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


ABSTRACT


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: *Peragmomycites*, *Notosporites*, *Parmatrichites*, *Kueichiyites*, *Inapertispores*, *Dickeliaesporites*, *Multicellularspores*, *Pluricellulasesporites* and *Dyadosporites*. 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

जयनिवन परिवर्त्यों (पेशान) एवं काँग्र (असम) में सोनपुर-बदरपुर भार्ट खंड के संग-संग हिदेसित सुरमा (अधिर मध्यवर्त) एवं बैरेल (पश्चिम) अवशेष में पाये हुए अत्याद्वैतिक अत्यावश्यक भाग 2—कांक्षी अवशेष

हरीयाल शिखर, रोमेश कृष्ण सिंह एवं बहसीलस्वल्प रामचंद राव

इस शोध-पत्र में मेनाचाल एवं असम में आवश्यक: जयनिवन परिवर्त्यों एवं काँग्र में सोनपुर-बदरपुर भार्ट खंड के संग-संग हिदेसित बैरेल एवं सुरमा समूह (पश्चिमपठान-अधिर मध्यवर्त) में उपलब्ध कांक्षी अवशेषों को प्रस्तुत किया गया है। इस समुच्चय में कुल लिखित जी 17 अवशेषों एवं 33 जीवन्त विविधता है। इनमें से 3 प्रजातियों एवं 6 जीवन्त विविधता के तत्त्व का भाग शामिल गरीष्म है। इस समुच्चय में लिखित जी 24 जीवन्त विविधता की ज्ञान की है। जीवन्त जीवन्त की स्थापीत की गई है। फ्रान्सिया, नीटोपाराडिम, परमफ्राया, बाइफ्राया, विया, दाइसिया, माटीसिया, घारीयाल शिखर एवं नामक मूल जीवन्त जीवन्त हैं। इस समुच्चय के परिमाणिक विविधता से यथा होता है कि सुरमा में जीवन्त जीवन्तों और जीवन्त के मूल जीवन्तों की अमूल्यता है जबकि बैरेल समूह में इनकी प्रतिवेशता कम हो जाती है। इस समुच्चय के तुलना से भारत की तुलीयादेश भारतीय बृहत् से ज्ञात कांक्षी समूहों के कोई नहीं 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), Saluja, Kindra and Rehman (1972, 1974), Saluja, Rehman and Kindra (1973), Sah and Singh (1974), 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, Jena and Renji formations. The Laisong Formation represents mainly the arenaceous facies consisting of grey, hard, thinly bedded, fine to medium grained sandstones alternating with subordinate, hard, sandy shales. The Jena 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 overlaid by the Surma Group which is divided into Bhuban and Bokabil formations. The Bhuban Formation is divided into Lubha, Umkiaang 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**


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


Description—Ascomata circular to subcircular in shape with crenate to almost entire margin. Nonostiolate. Size range 65-130 X 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.


*Phragmothyrites* sp.

Pl. 1, fig. 3

Description—Ascomata subcircular in shape. Nonostiolate. Size 90 X 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.

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**PLATE 1**

(All photomicrographs are enlarged. ca X 500)

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

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

4. *Paramicrobalites menonii* Jain & Gupta; B.S.I.P. slide no. 8103, coordinates 148.8 X 103.8.

5, 6. *Notocorythitesiseterus* Cookson; B.S.I.P. slide no. 0000, coordinates 48.8 X 103.8, coordinates 51.0 X 108.7; B.S.I.P. slide no. 8109, coordinates 107.1 X 93.8.

7. *Notocorythites padappaurenensis* Jain & Gupta; B.S.I.P. slide no. 8107, coordinates 70.2 X 114.7.

8, 9. *Parmathyrites ramanujamii* sp. nov.; B.S.I.P. slide no. 8108, coordinates 45.3 X 105.2; B.S.I.P. slide no. 8109, coordinates 48.4 X 93.5 (Holotype). *Notocorythites amorphus* Kar & Saxena; B.S.I.P. slide no. 8106, coordinates 75.7 X 113.6.

10. *Kutchiahyrites* sp.; B.S.I.P. slide no. 8110, coordinates 55.1 X 96.10.

11, 12. *Lutraporos intergranger* Potonié & Sah emend. Jain & Kar, B.S.I.P. slide no. 8110, coordinates 40.0 X 103.5.

