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PALYNOLOGY OF NEOGENE SEDIMENTS AROUND QUILON AND VARKALA, KERALA COAST, SOUTH INDIA 1. FUNGAL REMAINS

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ABSTRACT

The Neogene sediments near Padappakkara, Edvai and Varkala have yielded a rich microflora. The present communication deals only with the morpho-taxonomy of fungal remains, comprising 17 genera and 19 species. Of these, two genera, viz., *Colligerites* and *Dendromyceliates* and four species, viz., *Colligerites chowdhryii*, *Parmathyrites robustus*, *Dendromyceliates splendus* and *Dicellaesporites ellipticus* are new. The assemblage is dominated by epiphyllous microthyriaceous forms.

Key-words — Palaeopalynology, Fungal remains, Neogene, Western Coast (India).

सारांश

कोल्लम एवं वरकला के आस-पास, केरल तट, दक्षिण भारत के निओजीन अवसादों का परागाणविक अध्ययन – 11 कवकी अवशेष – कृष्ण प्रसाद जैन एवं रणजीत कुमार कर

पडप्पाकारा, एडवा तथा वरकला के निकटस्थ निओजीन अवसादों से प्रचुर सूक्ष्म-वनस्पति जात प्राप्त हुआ है। प्रस्तुत शोध पत्र में कवकी अवशेषों की 17 प्रजातियों व 19 जातियों की आकृति-वर्गीकरण का वर्णन है। इनमें से दो प्रजातियाँ, **कोलिजेराइटिस** एवं **डेन्ड्रोमाइसिटीस**, तथा चार जातियाँ, **कोलिजेराइटिस चौधराई**, **पारमाथाइराइटिस रोबस्टस**, **डेन्ड्रोमाइसिटीस स्प्लेंड्स** व **डाइसेलास्पोराइटिस इलिप्टिकस**, नई हैं। समुच्चय में माइक्रोथिरियेसीय अधिपर्णी प्ररूपों का बाहुल्य है।

INTRODUCTION

THE general stratigraphic sequence of the Tertiary sediments along the Kerala coast extending from Cape Comorin in the south to Manjeshwar in the north has been mostly divided into two stratigraphic units known as Quilon and Warkalli beds. The latter conformably overlies the former. The thickness of the Tertiary sediments is roughly estimated to be 400 m (Nair, 1976). Terms, viz., Warkala Series (Menon, 1967) and Warkalli Formation (Ramanujam & Rao, 1973) have also been used but are not in accordance with the Code of Stratigraphic Nomenclature of India (1971).

Poulose and Narayanaswami (1968) have discussed at length the aspects of lithology, stratigraphy, environment of deposition, age and correlation of Tertiary sediments developed along the Kerala coast.

The age of these beds is still a matter of controversy. It ranges from Lower Miocene to even Lower Pliocene. The Quilon limestone exposed at Padappakkara is rich in fauna. Its age has been concluded to be Upper Miocene (Poulose & Narayanaswami, 1968, p. 307) but Raju (1978, p. 10) on the basis of Miogypsinid lineage suggested an early Burdigalian age. No animal fossils have so far been discovered from the Warkalli beds.

Recently, Rao and Ramanujam (1975) in a short note have listed the palynological fossils from the Quilon beds exposed at Padappakkara, Paravur and Edvai in the state of Kerala. The report mentions the

occurrence of dinoflagellates, acritarchs, miospores and a fairly good number of fungal fruiting bodies and spores.

A perusal of the vast palaeopalynological literature available reveals a good representation of fungal remains belonging to ascomycetes, phycomycetes, basidiomycetes and fungi imperfecti along with several unrecognized forms (Jain, 1974). Out of these, ascomycetes — specially microthyriaceae predominates followed by phycomycetes and fungi imperfecti in the Kerala coast sediments.

Following fossil fungi species have so far been recorded from the Neogene of Kerala.

1. *Quilon beds* (Rao, 1959; Jain & Gupta, 1970): *Parmathyrites cooksonii* (Rao) Jain & Gupta, 1970; *Parmathyrites indicus* Jain & Gupta, 1970; *Notothyrites padappakkarensis* Jain & Gupta, 1970; *Paramicrothallites menonii* Jain & Gupta, 1970; *Callimothallus quilonensis* Jain & Gupta, 1970; *Diploneurospora tewarii* Jain & Gupta, 1970; *Phragmothyrites* sp. cf. *P. eocaenica* Edwards, 1922; *PP. edwardsii* (Rao) Kar *et al.*, 1972; *Entophlyctis willoughbyi* Bradley, 1967; *Quilonia typica* Jain & Gupta, 1970; *Microthyriacites* sp.

2. *Warkalli beds* (Ramanujam & Rao, 1973): *Notothyrites setiferus* Cookson, 1947; *N. denticulatus* Ramanujam & Rao, 1973; *N. airensis* Cookson, 1947; *Callimothallus pertusus* Dilcher, 1965; *C. raoi* Ramanujam & Rao, 1973; *Asterina eocenica* Dilcher, 1965; *Asterothyrites* sp., *Authyrites keralensis* Ramanujam & Rao, 1973; *Plochmopeltinites cooksonii* Ramanujam & Rao, 1973.

The present paper forms the first part of the palynostratigraphic studies of Neogene sediments of Kerala coast. The other parts dealing with pteridophytic spores, gymnospermous and angiospermic pollen, dinoflagellates, acritarchs and biostratigraphy will be published separately.

The purpose of the present investigation is to describe the fossil fungi recovered from the following six measured sections confined to the surface exposures near Padappakkara, Edvai and Varkala. The samples were collected by one of us (K.P.J.) during the field seasons of 1972, 1973 and 1976.

