PALYNOLOGICAL INVESTIGATION OF AKLI LIGNITE, RAJASTHAN, INDIA

PRONAB NASKAR & SUBHENDU KUMAR BAKSI

Department of Geological Sciences, Jadavpur University, Calcutta, India

ABSTRACT

The paper presents the first account of the microfloral assemblage of Akli Lignite. The palynological assemblage of the lignite is recovered from the subcrop lignite of dug-well sections a around depth of 30 metres near Kapurdi (25°54′30″: 71°22′30″) (the well locally known as *Bachal Singh Ka Kua*). This is characterized by the dominance of angiosperms with subdued amount of pteridophytes, the gymnosperms being practically absent. 25 genera and 34 species of dispersed fossil spores and pollen grains are described. Of these, 1 genus and 9 species are new. The overall assemblage recovered so far at this preliminary stage of investigation suggests a Palaeocene-Eocene age for this lignite sequence.

INTRODUCTION

THE Barmer embayment represents a series of sedimentary sequences from Cretaceous to Pleistocene and Recent formations as shown later in synoptic stratigraphy of the area (p. 315). The lignites which occur as lenses and pockets within the Akli Formation have been informally named as 'Akli Lignite'. The Akli Formation is a bentonitic clay sequence with sandstones and shales as intercalations. Although the lignite is not of economic importance due to its scanty occurrence as lenses and pockets, the rich palynological assemblage recovered from the lignite helps in age determination of the lignite and thus has significant bearing on the stratigraphy of the associated sediments.

REVIEW OF PREVIOUS WORK

A review of previous work reveals that none has attempted for the systematic stratigraphy of the Barmer basin. Many have worked on different aspects of different formations of the basin. The geology of the area was briefly discussed by Blanford (1876), Oldham (1886), La Touche (1902), and Bhola (1947). Most of the works were concentrated on the bentonitic clay deposits of the Akli Formation. Barooah (1946) only reported a few molluscs and foraminifers from the Fuller's Earth bed of Kapurdi Formation without any systematic description of the remains. Similarly, he (1950) also reported some fossil fish and crabs from the same deposit. Glaessner and Rao (1957) reported a new species of crab from the Fuller's Earth deposit. Another new species of crab was reported by Glaessner and Rao in 1960. Ghouse and Datar (1961) have identified *attapulgite* as a major mineral in the Fuller's Earth bed. Prasad (1961) identified Decapod crustaceans from the same deposit. Srivastava (1961) reported wood tracheids, wood and ray parenchymatous cells and a few tricolpate pollen grains from the bentonite deposits. The comparative study of the Barmer basin and the adjacent Jaisalmer basin was undertaken by Siddiquie (1963). *Panaeid shrimps*, a new species of Nuculana Link and a new fossil percoid fish was reported by Tiwari in 1963, 1966 and 1968 respectively from the Fuller's Earth deposit at Kapurdi. *Matsyana*, a new fossil fish genus was reported by Singh and Choudhury (1972) from the same Fuller's Earth deposit of Bothia Village, Barmer District.

La Touche (1911) reported first the occurrence of angiospermous leaves from Barmer sandstone. The preliminary note by Bose (1949) with photographs of an impression and three pollen grains, the occurrence of fossil leaves and fruits of the family Guttiferae reported by Lakhanpal and Bose (1951) and Lakhanpal (1964) from the Fuller's Earth bed and the findings by Bose (1952) of the occurrence of dicot leaves, spores, pollen and funga remains from the Barmer sandstone are the only information regarding the palaeobotanical and palynological contents of the area. Singh and Natarajan (1950) compared the fossil pollen grains which were reported by Bose (1949) from the area. The worth mentioning and latest palynological work of the area was by Jain, Kar and Sah (1973) on the Barmer Formation and they came to the conclusion that the Barmer Formation cannot be older than the Palaeocene.

The sedimentary sequence present in the area as deduced in the present work lies on a basement made up of Malani igneous suite and are partly marine, partly estuarine and partly fresh water in origin. The stratigraphic sequence of the rock formations is given below:

Recent to Sub-Recent	: Blown Sand, Gypsite
Eocene to	Kapurdi Formation Matajika Dungar Formation Akli Formation
Palaeocene	Barmer Formation
Palaeocene	Fatehgarh Formation
	......Unconformity......
Lower Cretaceous	Sarun Hill Formation
	......Unconformity......
Middle Jurassic	Jaisalmer Formation
Lower to Middle Jurassic	Lathi Formation
	......Unconformity......
Pre-Cambrian	Malani igneous suite

MATERIAL AND METHODS

The material consists of dark brown lignite samples collected from dug wells of the Akli Formation from near Kapurdi (Map 1), Rajasthan. The soft, fragile lignite samples were broken into small pieces and treated with 25% HNO_3 for 2 to 2½ hours, then diluted and kept for 24 hours. The macerated residue was then repeatedly washed in distilled water and kept in 5% Na_2CO_3 for 3 to 4 minutes. The residue was repeatedly washed in distilled water to remove alkali. A good number of permanent and single grain slides have been made with D. P. X. mountant and glycerine jelly. The lignite samples and the prepared slides are in the collection of the Palaeontological Laboratory of the Department of Geological Sciences, Jadavpur University, Calcutta.

SYSTEMATIC PALYNOLOGY

Anteturma — *Sporites*
Turma — *Triletes*
Subturma — *Azonotriletes*
Infraturma — *Laevigati*

Genus — *Cyathidites* Couper, 1953

Cyathidites minor Couper, 1953
Pl. 1, fig. 1

Description — Spores trilete, 60·0-63·0 μ in diameter; sub-triangular, angles broadly rounded, interapical regions convex; laesurae clearly defined, short, measuring 10·0-15·0 μ in length, thin. Exine 2·0 μ thick, psilate.

Natural Affinity — Cyatheaceae.

Cyathidites australis Couper, 1953
Pl. 1, fig. 2

Description — Spores trilete, 54·0-57·0 μ in diameter; sub-triangular, angles broadly rounded; laesurae distinct, long, measuring 19-25 μ in length, wide. Exine > 2·0 μ thick, thicker at the angles (3·0 μ), psilate.

