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Palynology of the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part II. Fungal remains

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ABSTRACT

Singh, H. P., Saxena, R. K. & Rao, M. R. (1986). Palynology of the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part II. Fungal remains. *Palaeobotanist* **35**(1) : 93-105.

Fungal remains recovered from the Barail and Surma groups (Oligocene-Lower Miocene) exposed along the Sonapur Badarpur Road Section in Jaintia Hills, Meghalaya and Cachar, Assam have been described. The assemblage consists of 17 genera and 33 species. Of these, 6 genera and 9 species are of fungal bodies and 11 genera and 24 species of fungal spores. Five new species have been established. The important genera are : *Phragmothyrites, Notothyrites, Parmathyrites, Kutchiathyrites, Inapertisporites, Dicellaesporites, Multicellaesporites, Pluricellaesporites, Diporicellaesporites* and *Dyadosporonites*. Quantitative analysis of the assemblage reveals that both fungal bodies and spores are richly represented in the Surma Group (Lower Miocene) while their frequency decreases in the Barail Group. The assemblage has been compared with the known fungal assemblages from the Tertiary rocks in India.

Key-words—Palaeopalynology, Fungi, Jaintia Hills, Oligocene-Miocene (India)

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सारांश

जयन्तिया पहाड़ियों (मेघालय) एवं कछार (असम) में सोनपुर-बदरपुर मार्ग खंड के संग-संग विगोपित सूरमा (अधरि मध्यनूतन) एवं बैरेल (पश्चनूतन) अवसादों का परागाणविक अध्ययन. भाग 2—कवकीय अवशेष

हरीपाल सिंह, रमेश कुमार सक्सेना एवं मलागलापल्ली रामचंद्र राव

इस शोध-पत्र में मेघालय एवं असम में क्रमशः जयन्तिया पहाड़ियों एवं कछार में सोनपुर-बदरपुर मार्ग खंड के संग-संग विगोपित बैरेल एवं सूरमा समूहों (पश्चनूतन-अधरि मध्यनूतन) से उपलब्ध कवकीय अवशेषों का वर्णन किया गया है। इस समुच्चय में कुल मिलाकर 17 प्रजातियाँ एवं 33 जातियाँ विद्यमान हैं। इनमें से छः प्रजातियाँ एवं नौ जातियाँ कवकीय कायों की तथा 11 प्रजातियाँ व 24 जातियाँ कवकीय बीजाणुओं की हैं। पाँच नवीन जातियाँ भी स्थापित की गई हैं। फ्रेग्मोथाइराइटिस, नोटोथाइराइटिस, परमाथाइराइटिस, कच्छिआथाइराइटिस, इनएँपर्टिस्पोराइटिस, डाइसेल्लिस्पोराइटिस, मल्टीसेल्लिस्पोराइटिस, प्लूरीसेल्लिस्पोराइटिस, डाइपोरिसेल्लिस्पोराइटिस एवं डाइएँडोस्पोरोनाइटिस नामक मुख्य प्रजातियाँ हैं। समुच्चय के परिमाणात्मक विश्लेषण से व्यक्त होता है कि सूरमा समूह में कवकीय कायों और बीजाणुओं की बाहुल्यता है जबकि बैरेल समूह में इनकी प्रतिशतता कम हो जाती है। इस समुच्चय की तुलना भारत की तृतीयक युगीन चट्टानों से ज्ञात कवकीय समुच्चयों से की गई है।

INTRODUCTION

DURING the post-fifties, considerable palynological work has been done on the Tertiary sediments of Meghalaya and Assam by various workers namely, Biswas (1962), Baksi (1962;65) Ghosh and Banerjee (1963), Banerjee (1964a,b) Bose and Sah (1964), Sah and Dutta (1966, 1968, 1974), Dutta and Sah (1970, 1974), Salujha, Kindra and Rehman (1972, 1974), Salujha, Rehman and Kindra (1973), Sah and Singh (1974), Singh, Singh and Sah (1975), Singh (1977a,b) and Mehrotra (1981,1983). However, these workers have dealt chiefly with the spore-pollen assemblages of higher plants whereas the fungal spores or their fruiting bodies seem to have been either ignored or have received relatively much less attention for their proper investigation. The present paper is an attempt to present an account of fungal remains (fungal spores and ascomata) from the Barail and Surma groups (Oligocene-Lower Miocene) exposed along Sonapur-Badarpur Road Section, Meghalaya and

Assam. This road section constitutes a part of the Shillong-Badarpur Highway (National Highway 44) and is located in the south-east of Shillong exhibiting excellent exposures of the Barail and Surma sediments. The Barail Group is represented by Laisong, Jenam and Renji formations. The Laisong Formation represents mainly the arenaceous facies consisting of grey, hard, thinly beded, fine to medium grained sandstones alternating with subordinate, hard, sandy shales. The Jenam Formation is mainly argillaceous and consists of shales and sandy shales with fine to medium grained sandstone. The shale is generally carbonaceous. The Renji Formation is also arenaceous in nature and made up of thickly bedded or massive, fine to medium grained, hard, ferruginous sandstone alternated by thin shales. This formation is unconformably overlain by the Surma Group which is divided into Bhuban and Bokabil formations. The Bhuban Formation is divided into Lubha, Umkiang and Dona members; the lower and upper members being mainly arenaceous and the middle member argillaceous. The Bokabil Formation is made up of thick sandy shales with alternations of very fine grained laminated sandstone. The detailed lithostratigraphy of the section has been described by Saxena and Tripathi (1982).

The material was collected from the Barail and Surma groups (Oligocene-Lower Miocene) exposed along the above sections by one of us (R.K.S.). Altogether, 288 rock samples were collected, of which 201 samples proved to be palynologically productive. The palynofossils recovered from these samples include dinoflagellate cysts, fungal remains, spores, pollen grains and some other micro-remains of obscure origin. The first part of this study dealing with the dinoflagellate cysts has already been published (Saxena & Rao, 1984). All slides, negative and unused material have been deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

DESCRIPTION

Genus—*Phragmothyrites* Edwards, 1922 emend. Kar & Saxena, 1976

Type species—*Phragmothyrites eocaenica* Edwards, 1922 emend. Kar & Saxena, 1976

Phragmothyrites eocaenica Edwards, 1922 emend. Kar & Saxena, 1976

Pl. 1, figs 1, 2; Pl 2, fig. 15

Description—Ascomata circular to subcircular in shape with crenate to almost entire margin. Nonostiolate. Size range 65-130 × 60-115 μm in diameter. Hyphae not free, radially arranged and interconnected with each other to form mostly one-celled thick pseudoparenchymatous cells. Generally cells in the middle region less elongated than the marginal ones, marginal cells being darker and setose. In some specimens, cells of the central region bear a single pore in each cell, pore 1 to 2.5 μm in diameter.

