Palynological investigation of Miocene sediments exposed in Kannanellur-Kundara area, Quilon District, Kerala

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A palynological study on the Tertiary sediments exposed along the cliff section of Asthamudi Kayal, clay mine section at Kundara and Kallada Irrigation Project canal cutting at Kannanellur-Kundara road section, Quilon District, Kerala has been carried out. The palynoflora is represented by 48 genera and 59 species of fungal remains, pteridophytic spores and angiospermous pollen. Dinoflagellate cysts are also present. Angiospermous pollen dominate over pteridophytic spores/ fungal remains. The significant palynomorphs recorded from this study are: *Crassoretitriletes, Striatriletes, Quilonipollenites, Iridacidites, Plumbaginacipites, Warkallipollenites, Dipterocarpuspollenites, Marginipollis, Margocolporites, Tricolporopilites, Ctenolophonidites, Triorites, Myricipites, Verrutriporites, Polyporina* and *Malvacearumpollis.* On the basis of similarity with the modern flora, it is envisaged that the fossil taxa were representatives of tropical humid climate with heavy precipitation. The assemblage represents a mixture of ecological groups such as low-land, fresh water swamps and water edge, back-mangrove and sandy beach elements. Representation of dinoflagellate cysts, back-mangrove flora suggests a brackish water environment of deposition. The palynoflora has been compared with the contemporaneous deposits of east and west coasts of India and it supports a Miocene age to the sediments studied.

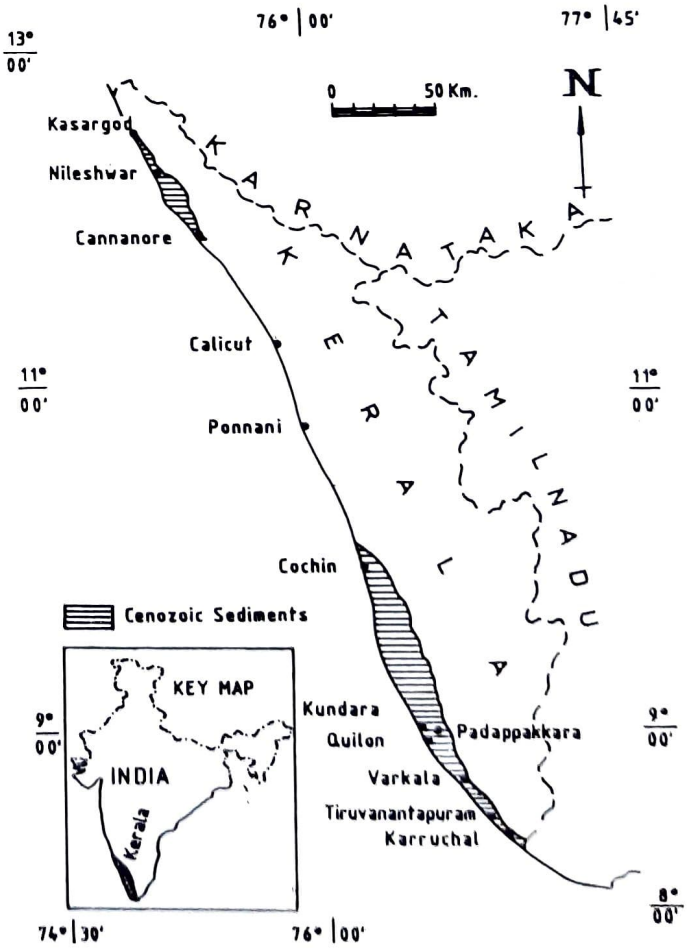
Key-words–Palynology, Palaeoecology, Miocene, Kerala Basin.

INTRODUCTION

THE present paper reports the occurrence and analysis of palynoassemblages recovered from clay mine section at Kundara and Kallada Irrigation Project canal cutting at Kannanellur-Kundara road section in Quilon District, Kerala. The details of location (Map-1) and the geology are discussed below :

Geology- The exposed lithounits of the area around Kundara-Kannanellur are Archean crystallines, the Tertiary sediments and the Quaternary alluvium. Both the crystallines and sedimentaries are lateritised and the laterite is about 10 m thick. Because of this thick blanket of laterite, rock outcrops are scanty. A tentative geological succession of the area is given below :

Period	Epoch/ Age	Formation	Lithology
Quaternary	Holocene	Periyar	Sand, silt and clay admixture
Tertiary	Miocene	Warkalli	Variegated clay, sandstone, ball clay, carbonaceous clay.
	Lower Miocene	Quilon	Limestone, marl (Fossiliferous)
Archean			Garnetiferous biotite gneiss



Map-1. Localities of Tertiary exposures in Kerala Basin.

Archean- The garnetiferous biotite gneiss (khondalite) exposed in the eastern part, i.e. east of Chattanur-Kundara area forms the basement rock. In the western part of the Tertiary sediments lie unconformably over this basement. A thick zone of lithomargic clay exists along the contact of the basement and the Tertiary, which probably represents the plane of unconformity/disconformity. The rock is medium grained, S 70° E and dips 80° northerly, quartz, feldspar, garnet and biotite are the chief minerals present.

Tertiary- Major part of the area under discussion, is covered by the Tertiary sediments, exposure of which is seen along the cliff section of Asthamudi Kayal, clay mine section at Kundara and Kallada irrigation project canal cutting at Kundara (Text-fig. 1). Tertiary sediments of the area consists of the Lower Quilon Formation and the upper Warkalli Formation.

Quilon Formation- This unit generally occurs as subcrops except near Padappakkara where it is exposed in the cliff section along the bank of Asthamudi Kayal. Occurrence of Quilon bed in other areas is inferred from the well sections. In general it is distributed in the western part of the area, i.e. west of Mylakkad-Kannanellur-Kundara road. Thickness of this unit appears to increase towards west as it is deposited in westerly sloping basin. Individual beds like hard, compact limestone, and consolidated, friable marl rich in marine fauna are discernible within the Quilon bed.

