ADDITIONAL DINOFLAGELLATES AND ACRITARCHS FROM GREY SHALE MEMBER OF DALMIAPURAM FORMATION, SOUTH INDIA

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ABSTRACT

The present communication is a continuation of two previous reports published by Jain and Subbaraman (1969) and Jain and Taugourdeau-Lantz (1973). Additional palaeophytoplankton taxa described from the present material, alongwith the known ones project a complete picture of dinoflagellate and acritarch assemblage from the Grey Shale Member of Dalmiapuram Formation, South India. Fluctuations in the environment of deposition within the exposed section have been indicated.

The present microplankton assemblage includes 38 genera and 59 distinct species, out of these 13 species are new. The Grey Shale Member has been assigned an Early Albian age.

INTRODUCTION

THE present palaeophytoplankton analysis is a continuation of the previous reports on the grey shale samples, made by Jain and Subbaraman (1969) and Jain and Taugourdeau-Lantz (1973), from the type section of Dalmiapuram Formation. It is based on fresh surface sample collections made from the type section during the field excursions of 1973 and 1976. Stratigraphically these samples underlie the sampling horizon of Jain and Subbaraman made in 1968. In previous reports only the grey shale samples were analysed as no other lithology was encountered with in the then exposed section of the grey shale. But the present study also includes the alternating bands of argillaceous limestone met within the Grey Shale Member of the Dalmiapuram Formation which represents the lower part of the section presently exposed.

The type section of Dalmiapuram Formation is located in the northern face of the Kallakkudi Limestone Quarry II near Kallakkudi on Trichinopoly-Vridhachalam road (Text-fig. 1).

Ramanathan and Rao (1965) for the first time recognized Grey Shale from the Kallakkudi Limestone Quarry II. Later, Subbaraman (1968) pointed out the presence of unconformities both at the top and the base of the grey shale. The underlying rocks are Upper Gondwana and Archeans and the overlying rock is Coral Reef Limestone. These unconformities have also been favoured by Bhatia and Jain (1969).

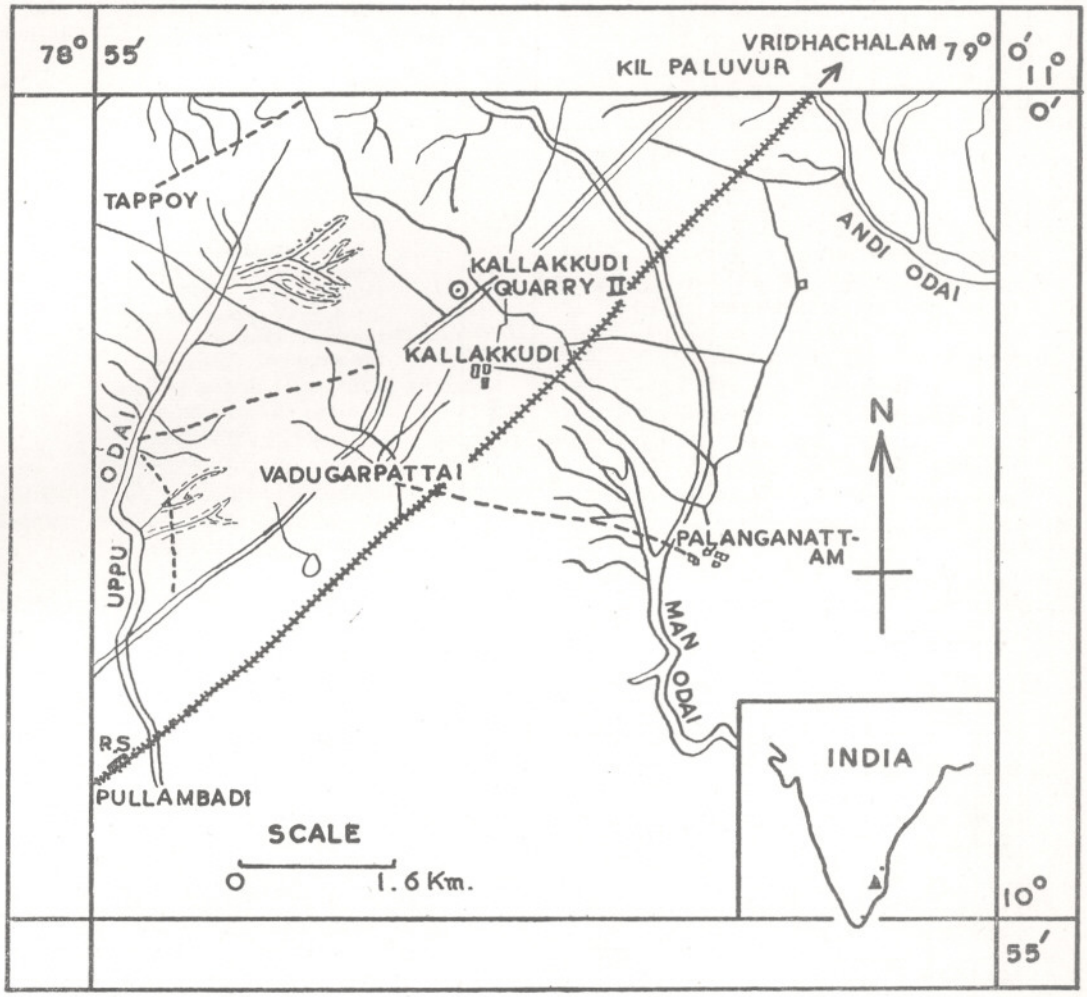
The rock stratigraphic name, Dalmiapuram Formation, was introduced by Bhatia and Jain (1969) with a single member "Grey Shale". Later, Banerji (1972) included within the same formation two members, viz., "Grey Shale" and "Limestone" (Table 1).

The recent collections made from kallakkudi Limestone Quarry II, a type section of Dalmiapuram Formation, show 3-4 alternating bands of argillaceous limestone (Text-fig. 2). The limestone is bluish grey, hard, compact, 30-60 cm thick and at places crystallised and shows thin layers of calcite within the limestone.

The thickness of grey shale in Cauvery Basin, around Dalmiapuram, based on surface and subsurface data ranges from 23-47 m. At the type section, however, it is 3 to 4 m thick and includes bands of argillaceous limestone (Text-fig. 2). Both the grey shale and the argillaceous limestone are highly fossiliferous but the flora and fauna have so far been described only from the grey shale, representing the upper part, which includes miospores, phytoplankton, Ostracodes, foraminifera and 'trace fossils' (Bhatia & Jain, 1969; Jain & Subbaraman, 1969; Jain & Taugourdeau-Lantz, 1973; Rao & Venkatachala, 1971; Jain, 1969; Banerji, 1972; and Chiplonker & Tapaswi, 1975).

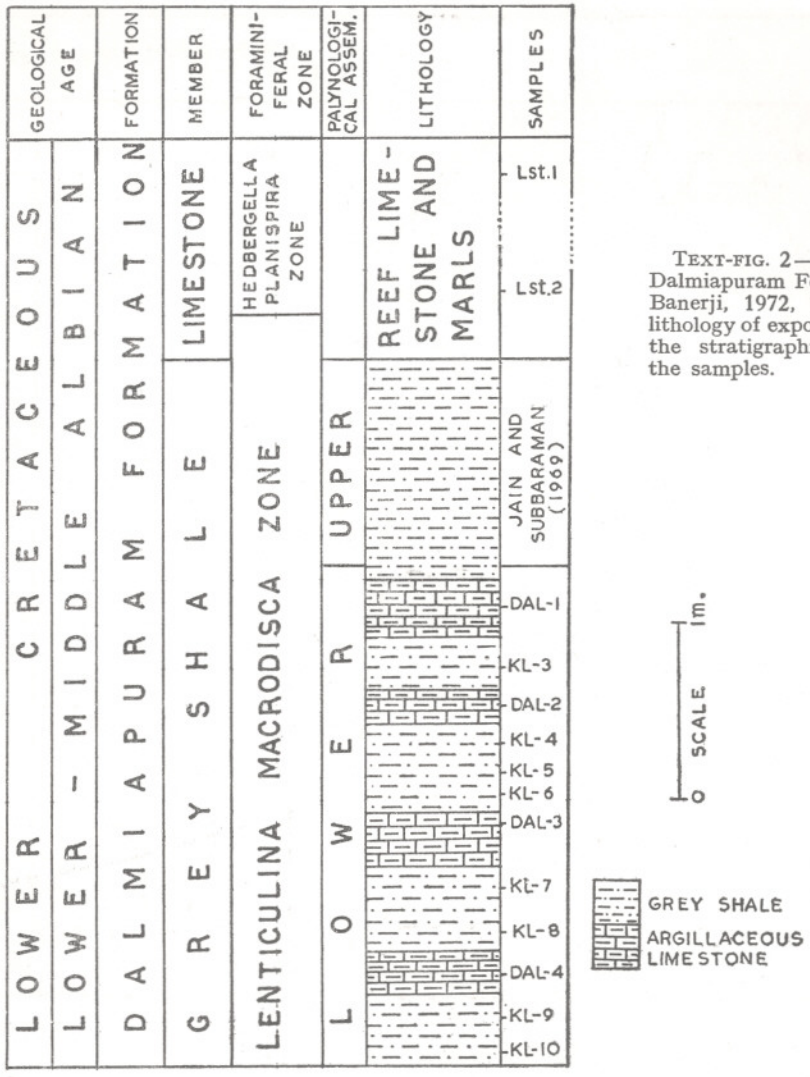
AGE OF GREY SHALE MEMBER

Since the discovery of Grey Shale in Cauvery Basin, its age has been debated. Ramanathan and Rao (1965, as cited in



TEXT-FIG. 1 — Map showing location of the type section.

Rao & Venkatachala, 1971) assigned a Neocomian-Albian age. They based their conclusions on microforaminifers. Subbaraman (1968) stratigraphically considered it to be pre-Uttatur. Jain and Subbaraman (1969) in a note pointed out an Aptian age, which on further work was extended to probably Aptian to Lower early Albian by Jain and Taugourdeau-Lantz (1973). These authors based their results on the study of dinoflagellates, spores and pollen grains. Bhatia and Jain (1969) worked out the ostracods and foraminifera, and stressed upon two Ostracod genera, viz., *Acrocythere* and *Pseudobythocythere* for considering the age of the member. *Pseudobythocythere* is restricted to Lower Albian of Germany whereas the other has a wide stratigraphic range from Hauterivian to Upper Albian. This led them to propose an Aptian-Albian (parts) age. Rao and Venkatachala (1971) considered Grey Shale to be Early Cretaceous in age and perhaps belonging to Early Albian. But in 1972, Venkatachala *et al.* gave a slightly different interpretation, stating that the palynoflora recovered from the grey shale of the Dalmiapuram Formation is closely comparable to the palynoflora of *Coptospora cauveriana* zone (Aptian-Lower Albian).



TEXT-FIG. 2 — Subdivision of Dalmiapuram Formation (after Banerji, 1972, 1973); showing lithology of exposed section and the stratigraphic position of the samples.

TABLE 1

BHATIA & JAIN (1969)	BANERJI (1972)
Coral Reef Limestone	Uttatur Formation
.....Unconformity.....	.....Unconformity.....
Grey Shale	Lime stone } Dalmiapuram Grey shale } Formation
.....Unconformity.....	.....Unconformity.....
Upper Gondwana or Archeans at places	Boulder beds (equivalent to Upper Gondwana) or Archean Crystallines at places.

Banerji (1972) described the planktonic foraminifera from the limestone, marls and shales and proposed two biostratigraphic zones (Text-fig. 2), viz. the Lower-*Lenticulina macrodisca* zone and the upper-*Hedbergella planispira* zone. A global comparison of these zone assemblages made him to conclude a Lower-Middle Albian age for the Dalmiapuram Formation. *Lenticulina macrodisca* zone includes, complete Grey Shale Member and in part Limestone (Coral Reef) (Text-fig. 2). The subdivisions of Dalmiapuram Formation proposed by Banerji are followed in the present text.

The type slides containing the holo- and paratypes are housed at the Museum, Birbal

Sahni Institute of Palaeobotany, Lucknow, India.

