AN UPPER CRETACEOUS DINOFLAGELLATE ASSEMBLAGE FROM VRIDDHACHALAM AREA, CAUVERY BASIN, SOUTH INDIA

K. P. JAIN

Birbal Sahni Institute of Palaeobotany, Lucknow-226007, India

ABSTRACT

Present article reports a dinoflagellate assemblage from Vriddhachalam area, Cauvery basin, South India. It includes 13 genera with 14 recognizable species and a single acritarch genus *Pterospermopsis*. The dominant constituents of the assemblage are: *Cordosphaeridium, Cyclonephelium, Areoligera, Spiniferites* and *Dinogymnium* with less common occurrence of *Apteodinium, Lanternosphaeridium, Diphyes* and *Ceratiopsis*. The age of the assemblage has been concluded to be uppermost Maestrichtian, may be representing Maestrichtian-Danian transition.

INTRODUCTION

UPPER Cretaceous palynology from Pondicherry and Vriddhachalam areas has been recently worked out by Venkatachala and Sharma (1974a, 1974b). They considered miospores alone to correlate the various bore-holes drilled in these areas. The study of dinoflagellates from Vriddhachalam Upper Cretaceous is attempted here for the first time, though much has been contributed towards its stratigraphy and palaeontology by Blanford (1865); Banerji (1965, 1967, 1968, 1968a, 1969, 1973); Banerji and Mohan (1970); Rasheed and Govindan (1963, 1966, 1968), Govindan (1969) and Sastry *et al.* (1972).

The stratigraphic sequence of Vriddhachalam area has recently been published by Banerji (1973). The Upper Cretaceous rock stratigraphic units proposed by Banerji (1973, Table 4) are reproduced as follows:

Geological age				Rock stratigraphic units	
Palaeocene				Pondicherry Formation	
Upper Cretaceous	Maestrichtian	Upp.		Kallankurchi Formation	Cullmoad Sandstone Member
		Mid.			Chokanadapuram Limestone Member
		Low.		Ariyalur Formation	Pallakollai Member
	Senonian		Campanian		Chendamangalam Member
			Santonian		Patti Member
			Coniacian		Parur Member

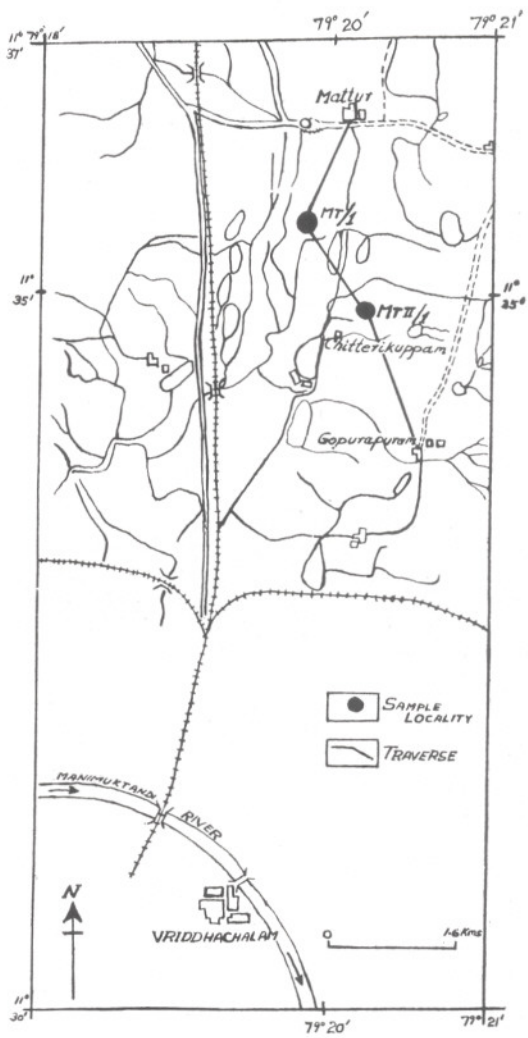
The two members of Kallankurchi Formation of Banerji (1973), viz., younger Cullmoad Sandstone and the older Chokanadapuram Limestone, occur both in Vriddhachalam and Ariyalur areas but are missing on surface in Pondicherry area. The Limestone Member is richly fossiliferous where as the Cullmoad Sandstone Member is more or less unfossiliferous. Banerji (1973, p. 27) dated the unfossiliferous member as Middle to Upper Maestrichtian. Sastry *et al.* (1972, p. 6) places unfossiliferous poorly sorted sands, sandstones and clays with dinosaurian bone remains in Ariyalur area at the top of the Maestrichtian under Kallamedu Formation.

The purpose of the present article is to demonstrate the occurrence of planktonic marine phytoplankton, which are useful indicators of environment and markers for age interpretation, from the palaeontologically unfossiliferous horizon as discussed above.

Location & Nature of Samples — The Cretaceous rocks in this area lie within the coordinates 11°31′ N: 79°15′ E and 11°46′ N: 79°25′ E.

The samples were collected from well cutting sections situated due south of Mattur Village in Vriddhachalam area (Map 1). The section (MT-II/1) includes medium to coarse grained sandstone at the top, underlying which are the sandy clays, the lowermost exposed bed of 1 m thickness consists of calcareous sandstone with no apparent fossils but carbonaceous streaks. The calcareous sandstone is greyish-white in colour similar to Cullmoad Sandstone Member (Banerji, 1973, p. 27). The author is thankful to Dr Surendra Kumar of Geology Department, Lucknow University for doing the petrology of the samples. The calcareous sandstone lithology alone has been proved to be productive, containing pollen, spores and dinoflagellates. Out of these, only the dinoflagellates and acritarchs have been considered here, the other palynofossils will be published elsewhere.

