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Algal and fungal remains from Jowai-Sonapur Road Section (Palaeocene-Eocene), Meghalaya

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This paper deals with the systematic description of dinoflagellate cysts and fungal remains recovered from the Jowai-Sonapur Road Section (Palaeocene-Eocene), Meghalaya. The dinoflagellate cysts are represented by 12 genera and 21 species. The fungal remains comprise fruiting bodies and spores assignable to 10 genera and 12 species.

Key-words—Palynology, Dinoflagellate cysts, Fungal remains, Palaeocene-Eocene (India).

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सारांश

मेघालय में जोवई-सोनपुर मार्ग खंड (पुरानूतन-आदिनूतन) से शैवालीय एवं कवकीय अवशेष

सूर्यकान्तमणि त्रिपाठी

इस शोध-पत्र में जोवई-सोनपुर मार्ग खंड (पुरानूतन-आदिनूतन) से उपलब्ध घृणीकशाभ पुटीयों एवं कवकीय अवशेषों का वर्गीकृत वर्णन किया गया है। घृणीकशाभ पुटीयाँ 12 प्रजातियों तथा 21 जातियों से निरूपित हैं जबकि कवकीय अवशेषों में फलन कायों एवं बीजाणुओं की 10 प्रजातियाँ एवं 12 जातियाँ हैं।

THE Jowai-Sonapur Road Section is located in the south-east of Shillong and encompasses strata ranging in age from Palaeocene to Eocene. The sediments belong to the shelf facies and are represented by Therria, Sylhet Limestone and Kopili Formation. Exposures of these formations are observed along the National Highway 44 connecting Shillong and Badarpur. The area of investigation is situated between latitudes 25°0′ and 25°30′ and Longitudes 92°0′ and 92°30′.

The basement for the deposition of the Tertiary sediments of Jowai-Sonapur Road Section is provided by the Precambrian Shillong Group. At Jowai the Shillong Group is unconformably overlain by the Therria Formation. Further southward the Therria Formation is overlain by the Sylhet Limestone which in turn is succeeded by the Kopili Formation. A detailed geological information with a geological map of the area has been published by Saxena and Tripathi (1982). Lithological characters of these formations have been discussed ahead in the paper in brief.

The Therria Formation is constituted by monotonous, white-brown and pale-red, medium to very coarse grained, often gritty, cross-bedded, ferruginous sandstone alternated by subordinate shale and fine grained carbonaceous sandstone. The shale is mostly bentonitic, sulphurous, occasionally pyritous and generally carbonaceous without megafossils. The carbonaceous sandstones are generally associated with thin coal seams. The Sylhet Limestone is made up mainly of limestone with thin alternations of sandstone. Lithologically this formation is divisible into five members.

Kopili Formation, the youngest stratigraphic unit of the Jaintia Group, is made up of grey, fine to very fine grained, massive to laminated, compact sandstone alternated with shales which represent ellipsoidal structures showing laminae-like successive layers of onion.

Sein and Sah (1974) studied the palynology of Jowai-Sonapur area and on its basis demarcated the Eocene and Oligocene sediments exposed along the road between Lumshnong and Sonapur. In this paper the morphology of the referred taxa has not been discussed and most of the forms are designated up to generic level only. Later, Dutta and Jain (1980) described acritarch and dinoflagellate assemblages from the Sylhet Limestone and Kopili Formation in the Lumshnong area near this road section and pointed out their biostratigraphic potential.

The palynostratigraphical informations presented in the above mentioned two papers are meagre and these studies are based on limited number of samples. Thus, there exists a scope for detailed morphological and palynostratigraphical work in this area.

MATERIAL AND METHOD

Stratigraphically located rock samples were collected from well-measured sections of the Therria, Sylhet Limestone and Kopili formations. Measurement of the sections was done following the standard Brunton tape method. In order to obtain fresh samples, the weathered rocks were removed. Precautions were also taken to avoid surface contamination.

The rock samples were first treated with dilute hydrochloric acid (10%) in order to remove the carbonates. The carbonate free rock samples were treated with hydrofluoric acid (40%) to remove silicates. The carbonaceous shales or coaly samples were treated with warm solution of sodium carbonate (10%) for 2-4 minutes and washed repeatedly with distilled water to remove alkali. The residue was finally washed through 400 mesh sieve. Some samples showed better results when the macerated residue was acetolysed. For acetolysis Erdtman's (1952) method was followed. The slides were prepared in polyvenyl alcohol and mounted in the DPX mountant. The slides prepared have been preserved in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

SYSTEMATIC DESCRIPTION

Dinoflagellate cysts

Family—Gonyaulacystaceae (Sarjeant & Downie) Sarjeant & Downie 1974

Genus—*Gonyaulacysta* Deflandre emend. Stover & Evitt 1978

Type species—*Gonyaulacysta jurassica* (Deflandre) Norris & Sarjeant 1965

Gonyaulacysta sp.
Pl. 3, fig. 5

Description—Cysts proximate, endocyst subspherical to ovoidal in shape, apical horn present, epipericoel and hypopericoel very ill-developed, parasutural septa with denticulate to spinulate crest. Periphragm between septa finely granulose, sometimes small spines also present, endophragm smooth. Paratabulation indicated by parasutural features, formula 0-1a, 6″, 6C, 5-6″″/, l_P, 1″″, 0-1S. Archaeopyle precingular, type P (3″ only), operculum free. Paracingulum distinct, indicated by sub-rectangular paraplates (6c), cingulum helicoid, parasulcus distinct, extending up to the epitract.

Dimensions:
Cyst body—100—100 × 90 μm
Apical horn—Up to 20 μm long

Occurrence—Upper part of Kopili Formation (Upper Eocene), Meghalaya.

Family—Apteodiniaceae Eisenack emend. Sarjeant & Downie 1974

Genus—*Apteodinium* Eisenack 1958

Type species—*Apteodinium granulatum* Eisenack 1958

Apteodinium sp.
Pl. 2, fig. 5

Description—Cysts proximate, body subspheroidal in shape, apical horn present, parasutural features absent or represented by faint markings of low ridges. Autophragm granulose. Paratabulation not indicated. Archaeopyle precingular, type P (3″ only), operculum free. Paracingulum indistinct and represented by shallow transverse groove, sometimes also bordered by low ridges, parasulcus not indicated.

