PALYNOLOGY OF THE NEOGENE QUILON BEDS OF KERALA STATE IN SOUTH INDIA I — SPORES OF PTERIDOPHYTES AND POLLEN OF MONOCOTYLEDONS

K. P. RAO

Department of Botany, N. B. Science College, Hyderabad, India

&

C. G. K. RAMANUJAM

Department of Botany, Science College Saifabad, Osmania University, Hyderabad, India

ABSTRACT

The paper constitutes the first part of a detailed palynological investigation of the Quilon beds outcropped at Padappakkara, Edavai and Paravur in Kerala State. The aim of the investigation was (i) to provide a comprehensive account of the spores and pollen grains of these Neogene sediments of Kerala, (ii) to find out the botanical affinities of the palynofossils recovered in order to interpret the ecological conditions prevalent at the time of the deposition of these sediments, and (iii) to assess the geological age of these beds based on their palynological assemblage. This part deals with the spores of pteridophytes and pollen of monocotyledons. The pteridophytes are represented by Lycopodiaceae, Gleicheniaceae, Ophioglossaceae, Schizaeaceae, Dicksoniaceae and Polypodiaceae, of which Polypodiaceae constitutes the most predominant taxon. *Polypodiisporites* possessing heavily sculptured (verrucate) spores represents the most abundant member of the pteridophytes. On the whole, the pteridophytic spores of the Quilon microflora are represented by 14 genera and 20 species, of which 10 species constitute new taxa.

Among the monocotyledons, the pollen grains referable to Palmae, Potamogetonaceae, Aroidae, Liliaceae, Lemnaceae and Gramineae have been recovered. Of these, Palmae is the predominant taxon consisting of as many as 10 genera, viz., *Palmaepollenites*, *Arecipites*, *Couperipollis*, *Quilonipollenites*, *Longapertites*, *Verrumonocolpites*, *Spinizonocolpites*, *Paravuripollis*, *Clavapalmaedites* and *Dicolpopollis*. The fossil pollen grains exhibit particularly significant resemblances with the pollen of *Cocos*, *Hyphaene*, *Pinanga*, *Iriartia*, *Lepidocaryum*, *Nipa*, *Calamus* and *Metroxylon*. On the whole, the monocotyledons of the Quilon microflora consist of 17 genera and 27 species, of which 4 genera and 20 species represent new taxa. Among the pollen grains of the monocotyledons, spinascent monosulcate or zonosulcate grains are quite abundant, followed by reticulate monosulcate and disulcate grains.

INTRODUCTION

PALYNOLOGICAL investigations of the Tertiary deposits of the Kerala State along the west coast of South India have been very few and far between (Vimal, 1953; Potonié & Sah, 1958; Ramanujam, 1960, 1967, 1972; Jain & Gupta, 1968; Ramanujam & Purnachandra Rao, 1973, 1973a). The present study is aimed at primarily to provide a comprehensive account of the palynological assemblages of the Tertiary deposits of the Kerala State, so that they may be meaningfully utilized for stratigraphical purposes. It is proposed to find out if the palynological complexes could also throw any light on the geological ages of the Tertiary sediments of Kerala. Based upon the known botanical affinities of the spores and pollen grains recovered, an attempt would be made to analyse and assess the general floristics of the Tertiary period of Kerala and the then climatical pattern. Lastly, it is also proposed to evaluate the depositional environments of the Tertiary beds in Kerala with the help of the microfloral elements recovered.

GENERAL GEOLOGY OF KERALA STATE

Resting directly upon the Archeans are seen the Tertiaries and the recent sediments in Kerala. The Archean crystalline complex consists of khondalites, leptynites, charnockites, and the mica-hornblende gneisses. There are no intervening strata belonging to the other geological periods between the Archeans and the Tertiaries. Because of a general cover of laterite over both the rock formations, the contact of the Tertiaries with the underlying crystallines is very much obscured at many places.

The Tertiaries of the Kerala state extend all along its coastal belt almost continuously from Cape Comarine in the south (now in Kanyakumari District of Tamil Nadu) to Manjeshwar bordering the Mangalore District of Mysore in the north. The Tertiary sediments are succeeded by beach, estuarine, lagoonal and alluvial deposits of Pleistocene to Recent age. The youngest formation is represented by the continental Warkalli beds, and underlying these beds are the marine Quilon beds without any marked unconformity. The Tertiary strata of Kerala reveal two major basins of deposition, viz. (i) a southern basin between Trivandrum and Ponnani in South and Central Kerala, and (ii) a northern basin, between Cannanore and Kasargod in North Kerala. They include mainly (i) the Quilon beds consisting chiefly of fossiliferous limestones, intercalated with thick beds of variegated sands, carbonaceous clays, calcareous and sandy clays and sands, and (ii) the overlying Warkalli beds of variegated sands, white plastic clays, carbonaceous clays, and associated seams of lignite.

The following is the general stratigraphic succession of the Tertiary and recent formations in Kerala as given by Poulose and Narayanaswamy (1962).

Recent to sub-recent		Soils and alluvium. Beach and sand-dune deposits; lime shell deposits in back waters. Old red 'Teri' sands. Sub-recent marine and estuarine formations. Sands, peat beds and peat bogs with semi-carbonised wood; black sticky and sandy, calcareous clays with shells etc. Laterite.
.... UNCONFORMITY		
Upper Tertiary (Miocene to Pliocene)	Warkalli beds (Mio-Pliocene)	Current bedded friable variegated sandstones, interbedded with white plastic clays and variegated clays. Carbonaceous clays with lignite seams and alum clays. Gravel and pebble beds-base generally marked by gibbistic sedimentary clays (white laterite) and China clays (Kaolinised gneiss).
	Quilon beds (Miocene) (Burdigalian)	Fossiliferous shell limestone (Padappakkara limestone) alternating with thick beds of sandy clays, calcareous clays, carbonaceous clays and sands. Base unknown.
.... UNCONFORMITY		
Archean		Khondalites, leptynites, charnockites, mica-hornblende gneiss and migmatites, locally Dharwar schists in North Kerala.

Although, in almost all the previously available literature on the geology of the Kerala coast it is reported that the Neogene sediments of Kerala are made up of two distinct formations, viz., Quilon beds and Warkalli beds, a more recent study of the lithological logs of numerous boreholes drilled in the area by the Central Ground Water Board has indicated that the Upper Tertiary sediments of Kerala are made up of three formations, viz., the Warkalli, Quilon, and Vaikom formations (Raghava Rao, 1975; Raghava Rao *et al.*, 1975). The Vaikom Formation which is similar to

Warkalli Formation, underlies the Quilon beds in the Vaikom area (76°24′ : 9°45′) and encompasses a thick sequence of continental beds consisting of gravel, coarse to very coarse sand and thin seams of lignite (Raghava Rao, 1975).

Description of Quilon Beds

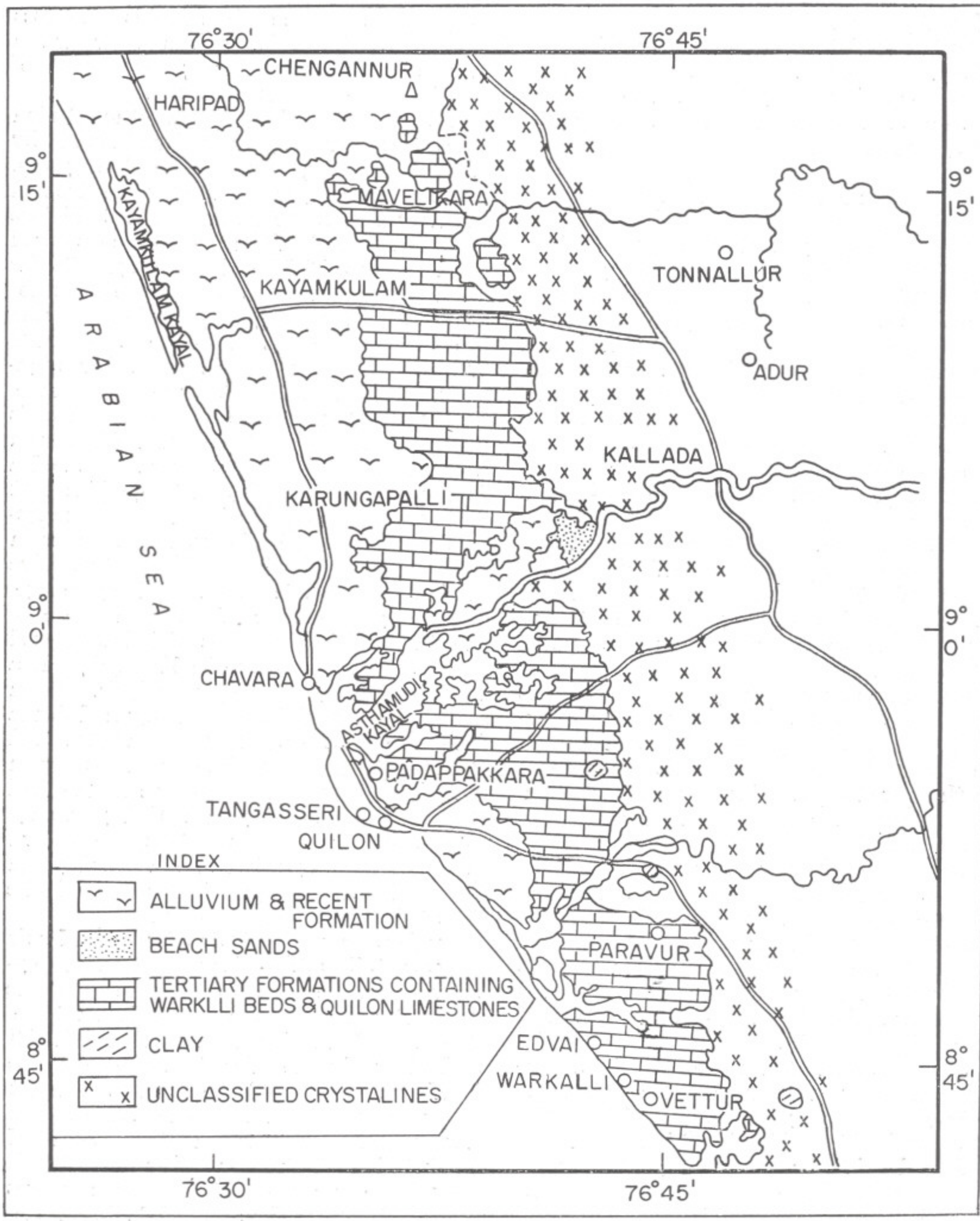
Although, King as early as 1882 classified the Kerala Tertiaries as consisting of the Upper Warkalli and the Lower Quilon beds, typical sections showing the precise order of superposition of Quilons and Warkallis are met with only rarely. Except for somewhat limited exposures of the Quilon limestones at the base of the sea cliffs near Paravur and the well-known exposure at the base of the cliff section near Padappakkara (Type locality) on the Asthamudi Kayal, our knowledge of the Quilon beds is restricted till recently to a few well sections and boreholes between Warkalli and Shertallai. The data obtained from the fairly extensive drilling by the Central Ground Water Board during the recent years in the southern region of Kerala, for assessing the ground water potential of this area, have added considerably to our knowledge of the Quilon beds. The maximum thickness of the Quilon beds as encountered in the boreholes at Karunagapalli, Takazhi and Chellanam is about 70 m (Raghava Rao *et al.*, 1975).

The Quilon beds were originally believed to be confined to the base of the cliff section of the type locality at Padappakkara. Subsequently Kumar and Pitchamuthu (1933) traced these limestone beds towards Nedungulam, Paravur and Varkalli, and Damodaran (1955) located them at Edavai (see Map 1). Jacob and Sastry (1952) located the same limestone band in a bore hole sample from Chavara. Reconnaissance geological mapping has been carried out by Poulose (1965, 1965a) in Trivandrum and Quilon districts bringing to light the extensive nature of the Quilon beds. Poulose and Narayanaswamy (1968) more recently indicated that the marine calcareous beds spread over a considerable area extending from Varkallai (Warkalli) to Shertallai under the cover of recent formations.

The Quilon limestone beds were said to have been deposited in a large lagoonal bay of the sea in this region. The rich and frequent occurrence of echinoids, molluscs and ostracods indicate a shallow warm marine environment during the period of the deposition of these beds.

According to King (1882) the Quilon limestones, overlain and overlapped by Warkalli deposits, constitute an older group. From a lithological similarity he treated the Warkallis as equivalent to the Cuddalore sandstones of Tamil Nadu and considered them to be of Middle Miocene age. So far no serious attempt has been made to establish the geochronological relation between the marine Quilons and the continental Warkallis based upon microfloral investigations. Several attempts have been made, however, to fix the age of the Quilon beds by faunal evidence. The foraminifera from a borehole sample from Chavara indicated a Lower Miocene (Burdigalian) age (Jacob & Sastry, 1952). Dey (1962) made an exhaustive study of the Molluscan fauna from Padappakkara and found an extensive marine Indo-Pacific fauna of Neogene age, exhibiting distinct affinities with those of the Gaj and Karaikal beds of India. Based on his findings, Dey (1962) assigned a Vindobanian age to the Quilon beds. From a study of foraminiferal and ostracod fauna from the outcrops of Padappakkara and Paravur and subsurface samples from Mainagapalli of Quilon District, Rao and Datta (1976) also assigned a Burdigalian age to the Quilon deposits. Thus the known faunal assemblages indicate a Burdigalian to Vindobanian age (Lower to Middle Miocene) for the Quilon beds.

Previous work on Palynology of Kerala Neogene Sediments — Very little palynological work has been published hitherto on the Upper Tertiary deposits of the Kerala State. Rao and Vimal (1952) and Vimal (1953) studied briefly the microflora of the lignite of Warkalli beds. These authors did not follow any binomial nomenclature but merely employed Erdtman's system of classification of sporomorphs (Erdtman, 1947). They have recorded pteridophytic spores referable to Polypodiaceae and Schizaeaceae. The angiospermous pollen grains recorded by them consist of the following morphotypes, viz., napites, monocolpites, tricolpites, tricolporites, tetracolporites, penta, hexa, septa and octa-colporites, triorites and polyporites and some of the pollen types were compared with the pollen of Potamo-



MAP 1 — Part of Kerala showing the geology around Quilon and the localities from where palynological samples were collected.

getonaceae, Palmae, Hamamelidaceae, Myrsinaceae, Rubiaceae, Solanaceae, etc. (Vimal, 1953). Potonié and Sah (1958) studied the palynology of the lignite from Cannanore beach on the Malabar coast. They found the Cannanore lignite to be rather poor in microfloral contents. *Lycopodiumsporites*, *Cyatheacidites* and *Polypodiidites* constitute the pteridophytic spores of this lignite. The angiospermous pollen recorded from Cannanore lignite consist of *Inaperturopollenites*, *Monoporopollenites*, *Monosulcites*, *Cupuliferoipollenites* and *Polyadopollenites* (Potonié & Sah, 1958).

Erdtman as early as 1956 indicated that some of the polycolpate grains recorded previously by Rao and Vimal (1952) showed affinities with the pollen of *Ctenolophon* of Ctenolophonaceae. Ramanujam and Purnachandra Rao (1973a) recently provided a detailed systematic account of *Ctenolophonidites* pollen grains from the Warkalli lignite. These authors recorded a number of species of this genus and indicated the abundant occurrence of *Ctenolophonidites costatus* resembling the modern *Ctenolophon engleri*. Ramanujam (1960, 1972) studied the occurrence of pteridophytic spores from the Warkalli lignites and recorded the species of *Neyvelisporites*, *Microfoveolatosporis*, *Schizaeoisporites*, *Polypodiidites*, *Foveosporites* and *Lycopodiumsporites*. Schizaeaceae and Polypodiaceae have been found to be the most common elements among the pteridophytic spores of the Warkalli lignite. In a subsequent publication, Ramanujam (1967) recorded the copious occurrence of syncolpate and parasyncolpate grains mainly referable to Myrtaceae and Sapindaceae from a peaty lignite of the Alleppey area.

