An Early Miocene palynofloral assemblage from Turavur bore-hole, Alleppey District, Kerala — its palaeoecological and stratigraphical significance*

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A rich palynofloral assemblage has been recorded from the subsurface Early Miocene sediments at Turavur in the Alleppey District, Kerala. 39 genera and 45 species belonging to different botanical groups such as dinoflagellate cysts, fungal remains, pteridophytic spores and angiospermous pollen have been recognised. Some of the stratigraphically significant palynotaxa are: *Striatriletes, Crassoretitriletes, Quilonipollenites, Iridacidites, Dipterocarpuspollenites, Plumbaginacipites, Ericipites, Clavaperiporites, Chenopodipollis* and *Malvacearumpollis*. The present palynofloral assemblage is closely comparable to that recorded from *Malvacearumpollis bakonyensis* Cenozone of Arthungal bore-hole in the Alleppey District, Kerala (Rao, 1990). The palynoflora has been compared with the modern equivalents and it reveals a tropical humid climate with high degree of rainfall during Early Miocene time in the area of investigation. The brackish water environment of deposition is indicated by the presence of back- mangrove elements and dinoflagellate cysts in the assemblage.

Key-Words- Palaeopalynology, palaeoecology, Tertiary, Early Miocene.

INTRODUCTION

RAHA, Rajendran and Kar (1987) for the first time have studied the bore-hole of Ambalapuzha (600 metre depth) in Alleppey District, Kerala and used spore-pollen as basis for demarcating Eocene to Early Miocene age to the succession studied. Subsequent palynological study of Arthungal, Kalarakod and Nirkunnam bore-holes, Alleppey District, Kerala by Rao (1990, 95) also provides cogent evidence that the palynoflora recovered from the bore-holes vary from Eocene to Early Miocene age. The Arthungal bore-hole palynological succession have been divided into three distinct cenozones, viz., *Malvacearumpollis bakonyensis* Cenozone (Early Miocene), *Crassoretitriletes vanraadshooveni* Cenozone (Oligocene) and *Triangulorites bellus* Cenozone (Eocene). Each cenozone contains age definite and ecologically important palynofossils. Later, Ramanujam, Rao and Reddy (1991) and Rao, Reddy and Ramanujam (1992-93) have also studied the bore-holes of Mynagapally, Pattanakod and Thakkazhi from Quilon and Alleppey districts, Kerala, respectively and recorded palynoflora indicating Early Miocene age to the sediments.

The present paper is an another attempt to study palynoflora recovered from the Turavur bore-hole, Alleppey District, Kerala (Map-1) and to utilize the same in palynostratigraphical and palaeoecological interpretations.

The Turavur bore-hole is about 221.70 metres deep and is located (Lat. 9°, 45, 18": Long. 76° 19'10") at panchayat L.P. School, west of NH 47 between 380 and 381 Km north of Alleppey. The area is covered by coastal alluvium and is underlain by a sequence of clays and sand with intercalations of limestone and lignite bands. The lithological details of the samples are shown in the text-fig.1.

The Tertiary sediments of Kerala coast are known as Warkalli and Quilon beds. They were first described by King (1882) and Foote (1882). The Quilon beds consists of fossiliferous limestone with intercalations of calcareous clays, carbonaceous clays and sands, while the Warkalli beds include variegated clays, car-

