

# Palynofloral analysis of sections from Bharathi and Kundara clay mines of Kerala Basin: Palaeoecological and tectonic perspective

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The carbonaceous clay beds and lenses of peat belonging to Bharathi and Kundara clay mine sections of Warkalli Formation have yielded a well-preserved palynoflora. The assemblage represents a mixture of ecological groups such as low-land, freshwater, and sandy beach elements. The recognition of salt glands signifies that the palynoflora has affinity with mangrove swamp/coastal vegetation. The relative abundance of fungal remains is indicative of a high organic input environment and a warm, humid climate with heavy rainfall during the deposition. Occurrence of *Compositoipollenites*, *Malvacearumpollis*, *Quilonipollenites*, *Trilatiporites* and *Ctenolophonidites costatus* suggests Neogene (Miocene) age. The assemblage is contemporaneous of 'Ratnagiri Beds' of Maharashtra coast as they were deposited in a near-shore environment and their floristic composition is comparable. Nevertheless, the Warkalli deposits remained relatively stable unlike the 'Ratnagiri Beds' which have been subjected to post-depositional displacement caused by tectonic activity. Analysis of accrued fossil pollen evidence and disjunct distribution of plant taxa in a tectonic perspective have also been discussed.

DURING our studies on the kaolin deposits in the coastal tract of South Kerala, carbonaceous clay beds and small bands and lenses of peat have been observed in the ceramic clay mine sections of Bharathi and Kundara<sup>1</sup>. As these deposits contain rich organic matter, the samples have been subjected to palynological study in order to ascertain the floristic composition and also to derive palaeoecological information, which is the main objective of this communication. The samples investigated belong to the Upper Tertiary sedimentary sequence (Warkalli Formation) of the Kerala Basin<sup>2</sup>.

The details of location (Figure 1) and clay mine profiles from where the samples were obtained are given below:

The Bharathi clay mine ( $8^{\circ}37'38''$ : $76^{\circ}49'1''$ ) is located at Sasthavattom of Thiruvananthapuram district. The mine section (Figure 2a) shows 10–13 m thick bed of white clay, overlain by a soil column containing laterite pebbles, of thickness up to 6 m. A lens of peat (CC 28)