1. Chanakkodi section located on the eastern side of the Ashtamudi Lake, Padappakkara (11 km W-E of Quilon) (Pl. 4, fig. 55). Lithological sequence is as follows in ascending order:

(iii) Lateritic soil — 1·5 m
(ii) Fossiliferous limestone — 0·5 m
(i) Carbonaceous clay — 0·25 m

2. Edvai cliff section, 2 km S-W of Edvai Railway Station. Lithological sequence shows only a narrow patch of 0·25 m thick plastic clay band containing shark teeth (Pl. 4, figs. 52, 53) overlain by 3 m thick lateritic soil and underlain by 0·5 m thick band of fossiliferous limestone (this section is now covered with big boulders placed to save the land from erosion).

3. Varkala sea cliff section, 4 km S-W of Varkala Railway Station.

The cliff is about 1/2 km wide. The beds are low dipping, almost horizontal. Samples from four well-developed sections along the strike were collected.

A. *Pulakkodi section*:

(iv) Lateritic soil — 4-5 m
(iii) Variegated sandstone — 6 m
(ii) Carbonaceous clay with carbonized woods — 3·5 m
(i) White plastic clay — 2 m
Base not seen.

B. *Papanasam section*:

(iii) Lateritic soil — 3-4 m
(ii) Variegated sandstone — 5 m
(i) Carbonaceous shale with few plant impressions — 1·5 m

C. *Vettur section* (Pl. 4, fig. 54):

(iv) Lateritic soil —5 m
(iii) Ferruginous sandstones — 10 m
(ii) Variegated sandstone alternating with carbonaceous shales and clays — 6 m
(i) Ferruginous clays, base not seen — 1·5 m

D. *Chillakur section*:

(vii) Lateritic soil — 3 m
(vi) Fine to coarse grained sandstone — 5 m
(v) Plastic black clay — 1 m
(iv) Unconsolidated sand — 1 m
(iii) Plastic black clay — 1 m
(ii) Sandstone with alternation of clay bands — 7 m
(i) Black clay — 3 m
Base not seen.

SYSTEMATIC DESCRIPTION

Class — Ascomyceteae
Order — Hemisphaeriales
Family — Microthyriaceae

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

Remarks — Kar and Saxena (1976) emended *Phragmothyrites* Edwards (1922) and considered *Microthyriacites* Cookson (1947), *Callimothallus* Dilcher (1965), *Microthallites* Dilcher (1965) and *Pseudosphaerialites* Venkatachala & Kar (1969) as its junior synonyms.

Phragmothyrites eocaenica Edwards emend. Kar & Saxena, 1976

Pl. 1, figs 1-7; Pl. 2, fig. 19

Remarks — The specimens studied here are dimidiate and non-ostiolate. The hyphae are radially arranged and interconnected with each other by means of transverse septa to form pseudoparenchymatous cells. Pore may be present or absent, the marginal cells are generally elongated, darker and setose.

In some of the specimens, the central cell is more or less circular and bigger than surrounding cells. The cells in the middle are darker and sometimes more thickened than the outer cells except the marginal ones.

Genus — *Parmathyrites* Jain & Gupta, 1970

Remarks — *Parmathyrites* is quite common in the Tertiary sediments of India. The specimen referable to this genus was first reported by Tilgner (1954) from the Tertiary brown coal of Germany. Rao (1959) reported the occurrence of *Parmathyrites* from the South Arcot of South India. Jain and Gupta (1970) established this genus after studying the specimens from Kerala while Kar, Singh and Sah (1972) reported them from the Tertiaries of Assam.

Parmathyrites indicus Jain & Gupta, 1970

Pl. 1, fig. 13

Parmathyrites robustus sp. nov.

Pl. 1, fig. 14; Pl. 2, fig. 34

Holotype — Pl. 1, fig. 14, size 90 μm. Slide no. 5402/3.

Type Locality — North of the Chillakur Village, Varkala, Kerala coast, South India.

Age — Miocene.

Diagnosis — Ascostromata dimidiate, 60-110 μm; central pseudoparenchymatous cells thickened, sometimes porate, non-ostiolate. Marginal cells spinose, spines robust, closely placed, radiate, tips pointed.

Comparison — The present species is distinguished from *Parmathyrites indicus* Jain & Gupta (1970), *P. cooksonii* (Rao) Jain & Gupta (1970) and *P. turaensis* Kar, Singh & Sah (1972) by its thickened cells in the central region and strongly built spinose processes along the margin.

Genus — *Kutchiathyrites* Kar, 1979

Kutchiathyrites eccentricus Kar, 1979

P. 1, fig. 15; Pl. 2, fig. 23

Remarks — Kar (1979) reported this genus from the Maniyara Fort Formation (Oligocene) of Kutch, western India. This genus is rare in the Miocene sediments of Kerala. It is characterized by eccentric development of the leathery ascostromata. The hyphae are radially arranged and diverge towards margin, they are transversely septate to form squarish-rectangular, pseudoparenchymatous cells.

Kendrick and Carmichael (1973) illustrated a number of Phycomycetes having eccentric ascostromata. In *Mycocenterolobium platysporum*, the ascostromata is like a fish scale as in *Kutchiathyrites* and also possesses similar pseudoparenchymatous cells. *Arbuscula eugeniae* is conspicuous by the presence of proliferation of the ascostromata developing one over the other. *Tretopileus sphaerophorus* has semicircular ascostromata and radially arranged hyphae which are occasionally transversely septate.