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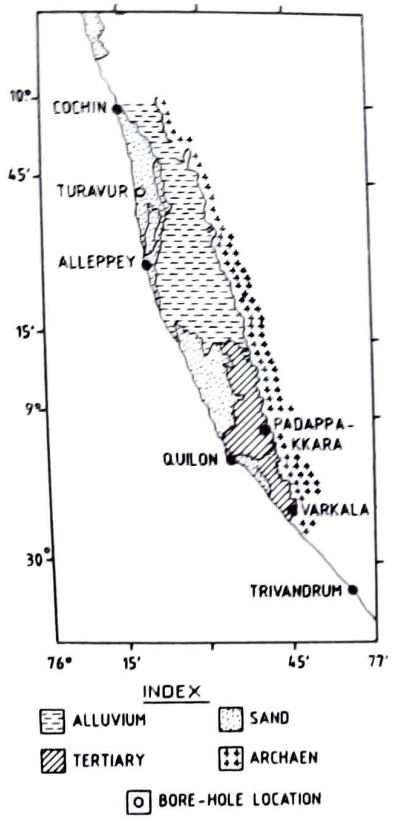
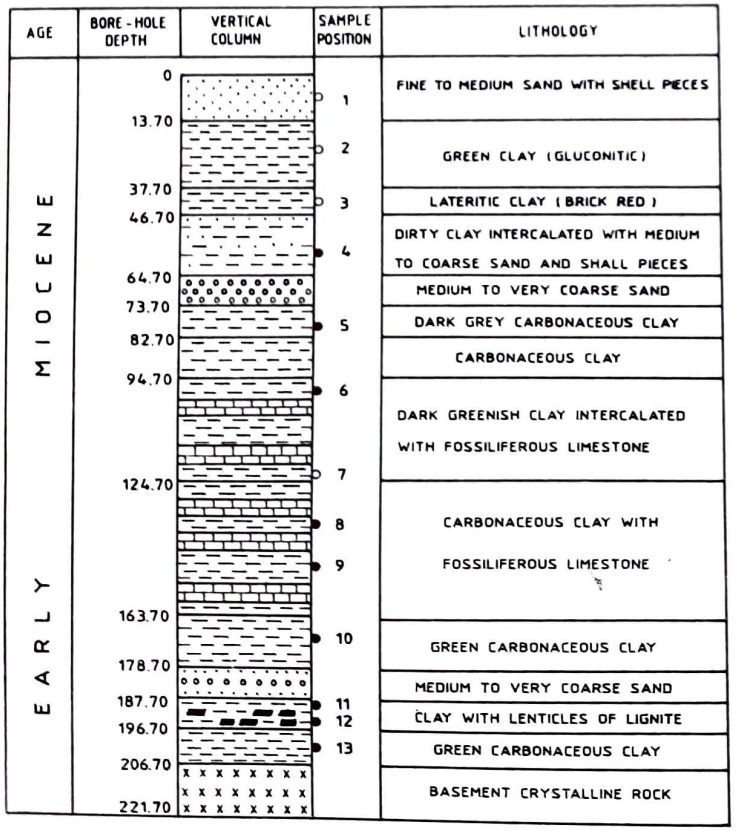


Map 1. Geological map of Kerala showing area of investigation.

bonaceous clays and seams of lignite. The Tertiary sequence rests unconformably over the Archean crystal-



Text-figure. 1. Lithological details of Turavur bore-hole, Alleppey district, Kerala.

line complex and is succeeded by recent to subrecent marine and estuarine sediments (Poulose & Narayanaswami, 1968).

Palynological studies of the Tertiary sediments of Kerala basin have been done by Rao and Vimal (1953), Potonié and Sah (1960), Ramanujam (1977, 1987), Rao and Ramanujam (1978, 1982), Kar and Jain (1981), Varma, Ramanujam and Patil (1986), Varma (1987), Raha, Rajendran & Kar (1987), Rajendran *et al.* (1989) Rao (1990, 1995), Singh and Rao (1990) and Rao and Rajendran (1996).

MATERIAL AND METHOD

Thirteen samples from Turavur bore-hole were provided by Central Ground Water Board, Trivandrum, Kerala. Out of these, 9 samples were productive. Samples were treated with HCL, HF and HNO_3 followed by a 5% solution of KOH. The material was finally washed with water through 400 mesh sieve. The slides were prepared in Polyvenyl alcohol and mounted in Canada balsam. An Olympus BH2 Microscope has been used for the study and photomicrography. The slides and negatives have been deposited in the Museum of Birbal Sahni Institute of Palaeobotany, Lucknow.

List of palynotaxa- The following is the checklist of the palynoflora present in the assemblage and the palynotaxa marked with asterisks (*) are described in the text.

Dinoflagellate cysts

Achmosphaera sp.

Thalassiphora pelagica (Eisenack) Eisenack & Gocht, 1960

Fungal remains

Phragmothyrites eocaenica Edwards, 1922

Notothyrites setiferus Cookson, 1947

Lirasporis intergranifer Potonie' & Sah emend. Kar & Jain, 1981

Parmathyrites indicus Jain & Gupta, 1980

Involutisporonites sp.