Dimensions:
Cyst body—95—108 × 90-92 μm
Apical horn—Up to 18 μm long

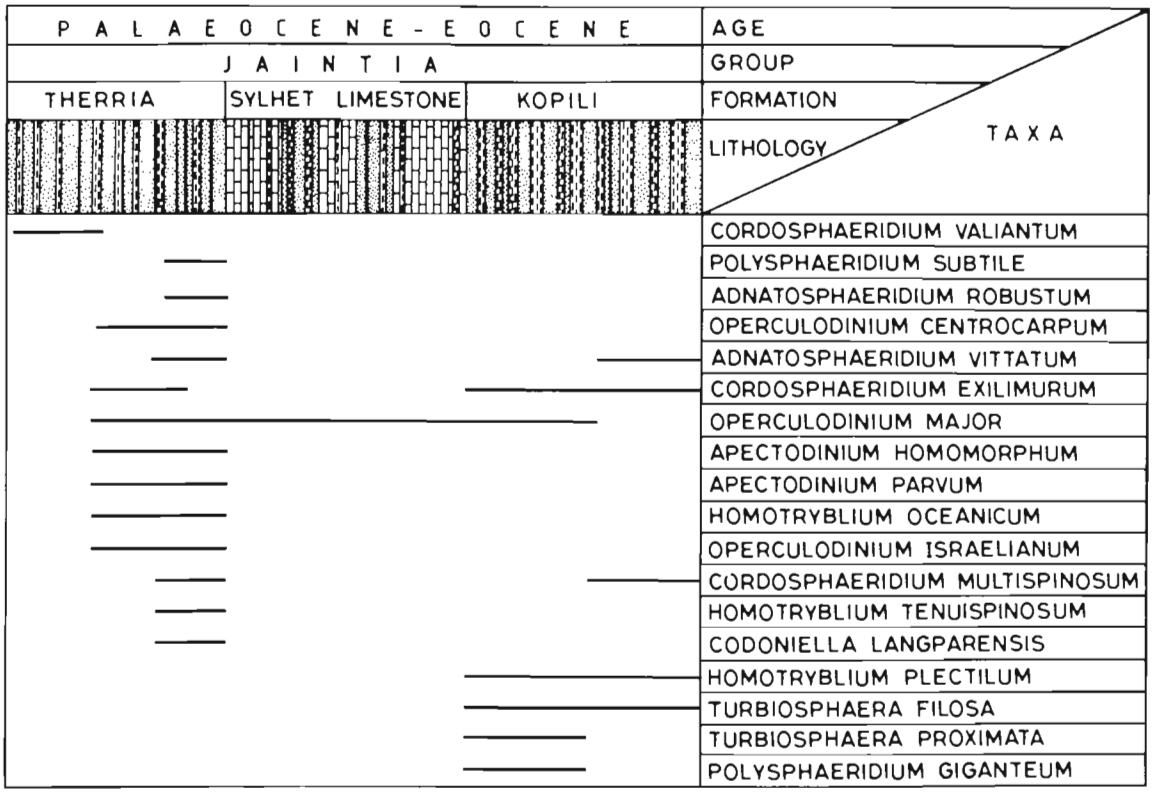
Occurrence—Middle-Upper part of Kopili Formation (Upper Eocene), Meghalaya.

Family—Spiniferitaceae Sarjeant emend. Sarjeant & Downie 1974

Genus—*Turbiosphaera* Archangelsky 1969

Type species—*Turbiosphaera filosa* (Wilson) Archangelsky, 1969

Turbiosphaera proximata sp. nov.
Pl. 1, figs 9, 12; Pl. 2, figs 6, 10; Pl. 3, fig. 6



Text-figure 1—Distribution of dinoflagellate species in Jaintia Group sediments (Palaeocene-Eocene) exposed along Jowai-Sonapur Road, Meghalaya.

Holotype—Pl. 1, fig. 9; Slide no. 9623.

Type horizon—Kopili Formation.

Type locality—At 131.25 km from Shillong on Shillong-Badarpur Road, Meghalaya.

Diagnosis—Cysts chorate; body ovoidal-ellipsoidal; processes intratabular, varying in shape and size, fibrous, two adjacent processes proximally connected by fibrous membrane, processes expanded distally; periphragm fibrous; endophragm smooth; archaeopyle precingular; paratabulation 1-4′, 6″, 5-6″, 1p, 1″″; paracingular processes not indicated.

Comparison—*T. filosa* (Wilson) Archangelsky (1969) exhibits small sulcul processes which are absent in the present form. *T. magnifica* Eaton (1976) and *T. gelatea* Eaton (1976) possess an apical and triangular horn or process which is expanded proximally. *T. proximata* sp. nov. is distinguished from other species in having proximally connected processes.

Dimensions :

Size range	*Holotype*
Cyst body-66-95 × 53-68 μm	66 × 60 μm
Processes-12-30 μm long	24-27 μm long
10-12 μm wide	20-22 μm wide

Occurrence—Lower part of Kopili Formation (Upper Eocene), Meghalaya.

Turbiosphaera filosa (Wilson) Archangelsky, 1969

Pl. 1, figs 2, 8; Pl. 2, fig. 11

Previous records—Eocene of Antarctica (Wilson, 1967); Eocene of Argentina (Archangelsky, 1969).

Occurrence—Lower part of Kopili Formation (Upper Eocene), Meghalaya.

Family—Deflandreaceae Eisenack emend. Sarjeant & Downie 1974

Genus—*Apectodinium* (Costa & Downie) Lentin & Williams 1977

Type species—*Apectodinium homomorphum* (Deflandre & Cookson) Lentin & Williams, 1977

Apectodinium homomorphum (Deflandre & Cookson) Lentin & Williams 1977

Pl. 1, figs 10, 14; Pl. 2, figs 15, 16

Previous records—Palaeocene of New Zealand (Wilson, 1967); Tasmania (Cookson & Eisenack, 1967); northern France (Chateauneuf & Grusas-Cavagnetto, 1968); northern Spain (Caro, 1973) and of India (Dutta & Jain, 1980); Lower Eocene of

Belgium (Pastiels, 1948—as *Hystrichosphaeridium geometricum*; De Coninck, 1965, 1967, 1968, 1972; Morgenroth, 1966 & Graus-Cavagnetto, 1968); the Hampshire and London basins in southern England (Williams & Downie, 1966; Downie, Hussain & Williams, 1971) and Victoria, Australia (Deflandre & Cookson, 1955); Middle Eocene of northern France (Graus-Cavagnetto, 1971); Upper Eocene and Lower and Middle Oligocene of northern France (Chateauneuf & Gruas-Cavagnetto, 1968).