Occurrence—Barail and Surma groups.

Distribution—Palaeocene, Lower Eocene and Oligocene of Kachchh, Gujarat (Kar & Saxena, 1976; Venkatachala & Kar, 1969; Kar, 1979). Neogene sediments around Quilon and Warkalli, Kerala (Jain & Kar, 1979).

Phragmothyrites sp.

Pl. 1, fig. 3

Description—Ascomata subcircular in shape. Nonostiolate. Size 90 × 110 μm in diameter. Hyphae radially arranged, interconnected with each other by means of transverse septa to form pseudoparenchymatous cells. The middle cells less elongated than the marginal cells. Outer margin thickened. Cells ornamented with finely foveolate-reticulate ornamentation.

→

PLATE 1

(All photomicrographs are enlarged. ca × 500)

1, 2. *Phragmothyrites eocaenica* Edwards emend. Kar & Saxena; B.S.I.P. slide no. 8100, coordinates 47.10 × 102.10; B.S.I.P. slide no. 8101, coordinates 70.0 × 93.8.

3. *Phragmothyrites* sp.; B.S.I.P. slide no. 8102, coordinates 50.5 × 110.4.

4. *Paramicrothallites menonii* Jain & Gupta; B.S.I.P. slide no. 8103, coordinates 48.8 × 103.8.

5, 6. *Nototbyrites setiferus* Cookson; B.S.I.P. slide no. 0000, coordinates 48.8 × 103.8, coordinates 51.0 × 108.7; B.S.I.P. slide no. 8105, coordinates 57.1 × 107.3.

7. *Nototbyrites padappakarensis* Jain & Gupta; B.S.I.P. slide no. 8107, coordinates 70.2 × 114.6.

8, 9. *Parmathyrites ramanujamii* sp. nov.; B.S.I.P. slide no. 8108, coordinates 45.3 × 105.2; B.S.I.P. slide no. 8109, coordinates 48.4 × 93.5 (Holotype).

10. *Nototbyrites amorphus* Kar & Saxena; B.S.I.P. slide no. 8106, coordinates 75.7 × 113.6.

11, 12. *Kutchiathyrites* sp.; B.S.I.P. slide no. 8110, coordinates 55.1 × 96.10.

13. *Lirasporis intergranifer* Potonié & Sah emend. Jain & Kar; B.S.I.P. slide no. 8110, coordinates 40.0 × 103.5.

14. *Dyadosporonites* sp.; B.S.I.P. slide no. 8129, coordinates 65.0 × 104.4.

15. *Lacrimasporonites* sp.; B.S.I.P. slide no. 8120, coordinates 52.5 × 107.8.

16. *Diporisporites* sp.; B.S.I.P. slide no. 8130, coordinates 71.6 × 104.6.

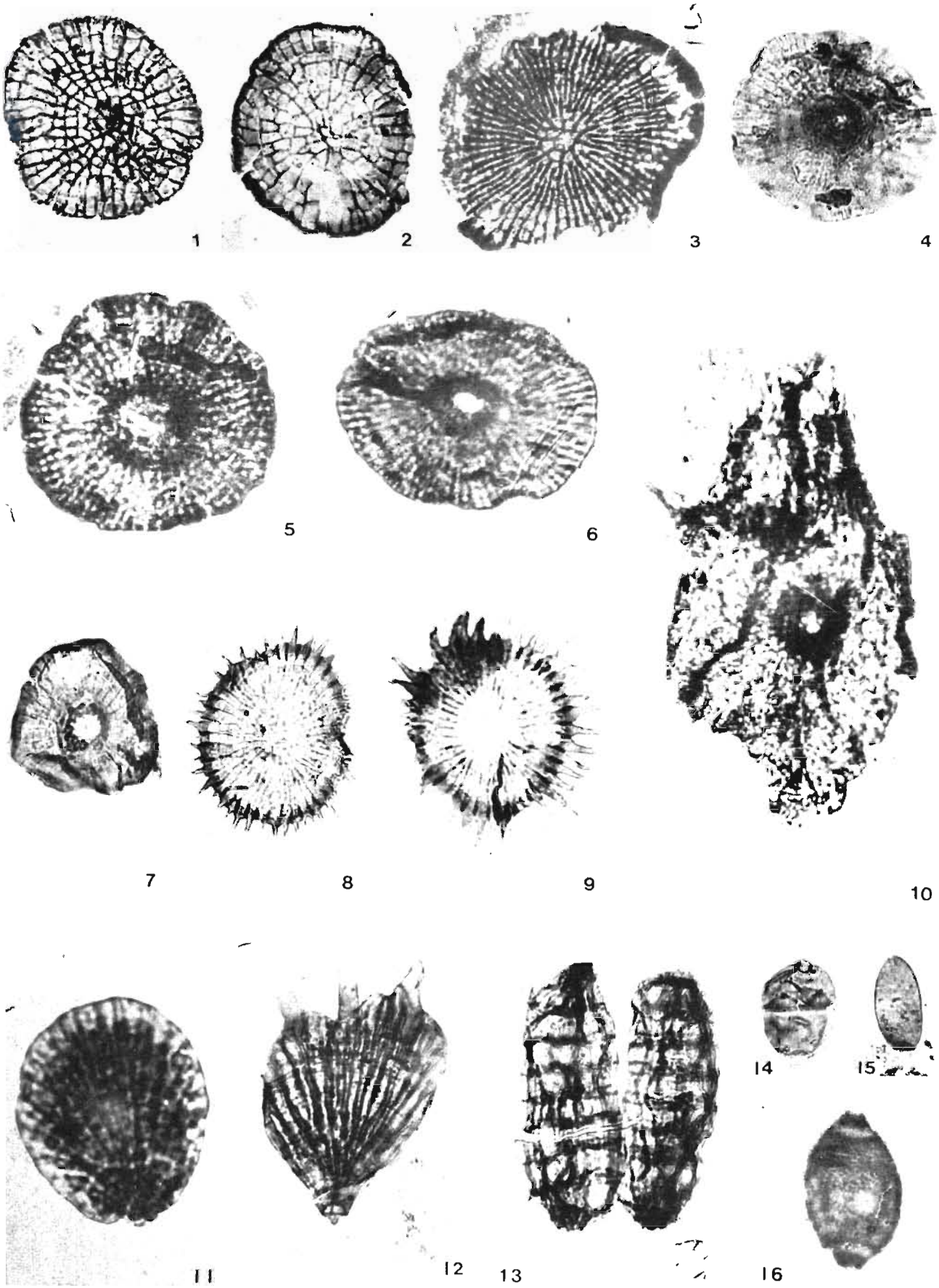

PLATE 1

Comparison—*Phragmothyrites* sp. closely compares with *P. eocaenica* Edwards (1922) emend. Kar & Saxena (1976), but the former can be distinguished by having foveolate to finely reticulate ornamentation.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Genus—*Paramicrothallites* Jain & Gupta, 1970

Type species—*Paramicrothallites spinulatus* (Dilcher, 1965) Jain & Gupta, 1970.