Frasnacritetrus sp.

Pteridophytic spores

Lygodiumsporites lakiensis Sah & Kar, 1969

L. padappakkarensis Rao & Ramanujam, 1978

Striatriletes susannae van der Hammen emend. Kar, 1979

Crassoretitriletes vanraadshooveni Germeraad *et al.* 1978

Cheilanthoidspora monoleta Sah & Kar, 1974

C. mioceneca Kar & Jain, 1981

Polypodiaceaesporites chatterjii Kar, 1979

Angiospermous pollen

Psiloschizosporis psilata Kar & Saxena, 1981

Pinjoriapollis lanceolatus Saxena & Singh 1981

Iridacidites warkalliensis Ramanujam, 1987

Quilonipollenites sahnii Rao & Ramanujam, 1978

Retimonosulcites ovatus Kar, 1985

Plumbaginacipites neyvelli Navale & Misra, 1979

Dipterocarpuspollenites retipilatus (Kar & Jain) Kar, 1992

Lakiapollis ovatus Venkatachala & Kar, 1969

Tribrevicolporites sarkarii Rao & Rajendran, 1996

**Tribrevicolporites* sp.

Triangulorites bellus Kar, 1985

Margocolporites tsukadae Ramanujam, 1966

Dermatobrevicolporites dermatus (Sah & Kar) Kar, 1985

**Dermatobrevicolporites alleppeyensis* sp. nov.

Tricolporopollis matanamadhensis (Venkatachala & Kar) Tripathi & Singh, 1985

T. alleppeyensis Rao & Rajendran, 1996

**Retitricolporites* sp.

Retitrescolpites indicus Rao & Ramanujam, 1982

Tricolporopilites pseudoreticulatus Kar, 1985

Ctenolophonidites costatus (van Hoeken-Klinkenberg) van Hoeken-Klinkenberg, 1966

Retistephanocolporites sp.

Myricipites singhii Rao, 1995

Proteacidites triangulus Kar & Jain, 1981

**Subtriporopollis* sp. A

**Subtriporopollis* sp. B

**Verrutriporites* sp.

Clavaperiporites jacobii Ramanujam, 1966

Chenopodipollis miocenica Kar & Jain, 1981

Malvacearumpollis bakonyensis Nagy, 1962

Ericipites congoensis Sah, 1967

Incertae-sedis

Heliospermopsis hungaricus Nagy, 1965

SYSTEMATIC DESCRIPTION

Genus- *Dermatobrevicolporites* Kar, 1985

Type species- Dermatobrevicolporites (Triorites) dermatus (Sah & Kar) Kar, 1985

Dermatobrevicolporites alleppeyensis sp. nov.

P1. 1, figs 9-10

Holotype- P1.1, fig.9, size 55x45 µm, slide no BSIP 11588

Type locality- Turavur bore-hole, 97-100m depth, Alleppey District, Kerala.

Age - Early Miocene

Diagnosis and description- Pollen grains oval-rhomboidal in shape. Size range 50-55x28-45µm. Tricolporate, colpi short, pore 4 µm diameter in the center, thickened around pore, 11 µm thick. Exine 5 µm thick, sexine 3 µm thick and nexine 2 µm thick, finely scabrate ornamentation.

Comparison- Dermatobrevicolporites alleppeyensis sp. nov. is closely comparale to the type species *D. dermatus* (Sah & Kar) Kar (1985) by having brevicolporate nature but the latter is differentiated by its smaller size (35µm), long colpi (15µm) and well developed pore (10 µm diameter). *D. exalus* Kar (1985) is distinct by its long colpi (20 µm) and different exinal thickening (interapertural and apertural thickenings).

Occurrence- 97-100 metre depth, Turavur bore-hole, Alleppey District, Kerala.

Affinity- Unknown.

Genus-*Tribrevicolporites* Kar, 1985

Type species- Tribrevicolporites eocenicus Kar, 1985

***Tribrevicolporites* sp.**

P1.1, fig.6

*Description-*Pollen grain sub-circular in shape. Size 62x60 µm. Tricolporate, brevicolpate, pore 7 µm diameter in the center. Exine 3 µm thick, exine 2 µm thick, baculate, nexine 1 µm thick, laevigate. Exine finely reticulate.

