PETRIFIED SPORES AND POLLEN GRAINS FROM THE JURASSIC ROCKS OF RAJMAHAL HILLS, BIHAR

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ABSTRACT

Forty-six types of spores and pollen grains have been described from the Nipania chert. They are classified in accordance with the classification suggested by Pant. Pteridophytic spores, cycadophytic pollen grains and the winged grains of the conifers are more or less equally represented in the microflora. Among the pteridophytic spores are some types resembling the spores of modern *Lycopodium, Selaginella,* Cyatheaceae and *Schizaea.* Megaspores are also described for the first time from the Jurassic rocks of India. The winged pollen includes two, three, and four-winged grains.

Some new groups and sub-groups have been proposed in the classification suggested by Pant.

INTRODUCTION

THE fossil spores and pollen grains described here were discovered from the Nipania chert in the Rajmahal Hills, Bihar. Some spores from the same chert have previously been described by Rao (1935, 1936 & 1943). The spores and pollen grains in the present paper have been classified in accordance with the classification proposed by Pant (1954). For some of the spore types which cannot be accommodated in any of the groups in Pant's classification, new groups and sub-groups have been proposed.

MATERIAL AND METHODS

The material of chert, collected by the late Professor Birbal Sahni and party in 1948, was kindly given to me for investigation by Dr. R. V. Sitholey. The chert is rich in plant remains, of which only the spores and pollen grains are described here. Owing to the highly silicified nature of the organic remains resulting in the failure of the maceration method attempted by Rao (1943) the present study is based only on thin sections of the chert. They have acquired a natural reddish brown stain due to the presence of iron oxides. No artificial staining was, therefore, needed.

The material comes from Nipania near Dumurchir in the Amrapara district, Santal Parganas, Bihar, and belongs to the Rajmahal series.

DESCRIPTION

Phylum — Sporites
Class — Rimales
Sub-class — Tririmosa
Group — Microsporites
Division — Azonalesporites
Sub-group — Laevigatisporites

TYPE 1

Pl. 1, Fig. 1

Spore triangular in polar view, 38 μ, angles markedly round, sides very much retracted. Exine laevigate. Tetrad scar extending more than three-fourths of the radial distance to the spore-wall and bordered by a prominent ridge which follows the contour of the opening. Lips widely open.

The specimens in Pl. 1, Fig. 2, and Text-figs. 1, 2, measuring 38, 35 and 30 μ respectively, are very similar to Type 1. Seven specimens present.

TYPE 2

Pl. 1, Fig. 4

Polar view triangular, 32 μ with round angles. Wall smooth with wrinkles. Trilete mark short, lips narrowly open. Two specimens present.

TYPE 3

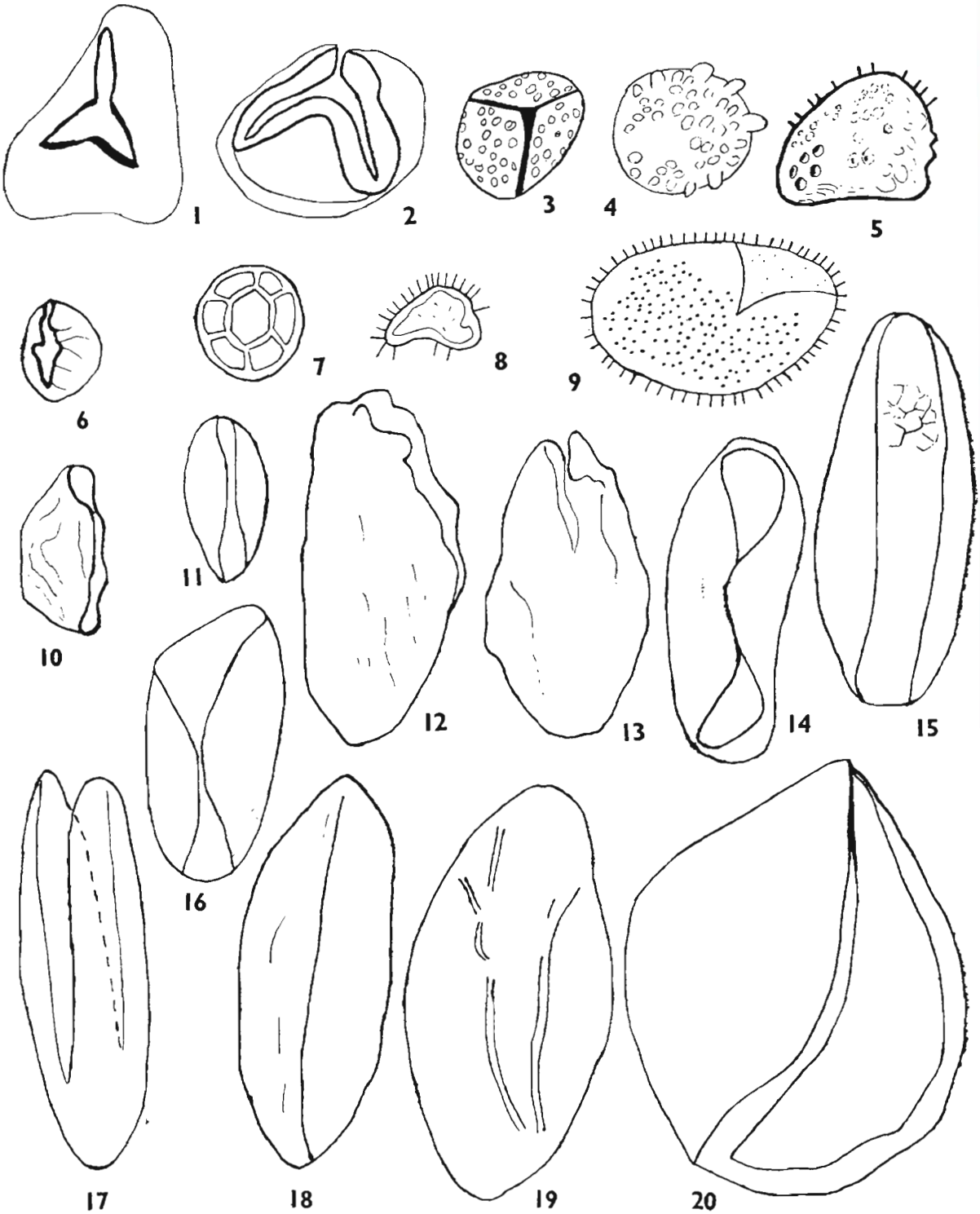
Pl. 1, Fig. 3

Spore irregularly round to sub-triangular in polar view, 31 μ. Wall thick and smooth. Arms of tetrad scar short and bordered by ridges. Single specimen present.

