

AN ASSEMBLAGE OF DINOFLAGELLATE CYSTS AND ACRITARCHS FROM DALMIAPURAM GREY SHALE, CAUVERY BASIN, TAMIL NADU, INDIA¹.

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ABSTRACT

A rich and varied assemblage of dinoflagellate cysts and acritarchs is described from the grey shales of Dalmiapuram Formation. A total of 26 genera and 69 species are identified. The significant genera are *Spiniferites*, *Cordosphaeridium*, *Tenua*, *Odontochitina*, *Cleistosphaeridium*, *Exochosphaeridium*, *Dicanthum*, *Hystrichosphaeridium*, *Oligosphaeridium*, *Gonyaulacysta*, *Leptodinium*, *Cannosphaeropsis*, *Palaeoperidinium*, *Tanyosphaeridium*, and *Cymatiosphaera*. Forma A and B are new forms described but formal generic names have not been given because their number is not sufficient.

The shales are considered Albian in age on the basis of present study. A nearshore, shallow, brackish to marine depositional environment is envisaged for Dalmiapuram Shales. The flora indicates a tropical climate.

INTRODUCTION

Fossil dinoflagellate studies in India are still in infancy and except for few records, detailed studies have not been undertaken. Jain (1974) reviewed the available information in India.

The Dalmiapuram Formation was recognized by Bhatia and Jain (1969) and Banerjee (1970) for the dark grey shales occurring in the Dalmiapuram quarry no. 2 near Kallakkudi in the Ariyalur area of Cauvery Basin. Rao and Venkatachala (1971) illustrated *Gonyaulacysta* sp. and *Hystrichosphaeridium* sp. as important phytoplankton components of a diversified palynological assemblage from the Dalmiapuram Formation. Jain and Taugourdeau-Lantz (1973) and Jain (1975, issued November, 1977) studied the dinoflagellate remains from Dalmiapuram Formation and listed several taxa. The present study records many new taxa. The material for present study was collected by B. S. Venkatachala and R. K. Banerjee. Bhatia and Jain (1969), Banerjee (1972) and Subbaraman (1968, 1974) have given detailed geology and stratigraphy of the area.

The "Grey Shale" which has yielded the fossils are catalogued in this paper, occur above the Archean basement and vary in thickness from 75 to 156 ft. (Subbaraman, 1968, p. 95). Venkatachala *et al.* (1972) studied the spore and pollen flora from these shales and designated to the *Coptospora cauveriana* zone and dated these shales as Aptian-Early Albian in age.

SYSTEMATIC PALYNOLOGY

The systematic placement of dinoflagellate taxa are

after Sarjeant and Downie (1974), and acritarch taxa are after Downie, Evitt and Sarjeant (1963).

<i>Class</i>	Dinophyceae PASCHER
<i>Subclass</i>	Diniferophycidae BERGH
<i>Order</i>	Peridiniales SCHITT, 1896
<i>Family</i>	Canningiaceae SARJEANT and DOWNIE, 1966 emend. SARJEANT and DOWNIE, 1974.
<i>Genus</i>	<i>Canningia</i> COOKSON and EISENACK, 1960 <i>Canningia</i> sp. A
<i>Genus</i>	<i>Tenua</i> EISENACK, 1958 emend. SAR- JEANT, 1968 <i>Tenua</i> aff. <i>hystrix</i> <i>Tenua</i> sp.
<i>Family</i>	Cannosphaeropsitaceae SARJEANT and DOWNIE, 1966
<i>Genus</i>	<i>Cannosphaeropsis</i> O. WETZEL, 1932 emend. WILLIAMS and DOWNIE, 1966 <i>C. peridictya</i> EISENACK and COOKSON, 1960
<i>Family</i>	Cleistosphaeridiaceae SARJEANT and DOWNIE, 1974
<i>Genus</i>	<i>Cleistosphaeridium</i> DAVEY <i>et al.</i> , 1966 <i>C. diversispinosum</i> DAVEY <i>et al.</i> , 1966 <i>C. cf. C. moderraneum</i> CORRADINI, 1972 <i>C. cf. C. polytes</i> (COOKSON and EISENACK) DAVEY, 1969. <i>Cleistosphaeridium</i> spp. A to C.

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Note: The views expressed in this paper are of authors and not necessarily of ONGC.

- Family Cordosphaeridiaceae SARJEANT and DOWNIE, 1974
 Genus *Cordosphaeridium* EISENACK, 1963 emend. DAVEY, 1969
C. cf. C. inodes (KLUMPP) EISENACK, 1963
C. cf. C. multispinosum DAVEY and WILLIAMS, 1966
Cordosphaeridium spp. A and B
 Family Deflandreaceae EISENACK, 1954 emend. SARJEANT and DOWNIE, 1974
 Genus *Astrocysta* DAVEY, 1970
A. manumcooksoni CORRADINI, 1972
 Family Exochosphaeridiaceae SARJEANT and DOWNIE, 1966
 Genus *Exochosphaeridium* DAVEY *et al.*, 1966
E. phragmites DAVEY *et al.*, 1966
Exochosphaeridium sp.
 Family Gonyaulacystaceae SARJEANT and DOWNIE, 1966 emend. SARJEANT and DOWNIE, 1974
 Genus *Gonyaulacysta* DEFLANDRE, 1964 emend. SARJEANT in DAVEY *et al.*, 1966
G. cf. G. diaphanis COOKSON and EISENACK, 1958
G. cf. G. fetchamensis SARJEANT in DAVEY *et al.*, 1966.
G. cf. G. hadra SARJEANT in DAVEY *et al.*, 1966
G. cf. G. orthoceras EISENACK, 1958
G. cf. G. perforans COOKSON and EISENACK, 1958
Gonyaulacysta spp. A to I
 Genus *Leptodinium* KLEMENT, 1960 emend. SARJEANT, 1969
Leptodinium spp. A and B
 ?*Leptodinium* spp. C and D
 Family Hexagoniferaceae SARJEANT and DOWNIE, 1966 emend. SARJEANT and DOWNIE, 1974
 Genus *Ascodinium* COOKSON and EISENACK 1960
Ascodinium sp.
 Family Hystrichosphaeridiaceae EVITT, 1963 emend. SARJEANT and DOWNIE, 1974
 Genus *Hystrichosphaeridium* DEFLANDRE, 1937 emend. DAVEY and WILLIAMS, 1966
H. coelenteratum TASCH, in TASCH *et al.*, 1964
H. monstruosum TASCH in TASCH *et al.*, 1964
H. stellatum MAIER, 1959
H. tubiferum (EHERENBERG) DAVEY and WILLIAMS in DAVEY *et al.*, 1966
H. unituberculatum TASCH in TASCH *et al.*, 1964
Hystrichosphaeridium spp. A and B
 Genus *Oligosphaeridium* DAVEY and WILLIAMS, 1966
O. complex (WHITE) DAVEY and WILLIAMS, 1966
Oligosphaeridium sp.
 Genus *Tanyosphaeridium* DAVEY and WILLIAMS, 1966
T. variecalamum DAVEY and WILLIAMS, 1966
 Family Palaeoperidiniaceae VOZZHENIKOVA, 1961 emend. SARJEANT, 1967
 Genus *Palaeoperidinium* DEFLANDRE, 1934 emend. SARJEANT, 1967
P. spinosum COOKSON and HUGHES, 1964
 Family Pariodiniaceae GOCHT, 1957 emend. SARJEANT and DOWNIE, 1974
 Genus *Apteodinium* EISENACK, 1958
A. reticulatum SINGH, 1971
 ?*Apteodinium* sp.
 Genus *Pareodinia* DEFLANDRE, 1947
P. villosa TASCH in TASCH *et al.*, 1964
 Family Pseudoceratiaceae EISENACK, 1961 emend. SARJEANT and DOWNIE, 1966
 Genus *Odontochitina* (DEFLANDRE) DAVEY, 1970
O. operculata (O. WETZEL) DEFLANDRE, 1946
Odontochitina spp. A and B
 Family Spiniferitaceae SARJEANT, 1970 emend. DOWNIE and SARJEANT, 1974
 Genus *Spiniferites* MANTELL, 1850 emend. SARJEANT, 1970
S. ramosa (EHERENBERG) DAVEY and WILLIAMS, 1966
S. scabrosa CLARKE and VERDIER, 1967
Spiniferites spp. A to C
 Family Systematophoraceae SARJEANT and DOWNIE, 1974
 Genus *Prolixosphaeridium* DAVEY *et al.*, 1966
Prolixosphaeridium sp.
 Family Uncertain
 Genus *Canningiopsis* COOKSON and EISENACK, 1962
Canningiopsis spp. A and B
 Genus *Dicanthum* HABIB, 1972
Dicanthum sp.
 Genus *Microdinium* COOKSON and EISENACK, 1960 emend. SARJEANT, 1960
Microdinium sp.

- Uncertain Genera Forma A and Forma B
 Group Acritarcha EVITT, 1963
 Subgroup Herkomorphitae DOWNIE, EVITT and
 SARJEANT, 1963
 Genus *Cymatiosphaera* O. WETZEL emend. DE-
 FLANDRE, 1954
 Cymatiosphaera spp. A and B
 Subgroup Pteromorphitae DOWNIE, EVITT and
 SARJEANT, 1963
 Genus *Pterospermopsis* W. WETZEL, 1952
 P. cf. P. australiensis DEFLANDRE and
 COOKSON, 1955
 Subgroup Uncertain
 Genus *Epicephalopyxis* DEFLANDRE, 1937
 Epicephalopyxis sp. A
 Genus *Palaeostomocystis* DEFLANDRE, 1935
 P. reticulata DEFLANDRE, 1935

MORPHOLOGICAL DESCRIPTION

Canningia COOKSON and EISENACK, 1960

Type species : *C. reticulata* COOKSON and EISENACK,
1960

Canningia sp. A
(Pl. I—2)

Slide and Coordinates : P—7—1 : 106.7×45.4

Description : Shell almost sphaerical, hollow, apical horn detached from the shell, antapical horns not clearly developed and are mostly round. Wall psilate to scabrate and has fold which give false appearance of plates.

Dimension : Shell diameter=66.0×58.3 microns
 Length of apical opening=38.0 microns
 Thickness of wall=3.0 microns

Comparison : The described specimen resembles *C. rotundata* Cookson and Eisenack (1961), but lacks an apical horn. *C. minor* illustrated by Drugg (1967, Pl. 3, Fig. 6) is also comparable, but has broken, still attached apical part and is more or less a perfect sphere.

Tenua EISENACK, 1958 emend. SARJEANT, 1968

Type Species : *T. hystrix* EISENACK, 1958

Tenua aff. *hystrix*
(Pl. I—6)

Slide and Coordinates : Paly/DF/A-18 (2), 18.0×105.0

Description : Shell broadly ovoidal with fairly sharp corners. The archaeopyle is represented by a broad opening in the shell. A narrow cingulum is seen in the corners, but faints out in the middle part of the shell. Wall is minutely granular and covered with numerous clavae.

Dimension : Length of shell=83.5 microns
 Width of shell=49.5 microns
 Length of archaeopyle=49.5 microns
 Width of archaeopyle=11.0 microns

Comparison : This specimen compares well with the specimens illustrated by Boltenhagen (1970, Pl. 6, Fig. 1-2) and Sarjeant, (1972, Pl. 1, Fig. 6 and Pl. 7, Fig. 3).

Tenua sp.