More recently Rao and Ramanujam (1975) published an advance report of the palynology of Quilon beds incorporating their main results of study.

Comments on Nomenclature & Classification adopted in this Study — Nomenclature of the fossil spores and pollen grains employed in this study is based upon the rules of priority and typification as laid down in the International Code of Botanical Nomenclature. Binomial designations are used for all formally described and named taxa and the genera have been incorporated under the various suprageneric categories (Turma, Subturma, Infraturma) of a truly morphographic system of classification first proposed by Potonié and Kremp (1954) but subsequently elaborated and improved upon during the more recent years by Potonié (1956, 1958, 1960, 1966). This system is presently widely followed by the Indian palynologists. This seems to be the most comprehensive system of classification of *sporae dispersae* proposed to date, and has been based upon an overwhelming majority of the validly described spore and pollen genera.

While the classification of the myriad spore types under the Anteturma *Sporites* appears to be quite elaborate, that of pollen grains incorporated under the Anteturma *Pollenites*, seems to be rather of a limited extent. This is particularly glaring with reference to the treatment of angiospermous pollen grains. This aspect of the above morphographic classification of Potonié obviously requires further elaboration. Keeping this in view, a few new Infraturma have been instituted in this study to accommodate the various types of monosulcate pollen grains, under the Subturma *Monocolpates*.

Forms coming within the morphological circumscription of the known spore and pollen taxa, have been automatically placed within these genera, regardless of their putative natural affinities. For forms which do not compare *in toto* with any of the existing taxa, new generic and specific names have been proposed. An attempt has been made to indicate the affinities of the various fossil and spore taxa, wherever they could be recognized. An understanding of the botanical affinities of the fossil spores and pollen grains is considered to be very important in the Tertiary palynological studies not only to have a clear perspective of the vegetational spectra, but also to evaluate the palaeoclimatical patterns and the nature of the depositional environments.

MATERIAL AND METHODS

The material investigated by the authors include many samples of carbonaceous and calcareous clays of the Quilon beds from near Padappakkara, Paravur and Edavai. The following are the lithological details of the various beds which provided the palynological samples.

Padappakkara — The type locality of Quilon beds is at Padappakkara. The limestone here is exposed along the banks of Asthamudi Kayal. The Quilon limestone is situated on the left of the 5-6 km stone on Kundara-Padappakkara Road. The limestone occurs at the base of the laterite cliff of about 20 m height. The exposure is about 0·5 m thick, nearly horizontal and the dips do not exceed 5-8°. The limestone is weathered to yellow brown. This limestone band is overlain and underlain by calcareous clays rich in marine invertebrate fauna.

Following is the sequence of lithological setting at Padappakkara cliff section near Channakodi:

TOP	7. Pebbly laterite capping
	6. Mustard-coloured brown mud
	5. Red clay
	4. Hard yellow limestone with *Taberina malabarica*; highly fossiliferous
	3. Loose yellow mud
	2. Black to brownish highly plastic carbonaceous clays
BOTTOM	1. Yellow white loose sandy clay; highly fossiliferous.

Samples were collected from 1st, 2nd, 4th and 5th bands of the above sequence. All these samples contain many invertebrate remains in varying proportions and in varying degrees of preservation.

Paravur — The Quilon limestone bed is located here along the sea coast at the base of the laterite cliff. The place is called "Chilakal". The limestone bed is present behind a village Mosque, and occurs just above the sea level; a major part of it is covered with beach sand and gets exposed obviously at the time of low tide. The lithological sequence here is as follows:

	7. Hard laterite
	6. Loose red-white sandy clays and gravels-mottled
	5. Loose red sedimentary laterite, more or less conglomeratic
	4. Hard brown limonitic laterite with reddish bands
	3. Highly plastic black carbonaceous clay
	2. Fossiliferous blue clay with corals, etc.
	1. Hard compact olive green limestone; fossiliferous.
BASE NOT SEEN	

The palynological samples include the clayey material from the 2nd and 3rd bands of the above sequence.

Edavai — The Quilon limestone in this area is exposed at the sea level laterally along the sea coast. The limestone changes frequently from the hard to the soft variety. Inclusion of large quantities of amber and carbonaceous clayey material within the limestone is the outstanding feature of this locality. Overlying the limestone bed are the grey clays.

The material collected from this area consists of a number of carbonaceous clay samples, designated as Edv. C1, C2, C3, etc.

Usual techniques of maceration using a combination of HF, HCl, and HNO3 were employed in the recovery of plant microfossils. The acid treated material was then treated with 5% KOH for 3 to 5 minutes only. Slides were prepared with polyvinyl alcohol and canada balsam. In every case a few slides using glycerine jelly or glycerine were also prepared.

All measurements were taken with an oil immersion objective and ×15 eye piece. The size given for a taxon, unless otherwise mentioned generally represents the average of 10 specimens and excludes the sculptural processes such as spines, verrucae, clava and pila. When measurement of a pollen grain is given from its equatorial view, the first figure represents the polar axis, and the next, the equatorial axis. In those cases where the grains were found flattened regularly in polar view, only the polar diameter could be provided. The measurement for the thickness of the exine includes the size of the sculptural processes also whenever they are present.

The location of the Holotype is given uniformly by mentioning first the code for the sample, and the sample number, followed by the slide number and the co-ordinates from the mechanical stage of the microscope. The size of the Holotype is given in parenthesis.

The following are the codes for the samples investigated:

Pad. — Padappakkara sample
Par. — Paravur sample
Edv. — Edavai sample

All the slides and unused samples are in the palaeobotanical collection of Dr C.G.K. Ramanujam.

The microflora recovered from various samples is extremely rich and excellently preserved and consists of spores of pteridophytes, pollen grains of angiosperms, a sizable number of fungal spores and fruiting bodies and hystrichosphaerids. An advance report of this microflora was recently published by the authors (Rao & Ramanujam, 1975). The present account deals only with the systematic part of pteridophytic spores and monocotyledonous pollen grains. The second part of this contribution includes the systematic description of the pollen grains of dicotyledons and a general discussion concerning the floristics and geological age of the Quilon beds and the nature of the palaeoenvironment.

MICROFLORA

SYSTEMATIC DESCRIPTION

Anteturma — *Sporites* H. Potonié, 1893
Turma — *Triletes* (Reinsch) Dettmann, 1963
Subturma — *Azonotriletes* (Luber) Dettmann, 1963
Infraturma — *Laevigati* (Bennie & Kidston) Potonié, 1956

Genus — *Lygodiumsporites* (Potonié, Thomson & Thiergart) Potonié, 1956

Genotype — *L. adriensis* (Pot. & Gell.) Potonié, Thomson & Thiergart, 1950.

Lygodiumsporites padappakkarensis sp. nov.

Pl. 1, figs. 1, 2

Diagnosis — Spores light brown, amb rounded triangular, 43-51·5 μ in diameter, trilete, Y-mark distinct, rays short, extending only upto half of spore radius, margins thin, ends pointed. Exosporium 1·5 μ thick, surface smooth to infrapunctate.

Comments — Smooth-walled trilete spores of this type are quite common in the microflora of Padappakkara beds. The genotype *Lygodiumsporites adriensis* (Pot. & Gell.) Potonié, Thomson & Thiergart (1950) can be differentiated in its larger size. Similar spores have been recorded recently from the Oligocene-Miocene strata of the Cauvery Basin (Venkatachala & Rawat, 1973).

Affinity — The fossil spores are comparable with the smooth-walled spores of species of *Lygodium* of Schizaeaceae.

Type Locality — Padappakkara.

Holotype — Pl. 1, fig. 2; Pad. III-3; 17·6 ×75·3, (45·5 μ).

Genus — *Intrabaculisporis* Kedves & Rakosy, 1964

Genotype — *I. magnus* Kedves & Rakosy, 1964.

Intrabaculisporis quilonensis sp. nov.

Pl. 1, fig. 3

Diagnosis — Spores deep brown, amb ± rounded, polar diameter 37·5-40 μ, trilete, Y-mark distinct, rays long extending more than 3/4 of radial distance and forking near equatorial margin, sinuous with thickened margins. Exosporium upto 2·5 μ thick, intrabaculate, surface finely punctate.

Comments — The genus *Intrabaculisporis* recorded for the first time from the Neogene of Hungary is characterized by rounded to elliptical trilete spores with an intrabaculate exosporium (Kedves & Rakosy, 1964). It is presumed that these spores are stratigraphically important as they are characteristic of the Upper Tertiary deposits. *I. magnus* Kedves & Rakosy (1964) is larger with a finely granular surface. *I. quilonensis* sp. nov. is further distinguished from the former in possessing sinuous rays forking at their tips and also in its finely punctate wall.

Affinity — According to Kedves and Rakosy (1964) the affinities of this genus are with Schizaeaceae.

Type Locality — Padappakkara.

Holotype — Pl. 1, fig. 3; Pad. II-1; 22·7 ×87·9, (39 μ).

SPORE TYPE — A

Pl. 1, figs. 4, 5

Description — Spores brownish, amb triangular with concave sides, and flared up angles, polar diameter 26-28·5 μ, trilete, Y-mark distinct, rays long, almost reaching equatorial margins, lips thin, ends pointed to blunt. Exosporium upto 2 μ thick, proximal face smooth, distal face provided with a thickened triangular polar area surrounded by a flat, ribbon-like subequatorial 3-looped thickening (kyrtome), upto 2 μ thick.

Comments — The distal polar thickening and the well-developed subequatorially disposed 3-looped kyrtome gives a beautiful look to the spores. Only two specimens of this interesting spore type were encountered in our preparations. Our Spore type — A differs from *Gleicheniidites* in lacking interradial crassitudes. In *Concavisporites* the sides of the amb are more prominently concave and the apices are smoothly rounded; further the laesurae are shorter and there is no triangular thickened area on the distal side. The Kerala spore type shows apparent resemblance with the Upper Mississipian and the Pennsylvanian *Ahrensisporites* Potonié & Kremp (1954). A closer look at the generic features of *Ahrensisporites*, however, shows that it can be differentiated from our spore type in its truncated to rounded radial apices, equatorially originating kyrtome with no distinct loop formation and the absence of a thickened triangular area at the distal pole. *Dictyophyllidites* (Couper) Dettman (1963) is also quite different from our spore type. *Dictyophyllidites* accommodates triangular trilete spores with the exine thickened about the laesurae margins on the proximal side.

Despite its interesting morphology, as only two specimens of this spore type could be examined, the authors have decided not to give any name to this spore type.

Occurrence — Padappakkara.

Infraturma — *Tricrassati* Dettmann, 1963

Genus — *Gleicheniidites* (Ross) Dettmann, 1963

Genotype — *G. senonicus* Ross, 1949

Pl. 1, figs. 6, 7

Description — Spores brownish, amb triangular with concave sides and blunt apices, polar diameter 27-29·5 μ, trilete, Y-mark distinct but slender, rays extending over more than 2/3 of spore radius, margins thin, ends pointed. Exosporium 1·5-2 μ thick, surface smooth, distal face provided with arcuate folds and proximal face with three prominent interradial crassitudes with smooth or slightly lobed margins.

Comments — *Gleicheniidites* as emended by Dettmann (1963) consists of only smooth trilete spores with interradial crassitudes on proximal sides and three arcuate folds on the distal side. Because of the triangular amb and interradial crassitudes with a smooth exosporium the fossil spores are included under the genus *Gleicheniidites*. *G. cercinidites* from the Cretaceous of Australia (Dettmann, 1963), is slightly larger in size than the South Indian specimens. This species is occasionally met with in the Padappakkara samples.

Affinity — The fossil spores are related to *Gleichenia* of Gleicheniaceae.

Occurrence — Padappakkara.

Infraturma — *Apiculati* (Bennie & Kidston) Potonié, 1956

Genus — *Eximospora* Salujha, Kindra & Rehman, 1972

Genotype — *E. tuberculata* Salujha, Kindra & Rehman, 1972.

Eximospora sparsus sp. nov.

Pl. 1, fig. 8

Diagnosis —Spores light brown, amb spheroidal, polar diameter 19-25 μ, trilete, rays wavy, fairly long. Exosporium 2·5 μ thick, tuberculate, tubercles sparse and widely spaced, 2·5 μ in diameter at base, 2·5 μ high, tips truncate to rounded, intertubercular surface smooth.

Comments — The spheroidal amb, distinct trilete mark and tuberculate exine affiliate this spore with *Eximospora* Salujha *et al.* (1972) described originally from the Upper Tertiary of Assam. The genotype *E. tuberculata* Salujha *et al.* (1972) is much larger. *E. sparsus* is distinct in its small size and sparsely distributed tubercles.

Affinity — Unknown.

Type Locality — Paravur.

Holotype — Pl. 1, fig. 8; Par-7; 20·7 ×28·4, (22 μ).

Genus — *Verrucosisporites* (Ibrahim) emend. Potonié & Kremp, 1955

Genotype — *V. verrucosus* Ibrahim, 1932.

Verrucosisporites dakshinensis sp. nov.

Pl. 1, fig. 9

Diagnosis — Spores light brown, amb subtriangular with ± flat sides, polar diameter 30-39·5 μ, trilete, rays long extending over more than 3/4 of spore radius, margins beset with verrucae. Exosporium 3·5 μ thick, verrucate, verrucae 2-3 μ high with rounded tips, located on distal side, contact area smooth.

Comments — *V. dakshinensis* sp. nov. resembles *V. pulvinatus* recorded from the Tertiaries of Spitsbergen (Manum, 1962) in shape and size but the former differs in possessing longer rays beset with low verrucae. *Verrucosisporites* is an occasional element of the microflora of the Padappakkara samples.

Affinity — The fossil spores are related to Lycopodiaceae.

Type Locality — Padappakkara.

Holotype — Pl. 1, fig. 9; Pad. III-3; 25·9 ×66·0, (34 μ).

Infraturma—*Murornati* Potonié & Kremp, 1954.

Genus — *Foveosporites* Balme, 1957

Genotype — *F. canalis* Balme, 1957.

Foveosporites miocenicus Ramanujam, 1972

Pl. 1, fig. 10

Description — Spores light brown, amb rounded, polar diameter 45-49 μ, trilete, rays narrow, short, ± sinuous, margins thin, ends pointed. Exosporium upto 2 μ thick, foveolate, foveolae upto 2 μ in diameter, mostly rounded, locally slightly elongated, closely placed.

Comments — *Foveotriletes* (Hammen) Potonié (1956) is triangular with evenly distributed foveolae, while *Foveosporites* includes trilete spores with circular to rounded triangular amb. *F. canalis* Balme (1957) differs from the present species in its smaller size and also in possessing coalescent foveolae. *F. labiosus* from the Lower Cretaceous of Canada (Singh, 1971) also possesses coalescent foveolae. This species originally recorded from the Warkalli lignites (Ramanujam, 1972) has been encountered occasionally in the Padappakkara clay samples.

Affinity — The fossil spores resemble the spores of some species of *Ophioglossum* of Ohioglossaceae.

Genus — *Foveotriletes* (Hammen, V.D.) ex Potonié, 1956

Genotype — *F. scrobiculatus* (Ross) Potonié, 1956.

Foveotriletes bifurcatus sp. nov.