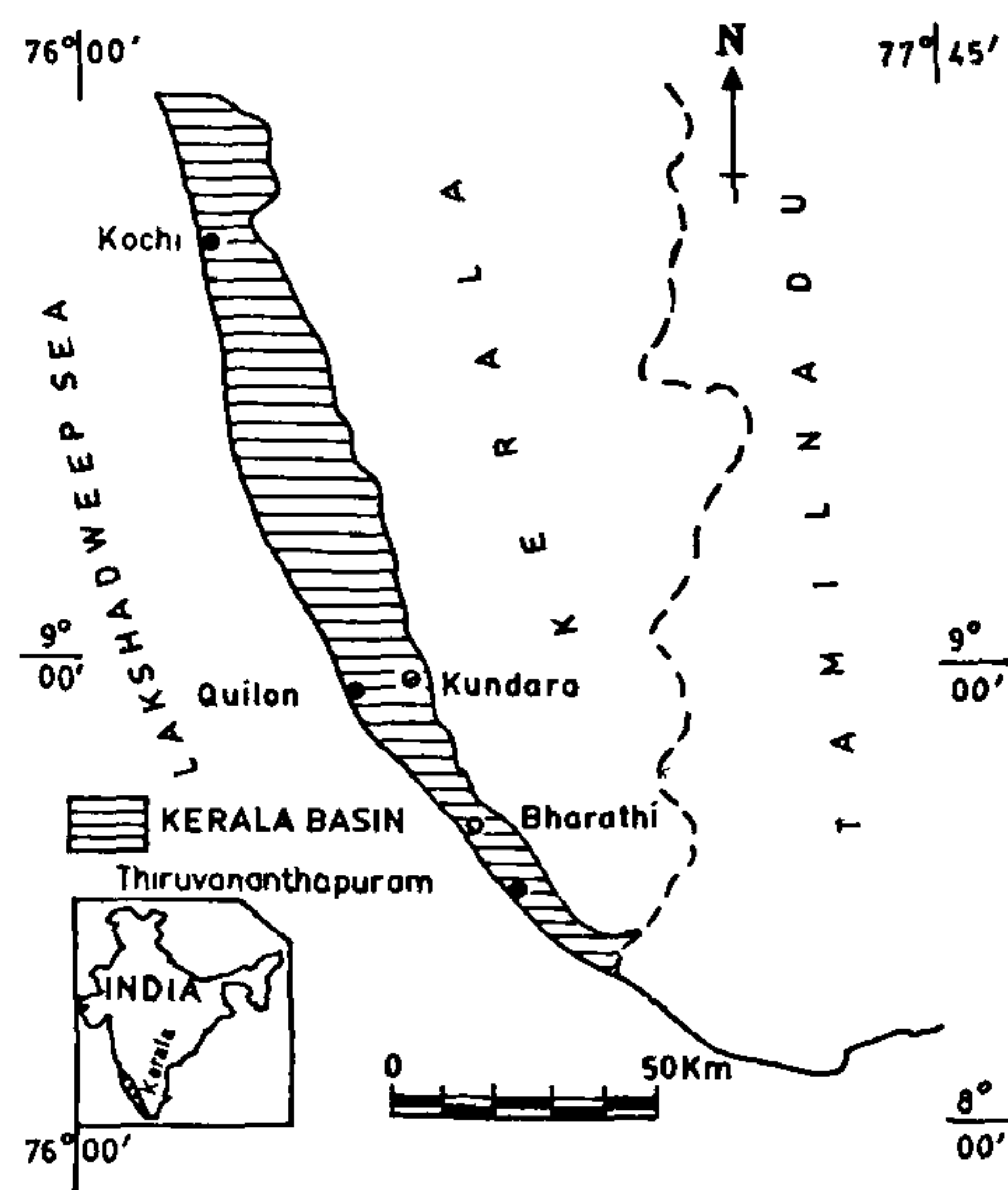


Figure 1. Map showing sampling localities.

