PALYNOLOGY OF THE TERTIARY SEDIMENTS OF PALANA, RAJASTHAN

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ABSTRACT

The Palana palynological assemblage described here consists of 8 genera and 11 species of pteridophytic spores, 24 genera and 36 species of angiospermic pollen grains, 9 genera and 16 species of algal and 3 genera and 4 species of fungal remains. Of the total of 44 genera and 67 species recorded, 10 genera and 31 species are new.

Quantitative analysis of the assemblage shows that angiospermous elements dominate the assemblage (70%), followed by pteridophytes (20%). Prominent monocot families are Potamogetonaceae, Palmae and Liliaceae. Dicots are comparatively better represented, the principal families include Nymphaeaceae, Leguminosae, Cruciferae, Rubiaceae, Anacardiaceae, Hippocrateaceae, Guttiferae, Meliaceae, Proteaceae and Onagraceae. Pteridophytic spores are mainly represented by Osmundaceae, Matoniaceae, Polypodiaceae, Schizaeaceae and Cheilanthaceae. The algal genus *Botryococcus* along with microplanktons are found in abundance in some stratigraphic levels.

INTRODUCTION

PALYNOLOGICAL investigation on the Palana beds of Rajasthan was initiated by Rao and Misra (1949) when they described *Botryococcus braunii*-like alga from them. Rao and Vimal (1950) also described plant microfossils from these beds. They followed an artificial classification and described the sporomorphs as type 1, type 2, etc. The present paper deals with the systematic description of the spores and pollen grains, algal and fungal remains obtained from different subsurface sections from Palana lignitic field.

The lignitic deposit at Palana in the district of Bikaner, Rajasthan has been commercially exploited since 1898. The following lithologies are observed in this field (see Bhadada, 1968):

Sand	up to 3 m
Kankar with ferruginous nodules	15-20 m
Weathered sandstone and clay	6-12 m
Multani matti (fuller's earth) with nummulitic limestone bands ...	15-20 m
Shale with sandstone bands	3-9 m
Lignite	8-15 m
Clay, fire clay	up to 1·2 m

Samples were collected from different lithologies from several subsurface sections and macerated. A very rich palynological assemblage was recovered. The slides were prepared in Polyvinyl alcohol and mounted in canada balsam. The slides and unused material have been deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

SYSTEMATIC PALYNOLOGY

Anteturma — *Sporites* H. Pot., 1893
Turma — *Triletes* (Rein.) Pot. & Kr., 1954
Subturma — *Azonotriletes* Lub., 1935
Infraturma — *Laevigati* (Benn. & Kids.) Pot., 1956

Genus — *Todisporites* Coup., 1958

Type species — Todisporites major Coup., 1958.

Todisporites flavatus Sah & Kar, 1969

Pl. 1, Fig. 1

Holotype — Sah & Kar, 1969, Pl. 1, Fig. 9.

Remarks — The specimens assignable to *T. flavatus* have 52-60 μ size range. Trilete rays are either equal or unequal, extending two-thirds to three-fourths radius, sometimes open. Exine up to 2 μ thick, laevigate, sometimes slightly intrapunctate, exine generally not folded.

Genus — *Dictyophyllidites* Coup., 1958

Type species — Dictyophyllidites harrisii Coup., 1958.

Dictyophyllidites sp.

Pl. 1, Fig. 2

Description — Spores triangular, 44-50 μ. Apices rounded, interapical margins ±

straight to slightly concave. Trilete, rays well developed, extending up to equator, associated with folds on distal side. Exine 2-3 μ thick, laevigate and intrapunctate particularly at interradial areas, may be irregularly folded.

Comparison — *Dictyophyllidites* sp. A & B described by Sah & Kar (1969) from the Kakdi Formation in Kutch resemble the present species.

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

Type species—*Dandotiaspora dilata* (Math.) Sah, Kar & Singh, 1971.

Dandotiaspora plicata (Sah & Kar) Sah, Kar & Singh, 1971

Pl. 1, Fig. 17

Infraturma — *Apiculati* (Benn. & Kids.) Pot., 1956

Genus — *Osmundacidites* Coup., 1953

Type species — *Osmundacidites wellmanii* Coup., 1953.

Osmundacidites sp.

Pl. 1, Fig. 3

Description — Spore subcircular, 54 × 50 μ. Trilete, rays extending less than two-thirds. Exine about 2 μ thick, granulose-microverrucose, sculptural elements closely placed, evenly distributed.

Comparison — *Osmundacidites wellmanii* Coup. (1953) resembles the present species in shape and size range but is readily distinguished by its confluent bases of the sculptural elements and granulose laesurate margin. *O. ciliatus* Sah (1967) has grana-papillae on the proximal and irregularly distributed coni on the distal surface. *O. minutus* Sah & Jain (1965) resembles the present specimen in general organization but is distinguished by its smaller size. *O. kutchensis* Sah & Kar (1969) has sparse grana as sculptural elements.

Turma — *Monoletes* Ibr., 1933
Subturma — *Azonomonoletes* Lub., 1935
Infraturma — *Psilamonoleti* v.d. Hamm., 1955

Genus — *Laevigatosporites* Ibr., 1933

Type species — *Laevigatosporites vulgaris* (Ibr.) Ibr., 1933.

Laevigatosporites lakiensis Sah & Kar, 1969
L. cognatus Sah & Kar, 1969

Infraturma — *Sculptatomonoleti* Dyb. & Jach., 1957

Genus — *Schizaeoisporites* Pot., 1951

Type species — *Schizaeoisporites phaseolus* Delc. & Spru., 1955.

Schizaeoisporites palanaensis sp. nov.

Pl. 1, Figs. 4-5

Holotype — Pl. 1, Fig. 4, Size 54 × 32 μ. Slide no. 4353/22.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Spores ± elliptical, 40-55 μ. Monolete distinct or indistinct, extending up to three-fourths along longer axis. Exine 1·5-2·5 μ thick, ribs 8-14, well developed, 3-7 μ broad, parallel to each other, mostly extending from one end to other.

Comparison — *Schizaeoisporites* sp. described by Sah and Kar (1969) resembles the present species in shape and size range but is distinguished by its very fine striations-like ribs. *Schizaeoisporites* sp. described by Sah and Dutta (1966) has smaller size range than the present species. *Schizaea pusilla* Pursh described by Ghosh, Jacob and Lukose (1964) possesses punctate exine.

Schizaeoisporites sp.

Pl. 1, Fig. 6

Description — Spores oval-elliptical, 46-50 μ. Monolete distinct or indistinct, extending up to three-fourths radius. Exine 1·5 μ thick, laevigate, fine striations-like ribs present on both surfaces.

Comparison — *Schizaeoisporites palanaensis* is distinguished from the present species by its coarse ribs. *Schizaeoisporites* sp. described by Sah and Kar (1969) from Kutch closely resembles the present specimens.

Genus — *Seniasporites* Sah & Kar, 1969

Type species —*Seniasporites verrucosus* Sah & Kar, 1969.

Seniasporites verrucosus Sah & Kar, 1969
S. minutus Sah & Kar, 1969

Genus — *Cheilanthoidspora* gen. nov.

Type species — *Cheilanthoidspora enigmata* sp. nov.

Generic Diagnosis — Spores subtriangular, subcircular or oval. Trilete to monolete with various transitional phases. Exoexine well developed, translucent, forming reticulation on both surfaces, exine ± laevigate.

Description — Spores with trilete mostly subtriangular or subcircular in shape with straight-convex interapical margins while in case of monolete, shape varies from broadly oval to oval. Haptotypic mark well developed, extending mostly up to equator, closed or open. In the case of monolete, an open suture looks like a colpus. There are various transitional phases from trilete to monolete or *vice versa* among present specimens. In some spores haptotypic mark is bent simulating a bilete mark while in others, third ray is shorter than rest and hardly recognizable. Exoexine in all specimens well developed, reticulation mostly broad, muri high, meshes ± squarish, in some specimens exoexine is totally or partially lost due to hard process of maceration. This condition is observed both in trilete or monolete spores. Nature of exoexine and pattern of reticulation are same in trilete and monolete spores. Exine is visible only when exoexine is dissolved, it is 1·5-3 μ thick, generally laevigate, in some specimens a few grana are also observed.

Comparison — *Lycopodiumsporites* Thierg. (1938) is comparable to the present genus in subtriangular-subcircular shape and presence of reticulation on both the surfaces. In the present genus, however, the reticulation is formed by the exoexine and the haptotypic mark is variable from trilete to monolete. *Weylandispollis* Taka. (1964) resembles *Cheilanthoidspora* in oval shape and broad reticulation on both the sides but is differentiated by its distinctly monocolpate nature. *Monocolpopollenites* Thom. & Pfl. (1953) also apparently approximates the present genus in shape and broad reticulation but is readily separated by its well developed colpus (see Manum, 1962; Takahasi, 1964). *Cheilanthoidspora* instituted here is distinguished from all of the known genera by its variable haptotypic mark, shape and presence of broad reticulation on both sides formed by the exoexine.

Remarks — *Cheilanthoidspora* commands some special attention for some of its peculiar features. The variable haptotypic mark from trilete to monolete condition with various transitional phases in the present genus is noteworthy. It may be mentioned here that in the extant pteridophytes, the haptotypic mark is also quite variable in a number of species. Nayar (1963) recorded trilete to monolete spores with intermediate forms in *Loxogramme* (Bl.) Pr. belonging to the family Polypodiaceae. Kremp (1967) studied extensively the haptotypic characters of ferns and fern allies embracing 277 genera. He observed that in 29% of cases the spores are wholly trilete, in 49% cases they are monolete while in 22% they are either mixed or show transitional forms. *Botrychium* of Ophioglossaceae, *Stenosemia* of Aspidiaceae, *Cerosora* of Pteridaceae and *Lophosoria* of Cyatheaceae are some of the genera which produce trilete as well as monolete spores. The present genus is, however, unfortunately not comparable to any of the genera mentioned above. In the dispersed fossil spores and pollen grains, a lot of variations of the haptotypic mark are also observed. The bisaccate genera, viz., *Illinites* (Kos.) Pot. & Kl., 1954, *Jugasporites* (Lesch.) Kl. (1963) and *Limitisporites* Lesch. (1956), are similar in all the major characters except that *Illinites* has trilete, *Jugasporites* has bilete and *Limitisporites* has monolete mark. The transitional phases are found in all these genera making it difficult to identify the pollen grain properly (see Leschik, 1956; Manum, 1960; Klaus, 1963; Bose & Kar, 1966).

Lele (1964) observed that in *Plicatipollenites indicus* Lele (1964) though the pollen grains are mostly having trilete mark but some of them show bilete and monolete condition through various transitional phases. Bharadwaj (1964) also noticed monolete to bilete condition in *Potonieisporites* (Bharad.) Bharad. (1964).

The presence of exoexinal layer in the extant pteridophytic spores is of common occurrence (Nayar & Devi, 1964, 1966, 1967, 1968). In the fossil spores this layer is mostly lost due to preservational factors and maceration. The presence of exoexinal thickening forming various ornamentational pattern, observed in *Velamisporites* by Bharadwaj and Venkatachala (1962) from the Carboniferous of Spitsbergen and in *Perotriletes* by Couper (1953) from the Upper Mesozoic sediments of New Zealand. Potonié (1956) also observed the same phenomenon in the megaspore genus *Thy-*

lakosporites Pot. (1956) from the Lower Cretaceous sediments of England.

The present genus is very much comparable to Cheilanthoid group of extant ferns because only in this group a definite perinal layer is observed in the tetrahedral spores. Moreover, the size range of this group (40-60 μ) falls within the size range of the present genus. In this group some plants also produce monolete forms in abnormal cases. In India, Cheilanthoid ferns are quite commonly found in dry places where the humidity is comparatively low. *Cheilanthes tenuifolia* Sw., *C. ferinosa* Kaulf. and *C. bulbosa* Kunze are very common in South India while *C. varians* Hook. and *C. mysorensis* Wall. are restricted to higher hilly tracts (Beddome, 1970). It is, however, difficult to ascertain which particular extant species resembles the fossil ones most because the spores in all those above-mentioned species are more or less similar to each other.

Cheilanthoidspora enigmata sp. nov.

Pl. 1, Figs. 7-10

Holotype — Pl. 1, Fig. 7, Size 51 μ; Slide no. 4354/4.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Spores subtriangular-subcircular, 42-59 μ. Trilete, rays almost reaching margin. Exoexine well developed, forming broad reticulation on both sides.

Description — Apices of spores broadly angular, interapical margins straight-slightly convex, uneven due to projection of muri. Trilete well developed, generally open, rays equal, uniformly broad, commissure recognizable in most of specimens. Exoexine 2-4 μ thick, regularly anastomosing to form broad reticulation, muri up to 5 μ high, meshes squarish, 6-12 μ broad. Exine laevigate to slightly granulose, observed only when exoexine is dissolved.