The dinoflagellate cysts and acritarchs have been classified according to the systems proposed by Sarjeant and Downie (1974) and Downie *et al.* (1963) respectively. The type slides are housed at the Museum, Birbal Sahni Institute of Palaeobotany, Lucknow, India.



Map 1. — Geographic set up of Vriddhachalam area showing the location of samples.

SYSTEMATIC PALYNOLOGY

Dinoflagellates and Acritarchs

Class — Dinophyceae Pascher
Subclass — Diniferophycidae Bergh
Order — Gymnodiniales Schütt
Family — Dinogymniaceae Sarjeant & Downie
Genus — *Dinogymnium* Evitt *et al.*
D. acuminatum Evitt *et al.*

Order — Peridiniales Schütt
Family — Spiniferitaceae Sarjeant emend. Sarjeant & Downie
Genus — *Spiniferites* Mantell emend. Sarjeant
S. cingulatus (Wetzel) Sarjeant
S. ramosus subsp. *spinosus* nov. Jain
S. ramosus subsp. *ramosus* (Ehrenberg) Lentin & Williams
Genus — *Achomosphaera* Evitt
Achomosphaera sp. cf. *A. ramulifera* (Deflandre) Davey & Williams

Family — Apteodiniaceae Eisenack emend. Sarjeant & Downie
Genus — *Apteodinium* Eisenack
A. maculatum Eisenack & Cookson
?*Apteodinium* sp.

Family — Deflandreaceae Eisenack emend. Sarjeant & Downie
Genus — *Ceratiopsis* Vozzhennikova
C. diebelii (Alberti) Vozzhennikova

Family — Hystrichosphaeridiaceae Evitt emend. Sarjeant & Downie
Genus — *Hystrichosphaeridium* Deflandre emend. Davey & Williams
H. tubiferum subsp. *brevispinum* (Davey & Williams) Lentin & Williams

Family — Cordosphaeridiaceae Sarjeant & Downie
Genus — *Cordosphaeridium* Eisenack emend. Davey
C. exilimurum Davey & Williams
C. fibrospinosum Davey & Williams
C. inodes gracilis (Eisenack) Gocht
C. sp. A

Family — *Areoligeraceae* Evitt emend. Sarjeant & Downie
Genus — *Cyclonephelium* Deflandre & Cookson emend. Cookson & Eisenack
C. ordinatum Williams & Downie
C. lemniscatum Stanley
Genus — *Areoligera* Lejeune-Carpentier emend. Williams & Downie
A. senonensis Lejeune-Carpentier
A. volata Drugg

Family — Exochosphaeridiaceae Sarjeant & Downie
Genus — *Lanternosphaeridium* Morgenroth
L. axialis (Eisenack) Morgenroth

Family — Systematophoraceae Sarjeant & Downie
Genus — *Diphyes* Cookson emend. Davey & Williams
D. colligerum (Deflandre & Cookson) Cookson

Family — Uncertain
Genus — *Silicisphaera* Davey & Verdier
Silicisphaera sp. A
Silicisphaera sp. B
Genus — *Cyclopsiella* Drugg & Loeblich
C. sp. A

Group — Acritarcha Evitt
Subgroup — Pteromorphitae Downie *et al.*
Genus — *Pterospermopsis* Wetzel
Pt. sp. cf. *heliantoides* De Coninck

DESCRIPTION

Genus — *Dinogymnium* Evitt, Clarke & Verdier, 1967

Dinogymnium acuminatum Evitt *et al.*, 1967

Pl. 1, fig. 9

Geologic & Geographic Distribution — Maestrichtian, California (Evitt *et al.*, 1967); Maestrichtian, Senegal Basin, W. Africa (Jain & Millepied, 1975); Maestrichtian, Jadukata & Mahadek formations, Assam, India (Jain *et al.*, 1975); for global distribution see Jain (1977).

Genus — *Spiniferites* Mentall emend. Sarjeant 1970

Spiniferites cingulatus (Wetzel) Sarjeant, 1970

Pl. 1, fig. 10

Geologic & Geographic Distribution— Cenomanian to Pleistocene (see Davey & Williams, 1966 in Davey *et al.*, 1966).

Spiniferites ramosus subsp. *spinosus* nov.

Pl. 1, fig. 3

Description — Cyst ovoidal, 46×36 μm in size. Periphragm ornamented with short processes, tabulation that of genus.

Comparison — *S. ramosus* subsp. *spinosus* nov. differs from rest of the subspecies of *S. ramosus* in having distinct ornamentation of short processes on the periphragm.

Holotype — Pl. 1, fig. 3; Slide no. 5511-8.

Type Locality — Mattur, Vriddhachalam area, South India.

Spiniferites ramosus subsp. *ramosus* (Ehrenberg) Lentin & Williams, 1973

Pl. 3, fig. 33

Geologic & Geographic Distribution—Middle Barremian to Ypresian (Davey & Williams, 1966).

Genus — *Achomosphaera* Evitt, 1963

Achomosphaera sp. cf. A. *ramulifera* (Deflandre) Davey & Williams, 1966

Pl. 1, fig. 4

Description — Cyst spherical, surface smooth to faintly granulate, lines marking the plate boundaries seen; process distribution that of genus, hollow, when bifurcate divide near base having proximal fenestrate wall, each stem further trifurcates with bifid tips. Some processes (?cingular) show distal connection between bifid tips. Archaeopyle large, pentagonal, precingular.