Warkalli Formation- These are fluvial and/or lacustrine deposits overlying the Quilon Formation. Towards eastern edge of the basin the beds lie uncomformably over the weathered basement. Warkalli beds consist of carbonaceous clay is seen at the bottom. Repetition of clay and sandstone bed is common. The maximum thickness of Warkalli Formation in the area is around 35 meters.

Kundara clay mine section (8° 58': 76° 40' 6") shows a thick sequence unconformably overlying the Precambrian. In this section, overlying the weathered crystalline rocks is a thick sequence of kaolinitic clay overlain by lignitic bands. A prominent band of conglomerate separates the overlying cross-laminated sandstone and underlying clay. The sandstone is mostly covered by the laterite in the upper part.

PALYNOLOGY

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

PLATE 1 →

(All photomicrographs are enlarged ca x 600, coordinates of specimens refer to Olympus microscope no. 217267-BH2)

1-2. *Verrutriporites kundaraensis* sp. nov. BSIP slide no. 11828, coordinates 9.0x134.0; 11830, coordinates 12.0x154.6 (Holotype).

3-4. *Marginipollis kutchensis*, BSIP slide no. 11832, coordinates, 6.5x141.0.

5. Tricolporate pollen type-I, BSIP slide no. 11833, coordinates 11.0x126.0.

6. *Rhoipites anacordioides*, BSIP slide no. 11828, coordinates, 19.0x161.0

7-8. *Tricolporopilites* sp. A., BSIP slide no. 11832, coordinates, 6.5x129.0.

9. *Tricolporopilites* sp. B., BSIP slide no. 11832, coordinates 11.0x156.0.

10. *Retitrescolpites* sp., BSIP slide no. 11837, coordinates, 7.0x148.0.

11. *Quilonipollenites sahnii*, BSIP slide no. 11835, coordinates, 20.0x150.0.

12. Tricolpate pollen type-I., BSIP slide no. 11831, coordinates, 5.0x164 .0.

13. *Tricolporopilites differentialis*, BSIP slide no. 11831, coordinates 18.0x154.5.

14. *Polyporina globosa*, BSIP slide no. 11828, coordinates, 14.5x145.5.

15. *Ctenolophonidites costatus*, BSIP slide no. 11833, coordinates 11.4x124.4.

16-17. *Triorites quilonensis* sp. nov. BSIP slide no. 11830, coordinates, 3.7x157.0; 11828, coordinates, 3.5x172.0 (Holotype).

18. Polycolporate pollen type-I., BSIP slide no. 11834, coordinates, 11.0x152.0.

19. *Dermatobrevicolporites dermatus*, BSIP slide no. 11835, coordinates, 20.0x150.0.

20-21. *Plumbaginacipites navalii* sp. nov., BSIP slide no. 11835, coordinates, 15.0x147.4 (Holotype).

22-23. *Warkallipollenites ramanujamii* sp. nov. BSIP slide no. 11835, coordinates, 11.5x161.0 (Holotype).

24. *Phragmothyrites eocaenica*, BSIP slide no. 11833, coordinates, 11.0x158.4.

25. Fungal body type-I, BSIP slide no. 11836, coordinates 18.0x150.0.

26. *Notothyrites setiferus*, BSIP slide no. 11836, coordinates 18.0x146.0.

27. *Meliapollis tamilii*, BSIP slide no. 11841, coordinates 10.0x155.0.