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


15. *Diporosporites* sp.; B.S.I.P. slide no. 8130, coordinates 71.6 X 104.6.
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 x 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


Occurrence—Barail and Surma groups.


*Notothyrites amorphus* Kar & Saxena, 1976

Pl. 1, fig. 10

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

Occurrence—Dona Member, Bhuban Formation, Surma Group.


*Notothyrites padappakarensis* Jain & Gupta, 1970

Pl. 1, fig. 7

Description—Ascomata circular to subcircular in shape, flattened, outline sinuous. Size range 60-100 x 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—Parmathyrtes Jain & Gupta, 1970**

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

*Parmathyrtes 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-Badalpur 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—*Parmathyrtes 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. turanssis* 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.


*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).

Type species — *Inapertisporites pseudoreticulatus* Rouse, 1959.

*Inapertisporites ovalis* Sheffy & Dilcher, 1971
Pl. 2, fig. 14


**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. unicellular, 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. kedvesl* Elisk, 1968
Pl. 1, fig. 1

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

**Comparison** — *Inapertisporites kedvesl* Elisk (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. unicellular. 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.

Type species — *Dicellaesporites popoiti* Elisk, 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. Unisepate. 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


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

Occurrence—Dona Member, Bhurban Formation, Surma Group.

Dicellaesporites sp. B

Description—Fungal spore elongated, biconvex. Size 126 × 46 μm. Dicellate. Inaperturate. Unisepitate, sepal 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.


Type species—Multicellaesporites nortonii Elsk., 1968.

Multicellaesporites sp. A

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 Elsk. (1968) is distinguished from the present species by possessing 5-celled spores with smaller size (37 × 15 μm).

Occurrence—Dona Member, Bhurban Formation, Surma Group.

Multicellaesporites sp. B

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

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

Occurrence—Dona Member, Bhurban Formation, Surma Group.

Multicellaesporites sp. C

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 sepa (4 μm thick) and laevigate spore wall.

Occurrence—Dona Member, Bhurban Formation, Surma Group.

Multicellaesporites sp. D

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.

PLATE 2

(All photomicrographs are enlarged, ca × 500)

1. Inapertisporites sp. cf. I. kudeshi Elsk.; B.S.I.P. slide no. 8115, coordinates 49.9 × 114.2.
2. Monosporites 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.
6. Dyadosporites grandisporus 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. Prasincocircus sp.; B.S.I.P. slide no. 8138, coordinates 41.5 × 109.3.
10. Dicellaesporites 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).
16. Gladiosporites sp.; B.S.I.P. slide no. 8112, coordinates 55.3 × 114.3.
17. Multicellaesporites sp. B; B.S.I.P. slide no. 8127, coordinates 50.0 × 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).
22. Dicellaesporites sp. B; B.S.I.P. slide no. 8122, coordinates 52.5 × 107.8.
23. Pluricellaesporites sp. B; B.S.I.P. slide no. 8135, coordinates 69.5 × 104.6.
24. Dicellaesporites sp. B; B.S.I.P. slide no. 8136; coordinates 57.1 × 98.5.
25. Dicellaesporites sp. A; B.S.I.P. slide no. 8112, coordinates 63.0 × 99.5.
**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**—*Multicellulora* 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**—*Lacrimalorus* Clarke, 1965 *emend.* Elsik, 1968

Type species—*Lacrimalorus levis* Clarke, 1965

*Lacrimalorus* 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**—*Lacrimalorus levis* Clarke (1965) is distinguished from *Lacrimalorus* sp. in having bigger pore diameter (1.2 µm) and smaller size.

**Occurrence**—Laisong Formation, Barail Group.

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

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

*Monoporispora* sp.

Pl. 2, fig. 2

**Description**—Fungal spore spherical in shape. Size 8 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 *Monoporispora smithii* Elsik (1968) by having a bigger pore (8 µm) and comparatively thinner and lighter pore margin.

**Genus**—*Dyadospora* Elsik, 1968

Type species—*Dyadospora schwabii* Elsik, 1968.

*Dyadospora* 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 kilometerstone, 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. reticulata*, *D. cannamorensis* and *D. denticulata* 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.