Genus — *Notothyrites* Cookson, 1947

Notothyrites setiferus Cookson, 1947

Pl. 1, figs 16-18

Remarks — The size of ostiole in *N. setiferus* is quite variable. The setae bordering the ostiole is mostly traceable. Pseudoparenchymatous cells surrounding the ostiole are darker and thickened. The micro-

thyriaceous ascostromata are generally radially symmetrical but sometimes they are unequally lobate along the margin.

Notothyrites amorphus Kar & Saxena, 1976

Pl. 2, figs 21, 22

Remarks — Specimens studied here are asymmetrical with uneven margin. The ostiole is ovoidal in shape and is surrounded by dark thickened cells. The ascostromata is leathery with indistinct pseudoparenchymatous cells.

Genus — *Lirasporis* Potonié & Sah, 1960 emend.

Remarks — Potonié and Sah (1960) instituted *Lirasporis* from the Cannanore lignites (Miocene) of Kerala to accommodate oval spores with notches at the ends and having parallel longitudinal ribs throughout the body. They placed this genus under the turma *Polyplicates* Erdtman (1952) and compared it with a few genera, viz., *Gnetaceaepollenites* Thiergart (1938), *Ephedripites* Bolkhovitina (1953), *Welwitschiapites* Bolkhovitina (1953) and *Vittatina* Luber (1940).

The fungal bodies assignable to *Lirasporis* are frequently found in the present material. It has been observed that these bodies do not possess any tectate exine. The parallel ribs seem to be the septate fungal mycelia arranged in longitudinal direction.

The fungal affiliation of the genus necessitated its transfer from *Polyplicates* to fungi.

Emended Generic Diagnosis — Fungal bodies oval-elliptical with equal or unequal, broad, generally notched ends. Mycelia, long, septate, ± parallel to one another, extending from one end to other; wall generally laevigate, sometimes granulose.

Lirasporis intergranifer Potonié & Sah, 1960 emend.

Pl. 2, fig. 25; Pl. 3, fig. 50

Holotype — Potonié and Sah, 1960, pl. 4, fig. 33.

Remarks—Potonie and Sah (1960) selected *Lirasporis intergranifer* as the type species of *Lirasporis* and referred them on pl. 4, fig. 4 (Potonié & Sah, 1960, p. 132). But such figure number does not exist in the illustrations. In the explanation of plates, however, they have designated fig. 33, pl. 4 as the genotype. The same figure of number has been maintained here.

Emended Specific Diagnosis — Oval-elliptical fungal bodies, 112-154 × 65-113 μm; ends equally or unequally broad, generally notched at one or both ends. Mycelia distinct, run from end to end, septate; wall mostly smooth.

Lirasporis sp.

Pl. 3, fig. 39

Description — Fungal body barrel-shaped, 96 × 63 μm in size, many-celled, cells ± rectangular, wall moderately thick and dark at ends.

Comparison — *Lirasporis intergranifer* Potonié & Sah emend. is generally notched at the ends and the pseudoparenchymatous cells are much narrower than the specimen described here.

Genus — *Bireticulasporis* Potonié & Sah, 1960

Bireticulasporis communis Potonié & Sah, 1960

Pl. 1, fig. 12; Pl. 2, fig. 24

Remarks — Potonié and Sah (1960) stated that the exine is characterized by two kinds of ornamentations — a finer reticulation in the higher focus and a clear, coarse reticulation in the deeper focus. The finer reticulation is, however, absent in *B. communis* which they attributed it due to bad preservation. The specimens studied here also do not have any finer reticulation. The mycelia anastomose to form broad, loose, reticulate pattern. The meshes are mostly subcircular and the lumina are shallow. The specimens generally exhibit a subcircular fold, parallel to the margin.

The fungal body described as Type-1 by Kar, Singh and Sah (1972) from the Tura Formation (Eocene) of Garo Hills broadly resembles *Bireticulasporis*.

Potonié and Sah (1960) mentioned figures 1 and 2 of plate 4 as the holotype of *Bireticulasporis communis*. But such figure numbers do not exist. In the explanation of plates, they have designated figure numbers 30 and 31 of plate 4 for the holotype of the species and the same have been maintained here.

Genus — *Chomotriletes* (Naumova) Naumova, 1953

cf. *Chomotriletes* sp.

Pl. 2, figs 26, 27

Description — Fungal bodies subcircular, 33-42 μm, concentric ridges present, wall in some specimens setose, ridges prominent in outer but obscure in middle region.

Remarks — The genus *Chomotriletes* (Naumova) Naumova (1953) resembles the specimens described here by their subcircular shape and concentric ridges. Naumova (1953) described them from the Upper Devonian of Russia while the present specimens are from Miocene. Considering the disparity in age and wide geographical distances, the specimens observed here have only been compared to *Chomotriletes*.

MICROTHYRIACEOUS FUNGI

TYPE-1

Pl. 1, fig. 8

Description — Ascostromata subcircular, 80×78 μm, non-ostiolate, margin uneven due to unequal development of pseudoparenchyma. Hyphae irregularly arranged, anastomose to form square-rhomboidal cells, cells longer along margin, nonsetose, sometimes porate.

TYPE-2

Pl. 1, fig. 9

Description — Ascostromata subcircular, 80×70 μm, dimidiate, non-ostiolate. Hyphae haphazardly arranged, anastomose to form pseudoparenchymatous cells, cells squarish in middle but longer, sometimes imperfect along outer region, pore rare.

Comparison — Microthyriaceous fungi Type-1 described earlier resembles the present specimen in the absence of prominent radial hyphae but in the former the pseudoparenchymatous cells are bigger and more or less uniform throughout the ascostromata.

Family — MELIOLACEAE

Genus — *Meliola* Fries, 1825

Meliola anfracta Dilcher, 1965

Pl. 3, fig. 51

Description — Ascomata attached with fungal mycelium, mycelium dark brown, septate, setose. Ascomata borne on lateral branches, elliptical, 21-34 μm, porate, pore margin not thickened.