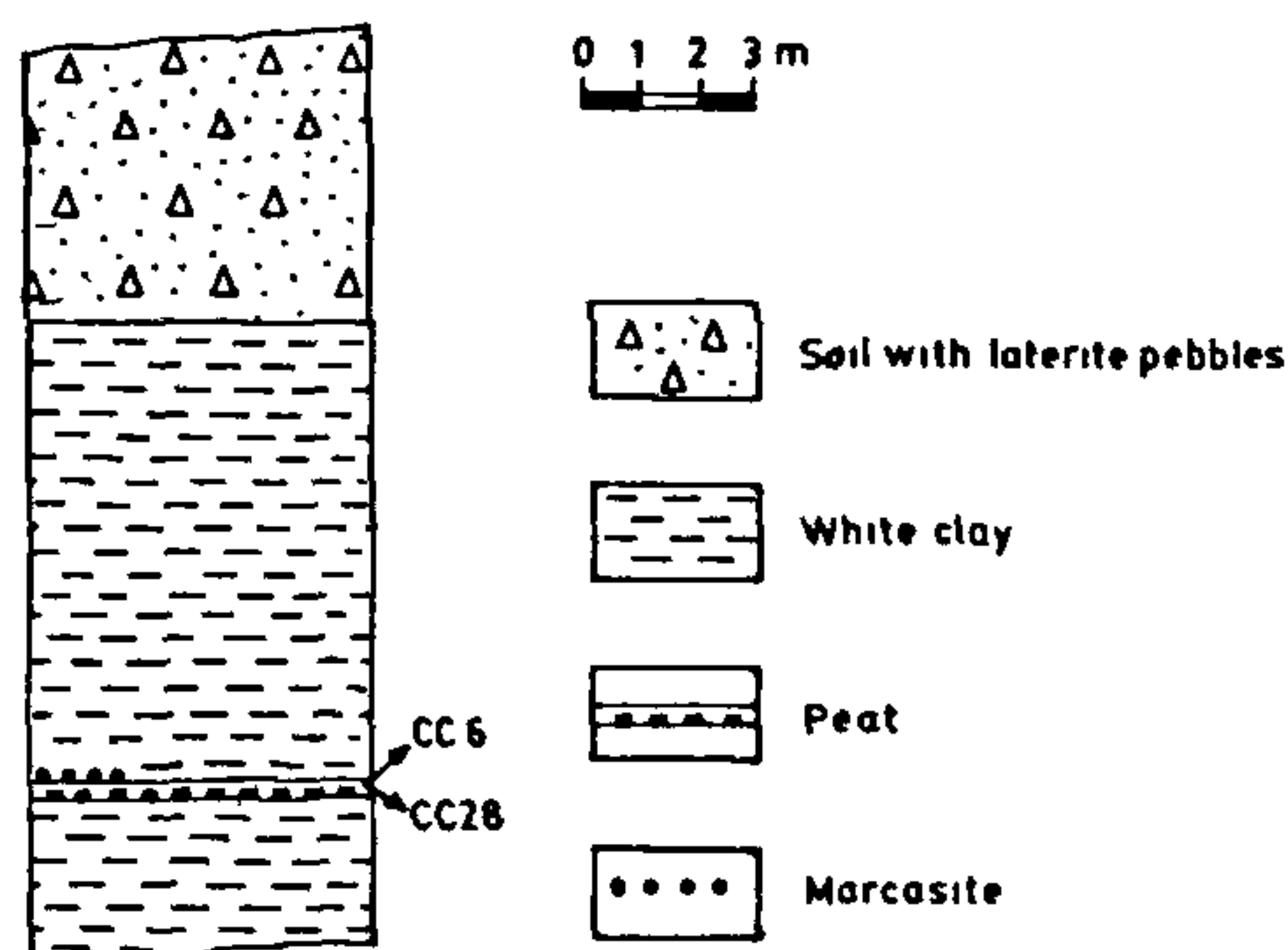


Figure 2a. Synoptic profile of Bharathi clay mine, Sasthavattom.

with associated marcasite occurs at a depth of 13.5 m from the surface within the white clay bed.

The Kundara clay mine section ( $8^{\circ}58'$ : $76^{\circ}40'6''$ ) shows a massive thick sequence unconformably overlying the Precambrian crystalline gneiss (Figure 2b). The maximum height of the southern wall of the mine is 50.7 m and the basal portion consists of residual clay having a thickness of 8 m. Residual clay is overlain by a sequence of sedimentary clay having thickness of 40 m and within this, carbonaceous clays, ball clays, variegated clays and pink clays occur alternatively. Although both the sections are separated by a considerable distance, the lithological features almost remain the same. Further field observations and details of synoptic profiles of Bharathi and Kundara clay mines have been dealt separately in the previous work<sup>1,3</sup>.