Natural Affinity — Cyatheaceae

Genus—*Dandotiaspora* Sah, Kar & Singh, 1971

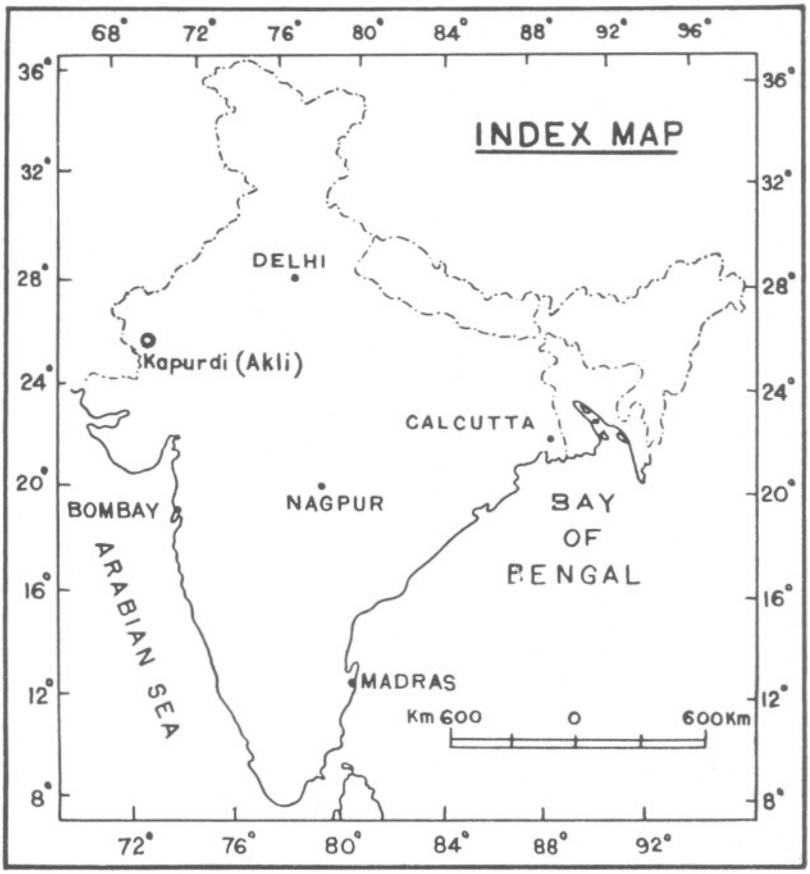
Dandotiaspora dilata (Mathur) Sah, Kar & Singh, 1971
Pl. 1, fig. 3

Description — Spores trilete, 50·0-77·0 μ in diameter; sub-triangular, angles widely rounded, interapical margins slightly convex; laesurae well-defined, long, measuring 27·0-31·0 μ in length, 4·5-6·5 μ wide, with characteristic crescent-shape thickenings of exine at the ray terminals. Exine > 3·0 μ thick, appears to be thickened (3·0 μ) at the apices, psilate.

Natural Affinity — Unknown.

Dandotiaspora plicata (Sah & Kar) Sah, Kar & Singh, 1971
Pl. 1, fig. 4

Description — Spores trilete, 69·0 μ in diameter; sub-triangular, angles very widely



MAP 1

rounded, interapical margins convex; laesurae distinct, moderate, measuring 16·0-24·0 μ in length, thin, thickenings appear at the ray angles. Exine 1·5 μ thick, thicker at the apical regions (> 2·0 μ), psilate.

Natural Affinity — Unknown.

Genus — *Dictyophyllidites* Couper, 1958

Dictyophyllidites sp.

Pl. 1, fig. 5

Description — Spores trilete, 65·0 μ in diameter; sub-triangular, angles broadly rounded, interapical margins convex; laesurae clearly defined, moderate, measuring 19·0-25·0 μ in length, having a distinct margo, wide. Exine uniformly 3·0 μ thick, psilate.

Natural Affinity — *Dictyophyllidites* may belong to the family Matoniaceae and Cyatheaceae.

Genus — *Stereisporites* Pflug, 1953

Stereisporites assamensis Sah & Dutta, 1967

Pl. 1, fig. 6

Description — Spores trilete, 62·0 μ in diameter; subspheroidal; laesurae well-defined, long, extending almost to the equatorial margin, gaping. Exine 2·0 μ thick, psilate.

Natural Affinity — Uncertain.

Genus — *Deltoidospora* (Miner, 1935) Potonié, 1956

Deltoidospora sp.

Pl. 1, fig. 7

Description — Spores trilete, 50·0 μ in diameter; triangular, angles broadly rounded, inter-apical margins slightly concave to straight; laesurae distinct, long, measuring 16·5 μ in length, thin, slender. Exine < 1·5 μ thick, psilate.

Natural Affinity — Uncertain.

Turma — *Monoletes*
Subturma — *Azonomonoletes*
Infraturma — *Psilamonoleti*

Genus — *Laevigatosporites gracilis* Wilson & Webster, 1946

Laevigatosporites gracilis Wilson & Webster, 1946

Pl. 1, figs. 8, 9

Description — Spores monolete, 22·0-24·0 × 33·0-34·5 μ; lateral view plano-convex to slightly concavo-convex, proximal view oval; lete narrow, measuring 27·0 μ in length, with pointed ends. Exine 1·5 μ thick, psilate.

Natural Affinity — Wilson and Webster are of the opinion that *L. gracilis* might be related to the spores of *Thylepteris*, *Asplenium*, *Athyrium*, *Aspidium* and *Blechnum*.

Infraturma — *Sculptatomonoleti*

Genus — *Polypodiidites* (Ross) Potonié, 1966

Polypodiidites ratnami Ramanujam, 1966-1967

Pl. 1, fig. 10

Description — Spores monolete, 27·0 × 42·0 μ; proximal view oval; lete long, measuring 30·0 μ in length, thin. Exine 2·0 μ thick, surface verrucate, verrucae hemispherical, numerous, widely spaced, sparse near the lete.

Natural Affinity — *P. ratnami* is related to the family Polypodiaceae.

Genus — *Schizaeoisporites* Potonié, 1951

Schizaeoisporites digitatoides (Cookson) Potonié, 1951

Pl. 2, fig. 11

Description — Spores monolete, 22·0-36·0 × 43·0-52·0 μ; lateral view concavo-convex to plano-convex, lete long, wide, ends blunt. Exine 1·5 μ thick, surface distinctly striated, longitudinally oblique, closely spaced, ridges and grooves 1·0-1·5 μ thick.

Natural Affinity — *S. digitatoides* resembles the spores of modern *Schizaea digitata* and *S. spirophylla* (Selling, 1944; Cookson, 1956; Bolkhovitina, 1961).

Schizaeoisporites sarnuensis sp. nov.

Pl. 2, figs. 12, 13

Diagnosis — Spores monolete, 28·0-30·0 × 42·0-46·0 μ; lateral view plano-convex, proximal view oval; lete long, extending almost end to end, slender with pointed ends. Exine 1·5 μ thick, surface prominently striated, striae widely spaced, 14-16 in number, longitudinally oblique, ridges and grooves are more or less uniformly thick (2·0-2·5 μ).