TYPE 4

Pl. 1, Fig. 5

Spore sub-triangular in polar view with somewhat round angles, 60 μ. Sides convex. Wall smooth, granular. Tetrad scar thin



TEXT-FIGS. 1-20

with long arms reaching the equator. Single specimen present.

TYPE 5

Pl. 1, Fig. 6

Spore flattened into an oval shape, 56 × 37 μ. Wall thin and finely granular. Triradiate mark short, distinct, with the arms reaching less than half of the radial distance. Margin of the scar slightly ridged, scar slightly open. Two specimens present.

TYPE 6

Pl. 1, Fig. 7

Polar view sub-triangular, 38 × 28 μ, angles round. Wall thin and finely granular. Distal side slightly arched. Triradiate scar short and thin. Three specimens present.

Sub-group — Camptosporites

TYPE 1

Pl. 1, Fig. 8

Spore oval, 58 × 37 μ. Wall thin and flexuous or vermiculate. Trilete scar distinct, only one arm of the scar seen in photo. Trilete long, closed, margins thin. Four specimens present.

TYPE 2

Pl. 1, Fig. 9

Spore spherical, probably tetrahedral in origin, 29 μ. Wall flexuously dissected or vermiculate. The sculpturing of the exine differs from that in Type 1 in this group. Three specimens present.

Sub-group — Tuberculatisporites

TYPE 1

Text-fig. 3

Spore triangular in polar view, 22 μ. Triradiate mark reaching the edge, closed, thin. Exospore finely nodulated. Two specimens present.

Liratosporites — a new sub-group

Trilete spores characterized by parallel and dichotomizing striations. The nearest to this in Pant's classification is *Periplecosporites* which includes spores with interwoven ridges. This sort of ornamentation is different from the parallel and dichotomizing ridges or striations characterizing the spores included here. This distinguishing nature of the ornamentation of these spores necessitated the creation of a new sub-group *Liratosporites* for them.

TYPE 1

Pl. 1, Figs. 10, 14-16

Spore triangular, 43 × 31 μ, angles round, sides retracted. Exospore striated, striations ridged, dichotomized and asymmetrical. Triradiate scar distinct, extending up to the angles, closed with thinly ridged margins.

Spore in (PL. 1, FIG. 16) measuring 57 μ is also similar except that the ridges are somewhat thicker and side wall straight. Ten specimens present.

Sub-group — Periplecosporites

TYPE 1

Pl. 1, Fig. 26

Spore small, 20 μ, sub-triangular. Wall bearing interwoven projections. Single specimen present.

Sub-group — Chomosporites

TYPE 1

Pl. 1, Fig. 27

Spore more or less spherical, 19 × 22 μ. Wall thickened by concentric rings. Triradiate mark present. Single specimen present.

←

TEXT-FIGS. 1-17 — 1, 2, smooth-walled trilete spores. × 800. 3, trilete spore with nodulated wall. × 800. 4, spore with tubercles. × 800. 5, spore with spines. × 800. 6, 10, 11, 14-16, 19, 20, pollen grains with a single furrow. × 800. 7, spore with reticulate wall. × 800. 8, 9, spores with spines. × 800. 12, 13, 17, spores with a furrow splitting the body, into two longitudinal halves. × 800.

Sub-group — Setosisporites

TYPE 1

Pl. 1, Fig. 13

Spore spherico-triangular, 31 × 25 μ. Wall bearing spines, 3·5 × 1·5 μ, ends of spines blunt. Triradiate scar present. Fifteen specimens present.

TYPE 2

Text-fig. 9

Spore sub-triangular, 54 × 41·25 μ. Spines thin and short. Triradiate mark short and open. Two specimens present.

TYPE 3

Text-fig. 5

Spore sub-triangular, 40 μ, spines short and thin. Triradiate mark indistinct. This spore differs from the types above in form as well as the nature of the spines which are intermediary to those of the Types 1 and 2. Two specimens present.

TYPE 4

Text-fig. 8

Spore sub-triangular, 14 μ. Spines very thin and fairly long, ending in thick heads. Triradiate mark not seen. One specimen present.

Sub-group — Reticulatisporites

TYPE 1

Pl. 1, Fig. 17

Spore sub-triangular, 28 μ. Exospore bearing reticulate ornamentation. Reticulation ridged. Meshes penta or hexagonal, 5 × 10 μ broad. Six specimens present.

TYPE 2

Pl. 1, Fig. 18

Spore sub-triangular, 34 × 28 μ, exospore bearing reticulate ridges. Meshes hexagonal, 7 × 10 μ. This spore differs from the above in its triangular shape and narrower meshes. Two specimens present.

TYPE 3

Pl. 1, Figs. 19, 20

Spore oval, 31 × 19 μ, bearing reticulate ridges. Meshes hexagonal and 5 × 8 μ broad. Two specimens present.

TYPE 4

Pl. 1, Figs. 22, 23

Spore triangular, 48 μ. Angles round and sides incurved. Wall ornamented with reticulation. Meshes irregular, narrow, 1-2 μ broad. Tetrad scar indistinct. Three specimens present.

TYPE 5

Pl. 1, Fig. 21

Spore oblong, 38 × 25 μ. Wall thick and bearing a narrow and irregular network. Triradiate scar present. One specimen present.