Paramicrothallites menonii Jain & Gupta, 1970

Pl. 1, fig. 4

Description—Ascomata circular in shape. Ostiolate. Size range 75-87 × 73-83 μm. Hyphae radially arranged, interconnected with each other forming pseudoparenchymatous cells. Central cells squarish, marginal cells rectangular, walls thin. Ostiole well defined, about 9 μm in diameter, centrally placed, not surrounded by any specialised cells. Margin lobed. Hyphae absent. Ascospores unknown.

Occurrence—Barail and Surma groups.

Distribution—Miocene sediments around Padappakara and Quilon, Kerala (Jain & Gupta, 1970).

Genus—*Notothyrites* Cookson, 1947

Type species—*Notothyrites setiferus* Cookson, 1947

Notothyrites setiferus Cookson, 1947

Pl. 1, figs 5, 6

Description—Ascomata circular to subcircular in shape. Ostiolate. Size range 80-125 × 70-115 μm in diameter. Cells of radiating hyphae interconnected, forming pseudoparenchymatous cells, cells towards ostiole squarish, peripheral cells rectangular. Ostiole 17-37 μm in diameter, bordered by 2-4 layers of thick-walled, dark brown cells. Hyphae absent. Ascospores unknown.

Occurrence—Barail and Surma groups.

Distribution—Palaeocene of Kachchh (Kar & Saxena, 1976). Upper Miocene (Warkalli Lignite) of Kerala (Ramanujam & Rao, 1973). Neogene sediments around Quilon and Warkalli, Kerala (Jain & Kar, 1979).

Notothyrites amorphus Kar & Saxena, 1976

Pl. 1, fig. 10

Description—Ascomata asymmetrical with uneven margin. Size 200 × 95 μm. Hyphae radially arranged, not anastomosing and hence do not form distinct pseudoparenchymatous cells. Ostiolate, ostiole ovoidal in shape surrounded by a few cells thick wall. No free hyphae observed. Ascospores unknown.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Distribution—Palaeocene of Kachchh, Gujarat (Kar & Saxena, 1976).

Notothyrites padappakarensis Jain & Gupta, 1970

Pl. 1, fig. 7

Description—Ascomata circular to subcircular in shape, flattened, outline sinuous. Size range 60-100 × 50-95 μm in diameter. Ostiolate. Radiating hyphae interconnected, cells smaller in central region and bigger towards periphery, tangential walls of peripheral cells strongly thickened and entire. Ostiole 7-10 μm in diameter, distinctly elevated, centric to slightly eccentric, bordered by two to four layers of dark brown, thick-walled papillate cells. Hyphae absent. Ascospores unknown.

Occurrence—Bhuban Formation, Surma Group.

Distribution—Miocene sediments around Padappakara and Quilon, Kerala (Jain & Gupta, 1970).

Genus—*Parmathyrites* Jain & Gupta, 1970

Type species—*Parmathyrites indicus* Jain & Gupta, 1970.

Parmathyrites ramanujamii sp. nov.

Pl. 1, figs 8, 9

Holotype—Pl. 1, fig. 9, size 90 μm; B.S.I.P. slide no. 8109.

Type locality—154.25 kilometre-stone, Sonapur-Badarpur Road Section, Meghalaya.

Type Horizon—Umkiang Member, Bhuban Formation, Surma Group, Lower Miocene.

Diagnosis and description—Ascomata circular to subcircular in shape. Nonostiolate. Size range 80-90 μm in diameter. Hyphae radially arranged, interconnected, forming pseudoparenchymatous nonporate cells. Central and marginal cells being squarish and rectangular in shape respectively. Outer peripheral cells prominent with thickened radial walls, each peripheral cell developing into a spine-like process, spines unequal, 5-15 μm long, pointed at the apex and broader at the base, about 40 in number, wall thick, radially fused at the base forming a continuous peripheral sheath around ascomata. Ascospores unknown.

Comparison—*Parmathyrites ramanujamii* sp. nov. closely compares with *P. indicus* Jain & Gupta (1970) in shape and the presence of spines along the margin but the former can be distinguished in having continuous arrangement of spines. Moreover, spines in the present species are smaller (5-15 μm long) than those in *P. indicus* (20-50 μm long). *P. turaensis* Kar, Singh & Sah (1972) differs in possessing ostiolate ascomata. *P. robustus* Jain & Kar (1970) possesses thickened cells in the central region and strongly built spines hence not comparable.

Derivation of name—The species is named after Dr C. G. K. Ramanujam, Botany Department, Saifabad Science College, Hyderabad.

Occurrence—Umkiang Member, Bhuban Formation, Surma Group.

Genus—*Kutchiathyrites* Kar, 1970

Type species—*Kutchiathyrites eccentricus* Kar, 1979

Kutchiathyrites sp.

Pl. 1, figs 11, 12

Description—Ascomata ± semicircular in shape some specimens look like fish scales, eccentric in development. Size range 88-110 × 67-75 μm. Nonostiolate. No free hyphae present, dimidiate. Radially arranged hyphae thick, dark, diverging from one another; transverse hyphae comparatively thinner, interconnecting radial ones forming squarish, pseudoparenchymatous cells without having any pore. Some specimens exhibit development of spines from the marginal cells.

Comparison—*Kutchiathyrites* sp. resembles *K. eccentricus* Kar (1979) in general organisation but can be distinguished by having spines which are developed as extensions of the marginal cells. Moreover, the present specimens are longer than broad as compared to *K. eccentricus* Kar (1979).

Occurrence—Bhuban Formation, Surma Group.

Genus—*Lirasporis* Potonié & Sah, 1960 emend. Jain & Kar, 1979

Type species—*Lirasporis intergranifer* Potonie & Sah, 1960 emend. Jain & Kar, 1979.

Lirasporis intergranifer Potonié & Sah, 1960 emend. Jain & Kar, 1979

Pl. 1, fig. 13

Description—Fungal body oval-elliptical in shape with equal or unequal, broad, notched ends. Size 100 × 35 μm. Mycelia long, distinct, run from end to end, parallel to one another. Wall laevigate.

Remarks—The present specimens are comparatively smaller in size than those described by Jain and Kar (p. 196)

Occurrence—Lubha Member, Bhuban Formation, Surma Group.

Distribution—Miocene sediments (Cannanore Lignite) of Kerala (Potonié & Sah, 1960).

Genus—*Inapertisporites* van der Hammen, 1954 emend. Sheffy & Dilcher, 1971

Type species—*Inapertisporites pseudoreticulatus* Rouse, 1959.