Pl. 1, fig. 11

Diagnosis — Spores light brown, amb triangular, sides flat and apices somewhat rounded, polar diameter 28-36 μ, trilete, rays broad extending to more than 3/4 of spore radius, gaping, margins thickened, ends bifurcating. Exosporium up to 2 μ thick, finely pitted (foveolate), pits upto 2 μ in diameter, surface finely foveolate-reticulate, contact area sparsely foveolate.

Comments — Spores of this type were encountered occasionally in the Padappakkara and Paravur samples. *F. parviretus* Dettmann (1963) differs from the present species in its larger size, straight to concave sides, and simple laesurae. *Foveotriletes miocenicum* from the South Arcot lignite (Ramanujam, 1966-67) is larger in size.

Affinity — Unknown.

Type Locality — Padappakkara.

Holotype — Pl. 1, fig. 11; Pad. II-11; 24·4×84·5, (30 μ).

Genus — *Crassoretitriletes* Germeraad, Hopping & Muller, 1968

Genotype — *C. vanraadshooveni* Germeraad, Hopping & Muller, 1968.

Crassoretitriletes ornatus sp. nov.

Pl. 1, fig. 14

Diagnosis — Spores brown to brownish yellow, amb rounded-triangular, distal pole hemispherical, polar diameter 60-72 μ, trilete, Y-mark fairly distinct, rays extending upto 1/2 of spore radius, often gaping, margins slightly thickened, ends pointed. Exosporium upto 4·5 μ thick, coarsely rugulate-reticulate over entire surface, muri upto 3 μ wide, often undulating, lumina 2·5 to 4 μ wide, smooth.

Comments — The coarsely rugulate-reticulate sculpture with prominent, often undulating muri imparts a characteristic ornate look to the spores. The conspicuous muri at the periphery were found in optical sections of a number of specimens. *Crassoretitriletes vanraadshooveni* described from the Neogene (Miocene) of Borneo, Nigeria and Carribbean area (Germeraad, Hopping &

Muller, 1968) and *C. cauveriensis* from the Oligo-Miocene subsurface sediments of the Cauvery Basin, Tamil Nadu (Venkatachala & Rawat, 1973) are considerably larger in size. *Lycopodiumsporites crassireticulatus* described from the Neogene of Barundi (Sah, 1967) in the possession of coarse and heavily reticulate ornamentation on both the proximal and distal facets shows striking resemblance with *Crassoretitriletes* and should be transferred to this genus. Mention may be made here that spores of *Lycopodiumsporites* show reticulate sculpture essentially on the distal facet only.

Affinity — The fossil spores are related to some modern members of *Lygodium* of Schizaeaceae. Germeraad, Hopping and Muller (1968) considered the spores of *Lygodium microphyllum* to be particularly comparable with *Crassoretitriletes*. *L. microphyllum* is a common climbing fern of the humid marsh and swamps of West Africa, and Indo-Malayan region. Spores of *Crassoretitriletes ornatus* have been found occasionally in the microflora of Quilon beds at Padappakkara and Paravur.

Type Locality — Padappakkara.

Holotype — Pl. 1, fig. 14; Pad. III-3; 16·8×75·3, (65 μ).

Subturma — *Zonotriletes* Waltz, 1935
Infraturma — *Cingulati* Potonié & Klaus, 1955

Genus — *Cingulatisporites* (Thomson) Potonié, 1956

Genotype — *C. levispeciosus* Pflug in Thomson and Pflug, 1953.

Cingulatisporites sinuatus sp. nov.

Pl. 1, figs. 12, 13

Diagnosis — Spores deep brown, amb triangular, sides convex, polar diameter 15-20 μ, trilete, Y-mark prominent, laesurae long, almost reaching equatorial margin, ray margins prominently sinuous, ends bluntly tapering; cingulate, cingulum 2·5-4 μ thick, extrema lineamenta ± undulating, surface bearing sparsely distributed low verrucae.

Comments — Cingulate spores of this type have been encountered only rarely in the microflora. *Cingulatisporites levispeciosus* Thomson and Pflug (1953) recorded from the Palaeocene of Hannover, Germany is larger with laevigate exine. *Cingulatisporites* sp. described from the Neogene of Barundi (Sah, 1968) is much larger and with straight laesurae.

Affinity — Unknown.

Type Locality — Paravur.

Holotype — Pl. 1, figs. 12, 13; Par. 2; 21·4×79·9, (17·5 μ).

Cingulatisporites sp.

Pl. 2, fig. 15

Description — Spores light brown, amb rounded triangular, polar diameter 40-48 μ, trilete, Y-mark distinct, rays long, almost reaching cingulum margin, straight, thickened, ends blunt; cingulate, cingulum upto 5 μ wide. Exosporium 1·5 μ thick, surface finely granular to smooth.

Comments — Spores of this type are quite common in all the samples investigated. *C. sinuatus* described above is much smaller and with sinuous laesurae.

Occurrence — Padappakkara, Paravur, Edavai.

Genus — *Pteridacidites* Sah, 1967

Genotype — *P. africanus* Sah, 1967.

Pteridacidites sahii sp. nov.

Pl. 2, fig. 16

Diagnosis — Spores deep brown, amb subtriangular with slightly concave sides, polar diameter 35-46·5 μ, trilete, rays prominent, long ± reaching equatorial margin, ray margins with faint verrucae; cingulate, cingulum upto 4 μ broad with evenly sinuous margin. Exosporium verrucate, verrucae coalescing and concentrated in 2 or 3 series inter-radially, of different sizes, upto 3 μ high, heads often rounded in surface view, contact area smooth.

Comments — Sah (1967) recently instituted the genus *Pteridacidites* which differs from *Polypodiaceaesporites* Potonié (1951) in lacking a reticulate sculpture on the distal side. The South Indian species differs from the Neogene Barundi species in its smaller size. It is, however, comparable with *Pteridacidites rotundus* described from Barundi

(Sah, 1967), but the fusion of verrucae on the distal face of *P. rotundus*, to form an irregular mass, is lacking in the present taxon.

The species is named in honour of Dr S. C. D. Sah of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Affinity — *Pteridacidites sahii* resembles the spores of the modern species of *Pteris* of Pteridaceae. The resemblances are particularly striking with the spores of *Pteris togoensis* (Nayar & Santha Devi, 1964). This species has been encountered occasionally in the Padappakkara and Paravur samples.

Type Locality — Padappakkara.

Holotype — Pl. 2, fig. 16; Pad. III-12; 19·5×78·1, (37 μ).

Genus — *Cibotidites* Ross, 1949

Genotype — *C. zonatus* Ross, 1949.

Cibotidites kundavaensis Sah, 1967

Pl. 2, fig. 17

Description — Spores light brown to yellowish, amb subtriangular, with concave sides and arched angles, polar diameter 28-32 μ, trilete, rays prominent, long but not reaching equatorial margin, wide and tapering, lips prominent and elevated, beset with low lying verrucae; cingulate, cingulum upto 4 μ broad, surface of body faintly verrucate, verrucae more on distal side and sparse on proximal side.

Comments — Spores of *Cibotidites* are fairly common in the microflora. The South Indian specimens are strikingly similar to the ones described from the Neogene of Barundi.

Affinity — *Cibotidites kundavaensis* spores are referable to Dicksoniaceae.

Occurrence — Padappakkara, Paravur.

Turma — *Monoletes* Ibrahim, 1933
Subturma — *Azonomonoletes* Luber, 1935
Infraturma — *Laevigatomonoletes* Dybova & Jachowitz, 1957

Genus — *Laevigatosporites* Ibrahim, 1933

Genotype — *L. vulgaris* (Ibrahim) Ibrahim, 1933.

Laevigatosporites ovatus Wilson & Webster, 1946

Pl. 2, fig. 18

Description — Spores yellowish brown, bilateral, bean-shaped, planoconvex, 36-40 ×29-33 μ, monolete, laesura simple, rather short, margins somewhat thickened, ends pointed to blunt. Exosporium 1·5 μ thick, psilate.

Comments — The fossil spores agree with the characters of *Laevigatosporites ovatus* described from the Tertiary coal of Montana, U.S.A. (Wilson & Webster, 1946). *L. ovatus* has been previously recorded from the Mesozoic and Tertiary strata (Dettmann, 1963; Ramanujam, 1966-67, 1972). From the Miocene brown coal of Lower Silesia Macko (1959) recorded more or less similar type of spores.

Affinity — Spores of this kind are found commonly in various members of Polypodiaceae, viz., *Thylepteris, Asplenium, Athyrium, Aspidium*, etc.

Occurrence — *Laevigatosporites ovatus* is a frequent element of almost all the samples investigated.

Infraturma — *Sculptatomonoleti* Dybova & Jachowitz, 1957

Genus — *Polypodiisporites* (Potonié, 1934) Potonié, 1956

Genotype — *P. favus* (Potonié) Potonié, 1934.

Comments — Monoletes polypodiaceous spores possessing verrucate sculpturing are generally treated under three different genera, viz., *Polypodiisporites* Potonié (1934), *Polypodiidites* Ross (1949) and *Verrucatosporites* Thomson & Pflug (1953). As there seems to be a considerable degree of overlapping between the various species of these genera, and also because of the variation exhibited in the nature of verrucae with each species, which closely parallels the variation of verrucae seen among the modern species of Polypodiaceae, Davalliaceae and some Dennstaedtiaceae, Khan and Martin (1971) recently suggested that the species of all these genera should be incorporated under one genus only and that should be *Polypodiisporites* as it was validly published earlier than the others. Sah (1967) and

Dutta and Sah (1970) also suggested that all the monoletes, verrucate spores should be treated under the genus *Polypodiisporites* only. We fully agree with the view expressed by these authors. Accordingly, we consider the variation seen in verrucae with regards to their size and shape (surface view) as of specific value only.

The genus *Polypodiisporites* as described by Khan and Martin (1971) includes bilateral, monolete spores possessing verrucate to gemmate or bluntly baculate sculptural elements. This genus is the most predominant taxon among the pteridophytic spores of the Quilon microflora and represented by a number of species. Spores with heavily and coarsely verrucate sculpture appears to be particularly abundant. Such heavily verrucate monolete polypodiaceous spores represent the conspicuous elements of various Neogene sediments, viz., Cauvery Basin in Tamil Nadu, South India (Venkatachala & Rawat, 1973), Rusizi Valley of Barundi in West Africa (Sah, 1967), Lower and Upper Silesia of Poland (Macko, 1957, 1959), Western Poland (Ziembinska, 1974) and Rhone Basin of France (Meon-Vilain, 1970).

Polypodiisporites ratnami (Ramanujam, 1966-67) comb. nov.

Pl. 2, figs. 19, 20

1966-67 *Polypodiidites ratnami* Ramanujam, p. 32, fig. 17.

Description — Spores yellowish-brown, bilateral, almost planoconvex laterally, 33-36·5 × 22-25 μ, monolete, laesura long, ends blunt. Exosporium upto 2 μ thick, verrucate, verrucae about 1·5 μ high, tips more or less rounded, more in numbers towards distal side, less towards proximal side.

Comments — *P. ratnami* represents a frequent member of this genus in the Quilon microflora and the forms recovered from Padappakkara are almost identical with the ones recorded from the Neyveli lignite (Ramanujam, 1966-67).

Affinity — These are polypodiaceous spores. In Polypodiaceae there are a number of genera characterized by the production of monolete spores with various kinds of verrucate sculpturing (Nayar, 1964; Nayar & Santha Devi, 1964).

Occurrence — Padappakkara.

Polypodiisporites ornatus Sah, 1967

Pl. 2, figs. 21, 22

Description — Spores brown, bilateral, plano-convex to slightly concavo-convex laterally, 42·5-50 × 28-32 μ, monolete, laesura short, margins thin, ends pointed to blunt. Exosporium upto 3·5 μ thick, thinner towards proximal side, densely verrucate, verrucae low, giving a crenate look to margin, 1·5 μ high and 3 to 5·5 μ broad at base, heads distinctly angular in surface view, becoming smaller gradually towards proximal region; surface areolate due to formation of negative reticulum.

Comments — Next to *Polypodiisporites impariter* (see below) this represents numerically the most abundant species of *Polypodiisporites* met with in the samples investigated. Our specimens are generally larger than the ones described by Sah (1967) from the Neogene of Barundi.

Occurrence — Padappakkara, Paravur and Edavai.

Polypodiisporites miocenicus sp. nov.

Pl. 2, fig. 23

Diagnosis — Spores light brown, bilateral, biconvex in lateral view, ends rounded, 40-58·5 × 30-40 μ; monolete, laesura short, thinly lipped, ends pointed. Exosporium upto 2·5 μ thick, conate, coni 1·5 to 2 μ high, with rounded bases, of various sizes in surface view, sparsely distributed all over.

Comments — The fairly large size of the spore, coupled with the biconvex shape in lateral view and the sparsely distributed coni, are the distinguishing features of this species. *Polypodiisporites turbinatus* from the Neogene of Barundi (Sah, 1967) although comparable in size and to some extent in sculpturing, is more or less reniform with densely packed coni. *P. miocenicus* sp. nov. has been encountered only occasionally.

Type Locality — Padappakkara.

Holotype — Pl. 2, fig. 23; Pad. III-9; 22·5 × 75·8, (46 × 36 μ).

Polypodiisporites impariter (Potonié & Sah, 1958) comb. nov.

Pl. 2, figs. 24-26

1958 *Polypodiidites impariter* Potonié & Sah, p. 126, pl. 1, figs. 9, 10.

Description — Spores brownish to golden yellow, ellipsoidal in polar view, plano-convex to occasionally concavo-convex laterally, 37-42×23-30 μ, monolete, laesura long, but not reaching spore ends, margins thickened. Exosporium 2-4 μ thick, beset with coni intermingled locally with verrucae; coni or verrucae upto 2·5 μ high and 3·5 μ wide at base.

Comments — *Polypodiisporites impariter* is the most commonly encountered species of this genus in the Quilon microflora and the parent plant producing these spores no doubt must have constituted an important element of the Quilon flora. Potonié and Sah (1958) recorded this species as a profuse element of the Cannanore lignite.

Occurrence — In almost all the samples studied by the authors.

Polypodiisporites perverrucatus (Couper, 1953) Khan & Martin, 1971

Pl. 3, fig. 29

Description — Spores light yellow, plano-convex laterally, 36-41×25-28 μ, monolete, laesura short, margins thin, ends pointed. Exosporium upto 3 μ thick, verrucate, upto 2 μ high, tips rounded, sparsely distributed more or less all over spore wall.

Comments — *Polypodiisporites perverrucatus* is a common element of the Quilon beds.

Polypodiisporites usmensis (Germeraad, Hopping & Muller, 1968) Khan & Martin, 1971

Pl. 2, fig. 27

Description — Spores light brown, plano-convex to faintly concavo-convex laterally, ends arching, 33-45×20-32 μ, monolete, laesura long, ends pointed, margins thin. Exosporium upto 3·5 μ thick, densely verrucate-gemmate, sculptural processes upto 2·5 μ high, distributed rather densely and evenly on distal side, sparse and smaller towards proximal side.

Comments — This is also a frequent element of the Quilon beds. The South Indian specimens are slightly smaller than the ones recorded from the Tertiaries of South America, Nigeria and Borneo (Germeraad, Hopping & Muller, 1968). The spores of *P. usmensis* seem to show closer resemblance with the spores of *Stenochlaena*, *Phlebodium* and *Histiopteris*.