Lophosporites — a new sub-group

TYPE 1

Pl. 1, Fig. 12

Spore triangular, 36 × 28 μ. Wall sculptured with thick, small, rod-like projections, 0·1 × 0·3 μ, densely arranged. Triradiate scar indistinct. Two specimens present.

TYPE 2

Pl. 1, Fig. 11

Spore sub-triangular, warty, 16 × 12 μ. Exospore bearing several large thick rod-like projections. Triradiate scar indistinct. Single specimen present.

TYPE 3

Text-fig. 4

Spore spherical, warty, 25 μ. Projections smaller than in Type 2. Single specimen present.

Group — Triletes
Division — Azonotriletes
Sub-group — Dictyotriletes

TYPE 1

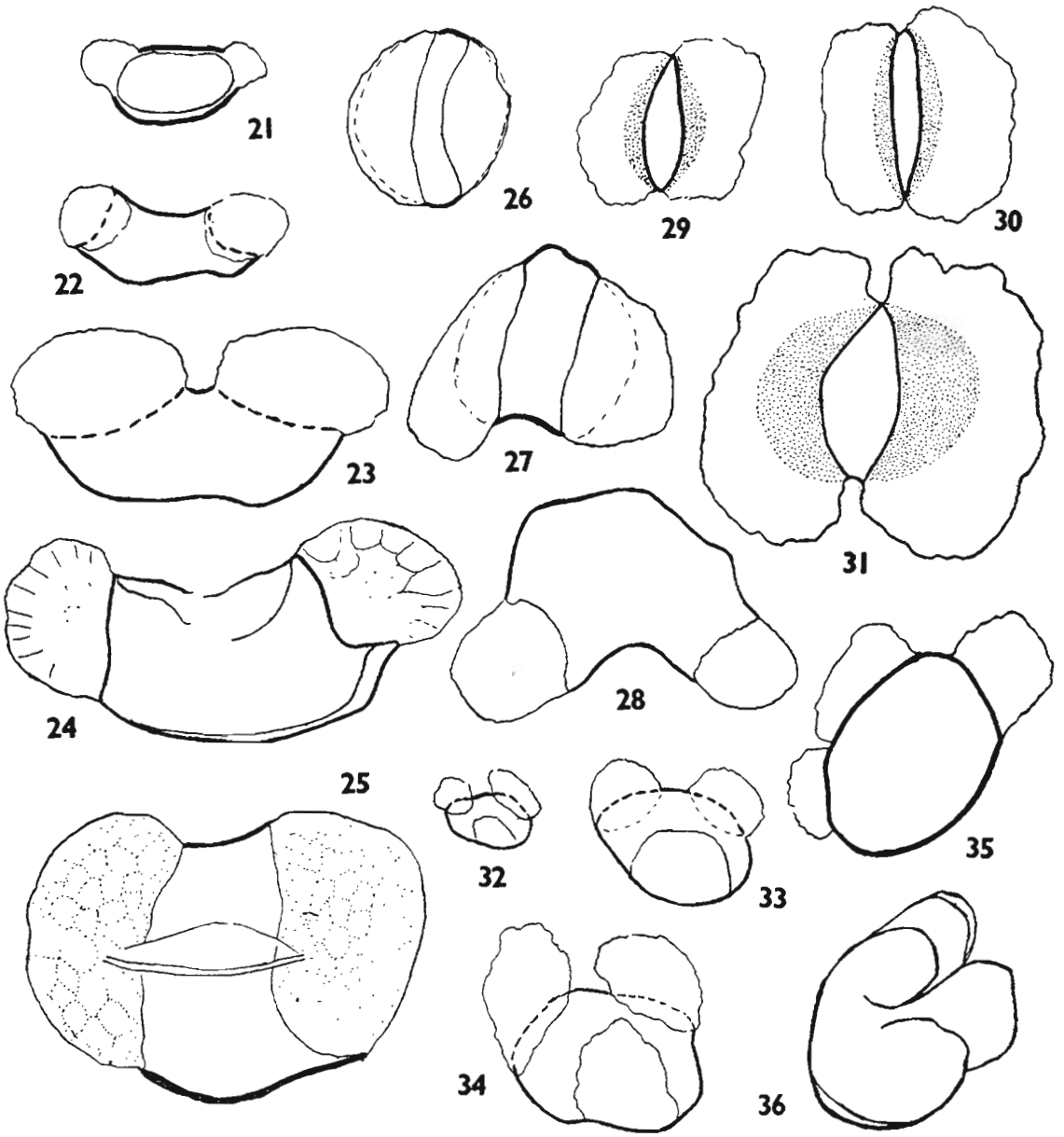
Pl. 2, Fig. 34

Trilete megaspore, 398 × 415 μ, more or less spherical. Exine characterized by broad-meshed, ridged reticulation, meshes 33·2 × 33·2 μ, pentagonal. Below the broad-meshed reticulation, a reticulation of comparatively much narrower meshes is there, meshes 6-8 μ in diameter. Ridges extend outwards like blunt rods, 26 μ long and 7 μ thick. Trilete mark distinct and more or less wavy. Three specimens present.

TYPE 2

Pl. 2, Fig. 35

Trilete spore, spheroidal, 220 μ. Exine ornamented with broad-meshed, ridged reticulation, meshes 16·6 × 33 μ, pentagonal. Reticulation of narrower meshes below the broad-meshed one absent. Wall of the meshes 7 μ thick. Ridges extend outwards as pointed rods, 6-8 μ long and 3·5 μ thick. Trilete mark wavy and distinct. Single specimen present.



TEXT-FIGS. 21-36 — 21-31, pollen grains with two wings. × 800. 32-35, pollen grains with three wings. × 800. 36, pollen grains with four wings. × 800.

Sub-class — Monorimosa
Group — Monoletes

Pant (loc. cit., p. 53) classified group Monoletes into two sub-groups, viz. *Azonomonoletes* and *Zonomonoletes*. *Azonomonoletes* type of the fossil and living spores show so many different kinds of exine-patterns (KNOX, 1938; SELLING, 1946) that *Azonomonoletes* as a sub-group may not prove suitable to include all such spore types. It is, therefore, proposed that the sub-groups *Azonomonoletes* and *Zonomonoletes* may be raised to the rank of divisions as in group Microsporites (PANT, loc. cit., p. 50) and new sub-groups may be formed to include the different types of spores on their exine pattern.