Remarks — In most of the general features the present specimen resembles *A. ramulifera* (Deflandre) Davey & Williams but differs in having a few larger processes with fenestrate proximal wall and varied nature of bifurcation.

Genus — *Apteodinium* Eisenack, 1958

Apteodinium maculatum Eisenack & Cookson, 1960

Pl. 2, figs. 17-18

Geologic & Geographic Distribution — Albian, South Australia (Cookson & Eisenack, 1960), Upper Cretaceous, Jadukata Formation, Assam, India (Jain *et al.*, 1975).

?*Apteodinium* sp.

Pl. 3, fig. 23

Description — Cyst ovoidal, double layered, outer surface rugulate, apical projection very small, cingulum distinct, tabulation 4′, 6″, 6c, 6‴, 1p, 1⁗. Archaeopyle precingular, operculum present.

Genus — *Ceratiopsis* Vozzhennikova, 1963

Ceratiopsis diebelii (Alberti) Vozzhennikova, 1967

Pl. 2, fig. 21; Pl. 3, fig. 34

Geologic & Geographic Distribution — Senonian, Germany (Alberti, 1959); Maestrichtian, Poland, (Gorka, 1963); Maestrichtian-Danian, California (Drugg, 1967); Palaeocene-Eocene, U.S.S.R. (Vozzhennikova, 1967).

Genus — *Hystrichosphaeridium* Deflandre emend. Davey & Williams, 1966

Hystrichosphaeridium tubiferum (Ehrenberg) subsp. *brevispinum* (Davey & Williams) Lentin & Williams

Pl. 2, fig. 14

Geologic & Geographic Distribution — Early Eocene, London Clay (Davey & Williams, 1966 in Davey *et al.*, 1966).

Genus — *Cordosphaeridium* Eisenack emend. Davey, 1969

Cordosphaeridium exilimurum Davey & Williams, 1966

Pl. 1, fig. 1

Geologic & Geographic Distribution — Early Eocene, Whitecliff Bay, Isle of Wight, London Clay (Davey & Williams, 1966 in Davey *et al.*, 1966).

Remarks — *C. exilimurum* Davey & Williams (1966) is quite common in the present material. Present specimens show marked resemblance with the forms des-

cribed by Stanley (1965, p. 25, figs. 1-6) as *H. inodes* from Fort Union Formation (Palaeocene).

Cordosphaeridium fibrospinosum Davey & Williams, 1966

Pl. 2, fig. 15

Geologic & Geographic Distribution — Maestrichtian, Southern Sweden (Kjellström, 1973); Early Eocene, London Clay (Davey & Williams, 1966 in Davey *et al.*, 1966); Maestrichtian, Texas (Zaitzeff & Cross, 1970).

Cordosphaeridium inodes gracilis (Eisenack) Gocht, 1969

Pl. 2, figs. 19-20

Geologic & Geographic Distribution — Eocene, Germany (see Gocht, 1969; pp. 41-42).

Cordosphaeridium sp. A

Pl. 2, fig. 13

Description — Cyst body ovoidal, endophragm smooth, periphragm pitted, giving rise to tubiform, hollow processes. Processes variable in width, generally unbranched, fibrous, stem striate, distally open, secate, tips bifid, in some terminal tubules present. Archaeopyle haplotabular, tabulation that of genus.

Measurements

Body size — 44×34 μm
Process length — upto 26 μm
Process width — 2-5 μm

Remarks — Presence of terminal tubules on some processes and pitted cyst wall makes it difficult to compare *Cordosphaeridium* sp. A with any known species of the genus.

Genus — *Cyclonephelium* (Deflandre & Cookson) Cookson & Eisenack, 1962

Cyclonephelium ordinatum Williams & Downie, 1966

Pl. 1, figs. 5, 8

Geologic & Geographic Distribution — Eocene, London Clay (Williams & Downie, 1966 in Davey *et al.*, 1966); Lower Eocene, Germany (Gocht, 1969).

Cyclonephelium lemniscatum Stanley, 1965

Pl. 3, fig. 24

Geologic & Geographic Distribution — Palaeocene, Cannon Ball Member, Ford Union Formation, U.S.A. (Stanley, 1965).

Genus — *Areoligera* Lejeune-Carpentier, 1939

Areoligera senonensis Lejeune-Carpentier, 1939

Pl. 2, fig. 16

Geologic & Geographic Distribution — Senonian, Belgium (Lejeune-Carpentier, 1939); Maestrichtian, Denmark (Wilson, 1971); Maestrichtian, U.S.A. (Zaitzeff & Cross, 1970); Eocene, London (Williams & Davey, 1966 in Davey *et al.*, 1966).

Areoligera volata Drugg, 1967

Pl. 1, figs. 6-7; Pl. 3, figs. 27-28

Remarks — Vriddhachalam specimens have been described as *A. volata* in view of two low antapical lobes and microreticulate surface ornamentation. The process complexes are variable and resemble to *A. coronata* (Wetzel) Lejeune-Carpentier (1938).

The specimen photographed by Zaitzeff and Cross (1973, pl. 4, fig. 33) and designated to *A. senonensis* shows close resemblance with the present specimen in the presence of two low antapical lobes; other details are not known.

Geologic & Geographic Distribution — Danian, California (Drugg, 1967).