Inapertisporites ovalis Sheffy & Dilcher, 1971

Pl. 2, fig. 14

Description—Fungal spore oval. Size range 15-17 × 10-11 μm. Unicellular, nonseptate. Inaperturate. Spore wall 15 μm thick, laevigate. Medium pigment.

Occurrence—Lubha Member, Bhuban Formation, Surma Group.

Distribution—Puryear Clay, south of Puryear, Henry County, Tennessee (Sheffy & Dilcher, 1971).

Inapertisporites miocenicus sp. nov.

Pl. 2, figs. 12, 13

Holotype—Pl. 2, fig. 13, size 218 × 24 μm; B.S.I.P. slide no. 8121.

Type locality—173 Kilometrestone, Sonapur-Badarpur Road Section, Meghalaya.

Type Horizon—Dona Member, Bhuban Formation, Surma Group, Lower Miocene.

Diagnosis and Description—Fungal spores elongated in shape. Size range 112-218 × 21-24 μm. Unicellate, nonseptate, inaperturate. Spores pointed at one end, blunt at the other. Spore wall hyaline, laevigate and irregularly folded.

Comparison—The present species can be differentiated from all the known species of *Inapertisporites* by being exceptionally long size (up to 218 μm).

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Inapertisporites sp. cf. *I. kedvesii* Elsik, 1968

Pl. 1, fig. 1

Description—Fungal spores sub-spherical in shape. Size 67-73 × 55-64 μm. Unicellate. Inaperturate. Spore wall up to 1 μm thick, laevigate. Several irregular folds present.

Comparison—*Inapertisporites kedvesii* Elsik (1968) compares in all the characters with the present species but the latter can be differentiated by being bigger in size.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Inapertisporites sp.

Pl. 1, fig. 3

Description—Fungal spore lanceolate in shape. Size 175 × 88 μm. Unicellate. Inaperturate. Spore wall 1 μm thick, laevigate. Few folds present.

Comparison—*Inapertisporites* sp. compares with *I. Pseudoreticulatus* Rouse (1959) in having laevigate spore wall but differs by being bigger in size (175 × 88 μm).

Occurrence—Lubha Member, Bhuban Formation, Surma Group.

Genus—*Dicellaesporites* Elsik, 1968 emend. Sheffy & Dilcher, 1971

Type species—*Dicellaesporites popovii* Elsik, 1968

Dicellaesporites fusiformis Sheffy & Dilcher, 1971

Pl. 2, fig. 7

Description—Fungal spore elliptical. Size 25 × 10 μm. Dicellate, both cells equal in size and shape. Uniseptate. Spore wall 1 μm thick, laevigate.

Occurrence—Dona Member, Bhuban Formation. Surma Group.

Distribution—Puryear Clay, south of Puryear, Henry County, Tennessee (Sheffy & Dilcher, 1971).

Dicellaesporites sp. A

Pl. 2, fig. 18

Description—Fungal spore elliptical in shape. Size 85 × 33 μm. Dicellate. Inaperturate. Uniseptate, septa 1 μm thick. Spore wall laevigate.

Comparison—The spore wall in *D. ellipticus* Jain & Kar (1979) is granulose-microverrucose whereas it is laevigate in the present species.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Dicellaesporites sp. B

Pl. 2, fig. 23

Description—Fungal spore elongated, biconvex. Size 126 × 46 μm. Dicellate. Inaperturate. Uniseptate, septa faint but clearly discernible, thicker than the spore wall. Spore wall less than 1 μm thick, foveolate, foveola sparsely placed but evenly distributed. Few irregular folds present.

Comparison—The present species can be differentiated from all the known species of *Dicellaesporites* in having foveolate spore wall.

Genus—*Multicellaesporites* Elsik, 1968 emend. Sheffy & Dilcher, 1971

Type species—*Multicellaesporites nortonii* Elsik, 1968.

Multicellaesporites sp. A

Pl. 2, fig. 5

Description—Fungal spore filamentous in shape. Size 140 × 12 μm, 13-celled, cells broader towards one end and narrower towards the other. Inaperturate. Septa 1.5-4 μm thick. Spore wall laevigate.

Comparison—Multicellaesporites nortonii Elsik (1968) is distinguished from the present species by possessing 5-celled spores with smaller size (37 × 15 μm).

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Multicellaesporites sp. B

Pl. 2, fig. 17

Description—Fungal spore spindle-shaped. Size 58 × 18 μm. Tetracellate, middle cells much bigger than the terminal ones. Inaperturate, triseptate, each septum 1 μm thick. Spore wall 0.5 μm thick, laevigate.

Comparison—The present specimen can be differentiated from *M. nortonii* Elsik (1968) in having dissimilar cells and bigger size (58 × 18 μm).

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Multicellaesporites sp. C

Pl. 2, fig. 21

Description—Fungal spore rod-shaped. Size 92 × 20 μm, 9-celled, all cells equal in size and shape except the terminal ones. Inaperturate. Septa prominent, complete, biconvex, about 4 μm thick. Spore wall 1 μm thick, laevigate.

Comparison—Multicellaesporites sp. C. can be distinguished from *M. nortonii* by its prominent septa (4 μm thick) and laevigate spore wall.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Multicellaesporites sp. D

Pl. 2, fig. 19

PLATE 2

(All photomicrographs are enlarged, ca × 500)

1. *Inapertisporites* sp. cf. *I. kedvesii* Elsik; B.S.I.P. slide no. 8115, coordinates 49.9 × 114.2.
2. *Monoporisporites* sp.; B.S.I.P. slide no. 8128, coordinates 52.5 × 99.5.
3. *Inapertisporites* sp.; B.S.I.P. slide no. 8116, coordinates 46.8 × 109.5.
4. *Pluricellaesporites* sp. cf. *P alleppeyensis* Ramanujam & Rao; B.S.I.P. Slide no. 8133, coordinates 55.6 × 115.2.

6, 22. *Dyadosporonites grandiporus* sp. nov.; B.S.I.P. slide no. 8100, coordinates 70.5 × 98.5 (Holotype); B.S.I.P. slide no. 8123, coordinates 41.1 × 98.4.

7. *Dicellaesporites fusiformis* Sheffy & Dilcher; B.S.I.P. slide no. 8119, coordinates 45.0 × 109.8.
8. *Fusiformisporites* sp.; B.S.I.P. slide no. 8137, coordinates 69.0 × 104.10.
9. *Frasnacritetrus* sp.; B.S.I.P. slide no. 8138, coordinates 41.5 × 109.3.
10. *Diporicellaesporites verrucatus* sp. nov.; B.S.I.P. slide no. 8134, coordinates 58.7 × 104.10 (Holotype).
11. *Pluricellaesporites* sp. A.; B.S.I.P. slide no. 8132, coordinates 52.2 × 111.5.