(i) Division — Azonomonoletes

TYPE 1

Pl. 1, Fig. 24

(?) Azonomonoletes

Spore bilateral, 53 × 37 μ. Wall obliquely striated, striations thick, broad and dichotomizing. Single specimen present. In Pant's classification no provision has been made for the spores ornamented with parallel and dichotomizing striations. Though the scar of dehiscence is nowhere to be seen in this type of spore, yet the affinities of the type specimen based upon the shape and the ornamentation are comparable with the modern genus *Schizaea*, the spores of which have a single slit of dehiscence. I feel a new sub-group should be created for including such types.

Laevigatimonoletes — a new sub-group

Smooth-walled spores with a median slit splitting the spore body into two valvular halves.

TYPE 1

Pl. 1, Fig. 28

Spore oval, with narrow ends, 53 × 25 μ. Wall smooth, dehiscing by a single median slit splitting apart the spore into two valvular halves. Text-figs. 12, 13, 17 and 18 have similar spores with smooth walls. Six specimens present.

TYPE 2

Pl. 1, Fig. 25

Spore oval, 78 × 28 μ, with both ends round. Wall characterized by pseudomeshes. A single slit of dehiscence present. Four specimens present.

(ii) Division — Zonomonolete
Crassizonomonoletes, a new sub-group

Monolete spores with a thick wing-like expanse.

TYPE 1

Pl. 2, Fig. 36

Spore spherical, 80 μ, with a thick wing-like expanse, 20-25 μ broad. Wing notched at two opposite points. Dehiscence scar single, widely open. Single specimen present.

Class — Irrimales

It is suggested that the sub-groups *Azonaletes* and *Zonaletes* (PANT, loc. cit., p. 53) may also be raised to the status of divisions under class Irrimales for the similar reasons as given above for group Monoletes.

(i) Division — Azonaletes
Dictyoaletes — a new sub-group

Alete spores characterized by reticulate ornamentation. Several of the spores examined showed that there was no slit of dehiscence. This alete nature characterized by the ornamentation of the wall necessitated the creation of another sub-group *Dictyoaletes*.

TYPE 1

Pl. 2, Figs. 37, 38

Spores bilateral, oval, 120-137 × 110-120 μ. Wall ornamented with reticulate ridges. Meshes pentagonal to hexagonal (PL. 2, FIG. 38), 8-9 μ broad forming an outer border in optical section (PL. 2, FIG. 37). Ten specimens present.

TYPE 2

Text-fig. 7

Spore spherical, 26·25 μ. Wall broadly reticulate, meshes unridged. Two specimens present.

Laevigataletes — a new sub-group

Alete spores with smooth walls.

TYPE 1

Pl. 2, Fig. 39

Spore spherical, 12·5 μ. Wall smooth. Spores seen in groups of two. Six specimens present.

TYPE 2

Pl. 2, Fig. 40

Spore spherical, 18-20 μ seen in sectional view. Wall thick and marked by folds. Spores occurring in groups. Several specimens present.

TYPE 3

Pl. 2, Fig. 41

Spore spherical, 19 μ. Wall smooth and without any folds. Several specimens present.

(ii) Division — Zonaletes

TYPE 1

Pl. 2, Fig. 42

Spore spherical, 84 × 80 μ, with a wing-like expanse 10 μ in breadth. Wall thick and smooth. The spore appears to be surrounded all round by a narrow expanse of a wing with a slightly irregular periphery. Wing is dense. No dehiscence scar is noted. One specimen present.

POLLEN GRAINS

Phylum — Pollenites
Class — Aporosa
Group — Saccata
Sub-group — Pityosporites

The two-winged pollen grains are described under the species, *Pityosporites nipanica* Rao.

Pityosporites nipanica Rao

Pl. 2, Figs. 43-46; Text-figs. 21-24; 26-28

Pollen grains with two sac-like swollen wings abound in the sections and show a fairly great range in size from 18·75 to 75 × 33·75 μ including wings. Besides, a range in form of the body of the pollen grains is also met with, e.g. body smaller than the wings, body larger than the wings, body oval, spherical or very much elongated or elliptical. Wings always smaller than the body, bladdery, granular or reticulate. The body of the grain in Text-fig. 28 is strongly arched on the dorsal side and the wings are outwardly projected.

Sub-group — Alisporites

Pollen grains with two flattened wings. A range in size of these grains is also met with. Size ranges from 25 × 11·5 μ to 78·75 × 50·75 μ. Body may be spherical or oval. Wings are either ventro-lateral or their bases are auriculate. Wings in latter case arranged symmetrically on either side of the body.

Pollen grains with wings in ventro-lateral position are described under the species, *Alisporites jurassicus* Rao.

Alisporites jurassicus Rao

Text-figs. 29-31

Body spherical, flattened, ventro-lateral in position. The pollen grain in Text-fig. 31 measures 78·75 × 50·75 μ including wings. Body alone is 33·75 μ broad.

Text-fig. 30 is similar to above, measures 45·75 × 30·75 μ including wings. The smallest grain shown in Text-fig. 29 measures 28·5 μ. Twenty specimens present.

Pollen grains with symmetrically arranged wings are described under the species, *Alisporites auriculiformis* Rao.

A. auriculiformis Rao

Pl. 2, Fig. 47; Text-fig. 25

Body oval with two flattened symmetrically arranged wings placed end to end to the body. Pollen grain 66 × 34 μ, body 37 × 22 μ. Ten specimens present.

Sub-group — Podosporites

The three-winged pollen grains are described under the species *Podosporites tripakshi* Rao.