Genus — *Lanternosphaeridium* Morgenroth, 1966

Lanternosphaeridium axialis (Eisenack) Morgenroth, 1966

Pl. 1, fig. 11

Geologic & Geographic Distribution — Eocene-Oligocene, Germany and Belgium (see Corradini, 1971, 1972); Upper Cretaceous, Maestrichtian, Italy (Corradini, 1972).

Genus — *Diphyes* Cookson emend. Davey & Williams, 1966

Diphyes colligerum (Deflandre & Cookson) Cookson, 1965

Pl. 1, fig. 2

Remarks — The present specimen possesses numerous processes with closed distal ends and a broad distally closed antapical process. The archaeopyle is apical. These features suggest their closest affinity with *D. colligerum* and *Lingulasphaera spinula* Drugg (1970). But *Lingulasphaera spinula* differs in possessing proximally closed processes and five sided apical archaeopyle with 4 apical plates.

The main characteristic features described for *Lingulasphaera* are similar to *Diphyes*. They are more or less overlapping genera. The holotype of *Diphyes* needs further study to confirm the separate generic status of *Lingulasphaera*.

Geologic & Geographic Distribution — Eocene, Australia (Deflandre & Cookson, 1955); Palaeocene, Fort Union Formation, U.S.A. (Stanley, 1965); Lower Tertiary U.S.A. (Drugg, 1967); Eocene, Southern England (Eaton, 1976); Cretaceous-Tertiary (Williams & Lentin, 1975).

Genus — *Silicisphaera* Davey & Verdier, 1976

Silicisphaera sp. A

Pl. 3, fig. 31

Description — Cyst subspherical, 58 μm in diameter; surface microgranulate, wall bearing simple and complex inflated processes. Antapical process large, longer than broad, faintly striated, distally truncated. Postcingular and precingular processes thin, complex, distally provided with tubules but no spines, tubules terminal or arise at any place on stem length. Base of each process covers most of each plate area. Archaeopyle precingular (3″).

Remarks — Present form compares best with *Silicisphaera tenera* Davey & Verdier (1976) in having numerous narrow terminal tubules, but differs in having ornamented wall.

Silicisphaera sp. B

Pl. 3, figs. 29-30

Description — Cyst spherical, body 40 μm in diameter, periphragm thin, microgranulate, gives rise to 10-20 μm high processes having narrow proximal and broader distal ends, striated, distally truncate to slightly recurved; archaeopyle indistinct, ? precingular.

Remarks — Only a single specimen has been found. It shows comparison with *Silicisphaera ? torulosa* Davey & Verdier (1976) but differs in having distally broader and proximally narrower processes.

Genus — *Cyclopsiella* Drugg & Loeblich, 1970

Cyclopsiella sp. A

Pl. 1, fig. 12; Pl. 3, fig. 32

Description — Cyst oblong, 70-84 × 54-60 μm in size, double layered, outer thin, smooth, extending beyond body margin; inner one micropunctate; ornamentation denser around circular opening (14 μm in diameter) having no distinct rim.

Remarks — No specific comparison has been attempted due to lack of specimens.

Gen. indet.

Pl. 3, figs. 25-26

Description — Cyst spherical, two layered, endophragm smooth, periphragm gives rise to tubular, hollow processes, distally expanded, sometimes bifurcate, recurved, having 4-5 points. Stem appears to be four sided, striated, four apical and six precingular processes distally and proximally free. Polygonal plates along cingular area do not develop complete cingular zone. Cingular processes indeterminable, postcingular 6 in number. Antapical plate possesses one bifurcated large process. Cingular, postcingular and antapical processes distally united by trabeculae. Trabeculae solid, forming slight net work. Archaeopyle ?precingular.

Remarks — Deflandre and Cookson (1955, p. 269) described *Hystrichokibotium trabeculiferum* from Middle Miocene of Victoria. It is characterized by having polygonal

fields which do not appear to form a distinct equatorial girdle. The processes are both free or connected distally to one another by filiform or ribbon-like trabeculae. These features are similar to the present form. The archaeopyle in this specimen, though doubtful, appears to be precingular. It differs from *Spiniferites pseudofurcata* (Klumpp) Sarjeant (in Gocht, 1969, p. 32, pl. 4, figs. 12-13) in having distally united cingular, postcingular and antapical processes through solid trabeculae. Verdier (in Deflandre *et al.*, 1970, p. 41) assigned *H. trabeculiferum* Deflandre & Cookson (1955) to *Nematosphaeropsis* sp. indet. But the characteristic feature of free apical and precingular processes with distally united other processes pose doubt to place it under *Nematosphaeropsis*. Deflandre and Cookson (1955, p. 269) considered that there was a tendency to develop connected processes in *H. trabeculiferum*.

Genus — *Pterospermopsis* Wetzel, 1952

Pterospermopsis sp. cf. *Pt. heliantoides* De Coninck, 1968

Pl. 2, fig. 22

Description — Body spherical, 68 μm in diameter, thick-walled (4-5 μm) scabrate, flange well-developed around central body, 30 μm in width; flange possesses numerous equidistant folds.

Remarks — In most of the morphological features the present specimen resembles *Pt. heliantoides* De Coninck (1968) described from Ypresian of Belgium but differs mainly in having numerous folds and scabrate central body. Only a single specimen has been recovered.

DISCUSSION

The palynological assemblage recovered from calcareous sandstone sample of Vriddhachalam area is a mixture of dispersed pteridophytic spores, angiospermic pollen, algal cysts (dinoflagellates & acritarchs), recycled Palaeozoic gymnospermous pollen grains and detritus of larger plants.