*Dyadospora* 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**—*Dyadospora schwabi* 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**—*Diporisorites* van der Hammen, 1954 *emend.* Elsik, 1968

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

*Diporisorites* 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**—*Diporisorites elongatus* van 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**—*Pluricellula* van der Hammen, 1954 *emend.* Sheffy & Dilcher, 1971

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

*Pluricellula* 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 Kilometerstone, 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 x 33 μm. 18-celled, cells wider in the middle than those towards the apertural end. Monoporate, pore apically placed at the narrower end. Septa 1.5-1.5 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. allepoeyensis Ramanujam & Rao, 1978
Pl. 2, fig. 4

Description—Fungal spore straight to slightly curved. Size range 70 x 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 x 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 x 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 x 53 μm; B.S.I.P. slide no. 8134.

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

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

Diagnosis and description—Fungal spore lanceolate in shape, biconvex. Size 155 x 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 x 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 x 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.

Type species—Fusiformisporites crabbi Rouse, 1962
**Fusiformisporites sp.**

*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—Frasnacritetus Taugourdeau, 1968 emend.*

*Type species—Frasnacritetus jostettei Taugourdeau, 1968 Saxena & Sarkar, 1985.*

*Frasnacritetus sp.*

*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 apices, 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.*

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**DISCUSSION**

The fungal remains described here from the Barail and Surma groups (Oligocene-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%).

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

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<table>
<thead>
<tr>
<th>Taxa</th>
<th>Laisong Formation %</th>
<th>Jenam Formation %</th>
<th>Renji Formation %</th>
<th>Bhuban Formation %</th>
<th>Bokabil Formation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phragmothyris exoacanthic</td>
<td>3 (18)</td>
<td>8 (34)</td>
<td>7 (34)</td>
<td>6 (12)</td>
<td>—</td>
</tr>
<tr>
<td>Paramicrothallites menomia</td>
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<td>5 (21)</td>
<td>4 (19)</td>
<td>3 (6)</td>
<td>—</td>
</tr>
<tr>
<td>Notomyrites setiferus</td>
<td>4 (24)</td>
<td>4 (17)</td>
<td>5 (24)</td>
<td>5 (10)</td>
<td>—</td>
</tr>
<tr>
<td>Notomyrites podagopakarensis</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1.5 (3)</td>
<td>—</td>
</tr>
<tr>
<td>Notomyrites amorphus</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1 (2)</td>
<td>—</td>
</tr>
<tr>
<td>Parmathyris ramamujamii</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2 (14)</td>
<td>—</td>
</tr>
<tr>
<td>Kutthioryzites sp.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2 (4)</td>
<td>—</td>
</tr>
<tr>
<td>Liraspores intengrimner</td>
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<td>—</td>
<td>—</td>
<td>1 (2)</td>
<td>—</td>
</tr>
<tr>
<td>Heliospermopsis sp.</td>
<td>4 (24)</td>
<td>5 (21)</td>
<td>5 (24)</td>
<td>6 (12)</td>
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<tr>
<td>Inapertisporites ovales</td>
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<td>—</td>
<td>—</td>
<td>2 (4)</td>
<td>—</td>
</tr>
<tr>
<td>Inapertisporites miomuncicus</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3 (6)</td>
<td>—</td>
</tr>
<tr>
<td>Inapertisporites sp. C. kedaesi</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>6</td>
</tr>
<tr>
<td>Dictellaesporites fusiformis</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2.5 (5)</td>
<td>—</td>
</tr>
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<td>Dictellaesporites sp. A</td>
<td>1 (6)</td>
<td>—</td>
<td>—</td>
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<td>—</td>
</tr>
<tr>
<td>Dictellaesporites sp. B</td>
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<td>—</td>
<td>—</td>
<td>2 (4)</td>
<td>—</td>
</tr>
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<td>Lacrimasporites sp.</td>
<td>2 (12)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Multicellulaesporites sp.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2.5 (5)</td>
<td>—</td>
</tr>
<tr>
<td>Pluricellulaesporites sp.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2 (4)</td>
<td>—</td>
</tr>
<tr>
<td>Monoporsporites sp.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Diporisporites sp.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2 (4)</td>
<td>—</td>
</tr>
<tr>
<td>Fusiformisporites sp.</td>
<td>1 (6)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Diporicellulaesporites verrucatus</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2.5 (5)</td>
<td>—</td>
</tr>
<tr>
<td>Diporicellulaesporites sp.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1.5 (3)</td>
<td>—</td>
</tr>
<tr>
<td>Dyadosporites grandiporus</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1.5 (3)</td>
<td>—</td>
</tr>
<tr>
<td>Dyadosporites grandiporus</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2.5 (5)</td>
<td>—</td>
</tr>
<tr>
<td>Dyadosporites sp.</td>
<td>—</td>
<td>2 (8)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Frasnacritetus sp.</td>
<td>1 (6)</td>
<td>—</td>
<td>—</td>
<td>1 (2)</td>
<td>—</td>
</tr>
</tbody>
</table>
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 Liraspis have affinity with the fruiting bodies of Ascomycetes whereas the fungal spores may be ascribed to Deuterozymetes. 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, Cucurbitariaceae, Pluricellaeasporites, Diporcellaesporites and Involutisporites 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, Liraspis, Inapertisporites, Dicellaesporites, Multicellaeasporites, Monoporsporites, Diporcellaeasporites, Dyadosporites, Laciniasporites and Fusiformisporites of the present material are absent from the Tura assemblage while reverse is the case with Cucurbitariaceae and Involutisporites. Saluja, Kindra and Rehan (1972) described Oudhkusumites immodicus and Phycopelites sp. from the Palaeocene of Garo Hills but these forms are absent from the present material. Saluja, Rehan and Kindra (1973) reported the presence of Oudhkusumites immodicus and few microthyriaceous disc in the Bhuban Formation but these forms are unrepresented in the present material. From the Palaeocene of Khari and Jaintia Hills, Saluja Kindra and Rehan (1974) reported Fusiformisporites foedus and Phycopelites tucundus, 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 fungal spores were meagerly represented therein or they have been ignored by the palynologists.