Comparison — *S. sarnuensis* sp. nov. is characterized by its long, slender lete, wide spacing of striae and greater thickness of ridges and grooves.

Holotype — Pl. 2, fig. 12; Slide no. S-44.

Natural Affinity — Related to the family Schizaeaceae.

Schizaeoisporites perforatus sp. nov.

Pl. 2, fig. 14

Diagnosis — Spores monolete, 24·0-26·0 × 30·0-33·0 μ; lateral view concavo-convex; lete long, slender with pointed ends. Exine 1·0 μ thick, surface distinctly striated, striae closely spaced, longitudinally oblique, pitted, pits distributed uniformly throughout the surface, ridges thin, grooves comparatively thicker (1·5 μ) than the ridges.

Comparison — *S. perforatus* sp. nov. is clearly differentiated from the other known species of the genus by its uniform pitted surface.

Holotype — Pl. 2, fig. 14; Slide no. S-9.

Natural Affinity — *S. perforatus* sp. nov. is most probably related to the family Schizaeaceae.

Anteturma — *Pollenites*
Turma — *Aletes*
Subturma — *Azonaletes*
Infraturma — *Psilonapiti*

Genus — *Inaperturopollenites* (Pflug) Potonié, 1958

Inaperturopollenites sp.

Pl. 2, figs. 15, 16

Description — Pollen grains broadly subspheroidal, 25·0-28·0 μ in diameter, inaperturate. Exine 1·0 μ thick, columellae absent, psilate, surface with a number of secondary folds, more or less longitudinally parallel.
Natural Affinity — Uncertain.

Turma — *Plicates*
Subturma — *Trichotomocolpates*
Infraturma — *Eutrichotomosulcate*

Genus — *Trichotomosulcites* Couper, 1953

Trichotomosulcites thumbliensis sp. nov.

Pl. 2, fig. 17

Diagnosis — Pollen grains trichotomosulcate; long axis 29·0-30·0 μ; equatorial outline triangular in polar view, aperture clearly defined, wide, tips pointed, maximum width of the sulcus near the pole. Exine < 1·5 μ thick, surface finely reticulate.
Comments — *T. subgranulatus* Couper, 1953 differs from the present species in having psilate to granulate exine.
Holotype — Pl. 2, fig. 17; Slide no. S-58.
Natural Affinity—Trichotomosulcate type of aperture is a primitive character. This type of aperture occurs in several families, such as Palmae, Liliaceae, etc.

Subturma — *Monocolpates* (*Monosulcites*) and *Zonocolpates*
Infraturma — *Sculptati*

Genus — *Couperipollis* Venkatachala & Kar, 1969

Couperipollis rarispinosus (Sah & Dutta, 1966) Venkatachala & Kar, 1969

Pl. 2, figs. 18, 19

Description — Pollen grains monosulcate, 24·0-26·0 × 38·0-42·0 μ; elliptical in polar view; sulcus long, extending end to end of the grain, narrow. Exine 1·5 μ thick, surface spinose, spines 3·0-4·0 μ long, apex pointed to slightly blunt, generally curved, base broad, sparsely and uniformly spaced.
Natural Affinity — *C. rarispinosus* is comparable to the genus *Arenga* (Palmae, subfamily Caryotoideae).

Genus — *Arecipites* (Wodehouse, 1933) Nichols, Ames & Traverse, 1973

Arecipites punctatus Wodehouse, 1933

Pl. 2, figs. 20, 21

Description — Pollen grains monosulcate, 13·0-21·0 × 36·0-46·0 μ; prolate in polar view, plano-convex in lateral view; sulcus long, extending end to end of the grain, narrow, tapered at ends. Exine 2·5 μ thick, surface finely punctate.
Comments — The species described here differs from *A. punctatus* Wodehouse, 1933 in having greater size.
Natural Affinity — *A. punctatus* is related to the family Palmae.

Genus — *Proxapertites* van der Hammen, 1956

Proxapertites operculatus van der Hammen, 1956

Pl. 2, figs. 22, 23

Description — Pollen grains oval to circular, 36·0-40·0 μ in diameter; sulculate, the grain usually separates into two slightly unequal parts by the sulculus, edges of aperture appear to be slightly irregular. Exine 1·5 μ thick, columellae distinct, tectate, tectum finely reticulate, occasionally psilate.
Comments — The type species is charactrized by its distinct sulculate aperture and well defined finely reticulate exine ornamentation. Often half grains are

visible as the grains are splitted along the aperture, where the aperture cannot be recognized.

Natural Affinity — The morphology and affinity of *P. operculatus* has been discussed by Muller (1968) in detail. A possible relationship with the extant palm genus *Nypa* has been suggested by him. Also comparable with some genera of the family Xanthorrhoeaceae.

Proxapertites cursus van Hoeken-Klinkenberg, 1966

Pl. 2, fig. 24

Description — Pollen grains oval to circular, 46·0 μ in diameter; sulculate, the grain usually separates into two slightly unequal parts by the sulculus, edges of the aperture irregular. Exine 1·5 μ thick, columellae distinct, tectate, tectum coarsely reticulate.

Comments — The type species is characterized by its distinct sulculate aperture and coarsely reticulate exine ornamentation.

Natural Affinity — Possibly related to extant palm genus *Nypa* and comparable forms occur in some genera of the family Xanthorrhoeaceae.

Subturma — *Dicolpates, Disulcites*

Genus — *Dicolpopollis* Pflanzl, 1956

Dicolpopollis sp.

Pl. 3, fig. 25

Description — Pollen grains isopolar, proximal view oval, 28·0×33·0 μ; disulcate, colpi short. Exine > 3·0 μ thick, columellae distinct pila type, > 2·0 μ long, intectate, pila heads arranged in polygonal outlines.

Natural Affinity — Unknown.

Subturma — *Tricolpates, Triptyches*
Infraturma — *Isotricolpates*

Genus—*Tricolpites* (Cookson, 1947 ex Couper, 1953) Belsky, Boltenhagen & Potonié, 1965

Tricolpites levis Sah & Dutta, 1966

Pl. 3, figs. 26, 27

Description — Pollen grains isopolar, polar compression; equatorial diameter 17·0-30·0 μ; subspheroidal, tricolpate, colpae long, not extending to the polar region, polar area fairly large. Exine < 1·0 μ thick, tectate, tectum finely reticulate.

Natural Affinity — Polygonaceae, comparable to the genus *Rumex* (Dutta & Sah, 1970).

Genus — *Clavatricolporites* van der Hammen, 1956

Clavatricolporites sp.