(Pl. I—8)

Slide and Coordinates : Paly/DF/A-11 (b), 46.4×111.0

Description : Shell oval to almost sphaerical. Archaeopyle visible as a small aperture in the shell. Wall thin and covered with short, solid, capitate, bulbous processes all over the surface. No plates or cingulum is visible.

Dimension : Maximum radius=49.5 microns
 Minimum radius=40.7 microns
 Process length=2.0 to 2.5 microns
 Process width=1.0 micron
 Archaeopyle dimension = 14.3 × 6.6 microns.

Comparison : This specimen compares well with *T. hyetricella* illustrated by Jain (1973, Pl. 3, Fig. 11, 16).

Cannosphareopsis O. WETZEL, 1932 emend.,
WILLIAMS and DOWNIE, 1966

Type Species : *C. utinensis* O. WETZEL, 1932

C. peridictya
(Pl. I—3)

Slide and Coordinates : P—17—2, 43.8×94.8

Description : A small shell, subsphaerical to ovoidal, thin walled, wall psilate to scabrate and covered by a loose mesh of threads without any connection to the central body.

Dimension : Total length=99.0 microns
 Diameter of shell=35.2×38.5 microns
 Thickness of threads=1.6 to 3.4 microns.

Cleistosphaeridium DAVEY *et al.* 1966

Type Species : *C. diversispinosum* DAVEY *et al.*, 1966

C. diversispinosum
(Pl. I—7)

Description : The specimens from Dalmiapuram Formation show a variation from polygonal to almost round archaeopyle. Processes are branched only at the tips, bifurcate to trifurcate or digitate and sometimes processes are covered with membranous sheath.

Dimension : Diameter of central body=33.0 to 60.5 microns
 Diameter of archaeopyle=16.5 to 27.5 microns
 Length of processes=13.2 to 22.0 microns
 Width of processes=1.5 to 2.5 microns.

Slides and Coordinates : P—7—2 : 25.6×93.9 & 46.8×102.1

P—7—1 : 22.7×99.4

Paly/DF/A—18—3 : 34.2×97.5

Paly/DF/A—11—c : 40.4×103.2

C. cf. C. mediterraneum

(Pl. I—12)

Slide and Coordinates : Paly/DF/A—19—1 : 20.0×105.1

Description : The present specimen shows an overall resemblance to *C. mediterraneum* Corradini, 1972, but "punctate endophragm and striate periphragm" characters are not clearly seen. Archaeopyle apical.

Dimension : Diameter of central body = 49.5 microns

Length of processes = 11.0 to 14.3 microns

Width of processes = 3.0 to 4.0 microns.

C. cf. C. polytes

(Pl—1, 4)

Slide and Coordinates : Paly/DF/A—19—1 : 20.2×105.1

Description : For description see Singh (1971) p. 324, Pl. 50, Figs. 4 and 5. The present specimen is smaller and has fewer processes.

Dimension : Diameter of central body = 24.2 to 27.5 microns

Length of processes = 11.0 to 14.5 microns

Width of processes = 3.5 microns at base and 1.0 micron at the tip.

Cleistosphaeridium sp. A

(Pl. I—10)

Slide and Coordinates : P—17—1 : 60.3×99.0

Description : This species is characterized by the presence of large apical archaeopyle with a zig zag margin. Body sphaerical with numerous, unbranched, acuminate processes, which are closed at their tips.

Dimension : Diameter of central body = 61.6 microns

Length of processes = 13.0 to 16.8 microns

Width of processes (at base) = 3.5 microns

Diameter of archaeopyle = 44.0 microns.

Cleistosphaeridium sp. B

(Pl. I—11)

Slides and Coordinates : P—7—2 : 28.8×111.4

Paly/DF/A—20—2 : 25.4×108.8

Description : The species closely resembles *C. diversispinosum*, but has a thin psilate wall instead of a granular one. Processes could be branched or unbranched, once or twice near the tip. Archaeopyle apical.

Dimension : Diameter of central body = 33.0 to 38.5 microns

Length of processes = 16.5 to 19.8 microns

Width of processes = 2.0 to 3.0 microns.

Cleistosphaeridium sp. C.

(Pl. I—5)

Slides and Coordinates : Paly/DF/A—11—A : 26.5×110.0

Description : Central body oval to subsphaerical, processes numerous, long, slender and unbranched, tapering out to a point, acuminate to evexate. Archaeopyle probably apical with a zig zag margin. Wall thin and psilate.

Dimension : Diameter of central body = 46.2 microns

Length of processes = 22.0 to 24.2 microns

Width of processes = 1.0 to 1.5 microns.

Cleistosphaeridium sp. D.

(Pl. II—3)

Slide and Coordinates : P-7-2 : 22.7×103.9 .

Description : Proximo-chorate cyst, subsphaerical to ovoidal, body covered with short numerous processes. Processes are clavate and broad based and are unbranched with closed pointed tips. Apical archaeopyle.

Dimensions : Diameter of cyst = 44.0 microns

Length of processes = 3.5 to 4.3 microns

Width of processes = 3.5 to 4.5 microns.

Cordosphaeridium EISENACK, 1963 emend. DAVEY, 1969

Type Species : *C. inodes* (KLUMPP) EISENACK, 1963

C. cf. C. multispinosum

(Pl. II—4)

Slide and Coordinates : Paly/DF/A—11/A : 8.4×112.0

Description : Subsphaerical cyst, wall two layered, periphragm forming processes, and endophragm is thin and psilate forming central body. Processes are short, wide, cylindrical with an open distal end, aculeate to orthogonal. Archaeopyle apical. Reflected tabulation is not clear.

Dimension : Diameter of central body = 66.0 microns

Diameter of archaeopyle = 45.0 microns

Length of processes = 11.0 to 13.5 microns

Width of processes = 16.5 to 20.0 microns

Comparison : This specimen compares with Davey *et al.*, (1966, Pl. 3, Fig. 6), but has fewer and wider processes.

Cordosphaeridium sp. A.

(Pl. II—1)

Slide and Coordinates : P—17—1 : 103.3×40.1

Description : Subsphaerical cyst, wall two layered, periphragm forming processes and endophragm forming the central body, which is thin and psilate. Processes (1+8) are of two kinds, open denticulate and thick and other kind is thin and slender. Archaeopyle apical, haplotabular. Reflected tabulation is not clear.

Dimension : Diameter of central body = 66.0 microns

Diameter of cyst = 121.0 microns

Length of processes = 26.5 microns

Width of thin processes = 8.5 microns.

Width of thick processes = 27.5 microns.

Diameter of archaeopyle = 42.0 microns.

Cordosphaeridium sp. B.

(Pl. III—10)

Slide and Coordinates : Paly/DF/A—18—1 : 45.0 × 111.0

Description . Sphaerical chorate cyst with thin and psilate endophragm forming the central body of the cyst and periphragm forming the processes. The processes are numerous, with broader base and branched apices. Branching may be bifurcate or trifurcate or even further divided. Archaeopyle apical. Reflected tabulation is difficult to ascertain.

Dimension : Diameter of central body=40.0 microns
Length of processes=16.5 to 18.0 microns
Diameter of archaeopyle=33.0 microns.

Astrocysta DAVEY, 1970

Type Species : *Palaeoperidinium cretaceum* POCOCK, 1962

Astrocysta sp.

(Pl. II—6)

Slide and Coordinates : Paly/DF/A—18—5 : 39.6 × 116.4

Description : Test flattened, of almost equal length and breadth, pentagonal in shape with more or less straight sides. One apical horn and two antapical horns are poorly developed. Tabulation is not clear and periphragm is thin. Position of archaeopyle uncertain, but probably post cingular. Cingulum marked by faint discontinuous ridges, and sulcus is also faintly marked.

Dimension : Length of test=84.5 microns
Width of test=93.5 microns.

Comparison : This specimen compares well with Corradini's specimen (1972, Pl. 28, Fig. 4, 6), except that Corradini's specimens do not show any indication of archaeopyle and are longer than broad with clear horns.

Exochosphaeridium DAVEY *et al.*, 1966

Type Species : *E. phragmites* DAVEY *et al.*, 1966

E. phragmites

(Pl. II—9)

Slides and Coordinates : P—7—2 : 38.4 × 107.0
P—3—2 : 15.5 × 96.6
Paly/DF/A—11—B : 20.0 × 107.1

Description : Central body subsphaerical, surface rough with numerous thin, long, fibrous, acuminate branched or unbranched processes, closed at the tips. Apical processes slightly longer than others. Archaeopyle precingular.

Dimension : Diameter of central body=45.0 to 60.0 microns.

Length of processes=10.0 to 14.0 microns
Width of processes=3.0 microns at base
and 1.0 micron at the tip.

Exochosphaeridium sp. A.

(Pl. II—2)

Slide and Coordinates : Paly/DF/A—19—2 : 47.5 × 112.7

Description: Subsphaerical central body with numerous processes which are of different sizes. Wall two layered, periphragm forms processes and endophragm central body. Archaeopyle precingular.

Dimension : Length of body=45.4 microns
Width of body=36.3 microns
Diameter of archaeopyle=22.0 microns
Length of processes=6.6 to 10.0 microns
Width of processes=2.5 microns at base
and 1.0 micron at the tip.

Remarks : *Exochosphaeridium* sp. A differs from *Exochosphaeridium phragmites* in having shorter body processes.

Gonyaulacysta DEFLANDRE, 1964

Type Species : *G. jurassica* DEFLANDRE, 1938 emend. SARJEANT in DAVEY *et al.*, 1966

Description : The following species from Dalmiapuram Formation do qualify the emended diagnosis of the genus *Gonyaulacysta* Sarjeant (1960). On a preliminary examination some of the specimens resemble already described species, but on the close examination of the Dalmiapuram specimens, the tabulation has never been found to correlate with the described species. Thus some of the species described in the literature are being reported here on the basis of overall resemblance, and other specimens which do not correspond to any described forms and thus are given names as species A, B and C, etc.

G. cf. G. diaphanis

(Pl. III—8)

Slide and Coordinates : Paly/DF/A—11—7 : 51.0 × 112.7

Description : The specimen compares well with Cookson and Eisenack's (1958, pl.-3, figs. 13 and 14) specimen, but has an extra plate 1a and does not show spiny ridges. The arrangement of hypotractal plates are not clear in the specimens of both regions, but the Australian specimen seems to have more number of plates than Indian specimen.

Dimension : Diameter of shell=98.0 microns
Length of apical horn=24.5 microns
Length of archaeopyle=44.0 microns
Width of archaeopyle=41.8 microns

G. cf. G. fetchamensis

(Pl. II—5)

Slide and Coordinates : P—7—2 : 32.3×105.5 & 7.5×95.5

Description : This specimen compares well with Sarjeant's (1966, Pl. 15, Figs. 1 and 2) specimen, but has only one posterior and no anterior intercalary plate, whereas, the English specimen has two posterior intercalary plates, and one anterior intercalary plate. Indian specimen also shows some intra tabular ridges.

Dimension : Diameter of shell=96.8 microns
Archaeopyle length=66.0 microns
Length of horn=25.3 microns
Width of horn=8.8 microns at base.

G. cf. G. hadra

(Pl. II—10)

Slide and Coordinates : Paly/DF/A—20—1 : 11.6×104.5

Description : Present specimen differs from Sarjeant's (1966, Pl. 14, fig. 1) specimen in having only three apical plates instead of 4, and cingular plates are not clearly seen, but probably are not more than 4. A round thick plate is present on the plate 3", which is, though detached from the shell, but is not separated.