SYSTEMATIC PALYNOLOGY

Class — Dinophyceae Pascher
Subclass — Diniferophycidae Bergh
Order — Peridiniales Schütt
Family — Gonyaulacystaceae Sarjeant & Downie emend. Sarjeant & Downie

Genus — *Gonyaulacysta* Deflandre emend. Sarjeant
G. orthoceras (Eisenack) Sarjeant
G. episoma Sarjeant
G. helicoidea (Eisenack & Cookson) Sarjeant
G. aichmetes Sarjeant
Genus — *Occisucysta* Gitmez
O. crestata sp. nov.
O. sp. A
Family — Apteodiniaceae Eisenack emend. Sarjeant & Downie
Genus — *Apteodinium* Eisenack
A. sp. A
Genus — *Trichodinium* Eisenack & Cookson
T. magnus sp. nov.
T. castanea (Deflandre) Clarke & Verdier
Family — Fromeaceae Sarjeant & Downie emend. Sarjeant & Downie
Genus — *Fromea* Cookson & Eisenack
F. microgranulosa sp. nov.
F. amphora Cookson & Eisenack
F. sp. A
Family — Spiniferitaceae Sarjeant emend. Sarjeant & Downie
Genus — *Spiniferites* Mantell emend. Sarjeant
S. ramosus subsp. *endoperforatus* (Corradini) stat. nov.
S. ramosus subsp. *granomembranaceus* (Davey & Williams) Lentin & Williams
S. ramosus subsp. *ramosus* (Ehrenberg) Lentin & Williams
S. ramosus subsp. *granosus* (Davey & Williams) Lentin & Williams
S. crassipellis (Deflandre & Cookson) Sarjeant
S. cingulatus subsp. *cingulatus* (Wetzel) Lentin & Williams
Genus — *Hystrichodinium* Deflandre emend. Clarke & Verdier
H. pulchrum Deflandre
Genus — *Kleithriasphaeridium* Davey
K. simplicispinum (Davey & Williams) Davey
Genus — *Florentina* Davey & Verdier
F. mantelli (Davey & Williams) Davey & Verdier
Genus — *Pterodinium* Eisenack
P. eisenacki sp. nov.
Family — Canningiaceae Sarjeant & Downie emend. Sarjeant & Downie
Genus — *Canningia* Cookson & Eisenack
C. microciliata sp. nov.
Genus — *Tenua* Eisenack
T. anaphrissa (Sarjeant) Benedek
T. hystrix Eisenack
T. hystricella Eisenack
Genus — *Necrobroomea* Wiggins
N. jaegeri (Alberti) Wiggins
Family — Hexagoniferaceae Sarjeant & Downie emend. Sarjeant & Downie
Genus — *Hexagonifera* Cookson & Eisenack
H. chlamydata Cookson & Eisenack
H. scabrata Jain & Taugourdeau-Lantz
Genus — *Senoniasphaera* Clarke & Verdier
S. sp. A
Genus — *Ovoidinium* Davey
O. indicum Jain & Taugourdeau-Lantz
Family — Muderongiaceae Neale & Sarjeant emend. Sarjeant & Downie
Genus — *Muderongia* Cookson & Eisenack
M. tetracantha (Gocht) Alberti
Family — Membranilarnaciaceae Eisenack emend. Sarjeant & Downie
Genus — *Valensiella* Eisenack
V. punctata sp. nov.
Family — Hystrichosphaeridiaceae Evitt emend. Sarjeant & Downie
Genus — *Hystrichosphaeridium* Deflandre emend. Davey & Williams
H. stellatum Maier
H. tubiferum subsp. *brevispinum* (Davey & Williams) Lentin & Williams
Genus — *Oligosphaeridium* Davey & Williams
O. poculum sp. nov.
O. perforatum sp. nov.
O. complex (White) Davey & Williams
O. complex subsp. *brevispinum* nov.
O. reniforme (Tasch) Davey & Williams

O. pulcherrimum (Deflandre & Cookson) Davey & Williams

Genus — *Surculosphaeridium* Davey *et al.*
S. granulosum sp. nov.
S. divarispinosum sp. nov.
S. cribrotubiferum subsp. *granulosum* nov.
S. vestitum (Deflandre) Davey *et al.*
S. longifurcatum (Firtion) Davey *et al.*

Genus — *Tanyosphaeridium* Davey & Williams
T. isocalamus (Deflandre & Cookson) Davey & Williams

Family — Exochosphaeridiaceae Sarjeant & Downie

Genus — *Exochosphaeridium* Davey *et al.*
E. indicum Jain & Taugourdeau-Lantz
E. phragmites Davey *et al.*
E. sp. A

Family — Homotrybliaceae Sarjeant & Downie emend. Sarjeant & Downie

Genus — *Callaiosphaeridium* Davey & Williams
C. asymmetricum (Deflandre & Courteville) Davey & Williams

Family — Systematophoraceae Sarjeant & Downie

Genus — *Coronifera* Cookson & Eisenack emend. Davey
C. oceanica Cookson & Eisenack
C. albertii Millioud
C. sp. A
C. sp. B

Genus — *Prolixosphaeridium* Davey *et al.*
P. deirense Davey *et al.*
P. elongatum sp. nov.
P. sp. cf. *P. granulosum* (Deflandre) Davey *et al.*

Family — Endoscriniaceae vozzh. Sarjeant & Downie

Genus — *Scriniodinium* Klement
?*S.* sp. A

Family — Cleistosphaeridiaceae Sarjeant & Downie

Genus — *Cleistosphaeridium* Davey *et al.*
C. polypes (Cookson & Eisenack) Davey

Family — Cannosphaeropsitaceae Sarjeant & Downie

Genus — *Cannosphaeropsis* Wetzel emend. Williams & Downie
C. peridictya Eisenack & Cookson

Genus — *Dictyopyxidia* Eisenack
D. punctata sp. nov.
D. imperfecta Brideaux & McIntyre

Family — Pseudoceratiaceae Eisenack emend. Sarjeant & Downie

Genus — *Odontochitina* Deflandre emend. Davey
O. cribropoda Deflandre & Cookson
O. operculata (Wetzel) Deflandre
O. sp. cf. *O. operculata* (Wetzel) Deflandre

Family — Areoligeraceae Evitt emend. Sarjeant & Downie

Genus — *Cyclonephelium* Deflandre & Cookson emend. Cookson & Eisenack
C. distinctum Deflandre & Cookson

Family — Uncertain

Genus — *Cassiculosphaeridia* Davey
C. reticulata Davey

Genus — *Astrocysta* Davey
A. cretacea Pocock ex Davey
?*A.* sp. A

Genus — *Heterosphaeridium* Cookson & Eisenack
H. sp. A

Genus — *Cyclopsiella* Drugg & Loeblich
C. ornamenta sp. nov.

Group — Acritarcha Evitt, 1963

Subgroup — Polygonomorphitae Downie *et al.*

Genus — *Veryhachium* Deunff emend. Downie & Sarjeant
V. sp. A
V. sp. B

Subgroup — Pteromorphitae Downie *et al.*

Genus — *Pterospermopsis* Wetzel
P. sp. A

DESCRIPTION

Genus — *Gonyaulacysta* Deflandre ex Norris & Sarjeant emend. Sarjeant, 1969

G. orthoceras (Eisenack) Sarjeant, 1966

Pl. 6, fig. 69

1973 — *G.* sp. cf. *G. orthoceras* (Eisenack) Sarjeant, in Jain & Taugourdeau-Lantz, p. 62; pl. 4, fig. 5.

1973 — *G.* sp. in Jain & Taugourdeau-Lantz, p. 62, pl. 4, fig. 4.

Remarks — *G. orthoceras* is a long ranging species from Valanginian to Turonian (see Singh, 1971).

Gonyaulacysta episoma Sarjeant, 1966

Pl. 6, fig. 68

Geologic & Geographic Distribution—Late Barremian to Albian (see Singh, 1971, p. 305); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Occisucysta* Gitmez, 1970

Remarks — Genus *Occisucysta* is known from Jurassic sediments (Gitmez, 1970). Its extension in younger sediments is seen in Albian of Senegal Basin (Jain & Millepied, 1975). They have described a single specimen as *Gonyaulacysta* sp. A. (pl. 2, figs. 21-22) which has an archaeopyle unlike of *Gonyaulacysta* and appears to be a combination of two plates as described for *Occisucysta.*

Occisucysta crestata sp. nov.

Pl. 5, figs. 63-65

Holotype — Pl. 5, figs. 63-65; Slide no. 5071-3.

Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.

Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.

Diagnosis — Cyst subspherical, sutural crest well-developed, made up of uniform processes, distally bifid and connected forming regular elevation, distal connection giving rise to lateral pseudoperforations; margin irregular to dentate. Apical horn not seen except high apical crest. Periphragm vermiculate. Tabulation that of the genus but not seen in holotype. Cingulum laevo-rotatory, sulcus distinct, only slightly extends towards epitract. Archaeopyle precingular (2″+3″).

Measurement	*Holotype*	*Range*
Cyst diameter	78 μm	60-80 μm
Central body diameter	65 μm	60-70 μm
Crest height	6 μm	3-6 μm
Apical Crest height	12 μm	6-12 μm

Comparison — *P. crestata* sp. nov. differs from the known species of the genus in having irregularly perforate sutural crest with vermiculate periphragm.

Remarks — Genus *Occisucysta* is characterized by its strong apical horn, but the present forms lack this feature. Presence or absence of an apical horn in this genus seems to be variable.

Occisucysta sp. A

Pl. 5, figs. 59-60

Description — Cysts subspherical, tabulation indeterminable; apical horn not seen, cingulum helicoid. Periphragm covered with spines and coni, endophragm smooth. Archaeopyle precingular, made up of two precingular plates (2″+3″).

Remarks — Only a single specimen of this type has been recovered.

Genus — *Apteodinium* Eisenack, 1958

Apteodinium sp. A

Pl. 5, fig. 58

Description — Cyst broadly pentagonal, dorsoventrally compressed, distorted. Apical horn well-developed with rounded apex; cingulum circular, distinct; body wall reticulate, ridges low. Archaeopyle precingular.

Remarks — The present specimen resembles best with *A. reticulatum* Singh (1971) in having reticulate body wall ornamentation but differs in its distinct cingulum and absence of any process on the apical horn tip. Only a single specimen has been recovered from the limestone band of the Grey Shale Member.

Genus— *Trichodinium* Eisenack & Cookson

Trichodinium magnus sp. nov.

Pl. 4, figs. 40-42

1973 — *Gonyaulacysta serrata* Cookson & Eisenack, in Jain & Taugourdeau-Lantz, p. 62, pl. 2, figs, 14-15.

1974 — *Trichodinium* sp., in Davey & Verdier, p. 640, pl. 92, fig. 7.

Holotype — Pl. 4, figs. 41-42; Slide no. 5049-17.

Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.

Horizon — Grey Shale Member, Dalmiapuram, Formation; Early Albian.

Diagnosis — Cyst oval, covered with sparsely placed processes, processes broader proximally, narrower distally, distal end peltate, closed. Transverse and longitudinal furrows distinct in holotype specimen. Archaeopyle precingular, broadly triangular. Apical horn rarely seen; tabulation indistinct (Oa, 5-6″, ?c, 5-6″; 1p, 1‴, 3-4S).

Measurements	*Holotype*	*Range*
Cyst size with processes	60×60 μm	60-70×60-85 μm
Length of processes	4·8 μm	3-5 μm
Width of archaeopyle	3 μm	3-5 μm

Comparison — *Trichodinium magnus* sp. nov. is characterized in having well-developed processes and indication of tabulation. The known species of the genus, viz., *T. castanea* (Deflandre) Clarke & Verdier, *T. hirsutum* Cookson, *T. paucispinum* Eisenack & Cookson and *T. pellitum* Eisenack & Cookson differ mainly in the absence of processes.

Remarks — The stratigraphic distribution of *Trichodinium* ranges from Upper Hauterivian to Palaeocene. Recently Cookson and Eisenack (1974) have reported it from Pebble Point Formation, S. W. Victoria, Australia.

Trichodinium castanea (Deflandre) Clarke & Verdier, 1967

Pl. 4, fig. 43

Geologic & Geographic Distribution — Upper Hauterivian to Senonian (for details see Clarke & Verdier, 1967, p. 20).

Genus — *Fromea* Cookson & Eisenack, 1958

Fromea microgranulosa sp. nov.

Pl. 6, fig. 74

Holotype — Pl. 6, fig. 74; Slide no. 5053-38.

Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.

Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.

Diagnosis — Shell spherical, surface ornamentation densely microgranulose, variously folded, mostly forming convolutions. Archaeopyle apical.

Measurements	*Holotype*	*Range*
Shell diameter	60 μm	45-70 μm

Comparison — *F. microgranulosa* sp. nov. differs from rest of the species of the genus in its surface ornamentation and constant convoluted foldings.

Fromea amphora Cookson & Eisenack, 1958

Pl. 3, fig. 26

Geologic & Geographic Distribution — Barremian, England (Davey, 1974); Aptian-Cenomanian, Australia (Cookson & Eisenack, 1958); Upper Barremian, Germany (Alberti, 1961); Albian, Canada (Singh, 1971); Upper Barremian (Middle part), England (Sarjeant, 1966); Albian, Rumania (Baltes, 1967); Early Albian, Dalmiapuram Formation, South India (Present study).

Fromea sp. A

Pl. 3, fig. 27

Description — Cyst oblong, thin-walled, longer than broad, 70×60 μm in size, surface with many folds, smooth; archaeopyle apical, broad. Cingulum faintly seen.

Remarks — In its size range, the present specimen falls within the specific circumscription of *F. amphora* but differs in having very thin cyst wall. *Fromea* sp. A resembles best with the Australian ?Albian-Aptian *Palaeostomocystis fragilis* Cookson & Eisenack (1962) in having folded, crumpled wall and broad unrimmed aperture. But differs in having cingulum indication.

Genus — *Spiniferites* Mantell emend. Sarjeant, 1970

Spiniferites ramosus subsp. *endoperforatus* (Corradini) stat. nov.

Pl. 3, fig. 37

Remarks — The present specimens of *S. ramosus* subsp. *endoperforatus* as well as

those photographed by Corradini (1972, pl. 26, figs. 9-10) show a very close resemblance with *S. ramosus* var. *reticulatus* (Davey & Williams) Davey & Verdier in their superficial appearance. But the latter differs in having ornamentated periphragm and smooth endophragm.

