurrence - Gumaghat, Mahadeo, Langpar and Cherrasandstone Formation.

*Hystrichosphaeridium sp.b.*

(Pl-I, Fig-16); (Pl-IV, Fig-3)

Description - Body spherical, brownish yellow. Body wall faintly discernible, finely granulate. Processes distinct, distributed all over the body, simple, tubular, supple and hollow, ending in open, swollen tips.

Present Occurrence - Gumaghat, Mahadeo, and Langpar and Cherrasandstone Formation.

*Hystrichosphaeridium sp.c*

(Pl-I, Fig-13)(Pl-IV, Fig-6)
Description - Body spheroidal, deep brown, body wall distinct, smooth, thick. Processes sparsely distributed over the body, simple, long, tubular or arising with a broader base, gradually narrowing towards the closed tips.

Present Occurrence - Gumaghat, Mahadeo, and Langpar and Cherrasandstone Formation.

**Hystrichosphaeridium sp.e**
(Pl-I, Fig-12)

Description - Body spheroidal, somewhat compressed, dark brown. Body wall not discernible. Processes simple and furcated types, closely distributed all over the body. Simple processes tubular, hollow and supple with open tips. Furcated type arising in a tubular fashion, branching into 2 or 3 from about half the length, ending in widening open tips.

Present Occurrence - Gumaghat, Mahadeo, and Langpar and Cherrasandstone Formation.

**Hystrichosphaeridium tubiferum (Davey & Williams 1966) Lentil & Williams 1973**
(Pl-VI, Fig-12)

Description - Cyst sphaeroidal, chorate, processes cylindrical, hollow with broad base, distally recurved, cingulum present, surface granulate, archaeopyle precingular.

Present occurrence - Gumaghat, Mahadeo, Langpar and Cherra Sandstone Formation.
Genus- *Oligosphaeidium* Davey & Williams, 1966

Type species- *Oligosphaeidium complex* (White) Davey & Williams, 1966

*Oligosphaeidium asterigerum* (Gocht 1959) Davey & Williams, 1966

(Pl-IV, Fig-5)

**Description**- Cyst sphaeroidal to subsphaeroidal, chorate, processes tubular, long 7-13μm, hollow, recurved distally or branched, periphragm endophragm depressed, smooth.

**Present occurrence**- Mahadeo and Langpar Formation.

*Oligosphaeidium* *diluculum* Davey 1982

(Pl-IV, Fig-10)

**Description**- Cyst subsphaeroidal, chorate, processes long, hollow, distally branched, 3-5 branches, spinulate, periphragm endophragm adpressed, smooth, archaeopyle apical.

**Present occurrence**- Langpar Formation.

*Oligosphaeidium* sp.cf.*O.pulcherrimum* (Deflandre & Cookson) Davey & Williams, 1966

(Pl-I, Fig.20); (Pl-II, Fig- 5)

**Description**- Body spherical reflected tabulation not clearly discernible; processes 11 in number, apical narrow and short, antapical broader and long, distally open, terminal expansion wide with vacuolated wall without spines. Archaeopyle apical. Cyst wall smooth.

**Remarks**- The specimen closely to those of Deflandre and Cookson (1955) except in size. It has gonyaulacean affinities with the hystrichosphaeridioid lineage.

**Family**- Exochosphaeridiaceae Sarjeant & Downie

Genus- *Exochosphaeridium* Davey et al, 1966
Type species- *E. phragmites* Davey et al, 1966

*Exochosphaeridium sp.cf. E. bifidum* (Clarke & Verdier) Clarke et. al., 1968

(Pl-VI, Fig-1)

Description- Cyst spheroidal, double layered, periphragm perforate, processes numerous, long, narrow, tips recurved and bifid, and bases circular, bulbose. Archaeopyle not seen.

Remarks- Recently Verdier et al. (1968) have transferred *Baltisphaeridium bifidum* Clarke & Verdier (1967) to *Exochosphaeridium* Davey et al (1966), which possess precingular archaeopyle. In most of the features Senegal specimens have an accord with figured forms of *Baltisphaeridium bifidum* by CLARKE & VERDIER(1967). But differs in having mixed type of process endings (recurved and bifid). The archaeopyle is indeterminable.