Dimension : Diameter of shell=91.3 microns
Length of archaeopyle=40.0 microns
Width of archaeopyle=35.0 microns.
Length of horn=22.0 microns
Width of horn=11.2 microns at base,
3.5 microns at tip.

G. cf. G. orthoceras

(Pl. II—8)

Slide and Coordinates : P—3—2 ; 28.5×103.9

Description : Cyst almost sphaerical with a long and prominent apical horn. Wall finely reticulate. Margins of plates are crested. Tabulation is 3', 6", 6c, 6"', IP, 1. Archaeopyle is formed by the loss of plate 3".

Dimension : Diameter along cingulum=110.0 microns
Diameter of archaeopyle=36.3 microns
Length of apical horn=30.8 microns
Width of apical horn=11.0 microns at base and 5.5 microns at tip
Length of sulcus=51.7 microns
Width of sulcus : Maximum=36.0 microns.
Minimum=6.6 microns.

Remarks : The present species compares well with Davey *et al.* (1966, Pl. 14, Figs. 5 and 6), but differs in having only 6 post cingular plates instead of 7, and also in the absence of anterior intercalary plates. The arrangement of epittractal plates is also a little bit different. In other specimen (Slide : Paly/DF/A—11—A Coordinates : 43.0×105.5) of *G. cf. G. orthoceras*, there

are 7 precingular plates but the general arrangement of plates is a little different.

G. cf. G. perforans

(Pl. III—6)

Slide and Coordinates : P—7—2 : 15.5×104.8

Description : Cyst elongated, longer than broad. Epitheca conical and hypotheca more or less round. Archaeopyle precingular and haplotabular. Plate boundaries are prominent and are marked by membranous crests, wall thin reticulate, apical horn with spiny outgrowths. Sulcus not clearly seen, thus correct tabulation cannot be done. Cingulum is helicoid and plates are not visible.

Dimension : Diameter of shell along cingulum=77.0 microns

Length of archaeopyle=45.0 microns
Width of archaeopyle=12.5 microns
Length of apical horn=27.5 microns
Width of apical horn=13.2 microns at base and 4.4 microns at tip

Remarks : The present specimen compares with Cookson and Eisenack's (1958, Pl.-1 and 2, Figs. 1 to 4) in overall shape and broad structures, and also the wall characters. Since the tabulation is not clear in the present specimen, exact comparison is impossible.

Gonyaulacysta sp. A

(Pl. II—7)

Slide and Coordinates : P—17—2 : 93.0×46.3

Description : Cyst sphaeroidal to ovoidal in shape. Tabulation is not clear. Cingulum is helicoid, and cingular plates form sharp contact with epittractal and hypottractal plates. The contacts are crested. Apical horn present. Sulcus not clearly seen. Archaeopyle precingular. Wall finely granulate and thin, with occasional spiny structures.

Dimension : Total length (including horn)=90.2 microns

Length of horn=27.5 microns
Diameter of body=60.5 microns
Diameter of archaeopyle=38.5 microns.

Remarks : The present specimen compares with *Gonyaulacysta sp.* of Jain and Tougeourdeau Lantz (1973, Pl.-4, fig.-4). Since the tabulation is not clear in either specimen, this comparison is on the basis of superficial resemblance.

Gonyaulacysta sp. B

(Pl. III—5)

Slides and Coordinates : P—17—2 : 28.7×100.8 & 24.0×100.0

Description : Body sphaerical to oval in shape without any prominent apical horn. Plates and their boundaries are not clear, thus precise tabulation is difficult. Wall

thick with cauliflorate processes all over the body, mostly unbranched. Archaeopyle precingular. Cingulum is more or less helicoid.

Dimension : Maximum diameter of shell=69.3 to 85.0 microns
 Length of archaeopyle=26.4 to 38.5 microns
 Width of archaeopyle=11.0 to 13.5 microns
 Length of processes=3.3 to 5.5 microns
 Width of processes=1.0 to 2.5 microns
 Thickness of wall=5.0 microns.

Remarks : These forms do not resemble with any described form, except *G. helicoidea* illustrated by Singh (1971, Pl.-4, figs. 6, 7).

Gonyaulacysta sp. C
 (Pl. II—11)

Slide and Coordinates : P—7—2 : 41.3×95.0

Description : Body sphaerical with apical horn. Plate boundaries are not clear. Archaeopyle precingular and seems to be formed by the loss of more than one plate. Plate margins are crested. Wall reticulate and thin. Cingulum and sulcus are not clearly visible.

Dimension : Diameter of shell=57.5 microns
 Length of horn=16.5 microns
 Width of horn=5.5 microns

Remarks : In overall appearance the specimen resembles *G. cf. G. wetzeli*, Deflandre and Cookson (1955, Pl.-1, fig. 3) but is smaller in size.

Gonyaulacysta sp. D
 (Pl. II—13)

Slide and Coordinates : P—7—1 : 17.7×93.6

Description : Subsphaerical cyst with a short apical horn. Cingulum and sulcus seen predominantly and sulcus extends both in epittractal and hypottractal plates and their boundaries are also not clear. Probable tabulation is 1', 6'', 6C, 6''', 1''''', wall is finely reticulate.

Dimension : Diameter of central body=60.5 microns
 Length of horn=2.2 microns
 Width of horn=8.5 microns at base

Remarks : This specimen resembles *Gonyaulacysta* sp. of Corradini (1972, Pl. 19, fig. 3).

Gonyaulacysta sp. E
 (Pl. III—4)

Slide and Coordinates : P—7—1 : 15.5×108.5

Description : Small subsphaerical cyst, with a prominent apical horn. Ventral side is not seen, thus the position of sulcus is hypothetically taken here for tabulation. Archaeopyle precingular. Wall thick and finely reticulate. Probable tabulation is 1', 6'', ? 6C, 6'''. No antapical plates are present.

Dimension : Diameter of shell=41.8 microns
 Length of horn=8.8 microns
 Width of horn=5.5 microns.

Gonyaulacysta sp. F.
 (Pl. III—9)

Slide and Coordinates : P—3—2 : 18.6×111.4

Description : Subsphaerical body without apical horn. Tabulation visible only on the dorsal side. Archaeopyle precingular, but the presence of sulcus is not clear. The presence of two plates on the ventral side probably are IP and IPV. Plate boundaries are marked by membranous crests. Wall is thick and reticulate.

Dimension : Diameter of body=64.0 microns
 Diameter of archaeopyle=17.5 microns
 Thickness of wall=2.5 microns
 Height of crests=3.5 microns.

Gonyaulacysta sp. G.
 (Pl. III—2)

Slide and Coordinates : P—3—2 : 112.0×9.0

Description : Sphaerical cyst with an apical horn. Plate boundaries are clear and crested. Wall thick and reticulate and spinose. Archaeopyle precingular. Sulcus covers both epittractal and hypottractal regions. Exact number of cingular plates are not visible. Tabulation is 3', 1a, 4'', 6c(?), 6''', 1P, 1PV, 1''''.

Dimension : Diameter of body=85.8 microns
 Length of horn=16.5 microns
 Width of horn=5.5 microns
 Length of archaeopyle=44.0 microns
 Width of archaeopyle=27.5 microns
 Thickness of wall=1.8 microns
 Height of crests=3.5 microns

Gonyaulacysta sp. H
 (Pl. II—12)

Slide and Coordinates : Paly/DF/A—10.1 : 6.6×110.0

Description : Body sphaerical with apical horn. Body surface is covered with plates but the presence of cingulum cannot be identified definitely. Wall thick and reticulate with small and few aculeate processes. The probable tabulation is 1', 6'', 1 or more c, 6'''. No antapical plates are observed. Plate boundaries are crested and archaeopyle precingular.

Dimension : Diameter of body=71.5 microns.
 Length of apical horn=27.5 microns
 Width of apical horn=16.5 microns
 Length of processes=4.5 microns
 Width of processes=2.5 microns
 Thickness of wall=1.5 microns

Gonyaulacysta sp. I.
 (Pl. III—7)

Slide and Coordinates : Paly/DF/A—11—B : 46.4 × 101.0

Description : Subsphaerical elongated cyst, without apical horn. Plates and margins are sharp and crested. The plates, which forms archaeopyle is detached from the body but not separated. Sulcus is not clearly seen. Wall reticulate. Tabulation is interpreted as 1', 6", 6c(?), 6" ', 1" ''.

Dimension : Length of body=83.6"
Width of body=66.0"
Maximum Diameter of archaeopyle=49.5"

Leptodinium KLEMMENT, 1960 emend. SARJEANT, 1969

Type species : *L. subtile* KLEMMENT, 1960

Leptodinium sp. A

(Pl. VI—5)

Slide and Coordinates : P—17—1 : 40.3 × 95.0

Description : Proximate subsphaerical cyst, with distinct endocoel. Wall two layered, which are in close contact. Endophragm is finely reticulate and periphragm forms small processes all over the body surface. The contact of the plates are marked by ridges. Tabulation is not very clear. Archaeopyle is precingular.

Dimension : Length of body=66.5 microns
Width of body=56.0 microns
Length of archaeopyle=20.0 microns
Width of archaeopyle=11.5 microns
Length of processes=2.5 to 4.0 microns
Thickness of wall=1.5 microns

Comments : This specimen though does not show clear tabulation, but roughly conforms to 4', 6", 5" ', IP, 1" ' tabulation given by Klemment (1960). Because of absence of apical horn and plates generally convex, this specimen is put under the genus *Leptodinium*.

Leptodinium sp. B

(Pl. V—3)

Slide and Coordinates : P—3/1, 17.0 × 96.0

Description : Proximate subsphaerical cyst without any horns or processes. Wall two layered, endophragm reticulate, and periphragm psilate-forming ridges at the boundaries of plates. Cingulum is well defined with probably 4 plates, but sulcus is faintly visible. Archaeopyle is probably formed by the loss of plate 5" and 5" ', and the probable tabulation is 3', 5", 4C, 5", 2" ''.

Dimension : Diameter of shell=67.0 microns
Length of archaeopyle=46.0 microns
Width of archaeopyle=16.5 microns

?*Leptodinium* sp. C

(Pl. VI—11)

Slide and Coordinates : Paly/DF/A—11—1 : 14.1 × 94.5

Description : Proximate, subsphaerical cyst. Wall thick and two layered, endophragm thick and reticulate, periphragm thin and psillate and forming crests on the plate margins. There are no processes or any horn and plate boundaries are not clear. Sulcus and cingulum is not seen, thus orientation and tabulation is difficult. Archaeopyle is probably precingular.

Dimension : Length of cyst=88.0 microns
Width of microns=73.7 microns

?*Leptodinium* sp. D

(Pl. VI—13)

Slide and Coordinates : P—3—1 : 95.1 × 6.0

Description : Proximate subsphaerical cyst, without any horn and processes. The position of sulcus and cingulum is uncertain, archaeopyle probably is precingular. Wall two layered, endophragm finely reticulate, and periphragm forms small hollow evexate processes.

Dimension : Length of body=90.2 microns
Width of body=77.0 microns
Diameter of archaeopyle=55.0 microns
Thickness of wall=3.3 microns

Ascodinium Cookson and Eisenack, 1960

Type Species : *A. acrophorum* Cookson and Eisenack, 1960

Ascodinium sp.

(Pl. III—3)

Slide and Coordinates : Paly/DF/A—20-1 : 23.0 × 94.5

Description : Cyst almost oval in shape with more or less straight boundaries. One short apical and probably two very short antapical rudimentary horns present. No plates developed. Periphragm and endophragm are in close contact. Cingulum is marked by two parallel clearly visible ridges. No archaeopyle is seen, but a small rupture in precingular position is present, which could be an archaeopyle.

