THE MIOSPORE GENERA IN THE COALS OF RANIGANJ STAGE (UPPER PERMIAN), INDIA

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ABSTRACT

43 miospore genera have been referred to in this treatise, out of which 15 genera are new to science. These have been diagnosed, described and compared with morphographically comparable other spore genera. The following genera are new — *Eupunctisporites* gen. nov., *Microbaculispora* gen. nov., *Microfoveolatispora* gen. nov., *Indospora* gen. nov., *Gondisporites* gen. nov., *Densipollenites* gen. nov., *Striomonosaccites* gen. nov., *Distriomonosaccites* gen. nov., *Verticipollenites* gen. nov., *Lahirites* gen. nov., *Hindipollenites* gen. nov., *Faunipollenites* gen. nov., *Striapollenites* gen. nov., *Distriatites* gen. nov., and *Tumoripollenites* gen. nov. Besides these *Striatites*, *Lunatisporites*, *Striatopodocarpites* and *Sulcatisporites* have been emended.— Some supra-generic taxa have also been created such as *Striasacciti*, and *Rectistriati*.

From this study some new morphographic features have come to light, e.g. the presence of ± triradiate muri on distal face of a triangular trilete spore; sculptured and zonate saccus-like body in a trilete spore; the occurrence of striated central bodies in monosaccate forms; the proximal surface of central bodies in disaccate grains bearing horizontal striations also crossed with vertical, connecting striations in many forms; occurrence of only vertical striations on the proximal side of central body in some saccate grains; occurrence of striations on the proximal as well as distal faces of the central body (1) in the same direction or (2) at right angles to one another in saccate grains. It has also been discovered that the proximal exine of central body in saccate grains may be smooth or microverrucose with indistinct, intrapunctate or intramicroreticulate structure. Bisaccate grains comparable to some modern members of Podocarpaceae are richly represented and non-saccate pollen grains morphographically similar to those of some living species of *Ephedra* and *Welwitschia* are also present in the horizon.

INTRODUCTION

INDIA is rich in coal deposits of Permian Age. These deposits occur in isolated coal basins spread over the central-eastern part of the country. In India, as in other countries, the correlation of coal seams has always been a problem and hence there has been a pressing need for the sporological study of coal seams for stratigraphical purposes.

For every sporological study, a detailed morphographical study of the spore assemblage is the primary requisite. It is not only necessary to circumscribe, adequately describe and suitably illustrate the spore types but also to refer them to a standard classification giving appropriate names in accordance with the rules of Botanical Nomenclature. Such a procedure lends standardization to the results which can be utilized for comparison by others. The only works of such a standard we know of from Lower Gondwana strata are by Balme and Hennelly (1955, 1956a, 1956b) from Australia, by Leschik (1959) from Karru-Sandstones (Lower Permian), S. W. Africa and Piérart (1959) from the coals of Luena (Katanga), Belgian Congo. Potonié and Lele (1960) have described the *Sporae dispersae* of Talchir shales from South Rewa Gondwana Basin, India, in detail. They have assigned them to 13 spore genera.

During the last two decades a number of investigations on Indian Lower Gondwana sediments have been published. Sen (1944) has given a preliminary account of micropalaeobotanical correlation of Satpukuria, Ghusick, and associated seams from West Raniganj Coalfield. Virkki (1945) has described a large number of spore types from Lower Gondwana sediments of India and Australia. Ghosh, Chandiok and Sen (1947) listed 8 spore types and their percentage in the only coal seam from Chope coalfield, Bihar. Ghosh and Sen (1948) investigated in detail the Satpukuria, Ghusick and certain other associated coal seams as there was a sharp controversy regarding their correct correlation. They recognized 52 spore types in the above seams. On the basis of the general spore types and rare spore types, they attempted to correlate the seams. They suggested Nega seam to be separate, Lower Dhadka and Kushadanga seams as one and the same and suspected Satpukuria seam to be the same as Ghusick seam. Trivedi (1950) has reported some megaspores from Lower Gondwana of Singrauli Coalfield.

Surange, Srivastava and Singh (1953) have published the results of their investigation on some Barakar coal seams of West Bokaro Coalfield. Sen (1953) has studied some Karharbari seams from Giridih Coalfield. Surange and Lele (1957) have described some microspores from Talchir Series. Datta (1957) has also studied miospores of Talchir Series and Barakar Stage and attempted correlation of coal seams. However, in none of these works a satisfactory, classified treatment of the spore forms has been persued.

Keeping in view the above facts, sporological investigation has been carried out on the seams of the East Raniganj Coalfield, India. The present work contains only the results dealing with the morphography of the miospore genera found in the coals of Raniganj Stage.

GEOGRAPHY AND GEOLOGY OF RANIGANJ COALFIELD

Raniganj Coalfield is one of the major coal producing areas now being worked in India. It has been geologically surveyed from time to time by Blanford (1861), Simpson (1913), Gee (1932), and Mehta (1956). Useful information about this coalfield is also available from Fox (1931, 1934).

Raniganj Coalfield lies in Damodar valley, at the border of the provinces of Bengal and Bihar. The major portion of the field lies east of Barakar river, in the western part of the province of Bengal, though smaller areas to the west of the Barakar river, south of the Damodar river and north of Ajay river encroach into Bihar. Damodar river traverses the southern area of the coalfield. The northern boundary of the coalfield is very irregular whereas the southern boundary is much more regular. The total area of Raniganj Coalfield is 619 square miles.

Raniganj Coalfield belongs to Lower Gondwana system. A complete succession of the strata in this coalfield as given by Mehta (l.c.) is as follows:

Lower Gondwanas
- Panchet Series
- Damuda Series
  - Raniganj Stage
  - Ironstone Shale Stage
  - Barakar Stage
- Talchir Series

Unconformity

Archaeans

According to Mehta (l.c.) in Raniganj Coalfield the general dip of the strata is southerly, so that Talchirs are normally exposed along the northern boundary and the successive Lower Gondwana horizons are met with from north to south.

Talchir Series, the lowest member of Lower Gondwanas, consists of a boulder bed which is succeeded by shales and sandstones. The boulder bed consists of an assorted mixture of boulders, pebbles and clay. The shales are greenish in colour and usually break up into prismatic fragments.

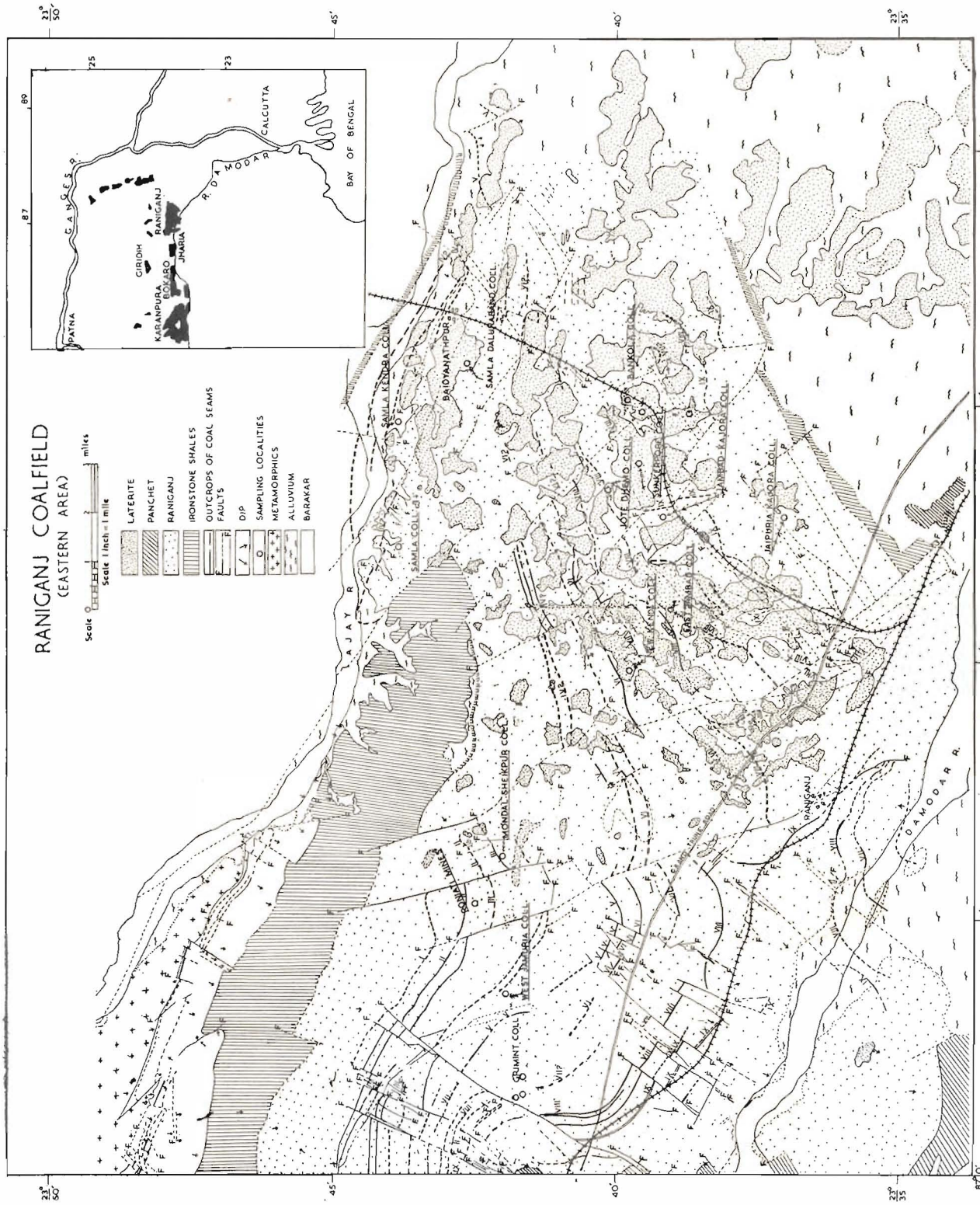
The Barakar Stage covers an irregular tract across the northern part of the coalfield. It consists of a massive formation of sandstones, grits and conglomerates with occasional beds of shale. The sandstones are light grey in colour and contain extensive carbonaceous matter in the form of seams, streaks and lenticles of coal.

The Ironstone Shale Stage is almost as thick as the Barakars and intervenes between the Barakar and Raniganj Stages. It is entirely barren of workable coal seams. The formation consists mostly of carbonaceous shale with clay ironstone nodules.

The Raniganj Stage with which we are concerned shows its maximum development in the Raniganj Coalfield. It occupies most of the area south of Iron shales in the coalfield, and its outcrop in the area varies in width from five to ten miles. It consists of fine sandstones, shales and coal seams, coarse grits being absent. The sandstones are greyish and greenish in colour Carbonaceous shales are limited. Coal seams are extensively developed. The maximum thickness of the Stage is 3400 ft.

Within the sediments of Damuda Series there is no evidence of marine conditions. The sediments are all of fresh water origin, laid down in large open flood plains, inland lakes or swamps, the inorganic material being derived locally from the land masses which adjoined these areas of deposition. The coal seams appear to be allochthonus in origin as no evidence of the existence of upright trunks or roots in the seam-floor is available. Raniganj Stage comprises of large number of coal seams. The succession of seams worked out by me occurs in the eastern part of Raniganj Coalfield (Map 1). In this part nine major coal seams are recognized.

The Panchet Series which overlies Raniganj Stage comprises greenish, buff and brownish sandstones and shales in the lower part, and greyish micaceous and felspathic sandstones and shales in the upper part.



MAP 1 — Geological map of eastern part of Raniganj Coalfield showing localities from where samples have been collected. (Geological details based on Mehta, 1956, Pl. 5, Mem. G.S.I. Vol. 84, pt. 1 — *Courtesy, Director, Geol. Survey of India*).

MATERIAL AND METHODS

Coal samples were collected from a number of collieries in East Raniganj coalfield (MAP 1, TABLE 1). Samples were collected from the exposed coal surfaces of the seams. The coal surface was scraped and dug sufficiently deep so as to expose clean, fresh layer, in order to avoid contaminations from wind-blown or water-swept particles. The samples were taken along a 15 cm. wide channel by chipping the coal to a depth of 7 cm. which gave about 1 kg. of coal pieces per foot length of the channel. The small pieces and dust were rejected and only such pieces as were about 1 cm. in size were taken. One foot or three feet samples were taken. Samples were collected in thick cloth bags and the data pertaining to each sample were noted and enclosed in the bag. The geological details of the succession within the seam as well as the nature of the floor and roof were noted and the location of sampling site plotted on a toposheet as well as on the map of the coalfield (MAP 1). In the laboratory they were entered in the field register.