P. tripakshii Rao

The pollen grains with three wings (TEXT-FIGS. 32-35) are found in abundance next to two-winged pollen. The range in size noted is from 16-40 μ in length to 16-35 μ

in breadth including wings. Body of the grains is generally spherical or elliptical. Dorsal wall is thicker.

In several sections the three-winged pollen grains are seen grouped in a mass and sectioned in various planes. One of these (TEXT-FIG. 34) measures $33{\cdot}75 \times 22{\cdot}50$ μ including wings. The smallest three-winged grain (TEXT-FIG. 32) measures 16 μ. Pollen grain in Fig. 33 measures 22·50 μ. Thirty specimens present.

Sub-group — Tetrasaccus

Pollen grains characterized by four sac-like swollen wings. The four-winged grains occur very rarely in our sections and have not been reported so far in fossil state.

TYPE 1

Text-fig. 36

Body is more or less spherical and dorsal wall is thick. The grain measures $37{\cdot}5 \times 30$ μ. One specimen examined.

Group — Intorta
Sub-group — Entylissa

TYPE 1

Pl. 1, Fig. 31; Text-fig. 11

Pollen grain ellipsoid or boat-shaped, $31 \times 15{\cdot}6$ μ. Wall smooth, bearing a single longitudinal furrow reaching both the ends, ends narrow. Pollen grain twice longer than the breadth. Twenty specimens present.

TYPE 2

Pl. 1, Fig. 32; Text-fig. 19

Pollen boat-shaped, 60×22 μ. Furrow median, single with round ends. Wall smooth.

Pollen grains in Text-fig. 15, 75×30 μ with some cellular structure inside the body and the grains in Text-fig. 14 measuring 56×36 μ are similar to Type 2. Twelve specimens present.

TYPE 3

Text-fig. 20

Pollen hemispherical, 100 μ in diameter. Furrow very broadly open, ends narrow and pointed, margin thick. Wall smooth. Single specimen present.

TYPE 4

Pl. 1, Figs. 30, 33

Pollen more or less ellipsoidal, 24-30 μ. Wall with wrinkles. Margin of furrow wavy and narrowly open.

Pollen grains in Text-figs. 6 and 10 measuring 24-28 μ are similar to Type 4 in general features. These are found grouped and jumbled together, bent and twisted in various ways thus causing wrinkles or twists on the exine and resulting in the wavy outline of the furrow. These resemble remarkably the pollen grains of *Williamsonia*. The pollen grains in Pl. 1, Fig. 33, 1 and 2 found profusely in our slides recall features of *Cycadocephalus Sewardi* Nath. Fifteen specimens present.

TYPE 5

Pl. 1, Fig. 29

Pollen oblong, 35×25 μ. Wall densely granular. Furrow fairly deep, narrow, broadly open in the middle with round ends. Five specimens present.

DISCUSSION

PTERIDOPHYTIC SPORES

So far the groups of Pteridophyta known from their megafossils in the Jurassic of the Rajmahal Hills, Bihar, are Lycopodiales, Equisetales, Osmundaceae, Gleicheniaceae, Cyatheaceae and Marattiaceae.

Spores described in the sub-group *Reticulatisporites* recall in their features spores of present-day lycopods. Spore Type 2 (PL. 1, FIG. 18) is remarkably similar to that of *Lycopodium alpinum* (KNOX, 1938, p. 441, FIG. 7) and spore Type 1 (PL. 1, FIG. 17) approaches *L. scariosum* (KNOX, 1938, p. 441, FIG. 6).

Setesisporites Type 1 (PL. 1, FIG. 13) is very much similar to *Sporites magadenis* Rao (1943) which Rao believes to belong to the Lycopodiales and which he compares with that of *Selaginella conferta*.

Lophosporites Type 1 (PL. 1, FIG. 12) approaches somewhat the warty microspore of *Selaginella spinosa*, *S. plumea*, *S. mongholia* and *S. haematodes* (KNOX, 1938, p. 441). Spore Type 3 (TEXT-FIG. 4) probably approaches *Saleginella picta* (KNOX, 1938, p. 441, FIG. 19). Comparisons of Type 1 can also be made with some Triassic

spores described by Daugherty (1941, PL. 39, FIG. 10) which have short, thick and blunt spines.

Of chief interest are the spores (PL. 1, FIGS. 10, 14-16) possessing an ornamentation consisting of parallel and dichotomizing striations. Spores with somewhat similar ornamentation are met with in the Cyatheaceae and the Schizaeaceae. The symmetrical arrangement of the striations differentiates the striated spores of Schizaeaceae from those of Cyatheaceae (KNOX, 1938, p. 456). The spores in *Liratosporites* Type 1 (PL. 1, FIG. 10, 14-16) in having asymmetrical arrangement of the parallel and dichotomizing striations approach more the Cyatheaceae than the Schizaeaceae (cf. KNOX, 1938, p. 453, FIG. 82).

Bilateral spore with striations described under (?)Azonomonoletes Type 1 (PL. 1, FIG. 24) is more Schizaeaceous. No bilateral spores are known in Cyatheaceae. Symmetrically striated bilateral spores produced by the genus *Schizaea* (SELLING, 1944a, p. 6; KNOX, 1938, p. 447) and fossil spores of this Type are already known from the younger horizons, viz. Palaeocene, Eocene, Miocene and Quaternary (SELLING, 1944b, pp. 64-73). The spore in Pl. 1, Fig. 24, however, differs from the Palaeocene and Eocene spores referred by Selling (1946, p. 65) to Schizaeaceae in its fewer and wider striations.

The megaspores described under two types of *Dictyotriletes* have been discovered for the first time from the Jurassic rocks of India. The casts of megaspores from the Triassic rocks of India were described by Sitholey (1943).

The fossil megaspores described here from Nipania differ from the so far described Mesozoic megaspores in the exine ornamentation. The distinctly reticulate and ridged reticulation of the Rajmahal megaspores described under *Dictyotriletes*, Types 1 and 2, shows that the megaspores may be of lycopodiaceous affinity.

WINGED POLLEN GRAINS

Pollen grains bearing wings are also abundant in the Nipania chert. These comprise two, three and four-winged pollen grains.