Dimension : Length of body=87.4 microns
Width of body=71.5 microns
Length of apical horn=5.5 micron
Width of apical horn=13.2 microns

Hystrichosphaeridium DEFLANDRE, 1937, emend. DAVEY and WILLIAMS, 1966

Type Species : *Xanthidium tubiferum* EHERENBERG, 1938

H. coelenteratum

(Pl. IV—10)

Slide and Coordinates : P—3—1 : 8.1 × 103.8

Description : The present specimen is similar to the illustration of Tasch *et al.* (1964, Pl. 2, Fig. 11), but the authors have not given the complete details of morpho-

logical features of the processes. In the illustration two types of processes are seen, one thin and the other thick. No mention has been made about the archaeopyle.

Dalmiapuram specimen has an apical archaeopyle. The wall is scabrate and the processes are of two types, thicker, hollow, longer and aculeate and thinner, solid, shorter, orthogonal and at times attached by thin membranous sheath. The unsheathed processes may be branched once or twice.

Dimension : Length of central body=48.4 microns
Width of central body=38.5 microns
Processes (a) Length=22.0 and Width=6.5 microns
(b) Length=16.5 and Width=3.0 microns
Diameter of archaeopyle=22.0 × 38.5 microns.

H. monstruosum

(Pl. IV—1)

Slide and Coordinates : Paly/DF/A—10-2 : 21.5 × 101.5

Description : This species has two kinds of processes, one are large tabular, patulate to tubiform and others are short, thin tubular, orthogonal and are often perforated. Total number of processes are 14 or more. Archaeopyle apical.

Dimension : Diameter of central body=44.0 microns
Patulate processes, Length=32.5 microns
Width=11.5 at base and 5.0 microns at the tip
Orthogonal processes, Length=16.5 microns
Width=2.5 microns

H. stellatum

(Pl. IV—7)

Slide and Coordinates : Paly/DF/A—10—2 : 30.5 × 106.4

Description : Body spherical, wall psilate, archaeopyle apical, processes tubiform and unbranched. This specimen compares well with Drugg (1967, Pl. 4, Fig. 11) and Cookson and Hughes (1964, Pl. 9, Fig. 11).

Dimension : Diameter of central body=45.0 microns
Length of processes=16.0 to 20.5 microns
Width of processes=10.0 to 14.5 microns

H. tubiferum

(Pl. III—12)

Slide and Coordinates : P—7—2 : 10.5 × 100.6

Description : Body spherical with short processes, archaeopyle apical. Processes are tubiform with distal denticulate to serrate circular margins. Present specimen compares well with Davey *et al.*, (1966, Pl. 10, fig. 10).

Dimension : Diameter of central body=41.9 to 49.5 microns

Diameter of archaeopyle=11.5 × 38.8 microns

Length of processes=14.0 to 27.5 microns

Width of processes=6.5 microns at base and 3.0 to 11.0 microns at tip.

H. unituberculatum

(Pl. III—11)

Slide and Coordinates : Paly/DF/A—20—2 : 19.0 × 97.2

Description : Oval to subspherical body with numerous processes distributed all over body. Archaeopyle apical. Processes solid, curved inwards, unbranched and capitate. Wall thin and psilate. Some processes are smaller than others. Present specimen compares Tasch *et al.*, (1964, Pl. 3, Fig. 8), but its processes are comparatively longer and in most cases curved inwards. The inner ring of pointed protuberances is faint but present in Dalmiapuram specimen.

Dimension : Diameter of central body=41.5 × 33.0 microns

Diameter of archaeopyle=23.0 microns

Length of processes=18.6 microns

Width of processes=8.0 microns

Hystrichosphaeridium sp. A

(Pl. IV—3)

Slide and Coordinates : P—7—1 : 7.6 × 108.3

Description : Central body subspherical with many short processes. Processes are aculeate, broader at base and branched at tips. Sometimes these processes are connected by a thin membranous sheath. Wall thin and scabrate to finely reticulate. Archaeopyle probably apical, but not seen clearly.

Dimension : Diameter of central body=50.0 microns

Length of processes=7.5 microns

Width of processes=5.0 microns.

Hystrichosphaeridium sp. B

(Pl. IV—5)

Slide and Coordinates : P—17—2 : 20.7 × 102.8

Description : Central body spherical, processes are of mainly two types, one thick and hollow, open distally and other are thin and brached distally. These processes are connected by a thin membranes sheath in most cases, and in tratubular hollow and tubiform. Archaeopyle apical.

Dimension : Total diameter (including processes)=60.5 microns

Diameter of archaeopyle=12 to 14 microns

Length of processes=13.5 microns

Width of processes, thick=13.0 microns
thin=3.5 microns

Oligosphaeridium Davey and Williams, 1966

Type Species: *Xanthidium tubiferum* complex White, 1848

Oligosphaeridium complex

(Pl. I—9 & IV—6)

Slides and Coordinates: P—3—2 : 14.0 × 107.7
P—3—2 : 6.7 × 109.5
P—3—2 : 3.5 × 109.5
Paly/DF/A-11-A : 34.1 × 112.9
P—17—2 : 8.0 × 107.8

Description: Central body subspherical with fewer processes all over the body. Processes branched, digitate, tubular, open distally and fairly large in relation to the diameter of the central body. Endophragm thin and psilate and periphragm forms processes. Archaeopyle apical with zig zag margins. Reflected tabulation difficult to infer, because mostly processes are broken.

Dimension: Diameter of central body=45 to 56 microns
Length of processes=28 to 45 microns
Width of processes=2.5 to 6.0 microns
Diameter of archaeopyle= 25.0 to 40.0 Microns

Oligosphaeridium sp.

(Pl. IV—4)

Slide and Coordinates: Paly/DF/A—11—C : 44.0 × 110.2

Description: Central body oval, processes more than 8, tabular, aculeate to orthogonal, wall thin and psilate. Archaeopyle apical.

Dimension: Diameter of body=30.5 × 45.5 microns
Length of processes=15.5 microns
Diameter of archaeopyle=33.0 × 16.5

Taxosphaeridium DAVEY and WILLIAMS, 1966

Type Species: *T. variecalamum* DAVEY and WILLIAMS, 1966

T. variecalamum

(Pl. V—2)

Slide and Coordinates: Paly/DF/A—19—2 : 39.6 × 116.4

Description: Body elongated cup shaped, with granular surface. Apical archaeopyle. Body covered with numerous processes, which are long, slender, broader at base than at the tip, slightly bifurcate at the tips. The present specimen compares with *Hystichosphaeridium isocalamus* described from Lower Cretaceous of Australia by Deflandre and Cookson (1955, Pl. 2, figs. 7 and 8). But the type of processes and their distribution is more like *T. variecalamum*, Davey and Williams (1966).

Dimension: Length of body=30.5 microns

Width of body=22.0 microns

Processes, Length=14.0 microns

Width=1.5 to 2.4 microns

Diameter of archaeopyle=22.0 microns

Palaeoperidinium DEFLANDRE, 1934 emend. SARJEANT, 1967

Type Species: *P. pyrophorum* (EHERENBERG) DEFLANDRE, 1934 emend. SARJEANT, 1967

P. spinosum

(Pl. IV—12)

Slide and Coordinates: P—17—2 : 18.4 × 100.7

Description: Body oval shaped, plates of epittract, cingulum and hypottract are clearly visible. Periphragm thin and covered with short evaxate and tubiform processes, endophragm finely reticulate. Archaeopyle precingular and formed by the loss of plate 3". Ornamentation heavy on the borders of plates. Tabulation 2', 5'', 6C, 4''.

Dimension: Length of shell=88.0 microns
Width of shell=82.5 microns
Archaeopyle length=52.8 microns
Width of archaeopyle=13.5 microns
Length of processes=4.0 microns
Width of processes=1.5 microns

Apteodinium EISENACK, 1958

Type Species: *A. granulatum* EISENACK, 1958

Slide and Coordinates: P—17—2 : 11.7 × 105.2

Description: Proximate cyst, oval and compressed, cingulum clear and forms a girdle along which the specimen is compressed, thus epittract and hypottract are superimposed on each other. Apical horn hollow, archaeopyle precingular, without tabulation and surface of the body finely reticulate.

Dimension: Length of body=100.0 microns
Width of body=71.5 microns
Length of apical horn=11.5 microns
Thickness of wall=2.0 microns

?*Apteodinium* sp.

(Pl. VI—8)

Slide and Coordinates: P—7—1 : 17.7 × 93.4

Description: Subspherical body with an apical horn. Body psilate, thin and without plates. No cingulum is visible and sulcus absent. A large opening in the body is present, which looks to be torn off wall, which might be an archaeopyle. The whole structure is like a sphere with a horn and an opening.

Dimension: Diameter of shell=41.0 microns
Length of horn=6.6 microns
Length of opening=27.5 microns

Width of opening=5.5 microns to 10.0 microns.

Comments : This specimen resembles with *Apteodinium reticulatum*, but is much smaller in size and does not have any cingulum and surface is psilate.

Pareodinia DEFLANDRE, 1947

Type Species : *P. ceratophora* DEFLANDRE, 1947

P. cf. P. villosa

(Pl. IV—9)

Slide and Coordinates : P—17—1 : 38.3 × 105.2

Description : Body subellipsoidal with a short neck like extension and covered with many processes. Wall thin, sectose, plates are not distinctive. Processes are short and hair like. Archaeopyle precingular.

Dimension : Length of shell=60.5 microns

Width of shell=38.5 microns

Odontochitina (DEFLANDRE), DAVEY, 1970

Type Species : *O. operculata* (O. WETZEL) DEFLANDRE, 1946

O. operculata

(Pl. I—1)

Slide and Coordinates : Paly/DF/A—19 : 39.6 × 116.4

Description : Cyst cavate and central body oval with one apical and two antapical horns. Apical horn long slender with perforations near the base. The two antapical horns are of different sizes and situated close together. One short thinner and almost of uniform thickness, other is long, broader at the base and thins out to a point at the tip. These horns do not show any kind of perforations.

Dimension : Central body=Length : 79.2 microns,
Width : 52.8 microns

Apical horn=Length : 95.7 microns,
Width : 11.0 microns at base, 5.5 microns at tip.

Antapical horns=

Length=104.5 microns

Width=22.0 microns at
base, 4.4 microns at
tip.

(b) Short :

Length=77.0 microns

Width=3.5 microns

Comments : The present species compares well with the specimen of Norvick (1976, Pl. 14, Fig. 1, Text Fig. 16) from Albian of Artesian Basin, Australia.

O. cf. O. operculata

(Pl. IV—11)

Slide and Coordinates : P—17—1 : 45.6 × 107.6

Description : Shell almost spherical, wall two layered periphragm forms one long antapical horn, and

endophragm forms the shell. The presence of apical horn looks doubtful. Archaeopyle apical. This species differs from *Odontochitina subbaramana* Jain and Lantz (1973) in having only one antapical horn and in the absence of perforations on horns.

Dimension : Diameter of central body=44.0 microns

Length of antapical horn=60.0 microns

Length of archaeopyle=27.5 microns

Width of archaeopyle=11.0 microns

Odontochitina sp. A

(Pl. V—11) :

Slide and Coordinates : Paly/DF/A—19(2) : 11.1 × 96.1

Description : Shell globular to oval in shape. There is no apical horn, but two antapical horns are present, one short and another long. Periphragm is thin and psilate. Apical horn probably is broken, which forms apical archaeopyle.