Pl. 3, fig. 28

Description — Pollen grains isopolar, polar compression; equatorial diameter 34·0-36·0 μ; subtriangular, tricolporate, colpae long, almost extending to the poles, ektoapertural furrow bordered by margo, endoaperture indistinct, polar area very small. Exine 2·5 μ thick, semitectate, ektexine much thicker than endexine; columellae distinct, clavae type, upto 2·0 μ long, semitectate, partially fused at places, but do not form any distinct reticulation.

Natural Affinity — Unknown.

Tricolpites sp. 1

Pl. 3, figs. 29, 30

Description — Pollen grains isopolar, polar compression; equatorial diameter 46·0-65·0 μ; subspheroidal, colpae very long, almost extending to the polar region; wall 3·0 μ thick, ektexine much thicker than endexine; partially tectate, columellae pila-type, 2·0 μ in length, partially fused, not forming any distinct reticulum, pila heads 0·5-1·5 μ wide, arranged in polygonal outlines.

Natural Affinity — Unknown.

Tricolpites sp. 2

Pl. 3, fig. 31

Description — Pollen grains isopolar, polar compression; equatorial diameter 47·0-56·0 μ; subtriangular, colpae long, not reaching to the pole, polar area small; ektoapertural furrow bordered by margo; wall uniformly 4·0 μ thick, ektexine as thick as endexine; columellae present, pila-type, 2·0 μ in length, not fused to form any reticulum, pila heads 0·5-2·5 μ wide, arranged in polygonal outlines.

Natural Affinity — Unknown.

Tricolpites sp. 3

Pl. 3, figs. 32, 33

Description — Pollen grains isopolar, polar compression; equatorial diameter 24·0-38·0 μ; subspheroidal; tricolpate, colpae long, polar area moderate. Exine 1·5-2·0 μ thick, ektexine as thick as endexine, columellae distinct, tectate, tectum reticulate, lumina diameter greater than muri diameter.

Comments — Although two grains of this type were found, the grains are well-preserved and appear to be quite distinct from the other known species of the genus *Tricolpites*.

Natural Affinity — Uncertain.

Tricolpites sp. 4

Pl. 3, fig. 34

Description — Pollen grains isopolar, polar compression; equatorial diameter 28·0 μ; subspheroidal; tricolpate; colpae fairly long, almost reaching to the polar region, slender. Exine 1·5 μ thick, ektexine as thick as endexine; columellae prominent, tectate, tectum reticulate, muri diameter greater than lumina diameter.

Comments — Only one grain of this type has been recovered. It is quite different from the other known species of the genus *Tricolpites*.

Natural Affinity — Uncertain.

Subturma — *Polycolpates, Polyptyches*
Infraturma — *Stephanocolpati, Stephanorugati*

Genus — *Retistephanocolpites* Leidelmeyer, 1966

Retistephanocolpites williamsi Germeraad, Hopping & Muller, 1968

Pl. 3, fig. 35

Description — Pollen grains isopolar, oblique polar compression; equatorial diameter 25·0 μ; ± spheroidal, 5 colpate, colpae short, gaping, polar region large. Exine about 2·0 μ thick, columellae distinct, arranged irregularly forming a spongy structure, tectate, tectum finely reticulate.

Natural Affinity — Germeraad, Hopping and Muller (1968) stated that *R. williamsi* may be related to *Ctenolophon parvifolius*.

Subturma — *Dicolporates*

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

Multiareolites decorus sp. nov.

Pl. 3, figs. 36, 37

Diagnosis — Single grain, radially symmetrical, 36·0 μ in diameter, pollen grain isopolar, subspheroidal with colpae intersubangular, dicolporate, colpae slender with pointed ends, ektexinous; pori distinct, probably endexinous. Endexine 0·5 μ thick, ektexine thickened on intercolpate areas and in single row of circular 'areoli', 8·0 μ in diameter. Exine 3·5 μ thick, columellae distinct, surface probably perforate.

Comparison — *M. decorus* sp. nov. is comparable to *M. formosus* van der Hammen (1956b), but the present species differs in having larger circular 'areoli'.

Holotype — Pl. 3, figs. 36, 37; Slide no. S-36.

Natural Affinity — Germeraad, Hopping and Muller (1968) suggested a close relationship with the family Acanthaceae.

Subturma—*Tricolporates, Ptychotriporines*
Infraturma — *Prolati*

Genus — *Rhoipites* Wodehouse, 1933

Rhoipites giralensis sp. nov.

Pl. 4, figs. 38-40

Diagnosis — Pollen grains isopolar, equatorial compression, 17·0-19·0 × 24·0-27·0 μ, prolate to subspheroidal, poles broadly rounded; tricolporate, colpae almost extending upto the polar region, ektoapertural furrow slender with wide margo, apparently interrupted at the equator by weakly developed endoaperture, flattened along the equator. Exine uniformly about 1·5 μ thick, ektexine as thick as endexine, columellae distinct, tectate, tectum psilate to finely reticulate.

Comparison — *R. giralensis* sp. nov. is distinguished from *R. conatus* (Venkatachala & Rawat, 1971) in having slender furrow with wide margo and psilate to finely reticulate exine ornamentation.

Holotype — Pl. 4, fig. 39; Slide no. S-36.

Natural Affinity — Unknown.

Rhoipites kapurdiensis sp. nov.

Pl. 4, figs. 41-43

Diagnosis — Pollen grains isopolar, equatorial compression, 19·0-24·0 × 24·0-29·0 μ; subprolate to subspheroidal, poles broadly rounded; tricolporate, colpae extending from pole to pole; ektoapertural furrow thin, bordered by thick margo, endoaperture characteristically subcircular to isodiametric, 2·5-4·0 μ in diameter with thin annulus, occasionally appears to be colloising with each other. Exine 1·5-2·0 μ thick, ektexine almost as thick as endexine, columellae distinctly well-defined, tectate, occasionally semitectate, tectum coarsely reticulate, lumina diameter wider than muri diameter.

Comparison — *R. kapurdiensis* sp. nov. is characteristically differentiated from the other known species of the genus by its prominent subcircular to isodiametric endoaperture.

Holotype — Pl. 4, fig. 41; Slide no. S-35.

Natural Affinity — Unknown.

Genus — *Paleosantalaceaepites* Biswas, 1962

Paleosantalaceaepites eocenicus sp. nov.

Pl. 4, fig. 44

Diagnosis — Pollen grains isopolar, equatorial compression, 18·0-21·0 × 20·0-24·0 μ; subspheroidal, poles broadly rounded; tricolporate, colpae relatively short, not reaching pole to pole, extending upto 3/4 of the polar axis, ektoapertural furrow thin, narrowing towards the pole, invaginated at the equator, endoaperture zonorate, characteristically forming a 2·0 μ wide ring around the equatorial region of the grain, appears to be sheathed by the ektexine. Exine uniformly 1·5 μ thick, columellae indistinct, ektexine as thick as endexine, tectate, tectum psilate.