The pollen grains belonging to *Pityosporites* Seward range from very small to fairly large size. Amongst the winged pollen grains of the conifers, smallest occur in Podocarpaceae, the range in size for the two-winged grains being from 27 to 45 μ. In Abietineae the pollen usually measures above 50 μ in diameter and the largest size may be up to 100 μ or more (WODEHOUSE, 1935, p. 255). The range in size of the two-winged grains from Nipania chert is from 18·75 to 75 μ. Perhaps the pollen grains described here are comparable with those of Podocarpineae and Abietineae.

Two-winged grains belonging to sub-group *Pityosporites* have been dealt with in detail by Rao (1943a, p. 188) under the name *Pityosporites nipanica* Rao. A great range in the form and size of *Pityosporites* has been mentioned in the present paper.

Text-figs. 23 and 24 are similar to the pollen grains of *Masculostrobus rajmahalense* Rao (1943b, p. 123), the only petrified male cone hitherto known from Nipania.

The pollen grains belonging to *Alisporites* Daugherty have also been previously reported by Rao (1943a, pp. 185-188) from Nipania chert. The specimens described here are similar in form to Rao's specimens but they vary in size. Such pollen grains are not known in the living conifers.

Three-winged pollen grains are produced by some of the Podocarpineae, viz. *Podocarpus dacrydioides*, *Pherosphaera Fitzgeraldi*, *P. Hookeriana* and *Microcachrys tetragona* (WODEHOUSE, 1935, p. 279, p. 280; THOMSON, 1909, p. 26, ERDTMAN, 1943, p. 134). Besides, in Abietineae three and four-winged grains are occasionally produced in *Abies balsamifera* (WODEHOUSE, 1935, p. 264), *Pinus tuberculata* (WODEHOUSE, loc. cit., p. 258), *P. excelsa* (WODEHOUSE, loc. cit., p. 261; PURI, 1945), *Cedrus deodara* (WODEHOUSE, loc. cit., p. 261; ERDTMAN, 1943, p. 130). But the three-winged pollen grains from the Nipania chert hardly reach the minimum size of the grains of Abietineae which is 50 μ. *Phaerosphaera Fitzgeraldi* also produces four or five-winged grains in addition to the three-winged ones (WODEHOUSE, loc. cit., p. 279, 280); so also *Microcachrys tetragona* produces two, three and four-winged grains (THOMSON, loc. cit., p. 26, PL. II). The three-winged pollen grains shown in Text-fig. 33 approach the smallest three-winged grains found in *Pherosphaera Fitzgeraldi*. Pollen grains of *P. dacrydioides* are comparatively larger than the Nipania specimens. From Nipania Rao (1943a, pp. 182-185) described three-winged pollen grains under the name *Podosporites*

tripakshi Rao. In size and other characters the specimens described here approach those described by Rao.

Tetrasaccus type of the pollen grains are found very rarely in the chert. At present it is not possible to say whether the *Tetrasaccus* type of grains were produced along with two and three-winged grains by the same microstrobus, as is found amongst some of the living conifers such as *Pherosphaera Fitzgeraldi* and *Microcachrys tetragona*, or they were produced by a plant producing four-winged pollen grains only.

Cycadophytic Pollen Grains

The Cycadophytic pollen grains occur in the Nipania chert as profusely as the winged pollen grains and the Pteridophytic spores. Such pollen grains are found in Cordaitales, Bennettitales, Cycadales and Ginkgoales.

The *Entylissa* type of pollen grains described here present a variety of forms and sizes. They are all characterized by smooth surface except where the exine bears wrinkles or folds due to bending or twisting of the grains as in *Entylissa* Type 4 (Pl. 1, Figs. 30, 33 ; Text-figs. 6, 10). These resemble very much the pollen grains of *Williamsonia* and are remarkably similar to those of *W. spectabilis* figured by Nathorst (1909, Taf. 2, 8, Figs. 5-10; Taf. 4, Figs. 12, 11) and also those of *Cycadocephalus Sewardii* Nathorst (loc. cit., Taf. 8, Fig. 4).

The exine of the pollen grains in the modern Cycadaceae are rarely smooth as in *Zamia*. But in Ginkgoales they are always smooth. *Entylissa* Type 5 in Pl. 1, Fig. 29, may approach somewhat the spores of Ginkgoales. Grains represented by Type 1 (Pl. 1, Fig. 31; Text-fig. 11) are twice as long as broad and in this respect differ from those of *Ginkgo* which are one-third longer than broad and those of *Cycas* which are slightly or not at all elongate (Wodehouse, 1935, p. 302).

Rao (1943a, pp. 191-192) described from Nipania a Cycadophytic grain under the name *Sporites navicula* Rao. *Entylissa* Type 2 (Pl. 1, Fig. 32, Text-figs. 19, 15) described here is very much similar to Rao's specimen but for the differences in their dimensions.

The pollen grains of *Sahnia nipaniensis* Vishnu-Mittre (1953, p. 78), the male flower of the Pentoxyleae, also appear to be cycadophytic in nature.

The megafossils of Cycadophyta are commonly found in the Rajmahal Hills. The bennettitalean genera known from the Rajmahal Hills include *Williamsonia, Ptilophyllum, Bucklandia, Dictyozamites, Nilssonia, Otozamites, Cycadinocarpus, Zamites, Pterophyllum*, etc. Remains of Ginkgoales have also now been reported from this area (Sah, 1952, 1953; Mehta & Sud, 1953).

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REFERENCES

Daugherty, L. (1941). The Upper Triassic flora of Arizona. *Carnegie Inst. Wash. Publ.* **526**.

Erdtman, G. (1943). An introduction to pollen analysis. *Waltham, Mass.*

Knox, E. A. (1938). The spores of Pteridophyta with observations on microspores in coals of Carboniferous age. *Trans. & Proc. Bot. Soc. Edinburgh.* **32**(3): 438-466.