Dimension : Length of the shell=49.5 microns

Width of the shell=33.0 microns

Length of archaeopyle=35.0 microns

Width of archaeopyle=27.5 microns

Length of longer horn=88.0 microns

Maximum width of longer horn=19.0 microns

Length of shorter horn=49.0 microns

Maximum width of shorter horn=10.0 microns

Odontochitina sp. B

(Pl. V—6)

Slide and Coordinates : Paly/DF/A—11(A) : 43.0 × 103.5

Description : Shell subspherical with only one antapical horn. The specimen seems to be broken and incomplete, otherwise it looks like *O. cf. O. operculata*. Wall is not well differentiated into the periphragm and endophragm.

Dimension : Diameter of shell=35.0 microns

Length of horn=55.0 microns

Width of horn at base=16.5 microns

Width of horn at the tip=3.5 microns

Spiniferites MANTELL, 1850 emend. SARJEANT, 1970

Type Species : *Xanthidium ramosa* EHERENBERG, 1838

Spiniferites ramosus var. *ramosus*

(Pl. V—12) :

Slide and Coordinates : Paly/DF/A—10—1 : 36.7 × 94.2

Description : Subspherical elongated cyst, two layered, endophragm thin, psilate, periphragm forms gonal and sutural processes. The gonal processes are triangular with distal trifurcate terminations. The sutural

processes are taeniate and bifurcate distally and also at times covered by a membranous sheath like covering. The sutural crests are connected with the processes and mark the plate boundaries. Archaeopyle precingular.

Dimension : Length of cyst=49.5 microns
Width of cyst=33.0 microns
Length of processes=11.5 microns
Width of processes=5.5 microns

Remarks : The present specimen compares well with Corradini (1972, Pl. 26, Figs. 1 and 2 ; Pl. 36, Figs. 2 3a and 3b).

Spiniferites scabrosa
(Pl. V—7)

Slides and Coordinates : Paly/DF/A—11(B) : 16.9 × 97.8
Paly/DF/A—11(C) : 7.9 × 111.4

Description : Central body ovoidal to sphaerical. The processes are gonal and sutural, their bases are joined by sutural crests. Sutural processes bifurcate and gonal processes are tubiform and divide twice with bifid tips. Wall layered, endophragm is psilate and periphragm is ornamented with 0.5 micron wide closely spaced granules. Cingulum is laevo-rotatory, clearly separating epittractal and hypottractal plates. Reflected tabulation is not clear. Sulcus distinct.

Dimension : Diameter of central body=51.0 to 55.0 microns
Length of processes=7.5 to 10.0 microns
Width of processes=2.0 to 4.5 microns

Remarks : This specimen compares with Singh (1971, Pl. 59, figs. 5-8 ; and Pl. 60, fig. 1).

Spiniferites sp. A
(Pl. V—8)

Slide and Coordinates : P—17—1 : 64.2 × 102.9

Description : Body subsphaerical almost cup shaped. Wall two layered, which are in close contact. Periphragm forms crests and sutural processes. Number of processes fewer and are distinctly placed. Processes are cylindrical and bulbous.

Dimension : Diameter of cyst=48.0 microns
Length of processes=6.4 microns
Width of processes=2.0 microns

Spiniferites sp. B
(Pl. V—13)

Slide and Coordinates : P—17—2 : 29.8 × 105.7

Description : Central body sphaerical. Reflected tabulation is shown by gonal trifurcate and intergonal bifurcate processes. Processes wider at the base and thinner at the top. The presence of archaeopyle is not clearly visible.

Dimension : Diameter of cyst=50.0 microns
Length of processes=6.0 microns
Width of processes=4.0 microns

Remarks : This specimen looks like *S. ramosus* var. *ramosus* but has shorter processes.

Prolixosphaeridium DAVEY *et al.*, 1966
Type Species : *P. deirense* DAVEY *et al.*, 1966
Prolixosphaeridium sp.
(Pl. VI—7)

Slide and Coordinates : P—3—1 : 16.4 × 95.6

Description : Body oval and elongated, apical part a little angular and antapical part round. The apical part does not show a clear archaeopyle, but a faint detachment is seen which probably could be the archaeopyle. Body covered with short, solid processes having capitate tips and wall is granulated.

Dimension : Length of body=46.2 microns
Width of body=31.5 microns
Length of processes=1.5 to 2.5 microns

Remarks : The present specimen does not show a clear archaeopyle and two antapical processes. In overall characters it compares with *P. capitatum*, Singh (1971, Pl. 57, fig. 1).

Canningiopsis COOKSON and EISENACK, 1962
Type Species : *C. denticulata* COOKSON and EISENACK, 1962
Canningiopsis sp. A
(Pl. V—1)

Slide and Coordinates : P—7—1 : 50.8 × 99.0

Description : Proximate cyst, without apical plates. Shell flat almost six sided, with base slightly indented. Cingulum is equatorial in position and sulcus is not present. Hypotract is broader than epittract. Plates of hypotract are distinct and their margins are crested. Wall thin, spinose and reticulate. Archaeopyle apical, formed by the loss of all the apical plates.

Dimension : Length of shell=80.3 microns
Width of shell=63.8 microns
Length of archaeopyle=61.6 microns

Remarks : The present specimen is different from *C. denticulata* Cookson and Eisenack (1962, Pl. 1, figs. 16 to 19) in not having a helicoid cingulum, and in the lack of oblique sulcus.

Canningiopsis sp. B
(Pl. V—4)

Slide and Coordinates : P—7—1 : 35.3 × 98.0

Description : The specimen is like *Canningiopsis* sp. A but is smaller in size.

Dimension : Length of shell=66.0 microns
 Width of shell=56.0 microns
 Diameter of archaeopyle=49.0 microns

Remarks : *Canningiopsis* sp. *B* is more or less cup shaped with round margins.

Dicanthum HABIB, 1972

Type Species : *D. hollisteri* HABIB, 1972

Dicanthum sp.

(Pl. VI—3)

Slide and Coordinates : P—7—2 : 20.0=107.0

Description : Proximate cyst, body sphaerical without any horns or processes. Archaeopyle precingular and formed by the loss of two plates 3'' and 4''. All the plates are clearly visible and their boundaries are crested. Surface striated and thick. Epitract is covered by thin membranous layer. Tabulation is 4', 6'', 6C, 6''', 2''''.

Dimension : Diameter of body=73.5 microns
 Length of archaeopyle=16.5 microns
 Width of archaeopyle=57.0 microns
 Thickness of membranous layer covering epitract=4.5 microns

Remarks : The specimen compares well with Habib (1972, Pl. 9, fig. 1, Text-fig. 2), but is smaller in size and has two antapical plates. Periphragm is striated and without spines.

Microdinium COOKSON and EISENACK, 1960 emend. SARJEANT, 1966

Type Species : *M. ornatum* COOKSON and EISENACK, 1960

Microdinium sp.

(Pl. VI—6)

Slide and Coordinates : P—3—1 : 16.4×95.6

Description : Proximate cyst, oval to elongated without any horn or processes. Wall psilate and forms minor smooth crests at plate margins. Cingulum broad, sulcus extends both in epitract and hypotract. Archaeopyle apical, but is not clearly visible in the specimen. The tabulation is ?1', 6'', 6C, 6''', 1'''' . The plate 1p is also not present.

Dimension : Length of body=55.0 microns
 Width of body=45.0 microns
 Length of archaeopyle=22.0 microns
 Width of archaeopyle=5.5 microns

Remarks : The present specimen is longer than the length range given by Sarjeant (1966) as 30 to 45 microns. The position of archaeopyle is also not very clear, whether it is apical or precingular in position.

Forma A

(Pl. VI—1 and 2)

Slide and Coordinates : P—17—1 : 51.5×110.4

Description : Proximate cyst, body oval to subsphaerical. Wall thick and two layered, endophragm is finely reticulate and thick, periphragm forms small clavate processes. Plate boundaries, though not very distinct, are marked by ridges and small processes. Archaeopyle is large, and probably formed by the loss of more than one plate, and extends in epittractal and hypottractal regions. Cingulum is not clearly marked and sulcus is not seen.

Dimension : Length of cyst=77.0 microns
 Width of cyst=65.0 microns
 Length of archaeopyle=35.0 microns
 Width of archaeopyle=20.0 microns
 Length of processes=5.5 microns
 Thickness of wall (including processes)=10.5 microns

Forma B

(Pl. V—9)

Slide and Coordinates : P—3—2 : 18.6×111.4

Description : Proximate cyst, oval to sphaerical body with short evexate or bulbous processes. Processes unbranched or membranous, broad and recurved at the tip. Wall thin and finely reticulate. The presence of cingulum, sulcus and archaeopyle is not clear. The general plate arrangement is not clearly seen.

Dimension : Length of cyst=60.5 microns
 Width of cyst=51.7 microns
 Length of processes=4.9 microns
 Width of processes=1.5 microns

Cymatiosphaera O. WETZEL, 1933 emend. DEFLANDRE, 1954,

Type Species : *C. radiata* O. WETZEL 1933

Cymatiosphaera sp. *A*

(Pl. VI—10)

Slide and Coordinates : P—7—2 : 36.9×104.1 and 12.5×101.8

Description : Test smooth, sphaerical, hollow, covered with thin membranes connecting short thickened hollow processes. These processes are of variable thickness. In all 16 to 20 polygonal field areas are present.

Dimension : Maximum diameter=60.5 microns
 Minimum diameter=58.2 microns
 Diameter of areas=6.0 to 10.5 microns
 Thickness of wall=2.0 microns
 Length of processes=8.8 to 11.8 microns

Remarks : This specimen resembles with *Cymatiosphaera* sp. *A* of Singh (1971, Pl. 77, fig. 1, 2), but has prominent membranous covering.

Cymatiosphaera sp. *B*

(Pl. VI—9)

Slide and Coordinates : P—7—1 : 32.6×99.8

Description : Shell hollow, oval in shape, external surface divided into polygonal field areas by thick membranous crests. The surface is smooth and the number of field areas range between 12 to 16.

Dimension : Maximum diameter=46.2 microns
Minimum diameter=30.8 microns
Diameter of fields=5.5 to 10.0 microns
Thickness of wall=1.5 microns
Thickness of crests=2.5 to 3.0 microns.

Pterospermopsis W. WETZEL, 1952

Type Species : *P. danica* W. WETZEL, 1952

P. cf. P. australiensis

(Pl. V—14)

Slide and Coordinate : P—3—2 : 15.6 × 106.8

Description : Test almost disc like, central body subsphaerical and scabrate and is surrounded by a flat membranous equatorial wing lamella with radial folds. Folds in the wing are regularly placed, but of varying magnitude. Diameter of central body is about 1/3 of the total diameter of the specimen.

Dimension : Total Diameter=71.5 microns
Diameter of central body=22.5 microns
Radius of lamella=16.5 to 20.0 microns.

Remarks : This specimen is poorly preserved, but it does resemble *P. australiensis* of Deflandre and Cookson (1955, Pl. 3, fig. 4) and the illustration of Singh (1971, Pl. 77, fig. 11 and 12).

Epicephalopyxis DEFLANDRE, 1935

Type Species : *E. adhaerens* DEFLANDRE, 1935

cf. Epicephalopyxis sp.

(Pl. V—10)

Slide and Coordinates : Paly/DF/A—18—4 : 21.0 × 103.0

Description : Oval shell with an opening at one end, without any processes or plates, wall fossulate, and made of chitinous matter.

