PALYNOLOGICAL INVESTIGATION OF RATNAGIRI LIGNITE, MAHARASHTRA

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ABSTRACT

A preliminary report of the palynological assemblage recovered from lignitic beds exposed in well sections on Ratnagiri-Pawas Road, Ratnagiri District, Maharashtra, has been presented. 25 morphotypes are recorded ; four belonging to fungi and pteridophytes each, and the rest to angiosperms. Microthyriaceae, Lygodiaceae, Polypodiaceae, Palmae, Graminae, Sonneratiaceae, Rhizophoraceae, Lecythidaceae, Anacardiaceae and Chenopodiaceae are the families represented. Samples are very rich in fungal mycelia and spores. Most frequently met-with pollen-spore morphotypes are *Laevigatosporites ovalis*, *Polypodiisporites usmensis*, *Palmaepollenites ovatus*, *Quilonipollenites ornatus*, *Marginipollis kutchensis*, *Striacolporites ratnagiriensis* and *Sonneratiopollis bellus*. Warm humid climatic conditions and estuarine depositional environment are indicated.

INTRODUCTION

Occurrence of lignitic beds in Ratnagiri District was first reported by WILKINSON (1871). Since then, a few other geologists have further added to the list of exposures at various localities in the district, mainly in well sections. These beds are generally believed to be northern extensions of Quilon lignites though detailed information is completely lacking and hence the present investigation has been undertaken.

In an earlier communication (KULKARNI & PHADTARE, 1979) a well preserved leaf cuticle of *Nypa* was described. The present report deals with commonly found microfloral elements of these beds which could readily be identified.

MATERIAL AND METHODS

This contribution is based upon the analysis of lignite collected from two well sections on Ratnagiri—Pawas Road near third Dharamshala Stop, 10 km South of Ratnagiri. Lignitic bed in these wells is situated at about 15 metre depth, extends to 2.5 metres in thickness. It is ash grey to deep black in colour and has ferruginous shales mixed with resiniferous material. The magafossils represented are fragile leaf impressions and wood fragments.

The sample (about 5 gms) was broken to small pieces and treated with fumigating concentrated nitric acid for 8 to 10 minutes. The macerated residue was repeatedly washed with distilled water and centrifuged till it got free from acid. It was then treated with 10% potassium hydroxide for 30 minutes followed by repeated washing with water to remove alkali. The microfossils recovered were mounted in glycerine-jelly and coverslips were sealed with paraffin.

The lignite samples and the prepared slides are deposited in department of Biological Sciences, Ramnarain Ruia College, Bombay.

SYSTEMATIC PALYNOLOGY

Anteturma SPORITES Potonie', 1893

Turma TRILETES Dettmann, 1963

Geophytology, **10**(2): 158-170, 1980

Subturma AZONOTRILETES Dettmann, 1963
Infraturma LAEVIGATI Potonie', 1956
Genus **Lygodiumsporites** Potonie', 1956
Genotype *Lygodiumsporites adriensis* Potonie', Thomson & Thiergart, 1950

Lygodiumsporites padappakkarensis Rao & Ramanujam, 1976
Plate 1, Fig. 5

Comments—Smooth walled trilete spores are included under the genus *Lygodiumsporites* instituted by POTONIE', THOMPSON AND THIERGART (1950).

L. padappakkarensis has been reported in India from Quilon beds (RAO & RAMANUJAM, 1976). Similar (or may be the same) morphotype has also been reported by VENKATACHALA AND RAWAT (1971) from Miocene of Cauvery basin.

Affinity—It resembles with smooth walled spores of *Lygodium*.

Infraturma MURORNATI Potonie' & Kremp, 1954
Genus **Foveotriletes** (Hamm.) Potonie', 1956
Genotype *Foveotriletes scrobiculatus* (Ross.) Potonie', 1956

Foveotriletes sp.
Plate 1, Fig. 6

Description—Spores pyramidal, 39.0×31.5 μm, trilete, amb triangular, with ±rounded ends, sides plane to concave ; rays unequal, the longer extending to more than $\frac{3}{4}$ of radius, ends pointed, exosporium more than 2.0 μm thick, surface foveolate.

Comments—Genus *Foveotriletes* Potonie' (1956) includes triangular trilete spores having foveolate exine and hence the present morphotype has been included under this genus. However, the different species described under this genus (*F. scrobiculatus* (Ross) Potonie' 1956 ; *F. parviretus* Dettmann, 1963 ; *F. miocenicum* Ramanujam, 1966-67 ; *F. bifurcatus* Rao & Ramanujam, 1976) do not appear to be pyramidal. Further, in *F. miocenicum* Ramanujam (1966-67) and *F. bifurcatus* Ramanujam (1966-67), the laesural arms are bifurcated at the tips.

Affinity—Unknown.