Geologic & Geographic Distribution — Maestrichtian, Italy (Corradini, 1972); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

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

Geologic & Geographic Distribution — London Clay, Eocene, England (Davey & Williams, 1966); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Remarks — *S. ramosus* subsp. *granomembranaceus* compares best with *S. scabrosa* Clarke & Verdier (1967) in having similar granulose ornamentation on the central body surface but the latter differs in not having well-developed membrane on plate boundaries particularly along the cingular or polar regions.

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

Geologic & Geographic Distribution — Middle Barremian to Ypresian (Davey & Williams,1966, p. 34); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

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

Geologic & Geographic Distribution — Eocene, London Clay (Davey & Williams, 1966); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Spiniferites crassipellis (Deflandre & Cookson) Sarjeant, 1970

Pl. 3, fig. 38

Geologic & Geographic Distribution — Lower Eocene, Australia (Deflandre & Cookson, 1954, 1955); Cenomanian, England (Davey & Williams, 1966); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Spiniferites cingulatus subsp. *cingulatus* (Wetzel) Lentin & Williams , 1973

Pl. 6, figs. 70-71

Geologic & Geographic Distribution — Albian to Pleistocene (see Davey & Verdier, 1971, p. 32); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Hystrichodinium* Deflandre emend. Clarke & Verdier, 1967

Hystrichodinium pulchrum Deflandre, 1935

Pl. 3, fig. 28

Description — Cyst ovoidal, thin-walled, covered with long, thread like processes. Cingulum divides central body into epi- and hypo-tract. Processes simple, distally closed. Archaeopyle precingular.

Measurements

Size of central body 65×57 μm
Lenght of processes upto 35 μm

Geologic & Geographic Distribution — Valanginian to Senonian (For details see Clarke & Verdier, 1967, p. 39); Barremian, England (Davey, 1974); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Kleithriasphaeridium* Davey, 1974

Kleithriasphaeridium simplicispinum (Davey & Williams) Davey, 1974

Pl. 2, figs. 12-13

Description — Central body spherical, two layered; periphragm smooth, covered with well-developed processes. Reflected tabulation that of the genus. Processes tubiform, slightly spongy and striated, distally open, margin serrate, circular, proximally broad, endophragm locally thickened granulate beneath processes. Sulcul pro-

cesses 4-5. Archaeopyle precingular, margin slightly zig-zag.

Measurements	*Range*
Diameter of central body	40-60 μm
Length of processes	25-30 μm

Geologic & Geographic Distribution — Aptian, Germany (Gocht, 1959), Middle Barremian, Speeton Clay, England (Davey & Williams, 1966; Davey, 1974); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Florentina* Davey & Verdier, 1973

Florentina mantelli (Davey & Williams) Davey & Verdier, 1973

Pl. 2, figs. 14-15

Remarks — The nature of archaeopyle seen in the present specimens is tearing between the apical and precingular plates. The processes do not bifurcate.

Geologic & Geographic Distribution — Lowest Campanian or possibly Santonian, Australia (Cookson & Eisenack, 1968); Cenomanian to Turonian, England, France (Davey & Williams, 1966; Davey, 1969); Barremian, England (Davey, 1974); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Pterodinium* Eisenack, 1958

Pterodinium eisenacki sp. nov.

Pl. 6, fig. 73

1962 — *Pterodinium cornutum* Cookson & Eisenack, p. 490, pl. 3, figs 5-6

Holotype — Pl. 6, fig. 73; Slide no. 5053-37.

Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.

Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.

Diagnosis — Cyst oval in shape; endophragm thick, periphragm hyaline. Apical horn short. Cingulum distinct, helicoid. Tabulation based on present specimens ?2-4, 6″, 4-5c, 6‴, 1⁗. Borders of fields high, strongly serrate. Archaeopyle not observed.

Measurements	*Holotype*	*Range*
Cyst size	60×54 μm	55-65×50-60 μm
Width of cingulum	2·4 μm	2-3 μm

Comparison — *P. eisenacki* sp. nov. differs from *P. aliferum* Eisenack (1958); *P. magnoserratum* Cookson & Eisenack (1962) and *P. cornutum* Cookson & Eisenack (1962) in its distinct tabulation with 5 cingular plates.

Remarks — The Australian forms described by Cookson and Eisenack (1962, p. 490, pl. 3, figs. 5-6) come from of ?Aptian-Albian horizon.

Genus — *Canningia* Cookson & Eisenack, 1960

Canningia microciliata sp. nov.

Pl. 3, fig. 25; Pl. 6, fig. 78

Holotype — Pl. 3, fig. 25; Slide no. 5049-25.

Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.

Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.

Diagnosis — Cyst oblong, no apical or antapical horn seen. Periphragm densely ornamented with fine cilia having bulbous base giving it coarsely granulate appearance. Cingulum absent. Archaeopyle apical, margin angular.

Measurements	*Holotype*	*Range*
Cyst size	60×56 μm	60-70×50-70 μm

Comparison — *C. microciliata* sp. nov. differs from rest of the species in having ciliate periphragm.

Genus — *Tenua* Eisenack emend. Sarjeant, 1968

Tenua anaphrissa (Sarjeant) Benedek, 1972

Pl. 3, fig. 36

1974 — *Doidyx anaphrissa* Sarjeant, in Davey, p. 50.

Geologic & Geographic Distribution — Lower Barremian, Speeton Clay, England (Sarjeant, 1966; Davey, 1974); Lower-?Upper Aptian, Senegal Basin (Jain & Millepied, 1975); Early Albian, Dalmiapuram Formation, South India (Present study).

Remarks — Dalmiapuram specimens of *T. anaphrissa* are smaller in size than holotype and possess one or two broader than long processes (7×3 μm in size). Asymmetry is also less pronounced. The taxonomic status of this species is controversial. Harker and Sarjeant (1975, p. 224) maintain *Doidyx anaphrissa*.

Tenua hystrix Eisenack, 1958

Pl. 6, fig. 75

Geologic & Geographic Distribution — Aptian, Germany (Eisenack, 1958); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Necrobroomea* Wiggins, 1975

Necrobroomea jaegeri (Alberti) Wiggins, 1975

Pl. 4, fig. 53

1971 — *Pseudoceratium gochtii*, in Rao & Venkatachala, pl. 2, fig. 17

Remarks — Only a single specimen of *N. jaegeri* (*"Broomea" micropoda* = *"B" jaegeri* in Davey, 1974, p. 71) has been recovered from the Grey Shale Member. The occurrence of a single form in a rich dinoflagellate assemblage, like this, creates doubt to accept it as a constituent of the present flora. It appears to be a recycled form from the marine Lower Cretaceous sediments probably Barremian, though the occurrence of this species in European Albian sediments is not unknown. If it is accepted as a constituent of the flora then it would represent the dwindling phase of the species in Early Albian in India.

Geologic & Geographic Distribution —Upper Hauterivian to Campanian, Germany, France, Canada, England (For detail see Brideaux & McIntyre, 1975, p. 24); Lower Cretaceous, Godavari Basin, Andhra Pradesh, India (Rao & Venkatachala, 1971).

Genus — *Hexagonifera* Cookson & Eisenack emend. Cookson & Eisenack, 1962

Hexagonifera chlamydata Cookson & Eisenack, 1962

Pl. 4, fig. 47

Geologic & Geographic Distribution — Albian-Cenomanian, Australia (Cookson & Eisenack, 1962); Middle Cretaceous, Australia (Cookson & Eisenack, 1974); Albian, Rumania (Baltes, 1966, 1967); Upper Albian to Santonian, England (Cookson & Hughes, 1964; Clarke & Verdier, 1967); Santonian, The Great Banks, Atlantic Continental margin (Williams & Brideaux, 1975).

Hexasphaera scabrata Jain & Taugourdeau-Lantz, 1973

Pl. 4, figs. 45-46

Remarks — The detached operculum in Pl. 4, fig. 46 shows that the hexagonal margin of the archaeopyle is variable (Hexa to heptagonal).

Genus — *Senoniasphaera* Clarke & Verdier, 1967

Senoniasphaera sp. A

Pl. 5, fig. 61

Description — Cyst double layered; periphragm spongy, punctate, loosely surround microgranulate endophragm. No specimen shows attached operculum, antapical horns indistinctly seen. Cingulum distinct, tabulation developed, indeterminable, formed by wrinkling of periphragm. Archaeopyle apical, margin angular.

Remarks — Only a few specimens from limestone band (Dal-2) of the Grey Shale Member has been recovered. Present forms resemble best with the Albian ones described by Davey and Verdier (1971, pp. 31-32, pl. 6, figs. 7-9) from Paris Basin, France.

Since *Senoniasphaera* is mainly known from Upper Cretaceous, its presence in Albian of France (Davey & Verdier, 1971) as derived from older sediments does not fit in well. The genus has been recently reported from Langton Bay Formation, uppermost part of the Crossley lakes member, Horton River Formation (Lower and Middle Albian) by Brideaux and McIntyre (1975). The occurrence of *Senoniasphaera* in Albian appears to be quite humble with quantitatively less representation. Its presence in Grey Shale Member (Present study) has stratigraphic significance.

Genus — *Muderongia* Cookson & Eisenack, 1958

Muderongia tetracantha (Gocht) Alberti, 1961

Pl. 5, fig. 57

Geologic & Geographic Distribution — Hauterivian, Germany (Gocht, 1957); Upper Hauterivian to Lower Barremian, Germany and Poland (Alberti, 1961); Lower Barremian, Speeton Clay, London (Sarjeant, 1966; Davey, 1974) ;Aptian, Canadian Arctic (Brideaux, 1975).

Remarks — The single specimen recovered from sample no. Kl—6 of grey shale is characterized by a distinct central body and notched lateral horns, with granular periphragm and slightly asymmetrically placed antapical horn.

Davey (1974, p. 66) opined that the Upper Barremian marks the end of *Muderongia* era. Its occurrence in younger sediments has been recorded by several authors. Recently Brideaux and McIntyre (1975, p. 34) have assigned a single specimen (fig. 5) to *Muderongia tetracantha* from Gilmore Lake Member of Lanton Bay Formation (Upper Aptian). Previously it was recorded from Aptian of Australia (Cookson & Eisenack, 1958).

The rare occurrence of *Muderongia* in the rich dinoflagellate assemblages from present Grey Shale member and Gilmore Lake Member, Canada, creates the only doubt to accept it as a constituent of these assemblages otherwise there is no other ground to recognize these forms as recycled. The quantitative paucity of this genus in the Post Barremian sediments (Aptian-Early Albian) might suggest the fading phase of *Muderongia*. More information is required to establish the upper age limit of *Muderongia*.

In Cauvery Basin, South India, there is every possibility of recycling, which can be supported from the fact that there are well developed marine Lower Cretaceous deposits having ammonite fauna (Mamgain *et al.*, 1973) equivalent to Raghavapuram, Vemavaram and Budavada beds of Godavary Basin. Robinson (1967) dated the latter three beds as Lower Cretaceous (Barremian) in age.

If this contention of Barremian recycling in Early Albian is accepted, then the occurrence of a single *Muderongia* specimen in grey shale becomes meaningful; on one hand it supports the Barremian extinction of the genus while on the other, strengthens the Barremian age for the East Coast Upper Gondwana plant beds. To confirm this view it is necessary to analyse the ammonite bearing sediments of Uttatur and other plant beds in Cauvery and Godavary basins, for their dinoflagellate constituents.

Genus — *Valensiella* Eisenack, 1963

Valensiella punctata sp. nov.

Pl. 4, fig. 44

Holotype — Pl, 4, fig. 44; Slide no. 5059-1

Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.

Horizon — Grey Shale Member, Dalmiapuram Formation; Lower Albian.

Diagnosis — Cyst ellipsoidal, covered with thick crest system forming irregular polygons on shell surface, crests distally appear like branching processes. Central body with crests surrounded by a thin, punctate membrane. Archaeopyle apical, seen in some specimens.

Measurements	*Holotype*	*Range*
Cyst size	74×54 μm	65-90×50-70 μm
Crest height	10 μm	10-20 μm

Comparison — *V. punctata* sp. nov. compares best with *V. ovulum* (Deflandre) Eisenack (1963) in general morphological features but differs in its punctate outer membrane. Formation of irregular polygons differentiates them from *Membranilarnacia* Eisenack, 1963.

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

Hystrichosphaeridium stellatum Maier, 1959

Geologic & Geographic Distribution — Hauterivian to Miocene (For details see Clarke & Verdier, 1967, p. 55).

Remarks — *H. stellatum* has been commonly described from Albian-Cenomanian sediments (Baltes, 1965; Cookson & Eisenack, 1962; Cookson & Hughes, 1964).

Hystrichosphaeridium tubiferum subsp. *brevispinum* (Davey & Williams, 1973) Lentin & Williams, 1973

Pl. 1, fig. 10

Measurements	*Range*
Central body diameter	50-60 μm
Processes length	12-15 μm
Processes width	9-18 μm

Geologic & Geographic Distribution — Eocene, London Clay, Berkshire (Davey & Williams, 1966); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Oligosphaeridium* Davey & Williams, 1966

Oligosphaeridium poculum sp. nov.

Pl. 1, figs. 1-3

Holotype — Pl. 1, fig. 3; Slide no. 5064-4.
Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.
Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.
Diagnosis — Cyst spherical, double-walled; periphragm covered with vase or cup shaped processes with narrow proximal and wider distal end, distally open, with recurved or denticulate margin. Proximal contact with periphragm form thick ring at the base; distinct hole seen when viewed through tube. Tabulation typical of the genus. Archaeopyle apical.