Remarks — Some of the spores figured by Macko (1957, pl. 75; Figs. 4-12) compares with the present species in shape and reticulation on both the surfaces but the former is differentiated by its absence of haptotypic mark. *Acanthotriletes* sp. described by Sah (1967, Pl. 1; Figs. 25, 30) from the Neogene of Rusizi valleys, Congo, also somewhat resembles the present species in shape and nature of ornamentation.

Cheilanthoidspora monoleta sp. nov.

Pl. 1, Figs. 11-14

Holotype — Pl. 1, Fig. 11, Size 74×60 μ; Slide no. 4357/11.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Spores oval, monolete distinct or indistinct. Exoexine forming very broad reticulation on both sides.

Description — Spores with equally broad lateral ends. Monolete generally well recognizable, open, extending almost one end to other. Sometimes it is bent and one short ray emerges from main ray at right angle. Exoexine 3-5 μ thick, muri raised, meshes squarish to rectangular, 6-13 μ broad. Exine up to 2 μ thick, laevigate to slightly granulose.

Comparison — *Cheilanthoidspora enigmata* resembles the present species in the nature of broad reticulation on both surfaces but the former is readily distinguished by its triangular-subcircular shape and presence of trilete rays.

Cheilanthoidspora reticulata sp. nov.

Pl. 1, Figs. 15-16

Holotype — Pl. 1, Fig. 15, Size 60×44 μ; Slide no. 4354/11.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Spores oval, monolete, exoexine forming reticulation of meshes, 3-6 μ wide on both sides.

Description — Spores with rounded or slightly pointed lateral ends, 54-65×40-48 μ. Monolete distinct or indistinct, straight or curved, closed or open, extending more than three-fourths radius. Exoexine well developed, muri up to 3 μ high, meshes ± same size, exine laevigate.

Comparison — *Cheilanthoidspora monoleta* closely resembles the present species in shape, size range and extension of the monolete but is differentiated by its broader reticulation and stronger muri. *C. enigmata* is triangular-subcircular and has distinct trilete rays.

Anteturma — *Pollenites* Pot., 1931
Turma — *Aletes* Ibr., 1933
Subturma — *Azonaletes* (Lub.) Pot. & Kr., 1954
Infraturma — *Subpilonapiti* (Erdt.) Vim., 1952

Genus — *Retipilonapites* Raman., 1966

Type species — *Retipilonapites arcotense* Raman., 1966.

Retipilonapites arcotense Raman., 1966
Pl. 1, Fig. 18

Remarks —The specimens assigned here to *R. arcotense* Raman. (1966) have subcircular-circular shape and densely placed bacula forming negative reticulum on surface view. According to Ramanujam (*l.c.*) the ornamentational pattern in *Retipilonapites* is retipilate.

Retipilonapites sp.
Pl. 1, Fig. 19

Description — Pollen grain nonaperturate, subcircular, 52 μ. Exine less than 2 μ thick, heavily sculptured with pila, pila 3-4 μ long forming negative reticulum on surface view.

Comparison — *Retipilonapites arcotense* Raman. (1966) and *Retipilonapites* sp. described here have both subcircular-circular shape and closely placed sculptural elements. *R. arcotense* Raman. (1966) is baculate whereas in the present species it is pilate. *R. delicatissimus* also described by Ramanujam from the South Arcot lignite of Madras has very delicate pila and coni on the exine. *Retipilonapites* sp. recorded here is readily separated from the former by its heavy sculptural elements.

Turma — *Plicates* (Naum.) Pot., 1960
Subturma — *Monocolpates* Iver. & Tr.-Sm., 1950

Genus — *Palmaepollenites* Pot., 1951

Type species — *Palmaepollenites tranquillus* (Pot.) Pot., 1951;

Palmaepollenites nadhamunii Venkat. & Kar, 1969.

Palmaepollenites sp.
Pl. 1, Fig. 20

Description — Pollen grain longish oval with somewhat pointed lateral ends, 31×15 μ. Colpus distinct, end to end, slit-like. Exine about 1 μ thick, laevigate.

Comparison — *Palmaepollenites* sp. described here is comparable to *P. nadhamunii* Venkat. & Kar (1969) in extension of colpus from one end to other end and in laevigate exine, the former is, however, distinguished by its longish oval shape. *P. kutchensis* Venkat. & Kar (1969) and *P. indicus* Raman. (1966) are larger in size range than the present species. *P. neyvelii* Raman. (1966) approximates the present species in shape and size but is distinguished by its thick exine (2·5 μ).

Genus — *Liliacidites* Coup., 1969

Type species — *Liliacidites kaitangataensis* Coup., 1953.

Liliacidites reticulatus sp. nov.
Pl. 1, Figs. 21-22

Holotype — Pl. 1, Fig. 21, Size 50×84 μ; Slide no. 4361/5.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Pollen grains monosulcate, 45-60 μ, sulcus distinct, end to end. Exine reticulate, meshes broader in middle region and narrower at ends.

Description — Pollen grains with intact sulcus rarely found in present material. Sulcus ruptures at one or both ends causing splitting of pollen grains. Exine 1-2·5 μ thick, sexine as thick as nexine, meshes well developed, simplibaculate, 3-5 μ in middle and 1-2 μ at ends.

Comparison — *Liliacidites ellipticus* Venkat. & Kar (1969) described from Kutch, Gujarat, is comparable to the present species in widening of sulcus but is readily distinguished by its uniformly small size of the meshes. *L. kaitangataensis* Coup. (1953) resembles the present species in different mesh sizes but is separated by longish oval shape. *L. intermedius* Coup. (1953) approximates the present species in shape, size range and extension of the sulcus but is differentiated by its clavate-baculate structures.

Liliacidites ellipticus Venkat. & Kar, 1969
Pl. 1, Fig. 23

Remarks — Pollen grains oval with rounded lateral ends, 42-50 μ. Sulcus distinct, ± uniformly broad, extending one end to other. Exine 1-2 μ thick, very finely reticulate.

The pollen grains referred here to *Liliacidites ellipticus* resemble the extant pollen grains of *Scilla* of Liliaceae in size range, shape and ornamentational pattern (Erdtman, 1952).

Liliacidites sp.

Pl. 1, Figs. 24-25

Description — Pollen grains monosulcate, 54-60 μ, sulcus distinct, extending from one end to other. Exine 4-6 μ thick, sexine thicker than nexine, tegillate, retipilate.

Comparison — *Liliacidites intermedius* Coup. (1953) closely resembles the present species in shape and size range but the latter is separated by its thicker exine. *L. baculatus* Venkat. & Kar (1969) is also comparable to the present species in size range but is distinguished by its intrabaculate structures forming negative reticulum on surface view.

Genus — *Couperipollis* Venkat. & Kar, 1969

Type species — *Couperipollis perspinosus* (Coup.) Venkat. & Kar, 1969.

Couperipollis rarispinosus (Sah & Dutta) Venkat. & Kar, 1969

Pl. 1, Figs. 26-27

Remarks — Specimens referred to this species have well developed spines, 4-8 μ long with pointed tip, spines sparsely placed, interspinal space granulose.

Couperipollis brevispinosus (Bis.) Venkat. & Kar, 1969

Pl. 1, Fig. 28

Remarks — Pollen grains oval with rounded lateral ends, 48-55 μ. Spines closely placed, with bulbous base and pointed tip, interspinal space granulose, sulcus discernible cnly in few specimens.

C. kutchensis Venkat. & Kar, 1969

Pl. 1, Fig. 30

Couperipollis sp.

Pl. 1, Fig. 29

Description — Pollen grain elliptical with pointed lateral ends, 46×20 μ. Exine 1 5 μ thick, spinose, spines 4-6 μ long, not very closely placed, interspinal space granulose. Sulcus lip-like, extending from one end to other.

Comparison — The present specimen closely resembles *Couperipollis perspinosus* (Coup.) Venkat. & Kar (1969) in size range and disposition of the spines, the former is, however, distinguished by its more elongated shape. *C. rarispinosus* (Sah & Dutta) Venkat. & Kar (1969), *C. brevispinosus* (Bis.) Venkat. & Kar (1969) and *C. kutchensis* Venkat. & Kar (1969) are separated by their broadly oval shape.

Infraturma — *Sphaerozonisulcates* Venkat. & Kar, 1969

Genus — *Nymphaeoipollis* Venkat. & Kar, 1969

Type species—Nymphaeoipollis marginatus Venkat. & Kar, 1969.

Nymphaeoipollis marginatus Venkat. & Kar, 1969

Pl. 2, Fig. 31

Remarks — The specimens assignable to this species do not show distinct scrobiculate structures as has been reported by Venkatachala & Kar (1969).

Nymphaeoipollis flavatus Venkat. & Kar, 1969

Pl. 2, Fig. 33

Nymphaeoipollis sp.

Pl. 2, Fig. 32

Description — Pollen grain subcircular, 42 μ, zonisulcate, sulcus distinct. Exine 2 μ thick, granulose-microverrucose, sculptural elements closely placed.

Comparison — The present species is distinguished from *Nymphaeoipollis marginatus* Venkat. & Kar (1969) and *N. flavatus* Venkat. & Kar (1969) by its granulose-microverrucose ornamentational pattern.

Subturma — *Triptyches* (Naum.) Pot., 1960

Genus — *Tricolpites* (Erdt.) Pot., 1960

Type species — *Tricolpites reticulatus* Cook., 1947.

Tricolpites reticulatus Cook., 1947

Pl. 2, Fig. 34

Tricolpites cf. *T. reticulatus* Cook., 1947

Pl. 2, Fig. 36

Description — Pollen grains broadly oval in equatorial view, 47-53 μ. Colpi long, extending almost end to end. Exine up to 3 μ thick, pilate-baculate, sculptural elements closely placed forming negative reticulum on surface view.

Tricolpites matauraensis Coup., 1953

Pl. 2, Fig. 37

Description — Pollen grain oval in equatorial view, 45 × 40 μ. Colpi long extending from one end to other. Exine 2 μ thick, pilate, tegillate, reticulate.

Tricolpites pachyexinus Coup., 1953

Pl. 2, Fig. 35

Description — Pollen grains subcircular in polar view, 42-50 μ. Colpi long, mesocolpia broad. Exine 2 μ thick, laevigate.

Tricolpites levis Sah & Dutta, 1966

Pl. 2, Fig. 41

Remarks — The exine is about 2 μ thick in the present specimen and it is weakly intrastructured.

Tricolpites paucireticulatus sp. nov.

Pl. 2, Figs. 39-40

Holotype — Pl. 2, Fig. 39, size 40 μ; Slide no. 4361/2.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Pollen grains subcircular-circular, 38-46 μ; 3 colpate, colpi broad, colpi margin laevigate. Exine reticulate only in middle part of mesocolpate region.

Description — Pollen grains generally subcircular in polar view with 3 prominent notches due to colpi. Colpi funnel shaped, long, reaching up to polar region. Exine up to 2 μ thick, reticulation ill — well developed in middle region of mesocolpi.

Comparison — The present species is comparable to *Tricolpites pachyexinus* Coup. (1953) in subcircular-circular shape and in the presence of long colpi, the former is, however, distinguished by its uniformly psilate exine. *T. levis* Sah & Dutta (1966), *T. longicolpus* Sah & Dutta (1966) and *T. brevis* Sah & Kar (1970) have smaller size range and laevigate exine. The present species is distinguished from all the other known species of *Tricolpites* by its reticulation present only in the middle region of mesocolpi.

Tricolpites sp.

Pl. 2, Fig. 42

Description — Pollen grain subcircular, 40 μ, 3 colpate, colpi long, funnel shaped. A triradiate ridge like structure present in middle region of pollen. Exine 1·5 μ thick, granulose, grana about 1 μ high.

Comparison — The present specimen closely resembles *Tricolpites pachyexinus* Coup. (1953) in shape, size range and nature of the colpi. The latter is, however, conspicuous by its presence of triradiate ridge like area in the middle.

Subturma — *Ptychotriporites* (Naum.) Pot., 1960

Infraturma — *Prolati* Erdt., 1943

Genus — *Cupuliferoipollenites pullius* (Pot.) Pot., 1951

Cupuliferoipollenites sp.

Pl. 2, Fig. 38

Description — Pollen grain oval in equatorial view, 52 × 30 μ, 3 colporate. Colpi long, extending almost end to end. Pore distinct, lalongate. Exine 1·5 μ thick, weakly intrastructured.

Comparison — *Cupuliferoipollenites ovatus* Venkat. & Kar (1969) is comparable to the present specimen in shape and general organization but the former is distinguished by its smaller size range.

Genus — *Rhoipites* Wode., 1933

Type species — *Rhoipites bradleyi* Wode., 1933.

Rhoipites pilatus sp. nov.

Pl. 2, Figs. 43-44

Holotype — Pl. 2, Fig. 43, size 26 × 18 μ; Slide no. 4360/19.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Pollen grains oval in equatorial view, 22-30×14-20 μ, 3 colporate. Exine pilate, pila forming negative reticulum on surface view.