Comparison — The comparison of the two kinds of aperture leads to suggest that the ektoaperture is vestigial and the endoaperture is functional. *P. eocenicus* sp. nov. differs from *P. primitiva* Biswas (1962) in having thin exine, wide endoapertural ring and smaller size. It also differs from *P. miocenicus* Ramanujam (1966) in having thin exine, smaller size, and indistinct columellae.

Holotype — Pl. 4, fig. 44; Slide no. S-16.

Natural Affinity — Comparable with Santalaceae, particularly with *Exocarpus* and *Omphacomeria*.

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

Zonocostites mulleri sp. nov.

Pl. 4, figs. 45, 46

Diagnosis — Pollen grains isopolar, equatorial compression, 18·0-21·0 × 19·0-22·0 μ; spheroidal to subprolate, poles broadly rounded; tricolporate, colpae short, not reaching pole to pole; ektoapertural furrow slender, endoapertural furrow transversely elongated, fused, distinctly costate. Exine 1·5 μ thick, thickest at the equator, ektexine as thick as endexine, columellae indistinct, tectate, tectum psilate.

Comparison — *Z. mulleri* sp. nov. is clearly distinguished from *Z. ramonae* Germeraad, Hopping & Muller (1968) by the apparent absence of columellae, surface ornamentation and larg size.

Holotype — Pl. 4, fig. 46; Slide no. S-41.

Natural Affinity — Comparable with the various species of the genera *Rhizophora*, *Bruguiera*, *Ceriops* and *Carallia* (Rhizophoraceae).

Genus — *Kielmeyerapollenites* Sah & Kar, 1972

Kielmeyerapollenites sp. cf. *K. eocenicus* Sah & Kar, 1972

Pl. 4, fig. 48

Description — Pollen grains in tetrahedral tetrads, diameter 37·0 μ. Individual pollen in polar compression, isopolar, triangular to subtriangular, 24·0 μ in diameter; tricolporate, ektoaperture long, funnel-shaped, endoaperture well-developed, margin appreciably thickened. Exine 2·0 μ thick, ektexine much thicker than endexine, columellae distinct, pila-type, tectate, tectum reticulate.

Comments— The present species is comparable in all respects to *K. eocenicus* Sah & Kar (1972), but the size of the present tetrads is characteristically smaller.

Natural Affinity — Related to the family Guttiferae.

Infraturma — *Sphaeroidati*

Genus — *Nyssapollenites* Thiergart, 1937

Nyssapollenites incertus Sah & Dutta, 1970

Pl. 4, fig. 47

Description — Pollen grains isopolar, polar compression, equatorial diameter 28·0 μ, subtriangular, with broad rounded ends; tricolporate, endoaperture indistinct, ektoaperture long, with distinct margo, almost reaching to the polar region, polar area very small. Exine 1·5 μ thick, surface finely reticulate.

Natural Affinity — Unknown.

Turma — *Poroses, Porates, Porines*

Subturma — *Polyporines*

Genus — *Barmeriapollis* gen. nov.

Type Species—Barmeriapollis pulcher sp. nov.

Pl. 4, figs. 49-51

Diagnosis — Pollen grains isopolar, polar compression, equatorial diameter 27.0-35.0 μ; subspheroidal, 6-7 porate, pores distinct, circular to subcircular in outline, placed inwards, occasionally elongated inwards with rounded ends; endexinous thickening around the pores in the equatorial regions. Exine 1·0-1·5 μ thick, ektexine as thick as endexine; columellae distinct, tectate, tectum reticulate, lumina diameter greater than muri diameter.

Comparison — *Barmeriapollis* gen. nov. is clearly and distinctly differentiated by its reticulate exine ornamentation from the genus *Nothofagidites* (Erdtman, 1947) Couper (1953) and *Pseudonothofagidites* (Venkatachala & Kar, 1968) by their spinulose and granulose exine ornamentation respectively.

Holotype — Pl. 4, fig. 50; Slide no. S-55.

Natural Affinity — Unknown.

DISCUSSION

The palynological assemblage obtained from Akli Lignite consists of 24 genera and 25 recognizable species. The assemblage comprises chiefly angiospermous pollen and pteridophytic spores, the gymnospermous pollen grains being totally absent. The overall palynological assemblage recovered is closely comparable to the known Palaeocene-Eocene assemblage of different parts of India and abroad. A few of the important taxa are taken into consideration and discussed in detail to elucidate the inferred Palaeocene-Eocene age for this palynological assemblage.

Amongst the different pteridophytic spore types recovered, the genus *Dandotiaspora* is most significant as a stratigraphic marker. This type of spore characterizes the Palaeocene-Lower Eocene sediments of India. The spore has been assigned by different workers to various genera. Vimal (1952) for the first time reported this type from the Dandot Lignites (Lower Eocene), West Punjab, Pakistan. Bose and Sah (1964) reported similar types from Laitryngew Coalfield, Assam. From the Supra-Trappean beds of Kutch, Gujrat, Mathur (1966) also reported the same spore type. Sah and Dutta (1966) reported similar type from Cherra sandstone stage of Shillong Plateau. From the Laki Series of Kutch, Sah and Kar (1969) described some spore types which are assignable to this group. Ghosh (1969) from Garo Hills, Meghalaya also reported similar types. A detailed study of this genus by Sah, Kar and Singh (1971) reveals that this type of spore is restricted to Palaeocene-Lower Eocene sediments only. Although the presence of a few spores of *Dandotiaspora dilata* and *D. plicata* from the Langpar Stage (Danian) of Therriaghat, Shillong Plateau suggests that the genus appeared for the first time during Danian but developed progressively during the Early Palaeocene, reached its maxima during the Upper Palaeocene and Lower Eocene and finally dwindled during the Middle-Upper Eocene (Sah, Kar & Singh, 1971). The genus *Schizaeoisporites* is well-represented in the present assemblage. Out of the three described species, two are new. The *Schizaeoisporites* spore types are common in the Neyveli and Warkali microflora (Ramanujam, 1966-67, 1972). Sah and Dutta

(1968) reported *Schizaeoisporites digitatoides* from the Paleogene of Assam. Potonié (1960a) also reported the same species from Kalewa beds of Burma. From the Cherra Formation of Assam, Dutta and Sah (1970) reported 3 species of this genus. *Schizaeoisporites* sp. has also been reported by Venkatachala and Rawat (1972) from the Palaeocene-Eocene palynological assemblage of Cauvery basin.