12, 13. *Inapertisporites miocenicus* sp. nov.; B.S.I.P. slide no. 8117, coordinates 54.1 × 98.10; B.S.I.P. slide no. 8121, coordinates 55.3 × 106.2 (Holotype).

14. *Inapertisporites ovalis* Sheffy & Dilcher; B.S.I.P. slide no. 8113, coordinates 39.6 × 117.4.
15. *Pbragmothyrites eocaenica* Edwards emend. Kar & Saxena
16. *Heliospermopsis* sp.; B.S.I.P. slide no. 8112, coordinates 53.5 × 114.3.
17. *Multicellaesporites* sp. B; B.S.I.P. slide no. 8127, coordinates 51.0 × 98.5.
18. *Dicellaesporites* sp. A; B.S.I.P. slide no. 8123, coordinates 62.4 × 106.5.
19. *Multicellaesporites* sp. D; B.S.I.P. slide no. 8125. coordinates 62.3 × 97.10.
20. *Pluricellaesporites verrucatus* sp. nov.; B.S.I.P. slide no. 8131, coordinates 67.2 × 109.2 (Holotype).
21. *Multicellaesporites* sp. C; B.S.I.P. slide no. 8126, coordinates 67.2 × 103.6.
23. *Dicellaesporites* sp. B; B.S.I.P. slide no. 8122, coordinates 52.5 × 107.8.
24. *Pluricellaesporites* sp. B; B.S.I.P. slide no. 8135, coordinates 69.5 × 104.6.
25. *Diporicellaesporites* sp. B; B.S.I.P. slide no. 8136; coordinates 57.1 × 98.5.
26. *Diporicellaesporites* sp. A; B.S.I.P. slide no. 8112, coordinates 63.0 × 99.5.

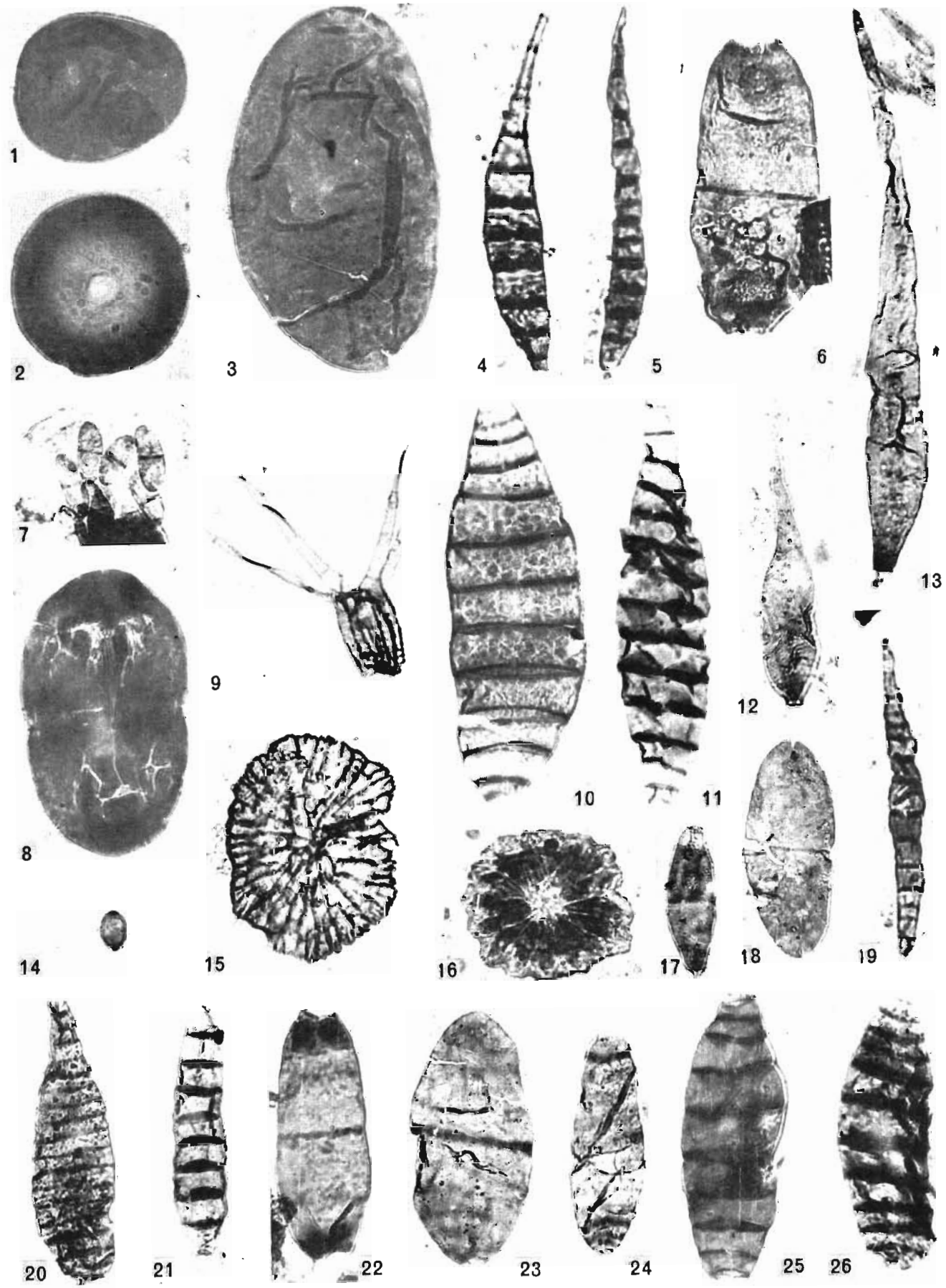

PLATE 2

Description—Fungal spore elongated. Size 126 × 30 μm, 15-celled, broader in the middle and pointed towards the ends. Inaperturate. Septa clearly discernible, thicker than the spore wall, complete. Spore wall 1 μm thick, laevigate.

Comparison—*Multicellaesporites* sp. D differs from *M. nortonii* Elsik (1968) in having 15-celled spore with laevigate spore wall.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Genus—*Lacrimasporonites* Clarke, 1965 emend. Elsik, 1968

Type species—*Lacrimasporonites levis* Clarke, 1965

Lacrimasporonites sp.

Pl. 1, fig. 15

Description—Fungal spore capsular in shape. Size 37 × 18 μm. Unicellate, nonseptate. Monoporate, pore apical, about 1 μm in diameter, pore margin not thickened, apertural end of the spore rounded while the other one completely flat. Spore wall less than 0.5 μm thick, laevigate.

Comparison—*Lacrimasporonites levis* Clarke (1965) is distinguished from *Lacrimasporonites* sp. in having bigger pore diameter (1-2 μm) and smaller size.