Mehta, K. R. & Sud, J. D. (1953). On some Ginkgoalean leaf impressions from the Rajmahal Hills, Bihar. *The Palaeobotanist.* **2**: 51-55.

Nathorst, A. G. (1909). Palaeobotanische Mitteilungen 8, Ueber *Williamsonia, Bucklandia, Cycadocephalus* und *Wiltrichia. Kungl. Svensk. Vet-Akad. Handl.* **45**(4): 1-38.

Pant, D. D. (1954). Suggestions for the classification and nomenclature of fossil spores and pollen grains. *Bot. Rev.* **20**(1): 33-60.

Puri, G. S. (1945). Some abnormal pollen grains of *Pinus excelsa* Wall. *Curr. Sci.* **14**: 255, 256.

Rao, A. R. (1935). Silicified plants from the Rajmahal series, India. *Proc. 22nd Ind. Sci. Cong. Calcutta*: 283.

Idem (1936). Winged pollen from the Jurassic of India. *Proc. 23rd Ind. Sci. Cong. Indore*: 304.

Idem (1938). Two petrified strobili from the Rajmahal Hills, Bihar. *Proc. 25th Ind. Sci. Cong.*: 151, 152.

Idem (1943a). Jurassic spores and sporangia from the Rajmahal Hills, Bihar. *Proc. Nat. Acad. Sci. India.* **13**(3): 181-197.

Idem (1943b). *Nipaniostrobus*, a new genus of *Dacrydium*-like seed-bearing cones and other silicified plants from the Rajmahal series. Ibid. **13**(2): 113-130.

SAH, S. C. D. (1952). Occurrence of Ginkgoales in the Rajmahal series of Bihar. *Curr. Sci.* **21**: 129, 130.

Idem (1953). On some species of *Ginkgoites* from the Jurassic of the Rajmahal Hills, Bihar. *The Palaeobotanist.* **2**: 55-59.

SELLING, O.H. (1944a). A new species of *Schizaea* from Melanesia and some connected problems. *Sven. Bot. Tidskrift.* **38**(3): 207-225.

Idem (1944b). Studies in the recent and fossil species of *Schizaea* with particular reference to their spore characters. *Meddelanden Göteborgs Botaniska Trädgård.* **16**: 1-109.

Idem (1946). Studies in Hawaiian Pollen statistics I. The spores of the Hawaiian Pteridophytes. *B.P. Museum, Honolulu. Special Publ.* **37**: 1-87.

SITHOLEY, R. V. (1943). Plant remains from the Triassic of the Salt Range in the Punjab. *Proc. Nat. Acad. Sci. India.* **13**(5): 300-327.

THOMSON, R. B. (1909). On the pollen of *Microcachrys tetragona*. *Bot. Gaz.* **47**: 26-29.

VISHNU-MITTRE (1953). A male flower of the Pentoxyleae with remarks on the structure of the female cones of the group. *The Palaeobotanist.* **2**: 75-84.

WODEHOUSE, R. P. (1935). Pollen grains. *New York & London.*

EXPLANATION OF PLATES

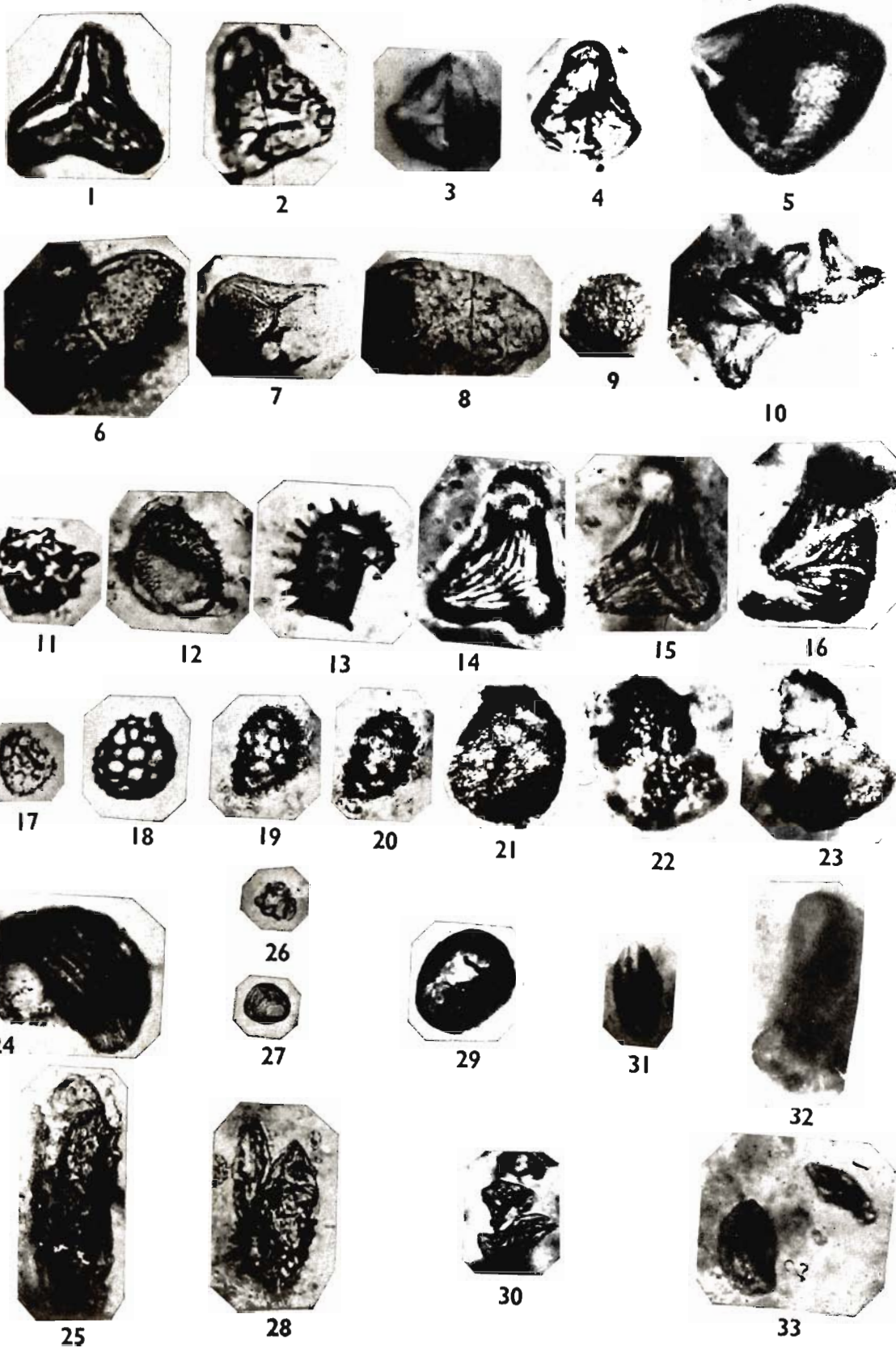
Magnification of photomicrographs 500 *times except mentioned otherwise.*