Family- Cordosphaeridiaceae Sarjeant and Downie 1974

Genus- *Cordosphaeridium* (Eisenack 1963) Davey 1969

(Pl-IV, Fig-7)

Description- Cyst almost spherical, chorate, processes 15 -16μm in length, broad, cylindrical, minutely branched at the apex, periphragm granulate.

Present occurrence- Gumaghat, Mahadeo and Langpar Formation.

Family- Systematophoraceae Sarjeant & Downie 1974

*Prolixosphaeridium elongatum* Jain, 1975

(Pl-IV, Fig-12)
Description – Spheroidal to oval in shape, spines distributed evenly on the surfaces, aperture apical in position, spines long, thin, almost uniform in breadth from base to apex., sharply pointed at the apex, straight or curved.

Present occurrence – Mahadeo and Langpar Formation

Family- Cleistophaeriaceae Sarjeant & Downie
Genus- Cleistosphaeridium Davey et al., 1966
Type species- Cleistosphaeridium diversispinosum Davey et al., 1966
Cleistosphaeridium sp.
(Pl-VI, Fig-7) (Pl-I, Fig-11)

Description- Cyst subspherical to broadly egg shaped. Autophram thin, psilate supporting 250-300 short stiff processes, 2-5 μm high. Processes solid tubiform to tapering, with pointed or minutely capitates bifid tips. Processes distributions possibly intratabular which may coincide with parasutures are left free of processes. Archaeopyle large to medium sized, with an irregularly margin. In some specimens an operculum is still attached. Comparison: It is closely comparable with C.australe sp. nov. These two forms were reported as C.sp. It has fewer and shorter, blunter processes. The process arrangement may be intratubular, but this is not distinct and no paratubulation formula could be derived.

Age – Upper Triassic to Middle Miocene.

Family- Lingulodiniaceae Sarjeant & Downie 1974
Genus- Lingulodinium Wall, 1967
Lingulodinium machaerophorum (Deflandre & Cookson) Wall, 1967
(Pl-IV, Fig-9)

Description- Body spherical to subspherical, both endo – and periphram appressed; non-tabular processes, hollow, flexous, finger like, base rounded with slight striations, distally closed tips
bluntly rounded and ornamented with minute granules and spinules, paratubulation apparently not seen which is generally so when the archaeopyle is epicystal. The specimen illustrated has neither the presence of a typical apical archaeopyle, nor the epicystal archaeopyle. But the shape and size of the cyst body and finger like processes with rounded base, slight striations and spinules at the distal end, allow its placement under *Lingulodinium machaerophorum* (Deflandre & Cookson) Wall, 1967. *Cleistophaeridim mikirii* Mehrotra, 1981 is, therefore, treated as junior synonym of *Lingulodinium machaerophorum* (Deflandre & Cookson) Wall, 1967.

**Remarks**—The known stratigraphic range of *Cleistophaeridim* is from Jurassic to Tertiary whereas *Lingulodinium* occurs only in post-Cretaceous sediments. Recently Jain & Tandon (1981) reported the presence of *Lingulodinium macherophorum* in the middle Eocene sediments of south – western Kachchh. The geological distribution of this species is quite long and extends from Danian to recent (Eaton, 1976; Williams & Bujak, 1977; Verdier, 1970).

**Family- Areoligeraceae** Evitt 1963

**Genus- Glaphrocysta** Stover & Evitt 1978

*Glaphrocysta retintexta* Stover & Evitt 1978

(Pl-IV, Fig-15)

**Description**—Marginal to trabrculate gonyaulacaceaen cysts, ovoid to polygonal; processes may be interconnected distally by trabeculae or a membranous cover, intratabular, aligned in rows or fused in crests archaeopyle with parasulcal notch offset to left.

**Age**—Upper Triassic to Upper Miocene.

**Family- Edoscriniaceae** Vozzhennikova 1965

*Scriniodinium crystallinum* Klement 1957

(Pl-III, Fig-9)

**Description**—Fossil dinoflagellates with relatively featureless surfaces, showing traces of diagnostic girdle and archaeopyle.
Age- Middle Jurassic to Upper Miocene.