Turma MONOLETES Ibrahim, 1933
Subturma AZONOMONOLETES Luber, 1935
Infraturma LAEVIGATOMONOLETES Dybova & Jachowitz, 1957
Genus **Laevigatosporites** (Ibrahim) Ibrahim, 1933
Genotype *Laevigatosporites vulgaris* (Ibrahim) Ibrahim, 1933

Laevigatosporites ovalis Wilson & Webster, 1946
Plate 1, Fig. 9

Comments—Genus *Laevigatosporites* instituted by IBRAHIM (1933) is characterised by smooth walled monolete spores. *L. ovalis* can be differentiated from *L. gracilis* Wilson & Webster (1946) which is smaller in size and *L. arcotensis* Ramanujam (1966) having strongly concavo-convex sides. *L. ovalis* has been reported so far in India from Warkalli and Neyveli lignites of South India (RAMANUJAM, 1972) and from Cauvery basin (VENKATACHALA & RAWAT, 1972). Similar forms have also been described from Intertrappean beds by CHITALEY (1951).

Affinity—*L. ovalis* has been compared by WILSON AND WEBSTER (1946) with the spores of *Thylepteris*, *Asplenium*, *Athyrium*, *Aspidium* and *Blechnum*. However, we have recovered these spores included in their sporangium from our beds. The sporangial struc-

ture is typical of polypodiaceae (Pl. 1, Figs. 7, 8) confirming the affinity of this morpho-type with that family. It is interesting to note that even the spores found in the sporan-gium do not show any trace of perine. As such, the affinity of these spores therefore lies with those members of polypodiaceae which have bilateral monolete smooth walled non-perinous spores. All the genera mentioned above except *Athyrium* have perinous spores. Certain species of *Athyrium* are perinous while others are nonperinous but nonperinous species have granulose or rugulose exine. The extensive comparison of these spores with living members of polypodiaceae (SANTHA DEVI, 1977) suggests that they are more close to the members of the subfamily Platyserioideae having smooth walled spores.

Infraturma SCULPTAMONOLETI Dybova & Jachowitz, 1957

Genus **Polypodiisporites** (Potonie') Potonie', 1956

Genotype *Polypodiisporites favus* (Potonie') Potonie', 1934

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

Plate 1, Fig. 10

Comments—Genus *Polypodiisporites* has been instituted to include monolete, bilateral spores having verrucate (ornamented) sculpturing. Illustrated morphotype is having all the diagnostic characters of *P. usmensis* (Germeraad, Hopping & Muller, 1968) Khan & Martin, (1971). *P. usmensis* has already been reported from Quilon beds of South India (RAO & RAMANUJAM, 1976). It is one of the dominant pteridophytic spore mor-photypes recovered from these beds.

Affinity—It shows closer similarity with spores of *Stenochlaena* (RAO & RAMANUJAM, 1976) which is quite abundant in present flora of South India.

Anteturma POLLENITES Potonie', 1960

Turma PLICATES (Naumova), Potonie', 1960

Subturma MONOCOLPATES Iversen & T. Smith, 1950

Infraturma LAEVIGATOMONOCOLPATES Rao & Ramanujam, 1976

Genus **Palmaepollenites** Potonie', 1951

Genotype *Palmaepollenites tranquillus* (Potonie') Potonie', 1951

Palmaepollenites neyveliensis Ramanujam, 1966

Plate 2, Fig. 11

Comments—This morphotype is somewhat bigger in size than that described from Neyveli and Quilon beds (RAMANUJAM, 1966 ; RAO & RAMANUJAM, 1976). *P. neyveliensis* is characterised by uniform narrow sulcus with thick margin and pointed ends. By these characters it can be distinguished from *P. eocenicus* (Biswas, 1962) Sah & Dutta (1966), which is having uniformly broad and thin margined sulcus. *P. neyveliensis* is frequently met-with in our preparations.

Affinity—Palmae.

Palmaepollenites ovatus Sah & Kar, 1969

Plate 2, Fig. 12

Comments—*P. ovatus* can easily be distinguished from all other species of *Palmae-pollenites* by its uniformly wide thin walled sulcus and psilate exine. *P. ovatus* is repre-sented abundantly in our locality. It has been reported from Laki sediments of Kutch (SAH & KAR, 1969).

Affinity—Palmae.

Infraturma APICULOMONOCOLPATES Rao & Ramanujam, 1976

Genus **Clavapalmaedites** Rao & Ramanujam, 1976

Genotype *Clavapalmaedites hammenii* Rao & Ramanujam, 1976

Clavapalmaedites hammenii Rao & Ramanujam, 1976

Plate 2, Fig. 14

Comments—Genus *Clavapalmaedites* instituted by RAO AND RAMANUJAM (1976) includes monosulcate pollen grains having clavate-pilate exine. This taxon so far has been reported only from Quilon (Neogene) beds of South India. It is frequently represented in this locality.