Occurrence—Middle-Upper part of Therria Formation (Palaeocene), Meghalaya.

Apectodinium parvum (Alberti) Lentin & Williams emend. Harland 1979
Pl. 1, figs 6, 13

Previous records—Upper Palaeocene and Lower Eocene of Germany (Alberti, 1961); Palaeocene of New Zealand (Wilson, 1967); Lower Eocene of Germany (Gocht, 1969); Sparnacian of Paris Basin (Gruas-Cavagnetto, 1968); Palaeocene and Lower Eocene of Germany and England; Landenian of Belgium (Costa & Downie, 1976) and Upper Palaeocene of North sea Basin (Harland, 1979) and India (Dutta & Jain, 1980).

Occurrence—Middle-Upper part of Therria Formation (Palaeocene), Meghalaya.

Apectodinium sp. cf. *A. hyperacanthum* (Cookson & Eisenack) Lentin & Williams 1977
Pl. 1, fig. 15

Description—Cyst proximochorate, cornucavate, body ovoidal in shape (antapical part of the cyst compressed), apical horn not observed, antapical horn single but compressed, two lateral horns conspicuous and well-developed. Processes numerous, nontabular, short, tubular, slender, distally open, rarely bifurcated distally. Periphragm smooth, forming the horns, endophragm smooth, giving an ovoidal shape to the body. Archaeopyle quadra style, intercalary, operculum free. Paracingulum and parasulcus not observed.

Dimensions :
Cyst body—90 × 50 μm (including horns)
Processes—5-10 μm long

Remarks—Only a single specimen of this type was recovered. It is noted that the apical horn is not developed, the antapical horn which ends into a single long blunt tip in *A. hyperacanthum* is also not very distinct here due to the compression of the antapical part of the cyst. However, the two lateral horns are more conspicuously developed. Due to these reasons and nonavailability of more similar specimens, the present form has only been compared with *A. hyperacanthum*.

Occurrence—Upper part of Therria Formation (Palaeocene), Meghalaya.

Family—Homotrybliaceae Sarjeant & Downie emend. Sarjeant & Downie 1974

Genus—*Homotryblium* Davey & Williams in Davey *et al.* 1966

Type species—*Homotryblium tenuispinosum* Davey & Williams in Davey *et al.* 1966

Homotryblium tenuispinosum Davey & Williams in Davey *et al.* 1966
Pl. 2, fig. 17

Previous records—Lower Eocene of northern Spain (Caro, 1973); of London Basin in southern England (Davey & Williams in Davey *et al.*, 1966; Downie, Hussain & Williams, 1971) and Lower, Middle and Upper Eocene of the Isle of Wight, southern England (Eaton, 1976).

PLATE 1 →

(All photomicrographs are enlarged Ca. × 500)

1 *Cordosphaeridium exilimurum* Davey & Williams; Slide no. BSIP 8340; coordinate: 116.6 × 14.8
2, 8. *Turbiosphaera filosa* (Wilson) Archangelsky; Slide nos. BSIP 8353 & 8352; coordinates: 114.2 × 15.3 and 117.8 × 26.7 respectively.
3. *Homotryblium oceanicum* Eaton; Slide no. BSIP 8347; coordinate: 80.9 × 14.8
4, 5. *Homotryblium plectilum* Drugg & Loeblich; Slide nos. BSIP 8341 and 8342; coordinates: 81.7 × 9.5 and 89.8 × 20.8 respectively
6, 13. *Apectodinium parvum* Lentin & Williams; Slide nos. BSIP 8351 and 9622; coordinates: 95.8 × 22.9 and 104.2 × 17.1 respectively
7. *Dicellaesporites popovii* Elsik; Slide no. BSIP 7034; coordinate: 98.5 × 11.5
9. *Turbiosphaera proximata* sp. nov. (Holotype); Slide no. BSIP 9623; coordinate: 89.6 × 20.8
10, 14. *Apectodinium homomorphum* Lentin & Williams; Slide nos. BSIP 9624 and 8365; coordinates: 86.1 × 14.4 and 96.7 × 18.8 respectively.
11. *Cordosphaeridium valiantum* (Sah, Kar & Singh) Stover & Evitt; Slide no. BSIP 8360; coordinate : 72.3 × 6.1
12. *Turbiosphaera proximata* sp. nov.; Slide no. BSIP 9625; coordinate: 101.10 × 15.2
15. *Apectodinium* sp. cf. *A. hyperacanthum* Lentin & Williams; Slide no. BSIP 8343; coordinate: 114.7 × 12.00