Remarks — The dark, robustly built, setose mycelium with ascomata on lateral branches characterize the order Meliolales of Pyrenomycetes. According to Müller and Arx (1973), most of them have only been recorded from warmer geographical areas and are common on tropical trees and shrubs. They are generally mentioned as "black mildews" and each species shows a narrow specialization with respect to a particular host species or genus.

Dilcher (1965) reported two fossil species of *Meliola* from the Eocene deposits in western Tennesse, U.S.A.

Class — FUNGI IMPERFECTI

Genus — *Inapertisporites* (van der Hammen) Elsik, 1968

Inapertisporites kedvesii Elsik, 1968

Pl. 2, fig. 33

Remarks — The spores assignable to *I. kedvesii* are very common in the present assemblage. They are subcircular in shape and 30-60 μm in size. The spore wall is about 1 μm thick and is irregularly folded.

Inaperturate spores are produced by many Hyphomycetes and Phycomycetes. This makes it extremely difficult to identify the fossil spores with the living ones.

Inapertisporites sp. A

Pl. 3, fig. 38

Description — Spore elliptical, 110×48 μm in size, one end slightly narrower than other, inaperturate, spore wall less than 1 μm thick, psilate, irregularly folded.

Comparison — The spore described here is distinguished from *Inapertisporites kedvesii* Elsik (1968) by its elliptical shape. *Inapertisporites* sp. described by Kar and

Saxena (1976) is spindle-shaped with lesser breadth.

Genus — *Dicellaesporites* Elsik, 1968

Dicellaesporites ellipticus sp. nov.

Pl. 2, figs 31, 32

Holotype — Pl. 2, fig. 31, size 70×60 μm. Slide no. 5414/5.

Type Locality — Papanasam, Varkala, Kerala Coast, South India.

Age — Miocene.

Diagnosis — Spores two-celled, elliptical, 45-70×30-60 μm in size, inaperturate, septa distinct, straight, cells equal. Spore wall 1-2 μm thick, ornamentation granulose-microverrucose, sculptural elements not more than 1 μm high.

Comparison — *Dicellaesporites popovii* Elsik (1968) approximates the present species in size range and shape but the latter is easily distinguished by its granulose-microverrucose sculptural elements.

Genus — *Colligerites* gen. nov.

Type Species — *Colligerites kutchensis* (Kar & Saxena) comb. nov.

Diagnosis — Spores multicellular, coiled, cells generally smaller, rounded in central region and bigger, rectangular in outer region. Spore wall mostly laevigate, sometimes granulose. Pore may be present or absent in each cell.

Comparison — *Involutisporonites* Elsik (1968) broadly resembles the present genus in coiled and multicellular character. It may, however, be mentioned here that the coiling in *Involutisporonites* is not perfect and it has got a hyaline cell at the tip. This is also observed in *Pluricellaesporites hilsii* Elsik (1968, pl. 3, fig. 5) and so they appear to be same.

Derivation of Generic Name — Latin word *colligere* meaning coil.

Colligerites kutchensis (Kar & Saxena) comb. nov.

Pl. 2, fig. 29

1959 Rao, p. 46, pl. 1, fig. 13.
1972 *Involutisporonites* sp. Kar, Singh & Sah, p. 152, pl. 2, fig. 28.
1976 *Involutisporonites kutchensis* Kar & Saxena, p. 12, pl. 3, figs 37, 38.

Diagnosis — See Kar and Saxena (1976, p. 12).

Remarks — *Colligerites* gen. nov. closely resembles the extant spores of *Hobsonia mirabilis* illustrated by Subramanian (1971). This is an imperfect fungi (Hyphomycetes). The spores of *Vanbeverwijkia spirospora*, *Helicoma mulleri* and *Helicomyces roseus* also broadly resemble this species but all are distinguished by their different coiling nature (Kendrick & Carmichael, 1973).

Colligerites chowdhryii sp. nov.

Holotype — Pl. 2, fig. 30, size 80 μm. Slide no. 5394/2.

Type Locality — Papanasam, Varkala, Kerala coast, South India.

Age — Miocene.

Diagnosis — Spores multicellular, coiled once in centre, generally keeping a hollow space. Cells smaller in centre and bigger in outer region. Spore wall granulose. Pore present or absent in cells.

Comparison — *Colligerites kutchensis* is much coiled and hence is easily differentiated from the present species.

Derivation of Name — The specific name is after Dr Harsh Chowdhry, Botany Department, Lucknow University.

Remarks — *Colligerites chowdhryii* resembles closely with the spores of *Helicominopsis fici* illustrated by Subramanian (1971). The spores of *Helicomina caperoniae* are also helicoid but the coilings are not so prominent as in the present species.

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

Diporisporites elongatus van der Hammen, 1954

Pl. 3, fig. 44

Remarks — Spore elliptical in shape, 60×30 μm in size, psilate. The pores are distinct and the margin is thickened.

The specimen referred by Kar and Saxena (1976) to this species is very much similar to the present one but is devoid of thickening along the margin of the pore. The spores described by Elsik (1968) from Rockdale lignites (Palaeocene) also do not have appreciable thickening around the pores.

Diporisporites anklesvarensis (Varma & Rawat) Elsik, 1968

Pl. 3, figs 42, 43

Genus — *Dyadosporonites* Elsik, 1968

Dyadosporonites schwabii Elsik, 1968

Pl. 2, fig. 35

Description — Spore elliptical, constricted in middle, septa distinct, separating spore in two equal halves; diporate, one pore at each end, pore margin thickened, appears to be operculate.