Affinity—It shows closer resemblance with pollen of Palmae, particularly of *Iriartea*, *Pinanga* and *Ceroxylon* (THANIKAIMONI, 1970).

Genus **Verrumonocolpites** Pierce, 1961

Genotype *Verrumonocolpites conspicuous* Pierce, 1961

Verrumonocolpites venkatachalai Rao & Ramanujam, 1976

Plate 2, Fig. 13

Comments—Genus *Verrumonocolpites* is distinguished by its peculiar colpus and verrucate exine. Illustrated taxon has been reported from Quilon (Neogene) beds of South India (RAO & RAMANUJAM, 1976). In our preparations frequency of this morphotype is very less.

Affinity—This morphotype shows closer similarity with pollen grains of Borassoid palms, particularly with *Borassus* (THANIKAIMONI, 1970).

Genus **Couperipollis** Venkatachala & Kar, 1968

Genotype *Couperipollis perispinosus* Venkatachala & Kar, 1968

Couperipollis punctitectatus Rao & Ramanujam, 1976

Plate 2, Figs. 16, 17

Comments—Monosulcate ornamented (verrucate, baculate or spinulate) pollen morphotypes having well developed sulcus extending from one margin to another are included under genus *Couperipollis* instituted by VENKATACHALA AND KAR (1968). *C. punctitectatus* has so far been reported only from Quilon beds of South India. Only few pollen grains of this type have been recovered from our beds.

Affinity—Palmae.

Infraturma MURORMONOCOLPATES Rao & Ramanujam, 1976

Genus **Quilonipollenites** Rao & Ramanujam, 1976

Genotype *Quilonipollenites sahnii* Rao & Ramanujam, 1976

Quilonipollenites ornatus Rao & Ramanujam, 1976

Plate 2, Fig. 19

Comments—*Quilonipollenites ornatus* can be distinguished from *Q. sahnii* Rao & Ramanujam (1976) by its fine reticulations and extended sulcus. This taxon has been reported only from Quilon (Neogene) beds. *Q. ornatus* is one of the dominant morphotypes attributed to palmae recovered from these beds.

Affinity—Palmae.

Genus **Longapertites** Hoeken-Klinkenberg, 1964

Genotype *Longapertites marginatus* Hoeken-Klinkenberg, 1964

Table 1—Comparative distribution of pollen-spore morphotypes recovered from Ratnagiri Lignite

Morphotypes	Ratnagiri	Neyveli (Miocene)	Warkalli (Miocene)	Quilon (Miocene)	Cauvery (Miocene)	Kutch (Laki, Akri, & Palana) (Eocene)	Assam (Tura & Cherra) (Eocene)
1. *Lygodiumsporites padappakkarensis* Rao & Ramanujam, 1976	+			+	+		
2. *Fokeotriletes* sp.	+						
3. *Laevigatosporites ovalis* Wilson & Webster, 1946	+	+	+		+		
4. *Polypodiisporites usmensis* Khan & Martin, 1971	+			+			
5. *Palmaepollenites neyveliensis* Ramanujam, 1966	+	+		+			
6. *P. ovatus* Sah & Kar, 1969	+					+	
7. *Clavapalmaedites hammenii* Rao & Ramanujam, 1976	+			+			
8. *Verrumonocolpites venkatachalai* Rao & Ramanujam, 1976	+			+			
9. *Couperipollis punctitectatus* Rao & Ramanujam, 1976	+			+			
10. *Quilonipollenites ornatus* Rao & Ramanujam, 1976	+			+			
11. *Longapertites klinkenbergii* Rao & Ramanujam, 1976	+			+			
12. *Dicolpopollis malesianus* Muller, 1968	+			+			
13. *Striacolporites ratnagiriensis* sp. nov.	+						
14. *Palaeosantalaceaepites minutus* Sah & Kar, 1969	+					+	
15. *Marginipollis kutchensis* Kar, 1976	+					+	+
16. *Polybrevicolporites cephalus* Venkatachala & Kar, 1968.	+					+	
17. *Monoporopollenites gramineoides* Meyer, 1956	+	+		+			
18. *Dorrenipites* sp.	+						
19. *Sonneratiopollis bellus* Venkatachala & Kar, 1968	+					+	
20. *Cauveripollis superbus* Venkatachala & Rawat, 1971	+		+		+		
21. *Polyporina globosa* Sah, 1967	+		+				+
22. *Notothyrites amorphus* Kar & Saxena, 1974	+					+	
23. *N. denticulatus*, Ramanujam & Rao, 1971	+		+			+	
24. *Callimothallus pertusus* Dilcher, 1965	+		+	+			
25. *Euthyrites keralensis* Ramanujam & Rao, 1971.	+		+				

Longapertites klinkenbergii Rao & Ramanujam, 1976
Plate 2, Fig. 18

Comments—In India the genus *Longapertites* so far has only been reported from Neyveli (RAMANUJAM, 1966) and Quilon and Warkalli (RAO & RAMANUJAM, 1976) beds of South India. Illustrated morphotype has been recorded only from Quilon beds of South India. *L. klinkenbergii* shows quite good frequency in our preparations.