The sulculate grains were first identified as *Proxapertites* by van der Hammen (1956) and then redefined by Muller (1968). According to van der Hammen (1956, 1957). *Proxapertites operculatus* forms the dominant and characteristic species of the Palaeocene of Columbia Lisma Formation. Previously, these grains were described by different workers under separate generic names, *Proxapertites* by van der Hammen (1956), *Schizosporis* by Cookson and Dettmann (1959), *Potamogetonaceaepites* by Biswas (1962), *Araceaepites* by Biswas (1962), *Microreticulatipites* by Baksi (1962), *Retialetes* by Sah and Dutta (1966), and *Nymphaeacidites* by Sah and Dutta (1968). Baksi (1974) grouped the above mentioned grains described under separate generic names, which are morphologically very close to one another, under the genus *Proxapertites*. This grouping of Baksi finds support from the statement by Sah and Dutta (1966) that it is quite likely " that *Schizosporis assamica* Sah & Dutta (1966) and *Proxapertites operculatus* van der Hammen (1956) may belong to the same species. The genus *Proxapertites* is a characteristic and significant element of Palaeocene-Eocene sediments and it has not been reported from sediments younger than Eocene in India and abroad. The *Proxapertites* zone of Baksi (1974) is well established in the Tura Formation and Cherra Formation of Garo, Khasi and Jaintia Hills of Meghalaya. Venkatachala and Rawat (1971) has established *Proxapertites hammennii* zone for the Palaeocene interval of the sediments of Cauvery basin, South India. The Palaeocene dating for the Barmer clay horizon, Rajasthan has been established by Jain, Kar and Sah (1973) on the basis of occurrence of the genus *Proxapertites*. It has also been established in the Jalangi Formation of the shelf area of Bengal Basin (Baksi, 1971a). The uppermost Cretaceous to Lower Eocene age interval of the *Proxapertites* zone of Muller (1968) known from Columbia, Venezuela and Malaysia is worth mentioning in this context. The Pantropical Zone which is recognized by the occurrence of *Proxapertites operculatus* and *P. cursus* in Venezuela and Nigeria (Germerrad, Hopping & Muller, 1968) also suggests the status of the genus *Proxapertites* as a stratigraphic marker in inter-regional correlation.

The other common elements such as *Cyathidites minor*, *C. australis*, *Stereisporites assamensis*, *Laevigatosporites gracilis*, *Polypodiidites ratnami*, *Trichotomosulcites thumbliensis* sp. nov., *Couperipollis rarispinosus*, *Arecipites punctatus*, *Tricolpites levis*, *Retistephanocolpites williamsi*, *Paleosantalaceaepites eocenicus* sp. nov., *Zonocostites mulleri* sp. nov., *Nyssapollenites incertus*, *Multiareolites decorus* sp. nov. of the Palaeocene-Eocene sequence are represented in the palynological assemblage of the Akli Lignite. On the other hand, the spinose zonisulcate-reticulate pollen grains — *Nypa* which usually occurs elsewhere in association with the *Proxapertites* is characteristically found to be absent in this assemblage. This might be due either to inadequate search or ecological factors.

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EXPLANATION OF PLATES

PLATE 1

1. *Cyathidites minor* Couper, 1953. × 450.
2. *Cyathidites australis* Couper, 1953. × 450.
3. *Dandotiaspora* (*Psilatriletes*) *dilata* (Mathur) Sah, Kar & Singh, 1971. × 450.
4. *Dandotiaspora* (*Todisporites*) *plicata* (Sah & Kar) Sah, Kar & Singh, 1971. × 450.
5. *Dictyophyllidites* sp. × 450.
6. *Stereisporites assamensis* Sah & Dutta, 1967. × 1000.
7. *Deltoidospora* sp. × 450.

8, 9. *Laevigatosporites gracilis* Wilson & Webster, 1946. × 450.

10. *Polypodiidites ratnami* Ramanujam, 1966-67. × 1000.

PLATE 2

11. *Schizaeoisporites digitatoides* (Cookson) Potonié, 1951. × 1000.

12, 13. *Schizaeoisporites sarnuensis* sp. nov. × 1000.

14. *Schizaeoisporites perforatus* sp. nov. × 1000.

15, 16. *Inaperturopollenites* sp. × 450.

17. *Trichotomosulcites thumbliensis* sp. nov. × 1000.

18, 19. *Couperipollis* (*Monosulcites*) *rarispinosus* Sah & Dutta, 1966; Venkatachala & Kar, 1969. × 1000.

20, 21. *Arecipites punctatus* Wodehouse, 1933. × 1000.

22, 23. *Proxapertites operculatus* van der Hammen, 1956. × 450.

24. *Proxapertites cursus* van Hoeken-Klinkenberg, 1966. × 450.

PLATE 3

25. *Dicolpopollis* sp. × 1000.

26, 27. *Tricolpites levis* Sah & Dutta, 1966. × 1000.

28. *Clavatricolporites* sp. × 1000.

29, 30. *Tricolpites* sp. 1. × 450.

31. *Tricolpites* sp. 2. × 450.

32, 33. *Tricolpites* sp. 3. × 1000.

34. *Tricolpites* sp. 4. × 1000.

35. *Retistephanocolpites williamsi* Germeraad, Hopping & Muller, 1968. × 450.

36, 37. *Multiareolites decorus* sp. nov. × 1000.

PLATE 4

38-40. *Rhoipites girelensis* sp. nov. × 1000.

41-43. *Rhoipites kapurdiensis* sp. nov. × 1000.

44. *Paleosantalaceaepites eocenicus* sp. nov. × 1000.

45, 46. *Zonocostites mulleri* sp. nov. × 1000.

47. *Nyssapollenites incertus* Sah & Dutta, 1970. × 1000.

48. *Kielmeyerapollenites* cf. *eocenicus* Sah & Kar, 1972. × 1000.