The dinoflagellate and acritarch constituents in the composite assemblage are quite conspicuous, representing about 20-25% of the total counts. The specific diversification is distinct but individual specimen are few. The significant dinoflagellate species recognized in the flora are, viz., *Dinogymnium acuminatum, Cordosphaeridium fibrospinosum, C. exilimurum, C. inodes gracilis, Apteodinium maculatum, Ceratiopsis diebelii, Diphyes colligerum, Cyclonephelium ordinatum, C. lemniscatum, Areoligera senonensis, A. volata* and *Lanternosphaeridium axialis*.

Comparison with Indian Dinoflagellate Assemblages — The records of fossil dinoflagellates from Indian Mesozoic and Cenozoic sediments are mostly found as casual mentions along with rich spore-pollen descriptions (Jain, 1974). Detailed dinoflagellate floras have only been recorded by Sah *et al.* (1970); Banerjee and Misra (1972); Jain and Taugourdeau-Lantz (1973), Jain (1977a) and Jain *et al.* (1975).

The dinoflagellate assemblage described by Sah *et al.* (1970) from the Langpar Formation of Therriaghat, South Shillong Plateau, Assam is dominated by the presence of *Spiniferites-Achomosphaera* elements. It has been dated Upper Cretaceous in age, but none of the constituents supports the age determination, and also does not compare with the present assemblage. This Therriaghat assemblage is probably younger than Cretaceous (Personal communication by Dr R. Y. Singh).

The Maestrichtian-Danian dinoflagellate flora described from Jadukata (Gumaghat), Mahadek and Langpar formations in Assam (Jain *et al.*, 1975; Sah & Singh, 1977, 1977a & MS.) compares best with the present Vriddhachalam dinoflagellate assemblage in having common elements of both Mahadek and Langpar, viz., *Dinogymnium, Cyclonephelium, Apteodinium, Cordosphaeridium, Ceratiopsis* and *Lanternosphaeridium*. The Mahadek Formation is of Maestrichtian age and consists of the following major dinoflagellate taxa, viz., *Dinogymnium, Odontiochitina, Apteodinium* and *Gonyaulacysta*. Out of these, *Dinogymnium* and *Apteodinium* are common to present flora. *Cyclonephelium, Areoligera, Cordosphaeridium* and *Ceratiopsis* are absent. The latter four genera are conspicuous elements of the Vriddhachalam assemblage and in Assam appear only in the Langpar sediments.

TABLE 1 — STRATIGRAPHICAL DISTRIBUTION OF SOME IMPORTANT VRIDDHACHALAM DINOFLAGELLATE SPECIES

Comparison with other Dinoflagellate Assemblages — Several Upper Cretaceous dinoflagellate assemblages are known from various parts of the world reported by Drugg (1967), Zaitzeff and Cross (1970), Malloy (1970), Wilson (1971, 1976), Brideaux (1971, 1971a), Corradini (1972), Felix and Burbridge (1973), Kjellström (1973), Williams and Brideaux (1975), Evitt (1973), Jain and Millepied (1973, 1975), Herngreen (1975), Harland (1976), Doerenkamp *et al.* (1976) and Koch *et al.* (1977). Of these, most of the assemblages remain uncomparable with the present one due to the presence of important genus *Deflandrea* which forms the basis of Upper Cretaceous zonation in Europe and Canada.

The dinoflagellate assemblage from Maestrichtian Marca shale of Upper Moreno Formation, Escarpado Canyon, California (Drugg, 1967), compares well with the present flora in having *Dinogymnium*, though different species, the genus does not extend into the Danian Lower Dos Palos shales. Comparable *Ceratiopsis diebelii* occurs in both the shales where as common *Areoligera volata* appears only in the Dos Palos shale.

Zaitzeff and Cross (1970) have listed 62 taxa from Maestrichtian of Navaro Group, California. Of these, *Cordosphaeridium fibrospinosum, Diphyes* cf. *colligerum, Areoligera senonensis* cf. *Achomosphaera ramulifera, Cyclonephelium* spp., *Cordosphaeridium inodes* and *Dinogymnium acuminatum* (their *Dinogymnium* sp. 4, pl. 4, fig. 42, resembles to *D. acuminatum*) are common. These forms characterise the Upper Zone B and C of Navaro Group. Zone A is older Maestrichtian and is characterized by the presence of *Odontochitina striatoperforata.*

In a preliminary report on European Late Cretaceous dinoflagellate Wilson (1971) summarized some interesting results. The rich dinoflagellate flora from Upper Maestrichtian of Enci Quarry, Curfs Quarry and the Albert Canal (Belgium & Holland) includes *Areoligera-Cyclonephelium* elements with moderate representation of *Cordosphaeridium* and no *Odontochitina.* This floral aspect is also represented in the Vriddhachalam assemblage but having only a few very thin-walled, large *Odontochitina*-like forms.

A perusal of the Upper Cretaceous and Palaeocene dinoflagellate literature reveals that *Odontochitina* and *Dinogymnium* are significant stratigraphic markers (Harker & Sarjeant, 1975). The upper limit of known *Odontochitina* species is as young as Campanian-Lower Maestrichtian (Harland, 1977; Wilson, 1971; Kjellström, 1973 ;Williams & Lentin, 1975) where as *Dinogymnium* extends throughout Maestrichtian (Jain, 1977). Recently, Schumacker and Chateauneuf (1976) recorded three species of *Dinogymnium* and two species of *Odontochitina* from the marls of Gelinden, Belgium. These occurrences appear to be due to reworking of Upper Cretaceous forms. Chateauneuf in a personal communication to author (4th August, 1977) also agrees with this possibility which confirms the Palaeocene dating of Gelinden marls and restricts the Upper Cretaceous extent of *Odontochitina* and *Dinogymnium.*

The stratigraphic distribution of Dinoflagellate species recovered from Mattur, Vriddhachalam area (Table 1) and the above discussions and comparisons clearly indicate that this assemblage represents an Uppermost Maestrichtian or transitional floral aspect of Cretaceous-Tertiary boundary. The equivalent of this assemblage is missing at Dawki and Cherrapunji in Assam area. However, the possibility of its occurrence elsewhere in Assam can not be ruled out at present.