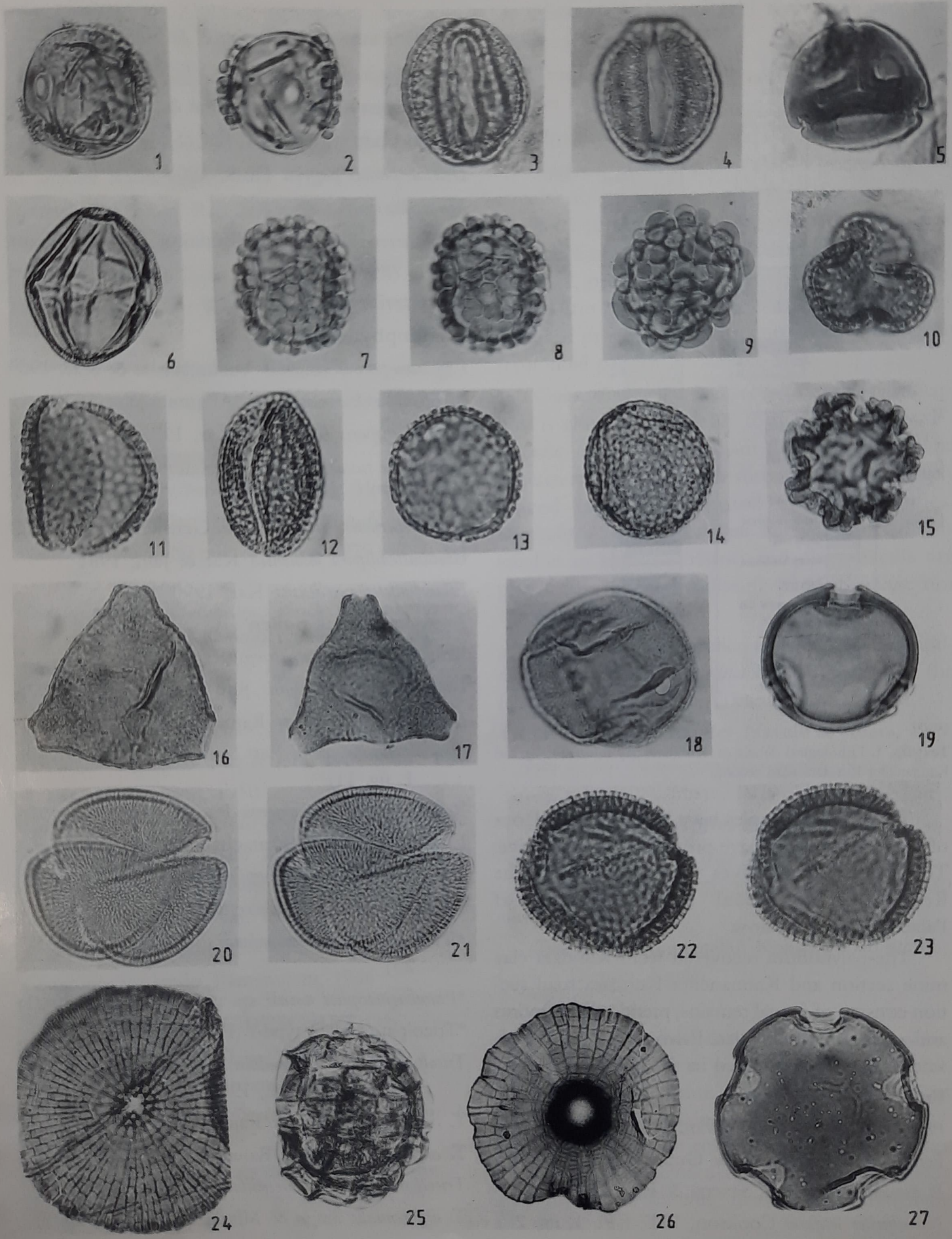
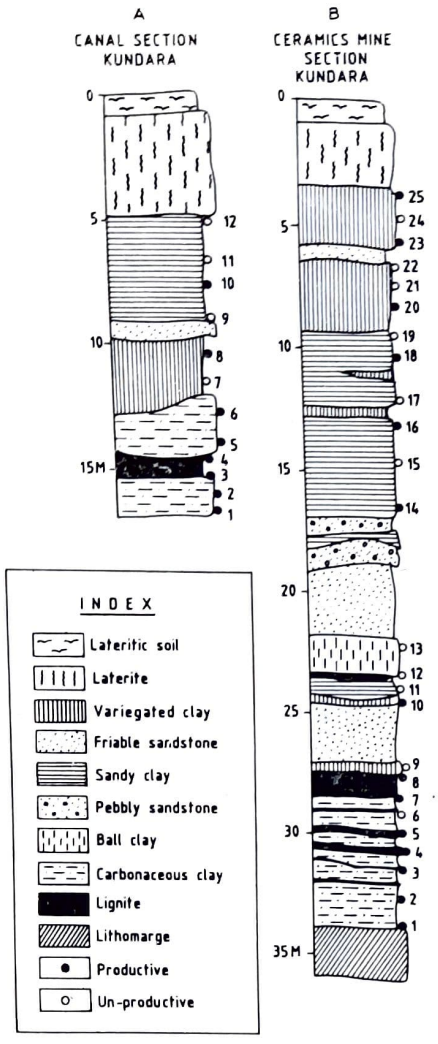


PLATE 1



Text-fig. 1. Lithological details of Kundara clay mine section and Kannanellur-Kundara road section.

Thirty seven samples have been macerated, out of these, 22 samples have proved to be productive. The slides and negatives were deposited in the Repository of Birbal Sahni Institute of Palaeobotany, Lucknow.

The palynoflora recovered from Kundara clay mine section and Kannanellur-Kundara road section consists of fungal remains, pteridophytic spores and angiospermous pollen. Palynotaxa marked with asterisks (*) are described in the text.

Fungal remains

Phragmothyrites eocaenica Edwards, 1922 (Pl. 1, fig. 24)

Parmathyrites indicus Jain & Gupta, 1970

P. ramanujamii Singh, Saxena & Rao, 1986

Notothyrites setiferus Cookson, 1947 (Pl. 1, fig. 26)

Lirasporis intergranifer Potonié, & Sah, 1960

Kutchiathyrites eccentricus Kar, 1979

Apendicisporonites typicus Saxena & Khare, 1992

Fungal body type -I (P.1, fig. 25)

Dicellaesporites papovii Elsik, 1968

Multicellaesporites sp.

Palaeocirrenalia mioceneca Ramanujam & Srisailam, 1980

Diporisporites sp.

Pteridophytic spores

Lygodiumsporites lakiensis Venkatachala & Kar, 1969

L. padappakkarensis Rao & Ramanujam, 1978

Intrapunctisporis harudiensis Kar, 1978

Striatriletes susannae van der Hammen emend. Kar, 1979

Crassoretitriletes vanraadshooveni Germeraad *et al.,* 1968

Cheilanthoidspora mioceneca Kar & Jain, 1981

Pilamonoletes excellensus Kar, 1990

Angiospermous pollen

Retipilonapites delicattissimus Ramanujam, 1966

Palmaepollenites keralensis Rao & Ramanujam, 1978

Iridacidites warkalliensis Ramanujam, 1987

Quilonipollenites sahnii Rao & Ramanujam, 1978 (Pl. 1, fig. 11)

Retimonosulcites ramanujamii Rao & Rajendran, 1996

Lakiapollis ovatus Venkatachala & Kar, 1969

Dipterocarpuspollenites retipilatus Kar, 1993

Tricolpites retibaculatus Saxena, 1979

**Warkallipollenites ramanujamii* sp. nov. (Pl. 1, figs. 22-23)

**Plumbaginacipites navalii* sp. nov. (Pl. 1, figs. 20-21)

*Tricolpate pollen type-I (Pl. 1, fig. 12)