Comparison- Tribrevicolporites sp. is closely comparable wih the type species by its brevicolporate nature but can be distinguished by its bigger size and fine reticulate ornamentation.

Occurrence- 127.70-163.70 metre depth, Turavur bore-hole, AlleppeyDistrict, Kerala.

Affinity- Unknown.

Genus-*Retitricolporites* van der Hammen & Wijmstra, 1964

Type species- Retitricolporites normalis (v.d.H.) van der Hammen & Wijmstra, 1964

***Retitricolporites* sp.**

P1.1, fig. 5

Description- Pollen grain sub-triangular in polar view. Size 55x52 µm. Tricolporate, pore 10µm wide in the center. Pore margin thickened. Exine 4 µm thick, sexine and nexine not differentiated, pilate, distinct reticulate ornamentation on the distal side.

Comparison- Retitricolporites crassioratus Rao & Ramanujam (1982) is closely comparable by its tricolporate and reticulate ornamentation but is distinct from the present species by its smaller size (35 µm) and thinner exine (1.8 µm).

Occurrence- 94-97 metre depth, Turavur bore hole,Alleppey District, Kerala.

Affinity- Verbenaceae (*Avecenia*).

Genus-Retistephanocolporites van der Hammen & Wijmstra, 1964

Type species- Retistephanocolporites quadriporus van der Hammen & Wijmstra, 1964

***Retistephanocolporites* sp.**

P1.1, figs 17-18

Description- Pollen grain hexagonal in shape. Size 45 µm. Hexacolporate, pore not distinct. Exine 5 µm thick, wavy, nexine thicker than sexine, nexine 3 µm thick, baculate, sexine 2 µm thick, smooth. Exine showing pitted reticulate ornamentation.

Comparison- Retistephanocolporites sp. closely resembles with *R. quadriporus* van der Hammen & Wijmstra (1964) by its general characters but the latter can be distinguished by having 4 colporate, smaller size (28 µm) and thinner exine (2 µm).

Occurrence–97-100 metre depth, Turavur bore-hole, Alleppey District, Kerala.

Affinity-Terminalia (Combretaceae).

Genus- *Subtriporopollis* Sah, 1967

Type species- Subtriporopollis tenuis Sah, 1967

***Subtriporopollis* sp. A**

P1.1, fig. 13

Description- Pollen grain sub-triangular in polar view. Size 51x50 µm. Triporate, pore 12 µm wide, subequatorially placed. Exine 3.5 µm thick, finely perforated. Distal surface showing finely reticulate ornamentation.

Comparison- Subtriporopollis sp. A is closely comparable with the type species *S. tenius* Sah (1967) by its triporate condition and reticulate ornamentation but the latter is distinguished by its pilate exine and distinct reticulate ornamentation.

Occurrence- 97-100 metre depth, Turavur bore-hole, Alleppey District, Kerala.

Affinity- Rubiaceae.

***Subtriporopollis* sp. B**

P1.1, fig.15

Description- Pollen grain sub-triangular, amb rounded. Cingulum or flap like structure present around pollen, 3.5 µm thick. Size 63x60 µm. Triporate, subequatorially placed, 11 µm wide. Exine thin, surface distinctly reticulate.

Comparison- Subtriporopollis tenius Sah (1967) is closely resembles with *Subtriporopollis* sp B by its triporate condition and finely reticulate ornamentation but the former is distinguished by its smaller size (42 µm) and thicker exine (2.5 µm thick).

Occurrence- 206-213.70 metre depth, Turavur bore-hole, Alleppey District, Kerala.

Affinity- Rubiaceae.

Genus-*Verrutriporites* Muller 1968

Type species- Verrutriporites lunduensis Muller, 1968

***Verrutriporites* sp.**

P1.1, fig.7

Description- Pollen grain sub-triangular in polar view. Size 61x45 µm. Triporate, pore not distinct due

ornamentation of verrucae. Exine 2.5 µm excluding verrucae. Exine verrucate, sexine and nexine not differentiated, verrucae of different sizes. Distal surface showing negative reticulate ornamentation.