Dimension : Length of shell=44.0 microns
Width of shell=35.0 microns
Diameter of opening=16.5 microns

Remarks : This specimen compares with *Epicephalopyxis* sp. of Corradini (1972, Pl. 31, figs. 10-11 and Pl. 32, figs. 7a, 7b) but does not show the same wall structure and the opening is not as well defined also.

Palaeostomocystis DEFLANDRE, 1935

Type Species : *P. reticulata* DEFLANDRE, 1935

P. reticulata

(Pl. VI—12)

Slide and Coordinates : Paly/DF/A—19-2 : 33.1 × 112.0

Description : Test flattened, longer than broad with each angular ends. Wall reticulate with small spines with longitudinal folds. Archaeopyle apical. Probably one apical and two antapical horns are present in the form of protuberances.

Dimension : Length of body=88.0 microns

Width of body=60.5 microns

PALYNOLOGICAL ASSEMBLAGE AND DISCUSSION ON AGE

Rao and Venkatachala (1971) reported a rich assemblage of spore and pollen and few dinoflagellates from the gray shale of Dalmiapuram Formation and designated the assemblage to the *Coptospora cauveriana* zone of Aptian—Lower Albian age (Venkatachala *et al.* 1972). This zone is established in the subsurface of Ariyalur-Pondicherry, Tranquebar and Thanjavur depressions. Additional pollen, spore and dinoflagellates are reported by Jain and Tougeourdeau-Lantz (1973) and Jain (1977). An Early Albian age has been given by Jain (1977) to the Grey Shale member of the Dalmiapuram Formation.

Many important taxa occurring in the Grey Shale member of the Dalmiapuram Formation are also found in the Early Cretaceous sediments of Australia, Papua and New Guinea. The following is the list of taxa which are common in their occurrence in Australia and Dalmiapuram.

(A) : Deflandre and Cookson, 1955.

1. *Hystrichosphaera crassipellis* (*Spiniferites scabrosa*) Early Eocene.
2. *H. ramosa* var. *ramosa* (*Spiniferites ramosus*) L. Cretaceous.
3. *Hystrichosphaeridium complex* (*Oligosphaeridium complex*) Senonian and Early Cretaceous.
4. *H. pulcherrimum* (*Oligosphaeridium complex*) E. Cretaceous.
5. *H. polytrichum* (*Cleistosphaeridium diversispinosum*) Senonian.
6. *H. inodes* Early Eocene.
7. *H. striatoconus* (*H. tubiferum*) Senonian.
8. *Pterospermopsis australiensis* Early Cretaceous.
9. *Epicephalopyxis* sp. Early Cretaceous.

(B) : Cookson and Eisenack, 1957

1. *Gonyaulacysta perforans* Late Jurassic.
2. *G. diaphenis* Aptian.
3. *Hystrichosphaeridium complex* (*Oligosphaeridium complex*) Aptian-Albian.
4. *H. anthophorum* (looks like *O. complex*) Aptian-Albian.
5. *Odontochitina operculata* Albian.

(C) : Eisenack and Cookson, 1960

1. *Gonyaulax* (*Gonyaulacysta*) *helicoidea* Aptian or older.
2. *Canningia colliveri* Aptian or older.
3. *Hystrichosphaeridium arundum* (*H. tubiferum*) Albian.

4. *Cannosphaeropsis peridictya* Late Albian to Cenomanian.

5. *Cymatiosphaera* sp. Albian.

(D) : Cookson and Eisenack, 1962

1. *Hystriochosphaeridium stellatum* Albian.

2. *Tenua* sp. Aptian-Albian.

3. *Palaeostomocystis fragilis* (?) Albian-Aptian.

4. *Canningiopsis* sp. (?) Albian-Aptian.

Most of the common taxa listed above belong to the Albian age. Although some of them have longer ranges but mostly they range either Albian and older or Albian and younger.

A list of 14 taxa from the Dalmiapuram grey shale assemblage are listed in Table no. 1. Their geological ranges are given from the Stratigraphic Range Charts of dinoflagellates of Millioud *et al.*, (1975). This clearly indicates an Albian age for the assemblage. In addition, *Apteodinium reticulatum* and *Dicanthum hollisteri* has been described by Singh (1971) from Late Albian of Alberta and by Habib (1972) from Albian of Leg 11, deep sea core 1 at site 100, respectively.

S.N.	Name of Taxa	Stratigraphic Range
1.	<i>Ascodinium</i> sp.	Albian-Cenomanian
2.	<i>Microdinium</i> sp.	Albian and younger
3.	<i>Canningia</i> sp.	Aptian-Albian and younger
4.	<i>Canningiopsis</i> sp.	Albian-Cenomanian
5.	<i>Cannosphaeropsis peridictya</i>	Albian-Cenomanian
6.	<i>Cleistosphaeridium polytes</i>	Barremian-Cenomanian
7.	<i>Cordosphaeridium inodes</i>	Aptian-Albian or older
8.	<i>Exochosphaeridium phragmites</i>	Albian-Cenomanian
9.	<i>Gonyaulacysta helicoidea</i>	Barremian-Albian
10.	<i>G. perforans</i>	Upper Jurassic-Albian
11.	<i>Hystriochosphaeridium arundum</i> (<i>H. tubiferum</i>)	Aptian-Cenomanian
12.	<i>H. stellatum</i>	Albian-Campanian
17.	<i>Odontochitina operculata</i>	Barremian-Campanian
14.	<i>Spiniferites ramosus</i> var. <i>ramosus</i>	Aptian-Cenomanian

Table no.-1—Stratigraphic range of characteristic dinoflagellate taxa from Dalmiapuram Grey Shale

DEPOSITIONAL ENVIRONMENT AND PALAEOECOLOGY

A preliminary statistical analysis of palynological composition shows the following distribution.

Pteridophytic spores	28% to 37%
Coniferous saccate pollen	34% to 37%
Inaperturate pollen	14% to 23%
Dinoflagellate cysts	19% to 22%
Among the dinoflagellate cysts,	
Chorate cysts	64% to 76%
Proximate cysts	24% to 36%
Cavate cysts	less than 4%

A major representation of pteridophytic spores mostly ascribes a nearshore terrestrial vegetation, and an equally

large representation of saccate pollen were perhaps derived from the highlands of central peninsular India. The growth of reefs with abundant amounts of algae, coral and molluscs in Dalmiapuram Farmation indicate a deposition in tropical warm waters, which is also substantiated by the presence of tropical pteridophytic taxa. The abundance of non-saccate gymnospermous taxa (specially *Classopollis*) also suggest a nearshore vegetation.

The occurrence of high percentage of land derived allochthonous elements in the palynomorph assemblage alongwith the autochthonous elements like phytoplankton generally indicate a nearshore shallow marine environment (Upshaw, 1964, Zaitzeff and Cross, 1970). A relatively high percentage of chorate cysts confirms the marine influence. Kumar (1978 : in press) has reviewed the available information on the interpretation of various depositional environments on the basis of dinoflagellate cysts and acritarchs.

Jain (1977) considers the lower part of the shale member was deposited in shallow, comparatively open marine environment, whereas the upper part was deposited in nearshore shallow marine environment. The palaeogeography of the area at the time of deposition of Dalmiapuram Formation does not suggest an open marine condition, but instead, the deposition took place in a bay. The Dalmiapuram bay of Albian time was shallow in which these shales were deposited. The growth of reefs along the margins and at the open end of bay restricted the mixing of bay waters with open sea. The deposition took place at a slow pace under reducing conditions.

CONCLUSION

(1) The present paper describes a varied and diversified assemblage of dinoflagellate cysts and acritarchs covering 26 genera and 69 species.

(2) The Grey Shale Member of Dalmiapuram Formation is assigned an Albian age.

(3) The deposition of these shales took place in reducing environment, in a shallow bay. The water circulation from this bay to the open sea was restricted by growth of reefs.

(4) The flora and fauna indicate tropical climate during the time of deposition.

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EXPLANATION OF PLATES

PLATE I

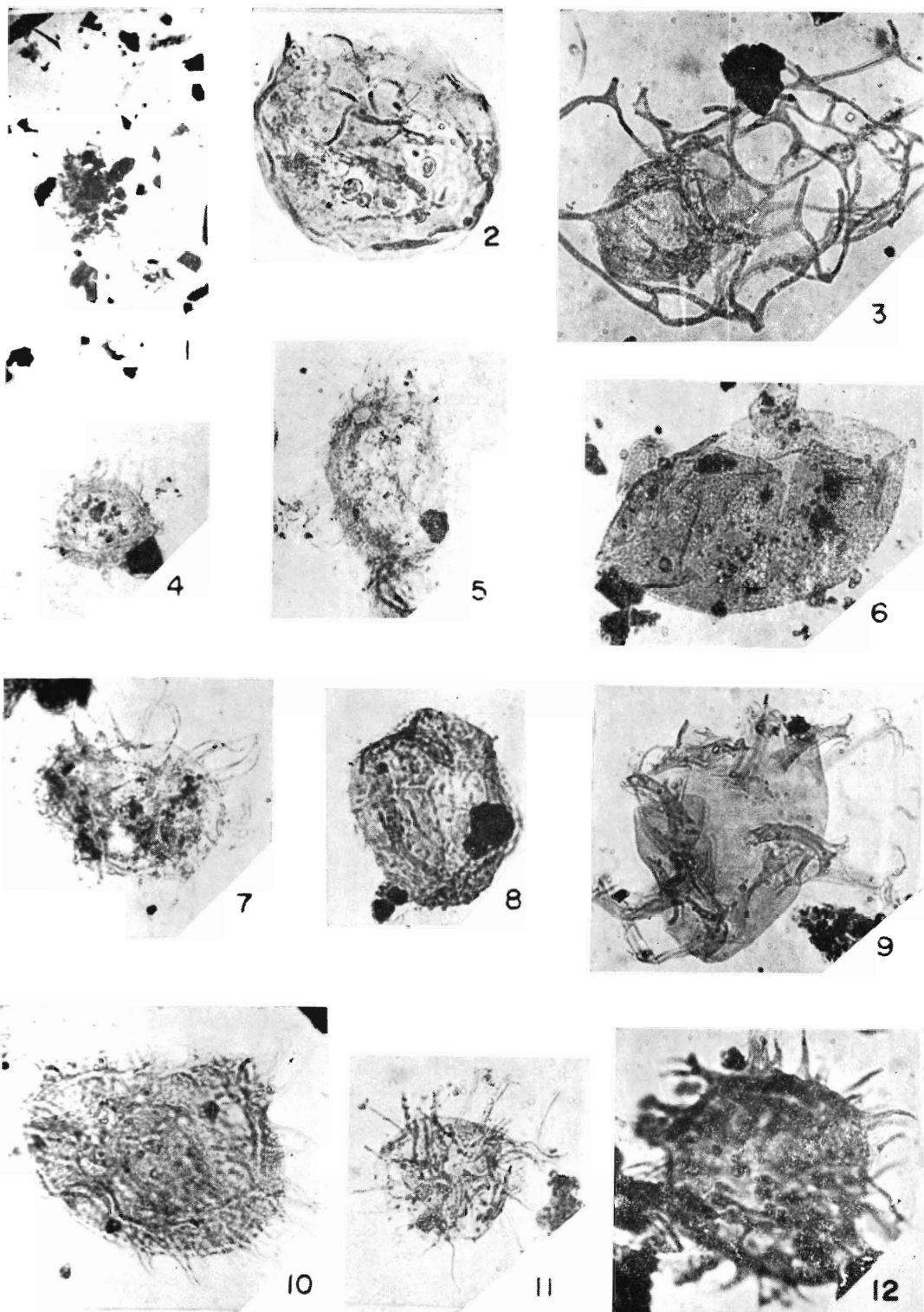
1. *Odontochitina opeculata*
2. *Canningia* sp.
3. *Cannosphaeropsis peridictya*
4. *Cleistosphaeridium* cf. *C. polytes*
5. *Cleistosphaeridium* sp. *C.*
6. *Tenua* aff. *hystrix*
7. *Cleistosphaeridium diversispinosum*
8. *Tenua* sp.
9. *Oligosphaeridium complex*
10. *Cleistosphaeridium* sp. *A.*
11. *Cleistosphaeridium* sp. *B.*
12. *Cleistosphaeridium* cf. *C. mediterraneum*