**Dinoflagellate** Cyst type 1
(Pl-VI, Fig-9)

**Description**- Cyst oval. Processes spine like, distally pointed, many, 5-6 in length, archaeopyle apical, surface granulate.

**Remark**- The morphology of the specimen is so indistinct that it is difficult to identify its taxonomical position.

**Present occurrence**- Langpar Formation.

**Dinoflagellate** Cyst type 2
(Pl-II, Fig-8, 9) ;( Pl-V, Figs-2, 11); (Pl-VI, Fig-6, 20)

**Description** – Cyst sphaeroidal, endophragm thick, dark brown surface granular.

**Present occurrence**- Langpar Formation.

**Dinoflagellate** Cyst type 3
(Pl-VI, Fig – 15, 21)

**Description** – Golden yellow, longish oval, divided into two en-equal halves by a thick plate; exine thick, faintly structured.

**Present occurrence**- Langpar Formation.

**Dinoflagellate** Cyst type 4
(Pl -VI, Fig - 13)
Description – Cyst proximate, elongated, apical horn single, antapical horn long, tapered, periphragm thick, surface scabrate

Remark- These cysts show morphological similarity with Odontochitina but due to lack of distinct structure it is difficult to identify it as a definite genus.

Present occurrence- Mahadeo and Langpar Formation

Dinoflagellate Cyst type 5
(Pl-III, Fig -11)

Description – Cyst membranate, spheroidal, central body spheroidal, endophragm thick, dark, periphragm thinner, surface membranate, granular.

Present occurrence- Langpar Formation

Division- Prasinophyta
Order- Pterospermales
Family- Tasmanitaceae
Genus- Concentricystis Rossignol, 1962
Concentricystis rubina Rossignol
(Pl-VI, Fig-11)(Pl-I, Fig-5)

Description - Algal body rounded to sub-rounded, spheroidal, isopolar. Concentric striae ornamented the two identical halves, transparent and hyalined. Wall thick, surface smooth or very faintly rough textured.

Affinity – Prasinophyta.

Present occurrence- Langpar Formation.
Discussion and Conclusion:

Stratigraphic Distribution of Fossil Algae in the Paleogene Sediments of Meghalaya

The algal assemblage recovered from the Early Tertiary sediments of Meghalaya includes Prasinophycean groups, dinoflagellates in association with various forms of acritarchs. Although assemblage is not so significant in the relative abundance that their presence along with the spore – pollen certainly indicates some significant parameters in the biostratigraphic and environmental interpretations. To characterize the assemblage pattern of the three sedimentary units i.e. Langpar, Cherra Sandstone and Sylhet Limestone, the distribution pattern of algae on the basis of total count (per sample) has been categorized as common (more than 20), medium (less than 20) and rare (less than 10).

The distributional behavior of the over all assemblage as shown in text figure, indicate their common occurrence in the Langpar and Cherra Sandstone but less in Sylhet Limestone Formation.

In Langpar and Cherra Sandstone Formation, the dinocysts, acritarch groups are frequently observed although their diversity is less. The commonly observed dinocysts taxa are Hystrichosphaeridium, Oligosphaeridium, Deflandre, Ceratiopsis, Paleocystidium, and Gonyaulacysta. The genus Cocentricystis of the family Tasmanitaceae is represented by one species such as C.rubina

Thirty five types of Dinoflagellates have been recorded from the Paleogene sediments of Meghalaya. The cysts of Dinoflagellates recovered are not well preserved and all of the cysts do not show very clearly the features for generic identification. The dinocysts recovered are of variable shapes of subspherical to ellipsoidal, the archaeopyle position precingular, and processes solid or hollow and branched. On the basis of these discernible characters the dinoflagellate cysts are provisionally identified as of Gonyaulax|Spinifertites complex.
The presence of algae in association with the spore – pollen considered as the best palaeoenvironmental indicator. By analogy, the modern ecosystem and the general world wide distributional pattern of the presently observed algal community help us to deduce the environmental condition of Meghalaya during Early Tertiary.