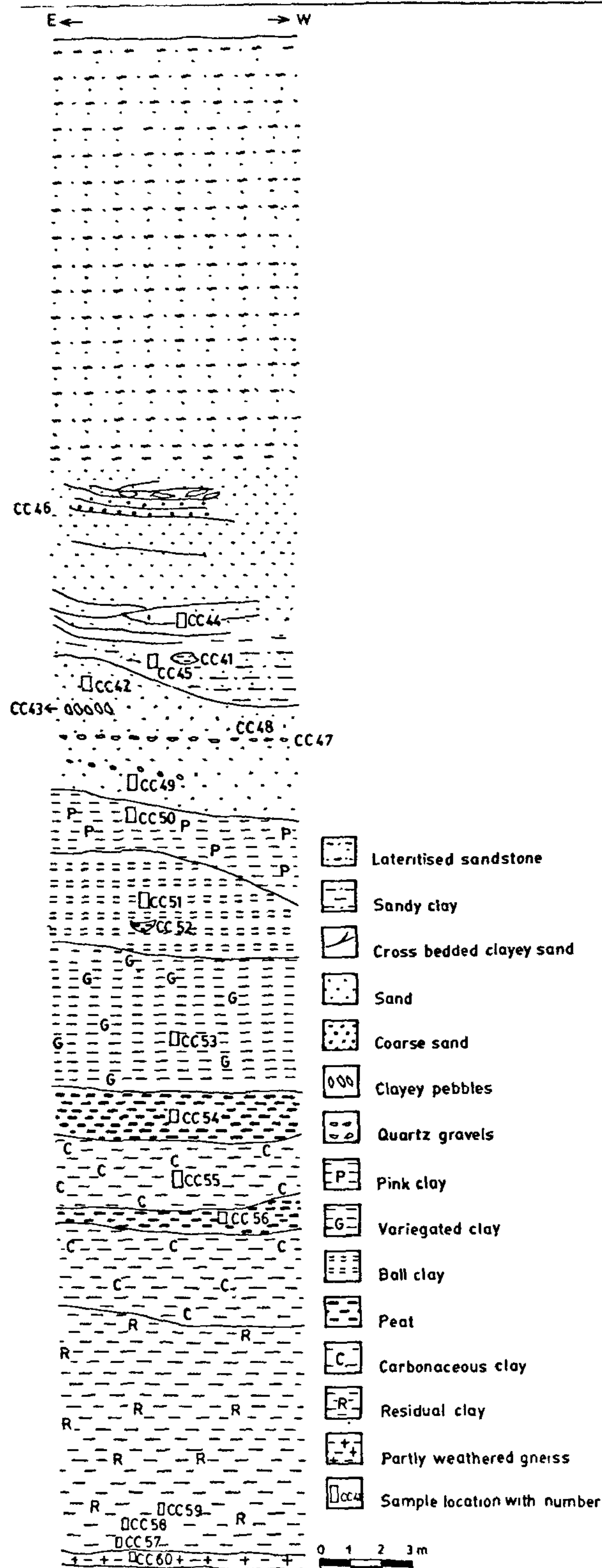


Figure 2b. Synoptic profile of Kundara clay mine.

Table 1. Details of samples and location

Sample	Lithology	Location
CC-6	Carbonized wood	Bharathy Clay Mine, Sasthavattom
CC-28	Peat	Bharathy Clay Mine, Sasthavattom
CC-41	White clay	Kerala Ceramics Clay Mine, Kundara
CC-45	White clay	Kerala Ceramics Clay Mine, Kundara
CC-50	Pink clay	Kerala Ceramics Clay Mine, Kundara
CC-51	Ball clay	Kerala Ceramics Clay Mine, Kundara
CC-52	Peat	Kerala Ceramics Clay Mine, Kundara
CC-53	Variegated grey clay	Kerala Ceramics Clay Mine, Kundara
CC-54	Peat	Kerala Ceramics Clay Mine, Kundara
CC-55	Carbonaceous clay	Kerala Ceramics Clay Mine, Kundara
CC-56	Peat	Kerala Ceramics Clay Mine, Kundara

The samples analysed are mainly carbonaceous clays, peat and other clays. The details of samples analysed are given in Table 1. Of the 11 samples macerated, only six proved to be productive (CC28, 51, 53, 54, 55 & 56), while the rest, particularly white and pink clays, were found to be non-polleniferous. Palynomorphs recovered from the samples were processed using the conventional separation methods followed by the ultrasonic cleaning to get rid of the finer particles adhering to the palynomorphs. The slides of figured specimens (Figures 3a-n, 4a-t) are deposited in the repository of palynological collections in the Geology and Palaeontology Laboratory for future reference.

The palynoflora recovered from the Bharathi and Kundara clay mines consists of pteridophytic spores, fungal remains and angiospermous pollen grains. Besides, the assemblage contains large number of cuticles, organic spherules and salt glands. The palynotaxa identified are given below:

#### Fungal remains: Spores and fruiting bodies

*Dyadosporonites* sp.; *Lirasporis* sp.; *Parmathyrites indicus* Jain & Gupta 1970; *Phragmothyrites eocaenica* Edward 1922.