Measurements	*Holotype*	*Range*
Cyst diameter without processes	80 μm	50-80 μm
Process height	6 μm	6-10 μm
Process distal width	upto 24 μm	8-24 μm
Process proximal width	upto 16 μm	6-16 μm

Comparison — *O. poculum* sp. nov. is characterized by its typical vase or cup shaped processes without stem. It can only be compared with *O. albertense* (Pocock) Davey & Williams (1966) in having a few distally broad processes with very small stem.

Polystephanephorus sp. cf. *P. urnaformis* (Cookson) Sarjeant described by Singh (1971, p. 341, pl. 57, figs. 1-2) and *P. urnaformis* (Cookson) Sarjeant by Pocock (in Press, pl. 1, fig. 5) from Albian of Canada appear to be synonymous. The specimens need critical re-examination.

Oligosphaeridium perforatum sp. nov.

Pl. 1, figs. 5-7

Holotype — Pl. 1, fig. 5; Slide no. 5053-30.
Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.
Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.
Diagnosis — Cyst subspherical to elongate, double walled, periphragm smooth to granular, gives rise to 18 processes, 4 apical (mostly not seen, separated with operculum), 6 precingular, 6 post cingular, one antapical and one posterior intercalary. Process stem short or absent. In processes with stem distal widening starts half way, in stemless it starts just from the surface. Processes thick at the proximal contact with periphragm giving rise to a basal ring like structure, distally perforate, branched, distal rim spinose and discontinuous; antapical process mostly stemless. Archaeopyle apical.

Measurements	*Holotype*	*Range*
Diameter of cyst	70 μm	30-70 μm
Length of process	26 μm	18-30 μm

Comparison — *O. perforatum* sp. nov. compares best with *O. pulcherrimum* in having distally perforate processes. Former differs in having very short processes with and without stem. *O. poculum* sp. nov. differs in having only vase or cup shaped stemless processes.

Oligosphaeridium complex (White) Davey & Williams, 1966

Pl. 1, fig. 8

1971 — *Hystrichosphaeridium* sp., in Rao & Venkatachala, pl. 2, fig. 13.
1973 — *Oligosphaeridium complex* (White) Davey & Williams, in Jain & Taugourdeau-Lantz, p. 61, pl. 3, figs. 1-2. (For detailed synonymy see Davey & Williams, 1966).

Geologic & Geographic Distribution — Valanginian to Early Eocene (For details see Singh, 1971, p. 334 and Davey & Verdier, 1971, p. 26).

Oligosphaeridium complex subsp. *brevispinum* nov.

Pl. 1, fig. 4

1971 — *Oligosphaeridium* sp., in Singh, p. 340, pl. 56, fig. 6.
1973 — *Oligosphaeridium albertense* (Pocock) Davey & Williams, in Jain & Taugourdeau-Lantz, p. 64, pl. 3, fig. 3.

Description — See Singh (1971, p. 340)

Measurements

Diameter of central body	42 μm
Length of processes	18-20 μm
Width of processes	3 μm

Geologic & Geographic Distribution — Late Albian, Lower Shaftesbury Formation of the Peace River area, Canada (Singh, 1971); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Oligosphaeridium reniforme (Tasch) Davey & Williams, 1966

Pl. 1, fig. 9

Remarks — Present forms assigned to *O. reniforme* are larger in overall size range. It extends the diameter of the cyst upto 66 μm and length of the processes 42 μm.

Geologic & Geographic Distribution — Albian-Cenomanian, Canada (Davey, 1969); Lower Cretaceous, U. S. A. (Tasch., *et al.*, 1964); Lower Albian, Grey Shale Member, Dalmiapuram Formation, South India. (Present study).

Oligosphaeridium pulcherrimum (Deflandre & Cookson) Davey & Williams, 1966

Remarks — Dalmiapuram grey shale forms possess distinct longitudinal striations along the process length arising from the surface contact. In other features it is similar to *O. pulcherrimum*. Variability in length and breadth of processes is quite pronounced.

Geologic & Geographic Distribution — Lower Cretaceous, Australia (Deflandre & Cookson, 1955); Cretaceous, France (Valensi, 1955); Eocene, England (Davey & Williams, 1966); Cenomanian to Coniacian, England (Clarke & Verdier, 1967); "Wealden" of Belgium (Delcourt & Sprumont, 1959); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Surculosphaeridium* Davey *et al.*, 1966

Surculosphaeridium granulosum sp. nov.

Pl. 2, fig. 17

Holotype — Pl. 2, fig. 17; Slide no. 5048-5.

Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.

Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.

Diagnosis — Cyst spherical, double-walled, endophragm smooth, periphragm granulose giving rise to solid, deeply branched, distally closed processes; reflected tabulation 4′, 6″, 6c, 6‴, lp, 3‴″, 4-5S. Cingular processes deeply furcate or completely divided into two. Archaeopyle apical, formed by complete detachment of apical part having four processes, margin angular. Some processes possess perforations along the proximal end.

Measurements	*Holotype*	*Range*
Diameter of central body	51 μm	40-60 μm
Length of processes	26 μm	upto 30 μm

Comparison — *S. granulosum* sp. nov. is characterized by the presence of deeply branched, proximally perforate processes, granulose periphragm and 4-5 sulcal processes. It resembles *S. cribrotubiferum* (Sarjeant) Davey *et al.* (1966), *S. vestitum* (Deflandre) Davey *et al.* (1966) and *S. longifurcatum* (Firtion) Davey *et al.* (1966) in having deeply branched processes but differs mainly in having distinctly granulose periphragm with 4-5 sulcal processes.

Remarks — Some post cingular processes in the present material show proximal connection with each other. This suggests comparison with the genus *Systematophora* Klement (1960) but is separated due to

lack of regular occurrence of circular to polygonal fields.

Surculosphaeridium divarispinosum sp. nov.

Pl. 6, fig. 77

Holotype — Pl. 6, fig. 77; Slide no. 5053-35.
Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.
Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.
Diagnosis — Cyst subspherical, central body surface microgranulose, covered with two types of distally closed processes, one thin, delicate, other stout, well-developed, distally bifurcate, trifurcate, deeply branched, some stout processes proximally disconnected leaving space in between. Tabulation that of genus. Archaeopyle apical.

Measurements	*Holotype*	*Range*
Cyst diameter	40 μm	35-50 μm
Length of process	upto 21 μm	upto 30 μm

Comparison — *S. divarispinosum* sp. nov. differs from *S. cribrotubiferum* (Sarjeant) Davey *et al.*, *S. vestitum* (Deflandre) Davey *et al.* and *S. longifurcatum* (Firtion) Davey *et al.* in having two distinct types of processes and microgranulate periphragm. The process endings and branching in all the above mentioned species are variable and so is the case in the present species.

Surculosphaeridium cribrotubiferum (Sarjeant) Davey *et al.*, 1966 subsp. *granulosum* nov.

Pl. 6, fig. 76

Description — Central body subspherical, periphragm coarsely granulate, covered with long, perforate, variously branched processes, some are deeply branched giving an appearance of 4-5 processes per plate. Archaeopyle apical, margin deeply notched.

Measurements

Central body diameter	42 μm
Length of processes	upto 24 μm

Comparison — Present forms differ from *S. cribrotubiferum* (Sarjeant) Davey *et al.* in having granular periphragm and deeply notched archaeopyle margin.

Surculosphaeridium vestitum (Deflandre) Davey *et al.*, 1966

Geologic & Geographic Distribution— Upper Jurassic (Davey *et al.*, 1966); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Surculosphaeridium longifurcatum (Firtion) Davey *et al.*,1966

Pl. 2, fig. 16

Geologic & Geographic Distribution — Lower Cenomanian, France (Firtion, 1952); Lower Cenomanian, England (Davey *et al.*, 1966); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Tanyosphaeridium* Davey & Williams, 1966

Tanyosphaeridium isocalamus (Deflandre & Cookson) Davey & Williams, 1969

Geologic & Geographic Distribution— Lower Cretaceous, Australia (Deflandre & Cookson, 1955); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Exochosphaeridium* Davey *et al.*, 1966

Exochosphaeridium phragmites Davey *et al.*, 1966

Pl. 5, fig. 66

Geologic & Geographic Distribution — Cenomanian, England and France (Davey *et al.*, 1966; Davey, 1969); Albian, England & France (Davey, 1969); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Exochosphaeridium sp. A

Pl. 2, fig. 22

Description — Central body spherical, double layered, both finely ornamented.

Periphragm covered with numerous fibrous, acuminate, bifurcate, distally closed processes. Archaeopyle distinct, ?precingular.

Measurements	*Range*
Diameter of central body	50 μm
Length of processes	upto 30 μm

Remarks — The specimen has been tentatively placed under *Exochosphaeridium* as it possesses numerous fibrous processes and doubtful precingular archaeopyle.

Genus — *Callaiosphaeridium* Davey & Williams, 1966

Callaiosphaeridium asymmetricum (Deflandre & Courteville) Davey & Williams, 1966

Pl. 2, figs. 23-24

1973 — *Cordosphaeridium* sp., in Jain & Taugourdeau-Lantz, p. 61, pl. 2, fig. 17.

Geologic & Geographic Distribution — Turonian and Senonian, France (Deflandre & Courteville, 1939; Foucher, 1971); Hauterivian to Santonian, England and France (Davey & Williams, 1966; Clarke & Verdier, 1967; Davey & Verdier, 1971; Davey, 1969, 1974); Maestrichtian, Southern Sweden and U. S. A. (Kjellström, 1973; Zaitzeff & Cross, 1970); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Coronifera* Cookson & Eisenack emend. Davey, 1974

Coronifera oceanica Cookson & Eisenack, 1958

Pl. 2, fig. 20; Pl. 6, fig. 79

Geologic & Geographic Distribution — Barremian, England (Davey, 1974); Aptian, Germany (Eisenack, 1958; Alberti, 1961); Albian, Cenomanian, Santonian & Lower Campanian, Australia (Cookson & Eisenack, 1958, 1968, 1969); Upper Albian to Basal Coniacian, England (Cookson & Hughes, 1964); Cenomanian, England (Clarke & Verdier, 1967); Upper Hauterivian to Lower Aptian, France (Millioud, 1969); Albian, France, America and Canada (Davey, 1969); Aptian and Albian, France (Davey & Verdier, 1971, 1974); Albian-Cenomanian, Australia (Cookson & Eisenack, 1974); Albo-Aptian, Senegal Basin, W. Africa (Jain & Millepied, 1975); Lower Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Remarks — *C. oceanica* though ranges from Upper Hauterivian to Campanian but is commonly reported in abundance from Albo-Aptian sediments. Davey (1969, p. 162) is of the opinion that its stratigraphic range is from Upper Aptian to Cenomanian.

The occurrence of *C. oceanica* in the present assemblage is common. The position of archaeopyle could be decisively observed in several specimens as precingular.

Coronifera albertii Millioud, 1969

Pl. 2, fig. 18

Geologic & Geographic Distribution — Late Hauterivian, France (Millioud, 1969); Aptian, Germany (Eisenack, 1958; Alberti, 1961); Albian, Paris Basin (Davey & Verdier, 1971); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Remarks — *C. albertii* is less represented in the Grey Shale Member dinoflagellate assemblage.

Coronifera sp. A

Pl. 2, fig. 19

Description — Cyst oblong, 60 μm in diameter; periphragm covered with bifurcating long processes (10 μm in length), distally closed, pointed, some hypothecal processes thread like (15-30 μm in length). Apical and antapical process distinct. Archaeopyle precingular.

Remarks — Except for some thread like hypothecal processes, the rest of the morphological features of the present specimen resemble *C. oceanica*.

Coronifera sp. B

Pl. 2, fig. 21

Description — Cyst oblong, 66×58 μm in size, double walled, endophragm 1·2 μm

thick, granulose; periphragm thin, covered with sparsely placed processes. Processes usually proximally connected by low crest, spongy with longitudinal surface striations, two types, one broader bifurcated and other longer simple, distally closed. Epithecal processes mostly of broad bifurcating type. Antapical process 36×15 μm in size, spongy with longitudinal striations, distally open, dirigate.

Remarks — *Coronifera* sp. B is characterized by its granulose endophragm and two types of processes with spongy surface having longitudinal striations. These features warrant creation of a new species, but due to lack of many specimens no specific status has been assigned.

Genus — *Prolixosphaeridium* Davey *et al.*, 1966

Prolixosphaeridium deirense Davey *et al.*, 1966

Pl. 3, fig. 29

Remarks — Dalmiapuram specimens have similar size range as given for holotype.

Geologic & Geographic Distribution — Lower Barremian, Speeton Clay, Yorkshire (Davey *et al.*, 1966; Davey, 1974); Upper Barremian and Lower Aptian, France (Millioud, 1969); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Prolixosphaeridium elongatum sp. nov.

Pl. 4, figs. 48-49

Holotype — Pl. 4, fig. 48; Slide no. 5056-25.

Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.

Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.

Diagnosis — Cyst elongate, longer than broad, periphragm coarsely granulate possessing spine like processes, distally, pointed, closed, more than 80 in number, distinct, antapical processes seen. Archaeopyle apical.

Measurements	*Holotype*	*Range*
Size of cyst	87×35 μm	70-90×30-40 μm
Length of processes	7 μm	4-8 μm

Comparison — *P. elongatum* sp. nov. differs from *P. deirense* Davey *et al.* (1966), *P. conulum* Davey (1969), *P. parvispinum* (Deflandre) Davey *et al.* (1966) and *P. granulosum* (Deflandre) Davey *et al.* (1966) in its longer than broad central body with more than 60 simple, acuminate processes.

