

# FOSSIL MICROPLANKTON FROM THE LANGPAR FORMATION OF THERRIAGHAT, SOUTH SHILLONG PLATEAU, ASSAM, INDIA

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## ABSTRACT

Extensive search for plant microfossils in the Langpar sediments of Shillong Plateau has resulted in the recovery of a rich palynological assemblage from a green calcareous shale exposed along the eastern bank of the Umsohryngkew river, Therriaghat. Only the microplankton remains have been recorded and illustrated in this paper. The assemblage comprises 13 species assigned to 11 genera. Two genera, viz. *Achomosphaera* Evitt (1963) and *Hystriochosphaeridium* (Deflan.) Dav. & Will. (1966) are dominant while the genera *Leptodinium* Klem. (1960), *Baltisphaeridium* Eisen. (1958), *Apteodinium* Eisen. (1958) and *Fromea* Cook. & Eisen. (1958) are meagrely represented.

## INTRODUCTION

ALTHOUGH a good deal of published information is available in India on fossil spores and pollen, little attention has been paid towards the study of fossil microplanktons. Lele and Chandra (1969) described Palaeozoic acritarchs from the Umaria marine beds. Rawat (1966), Venkatachala and Kar (1968) recorded Jurassic microplanktons from Kutch, Gujarat. Banerjee and Misra (1968) reported a few microplanktons from the Cretaceous rocks of South India. Baksi (1962) has figured a single specimen from the Tertiary rocks of Assam. A few species of Tertiary microplanktons have been figured by Mathur (1963), Varma and Dangwal (1964) from Western India. Biswas (1962) figured two specimens from Therriaghat, from the same locality from where the present material has been collected. In spite of all these publications our knowledge about the Indian fossil microplanktons remains very meagre. This is because most of the publications are in the form of short notes and do not deal with the entire microplankton assemblage of the region.

The contents of this paper are the outcome of a long term project on the Palyno-stratigraphy of the South Shillong Plateau, Assam. As part of this project the first paper was published in 1966 by Sah and Dutta on the

stratigraphic position of the Cherra Formation. Two papers, one dealing with the biostratigraphic zonation of the Cherra Formation and the other dealing with the age of the Laitryngew-Mawkma coal bearing sandstone and their relationship with the Cherra Formation are in press. Another comprehensive article dealing with the stratigraphy and palynology of the South Shillong Plateau has recently been sent to press.

The Cretaceous—Tertiary boundary in Assam still remains a controversial problem as opinion based on geological field evidence seems to be sharply divided. Extensive palyno-stratigraphical investigations are being carried out on the Cretaceous—Tertiary sequence of this region, to demarcate this boundary by means of palynological fossils.

While working on the Therriaghat section, along the eastern bank of the Umsohryngkew river ( $25^{\circ}11':91^{\circ}46'$ ), a green calcareous shale band yielded a rich palynological assemblage comprising spores, pollen grains and microplanktons. The geology of this area has been worked out by Oldham (1858); Medlicott (1869); Ghosh (1940); Biswas (1962) and others. The beds in the area are dipping  $40^{\circ}$ - $50^{\circ}$  due south and the following litho-units have been observed:

Cherra Formation Thickness $\pm 500'$ (Palaeocene)	}	Sandy brittle bed with plant remains Screes of boulders, sandstone, shale and calcareous sandstone.
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### Boundary indefinite due to passage of beds

Langpar Formation Thickness $\pm 700'$ (Upper Cretaceous)	}	Massive bedded pinkish limestone Massive limestone with thin shale bands Impure earthy limestone with thin beds of shale Green calcareous shale with thin earthy limestone Gap filled with alluvium)
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A large number of samples have been collected from this area. Laboratory in-

vestigations show that except for the green calcareous shale band with thin earthy limestone, samples from other horizons are devoid of microfossils. This sample has yielded a rich assemblage comprising spores, pollen grains and microplanktons.

The present article concerns only with the systematic description of the microplanktons. The probable age and stratigraphic position of the bed shall be dealt with later in a separate paper along with the systematic description of the spore-pollen grains.

The samples were kept in commercial Nitric acid (40%) for 3-4 days followed by alkali treatment (Potassium hydroxide solution 4%) for 2-3 minutes. The macerates were then kept overnight in Hydrochloric acid (20%). The slides were prepared with Polyvenyl alcohol and mounted in Canada balsam. The unused material and the slides have been deposited in the repository of the Birbal Sahni Institute of Paleobotany, Lucknow.