Polypodiisporites multiverrucosus Nagy, 1963

Pl. 2, fig. 28

Description — Spores brown to brownish yellow, bilateral, plano-convex laterally, 36-40×18-25 μ, monolete, laesura distinct, long extending upto both ends of spore, margins slightly thickened, ends tapering gradually. Exosporium upto 3 μ thick, prominently and densely verrucate, verrucae upto 2·5 μ high, 6 μ in diameter, ends rounded, distributed all over spore surface evenly.

Comments — This is a fairly frequently element of the microflora. The South Indian forms are smaller than the ones recorded from the Oligocene-Miocene boundary in North Hungary (Nagy, 1963), but otherwise similar to them.

Occurrence — Edavai, Paravur.

Genus — *Schizaeoisporites* Potonié, 1951

Genotype — *S. eocenicus* Selling, 1944.

Schizaeoisporites multistriatus sp. nov.

Pl. 3, fig. 30

Diagnosis — Spores golden yellow, plano-convex laterally, 41-50×25-30 μ, monolete, laesura long reaching both ends of spore, margins slightly thickened, ends pointed to blunt. Exosporium 1·5 μ thick, surface with numerous longitudinal striae formed of extremely fine grooves; striae essentially simple, straight to locally slanting.

Comments — *Schizaeoisporites grandiformis* recorded from the Warkalli lignite (Ramanujam, 1960, 1972) is comparable with the present species but is distinguishable in its thicker exosporium and larger size. Striated monolete spores referable to Schizaeaceae have been found only occasionally in the Quilon samples investigated. Such spores, however, constitute abundant elements of the Neyveli and Warkalli lignites (Ramanujam, 1966-67, 1972).

Affinity — The fossil spores are related to *Schizaea* of Schizaeaceae (Selling, 1946; Bolkhovitina, 1961).

Type Locality — Padappakkara.

Holotype — Pl. 3, fig. 30; Pad. III-2, 17·9×81·6, (41×25 μ).

Anteturma — *Pollenites* Potonié 1931
Turma — *Aletes* Ibrahim, 1933
Subturma — *Azonoletes* (Luber) Potonié & Kremp, 1954
Infraturma — *Subpilonapiti* (Erdtman) Vimal, 1952

Genus — *Retipilonapites* Ramanujam, 1966

Genotype — *R. arcotense* Ramanujam, 1966.

Comments — Nonaperturate and reticulate pollen grains have been described fairly commonly from various Tertiary horizons of India. Singh (1975) recently made a critical survey of these pollen. *Retipilonapites* (Ramanujam, 1966), *Assamiapollenites*, *Sahiapollis* and *Assamialetes* (Singh, 1975) represent the nonaperturate and reticulate taxa known so far from India. Of these, *Retipilonapites* and *Assamiapollenites* are known from the Quilon microflora. *Retipilonapites* was originally recorded from the Neyveli lignite (Ramanujam, 1966) and *Assamiapollenites* from the Tertiary of Assam (see Singh, 1975). In addition to these, the Quilon microflora also consists of a new kind of nonaperturate and reticulate taxon, viz., *Crotonoidaepollenites*. The reticulate sculpture of this genus is of the crotonoid type. Nonaperturate reticulate pollen grains have been recorded from almost all the samples investigated and appear to constitute an important element of the Quilon beds.

Retipilonapites tertiaris sp. nov.

Pl. 3, fig. 31

Diagnosis — Pollen grains spheroidal to subspheroidal, polar diameter 22-40 μ; inaperturate, but sometimes provided with a large and irregular central depression on one side. Exine 2·5-3·5 μ thick, sexine much thicker than nexine, intectate, retipilate; muri discontinuous, formed of prominent pila, upto 2·5 μ high, oligobrochate, homobrochate, brochi hexagonal to polygonal, lumina angular, often with a few free bacula.

Comments — Pollen grains of this type are very common. Similar grains have also been encountered in the Warkalli beds by us. *Retipilonapites tertiaris* sp. nov. differs from *R. arcotense* described from the Neyveli lignite (Ramanujam, 1966) in its larger meshes and free bacula in the lumina. *R. cenozoicus* Sah (1967) recorded from the Neogene of Barundi differs in being larger and possessing finely reticulate exine. Possession of large-meshed reticulum with free bacula in the lumina is the distinctive feature of *R. tertiaris*.

Affinity — The fossil grains show relationship with the pollen of *Potamogeton* of Potamogetonaceae.

Type Locality — Padappakkara.

Holotype — Pl. 3, fig. 31; Pad. IV-17; 22·4×86·4, (34 μ).

Retipilonapites conspicua sp. nov.

Pl. 3, fig. 32

Diagnosis — Pollen grains irregularly spheroidal, polar diameter 25-31 μ, inaperturate, but provided with a large central depression on one side. Exine 3-4 μ thick, sexine much thicker than nexine, intectate, surface prominently reticlavate-retipilate, clava-pila upto 3·5 μ high, heads rounded, locally clava-pila processes fused, meshes formed of reticulate alignment of clava or pila, rounded to angular.

Comments — *R. conspicua* is a frequent element of the Quilon beds at Padappakkara. It differs from all the other species of this genus in the possession of both clava and pila and in the local concrescence of these processes.

Affinity — The fossil grains are referable to Potamogetonaceae.

Type Locality — Padappakkara.

Holotype — Pl. 3, fig. 32; Pad. II-2; 11·2×95·5, (28·5 μ).

Genus — *Spinainaperturites* Pierce, 1961

Genotype — *S. recurvatus* Pierce, 1961.

Spinainaperturites neogenicus sp. nov.

Pl. 3, fig. 33

Diagnosis — Pollen grains isopolar, ovoid to spheroidal, 25-31·5 μ, inaperturate.

Exine thin, structure indistinct, spinous, spines 2·5 μ long, straight with pointed ends, mixed with coni, uniformly distributed all over, surface in between spines granular.

Comments — Inaperturate and spinascent grains of this type are fairly common elements of the microflora.

Affinities — These pollen grains are referable to Aroideae and show particular resemblance with the pollen of *Typhonium* (Thanikaimoni, 1969).

Type Locality — Paravur.

Holotype — Pl. 3, fig. 33; Par. 5; 18·6 ×81, (28 μ).

Genus — *Clavainaperturites* Hammen & Wymstra, 1964

Genotype — *C. clavatus* Hammen & Wymstra, 1964.

Clavainaperturites clavatus Hammen & Wymstra, 1964

Pl. 3, fig. 34

Description — Pollen grains isopolar, spheroidal, polar diameter 20-25 μ, inaperturate, but provided with a faint depression on one side. Exine upto 2·5 μ thick, thinner at depression region, sexine thicker than nexine, surface densely clavate, clava upto 1·5 μ high, closely and uniformly distributed.

Comments — Pollen grains of this type are occasional elements of the Quilon beds. The South Indian grains are almost identical with those recorded from the Lower Tertiary of Mombaka area, Kwakwani, British Guiana (Hammen & Wymstra, 1964), except for their smaller size.

Affinity — Potamogetonaceae.

Occurrence — Edavai.

Turma — *Plicates* (Naumova) Potonié, 1960

Subturma — *Monocolpates* Iverson & Troels-Smith, 1950

Infraturma — *Laevigatomonocolpates* infraturma nov.

Diagnosis — Monocolpate (monosulcate) pollen grains with smooth or very finely punctate exine.

Genus — *Palmaepollenites* Potonié, 1951

Genotype — *P. tranquillus* (Potonié) Potonié, 1951.

Palmaepollenites keralensis sp. nov.

Pl. 3, fig. 36

Diagnosis — Pollen grains heteropolar, amb roughly rhombic, narrow toward one and broader toward other end, 37·5-42 ×26-28 μ, monosulcate, sulcus long but not reaching equatorial margin, club-shaped, narrow at one end and gradually widening at other end, margins thickened at mid region, ends blunt. Exine 1·5 μ thick, sexine as thick as nexine, surface smooth.

Comments — *Palmaepollenites kutchensis* recorded from the Tertiary sediments (Eocene) of Kutch (Venkatachala & Kar, 1969) has a boat-shaped sulcus. *P. communis* from the Cherra Formation of Assam (Sah & Dutta, 1966) is slightly smaller, ellipsoidal in shape possessing a uniformly narrow sulcus. *P. eocenicus* (Biswas) Sah & Dutta (1966) is ovoid and possesses a uniformly wide and short sulcus with thin margins. *P. neyveliensis* from the Upper Tertiary Neyveli lignite (Ramanujam, 1966) resembles the present species in possessing a long crassimarginate sulcus but the latter is distinguishable in its club-shaped sulcus with crassimarginate condition confined to the mid region of the sulcus.

Affinity — These grains are fairly common in the samples studied and resemble the pollen of *Cocos* of Palmae (Thanikaimoni, 1970).

Type Locality — Padappakkara.

Holotype — Pl. 3, fig. 36; Pad. III-3, 20·1×88·9, (39×27 μ).

Palmaepollenites neyveliensis Ramanujam, 1966

Pl. 3, fig. 37

Description — Pollen grains heteropolar, amb ovoidal, 38·5×23 μ, monosulcate, long almost reaching both ends, uniformly narrow, margins thickened, ends blunt. Exine upto 2 μ thick, sexine slightly thicker than nexine, surface smooth.

Comments — The present specimen is slightly bigger than that of the Neyveli lignite (Ramanujam, 1966). Ramanujam (1966) originally described this taxon as *P. neyvelii*, however, since the specific name is obviously after the locality Neyveli, it should have the ending *neyveliensis* rather than *neyvelii*.

Affinity — Palmae.

Occurrence — Padappakkara.

Palmaepollenites eocenicus (Biswas) Sah & Dutta, 1966

Pl. 3, fig. 38

Description — Pollen grains heteropolar, amb ovoidal with rounded ends, 37·5 × 27·5 μ, monosulcate, sulcus fairly long, uniformly broad all along its length, margins thin, ends ± rounded. Exine 1·8 μ thick, sexine as thick as nexine, tectate, columella indistinct, surface finely scabrate.

Comments — The Padappakkara grains are almost identical with those recorded from the Tertiary (Eocene) of Assam (Sah & Dutta, 1966, 1968).

Affinity — Palmae.

Occurrence — Padappakkara.

Genus — *Arecipites* Wodehouse, 1933

Genotype — *A. punctatus* Wodehouse, 1933.

Arecipites keralensis sp. nov.

Pl. 3, fig. 39

Diagnosis — Pollen grains heteropolar, ellipsoidal to rhombic, 38-45 × 19-24 μ, monosulcate, sulcus long, narrow all along, margins slightly thickened, ends blunt. Exine upto 2·5 μ thick, sexine thicker than nexine, surface finely punctate, puncta locally in regular longitudinal rows.

Comments — Pollen grains referable to *Arecipites* constitute one of the common elements of the Quilon beds. *A. keralensis* sp. nov. differs from *A. punctatus* recorded from the Eocene Green River Formation of America (Wodehouse, 1933), in its much larger size. *A. bellus* described from the Palaeogene of Assam (Sah & Dutta, 1970) is oval and larger.

Affinity — *Arecipites keralensis* resembles the pollen of *Syagrus campylospatha* of Palmae (Thanikaimoni, 1970).

Type Locality — Padappakkara.

Holotype — Pl. 3, fig. 39; Pad. III-11, 17·7 × 89·5, (41 × 22 μ).

Infraturma — *Apiculomonocolpates* infraturma nov.

Diagnosis — Monocolpate (monosulcate) pollen grains with coni, spines, verrucae, clava, pila or gemma.

Genus — *Verrumonocolpites* Pierce, 1961

Genotype — *V. conspicuous* Pierce, 1961

Verrumonocolpites sp.

Pl. 3, fig. 40

Description — Pollen grains heteropolar, elliptical ends truncate, 23-50 × 15-25 μ, monosulcate, sulcus long reaching both ends along longitudinal axis, somewhat dumbel-shaped, margins thickened, ends smoothly arched. Exine upto 2 μ thick, sexine thicker than nexine, verrucate, verrucae locally closely placed, low, with flatly rounded tips.

Comments — About half a dozen specimens of this type were found in the Padappakkara samples.

Affinity — The resemblances of the fossil pollen grains are with the pollen of *Hyphaene* of Borassioidae of Palmae.

Occurrence — Padappakkara.

Verrumonocolpites venkatachalai sp. nov.

Pl. 3, fig. 41

Diagnosis — Pollen grains heteropolar, oval to ellipitcal, 50-56 × 30-34 μ, monosulcate, sulcus long extending to both ends along longitudinal axis, narrow at mid region and broader at ends, sulcus margins thick and beset with verrucae. Exine upto 4·5 μ thick, sexine much thicker than nexine, columella fairly distinct, surface essentially verrucate, verrucae intermingled locally with short blunt spines or coni; verrucae 2·5-4 μ high, heads rounded, distributed evenly all over pollen wall, interverrucal areas smooth to finely granular.

Comments — Verrucate monosulcate grains of this kind constitute frequent elements of the Quilon beds. The conspicuous verrucae intermingled locally with short spines or coni represent the important features of this taxon.

Affinity — A number of species of the Borassioidae Group of Palmae possess pollen grains with heavy verrucate sculpturing (Thanikaimoni, 1970). The fossil grains are related to these.

The species is named in honour of Dr B. S. Venkatachala, Oil and Natural Gas Commission, Dehra Dun.

Type Locality — Edavai.

Holotype — Pl. 3, fig. 41; Edv. C3; 14·6×73·1, (52×31 μ).

Genus — *Couperipollis* Venkatachala & Kar, 1969

Genotype — *C. perispinosus* Venkatachala & Kar, 1969.

Couperipollis ellipticus sp. nov.

Pl. 3, fig. 42

Diagnosis — Pollen grains heteropolar, polar view elliptical, 33·5-44×16-24 μ, monosulcate, sulcus narrow all along its length, margins thickened and sparingly beset with truncate spines or verrucae. Exine 3·5-4·5 μ thick, sexine much thicker than nexine, tectate, columella faintly seen, surface spinose, spines upto 3·5 μ high, blunt-tipped, locally truncate, widely spaced, surface between spines psilate.

Comments — Along with other *Couperipollis* taxa this constitutes a common elements of the Quilon beds. In its shape and nature of sculptural processes it differs from the other species of *Couperipollis*.

Affinity — Palmae.

Type Locality — Paravur.

Holotype — Pl. 3, fig. 42; Par. 41, 8·0 ×71·9, (41·5×22 μ).

Couperipollis sp.

Pl. 3, fig. 43

Description — Pollen grains subspheroidal, 30-38 μ, monosulcate, sulcus indistinct, margins thin. Exine upto 7·5 μ thick, sexine much thicker than nexine, tectate, columella distinct, surface echinate, spines few, widely placed, supratectal, upto 6 μ high, base slightly bulbose, tips blunt or pointed, interspinal area smooth.

Comments — Only a few specimens of this type have been encountered. The widely placed prominent spines with slightly bulbose bases are the distinguishing features of this type.

Occurrence — Padappakkara.

Couperipollis punctitectatus sp. nov.

Pl. 4, fig. 45

Diagnosis — Pollen grains heteropolar, more or less ovoidal, 40-48·5×28-35 μ, monosulcate, sulcus long extending all along long axis of the grain, fairly wide at mid region and narrowing toward ends, margins thickened, ends blunt. Exine upto 7 μ thick, sexine much thicker than nexine, punctitectate, columella distinct, and appear as radial striae near periphery, surface robustly echinate, spines supratectal, with pointed ends and bulbous bases, upto 5 μ high, interspinal areas punctate.