Description — Pollen grains only in equatorial view have met with. Colpi long, extending almost one end to other. Pore distinct or indistinct. Exine 1-2 μ thick, pila 2-3·5 μ long, sometimes interspersed with bacular elements.

Comparison — Among the species of *Rhoipites* described from India, *R. kutchensis* Venkat. & Kar (1969) approximates the present species in size range but is distinguished by its finely reticulate ornamentation. *R. striatoreticulatus* Sah (1967) is striatoreticulate and thus is easily differentiated from the present species.

Genus — *Caprifoliipites* Wode., 1933

Type species — *Caprifoliipites viridifluminis* Wode., 1933.

Caprifoliipites subglobosus sp. nov.

Pl. 2, Fig. 52

Holotype — Pl. 2, Fig. 52. Size 42 μ; Slide no. 4359/10.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Pollen grains subcircular, 36-45 μ. Tricolporate, pore distinct, lalongate, margin thickened. Exine finely reticulate.

Description — Pollen grains with entire margin except three notches due to apertures. Colpi distinct, long, funnel shaped, colpi margin ± laevigate, pore margin appreciably thickened, sexine thicker than nexine, reticulation distinct, meshes uniformly broad.

Comparison — *Caprifoliipites superbus* Sah (1967) described from Neogene of Congo broadly corresponds to the present species in shape and size range, the former is, however, distinguished by its retipilate nature of ornamentation. The species instituted here is differentiated from the other species by its subcircular shape and finely reticulate structure.

Genus — *Hippocrateaceaedites* Raman., 1966

Type species — *Hippocrateaceaedites van campoae* Raman., 1966.

Hippocrateaceaedites constrictus sp. nov.

Pl. 2, Figs. 45-46

Holotype — Pl. 2, Fig. 46. Size 46 μ; Slide no. 4354/9.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Pollen grains triangular with marked constriction at apices. 3 colporate, pore margin thickened. Exine pilate-reticulate.

Description — Pollen grains 40-50 μ with straight to slightly convex margin. Colpi long, funnel shaped, margin generally thickened. Pore distinct, well developed, margin 3-5 μ thick. Exine 3-5 μ thick, sexine as thick as nexine, pilate, pila 3-5 μ long with prominent bulbous head, closely placed, forming reticulate pattern.

Comparison — *Hippocrateaceaedites van campoae* Raman. (1966) resembles the present species in shape, size range and general organization but the former is distinguished by its presence of punctitegillate exine.

Genus — *Margocolporites* Raman., 1966

Type species — *Margocolporites tsukadai* Raman., 1966.

Margocolporites sitholeyi Raman., 1966

Remarks — Pollen grains subcircular, 35-43 μ; 3 colporate. Colpi long, funnel shaped, pore generally inconspicuous in polar view. Exine 2-3 μ thick, sexine slightly thicker than nexine, tegillate, reticulate.

Margocolporites sahnii Raman., 1966

Margocolporites complexum Raman., 1966

Remarks — Pollen grains subcircular with three lobes in polar view, 48-57 μ; 3 colporate, colpi well developed, mesocolpia broad. Pores mostly indistinct in polar view. Exine up to 3 μ thick, sexine as thick as nexine or slightly thicker, punctate-reticulate, muri not raised.

Genus — *Lakiapollis* Venkat. & Kar. 1969

Type species — *Lakiapollis ovatus* Venkat. & Kar, 1969.

Lakiapollis ovatus Venkat. & Kar, 1969
Lakiapollis matanamadhensis Venkat. & Kar, 1969

Genus — *Verrutricolpites* Pier., 1961

Verrutricolpites triangulus Sah & Kar, 1970

Pl. 2, Fig. 51

Genus — *Verrucolporites* Sah & Kar, 1970

Type species — *Verrucolporites verrucus* Sah & Kar, 1970.

Verrucolporites verrucus Sah & Kar, 1970

Pl. 2, Fig. 54

Genus — *Platoniapollenites* gen. nov.

Type species — *Platoniapollenites iratus* sp. nov.

Generic Diagnosis — Pollen grains 3-4 colporate, colpi long, pore mostly distinct, pore margin sometimes thickened. Colpi bordered by relatively thin exine, pore lalongate. Exine ± laevigate, thickened at mesocolpate regions.

Description — Pollen grains always found in polar view, 60-85 μ. Colpi conspicuous, funnel shaped, reaching up to polar region; colpi margin mostly dissolve due to its thinness providing a cross like appearance. Pore generally indistinct and not traceable in polar view because colpi margin mostly dissolve, while traceable pore seems to be lalongate, margin sometimes appreciably thickened. Exine 2-6 μ broad, sexine generally thinner than nexine, nexine more thickened in mesocolpial region. Exine mostly laevigate, in some specimens weakly intrastructured. In the present samples, the pollen grains have been badly infected by bacteria/viruses forming white specks all over the exine providing a pseudo-ornamentational pattern.

Comparison — *Meliapollis* Sah & Kar (1970) resembles the present genus in colporate condition and laevigate exine; the former is, however, distinguished by its short colpi and uniformly thickened exine. *Tetracolporites* Coup. (1953) approximates the present genus in tetracolporate nature but the apertures are placed in constricted regions of the polygonal shaped pollen grains. *Quadripollenites* Stov. (1966) is circular-subcircular in shape, tetracolporate and laevigate. This genus is distinguished from *Platoniapollenites* by its thickened margin of the colpi. *Platoniapollenites* proposed here is differentiated from all the colporate genera by its thinner margin of the colpi which generally dissolve to form a cross like appearance in the case of 4 colporate pollen grains and its thickened exine in the mesocolporate region.

Remarks — Tetracolporate pollen grains in the extant angiosperms are mostly found in the families Cucurbitaceae, Guttiferae, Loganiaceae, Meliaceae, Rutaceae and Violaceae. The pollen grains of *Cyclanthera naudiniana* of Cucurbitaceae are 4 colporate and the shape and size range resemble *Platoniapollenites*; but in the former, the sexine is thicker than nexine and is punctitegillate. The pollen grains of *Labordia* of Loganiaceae are comparable to the present genus in shape but are 4 porate and apertural margin is appreciably thickened. The pollen grains of *Viola tricolor* of Violaceae are also 4 colporate, and the size range also approximates the present genus but the exine is more or less uniformly thick and the colpi are comparatively short. The pollen grains of *Platoniapollenites*, however, very much resemble the extant pollen grains of *Platonia insignis* of Guttiferae in size range, 4 colporate condition, thin colpi margin and thickened mesocolpate region. In the present specimens, the colpi margin are mostly dissolved to form wide, funnel shaped colpi. This also provides a cross like appearance for the pollen grains.

In India, now-a-days no species of living *Platonia* is found though it is very common in the tropical forest of Brazil.

Platoniapollenites iratus sp. nov.

Pl. 2, Figs. 57-59

Holotype — Pl. 2, Fig. 57. Size 68 μ; Slide no. 4360/26.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Pollen grains 4 colporate, colpi long, margin thin, pores distinct or indistinct, pore margin thickened. Exine thickened at mesocolpate region, laevigate.

Description — Pollen grains always found in polar view, shape originally squarish-subcircular but appears as a cross due to dissolving of colpi margin, 61-78 μ. Colpi very distinct, funnel shaped, pores while discernible lalongate, margin appreciably thickened. Exine 2-5 μ thick, sexine generally thinner than nexine, thickening at mesocolpate region well developed in some specimens.

Platoniapollenites (*Tetracolporites*) *kivuensis* (Sah) comb. nov.

Holotype — Sah, 1967, Pl. 9, Fig. 8.

Type Locality — Burundi, Rusizi valley, Kundava, Congo. Bore hole Ru. 231, Neogene.

Comparison — *Platoniapollenites* (*Tetracolporites*) *kivuensis* (Sah) comb. nov. is distinguished from *P. iratus* by its intact colpi margin. Moreover, the pore margin is also not thickened in the former species.

Genus — *Calophyllumpollenites* gen. nov.

Type species—*Calophyllumpollenites rotundus* sp. nov.

Generic Diagnosis — Pollen grains subcircular-circular with three constriction due to apertures. Tricolporate, colpi long, pore margin ± thickened. Exine thick, ± laevigate-finely reticulate.

Description — Pollen grains mostly found in polar view, 36-48 μ. Colpi conspicuous in most specimens but in some specimens seem to be slit-like. Pore distinct or indistinct in polar view, margin somewhat thickened in most specimens. Exine 2·5-5 μ thick, sexine as thick as nexine or slightly thicker, exine generally folded along margin. Exine structure sometimes indistinct, reticulation while discernible very fine, otherwise it appears as laevigate.

Comparison — *Nyassapollenites* Thierg. (1937) approximates the present genus in the presence of tricolporate condition but is distinguished by its triangular-subtriangular shape and intrapunctate exine. *Villipites* (Wode.) Pot. (1960) is also triangular-subtriangular, and has thin exine. *Hippocrateaceaedites* Raman. (1966) resembles the present genus in tricolporate nature and thickening of the pores around the margin, but is readily separated by its triangular shape and strongly built reticulation. *Lakiapollis* Venkat. & Kar (1969) is comparable to the present genus in subcircular-circular shape and tricolporate condition. The apertures in *Lakiapollis* are, however, not placed at margin in polar view. Moreover, the colpi are very small and inconspicuous in most specimens. *Caprifoliacidites* Sah (1967) is subtriangular-circular in shape, 3 colporate but the colpi are short and the exine is distinctly reticulate. *Calophyllumpollenites* instituted here is distinguished from all the tricolporate genera by its well developed, long colpi, thickened pore margin, thick exine and laevigate-finely reticulate structure.

Remarks — *Callophyllumpollenites* closely resembles the extant pollen grains of *Calophyllum* belonging to the family Guttiferae (Selling, 1947; Pl. 6, Figs. 121-122). The pollen grains of *C. inophyllum* have a size range of 35-45 μ whereas the fossil pollen studied here closely correspond to the former with a size range of 36-48 μ. Both are 3 colporate, longicolpate with thick exine and finely reticulate structure. In the case of fossil pollen, however, reticulation is sometimes obscure and seems to be ± laevigate. The pollen grains of *Garcinia* of Guttiferae are also comparable to *Calophyllumpollenites* by circular-subcircular shape and 3 colporate condition, the former is, however, distinguished by its smaller size range (29 × 26 μ). Moreover, the sexine in *Garcinia* pollen grain is thinner than nexine and the structure of the exine is indistinct. The pollen grains of *Endodesmia calophylloides* also of Guttiferae approximate the present genus in size range (30 × 26 μ) but is easily distinguished by its brevicolpate nature.

It may be mentioned here that fossil leaves, fruits and woods of Guttiferae have already been reported from the various Tertiary formations of India. Chowdhury and Tandon (1949) described *Kayeoxylon assamicum* from the Upper Miocene of Assam. Lakhanpal and Bose (1951) recorded fossil leaves comparable to *Mesua* and *Garcinia*. Guttiferae is a big family with its restricted distribution to tropical, evergreen forests of Asia and America. The genus *Calophyllum* has about 25 species and they are mostly found in tropical Asia (Lakhanpal & Bose, *l.c.*). Some of the species are commonly found along the coast forming groves here and there (Selling, 1947).

Calophyllumpollenites rotundus sp. nov.

Pl. 2, Figs. 47-49

Holotype — Pl. 2, Fig. 47. Size 38 μ; Slide no. 4360/25.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Pollen grains subcircular-circular in polar view, 36-48 μ; 3 colporate, colpi long, pore margin thickened. Exine thick, laevigate to finely reticulate.

Description — Pollen grains with smooth margin except 3 notches due to apertures. Colpi mostly distinct, funnel shaped, sometimes slit-like. Pores distinct in most specimens, margin uniformly thickened. Exine 2-4·5 μ thick, sexine as thick as nexine or slightly thicker, reticulation while discernible very fine.

Genus — *Kielmeyerapollenites* gen. nov.

Type species — *Kielmeyerapollenites eocenicus* sp. nov.

Generic Diagnosis — Pollen grains mostly in tetrahderal tetrads, 3 colporate, colpi long, pore margin thickened, tetrads 60-77 μ. Exine thick, tegillate, retipilate.

Description — Tetrads mostly triangular-subtriangular, interconnecting area of tetrads thick, appear as triradiate ridge. Individual pollen triangular-subtriangular in shape. Apertures distinctly visible opposite to ridge. Colpi funnel shaped. Pore well developed, margin appreciably thickened in most specimens. Exine 2-5 μ thick, sexine as thick as nexine or slightly thicker, pilate, pila forming reticulate pattern.

Comparison — *Ericipites* Wode. (1933) is comparable to the present genus in the nature of the tetrads, the former is, however, distinguished by laevigate-granulose exine and smaller size range. *Ericaceoipollenites* (Pot.) Pot. (1960) also resembles the present genus in size range and ridge like contact area. *Kielmeyerapollenites* is differentiated from *Ericaceoipollenites* by its tricolporate condition. *Dicotetradites* Coup. (1953) has smaller size range (48 μ) than the present genus and is either colpate or orate (see Potonié, 1960). *Droseradites* Cook. (1947) approximates the present genus in size range but is spinose. *Ricciisporites* Lund. (1954) is a spore genus which is found in tetrads and has verrucose sculptural elements.