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

T. cannanorensis Rao & Rajendran, 1996

T. alleppeyensis Rao & Rajendran, 1996

Tricolporopilites pseudoreticulatus Kar, 1985

T. differentialis Singh & Misra, 1991 (Pl. 1, fig. 3)

**Tricolporopilites* sp. A (Pl. 1, figs. 7-8)

**Tricolporopilites* sp. B (Pl. 1, fig. 9)

Marginipollis kutchensis (Venkatachala & Kar) Rao & Ramanujam, 1982 (Pl. 1, figs. 3-4)

Margocolporites tsukadae Ramanujam, 1966

M. sitholeyi Ramanujam, 1966

Retitrescolpites indicus Rao & Ramanujam, 1982

**Retitrescolpites* sp. (Pl. 1, fig. 10)

Paleosantalaceaepites ovatus Sah & Kar, 1970

Rhoipites anacardioides Ramanujam, 1987 (Pl. 1, fig. 6)

Tribrevicolporites alleppeyensis Rao, 1996

Dermatobrevicolporites dermatus Kar, 1985 (Pl.1, fig. 19)

Favitricolporites magnus Sah, 1967

Bacuspinulopollenites baculatus Singh & Misra, 1991

*Tricolporate pollen type-I. (Pl. 1, fig. 5)

Meliapollis tamilii Navale & Misra, 1979 (Pl. 1, fig. 27)

Ctenolophonidites costatus (van Hoeken-Klinkenberg) van Hoeken-Klinkenberg, 1966 (Pl. 1, fig. 15)

*Polycolporate pollen type-I (Pl. 1, fig. 18)

Myricipites singhii Rao, 1995

**Triorites quilonensis* sp. nov. (Pl. 1, figs. 16-17)

Proteacidites triangulus Kar & Jain, 1981

P. truncatus Cookson, 1950

Subtriporopollis rotundis Rao & Ramanujam, 1982

**Verrutriporites kundaraensis* sp. nov. (Pl. 1, figs 1-2)

Malvacearumpollis bakonyensis Nagy, 1963

Polyporina multiporosa Kar, 1985

P. globosa Ramanujam, 1987 (Pl. 1, fig. 14)

Clavaperiporites jacobii Ramanujam, 1966

SYSTEMATIC DESCRIPTION

Genus ***Warkallipollenites*** **Rao & Ramanujam, 1984**

Type species- Warkallipollenites erdtmanii Rao & Ramanujam, 1984

Warkallipollenites ramanujamii **sp. nov.**

Pl. 1, figs. 22-23

Holotype- Pl. 1, figs 22-23; size 60x56 µm, BSIP slide no. 11835.

*Type locality-*Kannanellur - Kundara road section, Quilon District, Kerala.

*Age-*Miocene

Diagnosis and description - Pollen grains isopolar, circular to trilobed in polar view. Size range 60-65x56-63 µm. Tricolpate, longicolpate, widened at equator. Exine 7-8.5 µm thick (including sculpture), intectate, prominently clavate-baculate, processes upto 4 µm long, 3 µm wide, very closely placed, heads of process showing pentagonal to triangular (crotonoid pattern) in surface view.

Comparison - Warkallipollenites ramanujamii sp. nov. is closely comparable to the type species *W. erdtmanii* Rao & Ramanujam (1984) in its general characters but the latter is distinguished by densely placed clava surmounted by 3-4 spinules. *Warkallipollenites thanikaimonii* Ramanujam (1987) is smaller in size (44-55µm) and clava-bacula are placed in a distinct radiating pattern, hence not comparable.

*Affinity-*The fossil pollen resembles to the modern genus *Aegialites rotundifolia* and referable to the family Plumbaginaceae (Thanikaimoni, 1987).

Genus ***Plumbaginacipites*** **Navale & Misra, 1979**

Type species- Plumbaginacipites neyvelii Navale & Misra, 1979

Plumbaginacipites navalii **sp. nov.**

Pl. 1, figs 20-21

Holotype- Pl. 1, figs 20-21; size 60x60 µm, BSIP slide no. 11835.

Type locality- Kannanellur-Kundara road section, Quilon District, Kerala.

*Age-*Miocene

Diagnosis and description- Pollen grains isopolar, oblate to spheroidal in polar view. Size range 60-65x60-62 µm. Tricolpate, longicolpate, deep, almost reaching to poles. Exine 2-5 µm thick, gradually thinning towards the colpi margins. Sexine thicker than nexine. Sexine baculate to clavate, very closely placed. Surface showing distinct foveo-reticulate

ornamentation.

Comparison- Plumbaginacipites neyvelii Navale & Misra (1979) is comparable with the present species by its tricolpate condition and nature of exine but the former is distinguished by having bigger size (upto 95µm), thicker exine (5-7µm thick) and distinct micro-reticulate ornamentation.

Affinity-Plumbaginaceae.

Tricolpate pollen type-I

Pl. 1, fig. 12

Description- Pollen grain oval-elongate in equatorial view. Size 55x35 µm. Tricolpate, colpi distinct. Exine 4 um thick Sexine thicker than nexine, sexine 3 µm thick, pilate, nexine 1 µm thick, smooth. Surface showing retipilariate condition.

Locality - Kundara clay mine section, Quilon District, Kerala.

Genus ***Tricolporopilites*** **Kar emend. Singh & Misra, 1991**

Type species-Tricolporopilites robustus Kar, 1985

Tricolporopilites **sp. A**

Pl. 1, figs. 7-8

Description- Pollen grain sub-circular in shape. Size range 37-39x40-44 µm. Tricolporate, pore distinct, 4.5 µm diameter. Exine, pilate, verrucate, verrucae of different sizes, 3 µm thick, 2.5 µm in diameter, surface showing negative reticulum.

Comparison- Tricolporopilites sp. A is closely comparable with the type species *T. robustus* Kar (1985) in its general characters but the latter is distinguished by bigger size (53-70 µm) and interspinal space between pila is granulose.