#### SYSTEMATIC DESCRIPTION

Genus — *Achomosphaera* Evitt, 1963

*Achomosphaera operculata* sp. nov.

Pl. 1, Figs. 1-2

*Holotype* — Pl. 1, Fig. 1. Size  $42 \times 41 \mu$ . Slide no. 3638.

*No. of specimens studied* — 16.

*Diagnosis* — Cysts circular,  $30-45 \times 28-44 \mu$ . Archeopyle precingular, simple, processes well developed, branched at tips; cyst membrane thin, sculptured with grana or coni.

*Description* — Cysts sometimes subcircular or oval due to irregular foldings. Archeopyle well defined in most specimens,  $\pm$  rhomboidal. Processes  $20-30 \mu$  long, tapered, with or without branched tips. Cyst membrane  $1-1.5 \mu$  thick, surface granulate or sometimes conied or both these elements may be interspersed together; elements up to  $1 \mu$  in height, generally closely placed and uniformly distributed.

*Comparison* — *Achomosphaera sagena* Dav. & Will. (1966) compares with the present species in the presence of similar sculptural element but the former is readily distinguishable by its thick cyst membrane. *A. neptuni* (Eisen.) Gocht (1959) also resembles *A. operculata* in shape, size and nature

of the archeopyle, but differs in having well developed branched processes and reticulate or fibrous cyst membrane. *A. ramulifera* var. *perforata* Dav. & Will. (1966) has an oval shape and perforate processes.

*Achomosphaera cambra* sp. nov.

Pl. 1, Fig. 3

*Holotype* — Pl. 1, Fig. 3. Size  $60 \times 50 \mu$ . Slide no. 3640.

*No. of specimens studied* — 11.

*Diagnosis* — Cysts oval-subcircular,  $50-64 \times 48-62 \mu$ ; archeopyle precingular, simple; processes many, spinose, cingular processes joined together to form a girdle-like appearance; cyst membrane  $\pm$  laevigate to granulose.

*Description* — Cysts generally oval with broadly rounded lateral ends, sometimes folded at the margin. Cingular processes on both sides appear to fuse giving a sinuous outline at the cingular region. Processes up to  $12 \mu$  long, at both apical and antapical regions, robustly built, tapering, rarely bifurcating. Cyst membrane  $1-1.5 \mu$  thick, mostly laevigate, sometimes granulate. When present grana sparsely distributed.

*Comparison* — *Achomosphaera ramulifera* (Deflan.) Evitt (1963) approximates the present species in shape, size and precingular archeopyle but can be distinguished by its bigger processes with bifurcating tips. *A. ramulifera* var. *perforata* Dav. & Will. (1966) has also bigger processes with bifurcating or trifurcating tips. *A. operculata* appears different in having circular shape and in the absence of a reflected girdle in the cingular region.

*Achomosphaera delicata* sp. nov.

Pl. 1, Figs. 4-5

*Holotype* — Pl. 1, Fig. 4. Size  $64 \times 46 \mu$ . Slide no. 3638.

*No. of specimens studied* — 13.

*Diagnosis* — Cysts oval-subcircular,  $55-70 \times 40-65 \mu$ . Archeopyle precingular, simple; processes many bacular; cyst membrane thin, laevigate.

*Description* — Cysts with equally broad lateral ends, sometimes irregularly folded. Archeopyle observed in some specimens. Processes up to  $10 \mu$  long,  $\pm$  uniformly broad or slightly tapering, rarely bifurcating, forming a negative reticulum in surface view. Cyst membrane  $1-1.5 \mu$  thick.



*Comparison* — *Achomosphaera cambra* resembles the present species in shape and size but differs in having spinose processes which are joined together at the cingular region. *A. operculata* approaches near the present species in having bacular processes but can be easily distinguished by its predominantly circular shape and granulose cyst membrane. Both *A. sagena* Dav. & Will. (1966) and *A. neptuni* (Eisen.) Gocht (1959) differ in having well developed bifurcating processes.

*Achomosphaera robusta* sp. nov.

Pl. 1, Figs. 6-7

*Holotype* — Pl. 1, Fig. 6. Size  $70 \times 64 \mu$ . Slide no. 3642.