To enable microfossils to separate from coal matrix, 40 gm. of 2-5 mm. sized coal per sample was taken for maceration. Coal samples were washed several times before putting in glass jars and were covered with nitric acid (fuming). From day to day a small amount of acid was further added. Complete maceration took nearly a week. After the maceration, the acid was decanted off and the material was washed several times in water. This was done by adding small quantities of water at 5-10 minutes interval repeatedly till the jar was full. Subsequently the diluted contents of each jar were gradually poured out over a Müller gauze (0·06) seive and simultaneously washed by a thick spray of water as the contents poured out. The seive was then inverted over a large trough and the residue was washed down by spray of water. From this macerate 2-4 gm. of material was taken in a small porcelain dish and covered with 10 per cent KOH solution, and kept on water bath till the material started simmering. After cooling the macerate, it was washed free from alkali. The residue was collected in two jars for the study of miospores. As this material still contained sandy particles, cuticles and other finely divided organic matter, small portions from one of the jars were taken in watch glasses and gently shaken so as to cause separation of the lighter organic constituents floating on the surface, from the heavier particles of sand, etc., remaining at the bottom. The spores, floating on the surface, were drawn off by a pipette. By repeating the process, a good concentration of clean miospores was obtained to be utilized for qualitative study. For quantitative assessment unconcentrated macerate from the second jar was directly mounted. In the case of each coal seam exactly similar procedure was adopted. The glycerine jelly mounts were made in the usual way using Formalin to harden the jelly along the edges and sealing it with Gold Seal thereafter. The preparations for microscopic examination from each maceration bear the same number as the maceration number. Usually, 6 glycerine jelly preparations from each of the jars were studied to determine the spore forms present and their quantity in each of the East Raniganj coals.

TAXONOMIC CONSIDERATIONS

The *Sporae dispersae* of Raniganj Stage are represented adequately with trilete and monolete miospores as well as non-saccate and saccate pollengrains. In the systematics of these spores and pollengrains the basic approach has been morphographical, i.e. circumscription of the species and genera on the basis of similarity in various characters borne by the individuals. Some spores as well as pollengrains have been referred to the spore genera known from the northern floras as these could not be morphographically separated but others which exhibited an association of qualitative characters hitherto unknown have been described as new genera. Wide stratigraphical disparity has also been given weight as supplementary evidence in separating the genera. In certain cases, between closely allied yet separable, homogeneous groups of species, the difference in the tendencies of the manifestation of characters has been accorded adequate weight in generic separation.

To enable morphographic systematization of a spore assemblage it is necessary firstly to equitably differentiate between morphographical characters and thereafter to assess their taxonomic value. This preliminary step ensures easy systematization of an assemblage. But to accomplish this a very large number of well preserved specimens

TABLE 1

Sl. No.	Name and Number of coal seam	Name of colliery	Geological location	Total thickness of seam	Portion sampled	No. of samples	Maceration Nos.
1	Taltore (I)	West Jamuria colliery	Dip corner of 'b' rise of 2 west level in rise east section	5′	5′	5	167 to 171
2	Poniati (II)	Grimint colliery	Pit 3 — about 2000′ from the shaft bottom towards east 14th Gallery	13′7″	13′7″	14	216 to 229
3	?Poniati (II)	Poniati Mines	Eastern end of the quarry	14′9″	14′9″	15	142 to 157
4	Koithee (III)	Grimint colliery	Pit 2 — about 100′ from the shaft bottom towards west in the gallery to Pit No. 3	13′0″	Top 9′10″	10	234 to 243
5	?Koithee (III)	Mondal's Shaikpur coll.	Eastern end of the quarry	9′2½″	9′2½″	9	158 to 166
6	Samla (IV)	Samla-Kendra coll.	Along the 14th east level between 10th and 11th dips of east section of Pit No. 2	15′9″	15′9″	16	1 to 16
7	Samla (IV)	Samla coll.	10th rise off 36′ west level from west cross-cut in incline No. 3	16′2″	16′2″	17	25 to 41, 191 to 195, 201 to 205
8	Rana Poriarpur (V)	Grimint coll.	Between 9th and 10th rise, 6th level on the main haulage road Pit No. 1	7′2″	7′2″	7	172 to 178, 179 to 185
9	Dobrana (V)	North Chora colliery	2nd level, near barrier	16′3″	16′3″	16	257 to 272, 400
10	Chora (?V)	Samla Dalurband	About 230′ to the east of Pit No. 6	15′6″	15′6″	16	79 to 94
11	Toposi-Kenda (VI)	New Kenda coll.	From the shaft pillar about 120′ 3.E. of Pit No. 2	27′	Bottom 20′10″	20	48 to 53, 60 to 65, 71 to 78
12	Bonbahal (VII)	Jote Dhemo coll.	About 400′, S.S.W. from the shaft, bottom of Pit No. 1	14′2″	14′2″	15	329 to 342A, 186 to 190, 196 to 200
13	Jambad-Bowlah	Bankola coll.	(a) Top section — in No. 2 level in No. 2 drift area. (b) Top of bottom section in No. 3 level (north). (c) Bottom of bottom section in 2nd rise off 17th level	35′7″	27′5″	10	273 to 282
14	Jambad-Bowlah	Jambad Kajora coll.	No. 4, north drift in the junction of No. 5, north level and No. 1 west rise	39′7″	Bottom 35′7″	12	295 to 306
15	Jambad-Bowlah	Sunkerpur coll.	16th rise, main west level of Pit No. 5	37′8″	Bottom 33′1″	12	283 to 292
16	Upper Kajora (IX)	Jaipuria Kajora coll.	Pit 2. — 27th level between 17th and 18th dip. N.E. section	21′	Top 10′	10	132 to 141

need be studied. The present study has been possible after an examination of over 10,000 good specimens out of which about 4000 were photographed, described and compared.

In the systematic treatment of the miospores and pollengrains of Raniganj Stage the following morphographical characters have been considered.

Shape — Among the trilete spores, circular as well as triangular forms with their intergrades are represented in this assemblage. Some of the triangular trilete spores have a significant tendency to flatten also in meridional plane and assume a carrot-like shape (TEXT-FIG. 4B). The monolete spores are elliptical or bilateral. Among the non-saccate pollengrains bilateral form is common. The saccate pollengrains are circular or bilateral. There are, however, a number of intermediate conditions met with apparently due to inconsistency in the development of the saccus. Circular pollengrains are usually monosaccate and bilateral ones disaccate. However, many forms are found which have a continuous saccus and yet a bilateral shape or the saccus is discontinuous only on one of the lateral sides accompanied by a bilateral shape, or a number of extra lobes developed elaborating a monosaccate or a disaccate grain into a trisaccate or even a tetrasaccate one. In spite of the number of lobes, if the bladder is continuous and the notches not laterally placed, I have considered it a monosaccate condition and if the grain is bilateral even if the bladder is continuous I have supposed it to be a variation from disaccate condition.

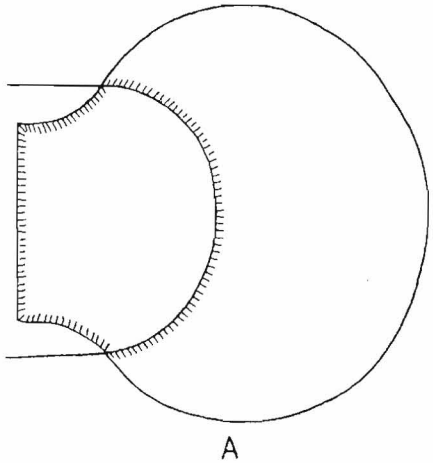
The shape of central body is ± circular in monosaccate grains and circular, vertically oval or horizontally oval in disaccate grains.

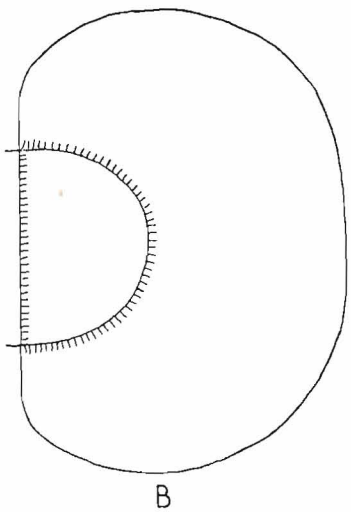
Ornamentation — The exine of trilete spores is either laevigate, punctate, granulose, verrucose, spinose, baculate or reticulate. The bacula in the case of one group of spores are uniform in size and equidistant all over and in others they are of varying sizes and irregularly distributed. Among the reticulate spores, some referred to *Reticulatisporites* and *Lycopodiumsporites* have high muri with wide meshes but others have low muri with small to wide meshes. The monolete spores have laevigate, granulose or verrucose ornamentation of the exine. In non-saccate pollengrains the exine is non-structured or structured, granulose to verrucose ornamented or striated as well as with various combinations of these.

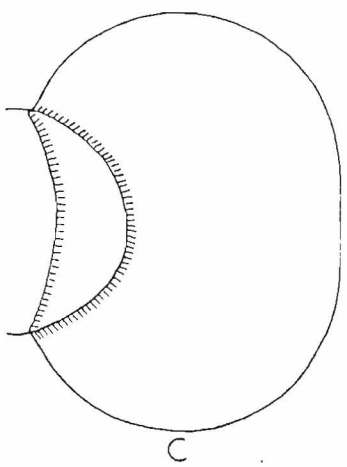
In saccate pollengrains the central body shows various types of ornamentation and structure. Thus the proximal face of the body, free from the saccus, is either smooth, verrucose or baculate sculptured, and intrapunctate or intramicroreticulate structured with or without striations. Among the striated exines some have horizontal striations only but others have vertical connecting striations between the horizontal striations. In some cases striations occur on both the proximal as well as the distal, saccus-free faces of the body which may either run parallel to each other on the two faces or those of one face may run at right angles to those of the other.

The intrareticulate structure of sacci appears varied. In some cases the reticulation is perfect, i.e. muri have no loose ends but in others the reticulation is imperfect. The size and shape of the meshes as well as the width of muri are variable. It has been possible to distinguish roundish and longish meshes as well as three sizes, i.e. small, medium and large meshes in the sacci. In some cases (PL. 16, FIGS. 215, 216) I suspect double intrareticulation, i.e. larger meshes within which finer reticulation exists.

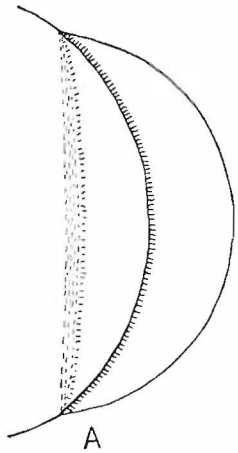
Saccus, Shape and Attachment — Saccus may be sac-like, i.e. covering the body on all sides but for a small area on one side or it may be girdling the body equatorially. The known examples of the first type are *Florinites, Wilsonia*, etc., and of the latter *Nuskoisporites*. Both these conditions of saccus shape are prevalent in the monosaccate pollengrains of Raniganj coals. In disaccate grains the saccus may be hemispherical (haploxylonoid, TEXT-FIG. 2) or more than hemispherical (diploxylonoid), i.e. subspherical or even pitcher-like in surfac. view (TEXT-FIGS. 1B, C & A). The attachment of sacci in disaccate grains of Raniganj coals as far as observed by me is proximally ±equatorial, often leaving a narrow to wide gap between the bladders on lateral sides and on the distal face of the body. All disaccate pollengrains have so far shown clear indication of distal inclination or distally lobed condition of the bladders. Distal lobing is also found in some monosaccate, circular as well as bilateral pollengrains as evident from the smaller area enclosed by the distal zones of saccus attachment as compared to the proximal area.

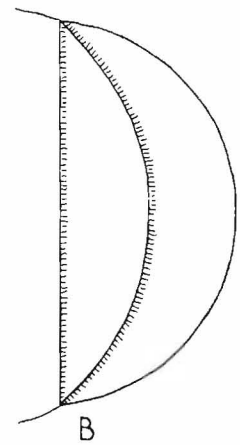


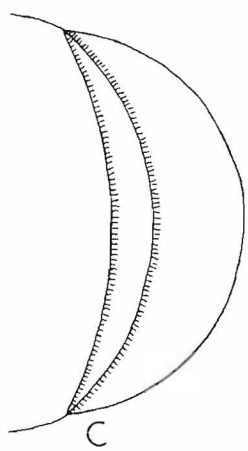




TEXT-FIG. 1 — Mode of bladder attachment in diploxylonoid, disaccate pollengrains.







TEXT-FIG. 2 — Mode of bladder attachment in haploxylonoid disaccate pollengrains.