Remarks — Tetrad spores and pollen grains are found in most of the geological ages. Chaloner (1958) recorded *Didymosporites* from the Lower Carboniferous while Hennelly (1958), Potonié and Lele (1960) recorded *Ouadrisporites* from the Gondwanas. Lundblad (1954) recorded *Ricciisporites* from the Lias of Sweden.

Among the extant angiosperms, the pollen grains in tetrads are found in Droseriaceae, Epacridaceae, Ericaceae, Gentianaceae, Guttiferae, Hydrostachyaceae, Monimiaceae, Orchidaceae, Saxifragaceae and Tiliaceae, etc. The tetrahedral tetrads in Droseriaceae are polyaperturate and the exine is spinose (Chanda, 1965). *Epacris microphylla* of Epacridaceae has isodynamosporous tetrahedral tetrads and are tricolporate but the size range of the tetrads are smaller (38 μ) than the present genus. *Rhododendron catawbiense* of Ericaceae has also tetrads. The size range is similar to the present genus but the former is distinguished by its laevigate exine. The tetrads of *Helia brevifolia* belonging to the family Gentianaceae are porate. The tetrads of *Hydrostachys verruculosa* of Hydrostachyaceae are rhomboidal and most probably nonaperturate. *Carpodetus serratus* of Saxifragaceae has also subtriangular tetrads but are tricolpate and the exine is ± laevigate-granulose. The orientation of the individual pollen grains in the tetrads of *Neotessmannia uniflora* of Tiliaceae is very different from the present genus.

The genus instituted here, however, closely resembles the pollen grains of *Kielmeyera* of Guttiferae. In both, the pollen grains are mostly found in tetrahedral tetrads and the size range is also same. Moreover, the position of the apertures in the tetrads are also identical and both are 3 colporate. The thickness and nature of the ornamentation are also closely resembling each other. *Kielmeyera*, however, is mostly confined to the tropical forest of Brazil in the present day.

Kielmeyerapollenites eocenicus sp. nov.

Pl. 2, Figs. 60-61

Holotype — Pl. 2, Fig. 60; Size 70 μ; Slide no. 4368/24.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Pollen grains mostly in tetrahedral tetrads. 3 colporate, colpi distinct, pore margin thickened. Exine thick, retipilate.

Description — Tetrads 65-72 μ, triangular-subtriangular, individual margin also triangular-subtriangular, ± equal in size. Contact area distinct, appears as a ridge, exine 2-4 μ thick, sexine as thick as nexine or slightly thicker, tegillate, retipilate.

Genus — *Meliapollis* Sah & Kar, 1970

Type species — Meliapollis ramanujamii Sah & Kar, 1970.

Meliapollis ramanujamii Sah & Kar, 1970

Remarks — Pollen grains subcircular-circular, 52-65 × 48-61 μ. Tetracolporate, colpi small, funnel shaped. Pores well developed, margin thickened. Exine 2-4 μ thick, laevigate.

Subturma — *Ptychopolyporines* (Naum.) Pot., 1960

Genus — *Polybrevicolporites* Venkat. & Kar, 1969

Type species — Polybrevicolporites cephalus Venkat. & Kar, 1969.

Polybrevicolporites cephalus Venkat. & Kar, 1969

Genus — *Polycolpites* Coup., 1953

Type species — Polycolpites clavatus Coup., 1953.

Polycolpites granulatus Sah & Kar, 1970
Polycolpites flavatus Sah & Kar, 1970

Genus — *Pseudonathofagidites* Venkat. & Kar, 1969

Type species — Pseudonathofagidites kutchensis Venkat. & Kar, 1969.

Pseudonathofagidites kutchensis Venkat. & Kar, 1969

Turma — *Poroses* (Naum.) Pot., 1960
Subturma — *Diporines* (Naum.) Pot., 1960

Genus — *Diporites* v.d. Ham., 1954

Type species — Diporites grandiporus v.d. Ham., 1954.

Diporites sp.

Pl. 2, Fig. 50

Description — Pollen grain oval, 36 × 30 μ. Diporate, pore distinct, margin not thickened. Exine about 2·5 μ thick, finely reticulate.

Comparison — *Diporites* sp. described by Sah & Kar (1970) approximates the present specimen in size but is distinguished by its laevigate exine. *D. grandiporus* v.d. Ham. (1954) is much larger in size than the present specimen and the pore margin is thickened.

Subturma — *Triporines* (Naum) Pot., 1960

Genus — *Trilatiporites* Raman., 1966

Type species — Trilatiporites erdtmani Raman., 1966.

Trilatiporites kutchensis Venkat. & Kar, 1969

Genus — *Proteacidites* Cook., 1950

Type species — Proteacidites adenanthoides Cook., 1950.

Proteacidites protrudus Sah & Kar, 1970

Remarks — Pollen grain triangular, 44 μ; 3 porate, pore distinct, margin not thickened. Exine 1·5 μ thick, sexine and nexine equally thick, scrobiculate.

Genus — *Triorites* (Erdt.) Coup., 1953

Type species — Triorites magnificus Cook., 1950.

Triorites triangulus Sah & Kar, 1970
Triorites hirsutus sp. nov.

Pl. 2, Fig. 53

1966 — *Triorites* sp. 1. Sah & Dutta, p. 83, Pl. 2, Fig. 35.

Holotype — Pl. 2, Fig. 53; Size 46 μ; Slide no. 4375/4.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Pollen grains triangular, 38-50 μ, 3 orate, ora protruding. Exine pilate-baculate, forming negative reticulum on surface view.

Description — Pollen grains generally triangular with ± straight interoral margin. Ora conspicuous, protruding up to 20 μ, margin not thickened. Exine 1-1·5 μ thick, sexine as thick as nexine. Pilate-baculate elements 2-4 μ long, closely placed, uniformly distributed.

Comparison — *Triorites triangulus* Sah & Kar (1970) resembles the present species in the presence of pilate-baculate elements but is differentiated by its larger and nonprotruding ora. *T. minutus* Sah & Kar (1970) is comparable to the present species in size and shape but it has finely scrobiculate structure. *T. communis* Sah & Dutta (1966) is ± subtriangular in shape and has granulose sculptural elements.

Incertae sedis

Tetracolporate Pollen Type 1

Pl. 2, Figs. 55-56

Description — Pollen grains tetracolporate, 44-61 × 34-42 μ. Colpi short, slit-like, pore distinct, margin thickened. Exine up to 2 μ thick, sexine as thick as nexine, reticulate at two ends in equatorial view.

Pollen Mass Type-1

Pl. 2, Fig. 62

Description — Pollen mass subcircular in outline, 86 μ, seems to be octad, tricolporate, colpi long. Exine about 3 μ thick, sexine thicker than nexine, tegillate, retibaculate.

ALGAE

Family — BOTRYOCOCCACEAE

Genus — *Botryococcus* Kutz., 1849

Botryococcus palanaensis sp. nov.

Pl. 3, Figs. 63-64

1953 — *Botryococcus braunii* Kutz.: Vimal, pp. 375-376, Figs. 1-6.

Holotype — Pl. 3, Fig. 63; Size 62 μ; Slide no. 4352/8.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Colonial algae, colony subcircular in shape with slightly serrated margin, 20-110 μ. Individual cells 5-10 μ long with swollen tip, tip somewhat lacerated, covered with a ± translucent wall providing a thimble like appearance. Individual cell divides longitudinally and is surrounded by a thick, cup shaped structure at each end.

Comparison—*Botryococcus luteus* described by Traverse (1955) from the Brandon lignite of Vermont closely resembles the present species in general organization. In *B. luteus*, the individual cells are rod shaped and not swollen at tip like the present species. *B. braunii* Kutz. reported by Cookson (1953) also approximates the present species in shape and nature of the colony but is distinguished by its very well developed cup shaped depression at each side of the rod like thimble.

Remarks — *Botryococcus* is a cosmopolitan genus found in both fresh and saline water. Its existence has been traced up to Ordovician and seems to be responsible for good amount of boghead coal in various countries. In India, *Botryococcus* is known from the Tertiary sediments. Rao and Misra (1949) reported for the first time *Botryococcus* from the Palana lignites. They described the algae but did not include them into any species. It may, however, be mentioned that the specimens resemble *Botryococcus braunii* described by Cookson (1953) from the different Cainozoic deposits of Australia. Since the present material also comes from the same locality it was possible to study many specimens resembling those photographed by them. It has been assumed that the specimens described by them also belong to the present species.

Vimal (1953) also reported *Botryococcus braunii* Kutz. from Eocene lignites of Kutch, Western India. From the photomicrographs provided by Vimal (1953), it seems that individual cells are mostly swollen at tips and the surrounding cup shaped cavities are not well pronounced. So it has been transferred into the present species.

Mathur (1964) pointed out the occurrence of *Botryococcus* along with other algal fossils in Subathu beds of Himachal Pradesh. The *Botryococcus* described by her (*l.c.*) also belongs to the present species.

Botryococcus palanaensis proposed here is thus quite frequently found in the Lower Eocene sediments of Palana, Kutch and Himachal Pradesh. The occurrence of *Botryococcus* in the similar sediments in Assam has not yet been reported so far. The general association of this genus along with the lignites in Western India perhaps point out their role in making the same.

Genus — *Tetraporina* (Naum.) Naum., 1950

Type species — *Tetraporina antiqua* Naum., 1950.

Tetraporina apora sp. nov.
Pl. 3, Fig. 65

Holotype — Pl. 3, Fig. 65; Size 50×36 μ; Slide no. 4353/26.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis—Squarish to rectangular spores (? aplanospores), $45\text{-}55 \times 31\text{-}37$ μ. No pore is observed in any specimen. Margin may be constricted in middle, laevigate, a scar may be observed in central region in some specimens.

Comparison—*Tetraporina horologia* (Stap.) Playf. (1963) is distinguished from the present species by its tetraporate nature. *Tetraporina* sp. described by Segroves (1967) is comparable to the present species by its nonporate condition and slight constriction at two lateral ends.

Remarks — The genus *Balmeella* instituted by Pant & Mehra (1963) from the Bacchus Marsh tillite (Lower Permian) of Australia has been regarded by Segroves (1967) as the junior synonym of *Tetraporina*. It has been observed that the specimens may be with or without pores. The pore number varies from one to four.

The stratigraphic range of *Tetraporina* is from Lower Carboniferous to Recent. Churchill (1960) thought them to be the aplanospores of *Cyanophyceae*. He reported many *Tetraporina* like spores from the subrecent peat deposits of Australia. He also reported *Tetraporina* from the Lower Tertiary glauconitic shales from the Perth basin. One of the figures (Churchill, 1960, Fig. 3) resembles very much the present species.

Tetraporina pachyderma sp. nov.
Pl. 3, Fig. 66

Holotype — Pl. 3, Fig. 66; Size 59×48 μ; Slide no. 4351/31.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — More or less rectangular, $48\text{-}65 \times 42\text{-}50$ μ. Spore coat 3-5 μ thick, laevigate. Margin may be undulated, ± constricted in middle region.

Comparison—*Tetraporina apora* resembles the present species in shape and size range but the latter is readily distinguished by its thickness of the spore coat.

Genus — *Psilosphaera* gen. nov.

Type species — *Psilosphaera plicata* sp. nov.

Generic Diagnosis — Microplanktons subcircular-circular. Operculum distinct, subcircular. Wall generally one layered but may be stratified to form several layers, laevigate. A subcircular fold present parallel to margin.

Description — Microplanktons with entire margin, 45-65 μ. Operculum conforms overall shape, opening smooth, operculum may be associated with minor fold. Wall 2-8 μ thick, generally one layered but may be stratified up to 8 layers. Wall strongly folded on opposite side of operculum along entire margin. It is always situated in between operculum and margin. Sometimes this fold is very juxtaposed to margin. In some specimens, some very weak plates seem to be present but their exact nature cannot be discernible.

Comparison — *Leiosphaeridia telmatica* described by Sarjeant & Strachan (1968) from the Pleistocene peats of Staffordshire, England is comparable to the present genus in shape, laevigate wall and circular opening. The present genus is, however, distinguished by its presence of regular, strong fold system parallel to margin and generally more than one layered wall.

Psilosphaera plicata sp. nov.
Pl. 3, Figs. 67-70

Holotype — Pl. 3, Fig. 67; Size 48 μ; Slide no. 4360/24.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Microplanktons subcircular-circular, 45-65 μ. Operculum distinct, subcircular-circular, opening smooth. Wall 2-8 μ thick, laevigate, mostly one layered but may be stratified up to 8 layers. A strongly built subcircular regular fold system is always found in between operculum and margin. This fold system seems to be present on opposite side of operculum.

Genus — *Temporina* gen. nov.

Type species — *Temporina globata* sp. nov.