#### Pteridophytic spores

*Cheilanthoidspora monoleta* Sah & Kar 1974; *Cingulatisporis* sp.; *Dandotiaspora plicata* (Sah & Kar) Sah, Kar & Singh 1971; *Osmundacidites cephalus* Saxena 1978; *Polypodiaceasporites* sp.; *Polypodiisporites* sp.; *Lygodiumsporites* sp.

#### Angiospermous pollen grains

*Compositoipollenites minimus* Ramanujam 1987; *Crotonoidaepollenites euphorbioides* Rao & Ramanujam 1982; *Ctenolophanidites costatus* (V. H. Klinkenberg) V. H. Klink. 1966; *Dermatobrevicolporites dermatus* (Sah & Kar) Kar; *Droseridites spinosa* (Cookson) Potonie 1960; *Jandufouria seqmrogiformis* Germeraad,



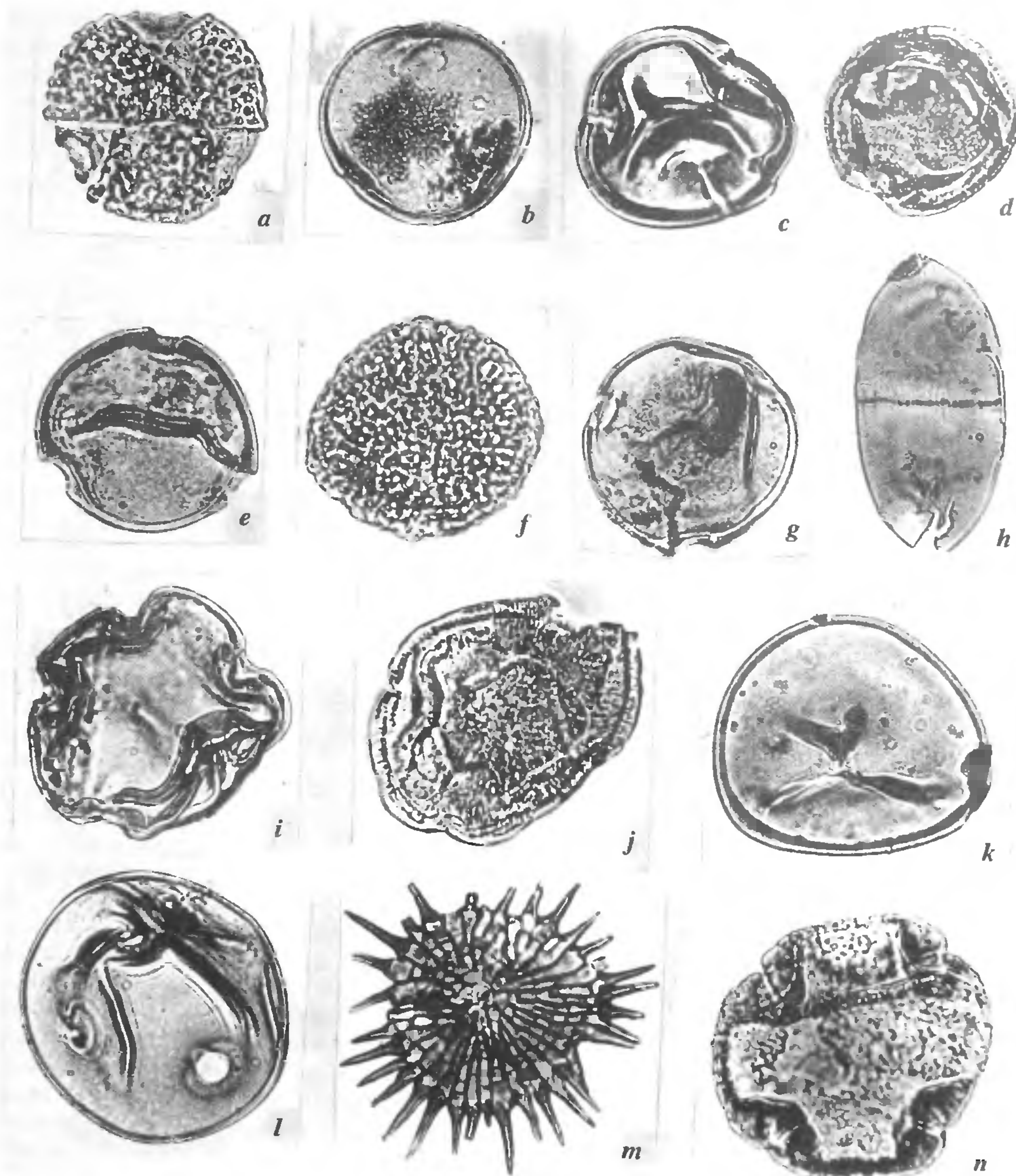


Figure 3. *a*, *Margocolporites tsukadai* Ramanujam; *b*, *Tricolporopollis* sp.; *c*, Zonocolpate pollen grain; *d*, *Retitricolporites crassirotatus* Rao & Ramanujam; *e*, *Dermatobrevicolporites dermatus* (Sah & Kar) Kar; *f*, *Crotonodaepollenites euphorbioides* Rao & Ramanujam; *g*, *Tricolporopollis* Rao & Ramanujam; *h*, *Dyadosporonites* sp.; *i*, *Meliapollis* sp.; *j*, *Jandufouria seamrogoformis* Germeraad, Hopping & Muller; *k*, *Dandotiaspora plicata* (Sah & Kar) Sah, Kar & Singh; *l*, *Lakiapollis ovatus*, Venkatachala & Kar; *m*, *Parmathyrites indicus* Jain & Gupta; *n*, *Meliapollis* sp. cf. *M. tamilii* Navale & Misra. (All photomicrographs are ca  $\times 650$ ).

Hopping & Muller 1968; *Lakiapollis ovatus* Venkatachala & Kar 1969; *Longapertites* sp.; *Malvacearumpollis estelae* (Germeraad, Hopping & Muller) Hekel 1972; *Margocolporites sitholeyi* Ramanujam 1966; *Margocolporites tsukadai* Ramanujam 1966; *Meliapollis tamilii* Navale & Misra 1979; *Meliapollis quadrangularis* (Ramanujam) Sah & Kar 1970; Rhizophoraceae (*Zonocostites*) type pollen grains; *Quilonipol-*

*lenites* sp. cf. *Q. sahnii* Rao & Ramanujam 1978; *Retitricolporites crassirotatus* Rao & Ramanujam 1982; *Tricolporopollis* sp.; *Trilatiporites* sp.; *Tricolpites crassireticulatus* Dutta & Sah 1970; *Tricolporopollites pseudoreticulatus* Kar 1985; Zonocolpate type.

Of the above-mentioned species, *Margocolporites* are abundant in the assemblage. *Meliapollis* is also fairly represented. Pollen grains belonging to Rhizophoraceae