The distal zones of saccus attachment enclose an area of the body wall where usually the exine is thin and smooth or sparsely sculptured. This region is described as the distal sulcus or channel. A number of kinds of distal channels have been recognized in the pollengrains of Raniganj coals. Thus where the zones of bladder attachment lie very close to each other a narrow, furrow-like sulcus results (TEXT-FIGS. 1A, 9A), or as in some others the zones of saccus attachment are very close to each other laterally but widely separated in the middle region resulting into a biconvex (boat-shaped) sulcus (TEXT-FIGS. 1C, 2C, 11A) and in the rest, the zones of saccus attachment are equally separated laterally as well as in the middle, resulting into straight edged simple sulcus (TEXT-FIGS. 1B, 2B, 10A, 11B). There has also been observed a group of pollengrains where the distal zones of saccus attachment are not sharply differentiated and thus no definite sulcus is delimited (TEXT-FIGS. 2A, 12A). In such cases usually the sacci are widely separated distally as well as laterally.

Size Ratio Between Sacci and Body — In disaccate, equatorially flattened pollengrains the bladders are either larger in their vertical height than the vertical height of the body (TEXT-FIG. 1) or smaller (TEXT-FIG. 2). The former condition is usually associated with diploxylonoid pollengrains and the latter with haploxylonoid pollengrains. In diploxylonoid grains the ratio in the height of the bladder and the body may be as high as 33 : 19 and as low as 33 : 32. In haploxylonoid grains this ratio may be as low as 15 : 16 to as high as 15 : 32.

Taxonomic Value of Various Characters — In keeping with my earlier view (Bhardwaj, 1955) qualitative characters have been valued for generic and supra-generic grouping of the *Sporae dispersae* and the quantitative characters for specific delimitation. Especially in the case of saccate grains the qualitative characters are those such as relating to the overall shape of the grain or the shape of the body, the nature of ornamentation, structure and the nature and arrangement of striations on the body. The type of distal attachment of sacci and the resulting shape of the sulcus, i.e. straight edged (narrow or wide), biconvex or ill-defined sulci and the shape of the sacci also are qualitative in nature and so is the perfect or imperfect intrareticulation of the saccus wall.

Among the qualitative characters not all have been accorded equal value. The presence or absence of striations on the central body, their nature and arrangement, the structure or sculpture of the body exine, the nature of sulcus and the shape of sacci have been given greater importance than the saccus intrareticulation or shape of the body. The presence or absence, or the direction of striations in the disaccate pollengrains, has been used by me for the broader grouping. The structure or sculpture of the body exine and the shape of the sulcus or saccus are the characters which in various combinations have been utilized to circumscribe the spore genera. In disaccate pollengrains the difficulty to resolve the shape of the saccus or sulcus due to the occasional irregular plane of flattening, twisting during flattening and lateral compression of the grains is easily circumvented by carefully resolving the zones of saccus attachment. The perfect or imperfect intrareticulation in saccus wall has not been utilized as an important qualitative character because in flattened sacci where the muri of one wall lie juxtaposed with those of the other, L-O analysis does not help to make out the true nature of reticulation.

Quantitative characters are many, e.g. the overall size of the spore, size of the body in saccate grains and the size of individual units of ornamentation, number of striations on the body, width of the sulcus and the width of muri as well as the meshes in the saccus of saccate grains. The overall size but for the trilete and monolete spores seems to be very widely variable in the saccate pollengrains. The size of the central body and the number of striations on it in saccate grains are variable within definable limits. The size of sculptural elements varies within definable limits in trilete and monolete spores. The width of the sulcus varies little but is rather a character difficult to measure because it varies with the nature of folding to which disaccate grains are subject during flattening. Usually discrepancy may result in specimens which have been laterally compressed, reducing the width of the sulcus. The size of the meshes in the saccus intrareticulation has been categorized into small, medium and large sized.

CLASSIFICATION

The classification of *Sporae dispersae* suggested by Potonié & Kremp (1954, 1955-56)

and subsequently elaborated by Potonié (1956, 1958) forms the basis of arrangement of the miospore genera from Raniganj Stage. Under Triletes and Monoletes the spore genera are included in their various series. In Pollenites under Monosaccites, a new series — *Striasacciti* has been instituted to include striated, monosaccate pollengrains. Under Disaccites, pollengrains have been sub-divided on the basis of having horizontal striated or non-striated central body. In addition to these a new group with pollengrains having vertical striations has also been distinguished. Thus four series, viz. Podocarpoiditi, Striatiti, Rectistriati and Disacciatrileti include all the disaccate spore genera described here.

The morphographical system of suprageneric arrangement followed here does not imply phylogenetic grouping. Thus it suffers from some misplacements of allied spore genera, e.g. in the present paper *Microbaculispora* and *Microfoveolatispora*, which are obviously closely related, had to be placed in two different series. The same probably holds good for *Eupunctisporites* and *Cyclobaculisporites*. But the biggest advantage of this system is its simplicity and convenience in treating the spore genera in an orderly way.

However, it is being increasingly felt that a phylogenetic arrangement of the morphographic suprageneric groups should be evolved to replace this system. But such a system for all *Sporae dispersae* is by no means easy. The affinities of a large number of spore genera of the Palaeozoic and Mesozoic are either not known or only doubtfully so and the phylogenetic value of identical characters in different groups of plants is frequently different.

In this paper while describing the saccate, bilateral forms I have used the expressions ' laterally ' or ' lateral sides ' which refer to the end region of the vertical axis or the shorter axis of equatorially flattened specimens in polar view, e.g. in bisaccate pollengrains the lateral region is that portion on the equator of the central body where the two sacci tend to meet or approach each other.

CLASSIFIED LIST OF MIOSPORE GENERA

SUPER DIVISION — **Sporites** H. Pot.
DIVISION — **Triletes** (Reinsch) Pot. & Kr.
SUB-DIVISION — **Azonotriletes** Luber

SERIES — **Laevigati** (B. & K.) Pot. & Kr.

1. Spore Genus — *Leiotriletes* (Naum.) Pot. & Kr.
2. do — *Eupunctisporites* gen. nov.
3. do — *Punctatisporites* (Ibr.) Pot. & Kr.
4. do — *Retusotriletes* Naum.

SERIES — **Apiculati** (B. & K.) Pot. (1956)

5. Spore Genus — *Cyclogranisporites* Pot. & Kr.
6. do — *Verrucosisporites* (Ibr.) Pot. & Kr.
7. do — *Anapiculatisporites* Pot. & Kr.
8. do — *Lophotriletes* (Naum.) Pot. & Kr.
9. do — *Acanthotriletes* (Naum.) Pot. & Kr.
10. do — *Microbaculispora* gen. nov.
11. do — *Cyclobaculisporites* Bhard.

SERIES — **Murornati** Pot. & Kr.

12. Spore Genus — *Microfoveolatispora* gen. nov.
13. do — *Indospora* gen. nov.
14. do — *Reticulatisporites* (Ibr.) Pot. & Kr.
15. do — *Lycopodiumsporites* Thierg.

DIVISION — **Zonales** (B. & K.) Pot. (1956)
SUB-DIVISION — **Zonotriletes** Waltz.
SERIES — **Zonati** Pot. & Kr.

16. Spore Genus — *Gravisporites* Bhard.
17. do — *Cirratriradites* Wils. & Coe
18. do — *Gondisporites* gen. nov.

DIVISION — **Monoletes** Ibr.
SUB-DIVISION — **Azonomonoletes** Luber
SERIES — **Psilamonoleti** V. D. Hamm

19. Spore Genus — *Latosporites* Pot. & Kr.

SERIES — **Ornati** Pot. (1956)

20. Spore Genus — *Punctatosporites* Ibr.
21. do — *Verrucososporites* (Knox) Pot. & Kr.

SUPER DIVISION — **Pollenites** R. Pot.
DIVISION — **Saccites** Erdtm.
SUB-DIVISION — **Monosaccites** Chitaley
SERIES — **Triletisaccites** Lesch.

22. Spore Genus — *Nuskoisporites* Pot. & Kl.

SERIES — **Aletesacciti** Lesch.

23. Spore Genus — *Densipollenites* gen. nov.

SERIES — **Striasacciti** ser. nov.

24. Spore Genus — *Striomonosaccites* gen. nov.
25. do — *Distriomonosaccites* gen. nov.

SUB-DIVISION — **Disaccites** Cookson
SERIES — **Podocarpoiditi** Pot., Thoms. & Thierg.

26. Spore Genus — *Platysaccus* Pot. & Kl.
27. do — *Cuneatisporites* Lesch.

SERIES — **Striatiti** Pant

28. Spore Genus — *Striatites* (Pant) emend.
29. do — *Verticipollenites* gen. nov.
30. do — *Lahirites* gen. nov.
31. do — *Hindipollenites* gen. nov.
32. do — *Lunatisporites* (Lesch). emend.
33. do — *Striatopodocarpites* (Soritsch. & Sed) emend.
34. do — *Kosankeisporites* Bhard.
35. do — *Faunipollenites* gen. nov.

SERIES — **Rectistriati** ser. nov.

36. Spore Genus — *Striapollenites* gen. nov.
37. do — *Distriatites* gen. nov.

SERIES — **Disacciatrileti** (Lesch.) Pot. 1958

38. Spore Genus — *Vesicaspora* Schemel
39. do — *Sulcatisporites* (Lesch.) emend.
40. do — *Tumoripollenites* gen. nov.

DIVISION — **Polyplicatus** Erdtm.

41. Spore Genus — *Gnetaceaepollenites* Thiergart
42. do — *Welwitschiapites* Bolchowitina

DIVISION — **Monocolpates** Iverson & Troel-Smith
SERIES — **Intortes** (Naum.) Potonié 1958.

43. Spore Genus — *Vittatina* Luber

DESCRIPTION

SUPER DIVISION — **Sporites** H. Pot.
DIVISION — **Triletes** (R.) Pot. & Kr.
SUB-DIVISION — **Azonotriletes** Luber
SERIES — **Laevigati** (B. & K.) Pot. & Kr.

Genus *Leiotriletes* (Naum.) Pot. & Kr.

Pl. 1, Figs. 1-3

Genotype — Leiotriletes sphaerotriangulus (Loose) Pot. & Kr.

Remarks — Leiotriletes is deemed to include triangular, trilete spores having laevigate, structureless exine.

Specimens illustrated in Pl. 1, Figs. 1-3 are referred to this genus.

Genus *Eupunctisporites* gen. nov.

Pl. 1, Figs. 4-7

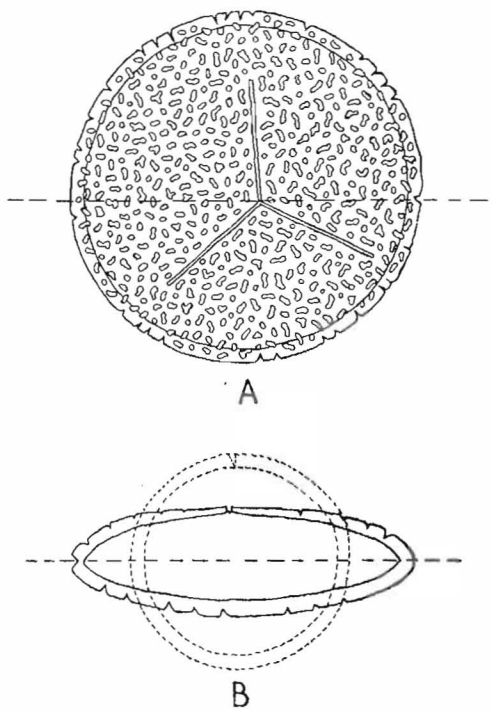
Genotype — Eupunctisporites poniatiensis sp. nov.

Generic Diagnosis — Miospores circular to subcircular, trilete mark distinct, labra thin, vertex and apex low. Exine thick, distinctly punctate (pitted).

Generic Description — Miospores mostly circular but sometimes subcircular due to oblique flattening. No consistent plane of flattening of the spore as apparent from inconsistant position of the trilete mark with reference to the equator of the flattened spore. Trilete mark well-defined and never reduced or vestigial, rays though slender, of equal length and with abrupt ends. Labra thin and level with the spore exine. Vertex low. Exine fairly thick, the thickness being clearly seen in optical section along the margin of the flattened specimens. Surface of the exine ornamented with pits of various sizes and outline, usually small and fairly evenly spaced. Spore outline broken or smooth accordingly as the margin runs across a pit or the space between the pits respectively.

Organization — From the inconsistent position of trilete mark in flattened specimens and the association of a ± circular shape it is apparent that the spore must have been spherical in original condition. This fact and the other details described above lead me to a reconstruction of the organization as illustrated in Text-figs. 3A, B.

Comparison — Punctatisporites (Ibr.) Pot. & Kr. lacks puncta (pits) in their exine sculpture. *Cyclobaculisporites* Bhard. agrees in circular shape and disposition of trilete mark but differs by having baculate sculpture. *Foveolatisporites* Bhard. possesses closed reticulum for sculpture.