Generic Diagnosis — Microplanktons subcircular-circular, a median suture generally present on one side, on other side four plates observed in some specimens. Wall 1·5-6 μ thick, laevigate-verrucose.

Description — Microplanktons generally subcircular, 45-98 μ. Median suture on one side while decipherable, simulates a sinuous line extending from one end to other. In some specimens, however, it falls short. Suture generally divides into two at one or both ends near margin. Sometimes, a small branching also observed in middle region perpendicular to median one. On other side four plates observed in some specimens. In most cases, however, these plates are not discernible. Outer margin of wall mostly smooth, a few verrucae found in some specimens. They are generally irregularly distributed but sometimes aligned in rows parallel to margin to provide a dentate appearance. Wall may be irregularly folded and unevenly thick in some specimens forming a depressed area in middle.

Comparison — *Psilosphaera* resembles the present genus in subcircular-circular shape but is distinguished by its presence of operculum and a subcircular fold parallel to margin.

Temporina globata sp. nov.

Pl. 3, Figs. 71-73

Holotype — Pl. 3, Fig. 71; Size 45 μ; Slide no. 4360/24.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis—Microplanktons generally subcircular, 75-94 μ. Median suture on one side mostly discernible. It is more or less sinuous and generally divides into two at ends. A small branching is also observed in middle region. On other side, wall is divided into four plates in few specimens. Wall up to 3·5 μ thick, mostly laevigate, sometimes scantily verrucosed.

Temporina dentata sp. nov.

Pl. 3, Figs. 74-75

Holotype — Pl. 3, Fig. 74; Size 90 μ; Slide no. 4376/1.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Subcircular-circular microplanktons, 80-98 μ. Median suture mostly not traceable. Wall up to 6 μ thick, verrucose, verrucae generally align into rows parallel to margin to furnish a dentate appearance, a few irregularly distributed verrucae also observed in middle. Wall may be unevenly thickened, a depressed area in middle may be observed in few specimens.

Comparison — *Temporina globata* fairly resembles the present species in shape and size, the former is, however, readily separated by its prominent median suture and a few irregularly distributed verrucae.

Genus — *Cephalia* gen. nov.

Type species — *Cephalia globata* sp. nov.

Generic Diagnosis — Microplanktons subcircular-oval. Plates generally not discernible, while discernible it seems to have a median suture with a branch in middle on one side. Numerous oil globules present. Apical appendage present in most specimens.

Description—Microplanktons vary greatly in shape, many transitional shapes from subcircular-oval found in present preparation. Size range in subcircular microplanktons 50-70 μ while in oval ones 50-80×40-50 μ. Apical appendage looks like a small projection at one end, in some specimens it may be septate. Suture generally obscure, in a few specimens a sinuous median suture observed, sometimes another suture emerges perpendicularly from it in more or less middle region. Thus in these specimens, one side is made of three plates only. Oil globules translucent and provide pseudoreticulate appearance. In oval specimens, a short antapical projection also seen in some.

Comparison — *Temporina* proposed earlier resembles the present genus in the presence of subcircular shape and a median suture. The former genus is, however, distinguished by its presence of four plates on one side and laevigate-verrucose wall. *Psilosphaera* also resembles *Cephalia* in subcircular-circular shape but is conspicuous by its presence of operculum.

Cephalia globata sp. nov.

Pl. 3, Figs. 76-77

Holotype — Pl. 3, Fig. 76; Size 70×64 μ; Slide no. 4360/6.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Microplanktons ± subcircular, 55-77×49-72 μ. Sutures generally not traceable, while discernible it appears to have a median suture with a branch ± in middle at one side. Numerous oil globules present to provide pseudoreticulate appearance. Wall up to 2·5 μ thick, intrastructured. Apical appendage conical, short, mostly discernible.

Cephalia ovata sp. nov.

Pl. 3, Figs. 78-80

Holotype — Pl. 3, Fig. 78; Size 60×38 μ; Slide no. 4377/22.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis—Microplanktons generally oval, 52-81×36-53 μ. Sutures not discernible in most specimens, in some a longitudinal suture is distinguishable. Oil globules many. Apical appendage present, sometimes septate. A small, antapical horn like projection also observed in some specimens.

Comparison — *Cephalia globata*, the type species of the genus, is distinguished from the present species by its subcircular shape.

Genus — *Octaplata* gen. nov.

Type species — *Octaplata rotunda* sp. nov.

Generic Diagnosis — Microplankton subcircular-oval. Plates mostly distinct, 8 in number, subcircular, squarish-polygonal in shape, wall thin or thick, laevigate.

Description — Microplanktons generally subcircular, sometimes oblongoid and ovate, 48-82×44-71 μ. Suture straight or sinuous, distinct. In case of subcircular specimens, one subcircular plate on each side in middle region observed. Other plates also seem to be irregularly subcircular in outline. Among oblongoid and ovate specimens, plates ± polygonal in shape. Wall may be as thin as 1 μ, in some it is quite thick and may be up to 5 μ. No opening observed in any specimen.

Comparison — *Psilosphaera* resembles the present genus in shape but is readily distinguished by its presence of distinct operculum. *Temporina* is also subcircular-circular but has mostly a median suture on one side and four plates on the other. Moreover, in some specimens of *Temporina*, verrucae are observed more or less parallel to margin. In *Cephalia*, plates are generally not discernible. *Octaplata* instituted here is conspicuous by its distinct plates which are mostly 8 in number.

Octaplata rotunda sp. nov.

Pl. 3, Fig. 81

Holotype — Pl. 3, Fig. 81; Size 58×56 μ; Slide no. 4368/21.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Microplanktons subcircular-circular, 48-77×46-75 μ. Plates distinct, 8 in number. Central plate on each side ± subcircular, other plates also subcircular, plates 21-39 μ in size. Wall laevigate, opening not observed.

Octaplata palanaensis sp. nov.

Pl. 3, Fig. 82

Holotype — Pl. 3, Fig. 82; Size 74×62 μ; Slide no. 4363/8.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Microplanktons oblongoid to ovoid, 62-82×50-71 μ. Plates prominent, 8 in number, plates ± polygonal in shape, 27-42×23-36 μ. Wall up to 4 μ thick, laevigate, opening not observed.

Comparison — *Octaplata rotunda* comes closer to *O. palanaensis* in the presence of same number of plates but is differentiated by its subcircular-circular shape. Moreover, in *O. rotunda*, the shape of the plates are subcircular whereas in the present species it is polygonal.

Genus — *Palanaea* gen. nov.

Type species — *Palanaea granulosa* sp. nov.

Generic Diagnosis — Microplanktons rectangular, generally tabular. Wall up to 3 μ thick, laevigate, granulose-warty. In some specimens, a few appendages are observed at one end.

Description — Microplanktons mostly with equally broad apical and antapical ends; in some specimens apical end slightly narrower than other one, 56-138×38-70 μ. Tabulation generally not distinct. It seems that apical and antapical ends composed of single plate. Lateral ends, on one side made of two rectangular plates, one being quite bigger than other. On other side, lateral ends seem to be made of three plates. At this view, 1-5 appendages sometimes observed at apical region. They are translucent, squarish to tubular in shape and originate below apical margin. In one specimen, it was observed that one of the appendages swollen at tip to form a dark brown, subcircular cyst like body. Grana while observed uniformly distributed, in some a few warts also observed.

Comparison — *Palanaea* does not closely resemble any of the genera described here. *Octaplata* is subcircular-oval in shape and is readily separated from the present genus by its presence of eight plates.

Derivation of Name — After the name of Palana lignite field.

Palanaea granulosa sp. nov.

Pl. 3, Figs. 83-84

Holotype — Pl. 4, Fig. 83; Size 118-60 μ; Slide no. 4379/18.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Microplanktons rectangular, 98-138 × 50-70 μ. Tabular, tabulation on one side seems to be formed by two plates at lateral ends of unequal size. In some specimens, one lateral plate at each end only traceable. On other side, lateral ends appear to be made of 3 plates. Apical and antapical ends made of one plate each. A few apical appendages arising below apical margin observed in some specimens. Wall up to 3 μ thick, uniformly granulose, a few warts also interspersed with them.

Palanaea laevigata sp. nov.

Pl. 4, Fig. 85

Holotype — Pl. 3, Fig. 85; Size 100 × 50 μ; Slide no. 4360/12.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Microplanktons rectangular, 60-110 × 34-55 μ. Lateral ends made of one plate on each side. Apical and antapical regions also made of one plate each. Wall 1·5 μ thick, laevigate, may be irregularly folded.

Comparison — *Palanaea granulosa* is distinguished from *P. laevigata* by its granulose-warty wall. Moreover, the former has also a bigger size range than the present species.

Genus — *Cryptosphaera* gen. nov.

Type species — *Cryptosphaera pachyderma* sp. nov.

Generic Diagnosis — Microplanktons subcircular-oval, 1-many chambered, operculum seems to be present. Within each chamber, a thick walled body present which on its turn bears another body with thin wall and generally with a pore. Outermost wall of microplanktons thick, mostly laevigate and intrastructured.

Description — Microplanktons conspicuous by their lobed appearance due to chambers. 36-88 × 32-81 μ. Chambers hardly of same size and some of them abortive. As a result, the specimen may be unichambered, bi, tri, quadri or many chambered. An operculum to each chamber seems to be present because each chamber has a thick outer wall and inner thin layer. In some specimens, a piece of operculum found detached (Pl. 4, Fig. 87). It is as thick as outermost wall and also similarly ornamented. Outermost wall thick, laevigate and intrapunctate, in some translucent verrucae also observed. In a few chambers, a subcircular-oval body seen. Its size varies from 36-87 μ, wall 3-8 μ thick, laevigate. Within it, another body develops conforming with the shape of inner body, its size ranges 30-80 μ, wall up to 2 μ thick, granulose-verrucose, sometimes it may be intrastructured. In mature specimens, a circular pore observed in this body. Detached bodies frequently found in present preparation. In addition to this pore in innermost body, another pore also observed in outermost wall in some specimens.

Comparison — *Cryptosphaera* instituted here is very peculiar in its organization and as such is not closely comparable to any of the known microplankton genera. *Psilosphaera* is somewhat comparable in shape but is readily distinguished by subcircular-circular operculum.

Cryptosphaera pachyderma sp. nov.

Pl. 4, Figs. 86a-86b

Holotype — Pl. 4, Figs. 86a, 86b; Size 68 × 65 μ; Slide no. 4351/7.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Microplanktons subcircular, one chambered, other chambers abortive. 45-68 × 41-65 μ. Operculum seems to be present but not observed. Outermost wall laevigate and intrapunctate, within it, a thick walled (3-8 μ), subcircular body seen. This on its turn gives rise to granulose-verrucose body. In mature stage, this may have a circular pore. Detached inner bodies frequently found in present preparation.

Cryptosphaera valvata sp. nov.

Pl. 4, Figs. 87-88

Holotype — Pl. 4, Fig. 87; Size 44×41 μ; Slide no. 4350/4.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Microplanktons 2-6 chambered, chambers of varying sizes, 41-64×37-61 μ. Operculum found detached only in one specimen. Outermost layer laevigate and intrapunctate, sometimes may be verrucose. Thick walled inner body not observed in most specimens. Apart from pore in innermost body, an additional pore noticed in outermost wall.

Comparison — The present species is comparable to *Cryptosphaera pachyderma* in general organization but the latter is distinguished by its presence of only one chamber.

Genus — *Cornplanktona* gen. nov.

Type species — *Cornplanktona fracta* sp. nov.

Generic Diagnosis — Microplanktons subcircular-oval. Appendages mostly present at both ends. Outer wall laevigate and intrastructured, sometimes verrucose-spinose, thick. Middle region thin, providing a cavity like appearance, one surface in middle region generally ruptures. In some specimens, a circular, inner body observed within cavity.

Description — Microplanktons generally thick walled (3-16 μ), thickness of wall in most specimens not uniform. Size range 41-115×34-107 μ. Appendages present at one or both ends. In most specimens, a horn like appendage observed at one end (? apical) with broad base and pointed tip, in others they may be up to 4 and look like nipples. In opposite end, appendage may be present or absent, it may be one and hornlike or may be up to 4, in others it may be ± rectangular. Appendages when present mostly at same plane, but in some rare cases they are not found in same plane. Inner cavity subcircular-oval, distinct, at one surface it ruptures irregularly, other surface generally remains intact, this latter surface mostly laevigate, sometimes intrastructured, in others this may be verrucose-spinose, sculptural elements ± translucent forming pseudoreticulate appearance on surface view. Within this cavity, in some specimens, inner body observed, in some five plates noticed on one surface of this inner body, in others they are absent, inner body may be granulose or intrapunctate.

Comparison—*Cryptosphaera* approximates the present genus in the possession of thick wall but is readily distinguished by its absence of any appendages at ends. Moreover, the specimens in *Cryptosphaera* are mostly chambered and there is a pore in the innermost body. *Apteodinium* Eisen. (1958) has an apical appendage but its wall is thin and devoid of prominent inner cavity as found in the present genus.

Cornplanktona fracta sp. nov.