Genus — *Scriniodinium* Klement, 1957

?*Scriniodinium* sp. A

Pl. 5, fig. 62

Description — Central body spherical, 42 μm in diameter, covered with thin delicate membrane, highly folded; furrows indistinct. Archaeopyle seen, position doubtful.

Remarks — Only a few specimens have been recovered.

Genus — *Cleistosphaeridium* Davey *et al.*, 1966

Cleistosphaeridium polypes (Cookson & Eisenack) Davey, 1969

Pl. 3, figs. 33, 39

Geologic & Geographic Distribution — Aptian-Albian, Australia (Cookson & Eisenack, 1962); Middle and Upper Cenomanian, France, England, Canada, U. S. A. (Davey, 1969); Albian, Paris basin and Barremian, England (Davey, 1974); Early Albian, Grey Shale Member, Dalmiapuram, Formation, South India (Present study).

Genus — *Cannosphaeropsis* Wetzel emend. Deflandre, 1937 emend. Williams & Downie, 1966

Cannosphaeropsis peridictya Eisenack & Cookson, 1960

Pl. 4, figs. 55-56

1958 — *Cannosphaeropsis fenestrata* Deflandre & Cookson, in Cookson & Eisenack, p. 46, pl. 7, figs. 1-3.

Description — Same as for holotype; present specimens possess pitted trabeculae.

Remarks — Dalmiapuram forms assigned to *C. peridictya* Eisenack & Cookson (1960) fall within the specific circumscription except for the pitted trabeculae (Pl. 4, fig. 56).

The pitted nature of the trabeculae is seen only under the high magnification. *P. perforata* Alberti (1961) compares in having perforate membrane of the radial processes and connecting string but differs in possessing numerous radially arranged processes.

Geologic & Geographic Distribution — Aptian-Cenomanian, Australia (Eisenack & Cookson, 1960); Aptian-Albian, Australia and New Guinea (Cookson & Eisenack, 1958); Early Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Odontochitina* Deflandre emend. Davey, 1970

Odontochitina cribropoda Deflandre & Cookson, 1955

Pl. 3, fig. 31

1955 — *Odontochitina cribropoda* Deflandre & Cookson, p. 292, pl. 58, fig. 3.

1968 — *Odontochitina cribropoda* Deflandre & Cookson, in Cookson & Eisenack, p. 112, fig. 2A-C.

1973 — *Odontochitina subbaramana* Jain & Taugourdeau-Lantz, p. 64, pl. 4, fig. 3.

Geologic & Geographic Distribution — ?Upper Cretaceous, Australia (Deflandre & Cookson, 1955; Cookson & Eisenack, 1968); Lower Cretaceous (probably Upper Aptian-Lower Albian) South India (Jain & Taugourdeau-Lantz, 1973).

Odontochitina operculata (Wetzel) Deflandre, 1946

Pl. 3, fig. 30

Geologic & Geographic Distribution — Late Hauterivian to Maestrichtian, Europe, Canada, Australia (For details see Singh, 1971, p. 372); Early Albian, Grey Shale Member, South India (Present study).

Odontochitina sp. cf. *O. operculata* (Wetzel) Deflandre, 1946

Pl. 3, fig. 32

Remarks — Morphological features are similar to *O. operculata* (see Singh, 1971, pp. 271-272) except that the present specimen possesses a distinct nipple-like projection in the inner body towards the long antapical horn.

Genus — *Cyclonephelium* Deflandre & Cookson emend. Williams & Downie, 1966

Cyclonephelium distinctum Deflandre & Cookson, 1955

Pl. 3, fig. 34

Geologic & Geographic Distribution — Berriasian to Campanian, Europe; Albian to Campanian, Australia; Cenomanian to Danian, North America (see Davey & Verdier, 1971; Davey, 1974).

Remarks — Dalmiapuram specimens assigned to *C. distinctum* have variable extent of ornamented zone with well developed blunt, capitate or bifid process tip. They resemble best with Australian Albian forms described by Cookson and Eisenack (1962).

Genus — *Dictyopyxidia* Eisenack, 1961

Dictyopyxidia punctata sp. nov.

Pl. 4, figs. 51-52

Holotype — Pl. 4, fig. 51; Slide no. 5050-2.

Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.

Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.

Diagnosis — Cyst spherical, double layered, periphragm reticulate, muri low, punctate, luminae irregular, polygonal. Cingulum present. Archaeopyle apical, margin angular.

Measurements	*Holotype*	*Range*
Cyst diameter	66 μm	55-70 μm

Comparison — The absence of sulcus and the presence of cingulum precludes its placement under *Ellipsoidictyum* Klement (1960) and *Cassiculosphaerida* Davey (1966). *D. punctata* sp. nov. differs from *D. areolata* Cookson & Eisenack (1960), *D. circulata* Clarke & Verdier (1967) and *D. reticulata* (Valensi) Lentin & Williams (1973) in having punctate muri.

Remarks — *Dictyopyxidia* has a common representation in the present dinoflagellate assemblage. Some specimens do not clearly show the presence of a cingulum which suggests their placement under the genus *Cassiculosphaeridia* Davey. The choice of the genus therefore becomes arbitrary and needs careful observation.

Dictyopyxidia imperfecta Brideaux & McIntyre, 1975

Pl. 4, fig. 50

Geologic & Geographic Distribution — Aptian to Middle Albian, Langton bay and Horton River Formation, (Brideaux & McIntyre, 1975); Lower Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

Genus — *Astrocysta* Davey, 1970

Astrocysta cretacea Pocock ex Davey, 1970

Pl. 4, fig. 54

Geologic & Geographic Distribution — Cretaceous, W. Canada (Pocock, 1962); Albian, Canada (Singh, 1964; Davey, 1970); Albian, Europe; Barremian, England (Davey, 1974); Lower Albian, Grey Shale Member, Dalmiapuram Formation, South India (Present study).

?*Astrocysta* sp. A

Pl. 3, fig. 35

Description — Cyst oblong, double layered, both periphragm and endophragm thin, delicate, smooth. Capsule faintly, marked, cingulum distinct, one apical and two antapical horns distinct, antapical horns short unequal in size. Archaeopyle intercalary.

Measurement	
Size of cyst	85×54 μm
Horn size	5-7 μm
Cingulum width	3-5 μm

Remarks — The non-pentagonal shape of the cyst creates doubt for its placement under the genus *Asterocysta* but other characters are similar.

Genus — *Heterosphaeridium* Cookson & Eisenack, 1968

Heterosphaeridium sp. A

Pl. 1, fig. 11

Description — Cyst subcircular, 46 μm in diameter, surface smooth, covered with numerous, solid, mostly equal in length, distally closed processes; processes distally bifurcated or simple, proximally joined together by low ridge which form broad polygonal areas. Archaeopyle apical.

Remarks — Only a few specimens belonging to *Heterosphaeridium* have been recovered from the Grey Shale Member. The genus is known from the Upper Cretaceous of Australia (Cookson & Eisenack, 1968).

Genus — *Cyclopsiella* Drugg & Loeblich, 1967

Cyclopsiella ornamenta sp. nov.

Pl. 6, fig. 72

Holotype — Pl. 5, fig. 68; Slide no. 5048-11.

Locality — Kallakkudi Limestone Quarry II, Dalmiapuram, South India.

Horizon — Grey Shale Member, Dalmiapuram Formation; Early Albian.

Diagnosis — Cyst ovoidal, aperture circular just below the apex, never seen closed with plug, rim margin thick, slightly raised. Wall double layered, endophragm smooth, periphragm punctate, extends beyond central body forming regular flange. No indication of cingulum.

Measurements	*Holotype*	*Range*
Central body size	57×45 μm	50-65 μm
Diameter of aperture	9 μm	40-50 μm

Comparison — The genus *Cyclopsiella* is known from Oligocene having only two species *C. elliptica* Drugg & Loeblich (1967) and *C. vieta* Drugg & Loeblich (1967). These differ from the present species in not having a punctate periphragm.

Genus — *Veryhachium* Deunff emend. Downie & Sarjeant, 1963

Veryhachium sp. A

Pl. 6, fig. 80

Description — Central body angular to spherical having six radiating processes, wall thick, smooth. Processes very long tappering, distally beaded, proximally connected with central body. Aperture not seen.

Measurements

Size of central body	30-50 μm
Length of processes	70-110 μm

Remarks — Only five specimens have been recovered.

Veryhachium sp.B

Pl. 6, fig. 81

Description — Central body oval, wall thin, smooth possessing nine radiating processes, proximally connected with inner wall, processes short equal in length. Pylome not seen.

Measurements

Size of central body	20×14 μm
Length of processes	up to 20 μm

Remarks — Only three specimens could be recovered from the present material.

Genus — *Pterospermopsis* Wetzel, 1952

Pterospermopsis sp. A

Pl. 6, fig. 82

Description — Central body spherical, 70 μm in diameter, outer membrane thin, smooth, broad folds along body margin prominent. Outer membrane extends beyond central body margin, flange 30 μm wide.

DISCUSSION

The chemical treatment of grey shale and argillaceous limestone samples (Text-fig. 2) revealed the presence of miospores, microplankton, fragments of cuticles, microthyriaceous fungal ascomata and wood tracheids.

The overall spectrum of the present palynological assemblage indicates total absence of angiospermous pollen grains, an abundance of disaccate pollen grains (Podocarpaceous) and dinoflagellate cysts. The trilete spores are rare and acritarchs are less represented. The dinoflagellates constitute the dominant floral group (78%) of the total palynological assemblage. Except for minor frequency differences, all the samples show marked similarity in their floral elements. Their qualitative and quantitative analyses reveal the dominance of *Oligosphaeridium*, with significant association of *Spiniferites*, *Kleithriasphaeridium*, *Cleistosphaeridium*, *Hystrichosphaeridium* and *Surculosphaeridium*. The subdominant genera are *Gonyaulacysta*, *Hexagonifera*, *Coronifera*, *Trichodinium*, *Tenua*, *Dictyopyxidia* and *Canningia*.

Comparison With Other Dinoflagellate Assemblages

Recently, Davey and Verdier (1974) have described in detail the dinoflagellate cysts from Aptian stratotype material from type localities at Gargas and La Bedoule, South-east France. Out of 62 total dinoflagellate species, only 17 following species are common to Grey Shale Member; *Astrocysta cretacea*, *Callaiosphaeridium asymmetricum*, *Cleistosphaeridium polypes*, *Cyclonephelium distinctum*, *Exochosphaeridium phragmites*, *Florentina mantelli*, *Fromea amphora*, *Gonyaulacysta helicoidea*, *Hystrichodinium pulchrum*, *Hystrichosphaeridium tubiferum*, *Odontochitina operculata*, *Oligosphaeridium complex*, *Spiniferites ramosus*, *Tanyosphaeridium isocalamus*, *Trichodinium castanea*, *Coronifera oceanica* and *Kleithriasphaeridium simplicispinum*. All these species are long ranging and are not of much value to mark the Albo-Aptian boundary. Davey and Verdier (1974, p. 646) have considered *Achomosphaera neptuni*, *Dingodinium albertii*, *Gardodinium trabeculosum*, *Meiourogonyaulax stoveri* and *Systematophora schindewolfi* to first appear in pre-Aptian strata and became extinct in the Gargasian and thus may be used as the Aptian restricted species. They also

considered the presence of *Aptea polymorpha* and *Chlamydophorella nyei* to be certainly indicative of Aptian age. The Grey Shale Member dinoflagellate assemblage is totally devoid of these seven species and contains *Hexagonifera chlamydata*, a post Aptian species. This supports the view of Davey and Verdier (1974) and permits consideration of the present dinoflagellate assemblage to be post Aptian in age.

The overall constituents of the Grey Shale Member dinoflagellate assemblage show a remarkable similarity with the Early Albian dinoflagellate assemblage described from Côtes Noires de Moeslains, Paris Basin (Davey & Verdier, 1971). It has many common elements, viz., *Hystrichosphaeridium tubiferum*, *H. stellatum*, *Surculosphaeridium longifurcatum*, *Spiniferites cingulatus*, *Cassiculosphaerida reticulata* which appear first in the Early Albian in Paris Basin. Out of 41 dinoflagellate species reported from Early Albian from Côtes Noires de Moeslains, 23 are common to the Grey Shale Member dinoflagellate flora.

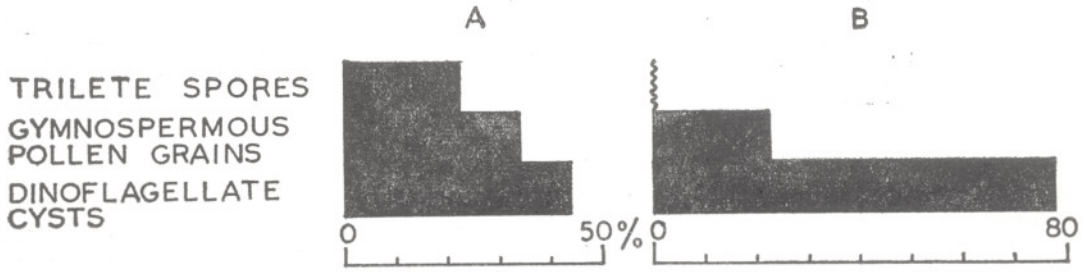
The Middle and Late Albian constituents of Paris Basin dinoflagellate assemblage are *Stephodinium coronatum*, *Phoberocysta ceratoides*, *Carpodinium obliquicostatum*, *Xiphophoridium alatum*, *Apteodinium grande*, *Ellipsoidinium rugulosum*, *Psaligonyaulax deflandrei*, *Hystiocysta palla*, *Spiniferites crassipellis*, *Hexagonifera chlamydata*. Apart from *H. chlamydata* and *Spiniferites crassipellis*, rest of the species are not recorded from the Grey Shale Member assemblage.