Present study significantly suggests that the dinoflagellates would be of greater help in deciphering the precise zonation and correlation of Cretaceous and Tertiary sediments in India.

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EXPLANATION OF PLATES

(*All microphotographs magnified* 500×)

PLATE 1

1. *Cordosphaeridium exilimurum* Davey & Williams, 1966; Slide no. 5508-24.

2. *Diphyes colligerum* (Deflandre & Cookson) Cookson, 1965; Slide no. 5577-4.

3. *Spiniferites ramosus* subsp. *spinosus* nov.; Slide no. 5511-8.

4. *Achomosphaera* sp. cf. *ramulifera* (Deflandre) Davey & Williams, 1966; Slide no. 5511-5.

5. *Cyclonephelium ordinatum* Williams & Downie, 1966; Slide no. 5515-6.

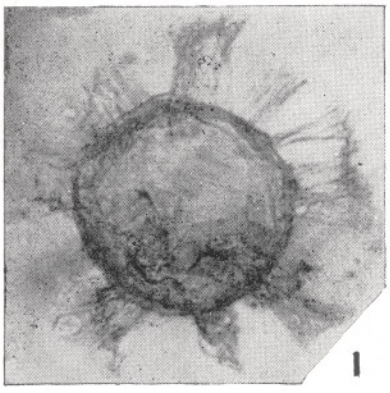
6-7. *Areoligera volata* Drugg, 1967; Slide nos. 5508-20 & 5517-12.
8. *Cyclonephelium ordinatum* Williams & Downie, 1966; Slide no. 5511-23.
9. *Dinogymnium acuminatum* Evitt *et al.*, 1967; Slide no. 5505-14.
10. *Spiniferites cingulatus* (Wetzel) Sarjeant, 1970; Slide no. 5511-20.
11. *Lanternosphaeridium axialis* (Eisenack) Morgenroth, 1966; Slide no. 5517-13.
12. *Cyclopsiella* sp. A.; Slide no. 5517-21.

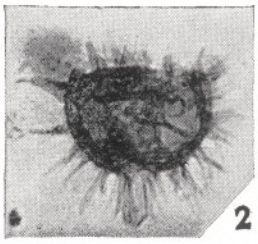
PLATE 2

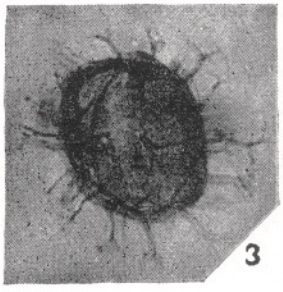
13. *Cordosphaeridium* sp. A.; Slide no. 5511-4.
14. *Hystrichosphaeridium tubiferum* Subsp. *brevispinum* (Davey & Williams) Lentin & Williams, 1973; Slide no. 5518-15.
15. *Cordosphaeridium fibrospinosum* Davey & Williams, 1966; Slide no. 5515-14.
16. *Areoligera senonensis* Lejeune-Carpentier, 1939; Slide no. 5511-10.
17-18. *Apteodinium maculatum* Eisenack & Cookson, 1960; Slide nos. 5508-17 & 5515-23.
19-20. *Cordosphaeridium inodes gracilis* (Eisenack) Gocht, 1969; Slide nos. 5515-10 & 5517-17.
21. *Ceratiopsis diebelii* (Alberti) Vozzh., 1967; Slide no. 5508-18.
22. *Pterospermopsis* sp. cf. *Pt. heliantoides* De Coninck, 1968; Slide no. 5505-12.

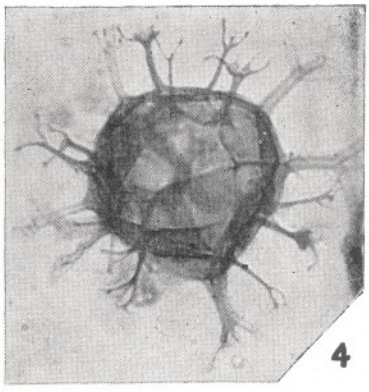
PLATE 3

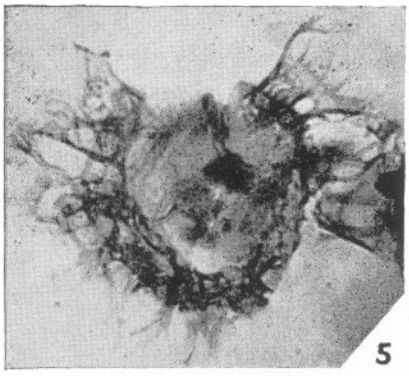
23. ?*Apteodinium* sp.; Slide no. 5505-20.
24. *Cyclonephelium lemniscatum* Stanley, 1965; Slide no. 5507-13.
25-26. Gen. indet.; Slide nos. 5518-19.
27-28. *Areoligera volata* Drugg, 1967; fig. 27 shows the presence of plates; Slide no 5511-20.
29-30. *Silicisphaera* sp. B; Slide no 5518-16.
31. *Silicisphaera* sp. A.; Slide no. 5517-9.
32. *Cyclopsiella* sp. A.; Slide no. 5517-20.
33. *Spiniferites ramosus* Subsp. *ramosus* (Ehrenburg) Lentin & Williams, 1973; Slide no. 5508-1.
34. *Ceratiopsis diebelii* (Alberti) Vozzhennikova, 1967; Slide no. 5517-26.