Affinity—Palmae.

Subturma DICOLPATES Erdtman, 1947
Genus **Dicolpopollis** (Pflanzl) Potonie', 1956
Genotype *Dicolpopollis kockeli* Pflanzl, 1956

Dicolpopollis malesianus Muller, 1968
Plate 2, Figs. 21, 22

Comments—This morphotype can clearly be distinguished from *D. edavensis* Rao & Ramanujam (1976) by its reticulate surfaces, from *D. microreticulatus* Rao & Ramanujam (1976) by its coarse and uniform reticulate thickening and from *D. elegans* Muller (1968) by its much bigger size and surface thickenings. First record of *D. malesianus* in India is from Quilon beds. This morphotype is represented by very few specimens in our preparations.

Affinity—Palmae, *Calamus* (THANIKAIMONI, 1970)

Subturma TRIPTYCHES (Naumova) Potonie', 1969
Infraturma PROLATI Erdtman, 1943
Genus **Striacolporites** Sah & Kar, 1969
Genotype *Striacolporites striatus* Sah & Kar, 1969

Striacolporites ratnagiriensis sp. nov.
Plate 2, Fig. 20

Holotype—Plate 2, Fig. 20 ; Slide no. R/30—17.6×78.1, (36.80×23.24 μm).

Diagnosis—Pollen grains tricolporate, prolate, oval in equatorial view and ± circular in polar view, 33.0—41.5×16.6—26.6 μm in equatorial view ; colpi extended up to the poles, margo wide, not much thickened, ora indistinct ; exine 1.0-1.7 μm thick and distinctly striato-reticulate, striations oblique to the margo and finely granular, poles broadly rounded.

Comments—Genus *Striacolporites* was instituted by SAH AND KAR (1969) to accommodate tricolporate pollen morphotypes with striato-reticulate exine. They have also discussed nomenclatural problems pertaining to *Striatricolporites* (v. d. HAMMEN, 1956) and *Striatocolporites* (RAMANUJAM, 1966). *Striacolporites ratnagiriensis* described here, differs from other species of this genus, viz., *S. striatus*, *S. ovatus* and *S. cephalus* in its significantly smaller size range. In addition, *S. cephalus* is having poorly developed apertures. SAH AND KAR (1969) have discussed the affinity of *Striacolporites* with pollen grains of certain genera of Solanaceae, Nolanaceae and Schrophulariaceae. However, tricolporate pollen grains with striate to striato-reticulate exine are also met-with in members of Anacardiaceae, Burseraceae, Meliaceae and Rutaceae (ERDTMAN, 1952). Our observations suggest the affinity of *S. retnagiriensis* with *Rhus* type of pollen of Anacardiaceae, to which *Anacardium*, *Magnifera* and *Semicarpus* belong.

Type Locality—Ratnagiri.

Genus **Palaeosantalaceaepites** Biswas, 1962
Genotype *Palaeosantalaceaepites primitiva* Biswas, 1962

Palaeosantalaceaepites minutus Sah & Kar, 1969
Plate 2, Figs. 27, 28

Comments—Our specimens resemble in almost all their characters with *P. minutus* described by SAH AND KAR (1968) from Laki sediments of Kutch and hence have been placed under the same.

Affinity—Various species of *Palaeosantalaceaepites* have been compared with pollen morphophytes found in modern members of family Santalaceae. However, SAH AND KAR (1969) have suggested affinity of *P. minutus* with pollen grains of Rhizophoraceae particularly with species of *Rhizophora*. Our observations also support this view.

Genus **Marginipollis** Clarke & Frederiksen, 1968
Genotype *Marginipollis concinnus* Clarke & Frederiksen, 1968

Marginipollis kutchensis (Venkatachala & Kar, 1968) Kar, 1976
Plate 2, Figs. 25, 26

Comments—Genus *Marginipollis* was described by CLARKE AND FREDERIKSEN (1968) from Upper Tertiary of Nigeria under the genotype *M. concinnus*. The genus was first reported from India by VENKATACHALA AND KAR (1968) from Laki sediments of Kutch as *Rostriapollenites kutchensis* which has now been included under the genus *Marginipollis*. *M. kutchensis* is most dominant pollen amongst all the pollen morphotypes so far recovered from our beds.

Affinity—VENKATACHALA AND KAR (1968, 1968a) and SAH AND KAR (1970) have rightly attributed the affinity of this morphotype to *Barringtonia* type of pollen. ERDTMAN (1952) has described it as *Planchonia* type of Lecythidaceae under which he includes *Barringtonia*, *Careya*, *Combretodendron* and *Planchonia*. Amongst these, our morphotype resembles closely with pollen of *Barringtonia* in size and shape.