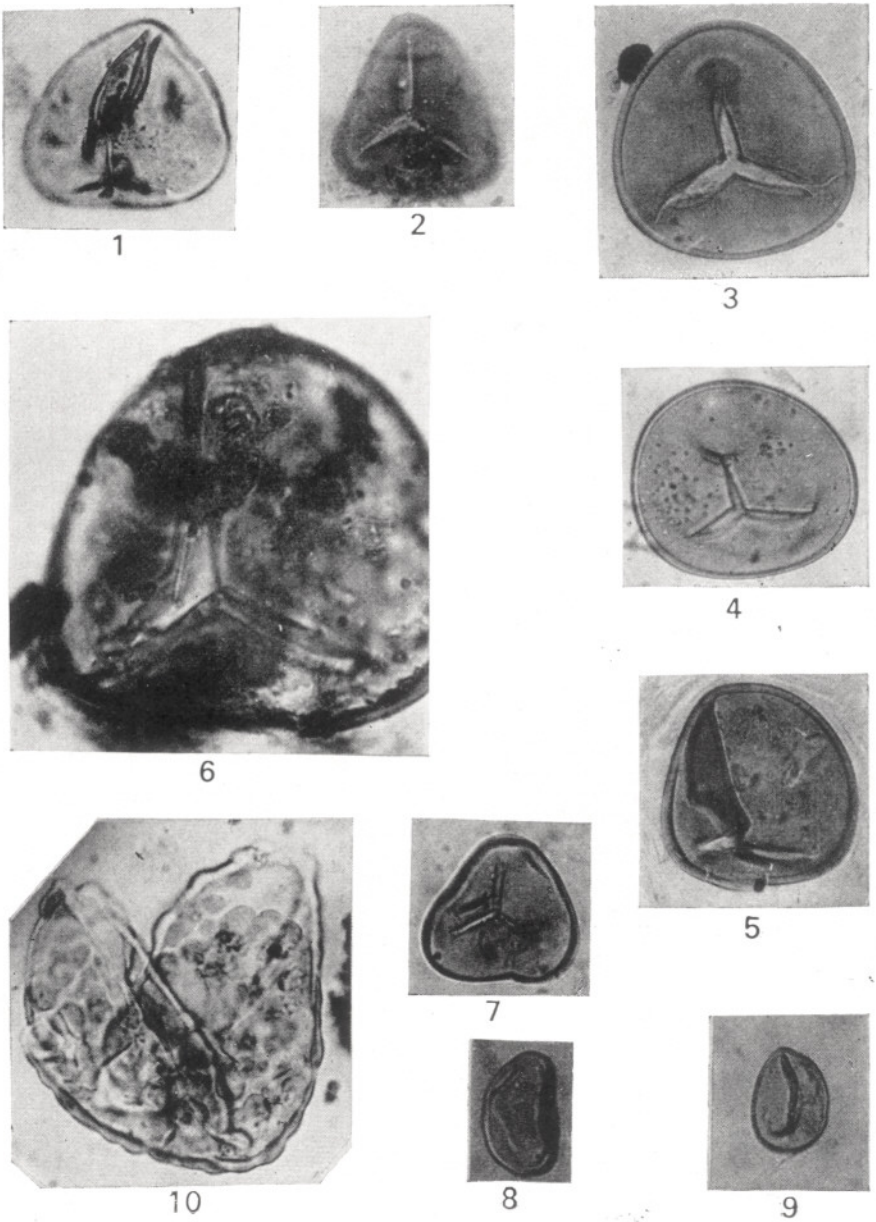

PLATE 1

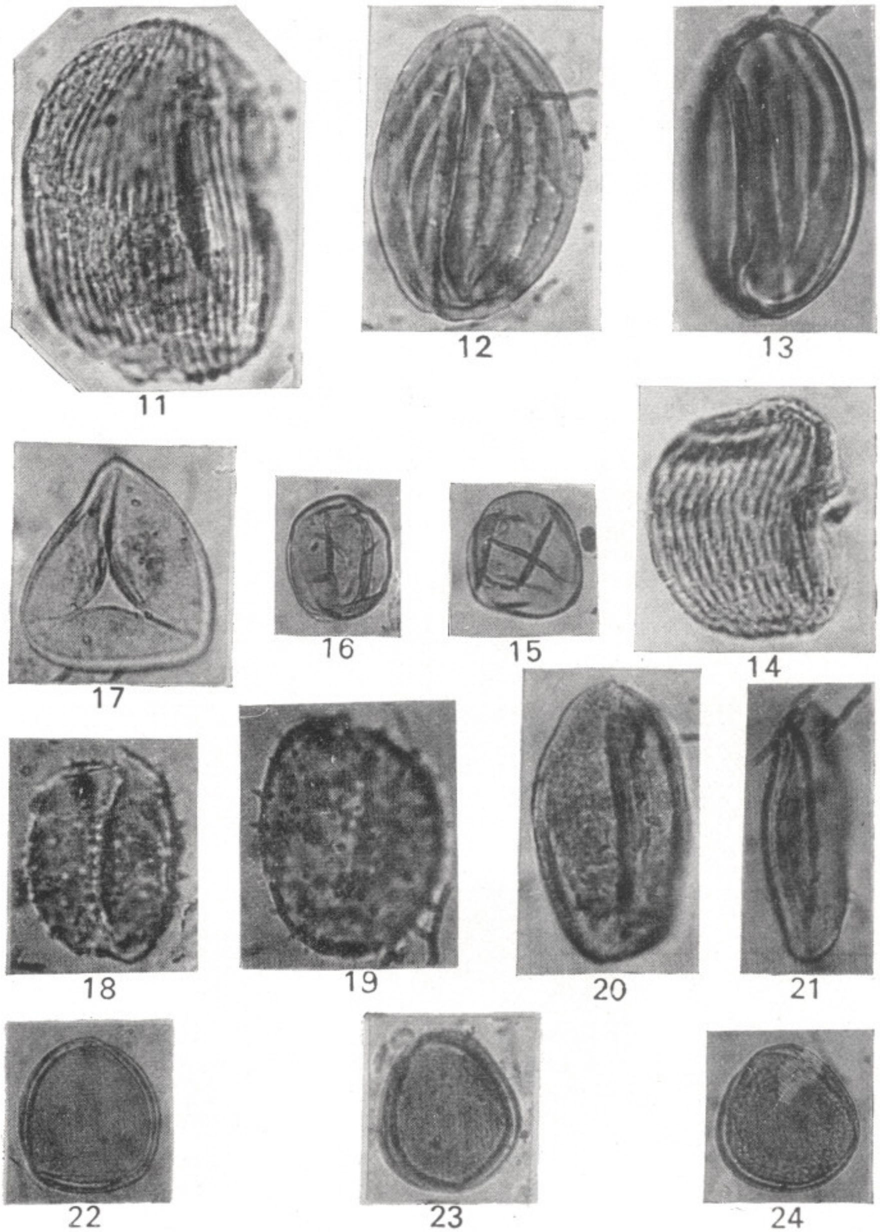

PLATE 2