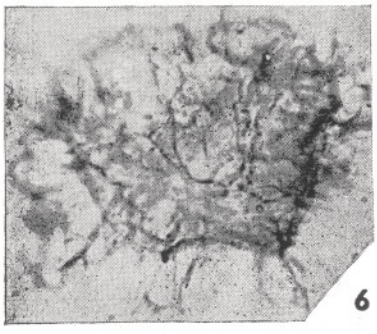


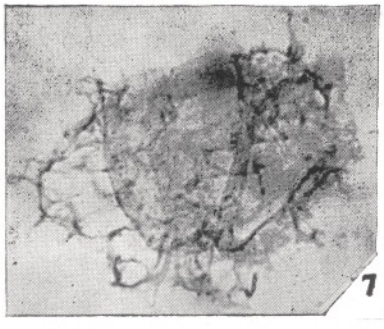


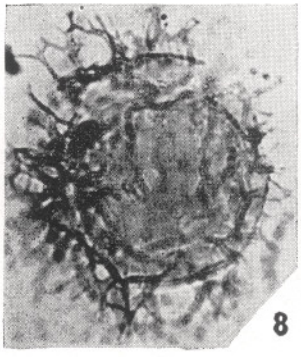


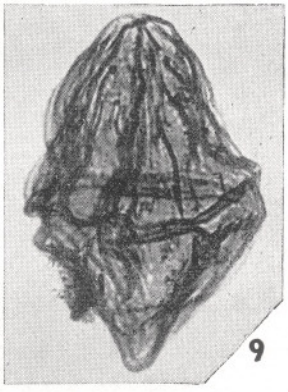


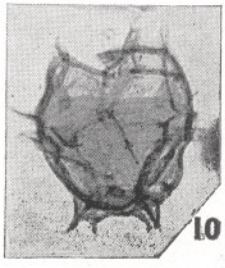


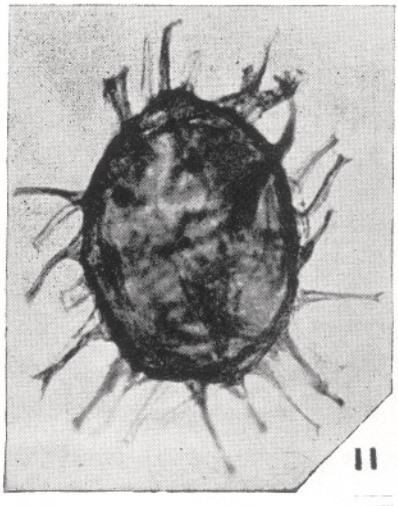












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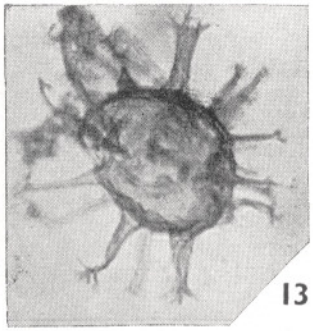
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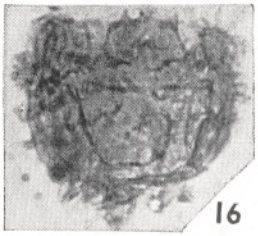
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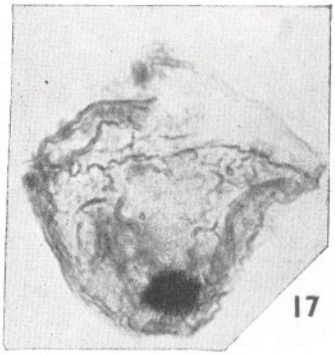
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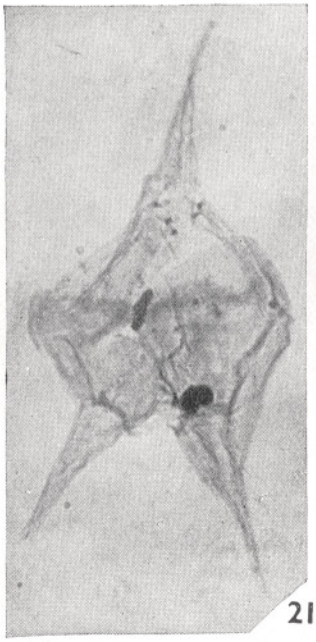
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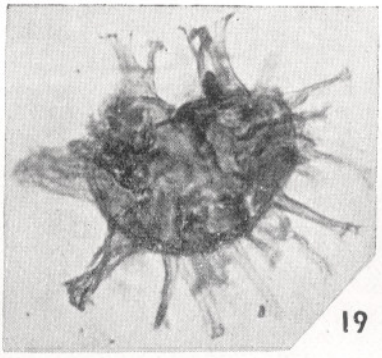
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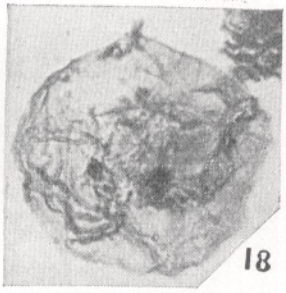
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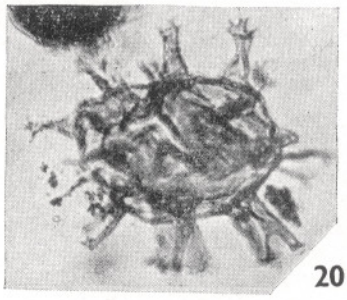
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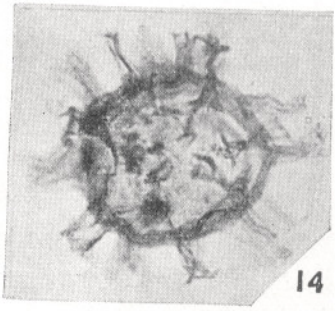
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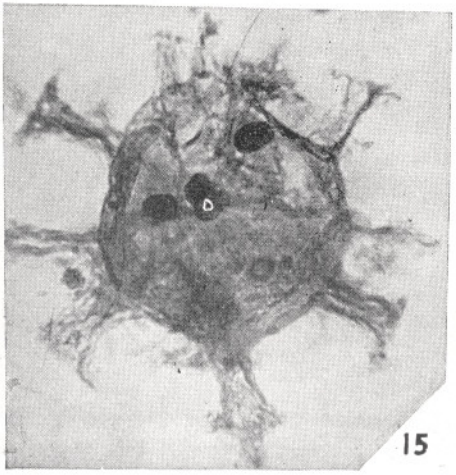