Comments — *Couperipollis* Venkatachala & Kar (1969) accommodates monosulcate pollen with spinous sculptural elements. Because of the possession of prominent spines the fossil grains have been included in this taxon. *Couperipollis kutchensis* recorded from the Tertiaries of Kutch (Venkatachala & Kar, 1969) is subcircular with an ill-developed sulcus and a smooth interspinal surface. *C. brevispinosus* (Sah & Dutta) Venkatachala & Kar (1969) is ovoidal, densely spinous and with a pitted reticulate exine in between the spines. *C. punctitectatus* sp. nov. also differs from the other species of *Couperipollis* recorded from Assam and Cauvery Basin (Venkatachala & Kar, 1969; Venkatachala & Rawat, 1972, 1973) in its conspicuous spines with bulbous bases and the punctate interspinal area. This is a common element of the Quilon beds.

Affinity — Palmae.

Type Locality — Padappakkara.

Holotype — Pl. 4, fig. 45; Pad. III-3; 17·0×79·8, (42·5×30 μ).

Couperipollis wodehousei (Sah & Dutta) Venkatachala & Kar, 1969

Pl. 4, fig. 46

Description — Pollen grains heteropolar, ovoidal to subspheroidal, 33-42·5×25-28 μ, monosulcate, sulcus indistinct, 10-13·5 μ wide at central region, tapering towards ends, margins thin. Exine 6-8 μ thick, sexine much thicker than nexine, tectate, columella clear, surface echinate, spines supratectal, upto 7·5 μ high, base bulbous and 2·5 to 3·5 μ broad, tips slender, pointed, straight or flexuous, densely placed all over pollen wall, interspinal areas pitted-reticulate.

Comments — The present grains are slightly smaller than those recorded from the Tertiary of Assam. *C. wodehousei* is a frequent element of the Quilon beds.

Affinity — Palmae.

Occurrence — Padappakkara.

Genus — *Clavapalmaedites* gen. nov.

Type Species — *C. hammenii* sp. nov.

Diagnosis — Pollen grains heteropolar, ellipsoidal to oval, or oblong, monosulcate, sulcus long, margins thin or slightly incrassate, membrane and sulcus margins densely beset with pila or clava. Exine densely and coarsely clavate-pilate; clava-pila processes free, heads rounded to angular, locally grouped to give a reticuloid look in surface view.

Comments — The genus *Clavatipollenites* Couper (1958) accommodates monosulcate pollen with finely clavate exine. The type species *Clavatipollenites hughesi* Couper (1958) was compared with the modern pollen of *Ascarina* (Chloranthaceae) with which there seems to be a clear similarity. It is of importance to note that in both these fossil and modern taxa, the nexine is either thicker or of the same thickness as the sexine (see Kuprianova, 1967). Moreover, the heads of the clavae in *Clavatipollenites* are fused to form a microreticulum. The new genus *Clavapalmaedites* instituted here includes monosulcate pollen with free, conspicuous clava or pila distributed densely all over pollen surface including the margins and membrane of the sulcus. *Paravuripollis*, described below, although possessing clavate-pilate sculpture, is distinguishable in its zonosulcate nature.

Clavapalmaedites hammenii gen. et sp. nov.

Pl. 4, figs. 47, 48

Diagnosis — Pollen grains ellipsoidal to oval, 25-31×16-21 μ, monosulcate, sulcus along extending all along long axis of grain, uniformly wide, margins incrassate, ends rounded or blunt, sulcus membrane and margins beset with clava or pila. Exine 3·8-4·5 μ thick, sexine much thicker than nexine, clavate-pilate, clava upto 3·5 μ high, heads free, rounded to angular with a tendency towards local reticuloid grouping.

Comments — Pollen grains of this type represent characteristic elements of the Quilon beds and have been recorded fairly abundantly from almost all the samples investigated. They are not strictly comparable with any of the known fossil monosulcate pollen.

The species is named in honour of Prof V. D. Hammen.

Affinity — These grains are particularly related to some members of Palmae, viz., *Iriartea*, *Pinanga* and *Ceroxylon* (Thanikaimoni, 1970).

Type Locality — Padappakkara.

Holotype — Pl. 4, fig. 47; Pad. II-7; 12·2 ×99·5, (29×19 μ).

Genus — *Crotonisulcites* gen. nov.

Type Species — *C. grandis* sp. nov.

Diagnosis — Pollen grains heteropolar, amb ovoidal, monosulcate, sulcus long, locally broader, margins thickened, exine tectate, heavily ornamented with free pilate-clavate processes with triangular heads, aligned in a reticuloid pattern of sculpture.

Comments — *Crotonisulcites* differs from all other known fossil monosulcate pollen in its characteristic crotonoid pattern of the exine sculpture.

The generic name denotes the " Croton pattern " of sculpture as described by Erdtman (1952).

Crotonisulcites grandis gen. et sp. nov.

Pl. 4, figs. 49, 50

Diagnosis — Pollen grains ovoidal, 45-56 ×37·5-43 μ, monosulcate, sulcus long, 8·5-12 μ broad, ± dumbel-shaped, sulcus margin incrassate and beset with clava. Exine 5-6·5 μ thick, sexine much thicker than nexine, tectate, pilate-clavate, pila and clava processes 3·75-4·5 μ high, densely and uniformly placed all over, heads triangular, free heads of these processes aligned in a reticuloid pattern resembling croton pattern of sculpture.

Comments — This is one of the easily distinguishable taxa of the Quilon beds and has been encountered in the samples of all the three localities investigated. The monosulcate nature with a more or less dumbel-shaped sulcus and the crotonoid pattern of sculpture are the diagnostic features of this taxon.

Affinity — The fossil grains show striking resemblances with the pollen of species of *Nomocharis* and *Lilium* of Liliaceae (Nair & Sharma, 1965).

Type Locality — Padappakkara.

Holotype — Pl. 4, figs. 49, 50; Pad. II-11; 18·9×96·1, (50×37·5 μ).

Genus — *Spinizonocolpites* Muller, 1968

Genotype — *S. echinatus* Muller, 1968.

Spinizonocolpites quilonensis sp. nov.

Pl. 4, figs. 51, 52

Diagnosis — Amb ovoid to subspheroidal, 35-42×26-30 μ, monosulcate, zonosulcate, sulcus extending all around equator and splitting the grain into two more or less equal halves, sulcus margin thin. Exine upto 3·5 μ thick, sexine thicker than nexine, echinate, spines widely placed, upto 3 μ high, slender, tips pointed, straight or flexuous.

Comments — These are occasional elements of the Quilon beds. *Spinizonocolpites echinatus* described from the Palaeogene of Malaysia, Nigeria and Carribbean area and the Palaeogene and Neogene of Borneo (Muller, 1968) is spheroidal with finely reticulate interspinal exine.

Affinity — The fossil grains closely resemble the pollen of *Nipa fruticans* of Palmae.

Type Locality — Padappakkara.

Holotype — Pl. 4, fig. 51; Pad. III-2, 14·8×73·3, (37×28 μ).

Genus — *Paravuripollis* gen. nov.

Type Species — *P. mulleri* sp. nov.

Diagnosis — Pollen grains zonosulcate, ellipsoidal or ovoidal, sulcus running all around equatorial zone splitting the pollen body into two more or less equal halves, sulcus margins beset with pila or clava. Exine densely pilate-clavate.

Comments — Although apparently resembling *Clavapalmaedites* described in this paper, the genus *Paravuripollis* is easily distinguishable in its zonosulcate nature.

Paravuripollis mulleri gen. et sp. nov.

Pl. 4, figs. 53-54

Diagnosis — Pollen grains ellipsoidal or ovoidal, with or without truncate ends, 22·5-29×19-23 μ, zonosulcate, sulcus running all around equatorial zone splitting the pollen grain into two more or less equal halves, sulcus margins slightly incrassate, studded with pila or clava. Exine upto 4·5 μ thick, sexine much thicker than nexine, intectate, surface densely beset with pilate-clavate processes, upto 3·5 μ high, heads of processes angular to locally rounded.

Comments — *Spinizonocolpites* of Muller (1968) which is also a zonosulcate taxon is easily distinguishable from the Kerala genus in its suboblate-spheroidal shape, echinate to baculate sculpture and often with reticulate interspinal surface.

Paravuripollis mulleri is a very common taxon of the Quilon beds. Almost all the samples studied showed the presence of this pollen abundantly.

The species is named in honour of Dr J. Muller.

Affinity — These pollen grains are referable to Palmae and probably related to the tribe Nipoidae.

Type Locality — Paravur.

Holotype — Pl. 4, fig. 53; Par. 1; 22·7 ×102·9, (28×21 μ).

Infraturma — *Murormonocolpates* infraturma nov.

Diagnosis — Monocolpate (monosulcate) pollen with foveolate to reticulate exine.

POLLEN TYPE — A

Pl. 4, fig. 55

Description — Pollen grains ellipsoidal, 28-32×20-23 μ, monosulcate, sulcus long, uniformly narrow all along its length, bordered by two longitudinal and prominent plicate on either side. Exine upto 2 μ thick, punctitectate, surface finely pitted, pits closely placed imparting a fine reticulate look to exine.

Comments — The above pollen is distinguishable from the rest of the monosulcate pollen of the Quilon beds in the possession of two conspicuous plica bordering the sulcus and finely pitted nature of its exine. Only two specimens of this interesting pollen type were encountered in the Edavai clay samples, hence no name was given to this type.

Occurrence — Edavai.

Pollen Type — B

Pl. 4, fig. 56

Description — Pollen grain oval, 29×16·5 μ, monosulcate, sulcus long reaching both ends along long axis of pollen, margins heavily incrassate, beset with spines in two rows, one on the outer face and other on inner face; spines slender upto 2 μ high, tips pointed. Exine 2 μ thick, mostly spinulate, spinules fine, inconspicuous.

Comments — *Couperipollis* of Venkatachala and Kar (1969) includes monosulcate pollen with robust spines often with bulbous bases, but the above described pollen type shows spinascent sulcus margin, and spinulate exine. Only one specimen of this type was encountered in one of the Padappakkara samples.

Affinity — The fossil pollen shows striking resemblance with the pollen of *Lepidocaryum gracilis* of Palmae (Thanikaimoni, 1970).

Occurrence — Padappakkara.

Genus — *Liliacidites* Couper, 1953

Genotype — *L. kaitangetensis* Couper, 1953.

Liliacidites padappakkarensis sp. nov.

Pl. 3, fig. 35; Pl. 4, fig. 44

Diagnosis — Pollen grains heteropolar, plano-convex to biconvex laterally, elliptical in polar view, 50-60×30-35 μ, monosulcate, sulcus long, often reaching both ends along long axis of pollen, uniformly narrow with tapering and blunt ends. Exine upto 4·5 μ thick, sexine much thicker than nexine, surface retipilariate, pila heads prominent, rounded or angular, reticulum homobrochate, brochi large, upto 5 μ across, muri formed of groups of fused pila, duplipilate, upto 3·5 μ high, lumina large, angular to rounded, smooth.

Comments — Pollen grains of this kind were frequently met with in the Quilon beds, particularly the Padappakkara samples. *L. padappakkarensis* sp. nov. differs from the other species of this genus in its characteristic sculpture. *L. baculatus* from the Tertiary of Kutch (Venkatachala & Kar, 1969) has a superficial resemblance with the present species, but the exine in the former is intrabaculate forming a negative reticulum in surface view.

Affinity — The above pollen grains are referable to Liliaceae (Nair & Sharma, 1965; Sharma, 1968).

Type Locality — Padappakkara.

Holotype — Pl. 4, fig. 44; Pad. II-1; 25·9×86·0, (52×31 μ).

Genus — *Longapertites* Hoeken-Klinkenberg, 1964

Genotype — *L. marginatus* Hoeken-Klinkenberg, 1964.

Longapertites klinkenbergii sp. nov.

Pl. 4, fig. 57

Diagnosis — Pollen grains heteropolar, plano-convex laterally, 41·5-48×25-32 μ, monosulcate, sulcus very long extending over 2/3rd of circumference of grain, 5 μ wide in the middle, narrowing at ends, margins thickened and beset with clava. Exine upto 3 μ thick, sexine much thicker than nexine, subtectate, columella distinct, surface reticulate, heterobrochate, brochi hexagonal to polygonal, curvimurate, muri upto 2 μ high, occasionally disjointed, simpliclavate, lumina angular to irregular with 1-3 free bacula in each lumen.

Comments — *Longapertites* is one of the abundant elements of the Quilon microflora and has been recorded from almost all the samples studied. It may be mentioned that the authors recovered this genus commonly from the continental Warkalli beds too. The genotype *L. marginatus* recorded from the Cretaceous of Nigeria

(Hoeken-Klinkenberg, 1964) is much larger and with perfotectate exine. *L. proxapertites* from the Palaeocene of Columbia (Hoeken-Klinkenberg, 1966) possesses a foveoreticulate sculpture. *L. cuddalorense* recorded from the Neyveli lignite is with a pitted exine (Ramanujam, 1966). The present species is distinguishable in the possession of sulcus beset with clava on its margins and in curvimurate condition.

The species is named in honour of Dr Hoeken-Klinkenberg.

Affinity — The authors consider *Longapertites* to be a member of Palmae. The exact relationships of this genus with the modern taxa of Palmae, however, are not yet known.

Type Locality — Padappakkara.

Holotype — Pl. 4, fig. 57; Pad. III-2; 9·1 × 86·0, (43 × 31 μ).

Longapertites hammenii sp. nov.

Pl. 4, fig. 58

Diagnosis — Pollen grains heteropolar, plano-convex laterally, 36-44 × 22-31 μ, distal side prominently arching, monosulcate, sulcus extending over 2/3rd of the circumference of the grain, narrow to fairly wide, margins thickened, ends tapering. Exine upto 3 μ thick, sexine thicker than nexine, subtectate, reticulate, reticulum homobrochate, brochi hexagonal to polygonal, muri upto 2 μ high, simplibaculate, lumina polygonal and smooth.

Comments — *L. hammenii* sp. nov. differs from *L. marginatus* Hoeken-Klinkenberg (1964) in its smaller size and in lacking perfotectate condition. *L. vaneedenburgi* recorded from the Tertiary of Carribbean area and Nigeria (Germeraad *et al.*, 1968) possesses a finely perforate tectum. *L. klinkenbergii* described above shows curvimurate meshes with free bacula in the lumina.

The species is named in honour of Prof V. D. Hammen.

Affinity — Palmae.

Type Locality — Padappakkara.

Holotype — Pl. 4, fig. 58; Pad. III-11; 19·5 × 75·0, (36 × 33 μ).

Genus — *Quilonipollenites* gen. nov.

Type Species — *Quilonipollenites sahnii* sp. nov.

Diagnosis — Pollen grains heteropolar, broadly oval to subspheroidal in polar view, somewhat biconvex laterally, monosulcate, sulcus long and of extended type, extending over a smaller or greater part of proximal facet, extended part of sulcus usually broader than rest, sulcus margins thin or thickened, even or uneven. Exine tectate, columella distinct, surface prominently and coarsely reticulate, retipilariate or retipilate-clavate.

Comments — The outstanding features of this beautiful taxon are its broad extended sulcus (see Thanikaimoni, 1966 for the concept of extended sulcus) and heavy sculpturing which is of suprareticulate type. The new genus *Quilonipollenites* differs from the other known fossil taxa of monosulcate type. *Longapertites* of Hoeken-Klinkenberg (1964) is plano-convex laterally and with a narrow extended sulcus of uniform width all through; further, the sculpture of this taxon is of a different type.

Quilonipollenites sahnii gen. et sp. nov.