Comparison- *Verrutriporites lunduensis* Muller (1968) is much smaller in size (24 µm) than the present species. *V. annulatus* Kar & Jain (1981) is distinct by the presence of pila and bacula in between verrucae.

Occurrence- 206.70-213.70 metre depth, Turavur bore-hole, Alleppey District, Kerala.

Affinity- Unknown.

DISCUSSION

A total of 39 genera and 45 species have been recorded. Of these, 2 genera and ? species belong to dinoflagellate cysts; 6 genera and 5 species to fugal remains; 5 genera and 7 species to pteridophytic spores and 26 genera and 20 species to angiospermous pollen including one new species, *Dermatobrevicolporites alleppeyensis*. *Heliospermopsis hungaricus* is kept under *Incertae-sedis*. Among the pteridophytes, the families of Schizaeaceae and Parkeriaceae are best represented. In the angiosperms, the monocotyledons are represented by the family Arecaceae while dicotyledons are dominating in the present assemblage and referable to the following families viz. Caesalpiniaceae, Bombacaceae, Ericaceae, Euphorbiaceae, Ctenolophonaceae, Thymeleaceae, Proteaceae, Apocynaceae. Chenopodiaceae, Combretaceae, Dipterocarpaceae, Magnoliaceae, Malvaceae, Myricaceae, Oleaceae, and Plumbaginaceae.

For the percentage frequency, only 19 species of different genera have been selected and plotted in text-figure 2. The palynofloral chart reveals that Crassoretitriletes, Striatriletes Quilonipollenites, Dipterocarpuspollenites, Lakiapollis, *Margocolporites*, *Tricolporopollis*, *Ctenolophonidites*, *Myricipites*, *Chenopodipollis* and *Malvacearumpollis* are important genera in the assemblage. Among pteridophytic spores, *Crassoretitriletes vanraadshooveni* (15%) and *Striatriletes susannae* (15%) are dominant in the upper part of the bore-hole and the percentage is decreasing in the lower part in the case of *Crassoretitriletes* (3%). *Lygodiumsporites paddappakkarensis* (2-10%) is present only in the lower part whereas *Striatriletes* is completely absent. *Quilonipollenites sahnii* (20%) and *Margocolporites tsukadae* (22%) are another important angiosperm taxa, dominant in the lower part and decreases their frequency (5% and 3% respectively) at the top. The frequencies of *Malvacearumpollis bakonyensis* (3%), *Retitrescolpites indicus* (5%) and *Chenopodipollis miocenica* (2%) are low but represented from lower to top of the bore-hole. *Lakiapollis ovatus* (19%), *Tricolporopollis matanamadhensis* (35%) are dominant throughout the bore-hole. *Retimonosulcites ovatus* (3%), *Plumbaginacipites neyvelii* (3%) and *Ericipites congoensis* (2%) are represented only in the lower part.