Pl. 4, Figs. 89-90

Holotype — Pl. 4, Fig. 89; Size 81×76 μ; Slide no. 4377/17.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis —Microplanktons subcircular-oval in shape, 74-115×62-107 μ. Appendages present at one or both ends, number varies from 1-4. Wall up to 16 μ thick, laevigate and intrapunctate, a few spines or verrucae may also be present. Inner cavity well defined, generally ruptures at one surface, an inner body with 5 plates at one surface sometimes found within it.

Cornplanktona unicorna sp. nov.

Pl. 4, Fig. 91

Holotype — Pl. 4, Fig. 91; Size 76×57 μ; Slide no. 4379/26.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Microplanktons subcircular-oval, 61-82×54-75 μ. Appendage generally one at each end. At one end (? apical) it is horn shaped whereas in other it is broad and ± rectangular. Inner cavity distinct, generally irregularly ruptures at one surface, other surface sculptured with translucent verrucae and spines forming negative reticulum. Within cavity in some specimens a granulose inner body with intrastructure observed.

Comparison — *Cornplanktona unicorna* closely resembles *C. fracta* in general organization, the former species is, however, distinguished by its presence of one horn like appendage at one end and rectangular on other. In addition to it, the wall is also verrucose-spinose forming pseudoreticulum.

Cornplanktona sp.

Pl. 4, Fig. 92

Description — Microplankton oval, 56 × 39 μ. Outer wall thick, laevigate and intrapunctate. One horn like appendage present at each end in one plane. Cavity distinct, ruptured at one surface.

Comparison — *Cornplanktona fracta* and *C. unicorna* are differentiated from the present specimen by their bigger size range. Moreover, horn like appendage at each end in the present specimen is also very characteristic.

cf. *Cornplanktona* sp.

Pl. 4, Fig. 93

Description — Microplankton subcircular, 82 × 80 μ with a horn like appendage at one end. Below the appendage, a precingular archaeopyle seems to be present. Outer wall up to 3 μ thick, foveo-reticulate. Inner cavity not observed.

Remarks — The specimen described here is distinguished from *Cornplanktona* by its absence of inner cavity though it resembles in general shape and its horn shaped appendage at one end. The presence of archaeopyle is also very remarkable and hence the present specimen has only been compared to *Cornplanktona*.

Microplankton Type-1

Pl. 4, Fig. 94

Description — Microplanktons oval, 61-76 × 50-64 μ. Outer wall laevigate, an inner cavity in middle region present, this may or may not conform general shape, in some specimens, a subcircular opening noticed at one surface of inner cavity.

Microplankton Type-2

Pl. 4, Fig. 95

Description — Microplankton oval, 58 × 48 μ. A precingular archaeopyle present. Plates not clearly discernible. Outer wall wrinkled, laevigate.

FUNGI

Genus — *Inapertisporites* (Ham.) Els., 1968

Type species — *Inapertisporites variabilis* van der Ham., 1954.

Inapertisporites kedvesii Els., 1968

Pl. 4, Fig. 96

Holotype — Elsik, 1968, Pl. 5, Fig. 8.

Description — Fungal spores, 55-77 × 49-72 μ, inaperturate. Wall less than 1 μ thick, irregularly folded.

Inapertisporites globatus sp. nov.

Pl. 4, Fig. 97

Holotype — Pl. 4, Fig. 97; Size 49 × 45 μ; Slide no. 4377/16.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Spores subcircular, inaperturate, 34-50 × 32-47 μ. Wall 3-6 μ thick, not folded.

Comparison — *Inapertisporites kedvesii* Els. (1968) resembles the present species in subcircular shape but is distinguished by its thin wall and irregular folds.

Inapertisporites sp.

Pl. 4, Fig. 98

Description — Fungal spores subcircular, 60-90 μ, inaperturate. Wall up to 1-2 μ thick, not much folded.

Comparison — *Inapertisporites kedvesii* Els. (1968) has thin wall with many folds.

Genus — *Dicellaesporites* Els., 1968

Type species — *Dicellaesporites popovii* Els., 1968.

Dicellaesporites constrictus sp. nov.

Pl. 4, Fig. 99

Holotype — Pl. 4, Fig. 99; Size 104 × 64 μ; Slide no. 4352/14.

Type Locality — Palana lignite field, Palana, Rajasthan.

Diagnosis — Two celled, psilate, inaperturate fungal spores, $89\text{-}120 \times 40\text{-}101$ μ, constricted in middle, uniseptate. Individual cell subcircular-oval.

Comparison — *Dicellaesporites popovii* Els. (1968) is much smaller in size range than the present species. Moreover, in the present species, constriction in the septate region is also much pronounced.

Genus — *Callimothallus* Dil., 1965

Type species — *Callimothallus pertusus* Dil., 1965.

Callimothallus assamicus Kar, Singh & Sah, 1972

Holotype — Kar, Singh & Sah, 1972, Pl. 2, Fig. 19.

Description — Ascomata subcircular with or without undulated margin, one celled thick, nonosteolate. Cells in middle region $\pm$ squarish, outer cells rectangular, thicker, pseudoparenchymatous, cells uniporate in middle region.

DISCUSSION

General Considerations — The samples from Palana lignite field, Rajasthan, yielded a rich palynological assemblage comprising algal filaments, microplanktons, fungal spores and microthyriaceous fruiting bodies; pteridophytic spores and angiospermic pollen grains. Not a single gymnospermous pollen was recovered from the present material. The assemblage consists of 8 genera and 11 species of pteridophytic spores, 24 genera and 36 species of angiospermic pollen, 9 genera and 16 species of algal and 3 genera and 4 species of fungal remains.

PTERIDOPHYTA

Pteridophytic spores are very common in the present material. Generally speaking they are found in abundance in shales than in lignites. 8 genera and 11 species representing the following 5 families have been recognized: Osmundaceae, Matoniaceae, Polypodiaceae, Schizaeaceae and Cheilanthaceae.

Osmundaceae — 2 genera, viz., *Todisporites* and *Osmundacidites*, belong to this family. The family is rather meagrely represented in the assemblage. The family is found both in tropical and temperate climate.

Matoniaceae — This family is also rarely found in the present material. The spores assigned to *Dictyophyllidites* most probably belong to this family.

Polypodiaceae — The typical bean shaped, monolete, verrucose spores of Polypodiaceae is not commonly found in the assemblage. The spores of *Laevigatosporites* represented here by *L. lakiensis* and *L. cognatus* have also been assigned to this family.

Schizaeaceae — The family is very well represented. The monolete, striate, oval spores resembling the extant genus *Schizaea* have been referred as *Schizaeoisporites*. The trilete, subtriangular, laevigate spores resembling *Lygodium* are very commonly met with.

Cheilanthaceae — This family is also quite abundant like Schizaeaceae. The spores of this family have distinct perine and the haptotypic mark is also variable. Three species, viz., *Cheilanthoidspora enigmata*, *C. monoleta* and *C. reticulata* belong to this family. In India, cheilanthoid ferns are found in dry places where the humidity is relatively low.

ANGIOSPERMAE

The angiospermic pollen together with the pteridophytic spores constitute more than 90% of the assemblage. The former has been referred to 24 genera comprising 36 species. Both the monocotyledonous and dicotyledonous plants are well represented in the assemblage.

MONOCOTYLEDONEAE

The monocotyledonous plants are represented by 3 families, viz., Potamogetonaceae, Palmae and Liliaceae. 4 dispersed genera have been included in them.

Potamogetonaceae — This acquatic family of annual or perennial herbs is meagrely represented in the present assemblage. *Retipilonapites arcotense* and *Retipilonapites* sp. belong to this family.

Palmae — This family is quite abundant. *Palmaepollenites* and *Couperipollis* both belong to this family. This family is one of the earliest known families from the Upper Mesozoic and is confined to tropical to subtropical region. They are either shrubs or trees and rarely climbers.

Liliaceae — This family is represented by the genus *Liliacidites*. The pollen grains of Liliaceae can be conveniently identified by its oval shape, monosulcate nature and presence of bigger meshes in middle region. In some samples this genus is quite common. This family comprises mostly herbaceous plants and are distributed in tropical as well as in temperate climate.

DICOTYLEDONAE

Nymphaeaceae — This family comprises the acquatic perennial herbs and is found both in temperate and tropical climate. In some samples this family is well represented by *Nymphaeoipollis marginatus*, *N. flavatus* and *Nymphaeoipollis* sp. The pollen grains belonging to this family have subcircular-circular shape, zonisulcate condition and scrobiculate structure.

Leguminosae — This is a very big family consisting of three suborders, viz., Papilionaceae, Caesalpiniaceae and Mimosaceae. The former is the largest of the three and cosmopolitan in its distribution. Caesalpiniaceae and Mimosaceae, on the other hand, do not extend beyond the tropical and warm temperate zones. The pollen grains of *Margocolporites* in all probability represent Caesalpiniaceae (see Ramanujam, 1966). The pollen grains of *Margocolporites* are frequently met with and are represented by three species, viz., *Margocolporites sitholeyi*, *M. sahnii* and *M. complexum*. Besides some tricolpate pollen grains described under the genus *Tricolpites* may also belong to Caesalpiniaceae.

Cruciferae — The presence of pollen grains belonging to Cruciferae is rather doubtful. Only one species, i.e. *Tricolpites levis*, may be attributed to this family. Cruciferae, it may be mentioned here, is a large and widely distributed family and mostly abundant in temperate and cooler regions though some species may be found in tropical belt only.

Rubiaceae — The presence of Rubiaceae in the present assemblage cannot be properly ascertained. However, *Cupuliferoipollenites* sp. described here may be referred to this family. This family is mostly confined to tropical-subtropical belts.

Anacardiaceae — This family consists either of trees or shrubs and is chiefly tropical. *Rhoipites pilatus* most probably belongs to this family.

Hippocrateaceae — The pollen grains of this family is perhaps represented by *Hippocrateaceaedites constrictus*.

Guttiferae — This family is very well represented in the assemblage. *Platoniapollenites*, *Calophyllumpollenites* and *Kielmeyerapollenites* closely resemble the extant pollen grains of *Platonia*, *Calophyllum* and *Kielmeyera* respectively. Guttiferae, it may be recalled here, was one of the most dominant forest flora during Tertiary in India. Most of the genera belonging to Guttiferae are found in the evergreen and semievergreen forests of the tropical zone or in areas with relatively mild monsoon climate.

Meliaceae — The tetracolporate, laevigate pollen grains resembling the extant pollen of *Melia* are quite commonly met with in the present assemblage and have been placed in the dispersed genus *Meliapollis*. This family consists mostly of trees and shrubs and is quite widespread in tropical belt.

Proteaceae — The family is represented by pollen grains referred to as *Proteacidites protrudus* and *Proteacidites* sp. This family seems to be widely distributed during Tertiary.

Onagraceae — This family in the present assemblage is mostly represented by triangular shaped pollen grains with 3 protruded ora. *Triorites triangulus* and *T. hirsutus* have been attributed to this family. The plants belonging to Onagraceae are chiefly subtemperate though some acquatic forms are also found in tropical belt.

Most of the algal and fungal elements cannot be traced up to family level and so their affiliations except in one or two cases remain open.

Comparison with the known Lower Tertiary assemblages from India

The present palynological assemblage from Palana closely resembles that of Kakdi Formation of Kutch, Gujarat, investigated by Mathur (1963, 1966), Sah and Kar (1969, 1970) and Venkatachala and Kar (1969). The Kakdi palynological assemblage so far known consists of total 64 genera and 98 species. Out of these 21 genera and 30 species belong to pteridophytes, 4 genera and 4 species to gymnosperms and 39 genera and 64 species to angiosperms. The Palana palynological assemblage is, however, not so diversified as it consists of

44 genera and 67 species. Of them, 9 genera and 16 species belong to algal and 3 genera and 4 species to fungal remains. Most of the spores-pollen genera found in Palana are also found in Kakdi Formation. Thus of the 8 pteridophytic genera, 7 are common to both the assemblages. They are: *Todisporites, Dictyophyllidites, Osmundacidites, Dandotiaspora, Laevigatosporites, Schizaeoisporites* and *Seniasporites*. Among the angiospermic genera, 20 are common to both: *Palmaepollenites, Liliacidites, Cupuliferoipollenites, Rhoipites, Hippocrateaceaedites, Margocolporites, Lakiapollis, Verrutricolpites, Verrucolporites, Meliapollis, Polybrevicolporites, Polycolpites, Pseudonathofagidites, Diporites, Trilatiporites, Proteacidites* and *Triorites*.

From the above mentioned data, it is evident that both Palana and Kakdi assemblages are homotaxial, though the latter assemblage is more diversified than the former. It may be stated here that the palynological assemblage of Kakdi Formation has been investigated intensively through a number of borehole cores from different localities whereas in Palana it could not be studied so thoroughly due to limited area of exposure.