Pl. 5, figs. 59-62

Diagnosis — Pollen grains biconvex laterally, subspheroidal in polar view, 50-55 × 40-52·5 μ, monosulcate, sulcus long, of extended type, considerably wide, 20-29 μ wide, margins thin. Exine upto 4 μ thick, thinner towards proximal facet, sexine much thicker than nexine, tectate, surface conspicuously and coarsely reticulate (suprareticulate), reticulum with large hexa to polygonal meshes, meshes upto 5·5 μ broad, muri thick, formed of fused clava, simplicavate, rarely duplicavate, upto 3 μ high, beaded in appearance, occasionally incomplete, lumina angular with 1-5 free baculoid processes.

Comments — The large-meshed reticulum with beaded muri and free baculoid processes in the lumina give a beautiful and ornate look to these pollen grains. These pollen grains are common elements of the Quilon beds.

The species is named in honour of late Prof Birbal Sahni.

Affinity — This pollen type is referable to Palmae (Thanikaimoni, 1966, 1970), but its exact relationships with the modern taxa are not known.

Type Locality — Padappakkara.

Holotype — Pl. 5, figs. 59, 60; Pad. III-3; 12·0×89·5, (50×43 μ).
Paratypes — Pl. 5, figs. 61, 62.

Quilonipollenites ornatus sp. nov.

Pl. 5, figs. 63, 64

Diagnosis — Pollen grains subspheroidal in polar view, 40-48×35-39 μ, monosulcate, sulcus of extended type, extending to a short distance on proximal side, 15-18 μ broad, margins uneven and ends rounded. Exine upto 2·5 μ thick, sexine thicker than nexine, tectate, columella distinct, surface reticulate (suprareticulate), reticulum heterobrochate, meshes 1·5 μ in diameter, decreasing in size towards proximal side, muri thick, simplibaculate, lumina small, angular, smooth.

Comments — The extended sulcus and the somewhat fine reticulum impart an ornate look to the pollen grains. This differs from *Q. sahnii* in its finer reticulum and smooth lumina.

Type Locality — Padappakkara.

Holotype — Pl. 5, figs. 63, 64; Pad. III-12; 13·3×90·9, (40×38 μ).

Genus — *Dicolpopollis* (Pflanzl) Potonié, 1956

Subturma — *Dicolpates* Erdtman, 1947

Genotype — *D. kockeli* Pflanzl, 1956.

Comments — The genus *Dicolpopollis* is one of the abundantly represented taxa of the Quilon microflora. The following constitute some of the more frequently encountered species of this genus. This genus has been recorded from diverse Palaeogene and Neogene deposits of India. The best representation of it, however, appears to be in the Neogene deposits. Potonié (1960a) recorded *Dicolpopollis* fairly commonly from an Eocene coal of Burma. The botanical affinities of the species recorded from the Quilon beds are with the various genera of Palmae with disulcate pollen, particularly genera like *Calamus*, *Metroxylon*, *Ceratolobus* and *Cornera* (Thanikaimoni, 1966, 1970).

Dicolpopollis edavensis sp. nov.

Pl. 5, fig. 65

Diagnosis — Pollen grains isopolar, more or less barrel-shaped in polar view, 28-35 ×18-22 μ, dicolpate. Exine upto 1·8 μ thick, sexine as thick as nexine, punctitectate, columella distinct, surface punctate, punctae fine, aligned in transverse rows (at right angles to colpae).

Comments — *Dicolpopollis edavensis* sp. nov. differs from *D. kockeli* Pflanzl (1956) in size and exine sculpture. *Dicolpopollis* (*Disulcites*) *kalewensis* recorded from the Eocene of Burma (Potonié, 1960a) has irregularly and closely disposed punctae, imparting a microreticulate look to pollen wall. *D. fragilis* and *D. proprius* recorded from the Eocene of South Shillong front, Assam (Salujha *et al.*, 1973) are much larger.

Type Locality — Edavai.

Holotype — Pl. 5, fig. 65; Edv. C1-8; 22·9×79·0, (31×18 μ).

Dicolpopollis elegans Muller, 1968

Pl. 5, figs. 66, 67

Description — Pollen grains isopolar, squarish to slightly rectangular, 17·5×18·5 μ, dicolpate, colpae almost reaching poles, margins thin, ends pointed. Exine 1·5 μ thick, columella distinct, surface reticulate, heterobrochate, brochi penta or hexagonal, upto 2 μ wide, those towards colpal margins smaller.

Affinity — The affinities of the fossil species are with *Calamus* and *Metroxylon* of Palmae.

Occurrence — Padappakkara.

Dicolpopollis microreticulatus sp. nov.

Pl. 5, fig. 68

Diagnosis — Pollen grains isopolar, polar view barrel-shaped with somewhat rounded ends, 29-38·5×22-30 μ, dicolpate, colpae fairly long, gradually tapering, margins thin. Exine 2 μ thick, columella distinct, surface very finely reticulate, meshes very small, angular.

Comments — *D. microreticulatus* sp. nov. resembles some extent *D. proprius* described from the Eocene of South Shillong front, Assam (Salujha *et al.*, 1972). In *D. proprius*, however, the colpae are wider and the reticulum is faint.

Affinity — The fossil grains resemble the pollen of *Ceratolobus laevigatus* and *Plect-*

mopsis paradoxa (Thanikaimoni, 1966, pl. 12, figs. 6-8) of Palmae.

Type Locality — Padappakkara.

Holotype — Pl. 5, fig. 68; Pad. II-11; 20·4×86·1, (31×25 μ).

Dicolpopollis cf. *malesianus* Muller, 1968

Pl. 5, fig. 69

Description — Pollen grains somewhat trapezoidal, 25-30×20-23 μ, dicolpate, colpae long, narrow. Exine 1·5 μ thick, columella distinct, surface finely reticulate, meshes slightly larger towards upper end than at other areas, lumina angular to locally rounded.

Comments — This is a rare type in our microflora and shows some similarity with the forms described from the Cretaceous-Eocene of Sarawak, Malaysia (Muller, 1968).

Affinity — The fossil taxon is related to *Calamus* of Palmae.

Occurrence — Paravur.

Turma — *Poroses* (Naumova) Potonié, 1960

Subturma — *Monoporines* (Naumova) Potonié, 1960

Genus — *Monoporopollenites* (Meyer) Potonié, 1960

Genotype — *M. gramineoides* Meyer, 1956.

Monoporopollenites gramineoides Meyer, 1956

Pl. 5, fig. 70

Description — Pollen grains subspheroidal, 20-28 μ, monoporate, pore 2·5-5 μ in diameter, with well-developed annulus. Exine 1·5 μ thick, sexine almost as thick as nexine, surface psilate to finely flecked.

Comments — Pollen grains of this kind have been encountered only rarely in the Quilon beds. Similar grain has been previously recorded from the Neyveli lignite (Ramanujam, 1966).

Affinity — Gramineae.

Occurrence — Padappakkara.

Genus — *Spinamonoporites* Sah, 1967

Genotype — *S. africanus* Sah, 1967.

Spinamonoporites indicus sp. nov.

Pl. 5, fig. 71

Diagnosis — Pollen grains ovoidal to smoothly rounded, 16-20 μ, monoporate, pore ulcerate, circular in outline, 4·5 μ across, margins thin, uneven or ragged and faint. Exine upto 2 μ thick, sexine thicker than nexine, surface densely studded with spinules all over.

Comments — *Spinamonoporites* instituted by Sah (1967) includes monoporate pollen with spinascent (spinulate) surface. *S. africanus* recorded from the Neogene of Barundi (Sah, 1967) is larger and with a larger pore and blunt spines. *Pandanidites* (Elsik, 1968) while apparently resembling the present taxon, differs in its incrassate pore margin. Fossil pollen described under the generic name *Pandanus* from the Miocene of Eniwetok and Bikini Atoll in the Pacific Ocean (Leopold, 1969) but for its larger size appears to be quite similar to the South Indian taxon.

Affinity—Both Pandanaceae and Lemnace possess pollen grains with monoporate and spinascent characters. In Pandanaceae, however, the pore margin usually is incrassate, while this is not so in Lemnaceae. The affinities of the fossil taxon are closer with the pollen of *Lemna* of Lemnaceae (Erdtman, 1952).

Type Locality — Padappakkara.

Holotype — Pl. 5, fig. 71; Pad. II-2; 19·8×96·5, (19·5 μ).

REFERENCES

BALME, B. E. (1957). Spores and pollen grains from the Mesozoic of Western Australia. *C.S.I.R.O. Austr. Coal Res. Sect. T. C.*, **25**: 1-48.

COUPER, R. A. (1953). Upper Mesozoic and Cainozoic spores and pollen grains from New Zealand. *N. Z. Geol. Surv. Palaeont. Bull.*, **22**: 5-77.

COUPER, R. A. (1958). British Mesozoic microspores and pollen grains. A systematic and stratigraphic study. *Palaeontographica*, **103B**: 75-179.

DAMODARAN, A. (1955). Geology of the Warkalli Formation in parts of Trivandrum District, Travancore State. *Unpublished Progress Report of G.S.I.*, 1954-1955.

DETTMANN, M. E. (1963). Upper Mesozoic microfloras from south eastern Australia. *Proc. R. Soc. Vict.*, **77**: 1-148.

DEY, A. K. (1962). The Miocene mollusca from Quilon, Kerala, India. *Mem. geol. Surv. India Palaeont. indica, N.S.*, **36**: 1-129.

DUTTA, S. K. & SAH, S. C. D. (1970). Palynostratigraphy of the Tertiary sedimentary formations of Assam-5. Stratigraphy and palynology of South Shillong Plateau. *Palaeontographica*, **131B**: 1-72.

ELSIK, W. C. (1968). Palynology of a Palaeocene Rockdale lignite, Milan county, Texas. I. Morphology and Taxonomy. *Pollen Spores*, **10**: 599-664.

ERDTMAN, G. (1947). Suggestions for the classification of fossil and recent pollen grains and spores. *Svensk. Bot. Tidskrift.*, **14**: 104-114.

ERDTMAN, G. (1952). *Pollen Morphology and Plant Taxonomy — Angiosperms.* Almqvist & Wiksel, Stockholm.

ERDTMAN, G. (1956). Pollen grains of *Ctenolophon* from Tertiary deposits of India. *Grana Palynol.*, **1**: 5-7.

GERMERAAD, J. H., HOPPING, C. A. & MULLER, J., (1968). Palynology of Tertiary sediments from tropical areas. *Rev. Palaeobot. Palynol.*, **6**: 189-348.

HAMMEN, T. VAN DER & WYMSTRA, T. A. (1964). A palynological study on the Tertiary and Upper Cretaceous of British Guiana. *Leidse. Geol. Meded.*, **30**: 183-241.

HOEKEN-KLINKENBERG, P. M. J. (1964). A palynological investigation of some Upper Cretaceous sediments in Nigeria. *Pollen Spores*, **6**: 209-231.

JACOB, K. & SASTRY, V. V. (1952). Miocene Foraminifera from Chavara near Quilon, Travancore. *Rec. geol. Surv. India*, **82**: 342-353.

JAIN, K. P. & GUPTA, K. P. (1970). Some fungal remains from the Tertiaries of Kerala coast. *Palaeobotanist*, **18**: 177-182.

KEDVES, M. & RAKOSY, J. (1964). *Intrabaculisporis* n. fgen. du Pannonien supérieur de Hongrie. *Pollen Spores*, **6**: 593-596.

KHAN, A. M. & MARTIN, A. R. H. (1971). A note on genus *Polypodiisporites* R. Potonié. *Pollen Spores*, **3**: 475-480.

KING, W. (1882). General sketch of the geology of Travancore State. The Warkalli beds and associated deposits at Quilon in Travancore. *Rec. geol. Surv. India*, **15**: 93-102.

KUMAR, C. P. & PITCHAMUTHU, C. S. (1933). Tertiary limestones of Travancore. *Q. Jl geol. Min. metall. Soc. India*, **5**: 85-98.

KUPRIANOVA, L. A. (1967). Palynological data for the history of Chloranthaceae. *Pollen Spores*, **9**: 95-100.

LEOPOLD ESTELLA, B. (1969). Miocene pollen and spore flora of Eniwetok Atoll, Marshall Islands. *U.S. Geol. Sur. Prof. Paper*, 260-II: 1133-1182.

MACKO, S. (1957). Lower Miocene pollen flora of the valley of Klodnica near Gliwice (Upper Silesia). *Proc. Wrocl. Tow. Nauk.*, **88B**: 1-312.

MACKO, S. (1959). Pollen grains and spores from Miocene brown coals in Lower Silesia. 1. *Proc. Wrocl. Tow. Nauk.*, **96**: 1-175.

MANUM, S. (1962). Studies in the Tertiary flora of Spitsbergen, with notes on Tertiary floras of Ellesmere Island, Greenland and Iceland. A palynological investigation. *Norsk Polar-Institut. Skrifter*, **125**: 1-124.

MEON-VILAIN, H. (1970). Palynologie des Formations Miocenes Superieures et Pliocenes du Bassin du Rhone. *Docum. Lab. Geol. Fac. Sci. Lyon*: 1-167.

MULLER, J. (1968). Palynology of the Pedawan and Plateau sandstone formations (Cretaceous-Eocene) in Sarawak, Malaysia. *Micropalaeontology*, **14**: 1-37.

NAGY, E. (1963). Spores et pollens norveaux d'une coupe de la briqueterie d'eger (Hongrie). *Pollen Spores*, **5**: 397-412.

NAIR, P. K. K. & SHARMA, M. (1965). Pollen morphology of Liliaceae. *J. Palynol.*, **1**: 38-61.

NAYAR, B. K. & SANTHA DEVI (1964). Spore morphology of Indian Ferns. *Grana Palynol.*, **5**: 342-395.

PFLANZL, G. (1956). Das Alter der Braunkohlen des Meissners, der Floze 2 and 3 des Hirschberges und eines benachbarten Kohlenlagers bei Laudenbach. *Notizbl. hess. Landesamt. Bodenforsch. Wiesbaden*, **84**: 232-244.

PIERCE, R. L. (1961). Lower Upper Cretaceous plant microfossils from Minnesota. *Minnesota geol. Surv. Bull.*, **42**: 1-86.

POTONIÉ, R. (1934). Zur mikrobotanik des eozänen Humodils des Geiseltales. *Arb. Inst. Palaeobot. Petr. Bremsteine*, **4**: 26-125.

POTONIÉ, R. (1951). Pollen und sporenformen als Leit-fossilien des Tertiars. *Mikroskopischen Forsch. Methodik*, **6**: 272-283.

POTONIÉ, R. (1956). Synopsis der gattungen der sporae dispersae. Teil I. Sporites. *Beih. geol. Jb.*, **23**: 1-105.

POTONIÉ, R. (1958). Synopsis der gattungen der Sporae dispersae. Teil II. Sporites (Nachträge), Saccites, Aletes, Praecolpates, Polyplicates, Monocolpates. *Beih. geol. Jb.*, **31**: 1-114.

POTONIÉ, R. (1960). Synopsis der gattungen der Sporae dispersae. Teil III. Pollenites. *Beih. geol. Jb.*, **38**: 1-180.

POTONIÉ, R. (1960a). Sporologie der eozänen Kohle von Kalawa in Burma. *Senckenberg. Leth.*, **41**: 451-481.

POTONIÉ, R. (1966). Synopsis der gattungen der Sporae dispersae. Teil IV. Nachträge zu allen Gruppen (Turmae). *Beih. geol. Jb.*, **72**: 1-244.

POTONIÉ, R. & KREMP, G. O. W. (1954). Die gattungen der Palaeozoischen Sporae dispersae und ihre stratigraphie. *Geol. Jahrb.*, **69**: 111-194.

POTONIÉ, R. & SAH, S. C. D. (1958). *Sporae dispersae* of the lignites from Cannanore Beach in the Malabar coast of India. *Palaeobotanist*, **7**: 121-135.