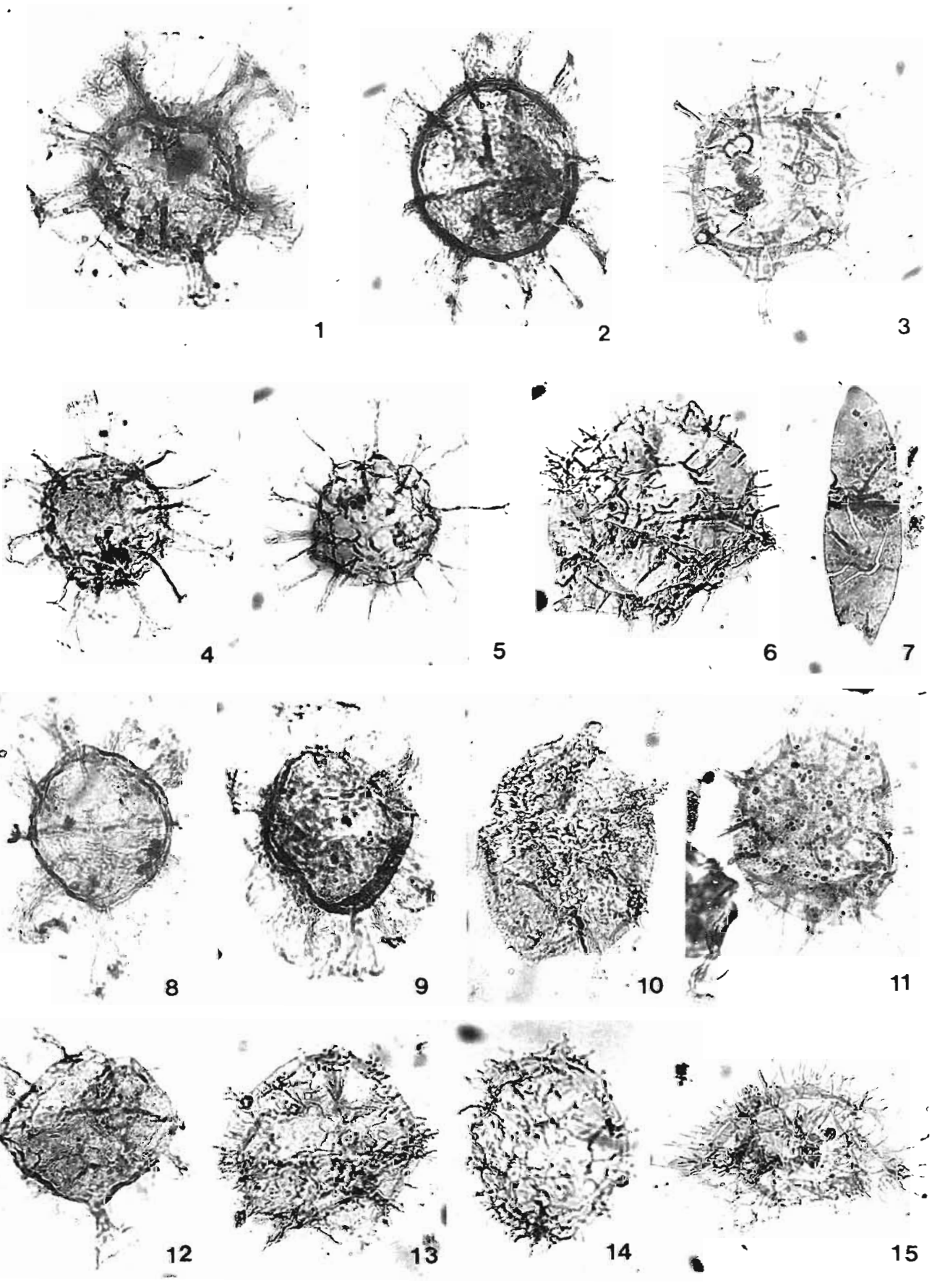


PLATE 1

Occurrence—Upper part of Therria Formation (Palaeocene), Meghalaya.

Homotryblium oceanicum Eaton 1976
Pl. 1, fig. 3

Previous record—Middle-Upper Eocene of Isle of Wight, southern England (Eaton, 1976).

Occurrence—Middle and Upper part of Therria Formation (Palaeocene), Meghalaya.

Homotryblium plectilum Drugg & Loeblich 1967
Pl. 1, figs 4, 5

Previous records—Middle-Upper Eocene of Isle of Wight, southern England (Eaton, 1976); Upper Eocene of north Germany (Agelopoulos, 1964, 1967) and India (Dutta & Jain, 1980); Oligocene of U.S.A. (Drugg & Loeblich, 1967).

Occurrence—Kopili Formation (Upper Eocene), Meghalaya.

Family—Cordosphaeridiaceae Sarjeant & Downie 1974

Genus—*Cordosphaeridium* Eisenack emend. Davey 1969

Type species—*Cordosphaeridium inodes* (Klumpp) Eisenack 1963

Cordosphaeridium exilimurum Davey & Williams 1966
Pl. 1, fig. 1

Previous records—Lower Eocene of Hampshire and London Basin, southern England (Davey & Williams in Davey *et al.*, 1966; Downie, Hussain & Williams, 1971); Lower-Middle and Upper Eocene of Isle of Wight, southern England (Eaton, 1976) and Middle Eocene of India (Dutta & Jain, 1980).

Occurrence—Therria Formation (Palaeocene) and Kopili Formation (Upper Eocene), Meghalaya.

Cordosphaeridium valiantum (Sah, Kar & Singh) Stover & Evitt 1978
Pl. 1, fig. 11

Previous record—Langpar Formation (Lower Palaeocene) of Therriaghat, South Shillong Plateau, Assam, India (Sah, Kar & Singh, 1970).

Occurrence—Lower part of Therria Formation (Palaeocene), Meghalaya.

Family—Systematophoraceae Sarjeant & Downie 1974

Genus—*Prolixosphaeridium* Davey *et al.* emend. Davey 1969

Type species—*Prolixosphaeridium parvispinosum* (Cookson & Eisenack) Davey *et al.* in Davey *et al.* 1966

Prolixosphaeridium conulum Davey 1969
Pl. 3, fig. 14

Remarks—The present form is very similar to *P. conulum* in shape and size of the cyst, but here the archaeopyle is very indistinct. Additionally, very few specimens representing this genus have been recovered.

Previous record—Upper Cenomanian of Fetcham Mill, Comptom Bay, Escalles (Davey, 1969).

Occurrence—Upper part of Therria Formation (Palaeocene), Meghalaya.

PLATE 2 →

1. *Adnatosphaeridium vittatum* Williams & Downie in Davey *et al.*; Slide no. BSIP 8359; coordinate: 77.6 × 15.7
2, 9. *Codoniella langparensis* Jain, Sah & Singh; Slide nos. BSIP 8346 and 9626; coordinates: 111.4 × 13.1 and 99.10 × 21.1 respectively
3. *Callimothallus pertusus* Dilcher; Slide no. BSIP 8363; coordinate: 91.6 × 21.6
4. *Diporicellaesporites* sp.; Slide no. BSIP 7030; coordinate: 96.1 × 21.0
5. *Apteodinium* sp.; Slide no. BSIP 8348; coordinate: 92.9 × 5.2
6, 10. *Turbiosphaera proximata* sp. nov.; Slide nos. BSIP 8353 and 8793; coordinates: 97.2 × 9.7 and 83.2 × 8.7 respectively.
7. *Inapertisporites kedvesii* Elsik; Slide no. BSIP 7036; coordinate: 86.4 × 15.5
8. *Cucurbitariacites bellus* Kar, Singh & Sah; Slide no. 8364; coordinate: 101.3 × 11.5
11. *Turbiosphaera filosa* (Wilson) Archangelsky; Slide no. BSIP 8793; coordinate: 95.6 × 18.7
12. *Polysphaeridium giganteum* Caro; Slide no. BSIP 8349; coordinate: 95.3 × 4.2
13. *Polysphaeridium subtile* Davey & Williams in Davey *et al.*; Slide no. BSIP 8358; coordinate: 117.5 × 23.8
14. *Phragmothyrites eocaenica* Edwards; Slide no. BSIP 8362; coordinate: 116.9 × 12.2
15, 16. *Apectodinium homomorphum* Lentin & Williams; Slide no. BSIP 8365; coordinate: 96.7 × 18.8 and 110.7 × 16.2 respectively.
17. *Homotryblium tenuispinosum* Davey & Williams in Davey *et al.*; Slide no. BSIP 8350; coordinate: 119.9 × 19.7
18. *Operculodinium israelianum* (Rossignol) Wall; Slide no. BSIP 8356; coordinate: 86.8 × 26.5
19, 20. *Operculodinium centrocarpum* (Deflandre & Cookson) Wall; Slide nos. BSIP 8790 and 8361; coordinate: 110.8 × 16.3 and 99.5 × 13.5 respectively.