Occurrence—Laisong Formation, Barail Group.

Genus—*Monoporisporites* van der Hammen, 1954 emend. Sheffy & Dilcher, 1971

Type species—*Monoporisporites minutus* van der Hammen, 1954.

Monoporisporites sp.

Pl. 2, fig. 2

Description—Fungal spore spherical in shape. Size μm. Monoporate, pore circular, 8 μm in diameter, centrally located. Spore wall 1.5 μm thick, laevigate.

Comparison—The present specimen can be differentiated from *Monoporisporites smithii* Elsik (1968) by having a bigger pore (8 μm) and comparatively thinner and lighter pore margin.

Genus—*Dyadosporonites* Elsik, 1968

Type species—*Dyadosporonites schwabii* Elsik, 1968.

Dyadosporonites grandiporus sp. nov

Pl. 2, figs 6, 22

Holotype—Pl. 2, fig. 6, size 112 × 47 μm; B.S.I.P. slide no. 8100.

Type locality—165.75 kilometrestone, Sonapur-Badarpur Road Section Meghalaya.

Type Horizon—Dona Member, Bhuban Formation, Surma Group, Lower Miocene.

Diagnosis and description—Fungal spores cylindrical in shape. Size range 95 × 34 μm. Dicellate, both cells equal in size and shape. Diporate, pore 14-16 μm in diameter, pore margin very much thickened. Uniseptate, septa 2 μm thick, complete. Spore wall less than 1 μm thick, laevigate, slightly folded.

Comparison—The present species can be distinguished from *D. schwabii* Elsik (1968) by being bigger in size (112 × 47 μm), having bigger pore diameter (14-16 μm), thicker pore margin and also thicker septa. *D. reticulatus*, *D. cannanorensis* and *D. denticulatus* described by Ramanujam and Rao (1978) from the Neogene sediments of Kerala, South India, can be distinguished by their smaller pores (up to 4 μm) and smaller size range.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Dyadosporonites sp.

Pl. 1, fig. 14

Description—Fungal spore oval in shape. Size 38 × 29 μm. Dicellate, both cells almost equal in size and shape. Uniseptate, septum with a slit-like opening, connecting the two cells. Diporate, one pore present at each end of the spore, measuring about 2 μm in diameter. Spore wall 0.5 μm thick, laevigate having some irregular wrinkles.

Comparison—*Dyadosporonites schwabii* Elsik (1968) is distinct from the present species in having two-layered spore wall and smaller size 9 × 20 μm.

Occurrence—Jenam Formation, Barail Group.

Genus—*Diporisporites* van der Hammen, 1954 emend. Elsik, 1968

Type species—*Diporisporites elongatus* van der Hammen, 1954.

Diporisporites sp.

Pl. 1 fig. 16

Description—Fungal spore oval in shape. Size 60 × 38 μm. Diporate, one pore at each end, 6 μm wide, annulus thick, present around both the pores. Spore wall serrate on one side and smooth on the other.

Comparison—*Diporisporites elongatus* var der Hammen (1954) resembles the present species but the latter can be distinguished by having bigger pores (6 μm in diameter) with distinct annulus.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Genus—*Pluricellaesporites* van der Hammen, 1954 emend. Sheffy & Dilcher, 1971

Type species—*Pluricellaesporites typicus* van der Hammen, 1964.

Pluricellaesporites verrucatus sp. nov.

Pl. 2, fig. 20

Holotype—Pl. 2, fig. 20, size 111 × 33 μm; B.S.I.P. slide no. 8131.

Type locality—150 Kilometrestone, Sonapur-Badarpur Road Section, Meghalaya.

Type Horizon—Lubha Member, Bhuban Formation, Surma Group, Lower Miocene.

Diagnosis & Description—Fungal spore elongated with one end wider and the other end tubular. Size 111 × 33 μm. 18-celled, cells wider in the middle than those towards the apertural end. Monoporate, pore apically placed at the narrower end. Septa 1-1.5 μm thick. Spore wall 1 μm thick, granulose-verrucose. Surface view giving a verrucose appearance.

Comparison—This species can be differentiated from all the other species of *Pluricellaesporites* by having a verrucose spore wall.

Occurrence—Lubha Member, Bhuban Formation, Surma Group.

Pluricellaesporites sp. cf. *P. allepoeyenesis* Ramanujam & Rao, 1978

Pl. 2, fig. 4

Description—Fungal spore straight to slightly curved. Size range 70 × 13 μm. Multicellate. Uniseriate. Septa about 3 μm thick, middle part of the spore broad with narrower and blunt ends. Spore wall 1 μm thick.

Comparison—The present specimen closely compares with *P. allepoeyensis* Ramanujam & Rao (1978) in its shape and general organisation but the latter can be distinguished in having larger size range (80-165 μm) and thicker septa (8-16 μm).

Occurrence—Lubha Member, Bhuban Formation, Surma Group.

Pluricellaesporites sp. A

Pl. 2, fig. 11

Description—Fungal spore fusiform in shape. Size 83 × 28 μm. Spore multicellate, cells unequal in size. Monoporate, pore apical, pore margin not thickened. Septa faint but visible, sometimes incomplete, thicker than the spore wall. Spore wall less than 0.5 μm thick, laevigate. Some folds present.

Comparison—The present species can be differentiated from the other species of *Pluricellaesporites* by having thinner and faintly visible septa and as such it is difficult to count the exact number of cells.

Occurrence—Umkiang Member, Bhuban Formation, Surma Group.

Pluricellaesporites sp. B

Pl. 2, fig. 24

Description—Fungal spore with blunt ends. Size 106 × 39 μm. Spore multicellate, 11 celled, middle cells wider than the terminal ones. Monoporate, pore apical, pore margin not thickened, 10 μm in diameter. Septa distinct, about 2.5 μm thick, thicker than spore wall. Spore wall less than 0.5 μm thick, pitted, pits sparsely placed.

Comparison—*Pluricellaesporites* sp. B can be differentiated from *Pluricellaesporites* sp. A by having distinct septa and sparsely pitted spore wall.

Occurrence—Lubha Member, Bhuban Formation, Surma Group.

Genus—*Diporicellaesporites* Elsik, 1968

Type species—*Diporicellaesporites stacyi* Elsik, 1968

Diporicellaesporites verrucatus sp. nov.

Pl. 2, fig. 10

Holotype—Pl. 2, fig. 10, size 155 × 53 μm; B.S.I.P. slide no. 8134.

Type Locality—157.5 Kilometrestone, Sonapur-Badarpur Road section, Meghalaya.

Type Horizon—Dona Member, Bhuban Formation, Surma Group, Lower Miocene.