The aforesaid discussion suggests an Early Albian age for the Grey Shale Member of the Dalmiapuram Formation which corresponds to the *"Lenticulina macrodisca"* zone of Banerji (1972).

Palaeoenvironment

The Grey Shale Member of Dalmiapuram Formation at the type section is differentiated into two palynological assemblages, the Lower and the Upper (Text-fig. 2). The Lower, represents the lower part of the section (Present study), possesses little detrital plant material with 20% winged pollen grains and 78% microplankton. The trilete spores are almost negligible or absent (Text-fig. 3), though *Coptospora* is represented in the basal most sample (Kl-10). The microplankton have a diverse dinoflagellate assemblage. The dominant genera are *Oligosphaeridium* spp., *Kleithriasphaeridium* spp., *Hystrichosphaeridium* spp., *Spiniferites* spp., *Hexagonifera* spp., *Trichodinium* spp., *Odontochitina* spp., *Astrocysta* spp., *Gonyaulacysta* spp., *Cleistosphaeridium* spp. and others.

The upper part is represented by the palynological assemblage described earlier by Jain and Taugourdeau-Lantz (1973). A quantitative analysis based on their type slides revealed the following details; gymnospermous pollen grains (34%), trilete spores (22%) and dinoflagellate cysts (44%) (Text-fig. 3). Apart from the trilete spore genera described by Jain and Taugourdeau-Lantz (1973), Venkatachala and Jain (1970), Rao and Venkatachala (1971), it also includes *Aequitriradites spinulosus*, not reported so far. The dinoflagellates are represented by *Spiniferites* spp., *Ovoidinium* spp., *Oligosphaeridium* spp., *Odontochitina*



TEXT-FIG. 3 — Comparative percentage frequency of palynological groups in Upper (A) and Lower (B) palynological assemblages of the Grey Shale Member.

TABLE 2 — DISTRIBUTION OF DINOFLAGELLATE CYSTS IN GREY SHALE MEMBER SEQUENCE AT THE TYPE SECTION

Dinoflagellate Taxa	Samples													
	J & S (1969) J & T (1973)	DAL-1	KL-3	DAL-2	KL-4	KL-5	KL-6	DAL-3	KL-7	KL-8	DAL-4	KL-9	KL-10
Gonyaulacysta orthoceras	+	+	–	+	+	+	+	+	+	+	+	+	+
G. aichmetes	+	–	–	–	–	–	–	–	–	–	–	–	–
G. episoma	+	+	–	+	+	–	–	+	–	–	–	–	–
G. helicoidea	+	–	+	+	–	+	–	–	+	+	+	+	+
Occisucysta crestata sp. nov.	–	+	–	–	+	–	+	+	–	–	–	–	–
Trichodinium magnus sp. nov.	+	+	+	+	+	+	+	+	+	+	+	+	+
T. castanea	–	+	+	+	–	+	+	+	–	+	+	–	–
Fromea microgranulosa sp. nov.	+	+	+	+	+	+	+	+	+	+	+	+	+
F. amphora	+	+	+	+	+	+	+	+	+	+	+	+	+
Spiniferites ramosus subsp. *endoperforatus*	+	+	+	+	+	+	+	+	+	+	+	+	+
S. ramosus subsp. *granomembranaceus*	+	+	+	+	+	+	+	+	+	+	–	+	+
S. ramosus subsp. *ramosus*	+	+	+	+	+	+	+	+	+	+	+	+	+
S. ramosus subsp. *granosus*	+	–	–	+	+	+	+	+	–	+	+	+	+
S. crassipellis	+	–	–	+	–	–	+	+	+	+	+	+	+
S. cingulatus subsp. *cingulatus*	+	–	+	+	+	–	+	+	+	+	–	+	+
Hystrichodinium pulchrum	–	+	+	+	+	–	+	–	–	–	–	–	+
Kleithriasphaeridium simplicispinum	–	+	+	+	+	+	+	+	+	+	+	+	+
Florintina mantelli	–	+	+	+	+	+	+	+	+	+	+	+	+
Pterodinium eisenacki sp. nov.	+	+	–	–	+	–	–	+	–	–	+	–	–
Canningia microciliata sp. nov.	–	+	+	+	–	+	+	+	–	+	–	+	+
Hexagonifera chlamydata	+	+	+	+	+	+	+	+	+	+	+	+	+
H. scabrata	+	+	+	+	+	+	+	+	+	+	+	+	+
Tenua anaphrissa	+	+	+	+	+	+	+	+	+	+	+	+	+
T. hystrix	+	–	+	+	–	+	+	–	+	+	+	+	–
T. hystricella	+	–	+	+	–	+	+	–	+	+	–	+	+
Ovoidinium indicum	+	–	–	–	–	–	–	–	–	–	–	–	–
Muderongia tetracantha	–	–	–	–	–	–	+	–	–	–	–	–	–
Valensiella punctata sp. nov.	–	+	+	+	+	+	+	–	+	+	–	+	+
Hystrichosphaeridium stellatum	+	+	+	–	+	+	+	+	+	–	–	+	+
H. tubiferum subsp. *brevispinum*	–	+	–	–	–	–	+	+	–	+	+	–	–
Oligosphaeridium poculum sp. nov.	–	+	+	+	+	+	+	+	+	+	+	+	+
O. perforatum sp. nov.	+	+	+	+	+	+	+	+	+	+	+	+	+
O. complex	+	+	+	+	+	+	+	+	+	+	+	+	+
O. reniforme	–	–	–	+	+	+	+	+	+	–	+	+	+
O. pulcherrimum	+	+	+	+	+	+	+	+	+	+	+	+	+
Surculosphaeridium granulosum sp. nov.	–	+	+	+	+	+	+	–	–	+	–	+	+
S. diverispinosum sp. nov.	–	–	–	–	–	+	+	–	+	+	–	–	+
S. cribrotubiferum subsp. *granulosum* nov.	–	–	–	–	–	+	+	–	–	+	+	–	–
S. vestitum	–	–	–	–	–	+	+	–	–	–	–	–	–
S. longifurcatum	+	–	+	+	+	+	+	+	+	+	+	+	+
Tanyosphaeridium isocalamus	–	–	–	–	–	–	+	–	–	–	–	+	–
Exochosphaeridium indicum	+	–	–	–	+	+	+	–	–	–	–	–	–
E. phragmites	+	+	+	+	+	+	+	+	+	+	+	+	+
Callaiosphaeridium asymmetricum	–	+	+	+	+	+	+	+	+	+	+	+	+
Coronifera oceanica	–	–	+	+	–	+	+	–	+	+	+	+	–
C. albertii	–	–	–	–	–	+	+	–	–	–	–	–	–
Prolixosphaeridium deirense	+	–	–	+	–	–	+	–	–	–	–	–	–
P. elongatum sp. nov.	–	–	–	–	–	–	+	–	–	–	–	+	–
Cleistosphaeridium polypes	+	+	+	+	+	+	+	+	+	+	+	+	+
Cannosphaeropsis peridictya	–	–	+	+	+	+	+	+	+	+	–	+	–
Odontochitina cribropoda	+	+	+	+	+	+	+	+	+	+	+	+	+
O. operculata	+	+	+	+	+	+	+	+	+	+	+	+	+
Cyclonephelium distinctum	–	–	+	+	–	+	+	–	–	+	–	–	–
Dictyopyxidia punctata sp. nov.	–	–	+	–	+	+	+	–	+	+	–	–	–
D. imperfecta	–	–	–	–	–	–	+	–	–	–	–	–	–
Cassiculosphaeridia reticulata	–	–	–	+	–	–	+	–	–	–	–	–	–
Astrocysta cretacea	–	+	+	+	+	+	+	+	+	+	+	+	+
Cyclopsiella ornamenta sp. nov.	–	+	+	+	+	+	+	+	+	+	+	+	+
Senoniasphaera sp.	–	–	–	–	–	–	–	+	–	–	–	–	–

spp., *Gonyaulacysta* spp. and *Hexagonifera* spp. Other taxa listed for the lower part are absent or very poorly represented (Table-2).

Abundance of dinoflagellate cysts with winged pollen grains and poor representation of trilete spores and detrital plant material in the lower part of the section, is suggestive of a comparatively more open, although still shallow marine environment (Wall, 1965; Brideaux, 1971a, 1971b and Brideaux & McIntyre, 1975). The appearance of trilete spores and decrease in dinoflagellate frequency with less divergent assemblage in the upper part of the section supports shallowing of the sea. The depositional environment was near shore, shallow marine. The less divergent dinoflagellate assemblage indicates unfavourable conditions for their growth. This gets support from the fact that the reef growth along the margin, restricted marine circulation over the platform (Banerji, 1972, p. 39).

The spore-pollen spectrum of the upper part of the Grey Shale Member shows a close comparison to CR14A-68 section of Horton River section but for angiospermous pollen, though a few tricolporoidate pollen grains are present (Jain & Taugourdeau-Lantz, 1973, pl. 1, figs. 31-32), which may indicate more favourable conditions for the growth of the terrestrial flora of the region (Brideaux & McIntyre, 1975, p. 13).

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EXPLANATION OF PLATES

(All microphotographs magnified 500 x, until otherwise stated)

PLATE 1

1-3. *Oligosphaeridium poculum* sp. nov.; Slide nos. 5071-5, 5053-28, 5052-4.

4. *Oligosphaeridium complex* subsp. *brevispinum* nov.; Slide no. 5049-2.

5-7. *Oligosphaeridium perforatum* sp. nov.; Slide nos. 5053-30, 5049-1, 5053-26.

8. *Oligosphaeridium complex* (White) Davey & Williams; Slide no. 5049-3.

9. *Oligosphaeridium reniforme* (Tasch) Davey & Williams; Slide no. 5053-18.

10. *Hystrichosphaeridium tubiferum* subsp. *brevispinum* (Davey & Williams) Lentin & Williams; Slide no. 5049-2.

11. *Heterosphaeridium* sp. A; Slide no. 5049-4.

PLATE 2

12-13. *Kleithriasphaeridium simplicispinum* (Davey & Williams) Davey; Slide no. 5049-6 (fig. 13–showing broad proximal ends of processes. × 1000).

14-15. *Florentina mantelli* (Davey & Williams) Davey & Verdier; Slide nos. 5059-12 & 5064-2.

16. *Surculosphaeridium longifurcatum* (Firtion) Davey *et al.*; Slide no. 5071-4.

17. *Surculosphaeridium granulosum* sp. nov.; Slide no. 5048-5.

18. *Coronifera albertii* Millioud; Slide no. 5053-19.

19. *Coronifera* sp. A.; Slide no. 5053-25.

20. *Coronifera oceanica* Cookson & Eisenack; Slide no. 5062-1.

21. *Coronifera* sp. B.; Slide no. 5054-11.

22. *Exochosphaeridium* sp. A; Slide no. 5063-5.

23-24. *Callaiosphaeridium asymmetricum* (Deflandre & Courteville) Davey & Williams; Slide nos. 5047-10 & 5049-11.

PLATE 3

25. *Canningia microciliata* sp. nov.; Slide no. 5049-25.

26. *Fromea amphora* Cookson & Eisenack; Slide no. 5056-9.

27. *Fromea* sp. A; Slide no. 5056-20.

28. *Hystrichodinium pulchrum* Deflandre; Slide no. 5050-10.

29. *Prolixosphaeridium deirense* Davey *et al.*; Slide no. 5061-1.

30. *Odontochitina operculata* (Wetzel) Deflandre; Slide no. 5053-15.

31. *Odontochitina cribropoda* Deflandre & Cookson; Slide no. 5053-4.

32. *Odontochitina* sp. cf. *O. operculata* (Wetzel) Deflandre; Slide no. 5049-1.

33. *Cleistosphaeridium polypes* (Cookson & Eisenack) Davey; Slide no. 5057-1.

34. *Cyclonephelium distinctum* Deflandre & Cookson; Slide no. 5056-13.

35. *?Astrocysta* sp. A.; Slide no. 5049-5.

36. *Tenua anaphrissa* (Sarjeant) Benedek; Slide no. 5053-23.

37. *Spiniferites ramosus* subsp. *endoperforatus* (Corradini) Stat. nov.; Slide no. 5049-28.

38. *Spiniferites crassipellis* (Deflandre & Cookson) Sarjeant; Slide no. 5049-27.

39. *Cleistosphaeridium polypes* (Cookson & Eisenack) Davey; Slide no. 5053-3.

PLATE 4

40-42. *Trichodinium magnus* sp. nov.; Slide nos. 5059-7 & 5049-17.

43. *Trichodinium castanea* (Deflandre) Clarke & Verdier; Slide no. 5049-4.

44. *Valensiella punctata* sp. nov.; Slide no. 5059-1.