PLATE 1

1-4. Trilete spores with smooth walls.
5-7. Trilete spores with granular walls.
8, 9. Trilete spores with vermiculate sculpturing. Fig. 9 × 330.
10, 14-16. Trilete spores bearing asymmetrical parallel and dichotomizing striations. Fig. 10 × 300.
11, 12. Spores bearing tubercles. Fig. 11 × 750; Fig. 12 × 550.
13. Spore bearing spines.
17-20. Spores bearing ridged reticulation.
21-23. Spores bearing unridged reticulation.
24. Bilateral spores with parallel, dichotomizing striations.
25, 28. Spores dehiscing by a single slit into two equal halves. × 550.
26. Spore bearing interwoven projections. × 350.
27. Spore bearing concentric rings. × 350.
29, 31, 32. Smooth-walled pollen grains with a single furrow. Fig. 31 cf. Text-fig.11.
30, 33. Pollen grains with a single furrow and with folds on the wall.

PLATE 2

34, 35. Megaspores. × 200.
36. Monolete winged spore.
37. Alete spore with ridged reticulation.
38. Exine pattern in spore in Fig. 37. × 800.
39. Spherical spores, with smooth walls, grouped into two.
40. Spherical spores with folds on the wall.
41. Spherical spores with smooth walls.
42. Alete winged spore.
43-47. Two winged pollen grains.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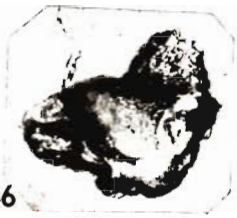

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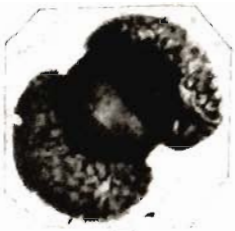

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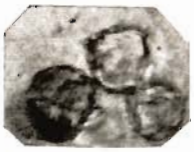

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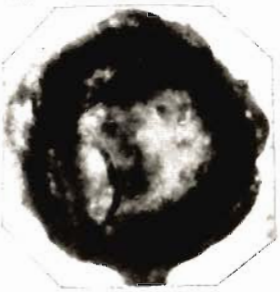

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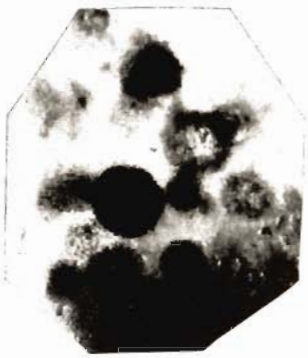

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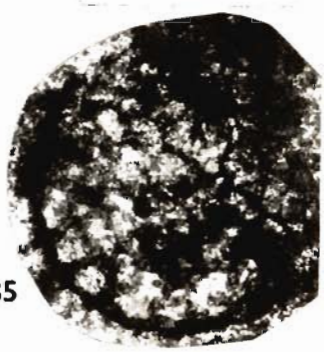

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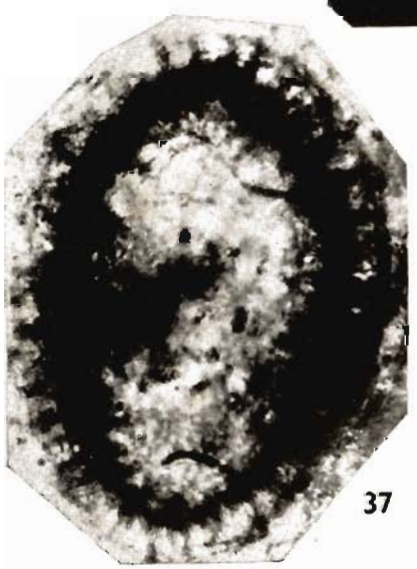

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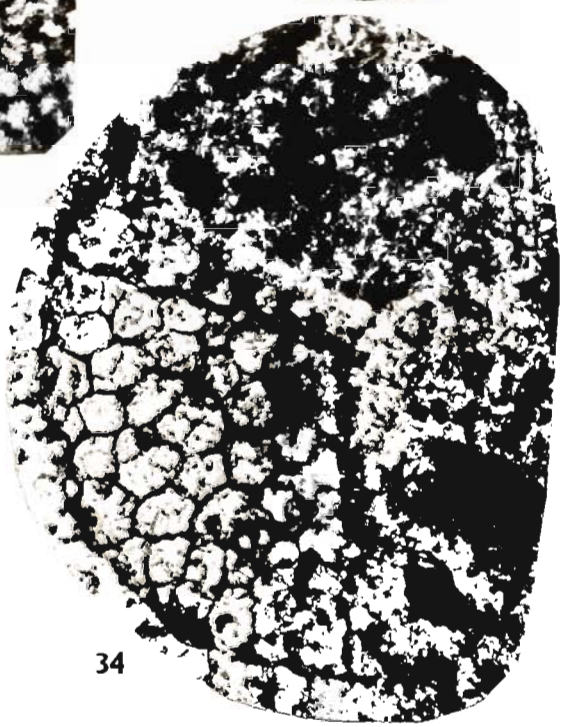

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