Diagnosis and description—Fungal spore lanceolate in shape, biconvex. Size 155 × 53 μm. 12-celled, cells wider in the middle and narrower at the ends. Diporate, pores apical, 11 μm in diameter. Septa 2-4 μm thick, dark, complete, thicker than the spore wall. Spore wall 1 μm thick, verrucose, verrucae flat-topped, 5 μm in size.

Comparison—The present specimen can be differentiated from *D. stacyi* Elsik (1968) in having bigger size (155 μm long), more number of cells (12 cells) and verrucose spore wall.

Occurrence—Dona Member, Bhuban Formation, Surma Group.

Diporicellaesporites sp. A

Pl. 2, fig. 26

Description—Fungal spore elongated, fusiform in shape. Size 110 × 91 μm. Multicellate, cells wider in the middle and narrower towards the apices. Diporate, pores apical. Septa prominent, complete thicker than the spore wall. Spore wall less than 0.5 μm thick, laevigate.

Comparison—*D. verrucatus* sp. nov. differs from the present species having verrucose spore wall. Also this specimen can be distinguished from *D. stacyi* Elsik (1968) by its bigger size, lanceolate shape and verrucose spore wall.

Occurrence—Umkiang Member, Bhuban Formation, Surma Group.

Diporicellaesporites sp. B

Pl. 2, fig. 25

Description—Fungal spore fusiform in shape. Size 177 × 36 μm. 15-celled, cells in the middle broader than the terminal ones. Diporate, one pore at each end, pore 6 μm in diameter, annulus not developed. Septa 1.5-3.5 μm thick, thicker in the middle and at the terminal ends. Spore wall less than 1 μm thick, laevigate.

Comparison—*Diporicellaesporites stacyi* Elsik (1968) possesses 4 cells with granular to punctate spore wall, hence different from the present specimen.

Occurrence—Lubha Member, Bhuban Formation, Surma Group.

Genus—*Fusiformisporites* Rouse, 1962 emend. Elsik, 1968

Type species—*Fusiformisporites crabbi* Rouse, 1962

Fusiformisporites sp.

Pl. 2, fig. 8

Description—Fungal spore ellipsoidal in shape, dark brown in colour. Size 100 × 45 μm. Dicellate, ends broadly arched. Transverse septa conspicuous, about 4 μm thick. Prominently striate, striae 4, longitudinal, seen on either side of the septum. Spore wall 1.5 μm thick, much thicker at each end.

Comparison—The present specimen can be distinguished from all the known species of *Fusiformisporites* by having bigger size (100 μm long) and thicker septum (4 μm thick).

Occurrence—Laisong Formation, Barail Group.

Genus—*Frasnacritetrus* Taugourdeau, 1968 emend.

Type species—*Frasnacritetrus josettee* Taugordeau, 1968 Saxena & Sarkar, 1985.

Frasnacritetrus sp.

Pl. 2, fig. 9

Description—Main body of the spore quadrangular, longer than wide. Size 37 × 21 μm. Longitudinally divided into 4 chambers. 4 multicellular hyphae arise from the main body, hyphae wider at the base and tapering towards the apcies, twisted, one hypha broken and incomplete. Spore wall about 0.5 μm thick, laevigate.

Occurrence—Barail and Surma groups.

INCERTAE—SEDIS

Genus—*Heliospermopsis* Nagy, 1965

Type species—*Heliospermopsis hungaricus* Nagy, 1965.

Heliospermopsis sp.

Pl. 2, fig. 16

Description—Body circular in outline with uniform wavy margin. Outer zone very distinct, consisting of long, linear to club shaped, radiating zones, 16 in number. Inner zone not clearly seen but darker than the outer zone, occupying more than half of the radius. Central zone well differentiated. Surface ornamentation granulose.

Dimensions—Body diameter: 57 μm; ridges in the outer zone: 11-13 × 5-7 μm; central zone: 12 μm in diameter.

Occurrence—Barail and Surma groups.

DISCUSSION

The fungal remains described here from the Barail and Surma groups (Oilgocene-Lower Miocene) are represented by 17 genera and 33 species. Of these, 6 genera and 9 species are of fungal bodies and 11 genera and 24 species of fungal spores. The fungal bodies show higher frequency (69%) than that of the fungal spores (31%). Quantitative analysis of the fungal remains reveals that their frequency is very high in Bhuban Formation (50%) whereas in Laisong, Jenam and Renji formations, they constitute 17%, 24% and 21% respectively. In Bokabil Formation they are meagrely represented (7%).

Qantitative evaluation of the various fungal taxa is summarized below (Table 1). The percentages of various

Table 1—Quantitative analysis of fungal taxa studied

Taxa	Laisong Formation %	Jenam Formation %	Renji Formation %	Bhuban Formation %	Bokabil Formation %
Phragmothyrites eocaenica	3 (18)	8 (34)	7 (34)	6 (12)	—
Paramicrothallites menonii	1 (6)	5 (21)	4 (19)	3 (6)	—
Notothyrites setiferus	4 (24)	4 (17)	5 (24)	5 (10)	—
Notothyrites padappakarensis	—	—	—	1.5 (3)	—
Notothyrites amorphus	—	—	—	1 (2)	—
Parmathyrites ramanujamii	—	—	—	2 (14)	—
Kutchiathyrites sp.	—	—	—	2 (4)	—
Lirasporis intergranifer	—	—	—	1 (2)	—
Heliospermopsis sp.	4 (24)	5 (21)	5 (24)	6 (12)	—
Inapertisporites ovalis	—	—	—	2 (4)	—
Inapertisporites miocenicus	—	—	—	3 (6)	
Inapertisporites sp. C. *I. kedvesii*	—	—	—	—	6
Dicellaesporites fusiformis	—	—	—	2.5 (5)	—
Dicellaesporites sp. A	1 (6)	—	—	—	—
Dicellaesporites sp. B	—	—	—	2 (4)	—
Lacrimasporonites sp.	2 (12)	—	—	—	—
Multicellaesporites sp.	—	—	—	2.5 (5)	—
Pluricellaesporites sp.	—	—	—	2 (4)	—
Monoporisporites sp.	—	—	—	—	1
Diporisporites sp.	—	—	—	2 (4)	—
Fusiformisporites sp.	1 (6)	—	—	—	—
Diporicellaesporites verrucatus	—	—	—	2.5 (5)	—
Diporicellaesporites sp.	—	—	—	1.5 (3)	—
Dyadosporonites grandiporus	—	—	—	1.5 (3)	—
Dyadosporonites grandiporus	—	—	—	2.5 (5)	—
Dyadosporonites sp.	—	2 (8)	—	—	—
Frasnacritetrus sp.	1 (6)	—	—	1 (2)	—

taxa in the overall assemblage of each formation have been given outside brackets while the percentages of the same amongst the fungal remains only have been given within the brackets.