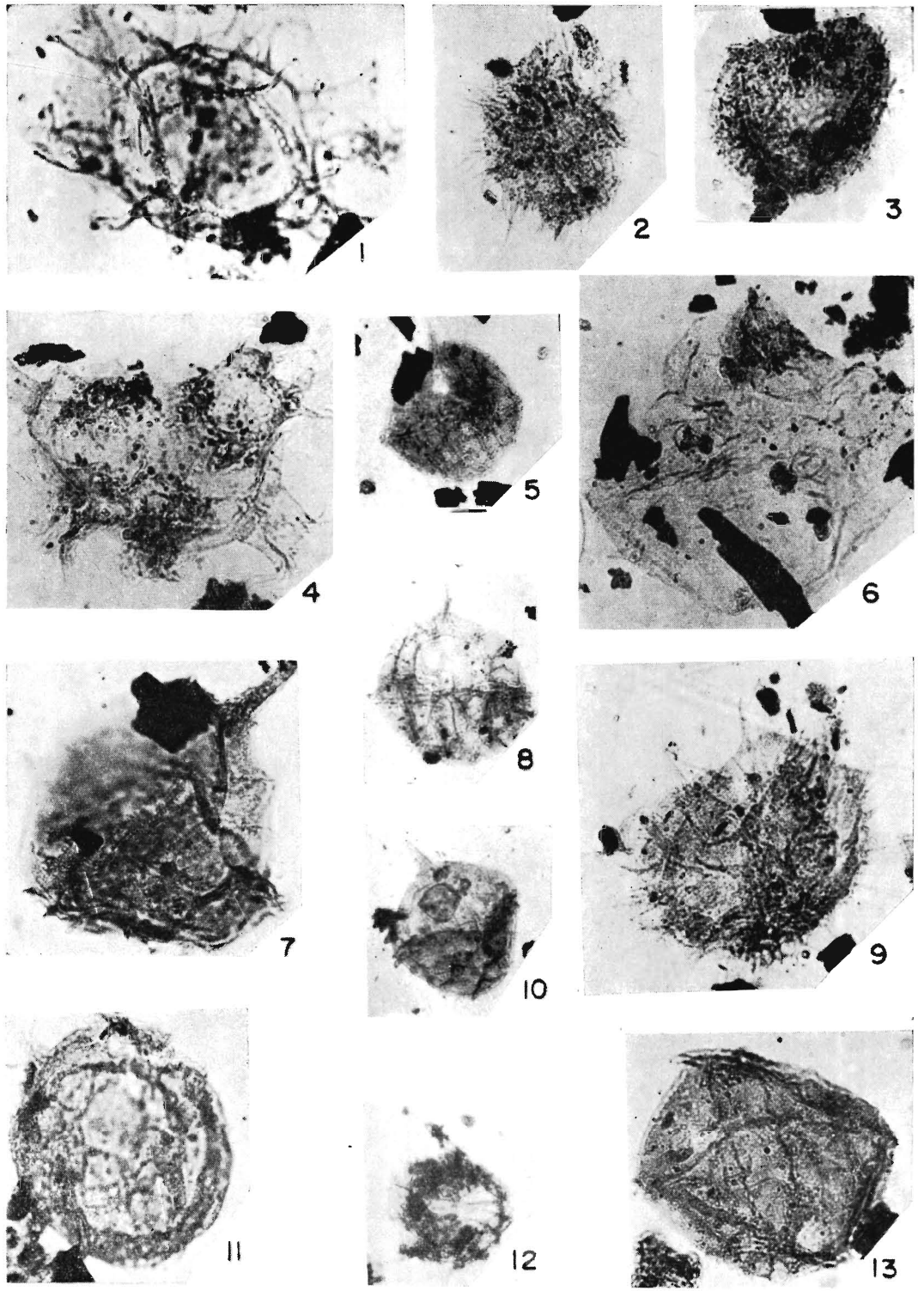
PLATE II

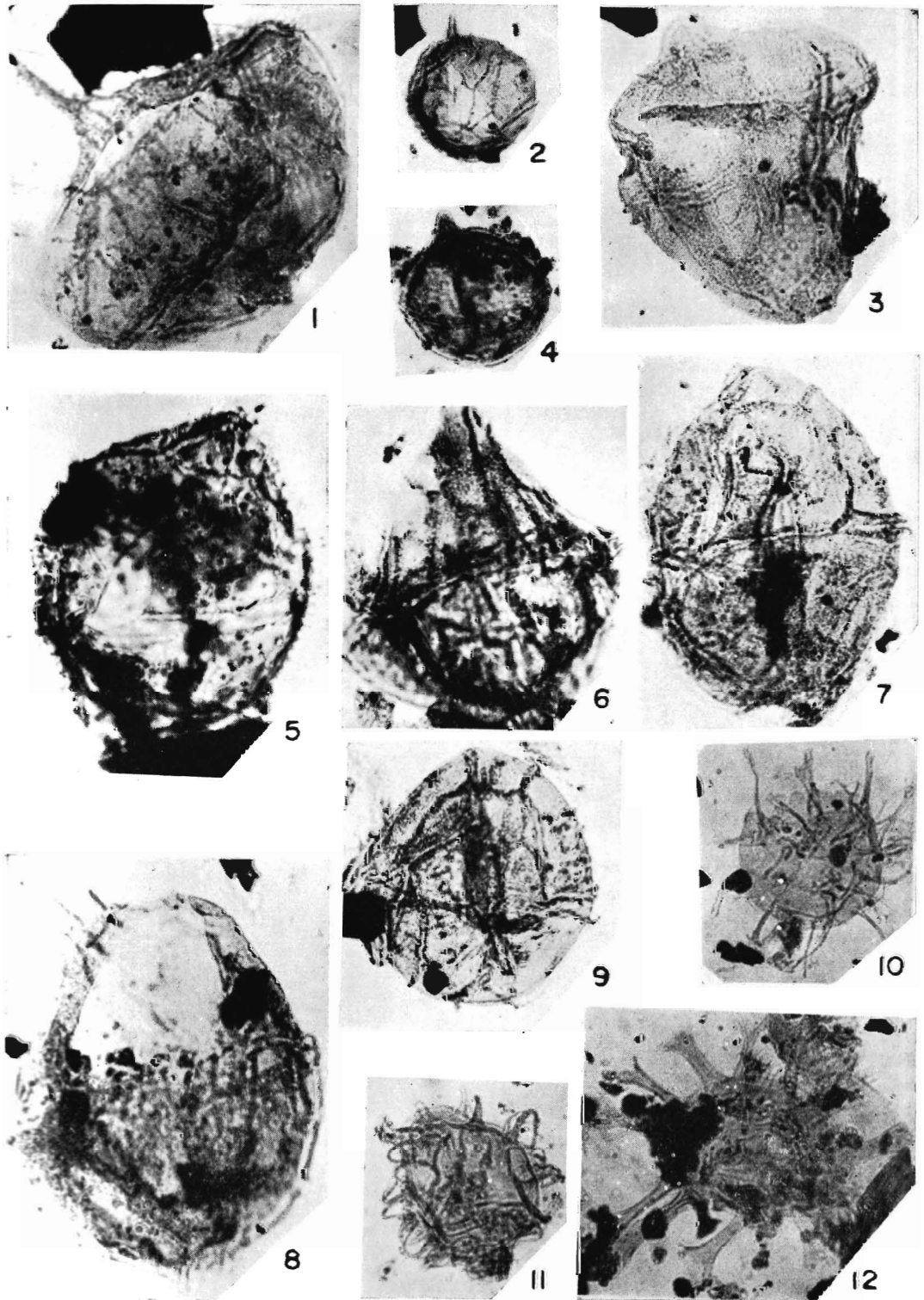
1. *Cordosphaeridium* sp. *A.*
2. *Exochosphaeridium* sp. *A.*
3. *Cleistosphaeridium* sp. *D.*
4. *Cordosphaeridium* cf. *C. multispinosum*
5. *Gonyaulacysta* cf. *G. fetchemensis*
6. *Astrocysta* sp.
7. *Gonyaulacysta* sp. *A.*
8. *Gonyaulacysta* cf. *G. orthoceras*
9. *Exochosphaeridium phragmites*
10. *Gonyaulacysta* cf. *G. hadra*
11. *Gonyaulacysta* sp. *C.*
12. *Gonyaulacysta* sp. *H.*
12. *Gonyaulacysta* sp. *D.*