TEXT-FIG. 3 — Organization of *Eupunctisporites* gen. nov. A, polar view. B, meridional section of flattened and unflattened spores.

Eupunctisporites poniatiensis sp. nov. (Pl. 1, Figs. 4, 5).

Holotype — Pl. 1, Fig. 4.

Locus Typicus — Poniati Seam, Poniati Mine, East Raniganj Coalfield, India.

Diagnosis — 75-100 μ, rays 33-39 μ long, exine 4-6 μ thick in optical section, puncta ± 1 μ wide and separated from others by 2-3 μ wide space.

Description — Normally circular, holotype 90 μ in diameter with each ray 38 μ in length. Exine brown in colour, without any folds, usually 4 μ thick in optical section and bearing distinct, minute, roundish, elliptical or irregularly shaped puncta usually clearly separated from the adjacent ones.

Pl. 1, Figs. 6, 7 also are referable to *Eupunctisporites*.

Genus *Punctatisporites* (Ibr.) Pot. & Kr.

Pl. 1, Fig. 8

Genotype — *Punctatisporites punctatus* Ibr.

Remarks — Trilete spores with roundish outline and laevigate but structured exine are usually included in *Punctatisporites*. It is scantily represented in the coals of Raniganj Stage. Pl. 1, Fig. 8 is referred to *Punctatisporites*.

Genus *Retusotriletes* Naum.

Pl. 1, Figs. 9, 10

Remarks — The forms presented here characterize themselves by their small size and the presence of usually distinguishable curvatures of *area contagionis*. The latter characteristic is normally absent in *Calamospora* as well as *Phyllothecotriletes* Luber but is present in *Retusotriletes* Naum., which is also usually small in size. Balme & Hennelly (1956b) described similar spores as a species of *Calamospora* S. W. & B., which is less tenable on morphographical grounds. *Retusotriletes* is known also from the Upper Devonian of Australia (Balme, 1961).

Pl. 1, Figs. 9, 10 are recognized as *Retusotriletes diversiformis* (Balme & Henn.) comb. nov.

Series ***Apiculati*** (B. & K.) Pot. & Kr.

Genus *Cyclogranisporites* Pot. & Kr.

Pl. 1, Figs. 11-14

Genotype — *Cyclogranisporites leopoldii* (Kremp) Pot. & Kr.

Remarks — *Cyclogranisporites* consists of trilete, circular spores whose exine bears closely spaced grana all over. The genus is rather scantily represented in the coals of Raniganj Stage.

Pl. 1, Figs. 11-14 are referred to *Cyclogranisporites*.

Genus *Verrucosisporites* (Ibr.) Pot. & Kr.

Pl. 1, Fig. 15

Genotype — *Verrucosisporites verrucosus* Ibr.

Remarks — *Verrucosisporites* differs from *Cyclogranisporites* essentially in the nature of its sculptural elements and their arrangement.

Pl. 1, Fig. 15 is referred here.

Genus *Anapiculatisporites* Pot. & Kr.

Pl. 1, Figs. 16, 17

Genotype — *Anapiculatisporites isselburgensis* Pot. & Kr.

Remarks — The chief diagnostic characteristics of *Anapiculatisporites* are the triangular form in polar view and progressive reduction in the size of coni from equator towards the proximal pole. Balme and Hennelly (1956b) have referred a number of species to *Acanthotriletes* even if they answer to the circumscription of *Anapiculatisporites*.

Following species is referred here to *Anapiculatisporites* —

Anapiculatisporites ericianus (Balme & Henn. 1956b) comb. nov. — Pl. 1, Figs. 16, 17.

Other species — *Anapiculatisporites dentatus* (Balme & Henn. 1956b) comb. nov.

Genus *Lophotriletes* (Naum.) Pot. & Kr.

Pl. 1, Figs. 18-21, 29, 30

Genotype — *Lophotriletes gibbosus* (Ibr.) Pot. & Kr.

Remarks — Coni, almost as high as broad at the base and occurring all over the exine of a triangular, trilete spore are the diagnostic features of *Lophotriletes*.

Lophotriletes is represented here by Pl. 1, Figs. 18-21. The specimens in Pl. 1, Figs. 29, 30 are referred here as cf. *Lophotriletes*, because of the baculate ornamentation in them, the like of which is not normal in species of *Lophotriletes*.

Genus *Acanthotriletes* (Naum.) Pot. & Kr.

Pl. 1, Figs. 22-28, 31, 32

Genotype — *Acanthotriletes ciliatus* (Knox) Pot. & Kr.

Remarks — The coni in *Acanthotriletes* are usually spinae, twice as long as broad at the base and usually pointed.

Acanthotriletes is represented here by Pl. 1, Figs. 22-24. The other specimens in Pl. 1, Figs. 25-28 and 31, 32 are referred as cf. *Acanthotriletes* because the elements of exine ornamentation are bacula instead of spinae as prevalent in the species of *Acanthotriletes* from Northern Hemisphere.

Genus *Microbaculispora* gen. nov.

Pl. 2, Figs. 33-35

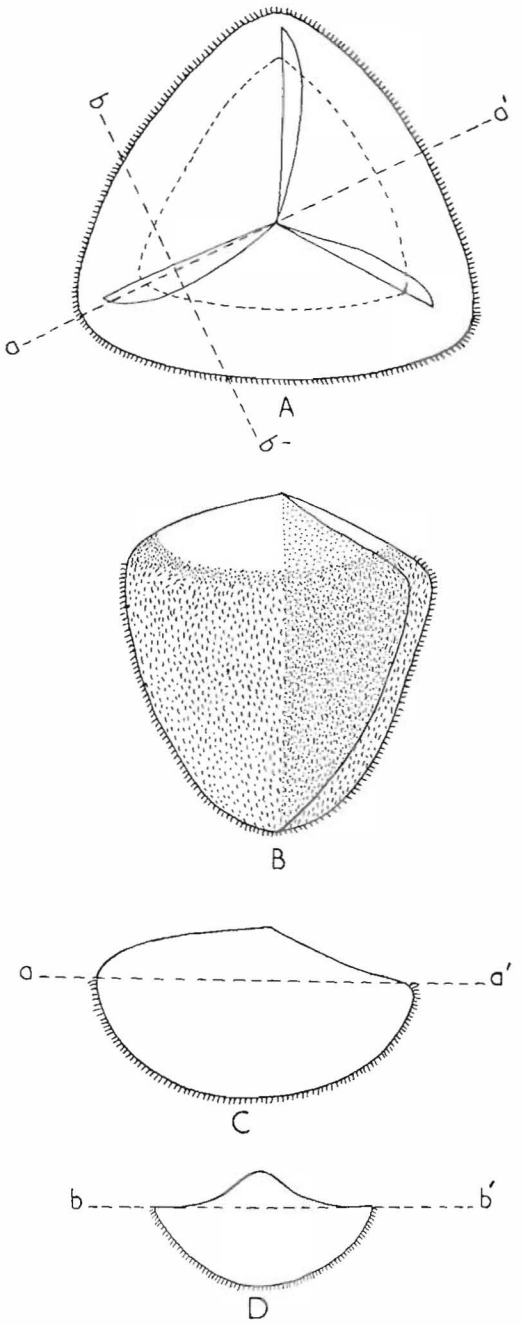
Genotype — *Microbaculispora gondwanensis* sp. nov.

Generic Diagnosis — Miospores triangular with broadly rounded angles and outwardly buldging convex sides in polar view; trilete mark distinct, labra thin, vertex low but usually appearing elevated due to secondary folds accompanying the labra on flattening. Exine thin, densely sculptured with thin, uniformly spaced and even sized bacula all over but for the inter-ray area proximally.

Generic Description — Miospores usually flattened in equatorial plane (TEXT-FIG. 4A), triangular, accompanied with large folds along the rays. Occasionally spores flattened in meridional plane, spindle-like with broad proximal face and angular distal face (TEXT-FIG. 4B). Y-mark well defined, rays ending shortly before the equator although nearer the equator the ray-ends imperceptible unless accompanied by secondary folds or the rays opened out. Labra smooth and low, the usually accompanying folds making them appear elevated. Exine thin and structureless but having well-defined microbaculate sculpture with the bacula slender, longish and closely set leaving uniformly thin space between the adjacent ones. Sculpture absent proximally in the inter-ray area.

Organization — From the invariable formation of secondary folds accompanying the rays in the species of *Microbaculispora* it appears that the spore wall along the rays is more curved and elevated and to accommodate this curvature on flattening the spore wall folds along the rays. In view of these observations, the reconstruction of the genus is suggested as given in Text-figs. 4A-D.

Comparison — *Microbaculispora* is closely comparable to *Acanthotriletes* in respect of its form and organization. However, the sculpture in *Microbaculispora* is distinctly microbaculate as compared to the sparsely connate or spinose sculpture in *Acanthotriletes*.



TEXT-FIG. 4 — Organization of *Microbaculispora* gen. nov. A, polar view. B, meridional view. C, meridional section along a, a' in A. D, meridional section along b, b' in A.

Considering the sculpture in the other species, viz. *Acanthotrileles villosa* Balme & Henn. (1956b), which will now be transferred to *Microbaculispora*, it is apparent that the specific differentiation in the genus is based upon variation in the length of the bacula.

Species referable to *Microbaculispora* gen. nov. —

1. *Microbaculispora gondwanensis* sp. nov. (PL. 2, FIGS. 33-35).

Holotype — Pl. 2, Fig. 33.

Locus Typicus — Samla Seam, Samla-Kendra Colliery, East Raniganj Coalfield, India.

Diagnosis — 70-90 μ, various axes usually unequal, bacula 1 μ broad but 1·5-2 μ long.

Description — Holotype 82 × 86 × 94 μ, in polar view roundly triangular, with densely set bacula appearing in lower focus as if forming a microreticulum. Bacula of uniform length as well as width.

2. *Microbaculispora villosa* (Balme & Henn.) comb. nov.

Syn. — *Acanthotriletes villosus* B. & H. 1956b.

Holotype — Balme & Hennelly, 1956b, Pl. 3, Fig. 38.

Diagnosis (emend.) — 68-98 μ (mean 85 μ), various axes usually unequal, bacula 1 μ broad but 3-4 μ long.

Comparison — *M. gondwanensis* has shorter bacula of a distinctive appearance.

Genus *Cyclobaculisporites* Bhard.

Pl. 2, Figs. 36-42

Remarks — *Cyclobaculisporites* has been described from the upper part of Upper Carboniferous of the Saar (BHARDWAJ, 1955) and Upper Carboniferous — Lower Permian of Kaiping basin in China (IMGRUND, 1952). It is now also known to be richly represented in the Raniganj coals.

Cyclobaculisporites is represented here by Pl. 2, Figs. 36-38 and Figs. 41, 42 as well as *Cyclobaculisporites trisecatus* (Balme & Henn. 1956b) comb. nov. — Pl. 2, Figs. 39, 40.

SERIES *Murornati* Pot. & Kr.

Genus *Microfoveolatispora* gen. nov.

Pl. 2, Figs. 43-49; Pl. 3, Figs. 50-53

Genotype — *Microfoveolatispora raniganjensis* sp. nov.

Generic Diagnosis — Miospores triangular with broadly rounded angles and convex sides when flattened in polar view or spindle-like with broad proximal face and angular distal face in equatorial view. Trilete mark well evident, labra thin, smooth, extending ± up to the equator, vertex low frequently appearing elevated due to secondary folds along the rays. Exine thin to mediumly thick, translucent, microreticulate sculptured with very thin to thick muri building a closed reticulum enclosing small to big foveolae all over, excepting the inter-ray area which is laevigate.

Description — Like *Microbaculispora*, the specimens of *Microfoveolatispora* flatten usually either in equatorial or meridional plane. In polar view, the spores are triangular but in equatorial view carrot-like shape is acquired.

The rays of the Y-mark end shortly before equator. Labra thin. Rays end imperceptibly. Ray-vertex low, apex also low but both appearing elevated due to secondary folds which frequently accompany them.

Exine thin to mediumly thick and structureless but having well-defined microreticulate sculpture on distal face and around the *area contagionis*. Muri enclosing ± equally broad foveolae in the meshes.

Organization — See Text-figs. 4A-D. But for the sculpture of the exine, *Microfoveolatispora* agrees with *Microbaculispora* in organization.