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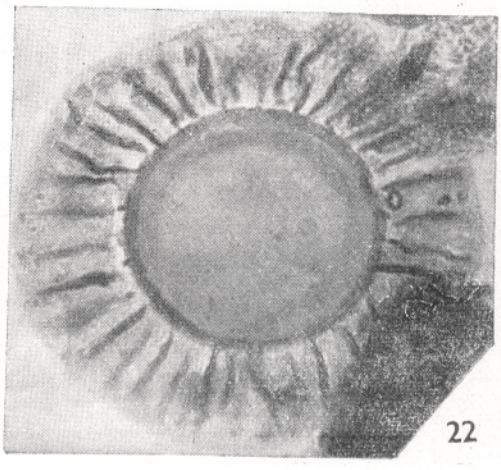
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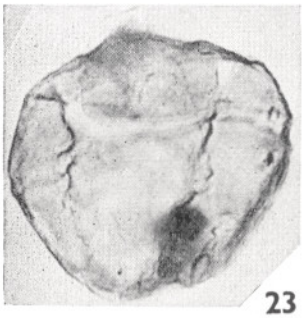
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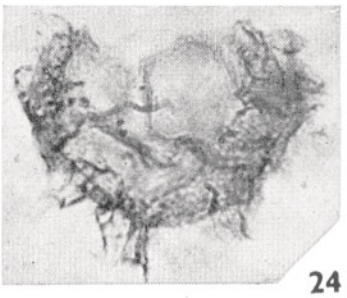
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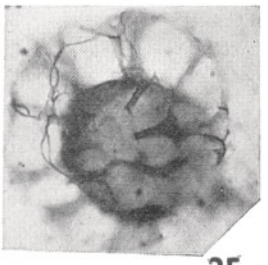
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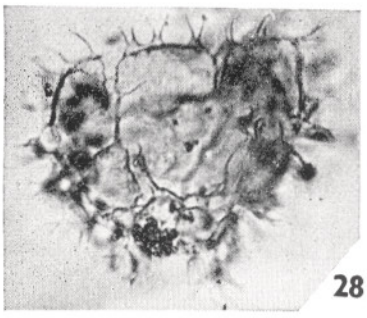
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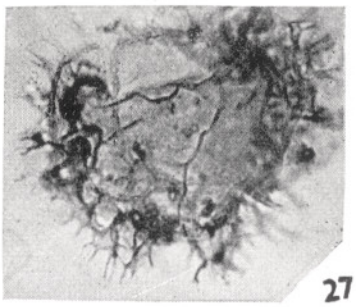
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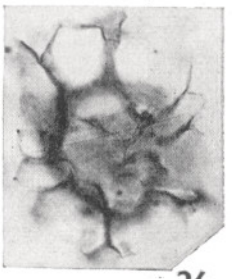
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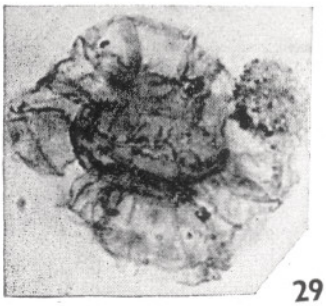
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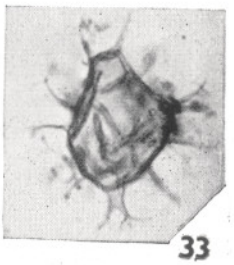
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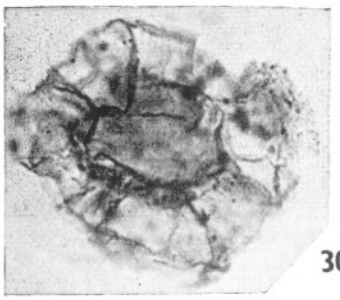
34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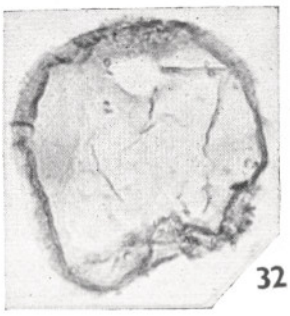
32

PLATE 3