Subturma PLYCHOPOLYPORINES (Naumova) Potonie', 1960
Genus **Polybrevicolporites** Venkatachala & Kar, 1968
Genotype *Polybrevicolporites cephalus* Venkatachala & Kar, 1968

Polybrevicolporites cephalus Venkatachala & Kar, 1968
Plate 2, Figs. 23, 24

Comments—The genus *Polybrevicolporites* is characterised by polycolporate, brevicolporate pollen grains with intrabaculate surface. On the basis of these characters, it can be differentiated from *Stephanocolpites* (v. d. Hamm.) Potonie' (1960) and *Polycolpites* Couper (1953) which have colpate nature.

P. cephalus has so far been reported only from Tertiary sediments of Kutch by VENKATACHALA AND KAR (1968). Only few pollen grains of this type have been recovered by us.

Affinity—Unknown.

Turma POROSES (Naumova) Potonie', 1960
Subturma MONOPORINES (Naumova) Potonie', 1960
Genus **Monoporopollenites** (Meyer) Potonie', 1960
Genotype *Monoporopollenites gramineoides* Meyer, 1956

Monoporopollenites gramineoides Meyer, 1956
Plate 2, Fig. 15

Comments—The genus *Monoporopollenites* Meyer (1956) is characterised by monoporate pollen with well developed ora and psilate surface. It can readily be distinguished

from the genus *Graminidites* Cookson (1947) which is having granulose to rugulose exine. *M. gramineoides* has already been reported from Quilon and Neyveli beds of South India (Rao & Ramanujam, 1976 ; Ramanujam, 1966). It is represented in our beds by very few specimens.

Affinity—Graminae.

Subturma Triporines (Naumova) Potonie', 1960

Infraturma Trilatiporiti Ramanujam, 1966

Genus **Dorrenipites** (Biswas, 1962) Navale & Misra, 1979

Genotype *Dorrenipites platydesma* Biswas, 1962

Dorrenipites sp.

Plate 2, Fig. 32.

Description—Pollen grains subspheroidal, heteropolar, 23.24×17.5 μm ; diporate, pores opposite to each other on the same hemisphere, crassimarginate, more or less circular, surrounded by thick annulus ; exine 1.5 μm thick, sexine as thick as nexine, exine distinctly psilate.

Comments—The genus *Dorrenipites* Biswas (1962) as emended by Navale and Misra (1979) is characterised by (2-) 3 (-4) porate, latiporate condition with crassimarginate pores situated on one hemisphere. The illustrated morphotype also shows similarity with *Diporites* Hammen (1954). But according to Sah and Kar (1969), *Diporites* is having pores without any thickened margin. Considering this pecularity of *Diporites* and the diagnostic features of *Dorrenipites* as emended by Navale and Misra (1979) our morphotype has been included under genus *Dorrenipites*. Illustrated morphotype does not resemble with any species of *Dorrenipites* so far described. It is characterised by diporate, latiporate condition with crassimarginate pores and distinctly smooth walled exine, while *D. platydesma* Biswas (1962) and *D. distinctus* Navale & Misra (1979) have granulate to microreticulate exine.

It is represented by very few specimens recovered from our beds.

Affinity—Unknown.

Genus **Sonneratiopollis** Venkatachala & Kar, 1928

Genotype *Sonneratiopollis bellus* Venkatachala & Kar, 1968

Sonneratiopollis bellus Venkatachala & Kar, 1968

Plate 2, Figs. 29, 30

Comments—The genus *Sonneratiopollis* recorded for the first time from Tertiary sediments of Kutch is characterised by triporate, perprolate morphotypes with psilate exine (Venkatachala & Kar, 1968). *S. bellus* is one of the dominant morphotypes amongst angiosperm pollen so far recovered from our beds.

Affinity—Sonneratiaceae.

Genus **Cauveripollis** Venkatachala & Rawat, 1971

Genotype *Cauveripollis superbus* Venkatachala & Rawat, 1971

Cauveripollis superbus Venkatachala & Rawat, 1971

Plate 2, Fig. 31

Comments—Pollen grains with triporate and tectate nature are described under the genus *Cauveripollis* Venkatachala & Rawat (1971). Sah (1967) has described the same morphotype under genus *Caprifoliipites* Wodehouse (1933). But as type species of

genus *Caprifoliipites* is tricolpate, VENKATACHALA AND RAWAT (1971) precluded this morphotype from *Caprifoliipites* and included under the genus *Cauveripollis*.

It is represented by few specimens recovered from our beds.

Affinity—Caprifoliaceae.