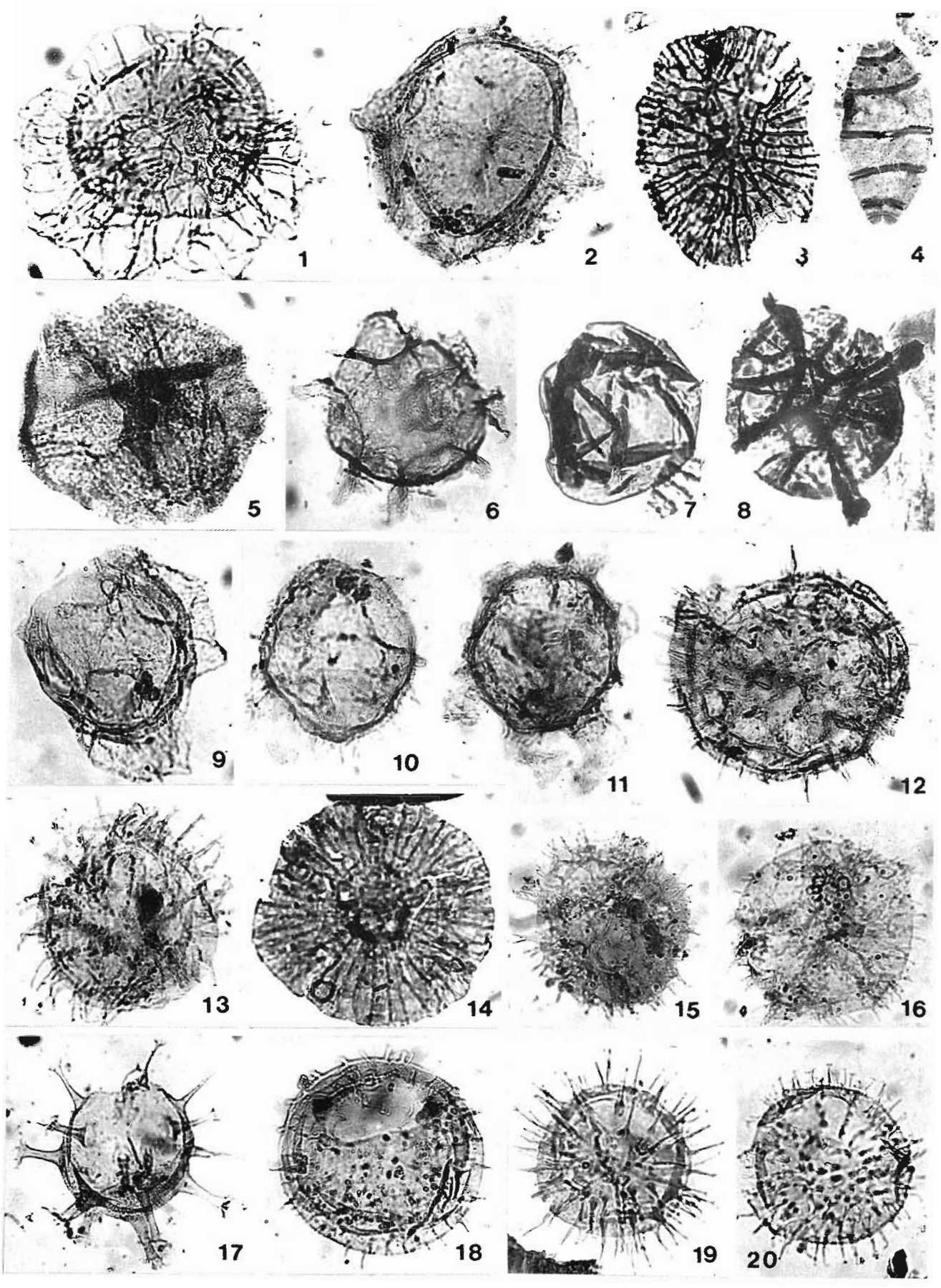


PLATE 2

Family—Cleistosphaeridiaceae Sarjeant & Downie 1974

Genus—*Polysphaeridium* Davey & Williams in Davey *et al.* 1966

Type species—*Polysphaeridium subtile* Davey & Williams in Davey *et al.* 1986

Polysphaeridium subtile Davey & Williams in Davey *et al.* 1966
Pl. 2, fig. 13

Remarks—Davey *et al.* (1966) recorded the cyst body of *P. subtile* up to 50 μm but the specimens from this assemblage range from 68-74 μm in size.

Previous records—Palaeocene and Lower Eocene of northern Spain (Caro, 1973); Lower Eocene of London Basin in southern England (Davey & Williams in Davey *et al.*, 1966, Gruas-Cavagnetto, 1970) and Lower, Middle and Upper Eocene of Isle of Wight, southern England (Eaton, 1976).

Occurrence—Lower and Upper part of Therria Formation (Palaeocene), Meghalaya.

Polysphaeridium giganteum Caro 1973
Pl. 2, fig. 12

Previous record—Palaeocene of northern Spain (Caro, 1973).

Occurrence—Lower part of Kopili Formation (Upper Eocene), Meghalaya.

Polysphaeridium ornamentum Jain & Tandon 1981
Pl. 3, fig. 4

Previous record—Middle Eocene of Kachchh, India (Jain & Tandon, 1981).

Occurrence—Middle part of Kopili Formation (Upper Eocene), Meghalaya.

Family—Lingulodiniaceae Sarjeant & Downie 1974

Genus—*Operculodinium* Wall 1967

Type species—*Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967

Operculodinium centrocarpum (Deflandre & Cookson) Wall 1967
Pl. 2, figs 19, 20

Previous records—Ypresian of Belgium (De Coninck, 1965); Oligocene of Kachchh (Dutta & Jain, 1980); Miocene of Australia (Deflandre & Cookson, 1955); Middle Oligocene to Middle Miocene of Germany (Gerlach, 1961); Pleistocene and Recent (Wall & Dale, 1968); Late Palaeocene to Pleistocene, offshore Florida and Scotian shelf (Williams & Bujak, 1977).