Comparison—*Microreticulatisporites* (Knox) Bhard. is closely comparable to *Microfoveolatispora* in its equatorially flattened shape as well as the sculpture to some extent although in the latter genus the muri have a tendency to become verrucose or baculate. But much more important distinction is what appears as the longer pole-axis in the usually meridionally flattened specimens of *Microfoveolatispora* as compared to *Microreticulatisporites*. The similarity of organization between *Microbaculispora* and *Microfoveolatispora* is so great that one can easily question the desirability of creating two separate genera. The main considerations prompting me to do so have been the difference in the sculpture as well as the difference in the trends of variation exhibited by the species in each of these genera. Thus, in *Microbaculispora* as exemplified by *M. gondwanensis* and *M. villosa* the size of the baculum varies whereas in *Microfoveolatispora* the sizes of the meshes and the muri are variable. I could as well have put the species of the latter genus within *Microbaculispora* after

creating one separate section for these but this would have resulted in taxonomic inconsistency in specifying each while generalizing for purposes of stratigraphy and floristics. There can hardly be any doubt about the close relationships of the parents of these spore genera yet they were certainly not the same.

Species referable to *Microfoveolatispora* gen. nov. —

1. *Microfoveolatispora trisina* (Balme & Henn.) comb. nov. (PL. 3, FIGS. 50-53).

Syn.— *Granulatisporites trisinus* B. & H. (1956b, p. 244, PL. 1, FIGS. 5, 6).

Holotype — Pl. 3, Fig. 50.

Diagnosis (emend.) — 90-110 μ, muri narrow, less than 1 μ wide, foveolae 1 μ across.

2. *Microfoveolatispora directa* (Balme & Henn.) comb. nov. (PL. 2, FIGS. 45-47).

Syn.— *Leiotriletes directus* B. & H. (1956b, p. 244, PL. 1, FIGS. 1-4, 7, 8).

Holotype — Pl. 2, Fig. 47.

Diagnosis (emend.) — 36-80 μ, exine faintly, minutely microfoveolate, thin.

Comparison — *M. trisina* is bigger and its microfoveolation is more distinct than *M. directa*.

3. *Microfoveolatispora pseudoreticulata* (Balme & Henn.) comb. nov. (PL. 2, FIGS. 43, 44).

Syn. — *Verrucosisporites pseudoreticulatus* B. & H. (1956b., p. 250, PL. 4, FIG. 42).

Holotype — Balme & Hennelly 1956b, Pl. 4, Fig. 42.

Diagnosis (emend.) — 80-115 μ, muri 1-1·5 μ wide, foveolae ± 1·5 μ across.

Comparison — Exine ornamentation is distinctly coarser than *M. directa* as well as *M. trisina*.

4. *Microfoveolatispora raniganjensis* sp. nov. (PL. 2, FIGS. 48, 49).

Holotype — Pl. 2, Fig. 48.

Locus Typicus — Samla seam, Samla-Kendra Colliery, East Raniganj Coalfield, India.

Diagnosis — 74-90 μ, muri low, 2-3 μ wide and foveolae 2 μ across.

Description — Holotype 80 μ, roundly triangular, rays 35-40 μ long, appearing flexuose and elevated, thin, spore exine 1 μ thick bearing muri forming perfect reticulum. Muri low, ± 2 μ wide and meshes 2 μ across. Muri and foveolae very finely granulose sculptured.

Comparison — *M. directa* has very faint and very small-sized reticulation, in *M. trisina* muri as well as the foveolae are less than 1 μ in width and in *M. pseudoreticulata* muri and the foveolae are slightly more than 1 μ in width.

Genus *Indospora* gen. nov.

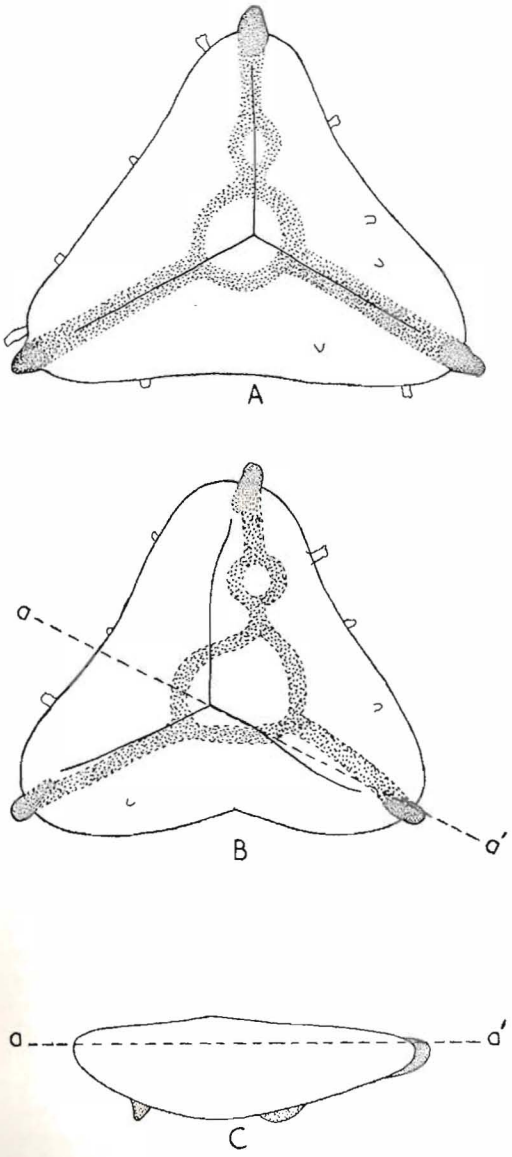
Pl. 3, Figs. 54-60

Genotype — *Indospora clara* sp. nov.

Generic Diagnosis — Triangular miospores with angles broadly rounded in polar view but having a small, blunt projection and the sides straight or slightly convex; trilete mark distinct, rays ending well behind the equator at the angles, labra thin and smooth; exine thin, verrucose or baculate and distally having three high muri with smooth or peaked vertex one each arising from the subequatorial region on the proximal face and extending from the angles, over the equator, to meet in the distal polar region in a plain, triradiate manner or forming one or more circular to polygonal meshes.

Generic Description — Specimens of *Indospora* rather smallish, trilete, triangular spores, the otherwise broadly rounded angles of the spore usually acquiring an acute angled appearance due to the occurrence of a small, blunt, rod-like projection extending out from the middle of each angle. Trilete mark discernible only with care as the lips of the rays hair-thin and low but the rays usually open, ending substantially behind the equator of the angles. Just beyond each ray-end a murus arising and rapidly gaining in height towards the equator and thence over the margin extending on to the distal pole. Thus, the marginal projection at the angles being nothing else than the murus in sectional view while crossing over from the proximal side to the distal side. The three muri, one each from the three angles, meeting either in a simple triradiate fashion or forming one to four or many small, circular to polygonal meshes in the distal, polar area. Murus-apex smooth or peaked with bacula. Normal spore exine thin and translucent, structureless, usually not secondarily folded and having small, sparse verrucae or bacula of various sizes for ornamentation.

Reconstruction — See Text-figs. 5A-C. Pl. 3, Figs. 54 and 55 clearly substantiate my interpretation of the organization in Indospora. In Pl. 3, Fig. 54, Y-mark is widely open and the distal muri are seen through its opening. In Pl. 3, Fig. 55, Y-mark is closed, rays being hair-thin and the distal muri are



TEXT-FIG. 5 — Organization of *Indospora* gen. nov. A, B, polar views. C, meridional section along a, a′ in B.

independent of it emphasizing that the two are not one and the same.

Comparison — Among the Upper Palaeozoic spore genera, *Indospora* possesses very singular organization and can hardly be compared satisfactorily with such genera as *Triquitrites* Wils. & Coe, *Tripartites* Schemel and *Trilobates* Somers which show special features on or along their angles and the sides. The distal, triradiate *muri* forming angular projections are features in *Indospora* quite unlike any of the above-named genera. The only, apparently comparable, spore genus is *Biretisporites* Delcourt & Sprumont (1955) from the Wealdon of Belgium. In this case, however, as interpreted by its authors, the trilete-rays are strongly developed and the rays seem to end in some forms as conical projection reminiscent of the condition in *Indospora*. In the light of now known organization of *Indospora* it may be worthwhile to re-examine the specimens of *Biretisporites* and see if it is not that the supposed trilete-rays are really on distal side and thus, are muri whereas the trilete mark is borne on the other side of them as is the condition in *Indospora*. Even then *Indospora* will continue to be valid in view of the tendencies to develop mesh-work and baculate exine. *Dictyotriletes* (Naum.) Pot. & Kr., is comparable to some extent.

Indospora clara sp. nov. (Pl. 3, Figs. 54, 55)

Holotype — Pl. 3, Fig. 54.

Locus Typicus — Samla Seam, Samla-Kendra Colliery, East Raniganj Coalfield, India.

Diagnosis — 49-64 μ (excl. projections), exine verrucose with bacula up to 6 μ long; distal muri peaked and forming none to four polygonal meshes at the point of contact.

Description — Triangular, trilete miospores, Y-rays ending shortly before the equator, labra thin, vertex low, distally muri 4-10 μ high, peaked, joining in triradiate manner forming none to four polygonal meshes around the distal polar region. Exine thin, sparsely verrucose with a few to many, 2-4 μ long bacula with truncate, smooth or dissected heads, interspersed among the verrucae.

Pl. 3, Figs. 55, 58-60 are also referable to *Indospora*.

Genus *Reticulatisporites* (Ibr.) Pot. & Kr., 1954

Pl. 3, Fig. 64

Genotype — *Reticulatisporites reticulatus* Ibr.

Remarks — *Reticulatisporites* is only rarely met with in the coals of Raniganj Stage.

Pl. 3, Fig. 64 is referred to *Reticulatisporites*.

Genus *Lycopodiumsporites* Thierg. 1938

Pl. 3, Figs. 62, 63

Genotype — *Lycopodiumsporites agathoecus* (R. Pot.) Thierg.

Remarks — The proximal as well as the distal faces of the spores are equally, strongly reticulate.

Pl. 3, Figs. 62, 63 are referred to *Lycopodiumsporites*.

DIVISION — **Zonales** B. & K. Pot. & Kr.
SUB-DIVISION — **Zonotriletes** Waltz
SERIES — **Cingulati** Pot. & Kl.

Genus *Gravisporites* Bhard.

Pl. 3, Fig. 61

Genotype — *Gravisporites sphaerus* (Butt. & Will.) Bhard.

Remarks — The crassitudinous equator and elevated labra are the characteristic features of *Gravisporites* besides the subcircular shape and sparsely, variously ornamented exine. In the coals of Raniganj Stage such spores are very rare.

Pl. 3, Fig. 61 is referred to *Gravisporites*.

Genus *Cirratriradites* Wils. & Coe

Pl. 3, Fig. 65

Genotype — *Cirratriradites saturni* (Ibr.) S. W. & B.

Remarks — One specimen (PL. 3, FIG. 65) which answers to the cricumscription of *Cirratriradites* has so far been found in the coals of Raniganj Stage and is referred as cf. *Cirratriradites*.

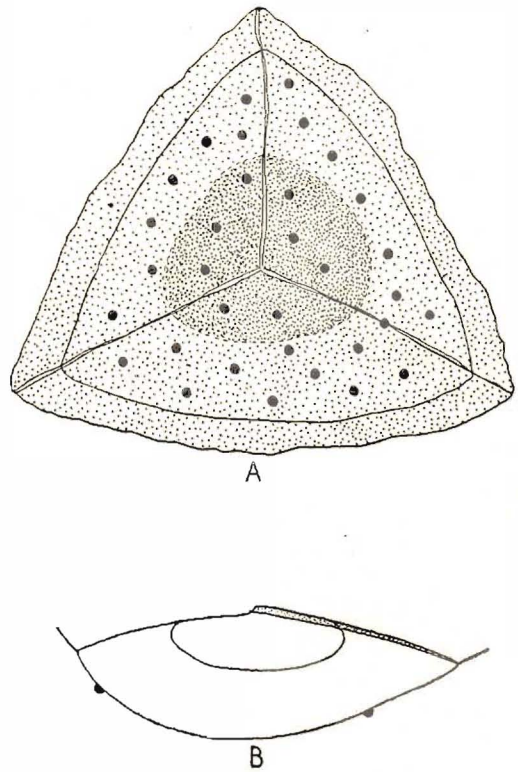
Genus *Gondisporites* gen. nov.

Pl. 4, Figs. 66-71

Genotype — *Gondisporites raniganjensis* sp. nov.

Generic Diagnosis — Roundly triangular to subcircular miospores with a denticulate, thin zona or a ridge surrounding subequatorially a large central body which contains a small inner body. Trilete rays distinct, well developed and extending to the margin of the zona or the ridge. Body exine uniformly granulose as well as sparsely spinulate or baculate.