Subturma POLYPORINES (Naumova) Potonie', 1960

Infraturma PERIPORITI (v. d. Hammen) Potonie', 1960

Genus **Polyporina** (Naumova) Potonie', 1960

Genotype *Polyporina multistigmosa* Potonie', 1934

Polyporina globosa Sah, 1967

Plate 2, Fig. 33

Comments—The genus *Polyporina* (Naumova) Potonie' (1960) is characterised by polyforate panaperturate morphotypes. *P. globosa* Sah (1967) reported in India from Tertiary of Assam (SAH & DUTTA, 1967) can be differentiated from *P. excellens* Sah & Dutta (1967) by its smaller size and ± punctate exine. It has also been reported from Workalli beds (RAMANUJAM & RAO, 1977).

In our preparations *P. globosa* is represented by very few specimens.

Affinity—Chenopodiaceae.

Class ASCOMYCETES

Order HEMISPHAERIALES

Family MICROTHYRIACEAE

Subfamily MICROTHYRITES

Genus **Notothyrites** Cookson, 1947

Genotype *Notothyrites setiferous* Cookson, 1947

Notothyrites amorphus Kar & Saxena, 1974

Plate 1, Fig. 2

Comments—The genus *Notothyrites* Cookson (1947) includes microthyreaceous ascomata having radiate and ostiolate nature. *N. amorphus* can readily be distinguished from all other species of *Notothyrites* by its typical amorphous nature. In India it has so far been reported only from Matanomadh of Kutch. (KAR & SAXENA, 1974).

Notothyrites denticulatus Ramanujam & Rao, 1971

Plate 1, Fig. 1.

Comments—*Notothyrites denticulatus* Ramanujam & Rao (1971) reported so far only from Warkalli lignites, is characterised by ostiolate thyriothecium with denticular processes projecting into the ostiole cavity. KAR AND SAXENA (1974; p. 9, pl. 3, fig. 21) have reported *N. setiferus* Cookson (1947) from Matanomadh of Kutch which shows closer resemblance to the *N. denticulatus* Ramanujam & Rao (1971) rather than with *N. setiferus* Cookson (1947).

Affinity—Asterinaceae.

Genus **Callimothallus** Dilcher, 1965

Genotype *Callimothallus pertusus* Dilcher, 1965

Callimothallus pertusus Dilcher, 1965

Plate 2, Fig. 4.

Comments—The genus *Callimothallus* Dilcher (1965) is characterised by non-ostiolate ascomata having porate cells. *C. quilonensis* Jain & Gupta (1969) can be differentiated

from *C. pertusus* by peripheral porate cells. *C. dilcherii* Rao & Ramanujam (1976) is characterised by bottle shaped marginal cells ; *C. assamicus* Kar *et al.* (1970) has only central cells porate while *C. raoi* Ramanujam & Rao (1971) is typified by central disintegrated ostiole like portion and typical proximally pored cells.

In India *C. pertusus* has been recorded from Warkalli beds (RAMANUJAM & RAO, 1971).

Subfamily ASTERINEAE

Genus **Euthyrites** Cookson, 1947

Genotype *Euthyrites oleinites* Cookson (1947)

Euthyrites keralensis Ramanujam & Rao, 1971

Plate 1, Fig. 3

Comments—Genus *Euthyrites* Cookson (1947) is characterised by linear ascomata with median longitudinal slit. *E. keralensis* Ramanujam & Rao (1971) can be differentiated from *E. oleinites* Cookson (1947) by its hypopodiate mycelial hyphae, which are absent in the latter.

In India *E. keralensis* has been reported so far only from Warkalli lignites of South India (RAMANUJAM & RAO, 1971).

Affinity—According to RAMANUJAM AND RAO (1971) *Euthyrites keralensis* shows an affinity with species of modern genus *Lembosia* of Asterinaceae.

DISCUSSION

Of the 25 morphotypes described here, four belong to fungi, four to pteridophytes and the rest to angiosperms. Gymnospermous types are typically wanting.

The lignite samples are very rich in fungal mycelia and spores. The four fruiting bodies included here have been attributed to Microthyriaceae, a family abundantly represented in warm humid regions.

All the pteridophytic spores described here have been attributed to filicales. Except *Lygodiumsporites* the rest are assigned to Polypodiaceae. *Laevigatosporites ovalis* has been recovered along with the sporangium which confirms the affinity of this morphotype with Polypodiaceae. *Laevigatosporites ovalis* and *Polypodiisporites usmensis* are most frequently met-with.

The angiospermous morphotypes recorded, represent Chenopodiaceae, Rhizophoraceae, Lecythidaceae, Sonneratiaceae, Anacardiaceae, Palmae and Graminae. Of the eight monocotyledonous palynomorphs recovered, seven have been assigned to Palmae. *Palmaepollenites ovatus* is abundantly found in the macerations. Amongst dicotyledonous types *Marginipollis kutchensis*, *Striacolporites ratnagiriensis* and *Sonneratiopollis bellus* are very common. The affinity of *Marginipollis kutchensis* with *Careya-Berringtonia* pollen type of Lecythidaceae appears to be very certain. Presence of *Palaeosantalaceaepites minutus* and *Sonneratiopollis bellus* referred to Rhizophoraceae and Sonneratiaceae respectively and the *Nypa* cuticle earlier described (KULKARNI & PHADTARE, 1979) suggests estuarine conditions of deposition.