Genus — *Diporicellaesporites* Elsik, 1968

Diporicellaesporites pluricellus Kar & Saxena, 1976

Remarks — This species is frequently found in this assemblage.

Diporicellaesporites sp. A

Pl. 3, fig. 41

Description — Spore seven-celled, 132×31 μm in size. One pore at each end, pore distinct, margin not appreciably thickened. Septa distinct, some septa oblique forming cells of various shapes. Most septa have one flap at each lateral end. Spore wall about 1·5 μm thick, laevigate.

Comparison — *Diporicellaesporites pluricellus* Kar & Saxena (1976) comes closest to the present specimen in size and shape but the latter is distinguished by its undulating shape and cells of various shapes. *D. stacyi* Elsik (1968) is always tetracellate.

Diporicellaesporites sp. B

Pl. 3, fig. 49

Description — Spore nine-celled, 84×25 μm in size; septa distinct, thickened, straight. One pore at each end, pore surrounded by a net work. Spore wall less than 1 μm thick, foveolate, foveola appears as white speck in surface view.

Comparison — This form is differentiated from all the known species of *Diporicellaesporites* by its foveolate spore wall.

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

Pluricellaesporites sp.

Pl. 3, fig. 37

Description — Spore fusiform, 150×30 μm in size, seven-celled, septa distinct, straight, operculum two-celled, spore wall less than 1 μm thick, laevigate.

Comparison — *Pluricellaesporites melanii* is easily differentiated from other species of the genus by its pitcher shape and three-celled spore. *P. hilsii* Elsik (1968) like the present one, is also multicelled but has flaps at each septa.

Genus — *Dendromyceliates* gen. nov.

Type Species — *Dendromyceliates splendus* sp. nov.

Diagnosis — Hyphae thick-walled, septate, cylindrical, base swollen, hyphae length divided into several cells by septa, cells with or without pores, generally uniporate. Tip of hyphae dichotomously branched 3-4 times, acutely pointed.

Remarks — *Dendromyceliates* gen. nov. is conspicuous by the presence of dichotomously branched tip of the hyphae. Intact specimens are rare, the basal part of the hyphae shows some disc-like parts which perhaps point out that the hyphae were attached to some other organ — probably on an ascocarp.

The affinity of this genus is not definitely known. However, if the hyphae were borne on ascocarps then it might be related to Plectomycetes, because they produce closed ascocarps where globose, evanescent asci are developed at all levels from the ascogenous hyphae, which branch irregularly throughout the central tissue of fruiting bodies.

Amongst Plectomycetes, according to Fenell (1973) in Gymnoascaceae, the ascogenous hyphae and asci sometimes occur in naked clusters but are generally surrounded and enmeshed by a net work of hyphae similar to or different from the vegetative hyphae. They may be coloured, thick-walled, smooth or variously roughened, forming a net-or bramble like aggregate with or without modified peripheral appendages.

The ascogenous hyphae of *Myxotrichum chartarum* (Fennel, 1973, p. 52, fig. 5a) closely resembles *Dendromyceliates*. The ascogenous hyphae in this species are also dichotomously branched but no further detail of the hyphae is available for close comparison.

Dendromyceliates splendus sp. nov.

Pl. 3, figs 45, 46

Holotype — Pl. 3, fig. 45, size 102 μm. Slide no. 5416/3.

Type Locality — Chanakkodi, Quilon, Kerala coast, South India.

Age — Miocene.

Diagnosis—Fungal hyphae 52-165 μm long, dark brown, thick-walled, septate, cells longer at unbranched region, smaller in upper part, with or without pores. Hyphae dichotomously branched 3-4 times, tips pointed.

Genus — *Lacrimasporonites* Clarke emend. Elsik, 1968

Lacrimasporonites longus Kar, 1979

Pl. 3, fig. 47

Remarks — Kar (1979) instituted this species from the Oligocene of western India which is nonseptate, monoporate and is characterized by the presence of a lid-like projection on the pore.

Korf (1973) is of the opinion that the nature of operculum on the pore is a very diagnostic character for identifying the Dichomycetes and the Tuberales. In Pezizales, the asci at maturity become cylindrical-ovoid in shape and possess an apical or subapical operculum through which the ascospores are discharged violently. A broad apical pore is present in the Cyttariales and a distinct plug is present in the orders Phacidiales, Ostropales and Helotiales.

Asci with apical operculum have only been found in the present material. In some specimens operculum is attached only at certain point while in others they are found intact. Some of the asci are more flattened at one side while others are tapering at one end. They probably belong to the different species of Pezizales but here they have been grouped together into one species.

FUNGAL TYPE-1

Pl. 2, fig. 28

Description — Conidia Y-shaped, many-celled, cells broader in middle and longer at extreme ends, cells in middle region dark, full of oil globules. Conidial arms narrow, hyaline, one-two, septate.

Remarks — Many *Hyphomycetes* produce Y-shaped conidia and hence is very difficult to identify the present specimen with the living ones. However, it resembles most with the conidia of extant *Diplocladiella scalaroides* illustrated by Subramanian (1971) and Kedrick and Carmichael (1973). The conidia of *Iyengarina elegans* described and illustrated by Subramanian (1971) also seem to be quite similar to the present specimen. Besides, the conidia of *Tetraposporium asterrinaerum* is also broadly comparable.

FUNGAL TYPE-2

Pl. 3, fig. 48

Description — Conidia pitcher-shaped, two conidia joined together, a minute pore observed at one end, wall less than 1 μm thick, weakly granulose.