Generic Description — Subcircular spores with the triangularity acquired due to the angular points where the rays end. Frequently one or more of the angles curved inwards due to flattening of the spore. Trilete mark mostly distinctly observable, the rays being $\pm$ 2 μ broad nearer the apex and continuing over the body to the zona or the ridge. Zona thin, transparent and having an irregularly toothed or denticulate edge. Ridge usually dense and bearing verrucae or spinules. Zona or the ridge subequatorially surrounding a thin-walled body whose exine is doubly sculptured, i.e. with granulose surface interspersed with spinules or tubercle-like bacula. Inside the body usually a smaller sac-like inner body present whose wall is mostly darker brown in colour than the body-exine.



TEXT-FIG. 6 — Organization of *Gondisporites* gen. nov. A, polar view. B, meridional section.

Reconstruction — A study of large number of specimens flattened in various planes suggests that the ridge or the zona is not attached exactly in the middle between the proximal and distal faces but slightly inwards on the proximal side. The reconstruction of the spore in various planes is given in Text-figs. 6A, B.

Comparison — The organization of *Gondisporites* compares very closely with *Cirratriradites* Wils. & Coe, so much so that but for the occurrence of spinules and bacula

on the body-exine in the former and their absence in the latter the two could have been merged together. Another comparable genus is *Endosporites* which, however, differs by the absence of the external ornamentation and the zona. *Grandispora* Hoffm., Staplin & Malloy lacks the zona and is also geographically as well as stratigraphically far removed. *Hymenozonotriletes* (Naum.) Naum., as defined by Potonié (1958), appears to be similar in organization to *Gondisporites* but the latter lacks the finger-like processes in the zona. *Hymenozonotriletes* is also geographically as well as geologically far removed from the specimens referable to *Gondisporites*.

Derivation of Name — *Gond*, an aboriginal tribe in Peninsular India leading to the name Gondwanaland.

Gondisporites raniganjensis sp. nov.
(Pl. 4, Figs. 66, 67).

Holotype — Pl. 4, Fig. 67.

Locus Typicus — Samla Seam, Samla-Kendra Colliery, East Raniganj Coalfield, India.

Diagnosis — 90-115 μ, granulose, exine sparsely ornamented with 2-3 μ wide tuberculate bacula, zona membraneous, 6-8 μ wide.

Description — Holotype 106 × 110 μ, triangular with pointed apices but outwardly bulging sides. Y-mark distinct, rays 2-4 μ broad, reaching the edge of the zona. Body-exine thin, granulose all over with sparsely interspersed bacula. Inside the body an inner body detectable which is variable in size. Zona membraneous, granulose and the edge undulating to dentate.

Pl. 4, Figs. 68-71 are also referable to *Gondisporites*.

Division — **Monoletes** Ibr.
Sub-Division — **Azonomonoletes** Luber
Series — **Psilamonoleti** V. D. Hamm.

Genus *Latosporites* Pot. & Kr.

Pl. 4, Figs. 72-74; Pl. 5, Figs. 75, 76

Latosporites colliensis (Balme & Henn. 1956a) comb. nov. (Pl. 4, Figs. 72, 73).

Syn. — *Laevigatosporites vulgaris* forma *colliensis* Balme & Henn. (1956a, p. 55).

Holotype — Balme & Henn. 1956a, Pl. 1, Fig. 1.

Diagnosis (emend.) — Longitudinal axis 50-100 μ, holotype 75 μ, monolete mark distinct, ± 2/3 the long axis in length, ends not bifurcated, labra thin; exine laevigate, thin, frequently folded.

Remarks — The Australian specimens are usually smaller than the Indian ones.

Other specimens referred here to *Latosporites* — Pl. 4, Fig. 74; Pl. 5, Figs. 75, 76.

Series — **Ornati** Pot.

Genus *Punctatosporites* Ibr.

Pl. 5, Figs. 77-79

Genotype — *Punctatosporites minutus* Ibr.

Pl. 5, Figs. 77-79 are referred to *Punctatosporites*

Genus *Verrucososporites* (Knox) Pot. & Kr.

Genotype — *Verrucososporites obscurus* (Kos.) Pot. & Kr.

Pl. 5, Figs. 80-83 are referred to *Verrucososporites*.

Division — **Saccites** Erdtman
Sub-Division — **Monosaccites** Chitaley
Series — **Triletesacciti** Lesch.

Genus *Nuskoisporites* Pot. & Kl.

Pl. 5, Fig. 95; Pl. 6, Figs. 96-98

Remarks — The spore forms referred here as well as those assigned by Balme and Hennelly (1956b) to *Nuskoisporites* are characterized by proportionately lesser extent of the bladder as compared to the dimensions of the central body than is the case in the genotype, *N. dulhuntyi* Pot. & Kl. (1954), or *N. klausi* Grebe (1957) from the European Upper Permian and the other nearly contemporaneous strata. Besides this, the central body in the species from Gondwana countries is invariably thin-walled and the saccus lacks the so characteristic limbus. In view of the rather scanty representation of this genus in the Raniganj coals it has not been possible to assess the value of these variations for closer systematic considerations. Pollengrains closely similar in organization to the Gondwana specimens referred here

are found in some species of *Dacrydium*, e.g. *D. araucarioides*, *D. guillauminii* and *D. falci-forme* (ERDTMAN, 1957). However, these living specimens lack the trilete mark which is often seen, though feebly in the fossil species, otherwise the resemblance is striking.

Pl. 5, Fig. 95 and Pl. 6, Figs. 96-98 are referred to *Nuskoisporites* as cf. *Nuskoisporites* in view of the differences explained above.

SERIES — **Aletesacciti** Lesch.

Genus *Densipollenites* gen. nov.

Pl. 6, Figs. 99-104; Pl. 7, Figs. 105, 106

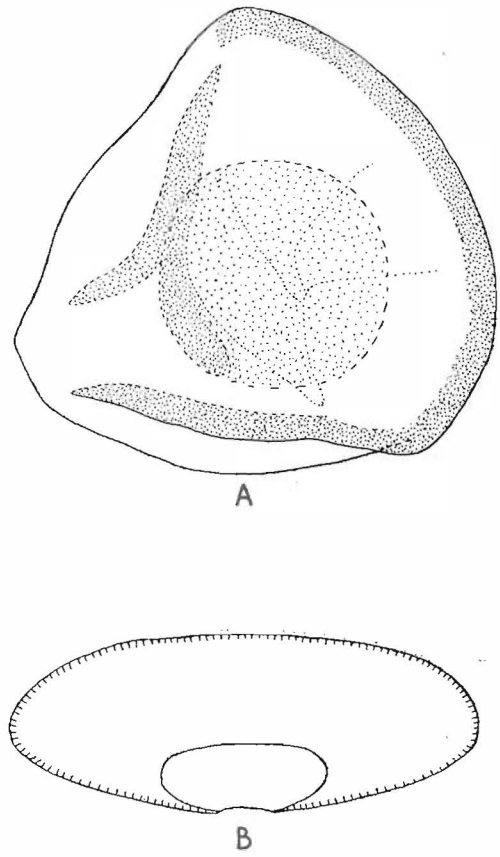
Genotype — *Densipollenites indicus* sp. nov.

Generic Diagnosis — Circular, subcircular or elliptical spores in flattened condition usually with a number of folds in the saccus; central body dark brown and dense to light brown or ill-defined, circular or subcircular, without monoradiate slit, Y-mark or striations, exine densely granular to smooth; saccus finely intrareticulate on one side and coarsely intrareticulate on the other.

Generic Description — Normally flattened specimens are rare when these are subcircular with a distinctly demarcated, dark to light brown central body surrounded by a broad saccus. Usually the specimens are irregularly, i.e. obliquely or eccentrically flattened with the central body shifted more to one side and the saccus severally folded (PL. 6, FIGS. 99, 101). A bilateral shape has been never seen.

Central body is circular, subcircular or roundly triangular. Body exine is either thick, dense and translucent or thin. In some specimens the central body is almost invisible appearing as if the saccus is without the central body. The central body lacks any of the usual haptotypic marks or even the striations. Saccus is finely intrareticulate on one side but coarsely intrareticulate elsewhere. A wide zone along the equator in flattened specimens appears denser as if a limbus were present but the association of similar density with extra-equatorial fold (PL. 6, FIG. 100) negativates such an assumption. However, limboid edges are characteristic.

Organization — A comparison of Pl. 6, Figs. 99-101, 103, 104 suggests that the central body is attached to the saccus in a small area only on one face (TEXT-FIG. 7B), the other being free from the saccus. It has also been ascertained that the intrareticulation in the saccus is much coarser on the latter — free from the body-face. Taking these deductions into consideration, an organization represented in Text-fig. 7 is suggested.



TEXT-FIG. 7 — Organization of *Densipollenites* gen. nov. A, polar view. B, meridional section.

Comparison — The absence of any haptotypic features on the central body or on the saccus distinguishes *Densipollenites* from such monosaccate genera as *Wilsonia*, *Guthörlisporites*, *Potonieisporites*, *Nuskoisporites* and the like. It differs from *Florinites* in the tendency of having a scarcely to sharply differentiated central body. The development of limboid margin along the equator or the folds is unknown in the saccus of *Florinites*. *Prima facie*, the group of species assigned here to *Densipollenites* looks very different from *Florinites* which

when considered with reference to the geographical disparity between *Densipollenites* and the comparable monosaccate genera from the Northern Hemisphere has led me to suggest a new generic designation as *Densipollenites*.

The diplotype of *Succinctisporites* (LESCH., 1955), *S. grandior* presents a look similar to *Densipollenites*, hence the type specimen was examined through the courtesy of Dr. Leschik. It is a distinctly disaccate pollengrain and hence widely different from *Densipollenites*.

Densipollenites indicus sp. nov.
(PL. 6, FIGS. 103, 104).

Holotype — Pl. 6, Fig. 103.

Locus Typicus — Samla Seam, Samla Colliery, East Raniganj Coalfield, India.

Diagnosis — Central body circular to subcircular, 40 to 76 μ in longest diameter, mostly transparent but for its margin in flattened specimens.

Description — Holotype ± 122 μ with central body subcircular, 42 μ. Miospores ranging in size from ± 120 to 150 μ, central body 40-54 μ, overall shape subcircular. Saccus variously folded and each fold assumes dense, limbus-like appearace which is also always evident along the equator of the flattened spore irrespective of the position of the central body. The limbus-like appearance of the equator in these grains is characteristic and so is the bordered appearance of an otherwise faintly discernible central body.

Other specimens of *Densipollenites* — Pl. 6, Figs. 99-102; Pl. 7, Figs. 105, 106.

Affinities — Pollengrains, similar in organization to *Densipollenites*, as far as I am aware, have not been described *in situ*. Morphographically *Densipollenites* lacks every kind of haptotypic features known to be borne on proximal face in comparable types of pollengrains. It can, however, be assumed that the central body in *Densipollenites* is distally attached ± as is the case in *Florinites*. It is probable that *Densipollenites*, like *Florinites*, might also be the pollengrains of Cordaitales which are known to have been present in the Lower Gondwana flora.

SERIES — **Striasacciti** ser. nov.

Series Diagnosis — Monosaccate pollengrains bearing longitudinal striations on the central body.

Genus *Striomonosaccites* gen. nov.

Pl. 7, Figs. 107-114

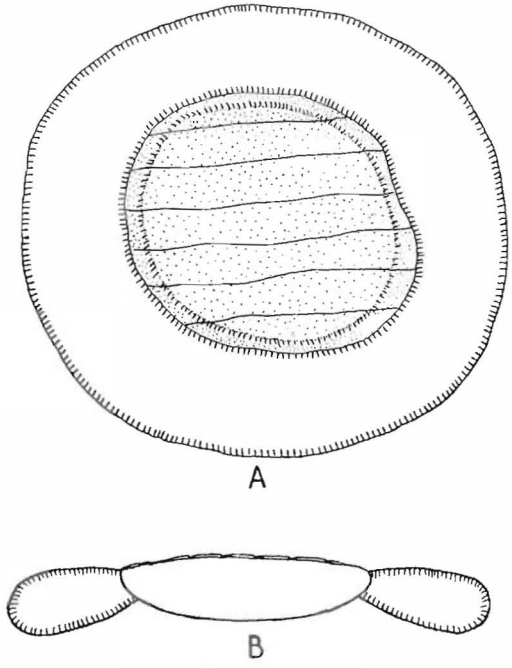
Genotype — *Striomonosaccites ovatus* sp. nov.

Generic Diagnosis — Monosaccate pollengrains of subcircular to circular overall shape, central body circular, thin-walled, exine intramicroreticulate, free from the saccus on distal side, bearing longitudinal, simple or branched striations on one of the two faces.

Generic Description — Monosaccate pollengrains with saccus occasionally having a notch. Central body usually thin-walled and circular. Proximal (?) exine of the central body intramicroreticulate and bearing a number of parallel, longitudinal, occasionally bifurcating striations. Distal (?) face of the central body free from bladder in a circular to subcircular area, exine without striations, granulose and thinner than on the proximal face. Saccus intrareticulate with meshes small and close together.