45-46. *Hexagonifera scabrata* Jain & Taugourdeau-Lantz; Slide nos. 5050-7 & 5050-8.

47. *Hexagonifera chlamydata* Cookson & Eisenack; Slide no. 5059-6.

48-49. *Prolixosphaeridium elongatum* sp. nov.; Slide nos. 5056-25 & 5058-5.

50. *Dictyopyxidia imperfecta* Brideaux & McIntyre; Slide no. 5053-17.

51-52. *Dictyopyxidia punctata* sp. nov.; Slide nos. 5050-2 & 5054-13.

53. *Necrobroomea jaegeri* (Alberti) Wiggins; Slide no. 5049-27.

54. *Astrocysta cretacea* (Pocock) Davey; Slide no. 5059-2.

55-56. *Cannosphaeropsis peridictya* Eisenack & Cookson; Slide nos. 5049-3 (fig. 56, magnified portion of trebaculae. × 1000).

PLATE 5

57. *Muderongia tetracantha* (Gocht) Alberti; Slide no. 5056-5.
58. *Apteodinium* sp. A.; Slide no. 5054-10.
59-60. *Occisucysta* sp. A.; Slide no. 5072-2, showing dorsal and ventral views.
61. *Senoniasphaera* sp. A.; Slide no. 5072-2.
62. ?*Scriniodinium* sp. A.; Slide no. 5056-19.
63-65. *Occisucysta crestata* sp. nov.; Slide no. 5071-3, showing equitorial, dorsal and ventral views.
66. *Exochosphaeridium phragmites* Davey *et al.*; Slide no. 5063-2.
67. *Forma* A.; Slide no. 5059-10.

PLATE 6

68. *Gonyaulacysta episoma* Sarjeant; Slide no. 5053-8.
69. *Gonyaulacysta orthoceras* (Eisenack) Sarjeant; Slide no. 5056-12.
70-71. *Spiniferites cingulatus* subsp. *cingulatus* (Wetzel) Lentin & Williams; Slide no. 5053-16.
72. *Cyclopsiella ornamenta* sp. nov.; Slide no. 5048-11.
73. *Pterodinium eisenacki* sp. nov.; Slide no. 5053-37.
74. *Fromea microgranulosa* sp. nov.; Slide no. 5053-38.
75. *Tenua hystrix* Eisenack; Slide no. 5053-26.
76. *Surculosphaeridium cribrotubiferum* subsp. *granulosum* nov.; Slide no. 5071-4.
77. *Surculosphaeridium divarispinosum* sp. nov.; Slide no. 5053-35.
78. *Canningia microciliata* sp. nov.; Slide no. 5049-25.
79. *Coronifera oceanica*; Slide no. 5067-2.
80. *Veryhachium* sp. A.; Slide no. 5049-4.
81. *Veryhachium* sp. B.; Slide no. 5053-12.
82. *Pterospermopsis* sp. A.; Slide no. 5059-7.