Remarks — The specimens are rarely observed. Some of the Hyphomycetes, viz., *Haplobasidion thalictri*, *Basipetrospora rubra*, *Sphaerosporium lignatile* produce chained conidia (Subramanian, 1971; Kendrick & Carmichael, 1973). Of these, *Basipetrospora rubra* is broadly comparable with the present one as both of them possess pitcher-shaped conidia.

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EXPLANATION OF PLATES

(*All photomicrographs of plates* 1-3 *are enlarged ca.* × 500)

PLATE 1

1-7. *Phragmothyrites eocaenica* Edwards emend. Kar & Saxena; Slide nos. 5392/4, 5393/13, 5394/8, 5395/3, 5394/2, 5396/4, 5397/1.
8. Microthyriaceous fungi Type-1; Slide no. 5395/4.
9. Microthyriaceous fungi Type-2; Slide no. 5398/12.
10, 11. Microthyriaceous germlings; Slide nos. 5399/9, 5400/7.
12. *Bireticulasporis communis* Potonié & Sah; Slide no. 5401/1.
13. *Parmathyrites indicus* Jain & Gupta; Slide no. 5397/8.
14. *Parmathyrites robustus* sp. nov.; Slide no. 5402/3.
15. *Kutchiathyrites eccentricus* Kar; Slide no. 5393/17.
16-18. *Notothyrites setiferus* Cookson; Slide nos. 5404/2, 5404/1, 5405/1.

PLATE 2

19. *Phragmothyrites eocaenica* Edwards emend. Kar & Saxena; Slide no. 5406/5.
20. Microthyriaceous germling; Slide no. 5407/3.
21, 22. *Notothyrites amorphus* Kar & Saxena; Slide nos. 5394/14, 5408/5.
23. *Kutchiathyrites eccentricus* Kar; Slide no. 5397/2.
24. *Bireticulasporis communis* Potonié & Sah; Slide no. 5409/2.
25. *Lirasporis intergranifer* Potonié & Sah; Slide no. 5410/3.

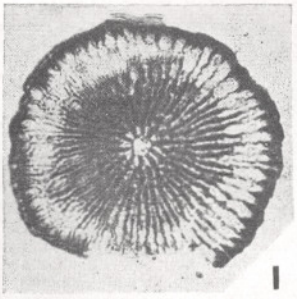
26, 27. cf. *Chomotriletes* sp.; Slide nos. 5411/11, 5412/3.
28. Fungal Type-1; Slide no. 5413/1.
29. *Colligerites kutchensis* (Kar & Saxena) comb. nov.; Slide no. 5394/2.
30. *Colligerites chowdhryii* sp. nov.; Slide no. 5394/12.
31, 32. *Dicellaesporites ellipticus* sp. nov.; Slide nos. 5414/5, 5415/1.
33. *Inapertisporites kedvesii* Elsik; Slide no. 5392/5.
34. *Parmathyrites robustus* sp. nov.; Slide no. 5404/6.
35. *Dyadosporonites schwabii* Elsik; Slide no. 5397/11
36. Fungal hyphae; Slide no. 5416/9.

PLATE 3

37. *Pluricellaesporites* sp.; Slide no. 5417/3.
38. *Inapertisporites* sp. A; Slide no. 5397/12.
39. *Lirasporis* sp.; Slide no. 5416/11.
40. Fungal hyphae; Slide no. 5418/2.
41. *Diporicellaesporites* sp. A; Slide no. 5419/11.
42. 43. *Diporisporites anklesvarensis* (Varma & Rawat) Elsik; Slide nos. 5414/8, 5420/7.
44. *Diporisporites elongatus* van der Hammen; Slide no. 5420/4.
45, 46. *Dendromyceliates splendus* gen. et sp. nov.; Slide nos. 5416/3, 5399/9.
47. *Lacrimasporonites longus* Kar; Slide no. 5421/5.
48. Fungal Type-2; Slide no. 5422/7.
49. *Diporicellaesporites* sp. B; Slide no. 5423/1.
50. *Lirasporis intergranifer* Potonié & Sah; Slide no. 5411/12.
51. *Meliola anfracta* Dilcher; Slide no. 5397/11.