The palynological assemblage of Cherra Formation worked out by Sah and Dutta (1966, 1968), Dutta and Sah (1970) consists of 49 genera and 103 species. Of them, 18 genera and 34 species belong to pteridophytes, 2 genera and 2 species to gymnosperms and 29 genera and 67 species to angiosperms. Among the pteridophytes, 5 genera are common to both Palana and Cherra Formation. They are: *Dictyophyllidites, Dandotiaspora, Laevigatosporites, Seniasporites* and *Schizaeoisporites*. Of the angiosperms, the following 10 genera are common to both: *Retipilonapites, Palmaepollenites, Couperipollis, Liliacidites, Nymphaeoipollis, Tricolpites, Polycolpites, Diporites, Proteacidites* and *Triorites*.

The palynological assemblage of Cherra Formation, though broadly corresponds to that of Palana, is different in some respects. Lycopodiaceous spores represented by *Lycopodiacidites* and *Lycopodiumsporites* are very common in Cherra but have not been recorded from Palana. Moreover, the overwhelming abundance of *Retialetes* and *Schizosporis* (50%) which is the main feature of Cherra assemblage is conspicuous by their absence in Palana. Besides, *Cheilanthoidspora* which is quite common in Palana is absent in Cherra. Perhaps, ecological factors and endemic vegetation were responsible for this dissimilarity in the assemblage.

Palynological assemblage described from Subathu sediments by Salujha *et al.* (1969) comprises a total of 28 genera and 45 species. Of them, 10 genera belong to pteridophytes, 1 to gymnosperms, 12 to angiosperms and 5 to microplanktons. Palynological fossils described by them are rather ill preserved and so a close comparison is not possible. However, among the pteridophytes the following genera seem to be common to both: *Todisporites* (*Scabratriletes* sp. D, pl. 3, fig. 13), *Dandotiaspora* (*Psilatriletes lobatus* Salujha *et al.*, pl. 3, figs. 7-8), *Osmundacidites* (*Scabratriletes* sp. A, pl. 3, figs. 10, 16) and *Seniasporites* (*Retimonoletes* sp. A, pl. 3, fig. 1). The angiospermic pollen grains are poorly represented in Subathu sediments in comparison to Palana and only 3 genera seem to be present in both the assemblages, viz., *Palmaepollenites* (*Retemonocolpites* sp., pl. 3, fig. 38), *Diporites* (*Brandiporites* sp., pl. 3, fig. 39; *Psilodiporites ovatus* Salujha *et al.*, pl. 4, fig. 41), *Tricolpites* (*Scabratricolpites* sp., pl. 4, fig. 43).

The miospore assemblage from Tura Formation worked out by A. K. Ghosh (1940), Sen (1948), Biswas (1962), T. K. Ghosh (1969) and others appear to come closer to that of the Cherra Formation than that of Palana because of the presence of forms like *Lycopodiumsporites* (*Stenozonotriletes kangmanni* Biswas: Ghosh, 1969, pl. 1, fig. 1, *Reticulatisporites* sp. Ghosh, 1969, pl. 1, fig. 2), *Retialetes* (*Microreticulatipites intecta* Baksi: Ghosh, 1969, pl. 1, fig. 3) and *Favitricolporites* (*Tricolporipites tiliaceaeformis* Biswas: Ghosh, 1969, pl. 1, fig. 25). Some of the genera are, however, common in both Palana and Tura Formation, viz., *Dandotiaspora* (*Leiotriletes vimali* Ghosh, 1969, pl. 2, fig. 48), *Seniasporites* (*Laevigatosporites* sp. Ghosh, 1969, pl. 2, fig. 32), *Palmaepollenites* (*Palmaepites* Biswas: Ghosh, pl. 1, fig. 3), *Couperipollis* (*Colocasioideaepites* sp. Ghosh, 1969, pl. 1, fig. 28), *Margocolporites* (*Paleocaesalpiniaceaepites eocenica* Biswas: Ghosh, 1969, pl. 2, fig. 33) and *Tricolpites*.

ECOLOGICAL INTERPRETATION

The Palana palynological assemblage comprising algal and fungal elements, spores and pollen grain reveal that this assemblage is a mixed one: there being the tropical, subtropical, temperate and acquatic elements. The general composition of the mioflora also indicates that most of the microfossils might have been terrestrial. A perusal of the different families present in the assemblage shows that out of the 22 families, 10 are confined to the present day tropical-subtropical regions while 12 are cosmopolitan in distribution. Not a single family recorded here has a strictly temperate distribution (Table 1).

Palynological evidence provided by the spores-pollen families suggests a tropical climate during the deposition of Palana beds. The abundance of pollen grains belonging to Guttiferae and Meliaceae further indicates an evergreen, moist forest not far from the place of deposition. The presence of pteridophytic spores in good number suggests a moist, humid climate.

The place of deposition of the Palana lignite beds was coastal, probably deltaic. This is evidenced by the presence of brackish-water elements like microplanktons which have been described here. That the shore line was not very far is also borne by the presence of pollen grain of fresh-water plants like Potamogetonaceae and Nymphaeaceae. It is also possible that areas fringing the shore line were swamps where fern and fern-allies found a natural habitat.

TABLE 1 — SHOWING THE CLIMATIC DISTRIBUTION OF DIFFERENT FAMILIES PRESENT IN PALANA ASSEMBLAGE

TROPICAL-SUBTROPICAL	COSMOPOLITAN (TROPICAL-TEMPERATE)
1. Microthyriaceae	1. Botryococcus (acquatic)
2. Matoniaceae	2. Cyanophyceae (acquatic)
3. Cheilanthaceae	3. Dinoflagellates (mostly marine)
4. Palmae	4. Osmundaceae
5. Leguminosae (*Caesalpiniaceae*)	5. Polypodiaceae
6. Rubiaceae	6. Schizaeaceae
7. Anacardiaceae	7. Potamogetonaceae (acquatic)
8. Guttiferae	8. Liliaceae
9. Meliaceae	9. Nymphaeaceae
10. Proteaceae	10. Cruciferae
	11. Hippocrateaceae
	12. Onagraceae

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EXPLANATION OF PLATES

(All photomicrographs are enlarged *ca.* × 500)

PLATE 1

1. *Todisporites flavatus* Sah & Kar. Slide no. 4350/5.

2. *Dictyophyllidites* sp. Slide no. 4351/29.

3. *Osmundacidites* sp. Slide no. 4352/31.

4-5. *Schizaeoisporites palanaensis* sp. nov. Slide nos. 4353/22, 4363/2.

6. *Schizaeoisporites* sp. Slide no. 4353/3.

7-10. *Cheilanthoidspora enigmata* gen. et sp. nov. Slide nos. 4354/4, 4354/11, 4355/1, 4356/10.

11-14. *Cheilanthoidspora monoleta* sp. nov. Slide nos. 4357/11, 4358/2, 4358/7, 4358/4.

15-16. *Cheilanthoidspora reticulata* sp. nov. Slide nos. 4354/11, 4359/11.

17. *Dandotiaspora plicata* (Sah & Kar) Sah, Kar & Singh. Slide no. 4350/1.

18. *Retipilonapites arcotense* Ramanujam. Slide no. 4360/1.

19. *Retipilonapites* sp. Slide no. 4357/2.

20. *Palmaepollenites* sp. Slide no. 4361/3.

21-22. *Liliacidites reticulatus* sp. nov. Slide nos. 4361/5, 4354/6.

23. *Liliacidites ellipticus* Venkatachala & Kar. Slide no. 4362/11.

24-25. *Liliacidites* sp. Slide nos. 4363/3, 4371/7.

26-27. *Couperipollis rarispinosus* (Sah & Dutta) Venkatachala & Kar. Slide nos. 4354/3, 4357/8.

28. *Couperipollis brevispinosus* (Bis.) Venkatachala & Kar. Slide no. 4355/5.

29. *Couperipollis* sp. Slide no. 4355/7.

30. *Couperipollis kutchensis* Venkatachala & Kar. Slide no. 4355/3.

PLATE 2

31. *Nymphaeoipollis marginatus* Venkatachala & Kar. Slide no. 4354/11.

32. *Nymphaeoipollis* sp. Slide no. 4364/2.

33. *Nymphaeoipollis flavatus* Venkatachala & Kar. Slide no. 4365/4.

34. *Tricolpites reticulatus* Cookson. Slide no. 4353/25.

35. *Tricolpites pachyexinus* Couper. Slide no. 4365/1.

36. *Tricolpites* cf. *T. reticulatus* Cookson. Slide no. 4352/2.

37. *Tricolpites matauraensis* Couper. Slide no. 4359/11.

38. *Cupuliferoipollenites* sp. Slide no. 4366/12.

39-40. *Tricolpites paucireticulatus* sp. nov. Slide nos. 4361/2, 4354/9.

41. *Tricolpites levis* Sah & Dutta. Slide no. 4364/4.

42. *Tricolpites* sp. Slide no. 4367/10.

43-44. *Rhoipites pilatus* sp. nov. Slide nos. 4360/19, 4360/21.

45-46. *Hippocrateaceaedites constrictus* sp. nov. Slide nos. 4368/7, 4354/9.

47-49. *Calophyllumpollenites rotundus* gen. et sp. nov. Slide nos. 4360/25, 4355/2, 4369/29.

50. *Diporites* sp. Slide no. 4370/8.

51. *Verrutricolpites triangulus* Sah & Kar. Slide no. 4366/11.

52. *Caprifoliipites subglobosus* sp. nov. Slide no. 4359/10.

53. *Triorites hirsutus* sp. nov. Slide no. 4375/4.

54. *Verrucolporites verrucus* Sah & Kar. Slide no. 4371/5.

55-56. Tetracolporate pollen type-1. Slide nos. 4372/1, 4362/1.

57-59. *Platoniapollenites iratus* gen. et sp. nov. Slide nos. 4360/26, 4374/43, 4368/16.

60-61. *Kielmeyerapollenites eocenicus* gen. et sp. nov. Slide nos. 4368/24, 4360/34.

62. Pollen mass type-1. Slide no. 4353/24.

PLATE 3

63-64. *Botryococcus palanaensis* sp. nov. Slide nos. 4352/8, 4371/6.

65. *Tetraporina apora* sp. nov. Slide no. 4353/26.

66. *Tetraporina pachyderma* sp. nov. Slide no. 4351/31.

67-70. *Psilosphaera plicata* gen. et sp. nov. Slide nos. 4360/17, 4360/17, 3474/36, 4368/19.

71-73. *Temporina globata* gen. et sp. nov. Slide nos. 4360/24, 4368/6, 4374/44.

74-75. *Temporina dentata* sp. nov. Slide nos. 4376/1, 4374/40.

76-77. *Cephalia globata* gen. et sp. nov. Slide nos. 4360/6, 4375/2.

78-80. *Cephalia ovata* sp. nov. Slide nos. 4377/22, 4378/5, 4370/17.

81. *Octaplata rotunda* gen. et sp. nov. Slide no. 4368/21.

82. *Octaplata palanaensis* sp. nov. Slide no. 4363/8.

PLATE 4

83-84. *Palanaea grandulosa* gen. et sp. nov. Slide nos. 4379/18, 4379/8.

85. *Palanaea laevigata* sp. nov. Slide no. 4360/12.

86a-86b. *Cryptosphaera pachyderma* gen. et sp. nov. Slide no. 4351/7.

87-88. *Cryptosphaera valvata* sp. nov. Slide nos. 4350/4, 4350/2.

89-90. *Cornplanktona fracta* gen. et sp. nov. Slide nos. 4377/17, 4363/7.

91. *Cornplanktona unicorna* sp. nov. Slide no. 4379/26.

92. *Cornplanktona* sp. Slide no. 4352/17.

93. cf. *Cornplanktona* sp. Slide no. 4379/25.