*Cocentricystis* (=*Circulisporites*) regarded as representing continental fresh water or brackish water indicator (Balmae and Sergroves 1966). *C.rubina* has been recorded by Gupta (1981), Sen and Banerjee (1988), from the marine to brackish aquatic assemblages of Holocene sediments from south of Bengal Basin. Similar forms have been recovered from the marine to brackish water assemblage of the subsurface sediments of Sundarbans, West Bengal (Banerjee & Sen, 1986).

The general worldwide distribution of acritarchs and their association with other biota indicate their planktonic habit. Their small size, great abundance and analogy with the modern ecosystem suggest that they must have been phytoplankton (Tappan 1980).

Presence of *Baltisphaeridium* found from the English Jurrasic suggests inshore environment. Diverse population and dominance of marine forms indicate offshore condition, whereas low population indicates inshore condition. Species with reduced processes appeared to be tolerant of turbulent conditions and those with long processes were restricted to the areas of quite deposition (Tappan 1980). Moreover, the diversity of acritarch in association with abundant dinocysts indicates transgressive phase.

The common occurrence but low species diversity of phytoplankton (*acritarch, dinoflagellates*) in the rocks Langpar Formation indicates the inshore brackish to salt water condition. Presence of chororate and proximo-chorate cysts, such as, *Hystrichosphaeridium, Achomosphaera, and Spiniferites* generally indicates nearshore planktonic form and saltwater condition.
Association of *Solisphaeridium, Baltisphaeridium* indicates the marine to brackish water and moderately quite to slightly turbulent condition of deposition at the basinal area and probably suggestive of closing stages of an Oligocene marine transgression.

Presences of *Concentricystis* also suggest the fresh to brackish water environment.

Therefore, from these algal associations the paleoenvironmental condition during the depositional period of Langpar Formation is deduced as brackish water inshore condition with mixing of fresh and marine water deposits.

On the other hand, low diversity and less abundance of phytoplankton with fresh water algal forms in the Cherra sequences indicate the decrease of brackish to marine water influence, whereas, their much less abundance in the Sylhet Limestone sediments indicate the gradual inhibition of brackish water environment possibly due to the further regression of the

The palynological assemblage recovered from the sample consists of excessive amount of organic detritus including large and small pieces of terrestrial cuticles and wood tracheids; algal cysts (dinoflagellates); fungal bodies; pteridophytic spores; pollen grains of gymnosperm and angiosperms; some recycled pollen grains

The dinocysts constitute the dominant component of the total palynological assemblage

The majority of the dinocyst flora is represented by a single species.

The palynological assemblage describe and discussed is characterized by the following features;

1) The dominance of dinoflagellate cysts

2) Low specific diversity and predominance of a single dinocyst species;

3) Abundance of terrestrial plant cuticles and wood tracheids, of larger size

4) Subdominance of palmae pollen grains.

These features respectively indicate marine influence at the time of deposition, low salinity, near-shore sedimentation bordering the land mass with influx of fresh water, and nearly in situ deposits. (Davey, 1971).
Table No. 3 Affinity and environmental analysis of algal assemblages recovered from the Paleogene sediments of Meghalaya:

<table>
<thead>
<tr>
<th>Algae</th>
<th>Name of the Taxa</th>
<th>Name of the Species</th>
<th>Botanical affinity</th>
<th>Environment</th>
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<td>Baltisphaeridium sp. a</td>
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<td>Open Sea Association</td>
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<td>Solisphaeridium</td>
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| Green Algae                  | Concentricystis rubina | Tasmanitaceae, Prasinophyta | Tropical Brackish water |
## Table No. 3A

**Distribution of Algal remains in the Paleogene Sediments of Meghalaya**

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<th>Cherra Formation</th>
<th>Langpar Formation</th>
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<td>+ +</td>
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<td></td>
</tr>
<tr>
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<td>+ +</td>
<td>+</td>
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<tr>
<td>Dinogynium cf. D. acuminatum</td>
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<td>+ + +</td>
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