Occurrence—Therria Formation (Palaeocene) and Lower part of Kopili Formation (Upper Eocene), Meghalaya.

Operculodinium israelianum (Rossignol) Wall 1967
Pl. 2, fig. 18

Previous records—Pleistocene of Israel (Rossignol, 1962); deep sea cores from Carribbean Sea (Wall, 1967).

Occurrence—Middle-Upper part of Therria Formation (Palaeocene), Meghalaya.

Operculodinium major Jain & Dutta in Dutta & Jain 1980
Pl. 3, fig. 9

Previous record—Upper Palaeocene of Lakadong member of Sylhet Formation, Meghalaya, India (Dutta & Jain, 1980).

Occurrence—Upper part of Therria Formation (Palaeocene), Meghalaya.

Family—Adnatosphaeridiaceae Sarjeant & Downie 1966

PLATE 3 →

1. *Microthallites* sp.; Slide no. BSIP 8362; coordinate: 110.10 × 10.8
2. *Phragmothyrites* sp.; Slide no. BSIP 8342; coordinate: 99.4 × 14.5
3. *Pluricellaesporites psilatus* Clarke; Slide no. BSIP 7036; coordinate: 101.5 × 15.8
4. *Polysphaeridium ornamentum* Jain & Tandon; Slide no. 8354; coordinate: 83.1 × 16.5
5. *Gonyaulacysta* sp.; Slide no. BSIP 8357; coordinate: 85.5 × 27.6
6. *Turbiosphaera proximata* sp. nov.; Slide no. BSIP 9627; coordinate: 114.8 × 14.2
7. *Paramicrothallites* sp.; Slide no. BSIP 8342; coordinate: 110.7 × 16.2
8. *Callimothallus pertusus* Dilcher; Slide no. BSIP 8363; coordinate: 110.3 × 12.2
9. *Operculodinium major* Jain & Dutta in Dutta & Jain; Slide no. BSIP 8345; coordinate: 117.9 × 17.10
10. *Eocladopyxis* sp.; Slide no. BSIP 8355; coordinate: 116.7 × 9.3
11. *Diporisporites* sp.; Slide no. BSIP 7034; coordinate: 90.10 × 20.0
12. *Dicellaesporites minutus* Kar & Saxena; Slide no. BSIP 7036; coordinate: 94.1 × 5.5
13. *Phragmothyrites eocaenica* Edwards; Slide no. BSIP 7034; coordinate: 118.7 × 16.9
14. *Prolixosphaeridium conulum* Davey; Slide no. BSIP 8347; coordinate: 90.2 × 16.2

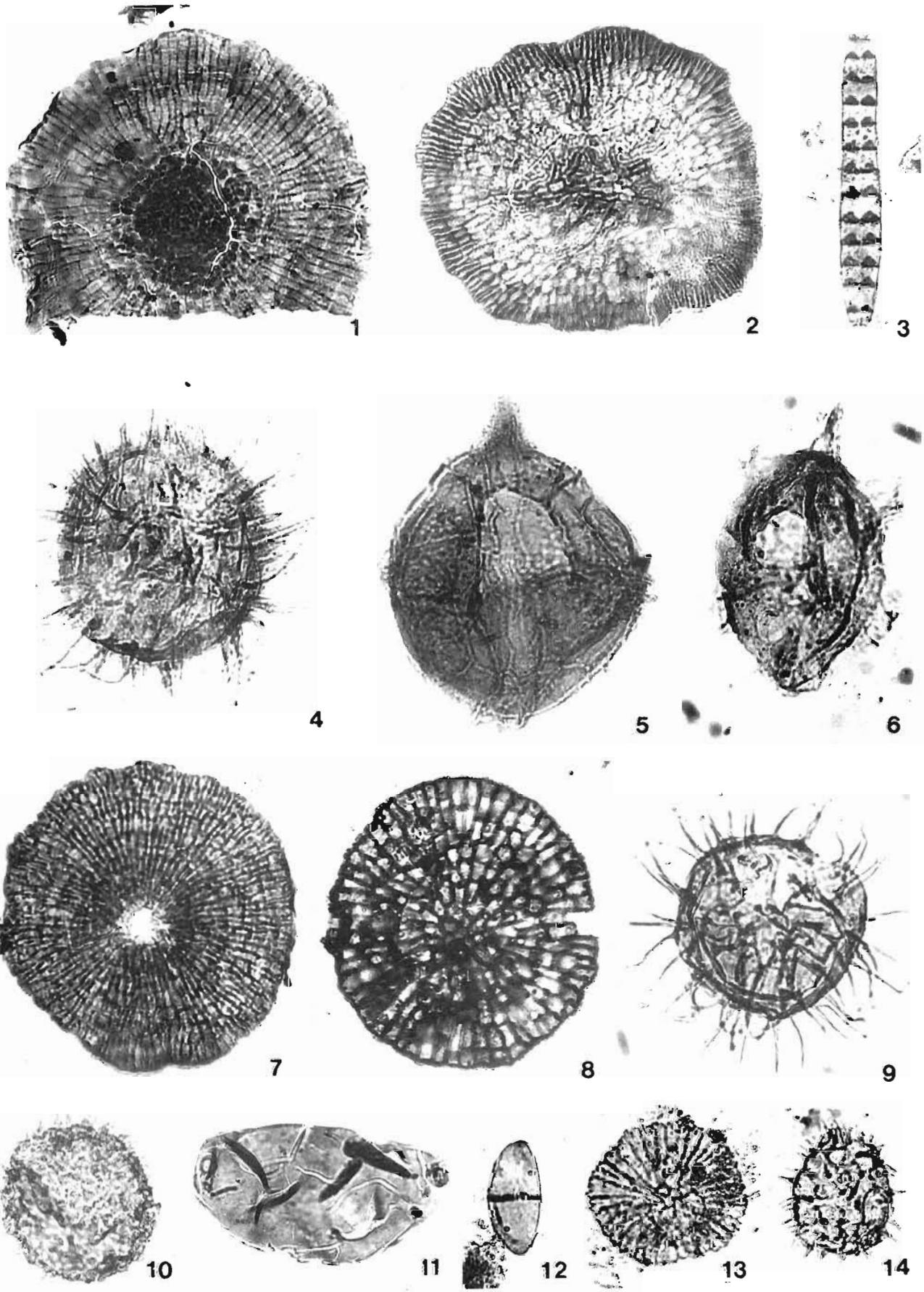


PLATE 3

Genus—*Adnatosphaeridium* Williams & Downie in Davey *et al.* 1966

Type species—*Adnatosphaeridium vittatum* Williams & Downie in Davey *et al.* 1966

Adnatosphaeridium vittatum Williams & Downie in Davey *et al.* 1966
Pl. 2, fig. 1

Previous records—Lower Eocene of southern England (Williams & Downie in Davey *et al.*, 1966); Palaeocene of northern Spain (Caro, 1973) and Lower to Upper Eocene of southern England (Eaton, 1976).