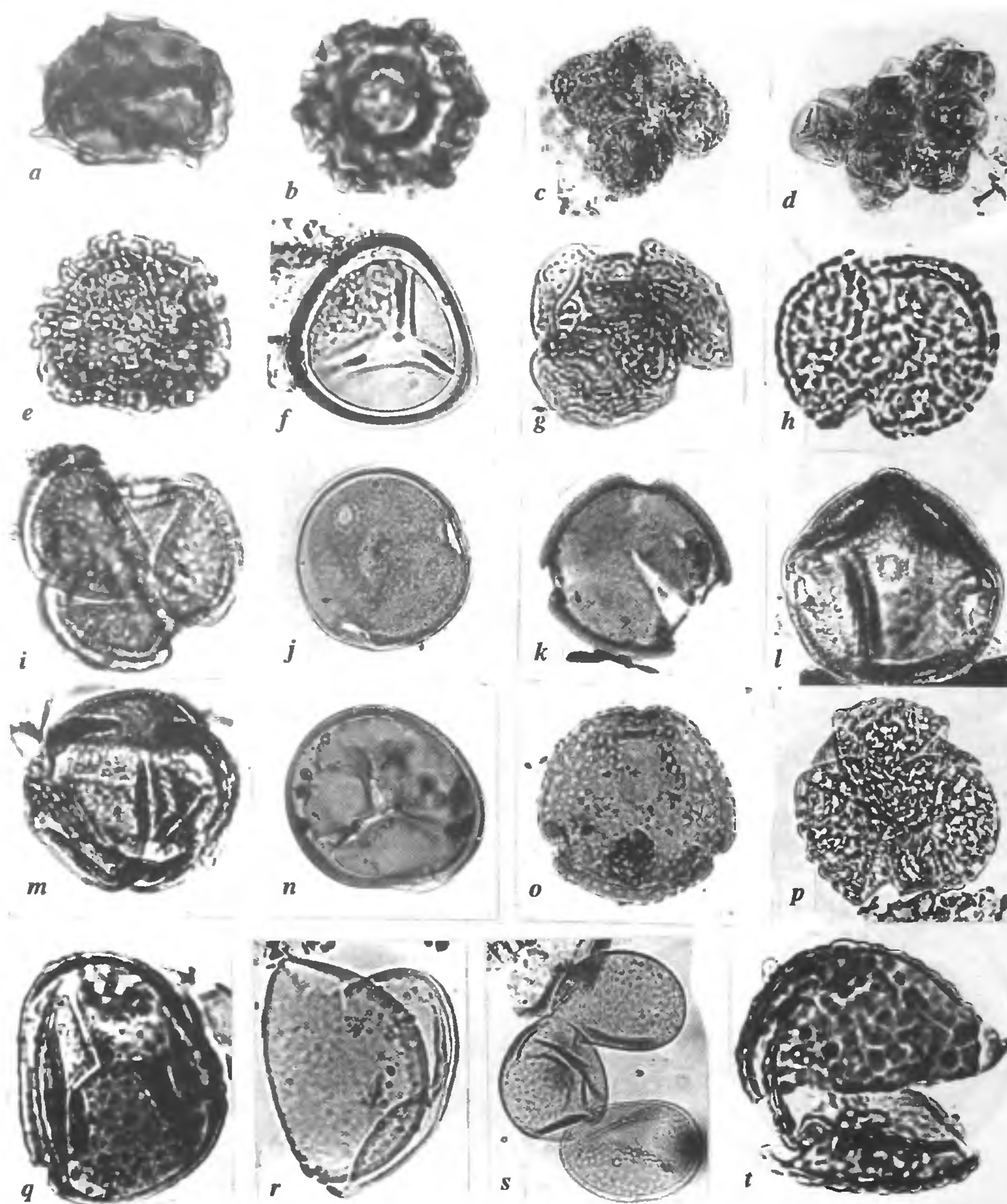


Figure 4. *a*, *Malvacearumpollis estelae* (Germeraad, Hopping & Muller) Hekel; *b*, *Ctenolophonidites costatus* sp. (Van Hoeken-Klinkenberg) Van Hoeken-Klinkenberg; *c*, *Droseridites spinosa* (Cookson) Potonie; *d*, *Palaeosantalaceapites* sp. (Group of pollen grains); *e*, *Cheilantheidspora monoleta* Sah & Kar; *f*, *Cingulatisporites* sp.; *g*, ? Group of Monocolpites finely reticulate pollen grains; *h*, *Quilonipollenites* sp.; *i*, *Tricolpites crassireticulatus* Dutta & Sah; *j*, *Tricolporopollis* sp.; *k*, *Meliapollis quadrangularis* (Ramanujam) Sah & Kar; *l*, *Trilutiporites* sp. cf. *T. normei* Ramanujam; *m*, *Rentricolporites crassirostratus* Rao & Ramanujam; *n*, *Lygodiumsporites* sp.; *o*, *Tricolporopilites pseudoreticulatus* Kar; *p*, *Margocolporites sitholei* Ramanujam; *q*, *Osmundacidites cephalus* Saxena; *r*, *Longapertites* sp.; *s*, *Polypodiaceuesporites* sp. (3 spores together); *t*, *Polypodisporites* sp. (All photomicrographs are ca  $\times 550$ ).