*No. of specimens studied* — 9.

*Diagnosis* — Cyst oval-subcircular,  $61-76 \times 58-75 \mu$ ; archeopyle precingular, simple; processes many, strongly built, dichotomizing at the tips; cyst membrane thin, laevigate, sometimes intrastructured.

*Description* — Cysts generally oval with broadly rounded lateral ends. Archeopyle  $\pm$  squarely-rhomboidal, operculum found attached in some specimens. Processes up to  $30 \mu$  in length and  $12 \mu$  in breadth. Tips mostly bifurcating, sometimes trifurcating. Cyst membrane  $1-1.5 \mu$  thick, an intrastructure discernible in some specimens, which seems to be intrapunctate.

*Comparison* — *Achomosphaera sagena* Dav. & Will. (1966) is comparable in shape and size range but differs in having a thicker cyst membrane and well developed sculptural elements. *A. alvicornu* (Eisen.) Gerl. (1961) differs in having longer tubular processes. *A. neptuni* (Eisen.) Gocht (1959) has a central body with a reticulate or occasionally slightly fibrous surface.

*Achomosphaera valianta* sp. nov.

Pl. 1, Figs. 8-9

*Holotype* — Pl. 1, Fig. 8. Size  $72 \times 64 \mu$ . Slide no. 3644.

*No. of specimens studied* — 15.

*Diagnosis* — Cysts oval,  $61-79 \times 59-76 \mu$ ; archeopyle precingular, simple. Processes long, filamentous, hardly dichotomizing; cyst membrane thin, laevigate.

*Description* — Cysts with equal or unequal lateral ends, sometimes folded at

margin. Archeopyle subconical,  $\pm$  spade-like. Operculum generally present. Cingular and apical processes of equal length (up to  $30 \mu$ ), processes uniformly distributed, scarcely bifurcated at the tips. Cyst membrane  $1-1.5 \mu$  thick, laevigate, sometimes weakly intrastructured.

*Comparison* — *Achomosphaera robusta* resembles the present species in shape and size, but differs in having mostly bifurcated processes. *A. neptuni* (Eisen.) Gocht (1959) is also characterized by having well developed bifurcating processes and the cyst membrane is also reticulate. *A. operculata* and *A. delicata* have comparatively shorter and delicate bacular processes.

*Achomosphaera globata* sp. nov.

Pl. 1, Figs. 10-11

*Holotype* — Pl. 1, Fig. 10. Size  $64 \times 62 \mu$ . Slide no. 3644.

*No. of specimens studied* — 10.

*Diagnosis* — Cysts mostly circular,  $58-67 \times 56-65 \mu$ ; archeopyle precingular, simple; processes about 30, bacular, dichotomizing; cyst membrane laevigate — minutely sculptured.

*Description* — Subcircular cysts rarely observed, sometimes irregularly folded. Archeopyle observed in some specimens, operculum squarely rhomboidal, seen attached on the cyst. Processes uniformly distributed, up to  $20 \mu$  long, mostly bifurcating or trifurcating at tips. Cyst membrane up to  $1.5 \mu$  thick, generally laevigate, sometimes sparsely coned.

*Comparison* — *Achomosphaera robusta* may be compared with the present species in size and nature of the archeopyle but differs in having an oval shape and robustly built processes. *A. valianta* also has an oval shape and has filamentous processes which rarely dichotomize at the tips. *A. neptuni* (Eisen.) Gocht (1959) agrees in circular shape but can readily be distinguished by its well developed branching processes and reticulate cyst membrane.

*Achomosphaera convexa* sp. nov.

Pl. 1, Figs. 12-13

*Holotype* — Pl. 1, Fig. 12. Size  $77 \times 66 \mu$ . Slide no. 3644.

*No. of specimens studied* — 9.

*Diagnosis*—Cysts oval with biconvex sides and pointed lateral ends; size range  $60\text{--}77 \times 46\text{--}66 \mu$ ; archeopyle precingular, simple; processes well developed,  $\pm$  uniform; cyst membrane laevigate.