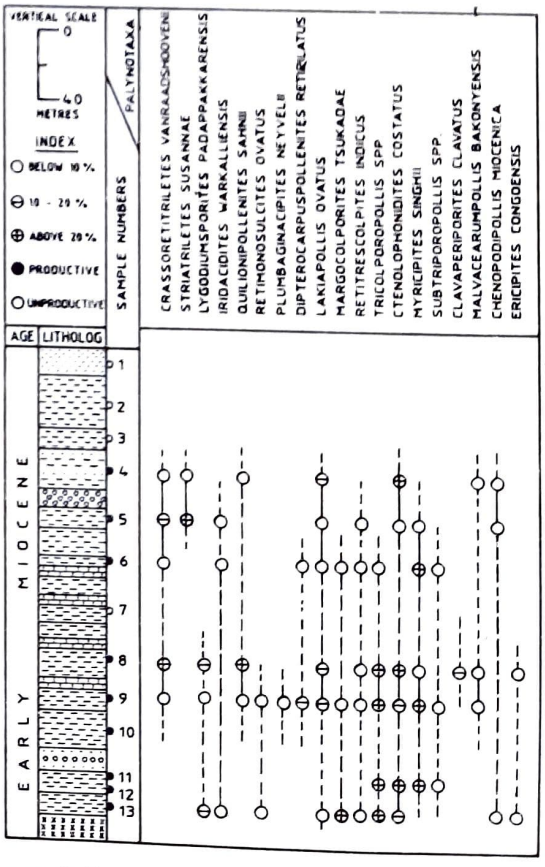
PALAEOECOLOGICAL INTERPRETATIONS

The bore-hole assemblage is rich and diversified. The palynoflora can be divided into different ecological groups such as montane, lowland, fresh water swamp and water edge, back-mangrove and sandy beach elements. An analysis of ecological groups reveal that fresh-water swamp and water edge and low-land elements are dominant over the montane, back-mangrove and sandy-beach elements. The different ecological groups are mentioned below:

Montane elements- *Clavaperiporites*, *Ericipites* and *Proteacidites*.

Low-land elements-*Lakiapollis*, *Margocolporites*, *Subtriporopollis and Tricolporopollis*.

Fresh-water swamp and water edge elements - *Lygodiumsporites*, *Crassoretitriletes*, *Striatriletes*,



Text-figure. 2. Percentage frequency of palynotaxa in Turavur bore-hole.

Polypodiaceaesporites, Cheilanthoidspora, Pinjoriapollis, Ctenolophonidites and *Chenopodipollis*

Back-mangrove elements- *Malvacearumpollis, Retitricolporites* and *Verrutriporites.*

Sandy-beach elements-*Iridacidites* and *Quilonipollenites.*

Palaeoclimate

The Turavur assemblage consists of palynoflora having affinities with 20 extant families (Table-1). Of these, 7 families are restricted to tropical to sub-tropical, 2 families are restricted to tropical, 10 families are restricted to tropical-temperate and one family is restricted to warm and humid climate. The presence of spore-pollen of Schizaeaceae, Parkeriaceae, Polypodiaceae, Caesalpiniaceae, Ctenolophonaceae, Oleaceae, Dipterocarpaceae, Malvaceae and Rubiaceae in the assemblage indicates that tropical climate prevailed at the time of deposition. The presence of fungal remains (*Phragmothyrites, Notothyrites, Parmathyrites* and *Lirasporis*), fern spores (*Lygodiumsporites, Crassoretitriletes, Striatriletes,* and *Polypodiacc esporites*) and tropical angiosperm pollen (*Ctenolophonidites, Retitrescolpites* and *Dipterocarpuspollenites*) support a climate with a high degree of rainfall.

Environment of deposition

The presence of *Lygodiumsporites, Crassoretitriletes, Striatriletes, Polypodiaceaesporites* and *Pinjoriapollis* indicates a fresh water swampy environment. The montane elements belonging to the families Thymelaeaceae, Ericaceae and Proteaceae may have derived from long distance. The coastal conditions are supported by the presence of palm pollen (*Iridacidites* and *Quilonipollenites*). The Presence of dinoflagellate cysts (*Thalassiphora* and *Achmosphaera* etc and back-mangrove elements suggested the existence of brackish mangrove swamps. Pollen taxa comparable to Chenopodiaceae show halophytic environment.

STRATIGRAPHICAL SIGNIFICANCE

The significant genera from 13.70-221.70 metres depths are *Lygodiumsporites, Striatriletes, Crassoretitriletes, Polypodiaceaesporites, Iridacidites, Quilonipollenites, Dipterocarpuspollenites, Lakiapollis, Retitrescolpites, Dermatobrevicolporites, Tricolporopollis, Margocolporites, Ctenolophonidites, Myricipites, Subtriporopollis, Chenopodipollis, Malvacearumpollis* and *Ericipites*. Of these, *Striatriletes, Crassoretitriletes, Pteridacidites, Quilonipollenites, Dipterocarpuspollenites, Chenopodipollis, Clavaperiporites, Malvacearumpollis* and *Ericipites* is indicative of Early Miocene age (Rao, 1990, 1995). The vertical distribution of the stratigraphically significant taxa is shown in text-figure-2. *Malvacearumpollis* (Nagy, 1962, Germeraad *et al.* 1968) is considered important for suggesting Early Miocene age and it occurs in the present bore-hole from depth range 46.70 to 169.70 metres. The genus occurs as a dominant element in the Khari Nadi Formation, Kutch (Kar, 1985), Surma group, Meghalaya and Assam (Rao *et al.* 1985) and also in Kerala Basin (Rao, 1990, 1995). The presence of *Iridacidites, Quilonipollenites, Dipterocarpuspollenites, Clavaperiporites, Chenopodipollis* and *Ericipites* also supports the above view. So, from the above palynological data it is inferred that the Turavur bore-hole palynological succession has been assigned as Early Miocene in age. The present assemblage is closely comparable to the Early Miocene palynoassemblage of *Malvacearumpollis bakonyensis* Cenozone of Arthungal (151.70-7.70