Locality-Kundara clay mine section, Quilon District, Kerala

Tricolporopilites **sp. B**

Pl. 2, fig. 9

Description-Pollen grain sub-circular in shape. Size 48x46 µm. Tricolporate, pore indistinct due to heavy ornamentation. Exine 6 µm thick, pilate, verrucate. Surface showing scrobiculate ornamentation.

Comparison- Tricolporopilites sp. B is distinct from type species by its thicker exine (6 µm) and scrobiculate ornamentation.

Locality- Kundara clay mine section, Quilon District, Kerala.

Genus ***Retitrescolpites*** Sah, 1967

Types species- Retitrescolpites typicus Sah, 1967

Retitrescolpites **sp.**

Pl. 1, fig. 10

Description- Pollen grain sub-triangular in polar view. Size 41x42 µm. Tricolporate, pore surrounded by thick annulus. Exine 5 µm thick, sexine and nexine differentiated, sexine 3.5 µm thick, pilate, nexine 1.5 µm thick, smooth. Surface showing retipilariate condition.

Comparison- The present species resembles *R. typicus* Sah (1967) in its spherical amb and general characters but differs in the possession of thick annulus around pore.

Locality- Kundara clay mine section, Quilon District, Kerala.

Tricolporate pollen type-I

Pl. 1, fig. 5

Description-Pollen grain sub-triangular. Size 40x47 µm. Tricolporate, brevicolpate, pore sunken. Exine thin, laevigate. Thick attachment scar on surface view.

Locality- Kannanellur-Kundara road section, Quilon District, Kerala

Polycolporate pollen type-I

Pl. 1, fig. 18

Description- Pollen grain sub-circular in shape. Size 56x53 µm. Pentacolpate, colpi long, pore surrounded by thickening. Exine 2 µm thick, foveolate. Surface showing foveo-reticulate ornamentation.

Locality- Kundara clay mine section, Quilon District, Kerala.

Genus ***Verrutriporites,*** **Muller, 1968**

Type species-Verrutriporites lunduensis Muller, 1968

Verrutriporites kundaraensis **sp. nov.**

Pl. 1, figs. 1-2

Holotype-Pl. 1, fig. 2; size 39x40 μm, BSIP slide no. 11830.

Type locality-Kundara clay mine section, Quilon District, Kerala.

Age-Miocene

Diagnosis and description- Pollen grains sub-circular. Size range 36-41x39-42 μm. Triporate, pore 8 μm diameter, slightly thickened around pore. Exine 3-5 μm thick, laevigate, verrucae sparsely placed.

Comparison- Verrutriporites kundaraensis sp. nov. closely resembles with *V. lunduensis* Muller (1968) in its general characters but the latter is distinguished by closely placed verrucae. *V. perverrucatus* Rao & Ramanujam (1982) differs in possessing smaller size (16-23 μm), thinner exine (1.5 μm) and surface showing verrucate ornamentation.

Genus *Triorites* (Erdtman & Cookson) ex Couper, 1953

Type species - Triorites magnificus, Cookson, 1950

Triorites quilonensis sp. nov.

Pl. 1, figs 16-17

Holotype-Pl. 1, fig. 17; size. 49x50 μm, BSIP slide no. 11828.

Type locality- Kundara clay mine section, Quilon District, Kerala.

Age-Miocene.

Diagnosis and description- Pollen grains sub-triangular in polar view. Size range 50-62x49-61 μm. Triporate, pore distinct. Exine 1.5 μm thick, foveolate. Surface showing foveo-reticulate ornamentation.

Comparison- Triorites magnificus Cookson (1950) is closely comparable to the present species by its shape and triporate condition but the former is distinguished by its bigger size and surface showing reticuloid pattern. *T. microreticulatus* Rao & Ramanujam (1982) possesses microreticulate ornamentation and smaller size (13-18 μm), hence not comparable.

DISCUSSION

Palynofloral assemblages of Kundara clay mine section and Kannanellur-Kundara road section consist of fungal remains, pteridophytic spores and angiospermous pollen. Dinoflagellate cysts have also been recorded. The angiosperm pollen dominate over pteridophyte in both the assemblages. Palynomorphs recovered from the above sections have been assigned to 48 genera and 59 species. The important genera are viz., *Crassoretitriletes, Striatriletes, Iridacidites, Quilonipollenites, Dipterocarpuspollenites, Warkallipollenties, Plumbaginacipites, Rhoipites, Tricolporopollis, Tricolporopilites, Margocolporites, Ctenolophonidites, Triorites, Verrutriporites, Polyporina* and *Malvacearumpollis.* Of these, *Warkallipollenites ramanujamii, Plumbaginacipites navalii, Triorites quilonensis* and *Verrutriporites kundaraensis* are proposed as new. The palynomorph assemblages from Kundara clay mine section and Kannanellur-Kundara road section are compared in table-1.

QUALITATIVE AND QUANTITATIVE ANALYSES

The possible botanical affinities of present palynotaxa with the modern distribution of families are given in Table-2.

Quantitative analysis of the assemblage has been done on the basis of palynotaxa in a count of 150 specimens per sample and from such counts, percentage of each palynotaxa was calculated. For the percentage frequency, only 22 species of different genera have been selected from Kannanellur-Kundara road section palynoassemblage and are plotted in Text-fig. 2.

The most dominant palynotaxa of the assemblage occurring throughout the sequence are : *Phragmothyrites eocaenica* and *Ctenolophonidites costatus.* Other important taxa are : *Iridacidites warkalliensis, Quilonipollenites sahnii, Warkallipollenites ramanujamii, Margocolporites tsukadae* and *Tricolporopollis* spp.