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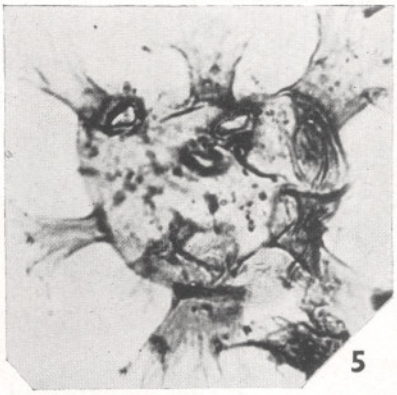
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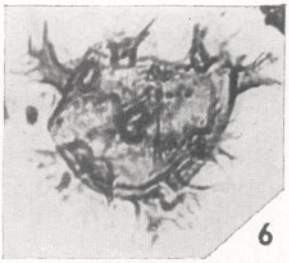
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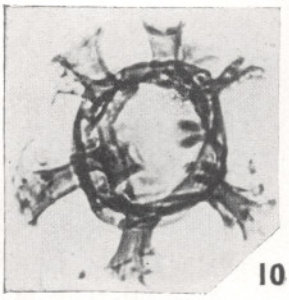
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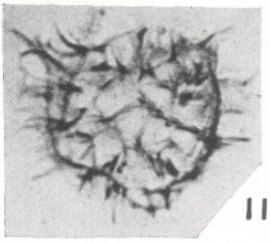
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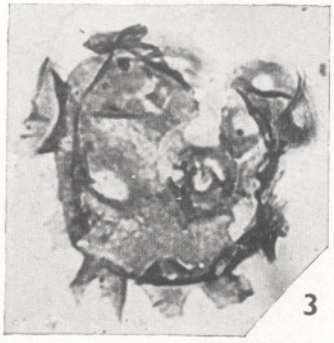
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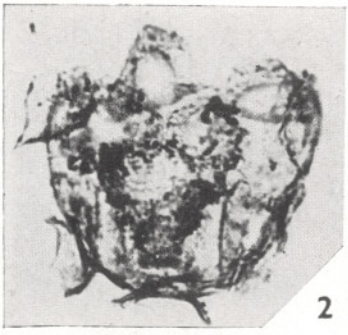
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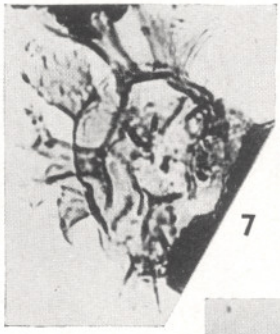
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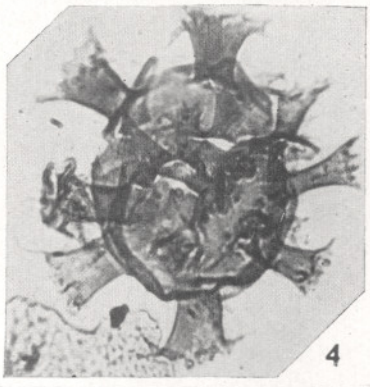
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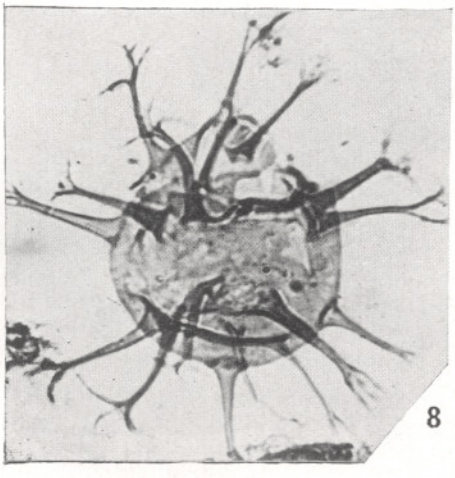
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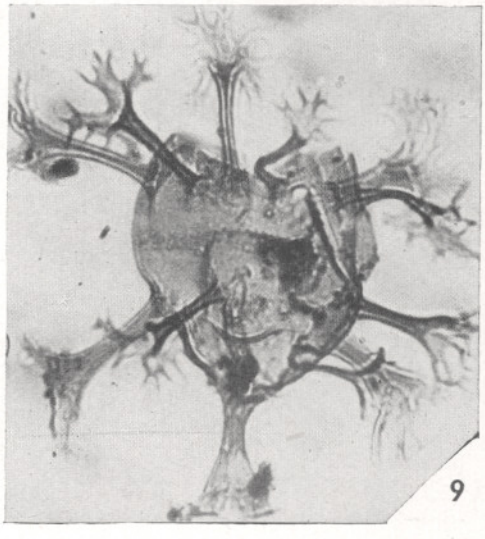
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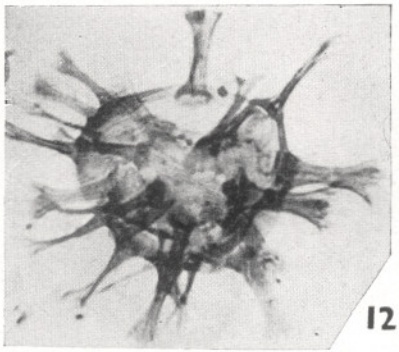
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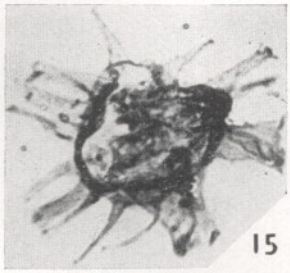
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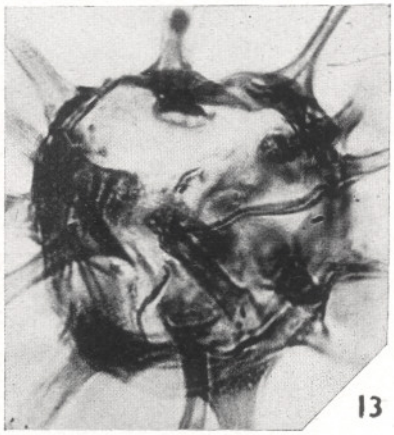
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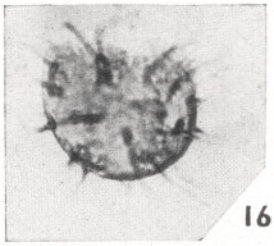
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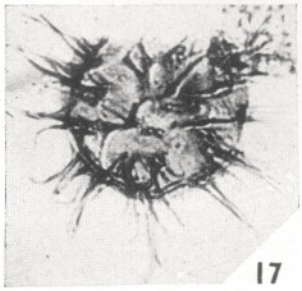
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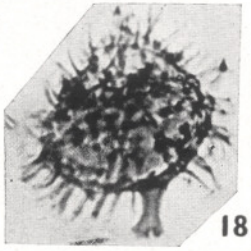
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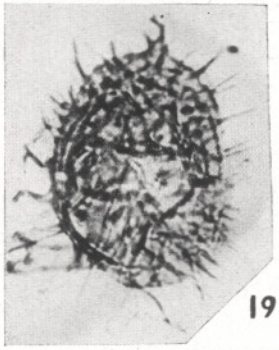
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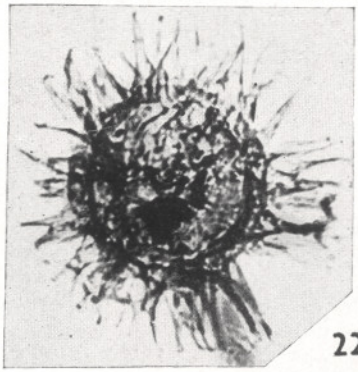
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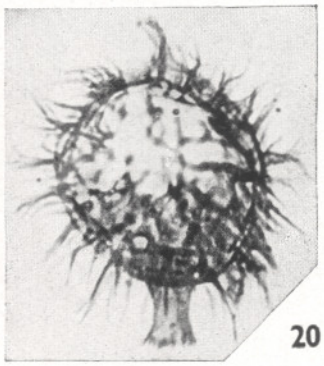
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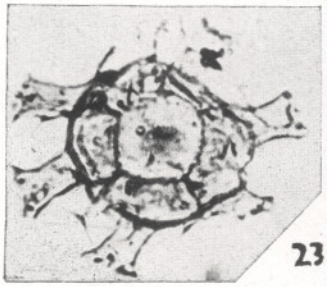
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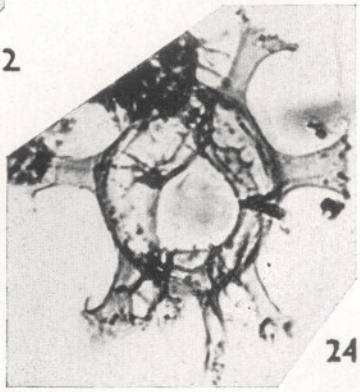
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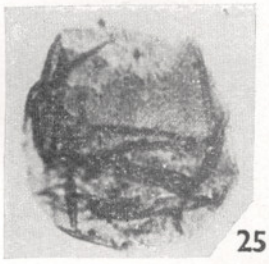
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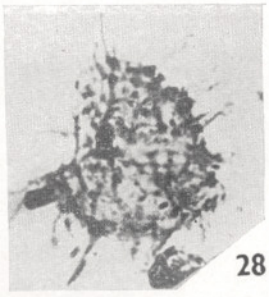
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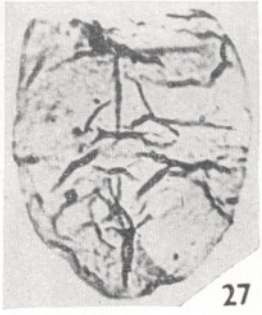
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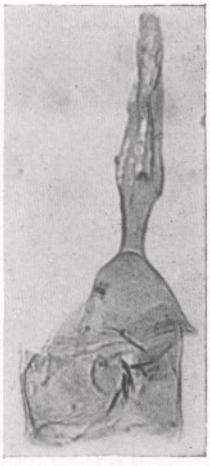
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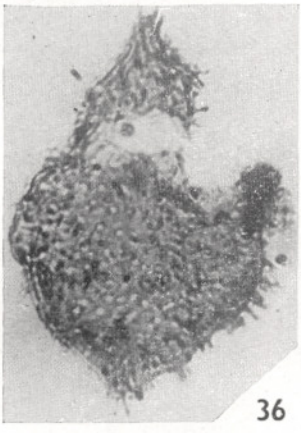
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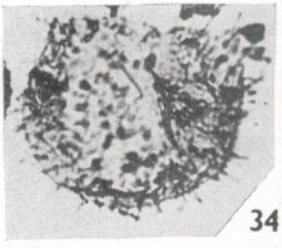
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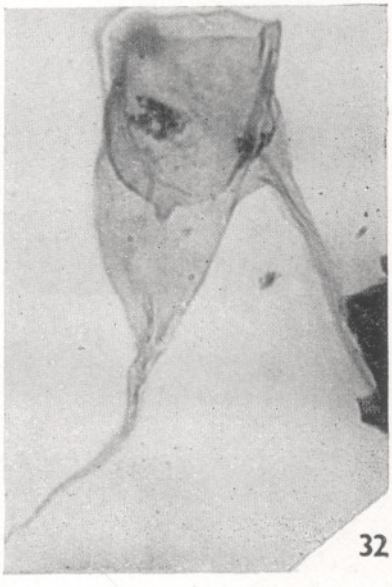
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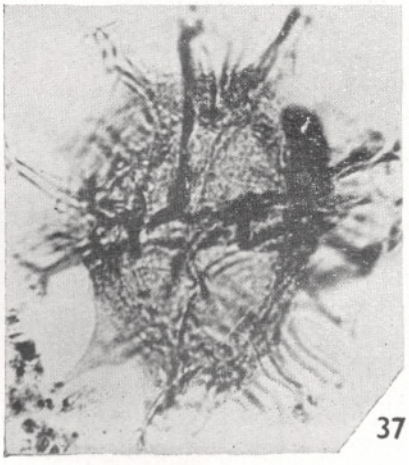
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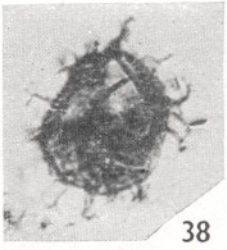
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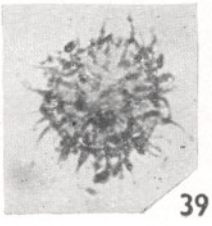
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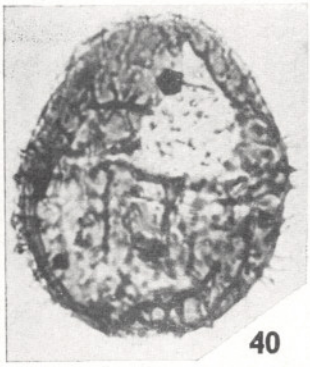
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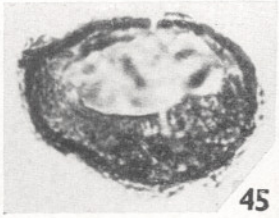
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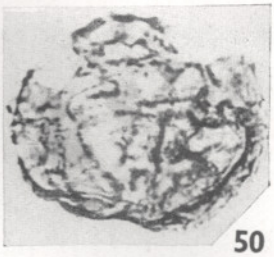
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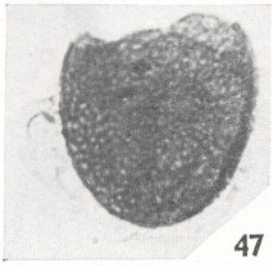
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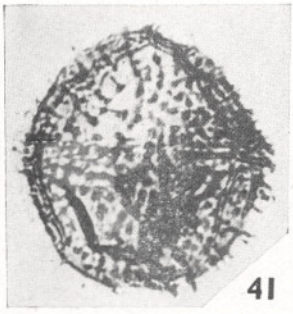
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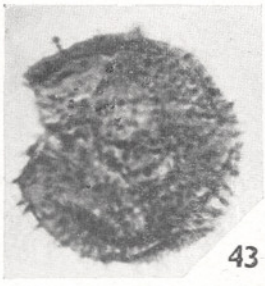
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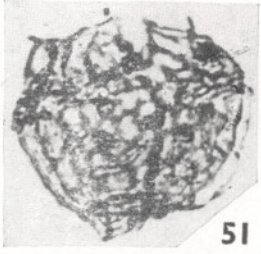
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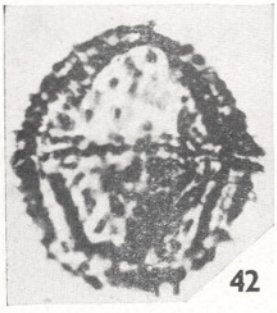
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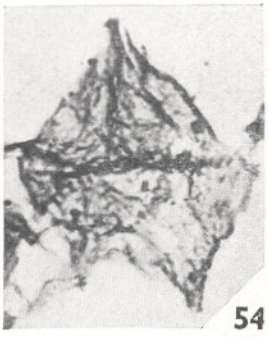
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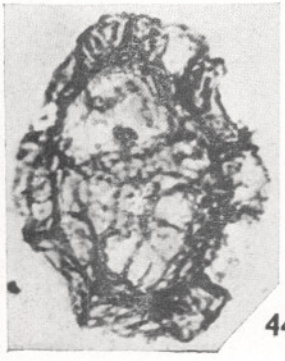
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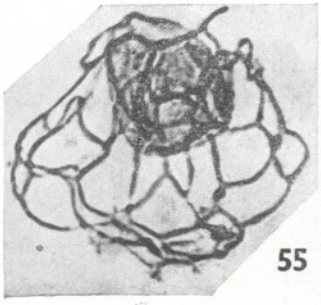
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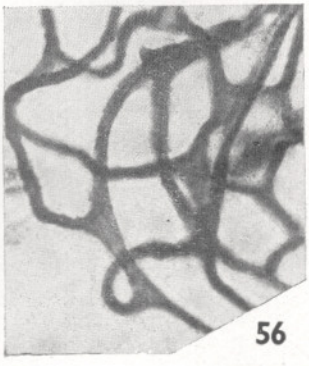
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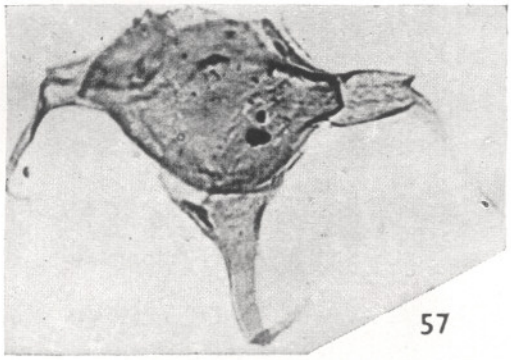
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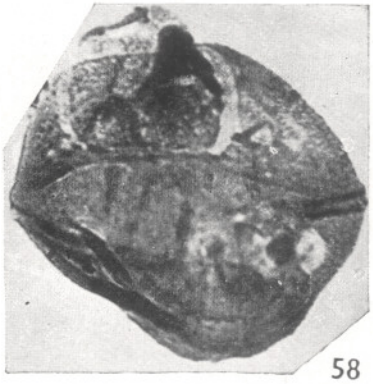
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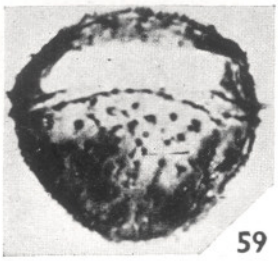
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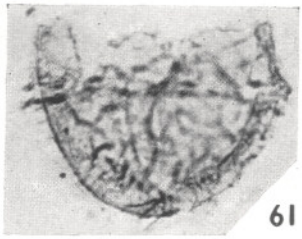
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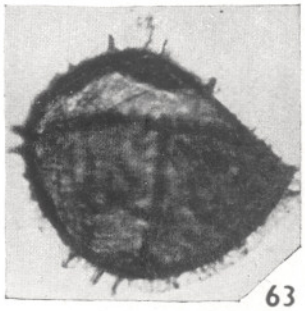
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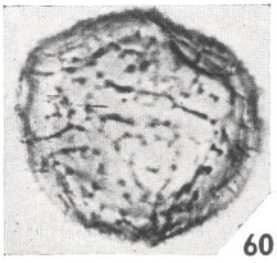
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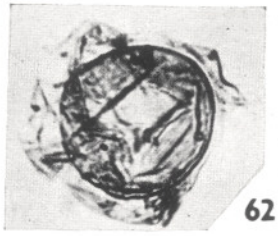
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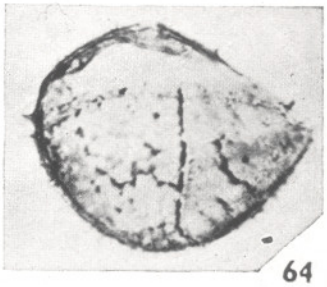
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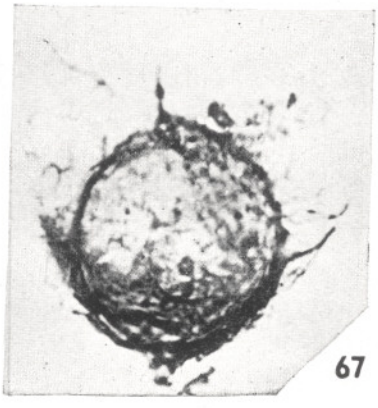
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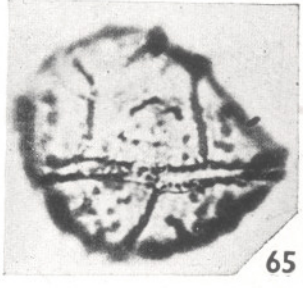
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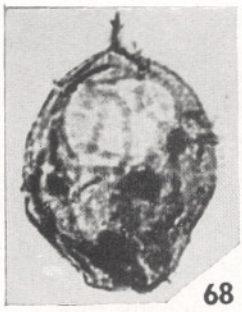
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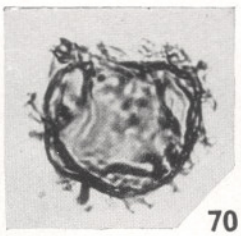
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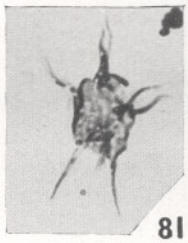
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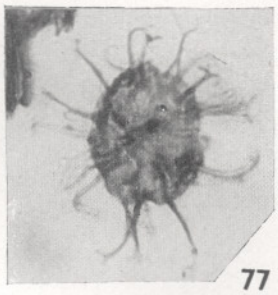
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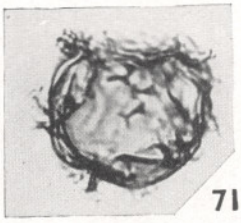
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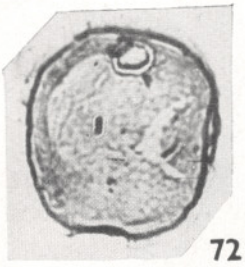
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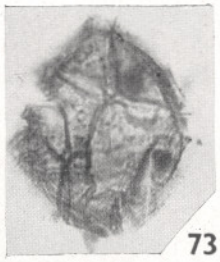
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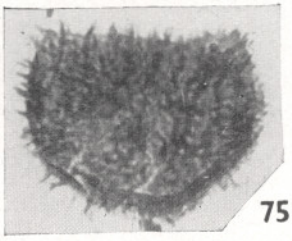
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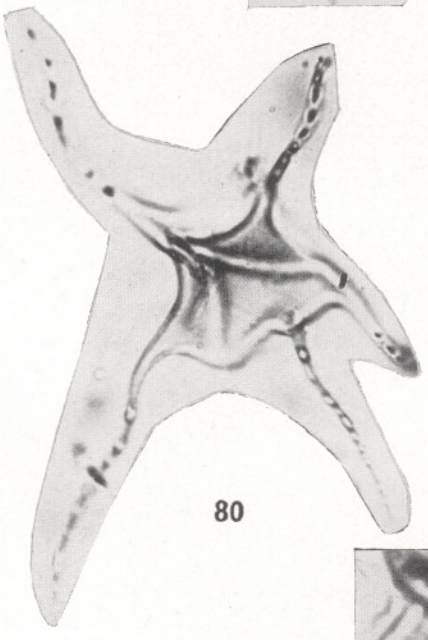
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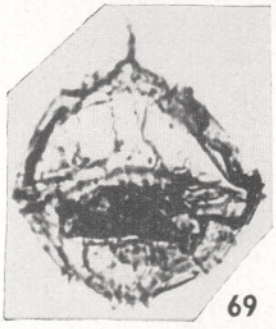
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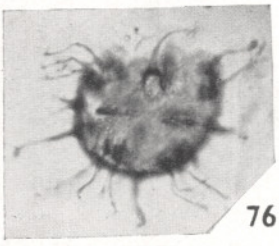
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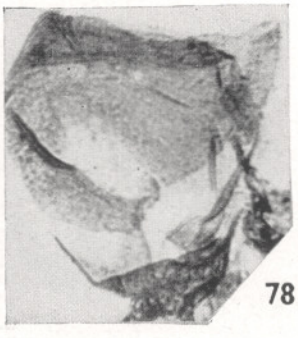
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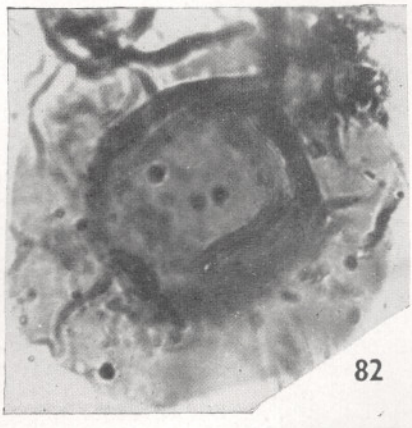
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