POTONIÉ, R., THOMSON, P. & THIERGART, F. (1950). Zur nomenklatur und Klassifikation der neogenen sporomorphae (Pollen und Sporen). *Geol. Jahrb.*, **65**: 35-69.

POULOSE, K. V. (1965). Reconnaissance geological mapping of the coastal Tertiaries in parts of Trivandrum, Quilon, Kottayam, Alleppey and Ernakulam districts, Kerala State. *Unpublished progress report of G.S.I.*, 1963-1964.

POULOSE, K. V. (1965a). Reconnaissance geological mapping of the coastal Tertiaries in parts of

Ernakulam, Trichur, Palghat, Calicut and Cannanore districts, Kerala State. *Unpublished progress report of G.S.I.*, 1964-1965.

POULOSE, K. V. & NARAYANASWAMI, S. (1968). The Tertiaries of Kerala coast. *Men. geol. Soc. India*, **2**: 300-308.

RAGHAVA RAO, K. V. (1975). Ground water exploration development and long term aquifer management in Kerala. *Symposium on "Mineral resources of Kerala and their utilization"*: 1-7.

RAGHAVA RAO, K. V. *et al.* (1975). Hydrologic parameters and preliminary evaluation of coastal sandstone aquifer system in Kerala State. *Proc. National Symposium on Hydrology*. Univ. of Roorkee, Roorkee, India: 40-44.

RAMANUJAM, C. G. K. (1960). Some pteridophytic spores from the Warkalli lignites in South India with special reference to those of Schizaeaceae. *J. Indian bot. Soc.*, **39**: 46-55.

RAMANUJAM, C. G. K. (1966). Palynology of the Miocene lignite from South Arcot District, Madras, India. *Pollen Spores*, **8**: 149-204.

RAMANUJAM, C. G. K. (1966-67). Pteridophytic spores from the Miocene lignite of South Arcot District, Madras. *Palynol. Bull.*, **2 & 3**: 29-40.

RAMANUJAM, C. G. K. (1967). Myrtaceous pollen from the peaty lignite of Alleppey in Kerala State, India. *Sci. Cult.*, **33**: 229-230.

RAMANUJAM, C. G. K. (1972). Revision of pteridophytic spores from the Warkalli lignite of South India. *Proc. Sem. Palaeopalynol. Indian Stratigr., Calcutta*: 248-254.

RAMANUJAM, C. G. K. & PURNACHANDRA RAO, K. (1973). On some microthyriaceous fungi from a Tertiary lignite of South India. *Palaeobotanist*, **20**: 203-209.

RAMANUJAM, C. G. K. & PURNACHANDRA RAO, K. (1973a). A study of the pollen grains of *Ctenolophonidites* from the Warkalli deposits of South India with a note on the geological history of *Ctenolophon*. *Palaeobotanist*, **20**: 210-215.

RAO, A. R. & VIMAL, K. P. (1952). Preliminary observations on the plant microfossil contents of some lignites from Warkalli in Travancore. *Curr. Sci.*, **21**: 302-305.

RAO, B. R. J. & DATTA, A. K. (1976). Foraminiferal and Ostracod fauna of the Early Miocene beds of Kerala coast and their stratigraphic significance. *General Proc. of Workshop on coastal sedimentaries of India — south of 18°N. latitude. O.N.G.C., Madras*: 33-34.

RAO, K. P. & RAMANUJAM, C. G. K. (1975). A palynological approach to the study of Quilon beds of Kerala State in South India. *Curr. Sci.*, **44**: 730-732.

ROSS, N. E. (1949). On a Cretaceous pollen and spore bearing clay of Scania. A preliminary report. *Bull. geol. Inst. Uppsala*, **34**: 25-43.

SAH, S. C. D. (1967). Palynology of an Upper Neogene profile from Rusizi Valley (Barundi). *Annls Mus. r. Afr. cent. Sér., Sci. geol.*, **8** (57): 1-173.

SAH, S. C. D. & DUTTA, S. K. (1966). Palynostratigraphy of Tertiary sedimentary formations of Assam. I. Stratigraphical position of the Cherra Formation. *Palaeobotanist*, **15**: 72-86.

SAH, S. C. D. & DUTTA, S. K. (1968). Palynostratigraphy of the Tertiary sedimentary formations of Assam. 2. Stratigraphic significance of spores and pollen in the Tertiary succession of Assam. *Palaeobotanist*, **16**: 177-195.

SAH, S. C. D. & KAR, R. K. (1970). Palynology of the Laki sediments in Kutch-3. Pollen from the bore holes around Jhulrai, Baranda and Panandhro. *Palaeobotanist*, **18**: 127-142.

SALUJHA, S. K., KINDRA, G. S. & REHMAN, K. (1972). *Eximospora*, a new genus from the Tertiary sediments of Assam. *J. geol. Soc. India*, **13**: 280-282.

SALUJHA, S. K., KINDRA, G. S. & REHMAN, K. (1973). Palynology of the South Shillong Front, Part I — The Palaeogene of Garo Hills. *Proc. Sem. Palaeopalynol. Indian Stratigr., Calcutta*: 265-291.

SHARMA, M. (1968). Pollen morphology of Indian monocotyledons. *J. Palynol.* (Spl. Vol.): 1-94.

SINGH, C. (1971). Lower Cretaceous microflora of the Peace River area, Northwestern Alberta. *Res. Coun. Alberta Bull.*, **1**: 1-299.

SINGH, R. Y. (1975). Morphological study of the Retialetes complex from Indian Tertiaries. *Geophytology*, **5**: 98-104.

THANIKAIMONI, G. (1966). Contribution a L'etude Palynologique des Palmiers. *Inst. Fr. Pondicherry, Trav. Sec. Sci. Tech.*, **5** (2): 1-90.

THANIKAIMONI, G. (1969). Esquisse Palynologique des Aracees. *Inst. Fr. Pondicherry, Trav. Sec. Sci. Tech.*, **5** (5): 1-31.

THANIKAIMONI, G. (1970). Les Palmiers: Palynologique et systematique. *Inst. Fr. Pondicherry, Trav. Sec. Sci. Tech.*, **11**: 1-286.

THOMSON, P. W. & PFLUG, H. (1953). Pollen und Sporen des mitteleuropäischen Tertiars. *Palaeontographica*, **94B**: 1-138.

VENKATACHALA, B. S. & KAR, R. K. (1969). Palynology of the Tertiary sediments in Kutch. I. Spores and pollen from the Borehole no. 14. *Palaeobotanist*, **17**: 157-178.

VENKATACHALA, B. S. & RAWAT, M. S. (1972). Palynology of the Tertiary sediments in the Cauvery Basin. 1. Palaeocene-Eocene palynoflora from the sub-surface. *Proc. Sem. Palaeopalynol. Indian Stratigr., Calcutta*: 292-374.

VENKATACHALA, B. S. & RAWAT, M. S. (1973). Palynology of the Tertiary sediments in the Cauvery Basin. 2. Oligocene-Miocene palynoflora from the sub-surface. *Palaeobotanist*, **20**: 238-263.

VIMAL, K. P. (1952). Tertiary spores and pollen from Warkalli lignites, Travancore. *Proc. Indian Acad. Sci.*, **38**: 195-200.

WILSON, L. R. & WEBSTER, R. M. (1946). Plant microfossils from a Fort Union coal of Montana. *Am. J. Bot.*, **33**: 271-278.

WODEHOUSE, R. P. (1933). Tertiary pollen II. The oil shales of the Eocene Green River Formation. *Bull. Torrey Bot. Club.*, **60**: 479-524.

ZIEMBINSKA, M. (1974). Palynological characteristics of the Neogene of western Poland. *Acta Palaeont. pol.*, **19**: 309-432.

EXPLANATION OF PLATES

PLATE 1

1-2. *Lygodiumsporites padappakkarensis* sp. nov. Fig. 2, holotype. × 1000.
3. *Intrabaculisporis quilonensis* sp. nov. Holotype. × 1000.
4-5. Spore type — A. Note the flat, ribbon-like 3-looped kyrtome on the distal side in fig. 5. × 1000.
6-7. *Gleicheniidites cercinidites.* × 1000.
8. *Eximospora sparsus* sp. nov. Holotype. × 600.
9. *Verrucosisporites dakshinensis* sp. nov. Holotype. × 1000.
10. *Foveosporites miocenicus.* × 1000.
11. *Foveotriletes bifurcatus* sp. nov. Holotype. × 800.
12-13. *Cingulatisporites sinuatus* sp. nov. Holotype. Fig. 12. × 600. Fig. 13. × 1000.
14. *Crassoretitriletes ornatus* sp. nov. Holotype. × 750.

PLATE 2

15. *Cingulatisporites* sp. × 1000.
16. *Pteridacidites sahii* sp. nov. Holotype. × 1000.
17. *Cibotidites kundavaensis.* × 800.
18. *Laevigatosporites ovatus.* × 500.
19-20. *Polypodiisporites ratnami* comb. nov. × 750.
21. *Polypodiisporites ornatus.* × 1000.
22. *Polypodiisporites ornatus.* Note the negative reticulum. × 500.
23. *Polypodiisporites miocenicus* sp. nov. Holotype. × 500.
24-25. *Polypodiisporites impariter* comb. nov. × 500.
26. *Polypodiisporites impariter.* × 1000.
27. *Polypodiisporites usmensis.* × 500.
28. *Polypodiisporites multiverrucosus.* × 500.

PLATE 3

29. *Polypodiisporites perverrucatus.* × 1000.
30. *Schizaeoisporites multistriatus* sp. nov. Holotype. × 1000.
31. *Retipilonapites tertiaris* sp. nov. Holotype. × 500.
32. *Retipilonapites conspicua* sp. nov. Holotype. × 500.
33. *Spinainaperturites neogenicus* sp. nov. Holotype. × 1000.
34. *Clavainaperturites clavatus.* × 750.
35. *Liliacidites padappakkarensis* sp. nov. × 600.
36. *Palmaepollenites keralensis* sp. nov. Holotype. × 1000.
37. *Palmaepollenites neyveliensis.* × 1000.
38. *Palmaepollenites eocenicus.* × 1000.
39. *Arecipites keralensis.* sp. nov. Holotype. × 750.
40. *Verrumonocolpites* sp. × 500.
41. *Verrumonocolpites venkatachalai* sp. nov. Holotype. × 1000.
42. *Couperipollis ellipticus* sp. nov. Holotype. × 500.
43. *Couperipollis* sp. × 500.

PLATE 4

44. *Liliacidites padappakkarensis* sp. nov. Holotype. × 1000.
45. *Couperipollis punctitectatus* sp. nov. Holotype. × 1000.
46. *Couperipollis wodehousei.* × 1000.
47-48. *Clavapalmaedites hammenii* gen. et sp. nov. Fig. 47, holotype. × 800.
49. *Crotonisulcites grandis* gen. et sp. nov. Holotype. × 600.
50. *Crotonisulcites grandis.* Crotonoid sculpture of holotype enlarged. × 1000.
51,52. *Spinizonocolpites quilonensis* sp. nov. Fig. 51, holotype. × 1000.
53,54. *Paravuripollis mulleri* gen. et sp. nov. Fig. 53, holotype. × 750.
55. Pollen type- A. × 1000.
56. Pollen type- B. × 500.
57. *Longapertites klinkenbergii* sp. nov. Holotype. × 1000.
58. *Longapertites hammenii* sp. nov. Holotype. × 1000.

PLATE 5

59-62. *Quilonipollenites sahnii* gen. et sp. nov. Figs. 59, 60 — holotype. Figs. 61, 62 — paratypes. × 1000.
63,64. *Quilonipollenites ornatus* sp. nov. Holotype. × 1000.
65. *Dicolpopollis edavensis* sp. nov. Holotype. × 1000.
66,67. *Dicolpopollis elegans.* × 800.
68. *Dicolpollis microreticulatus* sp. nov. Holotype. × 1000.
69. *Dicolpopollis* cf. *malesianus.* × 750.
70. *Monoporopollenites gramineoides.* × 500.
71. *Spinamonoporites indicus.* sp. nov. Holotype. × 750.