*Description*—Strong biconvex sides of the cysts provide the characteristic shape of this species. Lateral ends are acutely rounded. Archeopyle can be seen in some specimens. Processes up to  $20 \mu$  long, mostly with bifurcating tips, generally uniform, in some specimens processes at cingular and antapical regions seem to be better developed. Cyst membrane  $1\text{--}1.5 \mu$  thick, laevigate, irregularly folded.

*Comparison*—*Achomosphaera cambra* somewhat resembles the present species in shape and size range but differs in possessing spinose processes which are joined together at the cingular region. *A. ramulifera* (Deflan.) Evitt (1963) is oval with broadly rounded lateral ends and has very long and well developed bifid processes. *A. delicata* has many baculate processes which are up to  $10 \mu$  long.

*Achomosphaera* sp. 1

Pl. 1, Fig. 14

*Description*—Cyst oval,  $72 \times 50 \mu$ , apical end more broad than antapical region, sides biconvex. Archeopyle precingular,  $\pm$  rectangular. Processes well developed, up to  $35 \mu$  long, bifurcating or trifurcating at tips. No processes are seen in the apical region. Membrane about  $1 \mu$  thick, granulate, grana up to  $1 \mu$  high, closely placed and uniformly distributed.

*Comparison*—*Achomosphaera operculata* compares with the present species in having granulate membrane but is readily distinguished by its circular shape. *A. convexa* has laevigate cyst membrane, acutely rounded lateral ends and the processes are uniformly distributed.

*Achomosphaera* sp. 2

Pl. 1, Fig. 15

*Description*—Cyst oval with biconvex sides,  $72 \times 58 \mu$ . Archeopyle precingular,  $\pm$  roundly triangular. Processes at apical, antapical and cingular regions bigger than those of precingular region. Processes up to  $30 \mu$  long, bacular, scarcely bifurcating at the tips. Cyst membrane laevigate.

*Comparison*—The form described here differs from the other known species of the genus in possessing varied type of processes.

**Genus**—*Hystrichosphaeridium* (Deffan.) Dav. & Will., 1966

*Hystrichosphaeridium robustum* sp. nov.

Pl. 2, Figs. 16-17

*Holotype*—Pl. 2, Fig. 16. Size  $70 \times 62 \mu$ . Slide no. 3641.

*No. of specimens studied*—11.

*Diagnosis*—Cysts subcircular,  $58\text{--}76 \times 50\text{--}74 \mu$ ; processes small, robustly built, about 30 in number; cyst membrane laevigate.

*Description*—Cysts margin appear undulating due to presence of small processes. Processes up to  $20 \mu$  long and  $12 \mu$  broad with blunt tips,  $\pm$  uniform in size and distribution. Archeopyle not observed in any of the specimens. Cyst membrane  $1\text{--}2 \mu$  thick, space between processes laevigate.

*Comparison*—*Hystrichosphaeridium stellatum* Maier (1959) resembles the present species in general appearance but can be distinguished by its comparatively longer processes with fringed or serrated tips. *H. arundum* Eisen. & Cook (1960) is comparable in shape and nature of the processes but can readily be separated by its granulate cyst membrane and the unequal length of the tubular processes. *H. tubiferum* var. *brevispinum* Dav. & Will. (1966) is smaller in size than the present species, has larger number of processes and folds along the margin. *H. patulum* Dav. & Will. (1966) is characterized by two types of processes of same size.

*Hystrichosphaeridium assamicum* sp. nov.

Pl. 2, Figs. 20-21

*Holotype*—Pl. 2, Fig. 20. Size  $76 \times 74 \mu$ . Slide no. 3648.

*No. of specimens studied*—15.

*Diagnosis*—Cysts subcircular-oval,  $70\text{--}84 \times 66\text{--}80 \mu$ ; archeopyle apical; tubular processes less than thirty, mostly with tufted tips; cell membrane laevigate.

*Description*—Cysts mostly subcircular with generally closed archeopyle. When open, the sulcal notch appears less prominent. Processes  $\pm$  bacular, up to  $30 \mu$  in length; ramifications not well developed. Cyst membrane up to  $1.5 \mu$  thick, laevigate.



*Comparison* — The present species resembles *Hystrichosphaeridium difficile* Manum (1964) in shape, size range, number of processes and in the nature of the archeopyle but the latter differs in having a distinctly sculptured cyst membrane and comparatively more ramified processes. *H. stellatum* Maier (1959) has densely placed bacular processes which are unequal in length. *H. zoicum* is smaller in size and has comparatively shorter bacular processes.