Vertical distribution of the palynotaxa clearly indicates that the sequence is divisible into two palynozones; the palynological zone-I and II. In palynological zone-I, the fungal remains are dominant and represented by *Phragmothyrites eocaenica, Notothyrites setiferus* and *Dicellaesporites papovii.* Arecaceous pollen represented by *Quilonipollenites*

Table-1

Name of palynotaxa	KCM	KKRS
Phragmothyrites eocaenica	+	+
Parmathyrites indicus	+	+
P. ramanujamii	+	-
Notothyrites setiferus	+	+
Lirasporis intergranifer	+	+
Kutchiathyrites ecentricus	-	+
Apendicisporonites typicus	+	-
Fungal body type -I	-	+
Dicellaesporites papovi	+	+
Multicellaesporites sp.	-	+
Palaeocirrenalia mioceneca	-	+
Diporisporites sp.	-	+
Lygodiumsporites lakiensis	-	+
L. padappakkarensis	+	+
Striatriletes susannae	-	+
Crassoretitriletes vanraadshooveni	-	+
Cheilanthoidspora mioceneca	+	+
Pilamonoletes excellensus	-	+
Intrapunctisporis harudiensis	+	-
Retipilonapites delicattissimus	-	+
Palmaepollenites keralensis	+	+
Iridacidites warkalliensis	+	+
Quilonipollenites sahnii	+	+
Retimonosulcites ramanujamii	+	-
Tricolpate Pollen type-I	+	-
Lakiapollis ovatus	+	+
Dipterocarpuspollenites retipilatus	-	+
Tricolpites retibaculatus	+	+
Warkallipollenites ramanujamii	+	+
Plumbaginacipites navalii	+	+
Tricolporopollis spp.	+	+
Tribrevicolporites alleppeyensis	+	-
Margocolporites tsukadae	+	+
M. sitholeyi	+	-
Retitrescolpites indicus	+	-
Tricolporopilites spp.	+	+
Marginipollis kutchensis	+	-
Dermatobrevicolporites dermatus	+	+
Paleosantalaceaepites ovatus	+	-
Rhoipites anacardioides	+	-
Favitricolporites magnus	-	+
Meliapollis tamilii	+	-
Tricolporate pollen type-I	-	+
Polycolporate pollen type-I	+	-
Ctenolophonidites costatus	+	+
Triorites quilonensis	+	-
Myricipites singhii	+	+
Proteacidites triangulus	+	+
P. truncatus	+	-
Subtriporopollis rotundis	-	+
Verrutriporites kundaraensis	+	-
Polyporina multiporosa	+	+
P. globosa	+	+
Clavaperiporites jacobii	+	+
Malvacearumpollis bakonyensis	-	+

KCM- Kundara clay mine; KKRS- Kannanellur-Kundara road section

Table -2

Family	Taxa	Climate
Fungal remains		
Microthyriaceae	*Phragmothyrites eocaenica* *Parmathyrites indicus* *P. ramanujami* *Notothyrites setiferus* *Kutchiathyrites eccentricus* *Lirasporis intergranifer*	Warm and humid tropical
Ascomycetes	*Dicellaesporites papovii*	
Basidiomycetes	*Palaeocirrenalia mioceneca* *Multicellaesporites* sp. *Diporisporites* sp.	
Pteridophytic spores		
Schizaeaceae	*Lygodiumsporites lakiensis* *L. padappakkarensis* *Crassoretitriletes vanraadshooveni*	Tropical-subtropical
Parkeriaceae	*Striatriletes susannae*	Tropical-subtropical
Polypodiaceae	*Pilamonoletes excellensus*	Cosmopolitan
Angiospermous pollen		
Anacardiaceae	*Rhoipites anacordioides*	Tropical-subtropical
Arecaceae	*Quilonipollenites sahnii* *Palmaepollenites keralensis*	Tropical-subtropical
Bombacaceae	*Lakiapollis ovatus*	Tropical-subtropical
Caesalpiniaceae	*Margocolporites tsukadae*	Tropical-subtropical
Cheno/ Amarantaceae	*Polyporina multiporosa* *P. globosa*	Tropical-temperate
Ctenolophonaceae	*Ctenolophonidites costatus*	Tropical
Dipterocarpaceae	*Dipterocarpuspollenites retipilatus*	Tropical
Euphorbiaceae	*Tricolporopollis* spp.	Tropical-temperate
Iridaceae	*Iridacidites warkalliensis*	Tropical-temperate
Malvaceae	*Malvacearumpollis bakonyensis*	Tropical-temperate
Meliaceae	*Meliapollis tamilii*	Tropical
Myricaceae	*Myricipites singhii*	Tropical-subtropical
Oleaceae	*Retitrescolpites indicus*	Tropical
Plumbaginaceae	*Plumbaginacipites navalii* *Warkallipollenites ramanujamii*	Tropical-temperate
Potamogetonaceae	*Retipilonapites delicatissimus*	Cosmopolitan
Proteaceae	*Proteacidites truncatus* *P. triangulus*	Tropical
Rhizophoraceae	*Paleosantalaceaepites ovatus*	Tropical
Rubiaceae	*Favitricolporites magnus* *Subtriporopollis rotundis*	Tropical-temperate

and *Iridacidites* are other dominant genera. On the other hand, the angiosperms are dominant in the palynological zone-II and the dominant palynotaxa are : *Warkallipollenites ramanujamii, Margocolporites tsukadae* and *Tricolporopollis* spp. *Dipterocarpuspollenites, Lakiapollis, Warkallipollenites, Retitrescolpites, Polyporina* and *Malvacearumpollis* are restricted to this zone-II only. *Ctenolophonidites costatus* is dominant taxon throughout the sequence (Text-fig. 2).