94. Microplankton type-1. Slide no. 4350/16.

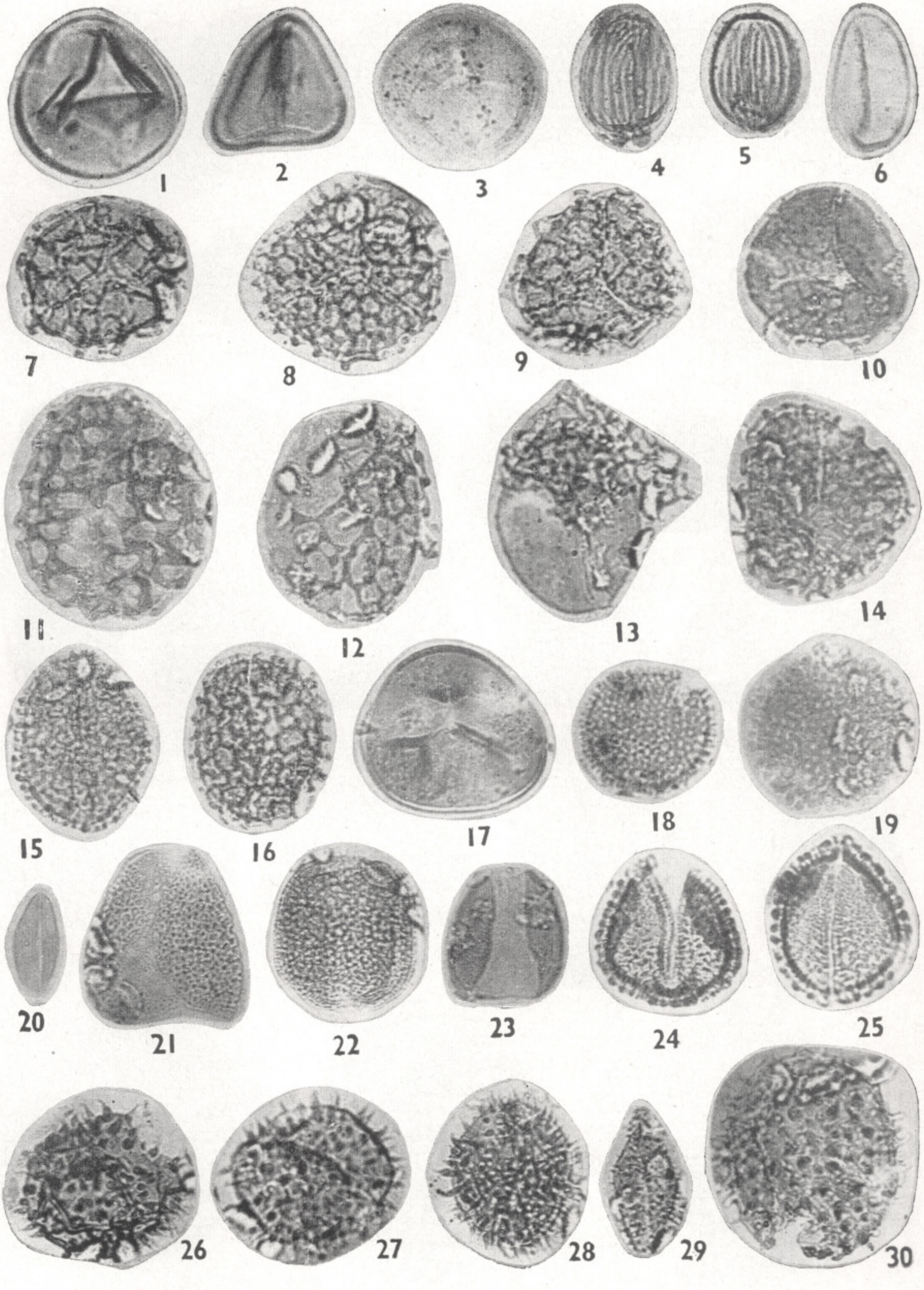
95. Microplankton type-2. Slide no. 4366/3.

96. *Inapertisporites kedvesii* Elsik. Slide no. 4377/4.

97. *Inapertisporites globatus* sp. nov. Slide no. 4377/16.

98. *Inapertisporites* sp. Slide no. 4366/13.

99. *Dicellaesporites constrictus* sp. nov. Slide no. 4352/14.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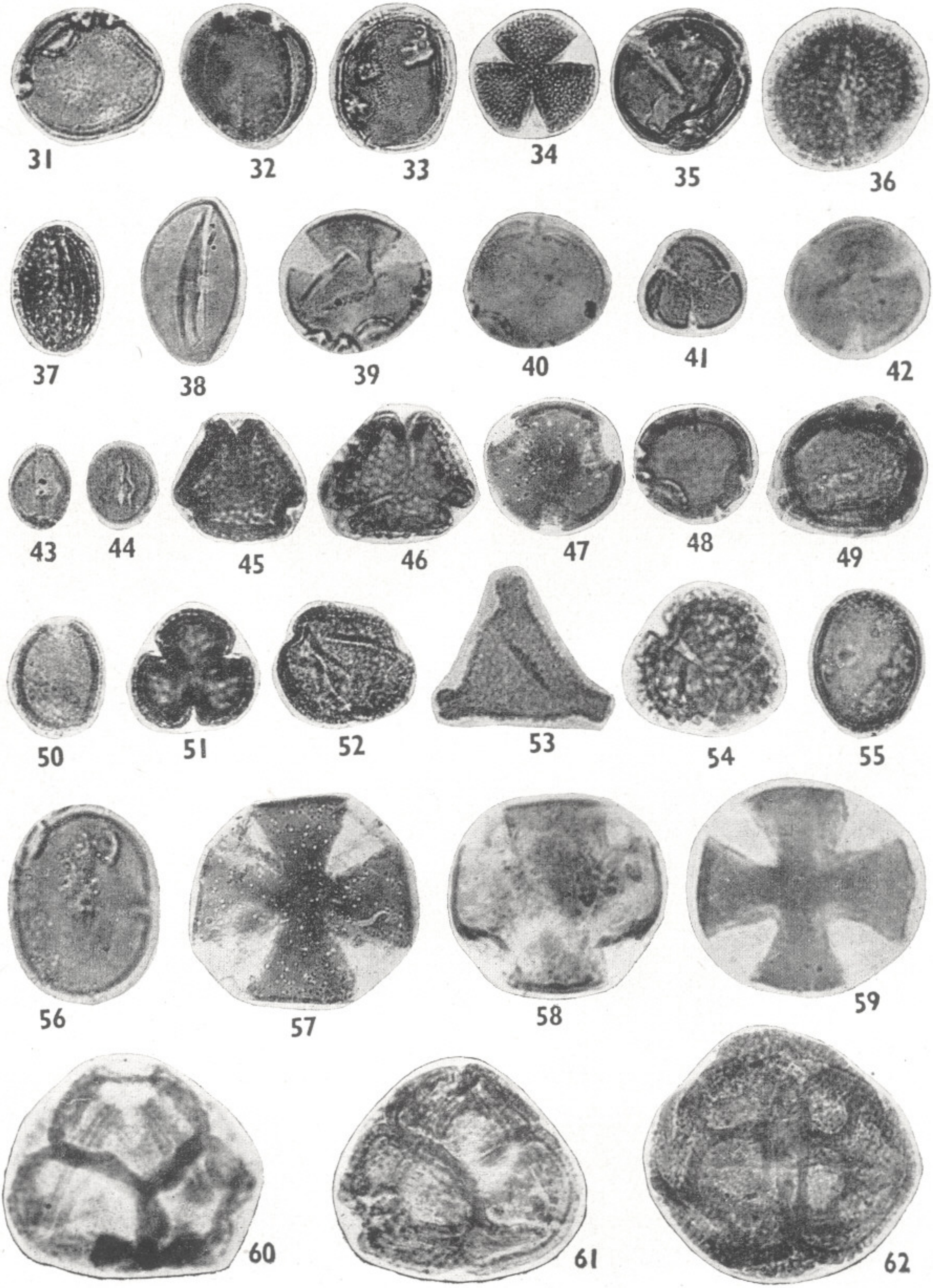
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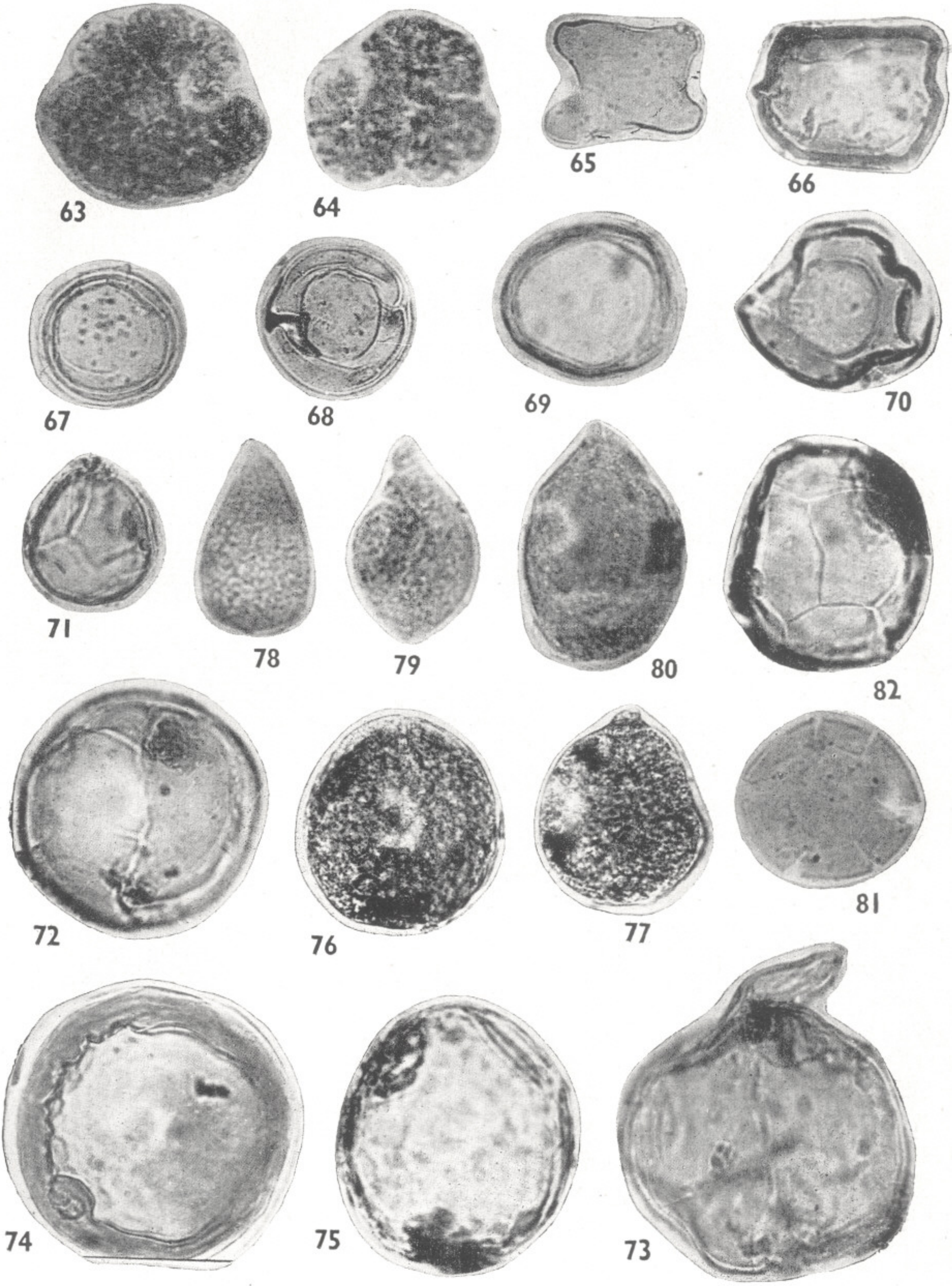
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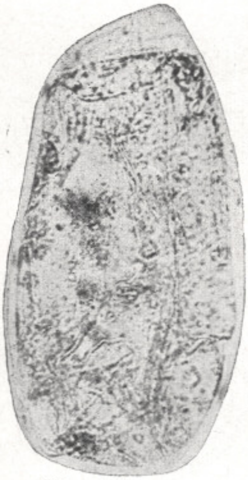
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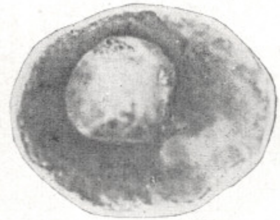
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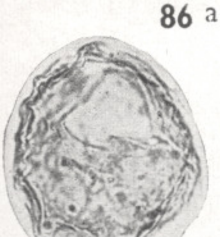
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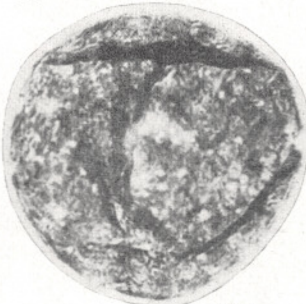
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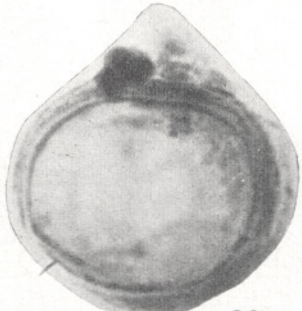
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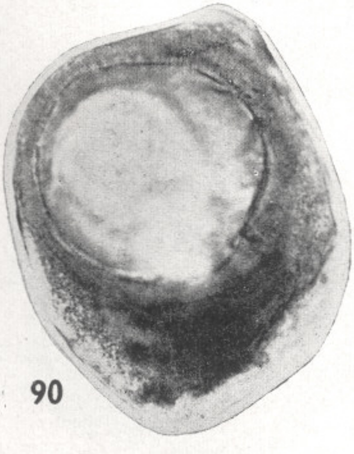
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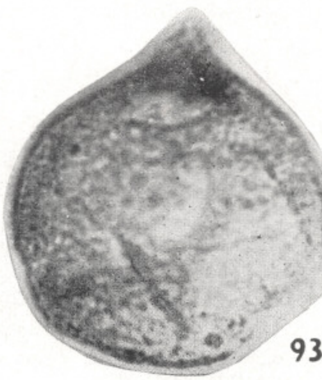
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