*Hystrichosphaeridium transculentum* sp. nov.

Pl. 2, Figs. 18-19

*Holotype* — Pl. 2, Fig. 18. Size  $76 \times 72 \mu$ . Slide no. 3647.

*No. of specimens studied* — 17.

*Diagnosis* — Cysts subcircular,  $60-86 \times 57-84 \mu$ ; processes with tufted tips, generally up to 30 in number; archeopyle apical; cyst membrane sculptured with translucent coni.

*Description* — Cysts sometimes with small irregular folds. Archeopyle mostly closed. Processes evenly distributed, up to  $30 \mu$ , dichotomizing at the tip region. Cyst membrane  $1-1.5 \mu$  thick, coni  $2-3 \mu$  in height, closely placed, evenly distributed, forming negative reticulum in surface view.

*Comparison* — *Hystrichosphaeridium difficile* Man. (1964) shows close resemblance with the present species in shape, size, nature of the archeopyle and the number of processes but the latter differs in having translucent sculptural elements. *H. assamicum* approximates *H. transculentum* in size and nature of the processes but the former is characterized by having a laevigate cyst membrane.

*Genus* — *Oligosphaeridium* Dav. & Will., 1966

*Oligosphaeridium cephalum* sp. nov.

Pl. 2, Figs. 22-23

*Holotype* — Pl. 2, Fig. 22. Size  $38 \times 36 \mu$ . Slide no. 3641.

*No. of specimens studied* — 12.

*Diagnosis* — Cysts subcircular,  $30-42 \times 26-40 \mu$ ; archeopyle apical, tubular processes 12 in number, tufted at the tip; cyst membrane laevigate, thin.

*Description* — Cysts generally oval but may be of varying shapes due to the presence of minute but numerous foldings. Archeopyle observed in some specimens. Sulcal

notch not prominent. Tubular processes up to  $30 \mu$  long, gradually tapered but ramifying at tips. Cyst membrane up to  $1.5 \mu$  thick.

*Comparison* — *Oligosphaeridium complex* (White) Dav. & Will. (1966) comes close to present species in shape, nature of the tubular processes and general organization. The Assam forms, however, differ in being smaller in size and also in possessing 12 tubular processes. The tubular processes in *O. complex* are generally more than 12 in number. *Hystrichosphaeridium stimuliferum* Deflan. (1938) is comparable to *O. cephalum* in size only but differs in the presence of non-ramified processes at the tips. *H. deanei* Dav. & Will. (1966) has larger number of processes than the present species.

*Genus* — *Polysphaeridium* Dav. & Will., 1966

*Polysphaeridium subtile* Dav. & Will., 1966

Pl. 2, Fig. 24

*Remarks* — The Assam specimens are mostly oval,  $40-60 \times 38-57 \mu$ . Archeopyle appears to be apical. Processes many with or without bifurcating tips. Cyst membrane  $1-1.5 \mu$  thick, surface having grana or coni.

*Genus* — *Leptodinium* Klem., 1960

*Leptodinium ovum* sp. nov.

Pl. 2, Fig. 25

*Holotype* — Pl. 2, Fig. 25. Size  $60 \times 51 \mu$ . Slide no. 3649.

*No. of specimens studied* — 12.

*Diagnosis* — Cysts oval, with simple pre-circular archeopyle; equatorial girdle distinct, sutures raised, protruding at the margin, occasionally ledged; cyst membrane up to  $1 \mu$  thick, surface  $\pm$  laevigate or finely sculptured with grana or coni, folds generally present.

*Description* — Cysts mostly oval with equally broad rounded ends, sometimes subcircular,  $50-70 \times 39-66 \mu$ . Archeopyle not seen in most specimens perhaps due to folding and crumpled susceptibility of cyst membrane. Ledge while discernible not more than  $4 \mu$  broad. Sutures well developed, straight, demarcating plate. Epittract and hypottract equal in size. Grana or coni less than  $1 \mu$  in height, closely placed and evenly distributed.

*Comparison* — *Leptodinium membranigerum* Gerl. (1961) and *Leptodinium* cf. *L. membranigerum* Drugg (1967) resemble the present species in shape and size but the two former types differ in having considerably thicker cyst membrane (up to 4  $\mu$ ) and well developed ledge.