Reconstruction — See Text-figs. 8A, B.

Comparison — So far no monosaccate genus with striations on the central body has been described. *Noeggerthiopsidozonaletes* Luber,



TEXT-FIG. 8 — Organization of *Striomonosaccites* gen. nov. A, polar view. B, meridional section.

as figured and described by Potonié (1958), which seems to have similar shape as *Striomonosaccites*, lacks striations on the central body. *Crustaesporites* Lesch. (1956) is trisaccate and has bands of thickened exine on the central body instead of striations.

Affinities — In absence of any valid evidence regarding the phylogeny of such pollengrains as are included in *Striomonosaccites* it is difficult to postulate much. However, one specimen of *Striomonosaccites* (PL. 7, FIG. 113) included here reminds one of its resemblance in organization to the pollengrains of the living conifer *Dacrydium* (ERDTMAN, 1957, FIGS. 20, 22).

Striomonosaccites ovatus sp. nov. (PL. 7, FIGS. 107-109).

Holotype — Pl. 7, Figs. 107, 108.

Locus Typicus — Poniati Seam, Poniati Mine, East Raniganj Coalfield, India.

Diagnosis — Subcircular, 5-7 horizontal striations on proximal face of central body, saccus one-third body diameter, finely intrareticulate.

Description — Holotype 110 × 100 μ; central body circular to subcircular, thin-walled, proximal exine irregularly intramicroreticulate with 5-7 horizontal striations, distal exine free from saccus in a circular area, thin and granular. Saccus finely intrareticulate, meshes being up to 1 μ broad and closely placed.

Other specimens referable to *Striomonosaccites* — Pl. 7, Figs. 110-114.

Genus *Distriomonosaccites* gen. nov.

Pl. 8, Figs. 115-118

Genotype — *Distriomonosaccites rotatus* sp. nov.

Generic Diagnosis — Monosaccate pollengrains of subcircular to circular overall shape, central body circular, thin- or thick-walled, free from the saccus on both sides, bearing longitudinal, simple or branched striations on both faces.

Generic Description — Monosaccate pollengrains with a continuous saccus around the thin- or thick-walled and circular central body. Exine of the central body intramicroreticulate structured or verrucose and bearing a number of parallel, longitudinal, occasionally bifurcating striations on both faces. Distal face of the central body free from saccus in a circular to subcircular area. Saccus intrareticulate with meshes small and close together.

Reconstruction — See Text-figs. 8A, B. for general plan.

Comparison — So far no monosaccate genus with striations on the both faces of the central body has been described. *Striomonosaccites* has striations only on the proximal face. *Noeggerthiopsidozonaletes* Luber, as figured and described by Potonié (1958), which seems to have similar shape as *Striomonosaccites* and *Distriomonosaccites*, lacks striations on the central body.

Distriomonosaccites rotatus sp. nov.
(PL. 8, FIGS. 115, 116)

Holotype — Pl. 8, Figs. 115, 116.

Locus Typicus — Poniati Seam, Poniati Mine, East Raniganj Coalfield, India.

Diagnosis — Holotype 104 × 92 μ, central body 54 × 52 μ with 7 striations on one side and only 42 × 42 μ saccus-free face with 6 striations on the other side, striations running in the same direction on both faces. Saccus 22-18 μ wide.

Description — Almost circular grains with a wide, girdle-like saccus round a comparatively small, circular, central body. In the holotype the striations are distinctly developed on both the free faces of the central body. The saccus is finely intrareticulate, the muri are thin and complete, the meshes circular to ovaloid and closely spaced. No limbus has been detected.

Other specimen referable to *Distriomonosaccites* — Pl. 8, Figs. 117, 118.

SUB-DIVISION — **Disaccites** Cookson

SERIES — **Podocarpoiditi** Pot., Thoms. & Thierg.

Genus *Platysaccus* (Naum.) Pot. & Kl.

Pl. 13, Fig. 185

Genotype — *Platysaccus papilionis* Pot. & Kl. 1954.

Remarks — An easily distinguishable diploxylonoid spore genus showing a combination of subspherical sacci with central body circular in polar view and devoid of any Y-mark, monolete mark or striations on proximal face. In this genus the distal attachment of the sacci is full-length and straight (TEXT-FIG. 1B).

Pl. 13, Fig. 185 is referred to *Platysaccus*.

Genus *Cuneatisporites* Leschik, 1955

Pl. 13, Fig. 185; Pl. 20, Figs. 262-264

Genotype — *Cuneatisporties radialis* Lesch.

Remarks — Potonié (1958, p. 67) remarks about the difficulty of separating *Cuneatisporites* Leschik from *Platysaccus*. On the basis of my study of the diplotype specimen of *Cuneatisporites* it seems that the chief differences between *Cuneatisporites* and *Platysaccus* lie in the distinctly, vertically oval shape of the body in the former and circular body in the latter, intramicroreticulate structure of body exine in the former and microverrucose sculpture of the body exine in the latter and convex, distal attachment of the sacci in the former and straight in the latter. What has been interpreted as the germinal crack (*Keimspalte*) by Leschik, appears to be formed due to folding of the body wall within.

Specimens referred to *Cuneatisporites* — Pl. 13, Fig. 185; Pl. 20, Figs. 262-264.

SERIES — **Striatiti** Pant

Genus *Striatites* Pant (1955) emend.

Pl. 8, Figs. 119-121, 123, 124; Pl. 9, Figs. 125, 128; Pl. 10, Figs. 140, 147, 148; Pl. 11, Figs. 149, 151, 154, 156; Pl. 12, Figs. 166, 167; Pl. 13, Fig. 179

Genotype — *Striatites sewardii* (Virkki) Pant, 1955.

Remarks — The generic diagnosis given by Pant (l.c.) as well as the description of the genotype given by Virkki (1937) are very scanty in contrast with the amount of evidence employed in this paper to diagnose the genera. Besides this, among the illustrations provided by Virkki (l.c., FIGS. 1A-C and FIGS. 2A-D) the spores of two different organizations, by my standards, have been included. Pant (l.c.) has illustrated this genus with haploxylonoid forms. The diagnosis of this genus given by Pant is very wide permitting such a heterogeneous membership. In view of the revised basis of taxonomy utilized by me for the systematics of the disaccate pollengrains it has become necessary to restrict this genus so as to make it a homogeneous taxon.

Virkki (l.c.) has not designated any of her illustrations of the genotype as the diplotype hence the first illustration (PL. 32, FIGS. 1A, 2A) is taken as the type. Fig. 2C of Virkki (l.c.) seems, in all probabilities of a morphographical conjecture, to be the polar view of a pollengrain similar to this type.

Unfortunately the original specimen of the type figures has not been available to me for examination, in spite of the best efforts of the authorities of the Botany Department, Lucknow University, where Virkki's slides are supposed to be located, to search them out. However, on the basis of some specimens, similar to the type, observed by me in Raniganj coals and coals of New Castle Stage, N.S.W., available with me and the description as well as figures of *Lueckisporites cancellatus* Balme & Hennelly (1955, pp. 92, 93, PL. 2, FIGS. 11-15) abundantly found in New Castle Stage of N.S.W., has enabled me to deduce a detailed generic diagnosis for *Striatites* as follows:

Generic Diagnosis (emend.) — Bilateral, disaccate, pollengrains with vertically oval to circular central body appearing dense and thick marginally having proximally distinct, horizontal striations with or without faint to prominent vertical striations between them and exine microverrucose. Distally sacci inclined, the saccus-free area variable in shape from wide to furrow-like or almost circular, distal saccus attachment full-length, straight or convex. Sacci hemispherical.

Generic Description — Central body vertically oval to circular being fusoid, rhomboid or circular in shape and normally smaller in height than the height of the sacci. Wall of central body unequally thick and dense as characteristically apparent along the equator in equatorially flattened specimens or uniformly dense. Exine microverrucose on the surface and structureless in optical section along the equator, proximally showing in surface view a copious number of horizontal striations with many to scarcely any vertical, connecting striations. Distally the zones of saccus attachment well demarcated and extending with a straight to convex edge from one lateral end to the other. Distally body exine in between the zones of saccus attachment thin and finely granulose. In some cases the thin distal exine shows one or more folds, presumably due to lateral compression while being flattened. Sacci more than hemispherical in polar view. Saccus intrareticulation imperfect but fine.

Reconstruction — See Virkki, 1937, Figs. 2A, C.

Comparison — *Striatopodocarpites* has intramicroreticulate structure of the exine in the central body. *Lueckisporites* lacks striations and so also other non-striated spore genera. *Fimbriaesporites* Leschik (1959) has baculate, non-striated central body.

In view of the apparent similarity between specimens of *Striatites* and the illustration of the diplotype of *Fimbriaesporites* (LESCHIK, 1959, PL. 4, FIG. 29) I examined the diplotype specimen through the cooperation of Prof. Dr. Kräusel and Dr. Leschik. The specimen is *disaccate, diploxylonoid, central body vertically oval, exine brown with marginal thickening, proximally bearing roundish, squarish to polygonal areas outlined by faint, narrow grooves, exine surface densely and finely microverrucose, exine in optical section apparently structureless, distally zone of saccus attachment convex, full-length; laterally sacci coming close to each other, saccus intrareticulation with medium-sized, widely spaced meshes.*

Affinities — As far as known to me there is no record of *in situ* pollengrains of the same structure and organization as *Striatites* from the Palaeozoic or the Mesozoic strata. The most characteristic features of this genus are the central body with striations on proximal face and full-length straight to convex, distal saccus attachment. The presence of striations in general is a feature of pollengrains only of Upper Palaeozoic age. Subsequently, but for its meagre manifestation during Triassic and rarely during Jurassic, this character does not occur in saccate pollengrains of younger ages. But for the striations the pollengrains possessing similar features have been profusely illustrated by Bolkhovitina (1956) as species of *Podocarpus*. A striking correspondence with some specimens of *Striatites*, Pl. 11, Figs. 150, 151; Pl. 9, Figs. 140, 147; Pl. 11, Figs. 152, 153; Pl. 11, Figs. 154, 156; is presented by the pollengrains of *Podocarpus angustifolius* var. *Wrightii*, *P. coriaceus*, *P. alpinus* var. *caespitosus* (ERDTMAN, 1957, Figs. 59A, B, C) and *P. spicatus* (ERDTMAN, 1943, FIG. 430) respectively.

Striatites sewardii (Virkki) Pant — Pl. 12, Figs. 166, 167.

Other specimens referable to *Striatites* — Pl. 8, Figs. 119-121, 123, 124; Pl. 9, Figs. 125, 128; Pl. 10, Figs. 147, 148; Pl. 11, Figs. 149-151, 154, 156; Pl. 13, Fig. 179.

Genus *Verticipollenites* gen. nov.

Pl. 9, Figs. 126, 127, 129-136; Pl. 10, Figs. 137-139, 143-146; Pl. 11, Figs. 158, 159; Pl. 12, Figs. 160, 162-165, 168-171, 173; Pl. 13, Figs. 177, 178, 180, 186

Genotype — *Verticipollenites secretus* sp. nov.

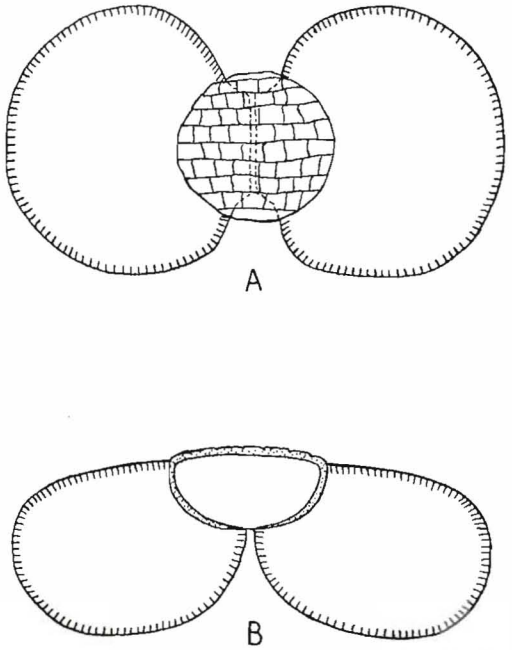
Generic Diagnosis — Bilateral, pollengrains with circular to vertically oval central body proximally microverrucose ornamented and having horizontal striations with or without vertically connecting striations. Sacci laterally separated, distally inclined and attached to the body on the distal side ± closely together. Distal zones of saccus attachment nearer the pole straight and restricted to an area usually smaller than the vertical diameter of the central body whence diverging laterally, i.e. sacci pitcher-shaped with a narrow to broad neck (TEXT-FIG. 1A).