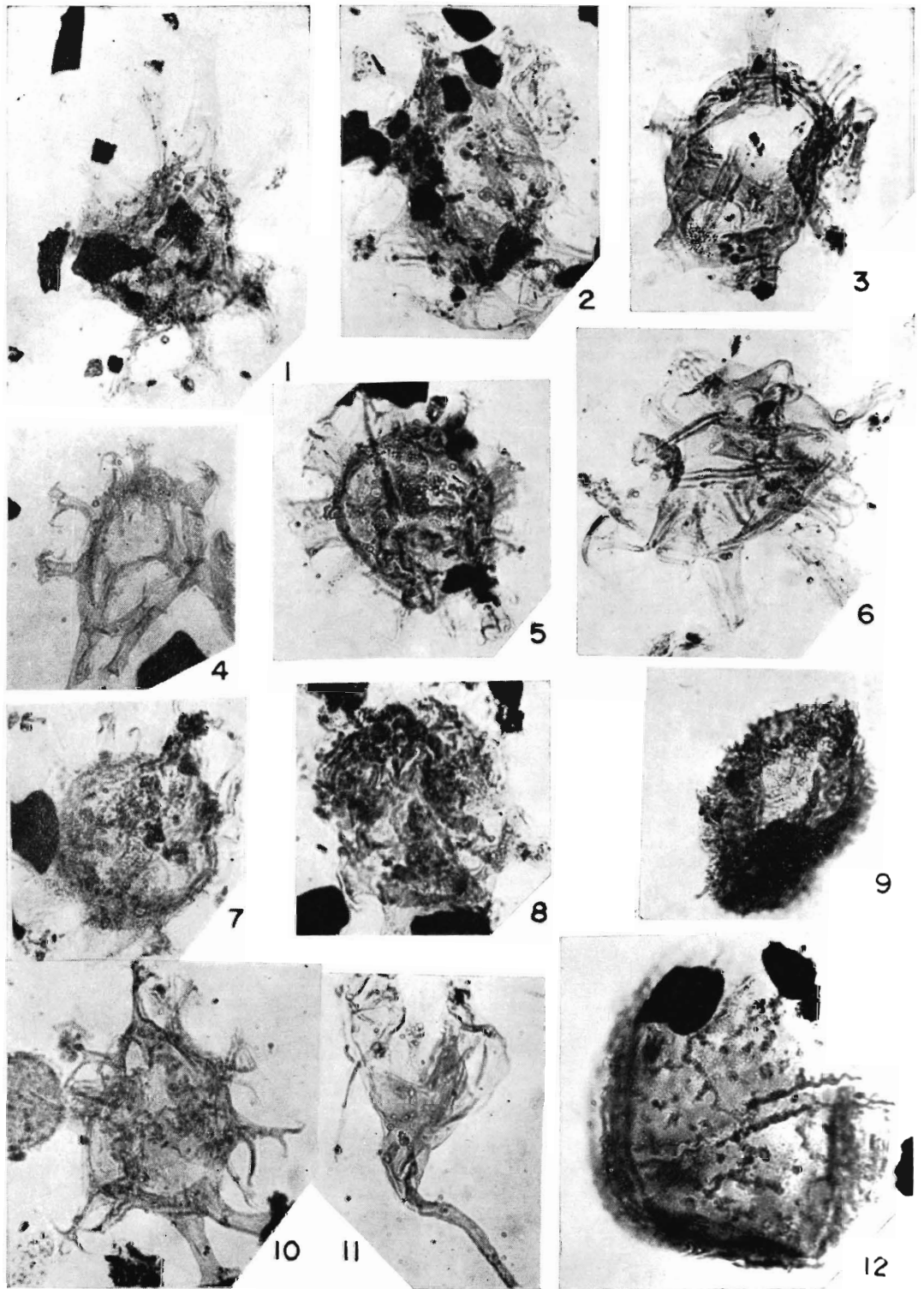
PLATE III

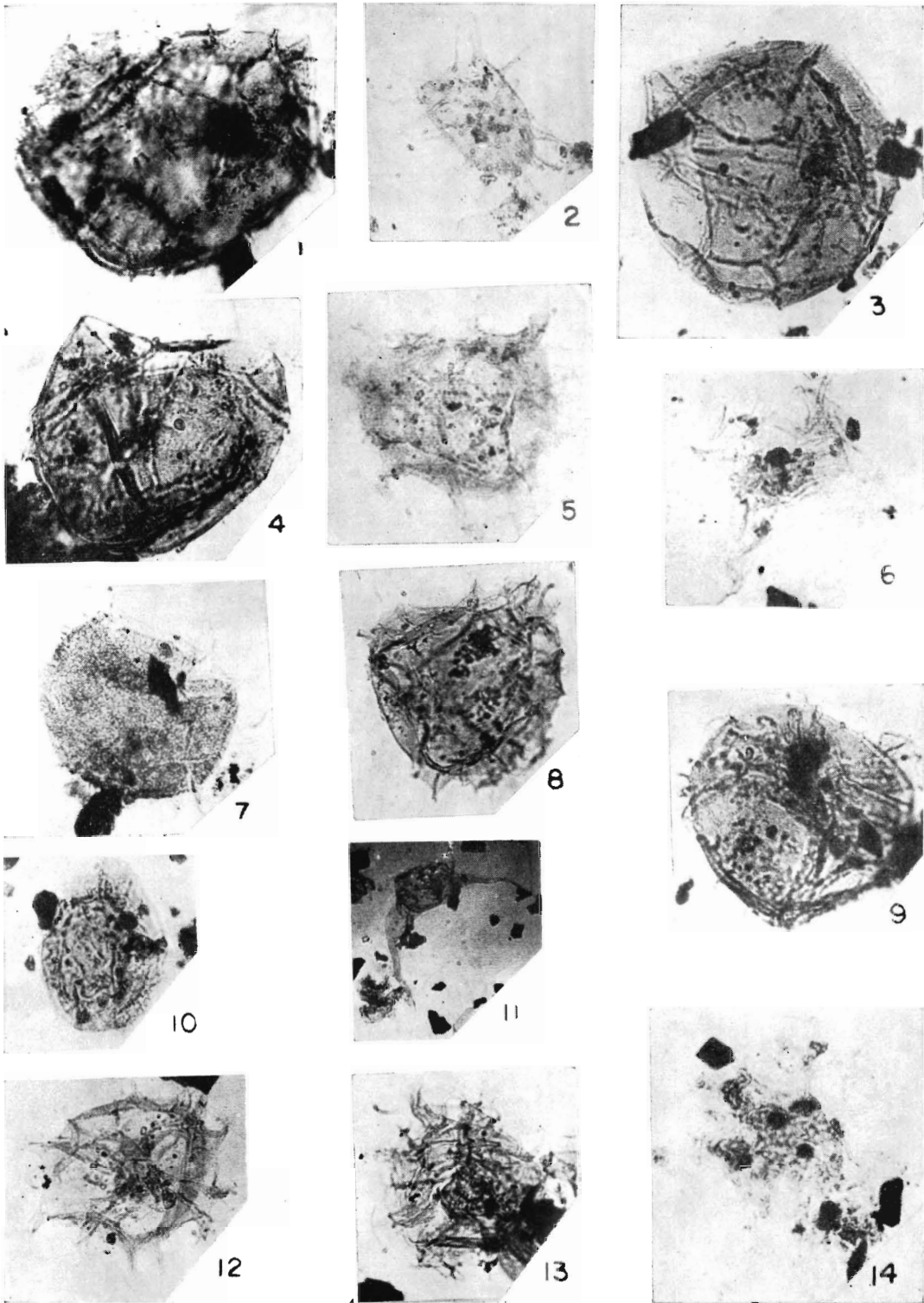
1. *Gonyaulacysta edwardsi*
2. *Gonyaulacysta* sp. *G.*
3. *Ascodinium* sp.
4. *Gonyaulacysta* sp. *E.*
5. *Gonyaulacysta* sp. *B.*
6. *Gonyaulacysta* cf. *G. perforans*
7. *Gonyaulacysta* sp. *I.*
8. *Gonyaulacysta* cf. *G. diaphanis*
9. *Gonyaulacysta* sp. *F.*
10. *Cordosphaeridium* sp. *B.*
11. *Hystrichosphaeridium unituberculatum*
12. *H. tubiferum*











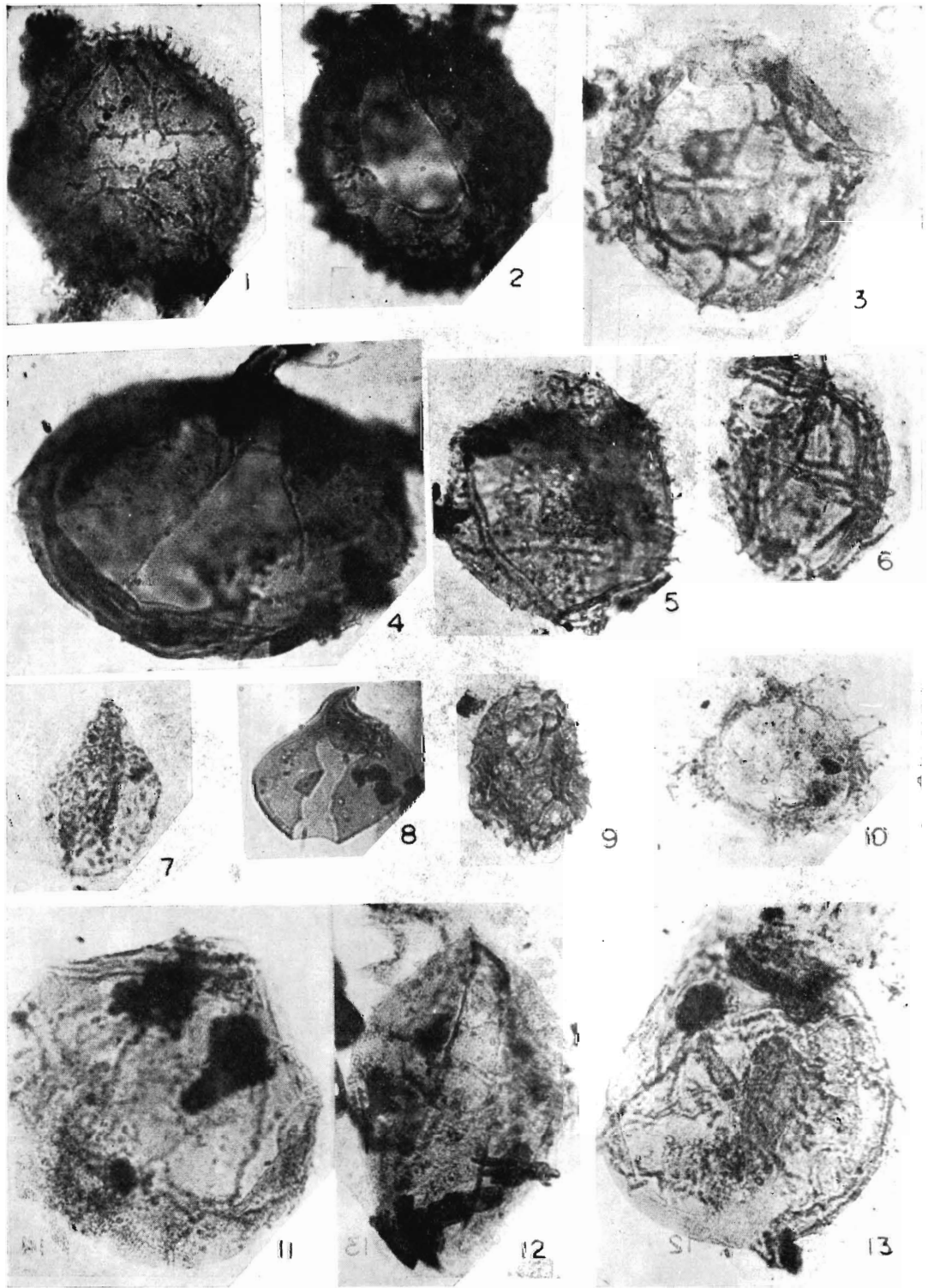


PLATE IV

1. *Hystrichosphaeridium monstruosum*
2. *H. tubiferum*
3. *H. sp. A.*
4. *Oligosphaeridium sp.*
5. *Hystrichosphaeridium sp. B.*
6. *Oligosphaeridium complex*
7. *Hystrichosphaeridium stellatum*
8. *Hystrichosphaeridium tubiferum* var. *brevispinosum*
9. cf. *Pareodinia villosa*
10. *Hystrichosphaeridium coelentratum*
11. *Odontochitina* cf. *O. Operculata*
12. *Palaeoperidinium spinosum*

PLATE V

1. *Canningiopsis sp. A.*
2. *Tanyosphaeridium variecalamum*
3. *Leptodinium sp. B.*
4. *Canningiopsis sp. B.*
5. *Spiniferites sp. C.*
6. *Odontochitina sp. B.*
7. *Spiniferites scabrosa*
8. *Spiniferites sp. A.*
9. *Forma B.*
10. cf. *Epicephalopyxis sp.*
11. *Odontochitina sp. A.*
12. *Spiniferites remosus* var. *ramasus*
13. *Spiniferites sp. B.*
14. *Pterospermopsis* cf. *P. australiensis*

PLATE VI

- 1 and 2. *Forma A.*
3. *Dicanthum sp.*
4. *Apteodinium reticulatum*
5. *Leptodinium sp. A.*
6. *Microdinium sp.*
7. *Prolixosphaeridium sp.*
8. ? *Apteodinium sp.*
9. *Cyamatosphaera sp. B.*
10. *Cyamatosphaera sp. A.*
11. ? *Leptodinium sp. C.*
12. *Palaeostomocystis reticulata*
- 13 ? *Leptodinium sp. D.*