The distribution of morphotypes recorded here amongst other Tertiary beds of India is shown in Table 1. Maximum common morphotypes are found with Quilon beds of South India assigned to Miocene Period. However, a characteristic pollen morphotype, *Marginipollis kutchensis*, very frequently found in our samples has not been so far reported from Quilon beds.

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EXPLANATION OF PLATES

(Magnifications of all photomicrographs ×2667 except when mentioned).

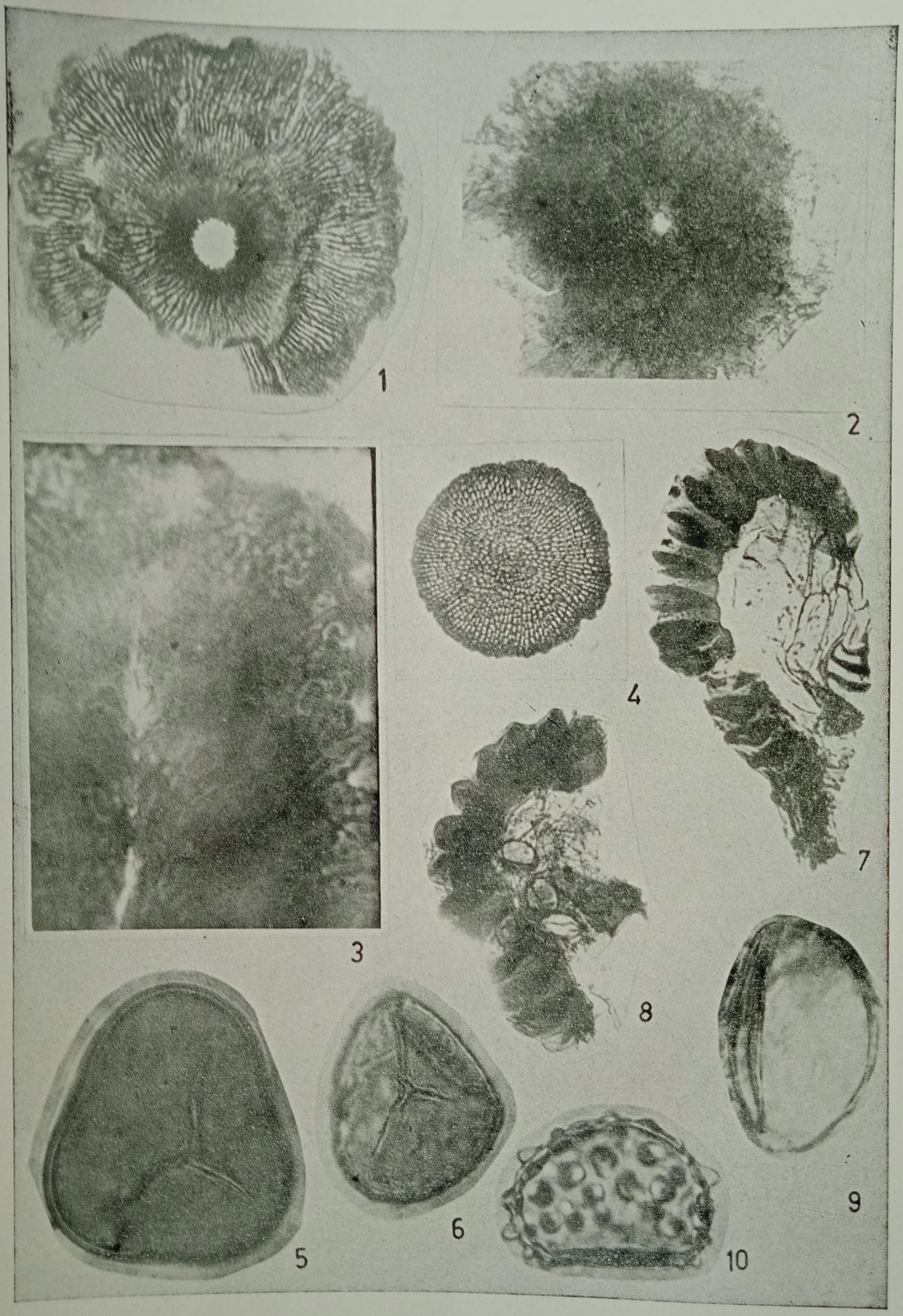
PLATE 1

1. *Notothyrites denticulatus* ×1875.
2. *N. amorphus* ×1875.
3. *Euthyrites* keralensis
4. *Callimothallus pertusus* ×1875.
5. *Lygodiumsporites padappakkarensis.*
6. *Foveotriletes* sp.
7. Entire sporangium ×1875.