Plate 1

(All photomicrographs are enlarged *ca* x 600. Coordinates on Olympus microscope no. 217267, BH2).

1. *Lygodiumsporites lakiensis* Sah & Kar, slide no. BSIP 11581, coordinates 7.3x133.0.
2. *Quilonipollenites sahnii* Rao & Ramanujam, slide no. BSIP 11582, coordinates 17.0x145.6.
3. *Margocolporites tsukadae* Ramanujam, slide no. BSIP 11583, coordinates 13.0x127.6.
4. *Plumbaginacipites neyvelii* Navale & Misra, slide no. BSIP 11584, coordinates 11.4 x 138.0.
5. *Retitricolporites* sp, slide no. BSIP 11585, coordinates 18.5x172.
6. *Tribrevicolporites* sp. slide no. BSIP 11586, coordinates 20.5x 263.2.
7. *Verrutriporites* sp. slide no.BSIP 11583, coordinates 8.4x137.4.
8. *Thalassiphora* sp, slide no. BSIP 11587, coordinates 8.7x137.4.
9-10. *Dermatobrevicolporites alleppeyensis* sp. nov, slide nos. BSIP 11588, coordinates 13.2x157.5 (Holotype) 11582, coordinates 22.5x143.0
11-12. *Ctenolophonidites costatus* (van Hoeken-Klinkenberg) van Hoeken-Klinkenberg, slide no BSIP 11589, coordinates 7.5x156.4
13. *Subtriporopollis* sp. A.slide no. 11590, coordinates 19.0x152.0.
14. *Lakiapollis ovatus* Venkatachala & Kar, slide no. BSIP 11583, coordinates 3.4x158.0.
15. *Subtriporopollis* sp. B, slide no. BSIP 11583, coordinates 8.0x175.0.
16. *Ericipites congoensis* Sah, slide no. BSIP 11583, coordinates 15.5x133.2.
17-18. *Retistephanocolporites* sp, slide no. BSIP 11591, coordinates 5.0x158.0.
19. *Chenopodipollis miocenica* Kar & Jain, slide no. 11583, coordinates 10.0x157.0.
20. *Clavaperiporites jacobii* Ramanujam, slide no. BSIP 11584, coordinates 13.0x141.0.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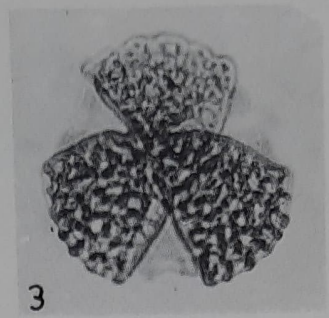
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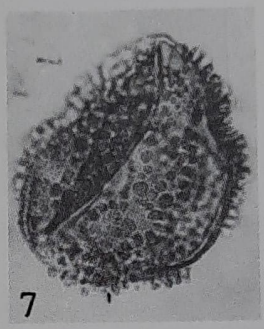
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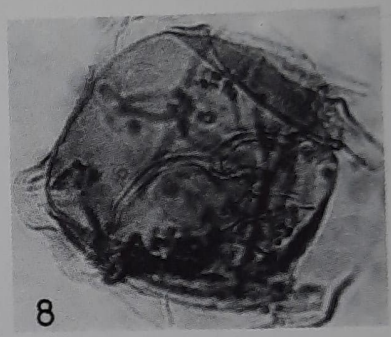
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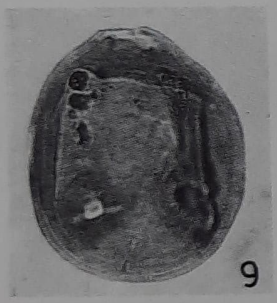
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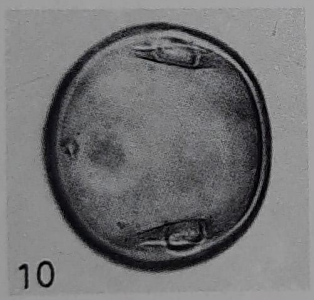
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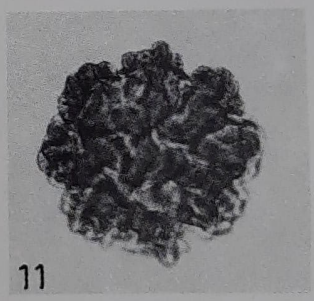
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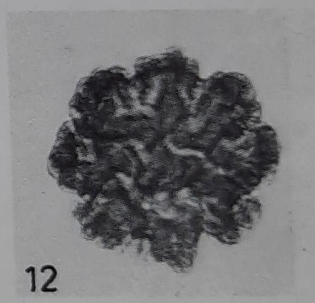
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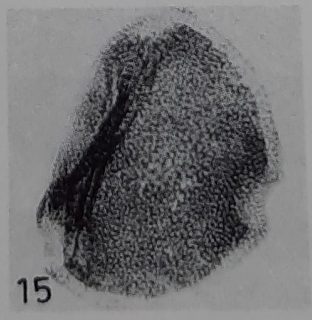
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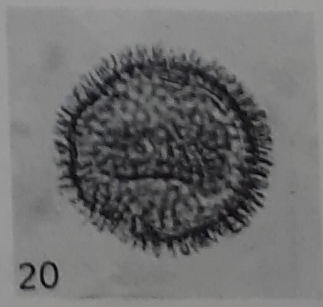
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Plate 1