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

<table>
<thead>
<tr>
<th>Genera</th>
<th>Maniyara Fort Formation (Oligocene)</th>
<th>Barali Group (Oligocene) present study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pluricellaeasporites</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Phragmothyrites</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Notothyrites</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Kutchiathyrites</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Inapertisporites</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Laciniasporites</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Dyadosporites</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Paramicrothallites</td>
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<td>+</td>
</tr>
<tr>
<td>Heliospermopsis</td>
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<td>+</td>
</tr>
<tr>
<td>Dicellaesporites</td>
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<td>+</td>
</tr>
<tr>
<td>Fusiformisporites</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>Prasnacraterius</td>
<td>−</td>
<td>+</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Melakonites</td>
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<tr>
<td>Haplokoelites</td>
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<tr>
<td>Microthallites</td>
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<td>+</td>
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<tr>
<td>Trichoothyrites</td>
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<tr>
<td>Trichopelmites</td>
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<td>+</td>
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<tr>
<td>Parmathyrites</td>
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<td>Plocosporites</td>
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<td>Euothyrites</td>
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<td>Asterothites</td>
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<td>Bireticulasporis</td>
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<tr>
<td>Chomorites</td>
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<td>+</td>
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<tr>
<td>Warkallisporites</td>
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<td>Reiheliscoporites</td>
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<td>Diploneurospora</td>
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<td>Meiolea</td>
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<td>Ornmosporites</td>
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<td>Quiloinia</td>
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<tr>
<td>Squazazzinia</td>
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</tr>
<tr>
<td>Phragmothyrites</td>
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<tr>
<td>Kutchiathyrites</td>
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</tr>
<tr>
<td>Liraspis</td>
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<tr>
<td>Dicellaesporites</td>
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<tr>
<td>Inapertisporites</td>
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<tr>
<td>Laciniasporites</td>
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<tr>
<td>Multicellaeasporites</td>
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<td>Dyadosporites</td>
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<td>+</td>
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<tr>
<td>Diporcellaeasporites</td>
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<td>+</td>
</tr>
<tr>
<td>Prasnacraterius</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

*Other areas—The fungal remains are known from the Oligocene (Maniyara Fort Formation) of Kachchh*
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 Prulleriaexsaiaris, 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 Fruinistriocetum, of the present Suma 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 which are not represented 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 Bhurban Formation whereas in Laisong, Jegan 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 Helospermopsis are the most important genera being represented in almost every stratigraphic unit in good percentage.

4. The fungal spores mostly occur in the Bhurban Formation while in the Laisong, Jegan 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 Barai 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 Bhurban Group and Bhurban Formation is suggestive of warm and humid climatic conditions during the sedimentation of these sediments.

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