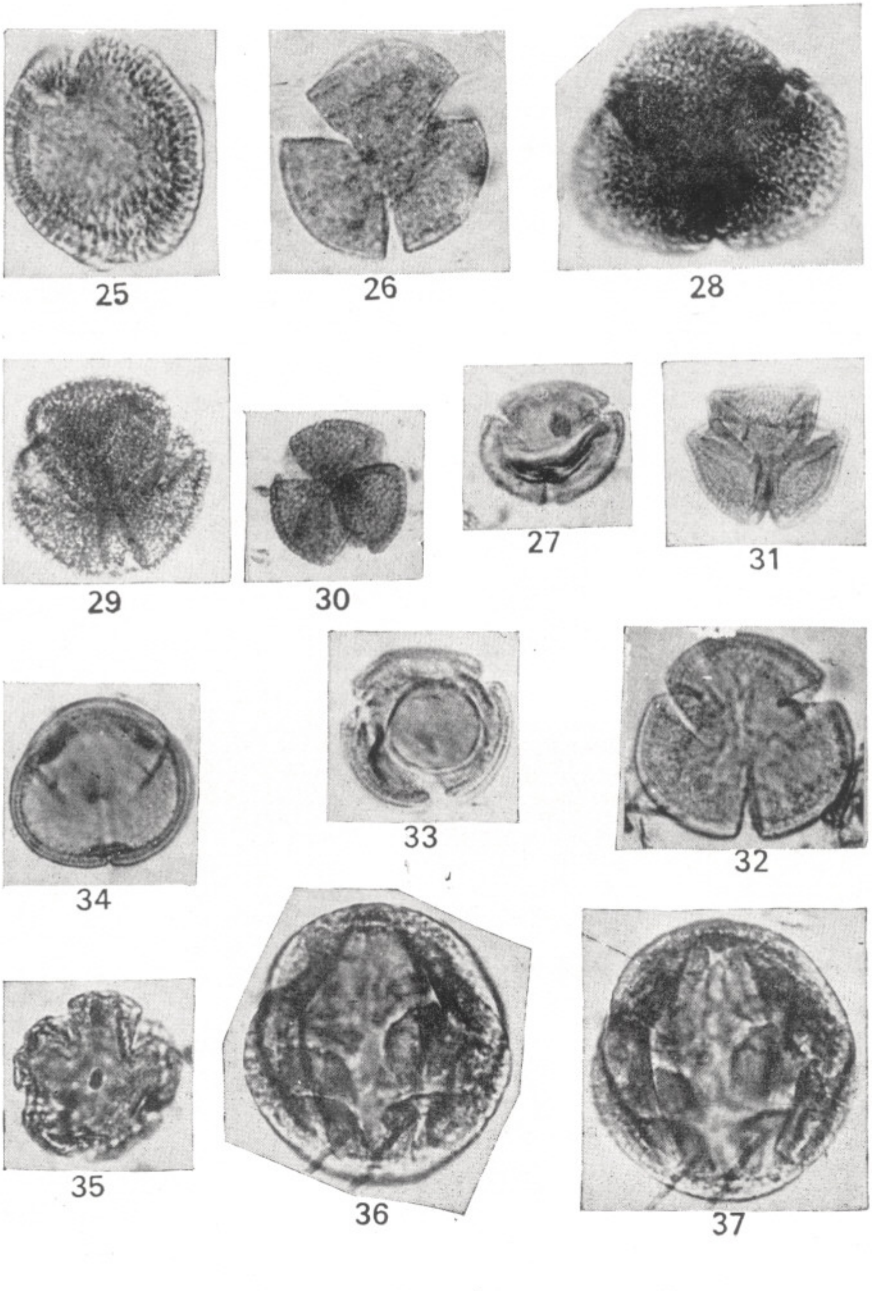

PLATE 3

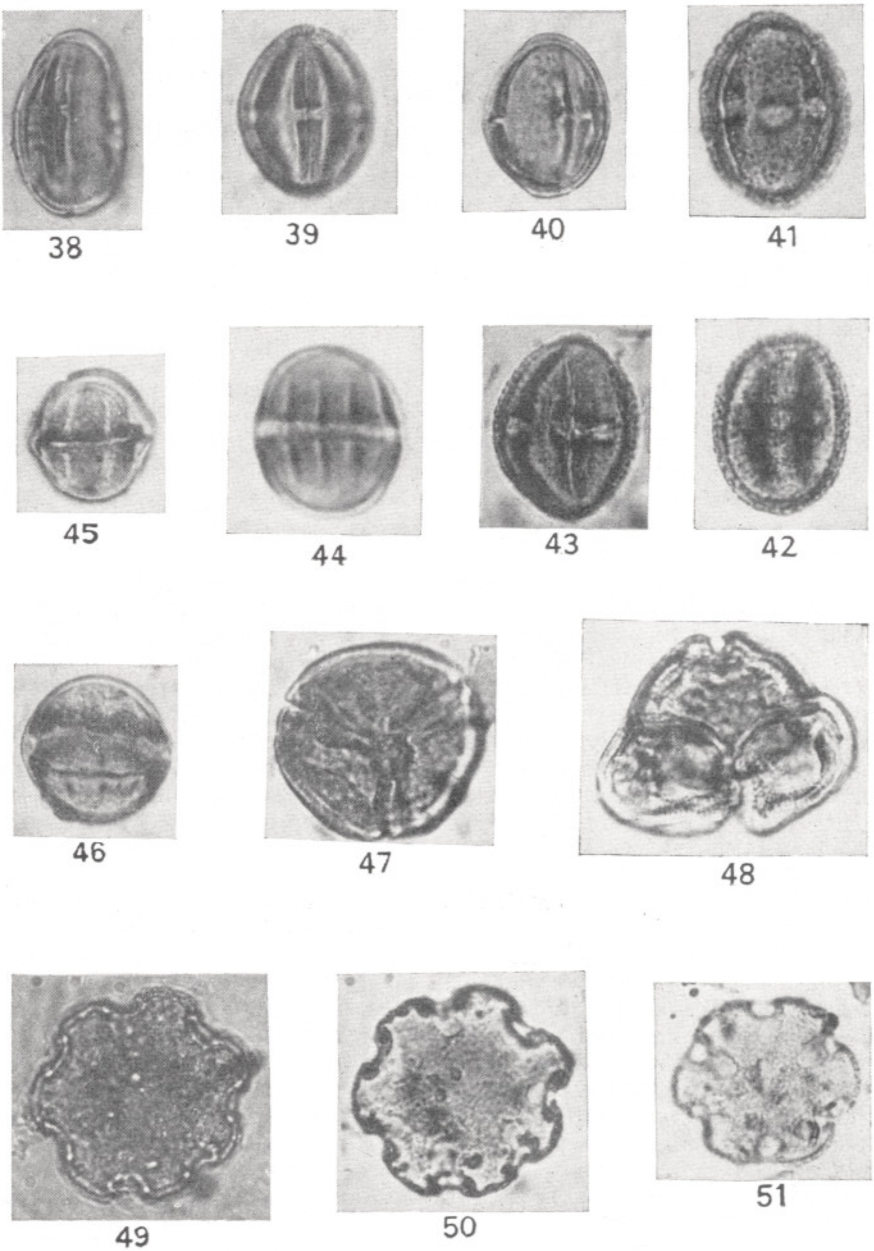

PLATE 4