Fungal bodies like *Phragmothyrites, Paramicrothallites, Notothyrites, Parmathyrites, Kutchiathyrites* and *Lirasporis* have affinity with the fruiting bodies of Ascomycetes whereas the fungal spores may be ascribed to Deuteromycetes. *Heliospermopsis* has been kept under *Incertae-sedis.*

MIOFLORAL COMPARISON

North-eastern India—Kar, Singh and Sah (1972) described 8 genera of fungal remains, viz., *Phragmothyrites, Notothyrites, Callimothallus, Parmathyrites, Cucurbitariaceites, Pluricellaesporites, Diporicellaesporites* and *Involutisporonites* from the Tura Formation (Palaeocene-Lower Eocene) of Garo Hills, Meghalaya. Though six of these genera are common to the present assemblage, the two assemblages are different at the specific level. Moreover, many genera like: *Kutchiathyrites, Lirasporis, Inapertisporites, Dicellaesporites, Multicellaesporites, Monoporisporites, Diporisporites, Dyadosporonites, Lacrimasporonites* and *Fusiformisporites* of the present material are absent from the Tura assemblage while reverse is the case with *Cucurbitariaceites* and *Involutisporonites.* Salujha, Kindra and Rehman (1972) described *Oudhkusumites immodicus* and *Phycopeltis* sp. from the Palaeogene of Garo Hills but these forms are absent from the present material. Salujha, Rehman and Kindra (1973) reported the presence of *Oudhkusumites immodicus* and few microthyriaceous discs in the Bhuban Formation but these forms are unrepresented in the present material. From the Palaeogene of Khasi and Jaintia Hills, Salujha Kindra and Rehman (1974) reported *Fusiformisporites foedus* and *Phycopeltis iucundus*, both of which are absent from the present material. It therefore, appears from the comparative study that the present assemblage does not closely compare with any of the fungal assemblages described so far from the Tertiary sediments of Meghalaya and Assam. The scanty representation of fungal remains in these assemblages indicates that their the fungal spores were meagrely represented therein or they have been ignored by the palynologists.

Other areas—The fungal remains are known from the Oligocene (Maniyara Fort Formation) of Kachchh

Table 2—Comparative account of fungal remains from Maniyara Fort Formation and Barail Group

Genera	*Maniyara Fort Formation (Oligocene) Kar, 1979*	*Barail Group (Oligocene) present study*
Pluricellaesporites	+	–
Phragmothyrites	+	+
Notothyrites	+	+
Kutchiathyrites	+	+
Inapertisporites	+	+
Lacrimasporonites	+	+
Dyadosporonites	+	+
Paramicrothallites	–	+
Heliospermopsis	–	+
Dicellaesporites	–	+
Fusiformisporites	–	+
Frasnacritetrus	–	+

Table 3—Comparative account of fungal remains from the Neyveli lignite, Warkalli lignite and Quilon beds of South India with those of Surma Group

Genera	*Neyveli lignite (Reddy, Ramanujam and Srisailam, 1982)*	*Warkalli lignite and Quilon beds (Jain & Gupta, 1970; Ramanujam & Rao, 1973, 1978; Kar & Jain, 1979)*	*Surma Group (Present Study)*
Meliolonites	+		
Callimothallus	+		
Haplopeltis	+		
Microthallites	+		
Trichothyrites	+		
Trichopeltinites	+		
Parmathyrites	+	+	+
Plochmopeltinites	+	+	
Euthyrites	+	+	
Paramicrothallites	+		+
Asterina		+	
Asterothyrites		+	
Bireticulasporis		+	
Chomotriletes		+	
Warkallisporonites		+	
Alleppeysporonites		+	
Cannanorosporonites		+	
Colligerites		+	
Foveolatisporonites		+	
Dendromyceliates		+	
Retibelicosporonites		+	
Diploneurospora		+	
Meliola		+	
Ornasporonites		+	
Quilonia		+	
Spegazzinia		+	
Phragmothyrites		+	+
Kutchiathyrites		+	+
Lirasporis		+	+
Dicellaesporites		+	+
Inapertisporites		+	+
Lacrimasporonites		+	+
Multicellaesporites		+	+
Pluricellaesporites		+	+
Monoporisporites		+	+
Diporisporites		+	+
Dyadosporonites		+	+
Diporicellaesporites		+	+
Frasnacritetrus		+	+

and Miocene (Neyveli lignite, Warkalli lignite, Quilon Beds) of South India. A comparison of these assemblages with the present one is tabulated below (Table 2 & 3).

Table 2 clearly shows that the exception of *Pluricellaesporites*, all fungal genera of the Maniyara Fort Formation (Oligocene) are common to the present assemblage too, hence two assemblages appear to be well comparable. Similarly, Table 3 reveals that all genera, but *Frasnacritetrus*, of the present Surma assemblage also occur in the Warkalli lignite and Quilon beds of Kerala. However, the latter assemblages are more diversified and consist of many other genera whichare unrepresented in the former. The Neyveli lignite assemblage is, however, not comparable to the present Surma assemblage.

SUMMARY AND CONCLUSIONS

1. The fungal remains recovered from the Barail-Surma sediments (Oligocene-Lower Miocene) exposed along Sonapur-Badarpur Road are represented by 17 genera and 33 species (5 species new). Of these, 6 genera and 9 species (1 species new) belong to fungal bodies and 11 genera and 24 species (4 species new) pertain to fungal spores.
2. The fungal bodies show higher frequency (69%) than that of the fungal spores (31%). Quantitative analysis of the fungal remains reveals that their frequency is high (50%) in the Bhuban Formation whereas in Laisong, Jenam and Renji formations, they constitute 17 per cent, 24 per cent and 21 per cent of their respective assemblages. However, in Bokabil Formation they share only 7 per cent of the assemblage.
3. Quantitatively, *Phragmothyrites, Notothyrites, Paramicrothallites* and *Heliospermopsis* are the most important genera being represented in almost every stratigraphic unit in good percentage.
4. The fungal spores mostly occur in the Bhuban Formation while in the Laisong, Jenam and Renji formations, their representation is meagre and is only at free levels.
5. The fungal bodies described here show affinity with Ascomycetes whereas the fungal spores may be related with Deuteromycetes.
6. A comparison of the present assemblage with the known fungal assemblages from Meghalaya and Assam was made and it was observed that they are not closely comparable.
7. The fungal assemblage from the Maniyara Fort Formation (Oligocene) of Kachchh closely compares with the present Barail assemblage. Similarly, the fungal assemblages reported from the Warkalli lignite and Quilon beds of South India show similarities with the present Surma assemblage. However, the former are more diversified and consist of other genera which are not represented in the latter. The Neyveli lignite assemblage has been found to be distinctly different from the present one.
8. The high frequency of fungal remains in the Barail Group and Bhuban Formation is suggestive of warm and humid climatic conditions during the sedimentation of these sediments.

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