PLATE 4

52, 53. Shark teeth recovered from Edvai cliff section (*ca.* × 2).
54. Lithological section at Vettur, Varkala cliff section showing laterite (LAT.), sandstone (SST.) and carbonaceous clay (CARB. CLAY).
55. Chanakkodi section at Padappakkara showing limestone (LST.) outcrop.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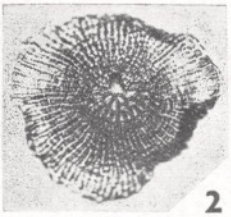
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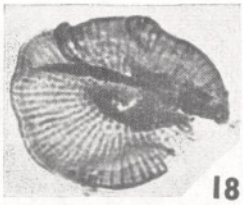
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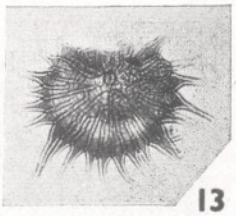
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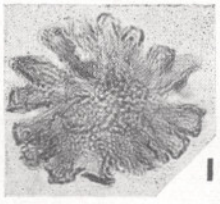
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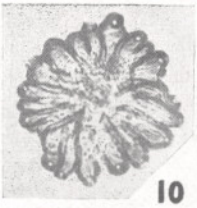
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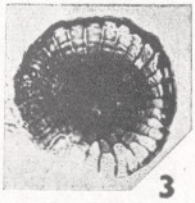
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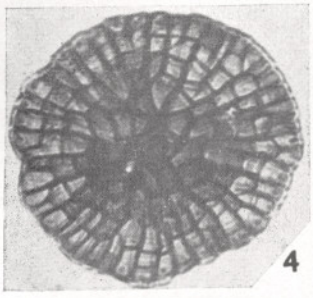
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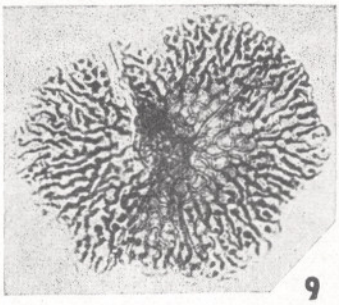
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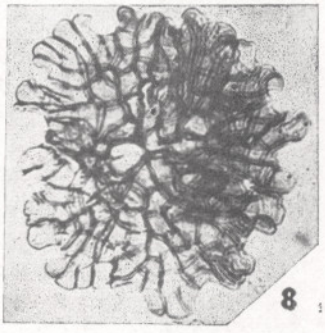
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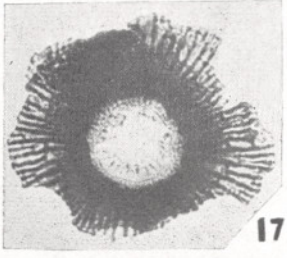
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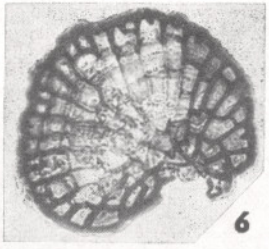
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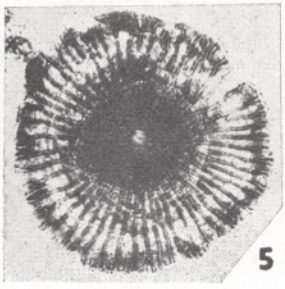
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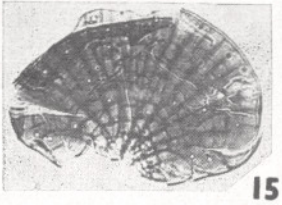
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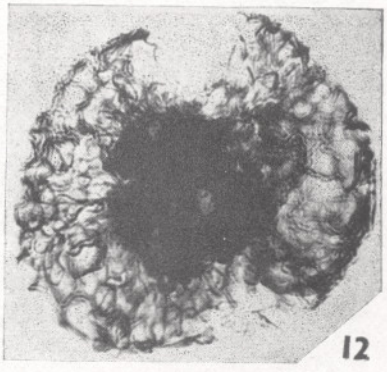
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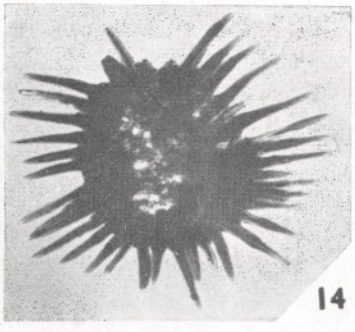
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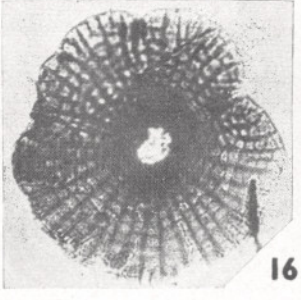
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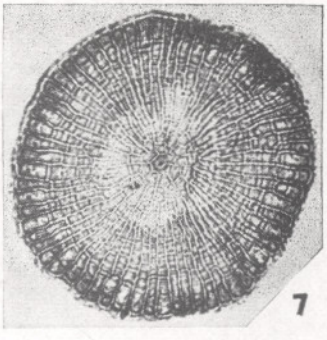
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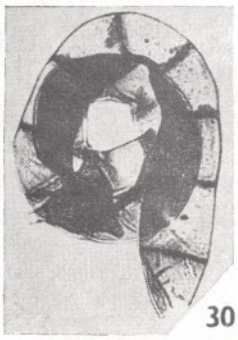
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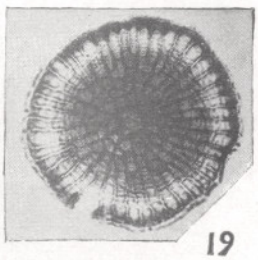
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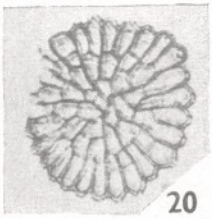
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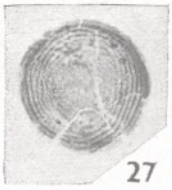
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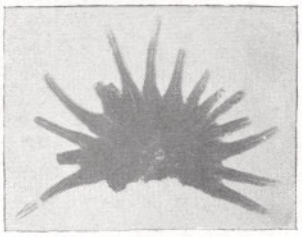
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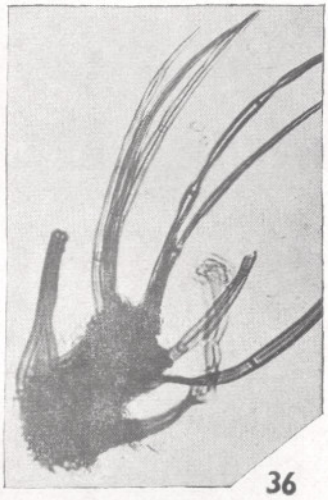
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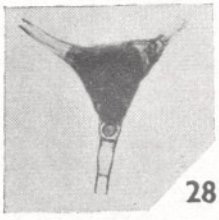
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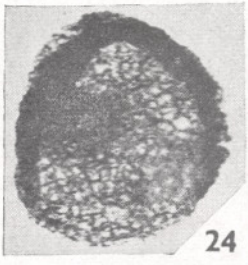
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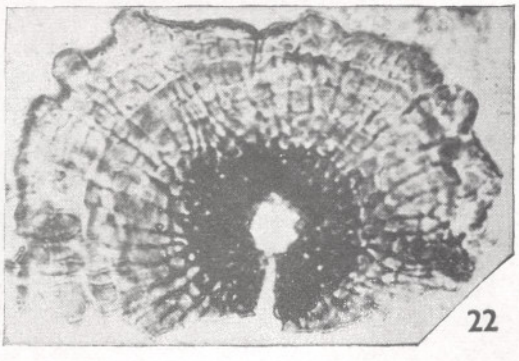
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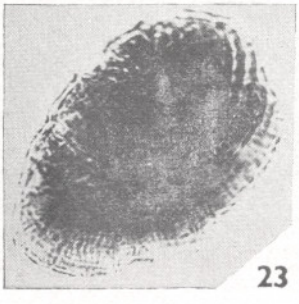
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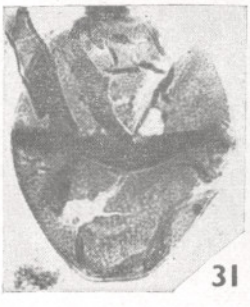
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PLATE 2