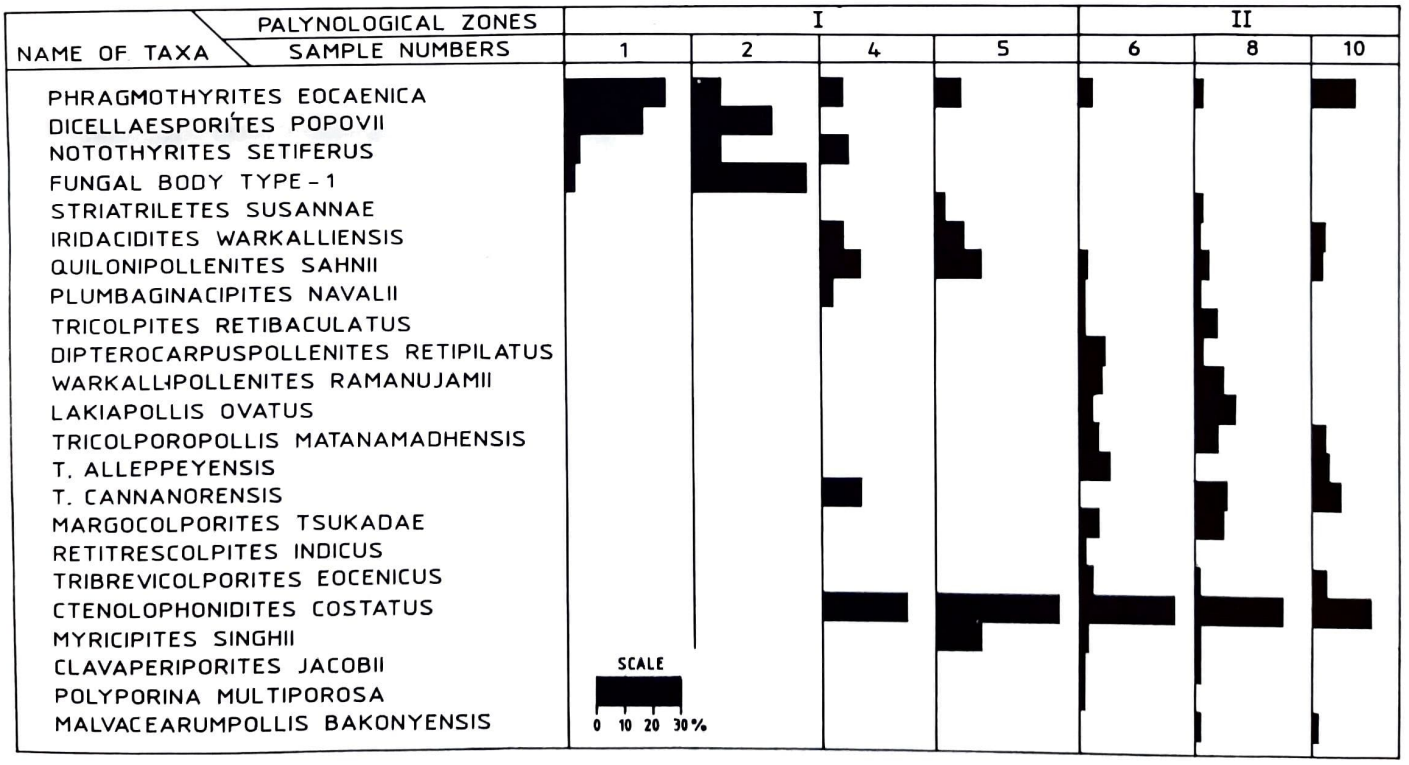
PALYNOFLORAL COMPARISON AND AGE

A comparison of present assemblage with the Neyveli lignite and Ratnagiri beds assemblages is discussed below:

A rich palynoassemblage has been recorded from Neyveli lignite (Miocene), South Arcot district, Tamil Nadu (Ramanujam, 1966, Navale & Misra, 1979 and Singh & Misra, 1991). The following genera are the common to both the assemblages: *Crassoretitriletes, Retipilonapites, Palmaepollenites, Quilonipollenites, Margocolporites, Marginipollis, Ctenolophonidites, Meliapollis, Clavaperiporites, Bacuspinulopollenites, Tricolporopilites, Rhoipites, Plumbaginacipites, Triorites, Polyporina* and *Malvacearumpollis.* The above comparison shows that the present assemblage is largely comparable with the Neyveli lignite, Tamil Nadu.

Saxena and Misra (1991) recorded a palynoflora from the Ratnagiri beds (Miocene) of Sindhudurg district, Maharashtra. The following genera of this assemblage have also been recorded in the present assemblage : *Lygodiumsporites, Striatriletes, Clavaperiporites, Dermatobrevicolporites, Favitricolporites, Lakiapollis, Malvacearumpollis, Paleosantalaceaepites, Quilonipollenites, Retipilonapites, Retitrescolpites, Tricolporopollis* and *Verrutriporites.* The above comparison indicates that the assemblage recorded by Saxena and Misra (1991) is broadly comparable with the present one.

The molluscan fauna and the microfossils of Quilon beds were studied in detail by Dey (1962) and Dutta (1981) respectively. These beds are rich in foraminifera, ostracod and other microfossils. Khosla and Nagari (1989) discussed in detail on the ostracods of Quilon beds. On the basis of



Text-fig. 2. Vertical distribution of palynotaxa in Kannanellur-Kundara road section, Kerala.

palaeonotological observations Quilon bed has been assigned a Lower Miocene (Burdigalian) age. It is now commonly agreed that the upper age limit of this marine bed cannot be younger than Middle Miocene.

A rich palynoflora has also been recorded from the Tertiary sediments exposed in Kannanellur-Kundara area. The important genera are : *Crassoretitriletes, Retipilonapites, Iridacidites, Quilonipollenites, Dipterocarpuspollenites, Warkallipollenites, Plumbaginacipites, Rhoipites, Tricolporopilites, Malvacearumpollis, Polyporina* and *Clavaperiporites*. They are stratigraphically important for the Miocene sediments and their presence in the present assemblage indicates Early to Middle Miocene age and supporting the above view.