(*Zonocostites*) occur mainly in groups attached to cuticles. *Lakiapollis ovatus* is another significant taxon of the assemblage. *Polypodiisporites* and *Polypodiaceâsporites* of Polypodiaceae are the important elements of the Pteridophytes. Only some of the forms have

been assigned to earlier published taxa, whereas others are referred to informal species.

The occurrence of *Ctenolophonidites*, *Droseridites*, *Jandufouria*, *Lakiapollis*, *Malvacearumpollis*, *Margocolporites*, *Meliapollis* and *Zonocostites* type of pollen



grain in the assemblage is significant as they are of stratigraphical and palaeocological importance<sup>4-8</sup>. The assemblage as a whole represents a mixture of ecological groups such as low-land, freshwater, mangrove and sandy beach elements, particularly that of the Bharathi clay mine. However, in the Kundara clay mine, the palynofloral spectrum could be differentiated at various levels of sampling. For example, sample CC-56 yielded mainly pteridophytic spores while CC-55 is rich in *Tricolpites crassirotatus*. The occurrence of angiospermous pollen grains namely *Margocolporites tsukadai* and *Meliapollis* spp. has been found to be increasing towards higher levels of sampling in the section. Fungal fruiting bodies are abundant, indicating heavy rainfall and high humidity. The recognition of salt glands in the sediments signifies that the palynoflora has an affinity with mangrove swamp/coastal vegetation. Presence of *Compositoipollenites*, *Malvacearumpollis*, *Margocolporites*, *Meliapollis* spp., *Quilonipollenites* and *Tricolporopilites* indicates that the carbonaceous clays and peat samples belong to the Upper Tertiary<sup>4-11</sup>.

The palynofloral assemblage does compare well with the other known contemporaneous deposits of the West coast as they have common floral elements. The palynoflora obtained from the 'Ratnagiri beds' resting on Deccan Trap having a few metre thickness, at Kotwade, Bankhot-Velas and Parchuri of Ratnagiri district of Maharashtra State have several comparable taxa. As this flora<sup>12</sup> was recovered from the deposits which occur at higher altitude of 100–120 m ASL, the assemblage described here comes from a considerably lower altitude, indicating that the former has been subjected to uplift during the post-Miocene age as suggested by several workers<sup>13,14</sup> while the deposits studied here were accumulated in a basin which remained relatively stable as reported earlier<sup>15-17</sup>.

Although palynological work has been done covering the Warkalli, the Quilon and the Vaikom formations, a finer resolution of the age of the entire sedimentary sequence of the Kerala basin is yet to be achieved<sup>7</sup>. Most of the published reports on palynoflora are sporadic covering either of one or two formations. Moreover, palynological data of the subsurface sediments are meagre to have meaningful biostratigraphy and to correlate the entire Tertiary sequence overlying the Archean basement. Therefore, it would be worthwhile to analyse more subsurface samples collected from widely drilled boreholes from Kanyakumari in the South to Kasargod in the North for finer resolution of age and a better understanding of palaeoecology and vegetational history of the Kerala coast using palynology as a tool.

Considering the pronounced neotectonic activity along the Maharashtra coast compared to the Kerala deposits, there would be further scope in analysing the palynological evidence for reasonable estimates of dispersal

probabilities of several taxa that had been growing along the West coast of India. The palynological evidence *vis-à-vis* present day distribution<sup>18</sup> of *Ctenolophon*, *Durio*, *Pentac*, *Sclerosperma*, *Syagrus*, *Nyssa*, *Elaeis*, *Gunnera*, *Kielmeyera*, *Nypa* and *Eugeissona*, to mention a few, does indicate that ecological stress brought about by tectonic activity might have played a decisive role in their displacement from the West coast of India. However, we have yet to establish the probable reasons for their disjunct distribution and restricted occurrences at oceanic distances as we do not have a comprehensive analysis of pollen data from the West coast. As not much thought is given to the phenological response/readjustment of the species<sup>19</sup> in relation to plate tectonic activity, it would be worth examining the palynological data that are being accrued in that perspective. We have to ponder and adopt a holistic approach<sup>20</sup> so that the role of tectonic activity and the accompanying change in physiography and climatic vicissitudes in geosphere and phytosphere could be understood in a much better way.

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