Occurrence—Therria and Kopili formations (Palaeocene-Eocene), Meghalaya.

Family—Uncertain.

Genus—*Codoniella* Cookson & Eisenack 1961

Type species—*Codoniella companulata* (Cookson & Eisenack) Downie & Sarjeant, 1965

Codoniella langparensis Jain, Sah & Singh, 1975
Pl. 2, figs 2, 9

Previous record—Lower Palaeocene of Lower Assam, India (Jain, Sah & Singh, 1975).

Occurrence—Upper part of Therria Formation (Palaeocene), Meghalaya.

Genus—*Eocladopyxis* Morgenroth emend. Stover & Evitt, 1978

Type species—*Eocladopyxis peniculata* Morgenroth, 1966

Eocladopyxis sp.
Pl. 3, fig. 10

Description—Cyst proximochorate, body ovoidal in shape, parasutural features very indistinct. Processes numerous nontabular, closely placed, having bulbous base and pointed tips, distally closed. Periphragm granulose, endophragm smooth. Paratabulation indistinct, many processes per plate area, archaeopyle combination type, formed by apical and precingular plates, operculum free. Paracingulum and parasulcus not indicated.

Dimensions:
Cyst body—60 × 54 μm
Processes—4-9 μm long

Remarks—*Eocladopyxis* sp. is represented by only a single specimen. It is distinct from *E. peniculata* in not exhibiting the paratabulation distinctly. *Eocladopyxis* sp. described by Dutta and Jain (1980) from the Upper Palaeocene sediments of Meghalaya possesses reticulate periphragm.

Occurrence—Middle part of Therria Formation (Palaeocene), Meghalaya.

Fungal Remains

Genus—*Callimothallus* Dilcher 1965

Type species—*Callimothallus pertusus* Dilcher 1965

Remarks—The genus *Callimothallus* was proposed by Dilcher (1965) with the following diagnosis: "No free hyphae. Stroma round, radiate, ascomate, no central dehiscence, individual cells may possess single pore. Spores undetermined". Subsequently, Kar and Saxena (1976) merged *Callimothallus* with *Phragmothyrites* after emending the diagnosis of the latter. Their main contention was that there exists uncertainty regarding the presence or absence of pores in individual cells of the ascomata in either of the genus. Elsik (1981) classified the fungal bodies on the basis of presence or absence of pores in the individual cells, and treated it as the main diagnostic characteristic. Personally I also subscribe to the same thought and concur with Elsik (1981) in maintaining the original taxonomic status of *Callimothallus*.

Callimothallus pertusus Dilcher 1965
Pl. 2, fig. 3; Pl. 3, fig. 8

Previous record—Eocene of western Tennesse, U.S.A. (Dilcher, 1965).

Occurrence—Lower part of Therria Formation (Palaeocene) and Lower part of Kopili Formation (Upper Eocene), Meghalaya.

Genus—*Phragmothyrites* Edwards 1922

Type species—*Phragmothyrites eocaenica* Edwards, 1922

Phragmothyrites eocaenica Edwards 1922
Pl. 2, fig. 14; Pl. 3, fig. 13

Previous records—Palaeocene of Kachchh (Kar & Saxena, 1976); and Lower Eocene of Kachchh (Venkatachala & Kar, 1969).

Occurrence—Lower part of Therria Formation (Palaeocene) and Lower part of Kopili Formation (Upper Eocene), Meghalaya.

Phragmothyrites sp.
Pl. 3, fig. 2

Description—Ascomata ovoidal in shape, 130 × 110 μm in diameter, non-ostiolate, lacking free hyphae, hyphae radially arranged, connected with each other forming pseudoparenchymatous cells, margin of ascomata uneven. Central cells comparatively thick-walled, slightly elongated,

arranged ± parallel to longer axis of the ascomata. Cells in the middle part isodiametric, thin-walled. Marginal cells radially elongated, narrow, thick-walled.

Remarks—*Phragmothyrites* sp. is represented by a single specimen only hence, no specific designation has been given to it. The present form is unique morphologically as it exhibits three distinct layers of pseudoparenchymatous hyphae.

Occurrence—Lower part of Kopili Formation (Upper Eocene), Meghalaya.

Genus—*Paramicrotballites* Jain & Gupta 1970

Type species—*Paramicrotballites spinulatus* (Dilcher) Jain & Gupta 1970

Paramicrotballites sp.
Pl. 3, fig. 7

Description—Ascomata ± circular in shape, ostiolate, 95-115 μm in diameter, lacking free hyphae, hyphae radially arranged, connected with each other forming pseudoparenchymatous cells, margin of ascomata smooth to uneven, all the cells isodiametric to slightly elongated. Ostiole not very well-defined, 13-15 μm across, cells around the ostiole slightly thickened, the ostiole appearing to be the result of the dissolution of central cells of the ascomata.

Occurrence—Lower part of Kopili Formation (Upper Eocene), Meghalaya.

Genus—*Microtballites* Dilcher 1965

Type species—*Microtballites lutosus* Dilcher 1965

Remarks—The genus *Microtballites* was proposed by Dilcher (1965) to accommodate ostiolate and non-ostiolate microthyriaceous forms having radiate parenchymatous hyphae. Later, Jain and Gupta (1970) transferred *Microtballites spinulatus* Dilcher (1965), an ostiolate form, to a new genus, viz., *Paramicrotballites*, proposing the former as Type Species. However, the genus *Microtballites* was retained for the reception of non-ostiolate forms having the central cells modified into a dense knob. During the present study a fungal thyrothecium having radiate, pseudoparenchymatous hyphae and numerous central dense knobs was examined. In my opinion this form should be kept under the genus *Microtballites*. Unfortunately, only a single specimen of this type has been observed. Thus it seems difficult to assign any specific designation to it.