**Genus — *Baltisphaeridium* Eisen., 1958**

*Baltisphaeridium* sp.

Pl. 2, Fig. 26

*Description* — Cyst oval, 40 $\times$ 30  $\mu$ . Archeopyle not observed. Processes many, up to 10  $\mu$  long, generally tapering.

*Comparison* — *Baltisphaeridium hirsutum* (Ehr.) Down. & Sarj. (1963) resembles the present species in the nature of the processes but can be distinguished by its circular shape.

**Genus — *Aptedinium* Eisen., 1958**

*Aptedinium* sp.

Pl. 2, Fig. 27

*Description* — Cyst subcircular, 90 $\times$ 81  $\mu$  with an apical horn of 12 $\times$ 6  $\mu$ . Archeopyle precingular, simple, intact. Equatorial girdle or other sutures not discernible. Epitract and hypotract can be distinguished by means of horn and archeopyle. Cyst membrane about 1  $\mu$  thick, laevigate and intrapunctate, irregularly folded.

*Comparison* — *Aptedinium grande* Cook. & Hugh. (1964) is closely comparable in size, nature of the cyst membrane and general disposition of the horn but can be readily distinguished by its hoof-shaped archeopyle. *A. granulatum* Eisen. (1958) is smaller in size and has granulose cyst membrane. *A. maculatum* Eisen. & Cook. (1960) is characterized by small thickened areas with circular outlines throughout the cyst membrane.

**Genus — *Fromea* Cook. & Eisen. 1958**

*Fromea acambra* sp. nov.

Pl. 2, Fig. 28

*Holotype* — Pl. 2, Fig. 28. Size 86 $\times$ 54  $\mu$ . Slide no. 3650.

*No. of specimens studied* — 9.

*Diagnosis* — Cysts  $\pm$  pitcher shaped; archeopyle apical; cyst membrane thin, granulose; equatorial girdle not discernible.

*Description* — Cysts with small or elongated neck-like opening. Size range 80-120 $\times$ 50-80  $\mu$ . Cyst membrane  $\pm$  1  $\mu$  thick, grana up to 1  $\mu$  high, densely placed, so much so that generally no intergranular space is left. Surface mostly irregularly folded. In some specimens a tubular process seems to be adpressed in the equatorial region.

*Comparison* — *Fromea amphora* Cook. & Eisen. (1958) resembles the present species in shape and size but the latter can be distinguished by the absence of an equatorial girdle, which in *F. amphora* is of diagnostic value and has been reported by most of the workers (Alber. 1961; Cooks. & Hugh., 1964; Man., 1964).

*Remarks* — None of the species described under the genus *Fromea* compare with the present species.

**Genus — *Caningia* Cook. & Eisen., (1960) 1961**

*Caningia* sp.

Pl. 2, Fig. 29

*Description* — Cyst oval, 72 $\times$ 60  $\mu$ . Archeopyle open, seems to be composite. Equatorial girdle or sutures not traceable. Cyst membrane about 2  $\mu$  thick, sculptured with grana and con.

*Remarks* — The different species of *Caningia* described by Cook. & Eisen. (1960, 1961), Cook. & Hugh. (1964) and Man. (1964) have distinct apical archeopyle. Although the present specimen does not possess an apical archeopyle in all the other characters the Assam form approximates the genus *Caningia* and hence placed under this genus.

**Genus — *Ascodinium* Cook. & Eisen., 1960**

*Ascodinium* cf. *A. scabrosum* Cook. & Hugh., 1964

Pl. 2, Fig. 30

*Description* — Cysts 60-80 $\times$ 40-60  $\mu$  including antapical appendage. Archeopyle apical, open, with or without sulcal notches, no specimen has been recovered with intact archeopyle. Sutures ill-developed or not traceable. Antapical appendage well developed, subcircular with slight constriction at outer margin, lighter than body, minutely granulose, attached at one surface of body.



Cyst membrane up to 2.5  $\mu$  thick, laevigate and intrastructured, mostly intrapunctate, an inner cavity is discernible in some specimens.

*Remarks* — The Assam specimens closely compare with *Ascodinium scabrosum* Cook. & Hugh. (1964) in size, nature of the archeopyle and in possessing antapical appendage but differs in having thin cyst membrane and granulose sculptural pattern. In the absence of apical parts the present specimens have been tentatively placed under *A. scabrosum*.