8. Piece of Sporangium with spores ×1875.
9. *Laevigatosporites ovalis.*
10. *Polypodiisporites usmensis.*

PLATE-2

11. *Palmaepollenites neyveliensis.*
12. *P. ovatus.*
13. *Verrumonocolpites venkatachalai.*
14. *Clavapalmaedites hamenii.*
15. *Monoporopollenites gramineoides.*
16 & 17. *Couperipollis punctitectatus.*
18. *Longapertites klinkenbergii.*
19. *Quilonipollis ornatus.*
20. *Striacolporites ratnagiriensis.*
21 & 22. *Dicolpopollis malesianus.*
23 & 24. *Polybrevicolporites cephalus.*
25 & 26. *Marginipollis kutchensis.*
27 & 28. *Palaeosantalaceaepites minutus.*
29 & 30. *Sonneratiopollis bellus.*
31. *Cauveripollis superbus.*
32. *Dorrenipites sp.*
33. *Polyporina globosa.*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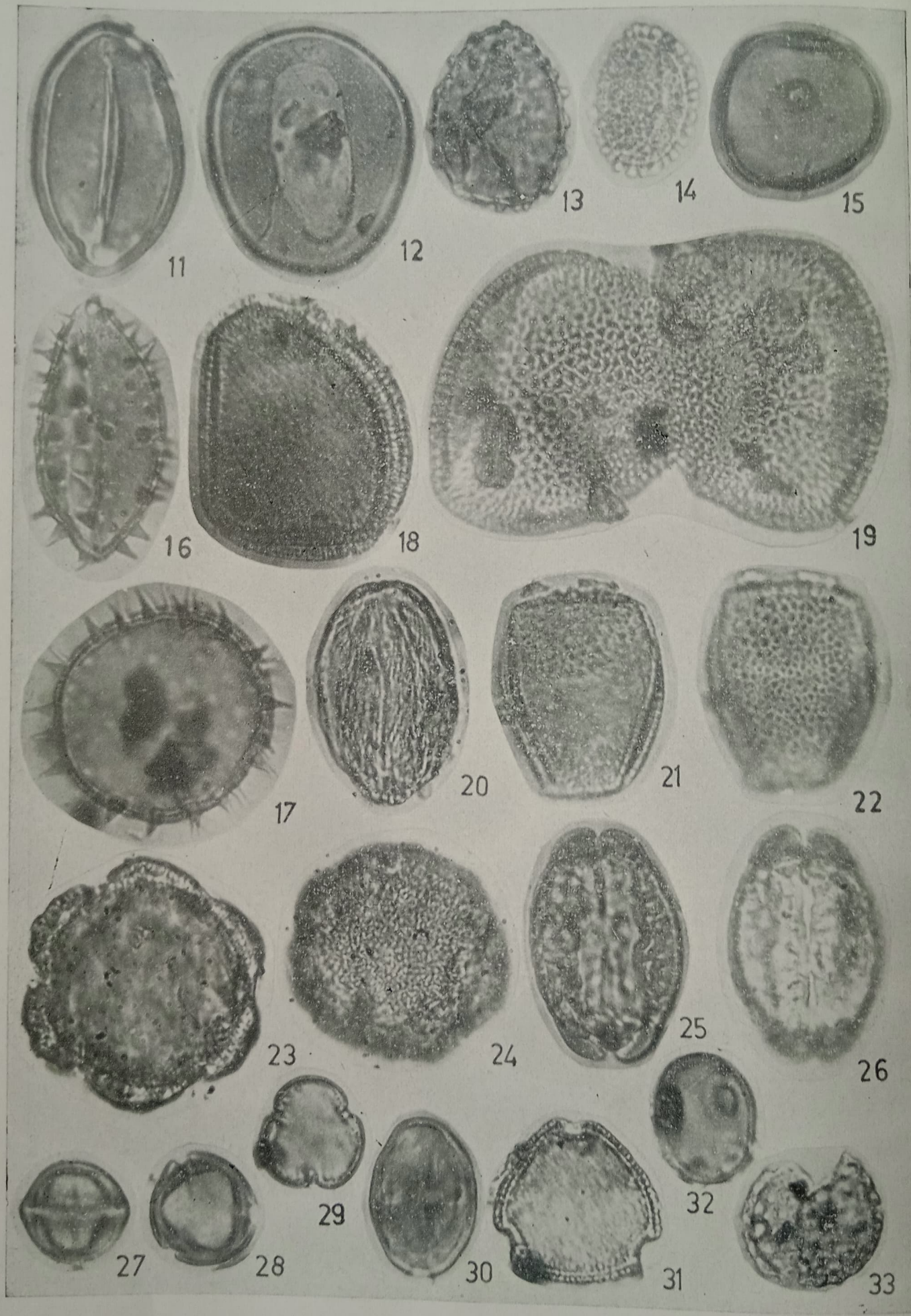

Phadtare & Kulkarni—Plate 2