Table-1

Family	Name of the taxa	Climate
Fungal bodies		
Microthyriaceae	*Phragmothyrites eocaenica* *Notothyrites setiferus* *Parmathyrites indicus* *Lirasporis intergranifer*	Warm and humid
Pteridophytic spores		
Parkeriaceae	*Striatriletes susannae*	Tropical to subtropical
Polypodiaceae	*Polypodiaceaesporites chatterjii*	Tropical to temperate
Schizaeaceae	*Lygodiumsporites lakiensis* *L. padappakkarensis* *Crassoretitriletes vanraadshooveni*	Tropical to temperate
Angiospermous pollen		
Arecaceae	*Iridacidites warkalliensis* *Quilonipollenites sahnii*	Tropical to subtropical
Bombacaceae	*Lakiapollis ovatus*	Tropical to subtropical
Chenopodiaceae	*Chenopodipollis miocenica*	Tropical to temperate
Combretaceae	*Retistephanocolporites* sp.	Tropical to subtropical
Ctenolophonaceae	*Ctenolophonidites costatus*	Tropical
Dipterocarpaceae	*Dipterocarpuspollenites retipilatus*	Tropical to subtropical
Ericaceae	*Ericipites congoensis*	Tropical to temperate
Magnoliaceae	*Pinjoriapollis lanceolatus*	Tropical to temperate
Malvaceae	*Malvacearumpollis bakonyensis*	Tropical to temperate
Myricaceae	*Myricipites singhii*	Tropical to subtropical
Oleaceae	*Retitrescolpites indicus*	Tropical to temperate
Plumbaginaceae	*Plumbaginacipites neyvelii*	Tropical to temperate
Proteaceae	*Proteacidites triangulus*	Tropical
Rubiaceae	*Subtriporopollis* sp.	Tropical to temperate
Thymelaeaceae	*Clavaperiporites jacobii*	Tropical to temperate
Verbenaceae	*Retitricolporites* sp.	Tropical to subtropical

metres depths) and Kalarakod bore-hole (158.00-22.00 metres depths), Alleppey District, Kerala.

CONCLUSIONS

The palynofloral assemblage suggests:

- A tropical humid climate with plenty of rainfall during the deposition of the sediments.
- The deposition took place in a near shore environment with sufficient fresh water or fresh water swamps or both.
- On the basis of palynological data, the sequence studied has been assigned an Early Miocene age.

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