Cf. *Pediastrum*

Pl. 2, Fig. 31

*Description* — Colony subcircular, 70  $\times$  68  $\mu$ , compact without any internal spaces in between coenobia. Cells in middle region smaller in size, 7-10  $\times$  4-6  $\mu$ , roundly hexagonal, outer cells elongated, more or less rectangular, 10-16  $\times$  4-8  $\mu$ , thickened at outer margin. Each coenobia is provided with a hyaline spot. Processes are not observed at the outer margin. Colony is one layered at middle but seems to be two layered at the peripheral region. Colony on one side comprises approximately 39 cells and they are arranged as 5+12+22. Besides there are a few small, ill-developed coenobia.

*Comparison* — *Pediastrum kajaites* Wils. & Hoffm. (1953) and *P. delicatites* Wils.

& Hoffm. (1953) resemble the present specimens in size only but differs in the form and arrangement of the coenobia and in having distinctly bifid processes. *P. palaeogencites* Wils. & Hoffm. (1953) and *P. bifidites* Wils. & Hoffm. (1953) have pointed processes. A *Pediastrum* has been described by Mathur (1963) from the Subathu formation (Eocene) which also has bifid processes. Another fossil, resembling *Pediastrum* described by Kar (1968) from the Barren Measures (Permian) has knob-headed processes at each cell of the outer margin.

*Incertae sedis*

Type 1

Pl. 2, Fig. 32

*Description* — Disc subcircular-oval, 50-60  $\times$  46-52  $\mu$ . An inner cavity seems to be present. Body verrucose, verrucae of various sizes, closely placed, evenly distributed.

Type 2

Pl. 2, Fig. 33

*Description* — ? Cysts circular-subcircular, 74-110  $\times$  72-106  $\mu$ . An inner cavity traceable in most of the specimens; cavity semilunar-subcircular; with or without folded border. Membrane about 1  $\mu$  thick,  $\pm$  laevigate or sometimes sparsely sculptured with coni or grana.

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## EXPLANATION OF PLATES

(All photomicrographs are enlarged  
ca. × 500)

## PLATE 2

## PLATE 1

- 1-2. *Achomosphaera opeculata* sp. nov. Slide nos.— Holotype — 3638, 3639.
3. *Achomosphaera cambra* sp. nov. Slide no.— Holotype — 3640.
- 4-5. *Achomosphaera delicata* sp. nov. Slide nos.— Holotype — 3638, 3641.
- 6-7. *Achomosphaera robusta* sp. nov. Slide nos.— Holotype — 3642, 3643.
- 8-9. *Achomosphaera valianta* sp. nov. Slide nos.— Holotype — 3644, 3645.
- 10-11. *Achomosphaera globata* sp. nov. Slide nos.— Holotype — 3644, 3646.
- 12-13. *Achomosphaera convexa* sp. nov. Slide nos.— Holotype — 3644, 3646.
14. *Achomosphaera* sp. 1. Slide no.— 3642.
15. *Achomosphaera* sp. 2. Slide no.— 3647.
- 16-17. *Hystrichosphæridium robustum* sp. nov. Slide nos.— Holotype — 3641, 3648.
- 18-19. *Hystrichosphæridium transculentum* sp. nov. Slide nos.— Holotype — 3647, 3638.
- 20-21. *Hystrichosphæridium assamicum* sp. nov. Slide nos.— Holotype — 3648, 3638.
- 22-23. *Oligosphæridium cephalum* sp. nov. Slide nos.— Holotype — 3641, 3646.
24. *Polysphæridium subtile* Dav. & Will. Slide no. 3639.
25. *Leptodinium ovum* sp. nov. Slide no.— 3649.
26. *Baltisphæridium* sp. Slide no.— 3638.
27. *Apteodinium* sp. Slide no.— 3640.
28. *Fromea acambra* sp. nov. Slide no.— Holotype — 3650.
29. *Caningia* sp. Slide no.— 3651.
30. *Ascodinium* cf. *A. scabrosum* Cook. & Hugh. Slide no.— 3652.
31. Cf. *Pediastrum* Slide no.— 3639.
32. *Type* 1. Slide no.— 3647
33. *Type* 2. Slide no.— 3653.