Microtballites sp.
Pl. 3, fig. 1

Description—Ascomata ± circular in shape (partly broken), non-ostiolate, 140 μm in diameter, lacking free hyphae, hyphae radially arranged and connected with each other forming pseudoparenchymatous cells, margin of ascomata uneven. Central cells represented by dense knobs of 2-3 μm in diameter and gradually assuming isodiametric shape. Marginal cells thin-walled, elongated and narrow.

Occurrence—Lower part of Kopili Formation (Upper Eocene), Meghalaya.

Family—Cucurbitariaceae

Genus—*Cucurbitariaceites* Kar, Singh & Sah 1972

Type species—*Cucurbitariaceites bellus* Kar, Singh & Sah 1972

Cucurbitariaceites bellus Kar, Singh & Sah 1972
Pl. 2, fig. 8

Previous record—Palaeocene of Garo Hills, Meghalaya (Kar, Singh & Sah 1972).

Occurrence—Middle part of Therria Formation (Palaeocene), Meghalaya.

Family—Sporae Multicellae Elsik 1976

Genus—*Pluricellaesporites* (van der Hammen) Elsik 1968

Type species—*Pluricellaesporites typicus* van der Hammen 1954

Pluricellaesporites psilatus Clarke 1965
Pl. 3, fig. 3

Previous records—Upper Cretaceous of Central Colorado (Clarke, 1965); Eocene and Oligocene of Washington (Hopkins, 1969).

Occurrence—Lower part of Therria Formation (Palaeocene), Meghalaya

Family—Sporae Dicellae Elsik 1976

Genus—*Dicellaesporites* Elsik 1968

Type species—*Dicellaesporites popovii* Elsik 1968

Dicellaesporites popovii Elsik 1968
Pl. 1, fig. 7

Previous records—Palaeocene of Texas (Elsik, 1968) and Kutch, India (Kar & Saxena, 1976).

Occurrence—Lower part of Therria Formation (Palaeocene), Meghalaya.

Dicellaesporites minutus Kar & Saxena 1976
Pl. 3, fig. 12

Previous record—Palaeocene of Kachchh (Kar & Saxena, 1976).

Occurrence—Lower part of Therria Formation (Palaeocene), Meghalaya.

Genus—*Diporisporites* (van der Hammen) Elsik 1968

Type species—*Diporisporites elongatus* van der Hammen 1954

Diporisporites sp.
Pl. 3, fig. 11

Description—Spores unicellular, diporate, elliptical in shape, 95-102 × 52-60 μm in size, lateral ends rounded. Pores 3-4 μm across, situated at the extreme of the lateral ends, pore margin thickened. Spore wall ± 1 μm thick, dark in colour, associated with a few irregular folds.

Remarks—Diporisporites sp. is comparable to the fungal spore described by Hopkins (1969, pl. 12, fig. 174) as *Diporate* A, but in the latter pores are situated slightly away from the lateral ends.

Occurrence—Lower part of Therria Formation (Palaeocene), Meghalaya.

Genus—*Diporicellaesporites* Elsik 1968

Type species—*Diporicellaesporites stacyi* Elsik 1968

Diporicellaesporites sp.
Pl. 2, fig. 4

Spore 6-celled, oval in shape, 70 × 35 μm in size, diporate. Pores present at the lateral ends, sunken. Septa thick, spore wall very thin, granulose, granules sparsely placed.

Remarks—Diporicellaesporites sp. is different from the other species of the genus in having sunken pores, thin and granulose spore wall.

Occurrence—Lower part of Therria Formation (Palaeocene), Meghalaya.

Genus—*Inapertisporites* van der Hammen emend. Elsik 1968

Type species—*Inapertisporites typicus* van der Hammen 1954

Inapertisporites kedvesii Elsik 1968
Pl. 2, fig. 7

Previous records—Palaeocene of Milam county, Texas (Elsik, 1968) and Palaeocene of Kachchh, India (Kar & Saxena, 1976).

Occurrence—Lower and upper part of Therria Formation (Palaeocene), Meghalaya.

DISCUSSION

Composite lithosection representing the Jowai-Sonapur Road Section (Palaeocene-Eocene), Meghalaya along with sample position is published by Tripathi and Singh (1984) while establishing palynostratigraphic zones in this geological section hence, is not being given here. Litholog (not to the scale) and distribution of recovered dinoflagellate species have been given in Text-figure 1. Dinoflagellates register a low frequency in the lower part of Therria Formation but share 78 per cent of the total assemblage in upper part of this formation which has been identified as *Apectodinium homomorphum* Cenozone (Tripathi & Singh, 1984). This cenozone is characterised by the dominance of the genus *Apectodinium* (23%) being represented by *A. homomorphum* (14%) and *A. parvum* (9%). The Sylhet Formation is devoid of dinoflagellates except the recovery of a few forms of *Operculodinium major*. Lower part of the Kopili Formation shows a high frequency of dinoflagellate cysts in comparison to the upper part.

Occurrence of *Apectodinium parvum* in the Upper Palaeocene-Lower Eocene sediments has been reported from Europe, New Zealand and North sea (Alberti, 1961; Wilson 1967; De Coninck, 1969; Gocht, 1969; Gruas-Cavagnetto, 1968; Costa & Downie, 1976). Chateauneuf and Gruas-Cavagnetto (1978) discussed Palaeogene zones based on *Apectodinium* in Paris Basin and correlated them with other north-west European zones. They found that the lower most C-1, *Apectodinium homomorphum* Zone extends from top of Thanetian to the base of Sparnacean. They also observed that at the base of Sparnacean *Apectodinium homomorphum* is represented by 80-90 per cent of palynological assemblage, thus, being characterised by monospecific microplankton assemblage.

Dutta and Jain (1980) recovered three species of the genus *Apectodinium*, viz., *A. homomorphum, A. parvum* and *A. hyperacanthum* from Lakadong Sandstone Member of Sylhet Formation. Keeping in view the geological distribution of *A. parvum* they dated the lower part of Sylhet Formation as Palaeocene and placed Palaeocene-Eocene boundary at the upper part of Lakadong Sandstone member of Sylhet Formation. But present studies indicate that *A. parvum* marks its first appearance in the upper part of Therria Formation. Therefore, top of the Therria Formation has been dated as Upper Palaeocene.

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