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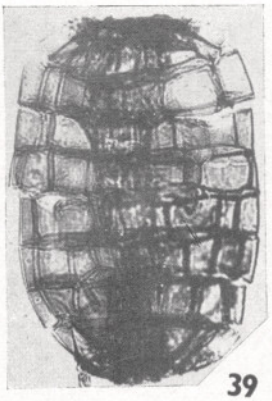
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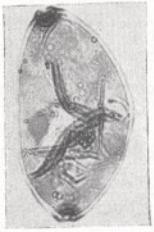
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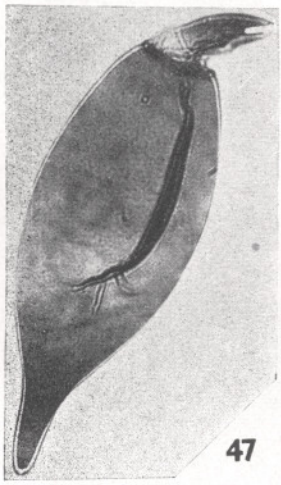
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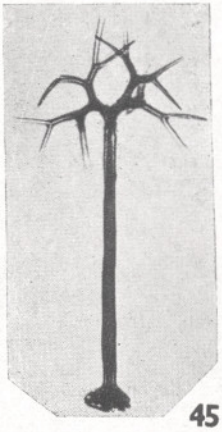
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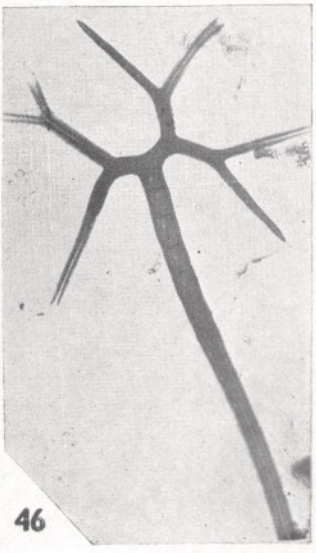
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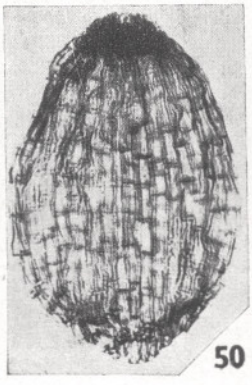
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PLATE 3

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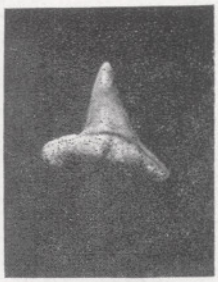

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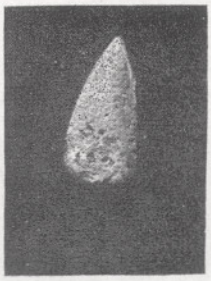

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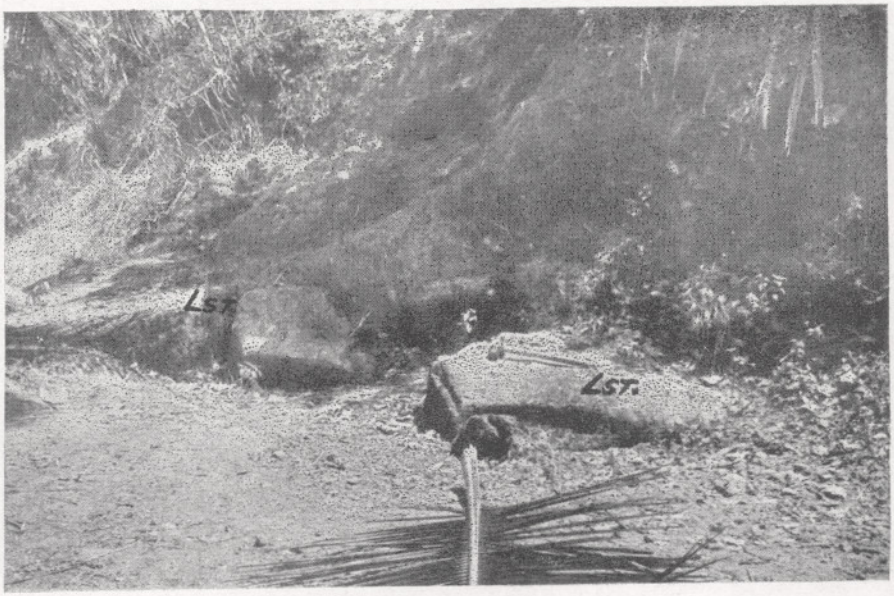

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PLATE 4