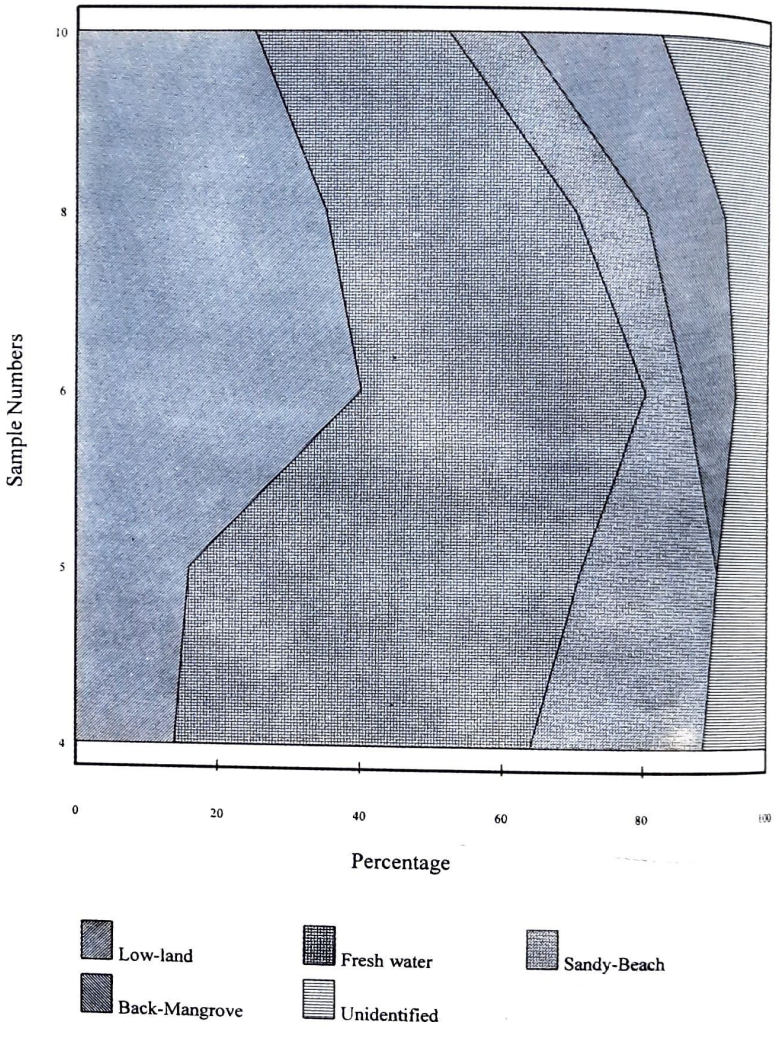
PALAEOECOLOGY

The palynoassemblage of Kundara-Kannanellur area is rich and diversified. It consists of pteridophytic spores and angiospermous pollen. An analysis of these palynofossils as a whole represents palaeoassociations of ecological groups such as low-land, fresh water swamp and water edge, back-mangrove, and sandy beach elements (Table-3).

Table-3

Ecological groups	Taxa
Low-land	*Subtriporopollis, Margocolporites, Lakiapollis, Tricolporopollis, Myricipites.*
Fresh water swamp	*Lygodiumsporites, Striatriletes, and water edge Retipilonapites, tenolophonidites, Meliapollis, Polyporina.*
Back-mangrove	*Warkallipollenites, Malvacearumpollis, Paleosantalaceaepites, Verrutriporites.*
Sandy-beach	*Palmaepollenites, Iridacidites, Quilonipollenites.*

The ecological groups of Kannanellur-Kundara road section shows that fresh water swamp and water edge elements are dominant over the low-land/sandy-beach/back-mangrove elements. The ecological diagram indicates that the deposition of the Kundara-Kannanellur road section sediments could have taken place in a cycle of slightly transgressive, regressive and transgressive phases (Text-fig. 3).



Text-fig. 3. Percentage palynotaxa belong to different ecological groups in Kannanellur-Kundara road section, Kerala.

PALAEOCLIMATE AND ENVIRONMENT OF DEPOSITION

The palynofossils recovered from the present study have affinities with 22 modern families. Of these, 7 families are restricted to tropical, 7 families pertain to tropical to subtropical, 6 families belong to tropical-temperate and 2 families are cosmopolitan in distribution.

The palynoassemblage recovered from the sediments of Kundara-Kannanellur area, Kerala Basin indicates a tropical humid climate with heavy precipitation during the sedimentation. In this connection, the recognition of spores and pollen types of the following families, viz., Schizaeaceae, Parkeriaceae, Anacardiaceae, Caesalpiniaceae, Ctenolophonaceae, Dipterocarpaceae, Oleaceae and Rubiaceae in support the above view. The microthyriaceous fruiting bodies *(Phragmothyrites, Notothyrites, Kutchiathyrites, Dicellaesporites, Palaeocirrenalia* etc.*)* are typical ephiphyllous fungi and their occurrence in the present assemblage indicates the existence of terrestrial plant eco-system and supports a warm and humid condition and heavy rainfall.

The pteridophytic elements generally favour moist and shady habitat. Presence of *Lygodiumsporites, Striatriletes* and *Crassoretitriletes* is indicative of fresh water swamps and ponding conditions near the site of the deposition. The occurrence of pollen grains belonging to Arecaeae and Bombacaceae indicates that these plants had luxuriant growth and helped in developing rich vegetation in the area. The presence of dinoflagellate cysts and back-mangrove pollen in the palynoflora indicates that there was influx of brackish-water during deposition. Pollen belonging to Amarantaceae/ Chenopodiaceae *(Polyporina)* are salt loving and occur near sea-coast. The montane elements may have been derived from long distance.

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