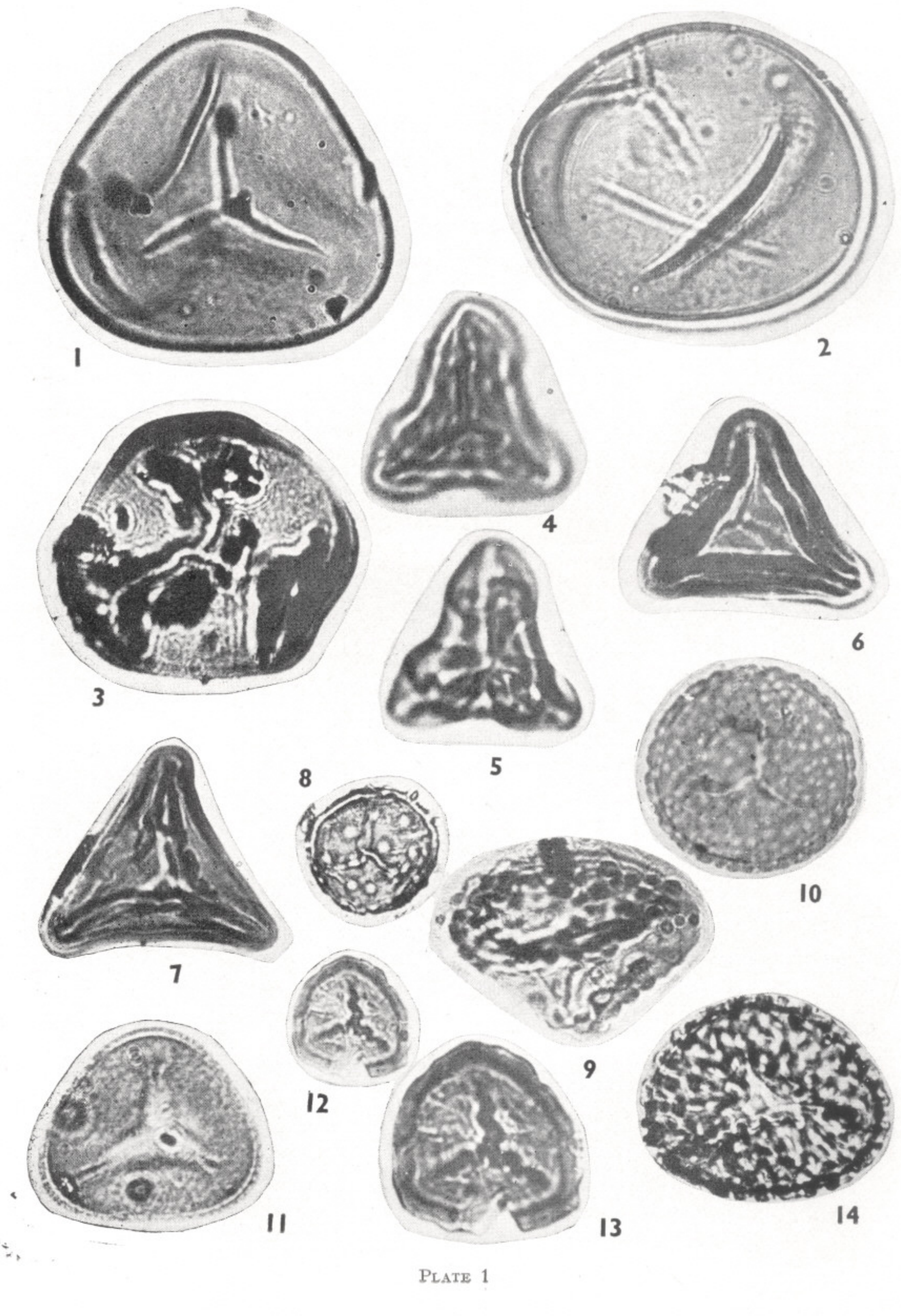


PLATE 1

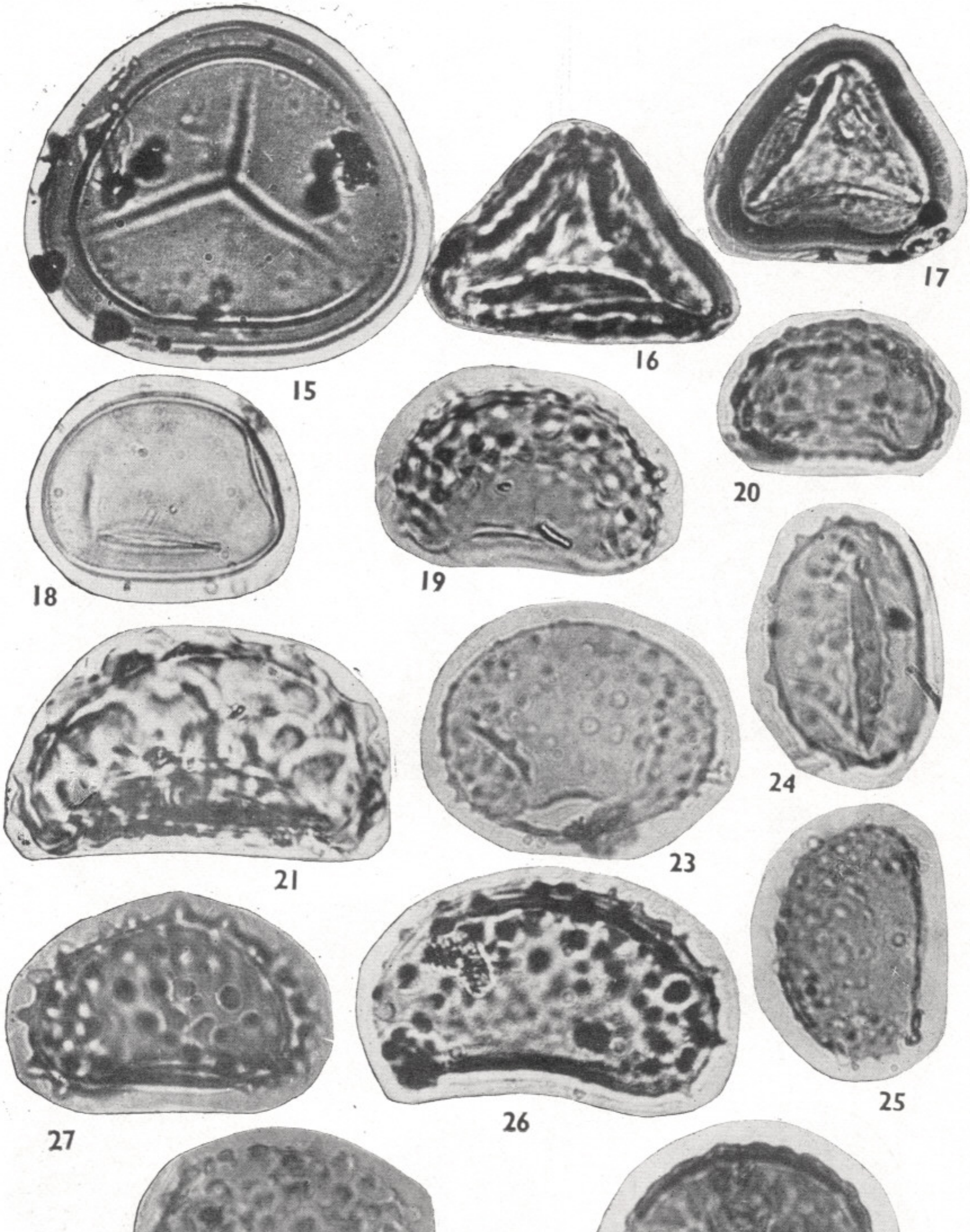


PLATE 2

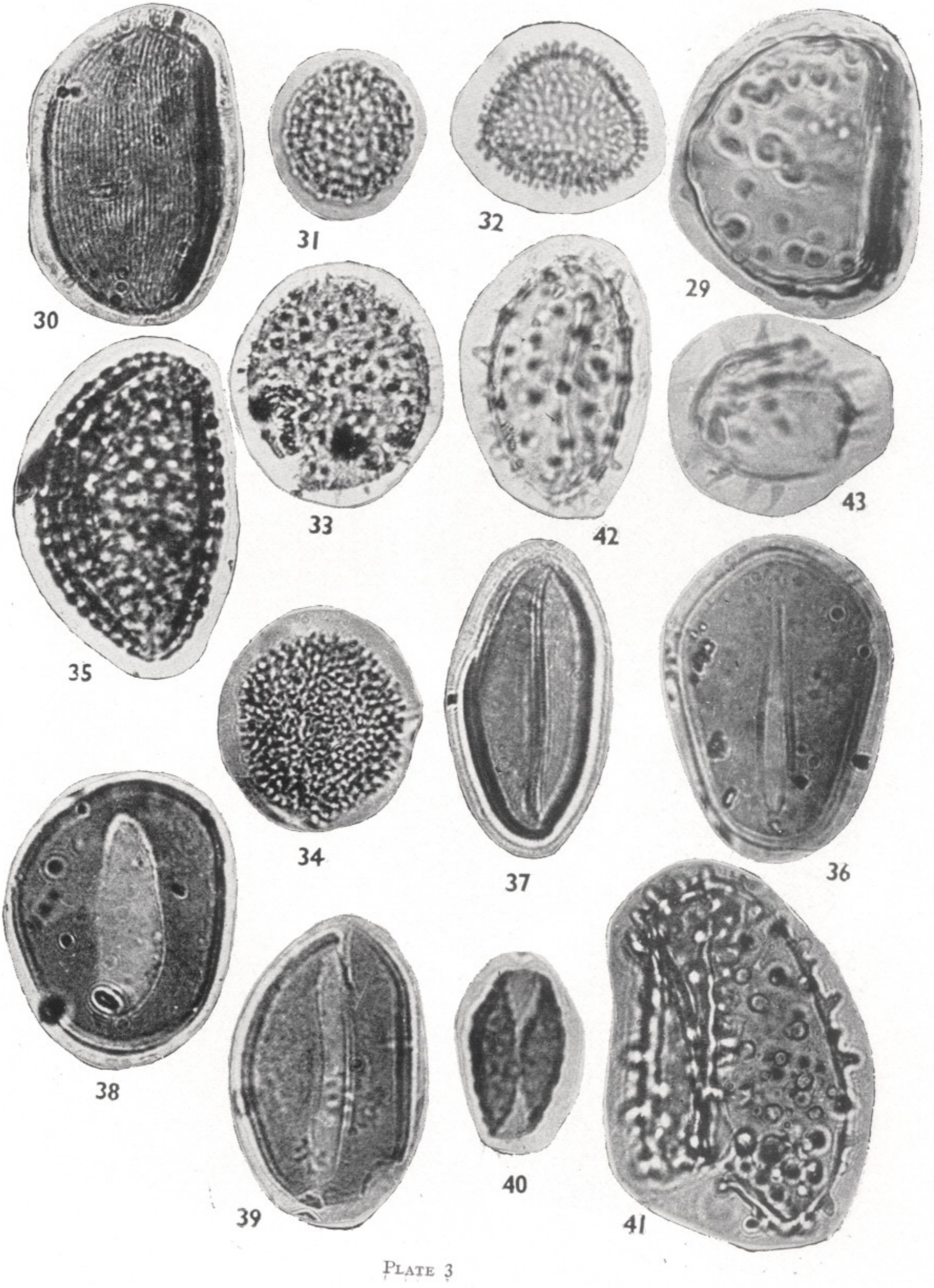


PLATE 3

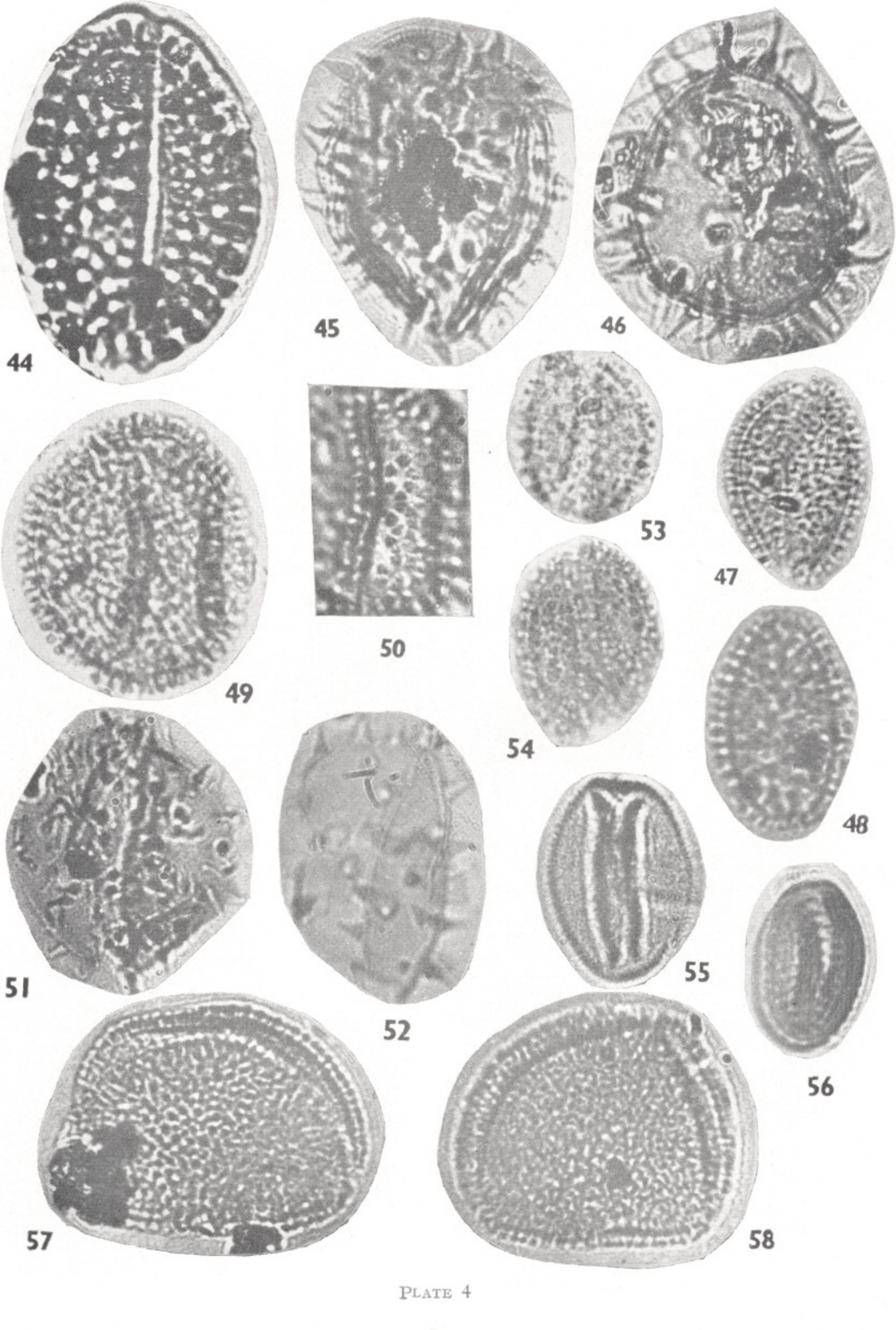


PLATE 4

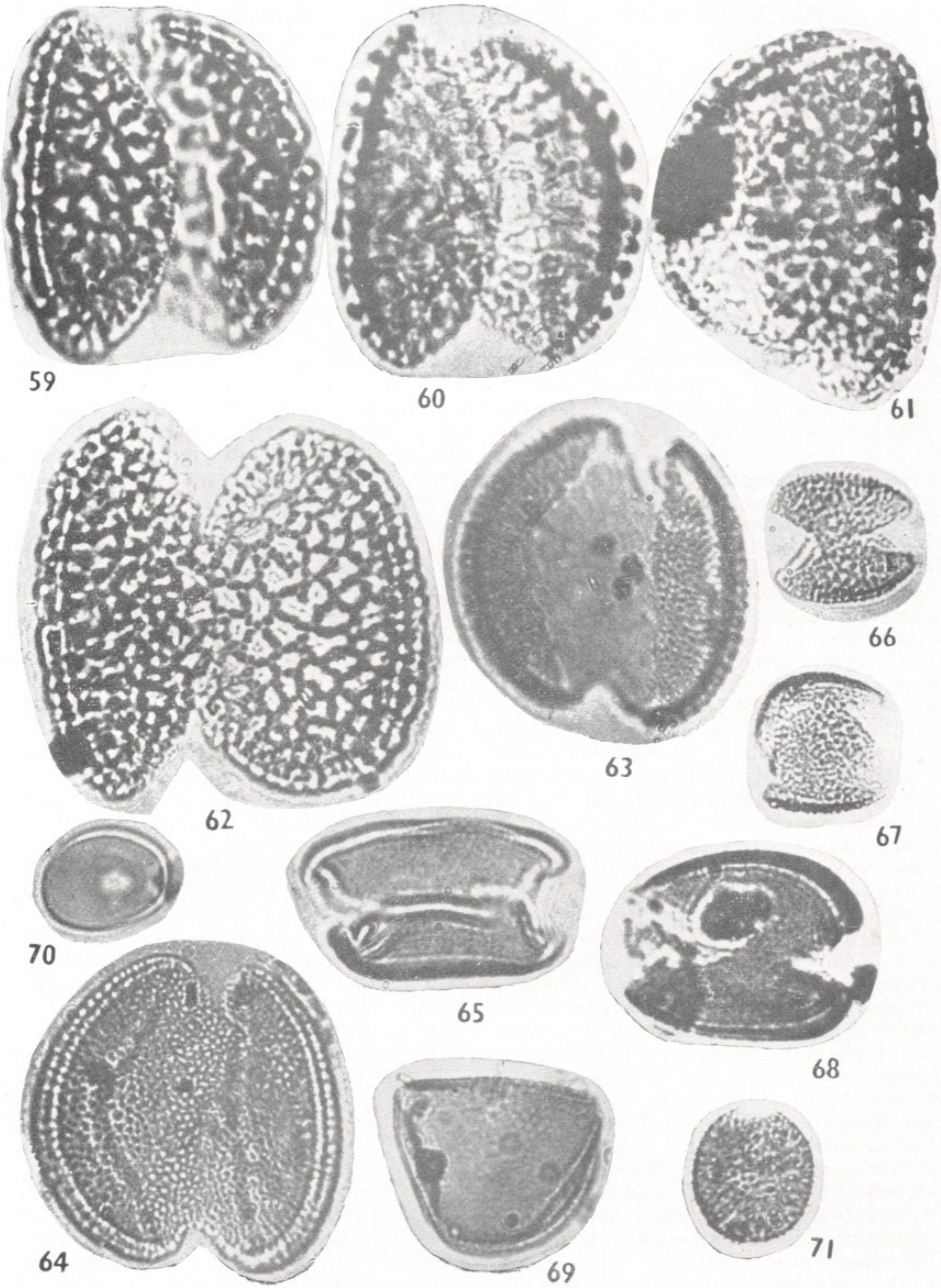


PLATE 5