Generic Description — Pollengrains distinctly bilateral with the central body smaller than the vertical diameter of sacci. Central body usually brown, exine thin or thick, translucent and proximally, horizontally or criss-cross striated. Exine in between the striations irregularly microverrucose. Laterally sacci usually widely separated. Distally, nearer the pole, the sacci attached to the body vertically, often in a length smaller than the vertical diameter of the body, distal zones of bladder attachment lying close together, sometimes ill-defined but mostly giving appearance of a narrow furrow. Sacci ± subcircular, in flattened condition appearing as round-bottomed pitcher with a short neck (TEXT-FIG. 1A). Bladder exine intrareticulate.

Reconstruction — See TEXT-FIGS. 9A, B.

Comparison — The other validly described, saccate genera are *Podocarpidites* (Cookson) Pot., *Striatites*, *Fimbriaesporites* Lesch. and *Platysaccus*. *Podocarpidites* (Cookson) Pot. is a genus for Tertiary pollengrains and it has laterally widely separated and full-length, convex zones of saccus attachment. The organization of *Verticipollenites* is quite unlike that of *Podocarpidites*. *Platysaccus* lacks the proximal striations on the body which are so characteristic of *Verticipollenites*, and *Striatites* has subspherical sacci as compared to the pitcher-shaped sacci in *Verticipollenites*. *Fimbriaesporites* lacks horizontal striations on the central body.

Affinities — The pitcher-like saccus (TEXT-FIG. 1A) so characteristic of *Vertipollenites* as far as known does not occur in any living,



TEXT-FIG. 9 — Organization of *Verticipollenites* gen. nov., A, polar view, B, meridional section.

disaccate, coniferous pollengrains. The pollengrains illustrated by Erdtman (1957, FIGS. 58, 62) for *Pinus thunbergii* and *Pseudolarix amabilis* show as if the sacci are pitcher-shaped which is really not the case.

Derivation of Name — *L. vertex*, meaning 'the head'.

1. *Verticipollenites secretus* sp. nov.

Holotype — Pl. 12, Fig. 160.

Locus Typicus — Poniati seam, Poniati Mine, East Raniganj Coalfield, India.

Diagnosis — Central body circular to horizontally oval, sometimes appearing rhomboidal, with brown exine showing ± 7 horizontal striations with vertical connectives. Distally the zones of saccus attachment forming a very narrow furrow.

Description — Holotype 112 μ long, central body 50×44 μ; grain bilateral, with brown, horizontally oval or circular central body and more than hemispherical sacci. Laterally sacci widely separated but distally coming very close together and forming a narrow, well-defined, slit-like sulcus.

2. *Verticipollenites gibbosus* sp. nov. (PL. 12, FIGS. 173, 174).

Holotype — Pl. 12, Fig. 174.

Locus Typicus — Samla Seam, Samla Colliery, East Raniganj Coalfield, India.

Diagnosis — Central body horizontally oval and dense, smooth, brown, 5-7 horizontal striations only. Distally the zones of saccus attachment 4/5 full-length and straight with a narrow furrow in between, saccus intrareticulation fine.

Description — Holotype 102 μ long, central body 38×44 μ; grain bilateral usually disaccate with dark brown, horizontally oval, central body having 5-7 horizontal striations, exine surface faintly microverrucose. Laterally sacci widely removed but distally, normally only 1 μ wide channel between the sacci.

Comparison — *V. secretus* sp. nov. has many vertical striations between the horizontal striations and the zones of saccus attachment on distal side are smaller in height. Both these features do not occur in *V. gibbosus* sp. nov.

3. *Verticipollenites oblongus* sp. nov.

Holotype — Pl. 13, Fig. 180.

Locus Typicus — Poniati Seam, Grimint Colliery, East Raniganj Coalfield, India.

Diagnosis — Central body vertically oval, 10 horizontal striations with many vertically connecting striations. Distally sacci ± 10 μ apart.

Description — Holotype 126 μ long, central body 62×44 μ, grain bilateral with dense brown, vertically oval central body. Laterally sacci widely separated but distally only 10 μ apart, the distal zones of saccus attachment straight, 4/5 full-length. Sacci meshes medium-sized.

Comparison — *V. secretus* has a distal slit-like furrow and horizontally oval central body, *V. gibbosus* has a horizontally oval central body bearing only horizontal striations and a distal, narrow slit-like sulcus.

Other specimens referable to *Verticipollenites* — Pl. 9, Figs. 126, 127, 129-134; Pl. 10, Figs. 145, 146; Pl. 11, Figs. 158, 159; Pl. 12, Figs. 163-165, 168-171, 173, 175, 176; Pl. 13, Figs. 177, 178, 186.

Genus *Lahirites* gen. nov.

Pl. 11, Figs. 152, 153; Pl. 12, Fig. 172; Pl. 13, Figs. 181, 183, 188

Genotype—*Lahirites raniganjensis* sp. nov.

Generic Diagnosis — Bilateral, pollengrains with circular to vertically oval, central body usually bearing proximally a number of horizontal striations, occasionally with vertical, connecting striations also, the exine in between being microverrucose or laevigate

sculptured and intrapunctate structured. Sacci distally inclined, zones of saccus attachment straight to convex and full-length, narrowly to widely separated from each other. Sacci subspherical.

Generic Description — Pollengrains almost always bisaccate and bilateral. Central body vertically oval, rhomboid or almost circular, margin uneven. Central body bearing a number of horizontal, simple or forked striations with none or few to many vertical, connecting striations. In some specimens proximal face comprised of roundish or squarish humps formed by the compartmentation due to striations. Exine usually laevigate but in a few cases microverrucose ornamentation also observed. Exine invariably intrapunctate structured. Intrapunctation may be finer but uniformly developed all over or coarser and localized along the crests of the interstriation ridges in specimens without vertical striations or in the central part of the humps in criss-cross striated exines. Laterally sacci may lie close together or be widely separated from each other. Distally, zones of saccus attachment straight to convex, extending full-length with the space in between the two zones narrow to wide. Sacci more than a hemisphere, subspherical, i.e. without a neck.

Reconstruction — The organization of *Lahirites* agrees in full with *Striatites*. See Text-fig. 10.

Comparison — *Striatites* differs in lacking any obvious structure in the exine of the central body and so also *Verticipollenites* which in addition has a different form of distal saccus attachment, thereof having pitcher-like sacci. *Striatopodocarpites* has intramicroreticulate structure in the body exine.

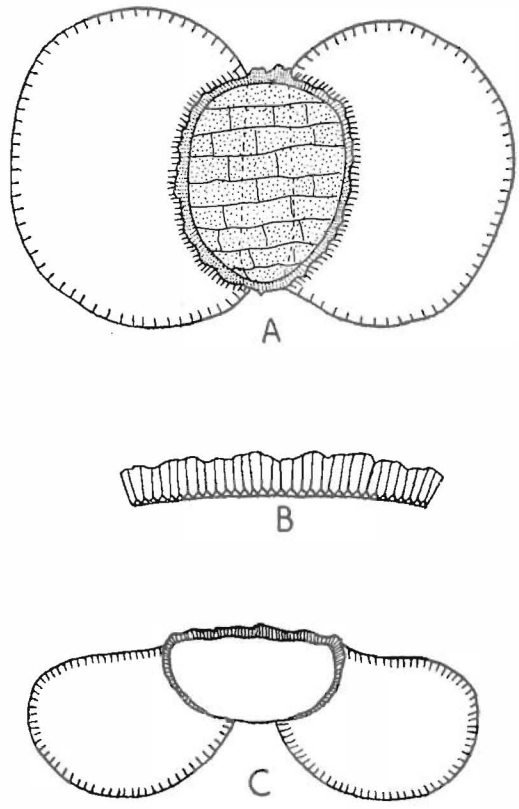
Lahirites is named after Padma Shri Dr. A. Lahiri, Director, Central Fuel Research Institute of India, in grateful recognition of his spirited support to this work.

Lahirites raniganjensis sp. nov.

Holotype — Pl. 12, Fig. 172.

Locus Typicus — Dobrana Seam, North Chora Colliery, East Raniganj Coalfield, India.

Diagnosis — Central body circular, brown, equatorial border indistinct, 9-horizontal striations with many vertical connecting striations, the exine in between the striations intrapunctate. Laterally as well as distally sacci markedly separated from each other forming a wide, straight edged channel, sacci occasionally infolded, saccus intrareticulation consisting of medium sized meshes.



TEXT-FIG. 10 — Organization of *Lahirites* gen. nov. A, polar view. B, structure of exine in central body. C, meridional section.

Description — Holotype 114 μ long, central body 50 μ wide, pollengrains distinctly bilateral, diploxylonoid and disaccate, laterally sacci separated from each other, saccus subspherical, distally occasionally folded, intruding upon the wide, straight-edged sulcus.

Other specimens referred to *Lahirites* — Pl. 11, Figs. 152, 153; Pl. 13, Figs. 181, 183, 188.

Genus *Hindipollenites* gen. nov.

Genotype — *Hindipollenites indicus* sp. nov.

Generic Diagnosis — Bilateral pollengrains with circular to vertically oval central body bearing proximally a number of horizontal striations with or without vertical,

connecting striations. Exine laevigate or microverrucose, with intrapunctate structure. Sacci distally inclined, distal attachment more or less partial-length, usually so closely approaching each other as to result into a narrow, slit-like furrow. Saccus pitcher-shaped.

Generic Description — Specimens observed so far, always bilateral and disaccate, central body usually dense, dark brown in colour, fusoid, vertically oval or circular, mostly without appreciably developed marginal ridge, margin uneven. Number of horizontal striations on proximal face of the central body 8-10, wavy and with or without vertical, connecting striations. Exine mostly laevigate, intrapunctate structured — the structure being uniform or localized along the crests of ridges. Laterally and distally sacci mostly close together, distal saccus attachment partial length, a little less than the vertical height of central body to as much less as half that height, usually enclosing a narrow furrow appearing like a slit. Saccus pitcher-shaped with broad to narrow, short neck.

Reconstruction — As for *Verticipollenites* gen. nov. (TEXT-FIG. 9).

Comparison — *Verticipollenites* lacks the intrapunctate structure in the body-exine proximally. *Striatites* lacks the pitcher-shaped sacci besides the intrapunctate structure of body exine. *Lahirites* lacks the pitcher-shaped bladders. *Striatopodocarpites* has subspherical sacci as well as intramicroreticulate structure unlike *Hindipollenites*. Other known, valid, disaccate genera have nonstriated central body.

Derivation of Name — *Hind*, i.e. India.

Hindipollenites indicus sp. nov. (PL. 10, FIGS. 141, 142).

Holotype — Pl. 10, Fig. 141.

Locus Typicus — Samla Seam, Samla Colliery, East Raniganj Coalfield, India.

Diagnosis — Central body subcircular, dark brown, marginal ridge absent, proximally 7-10 simple or forked, wavy, horizontal striations, vertical, connecting striations few, ridge exine intrapunctate. Sacci laterally separated but distally coming close together leaving a narrow furrow, zones of saccus attachment $\pm \frac{3}{4}$ the height of central body. Saccus intrareticulation with small-sized roundish meshes.

Description — Holotype 124 μ long, central body 50 μ × 48 μ. Pollengrains distinctly bilateral, diploxylonoid and disaccate, saccus height in holotype $\pm 1\frac{1}{2}$ times the height of the body, well formed, pitcher-shaped with a neck only 3 μ high.

Other specimens referred to *Hindipollenites* gen. nov., Pl. 8, Fig. 122; Pl. 12, Fig. 161; Pl. 13, Fig. 182.

Genus *Lunatisporites* (Lesch., 1955) emend.

Pl. 14, Figs. 189-196, 199; Pl. 15, Figs. 200-208; Pl. 16, Figs. 209-217; Pl. 17, Figs. 218, 219

Syn. — *Taeniaesporites* Lesch. (pars.) 1955

Genotype — *Lunatisporites acutus* Lesch.

Remarks — Through the kindness of Dr. Leschik the diplotype of *Lunatisporites* was examined by me and a number of other specimens belonging to that genus and indistinguishable from *Taeniaesporites kraeuseli* Lesch. the genotype of *Taeniaesporites* were also found in the same slide. All these specimens when considered together did not present any significant difference and thus have been taken together as belonging to one genus, i.e. *Lunatisporites*, it having been instituted before *Taeniaesporites* in the same publication (Leschik 1955). The generic diagnosis of *Lunatisporites* given by Leschik (l.c.) is very meagre and hence a revised diagnosis is given as under:

Generic Diagnosis (emend.) — Bilateral, disaccate, pollengrains, central body subcircular to oval, with proximal exine thick to thin, intramicroreticulate, horizontally segmented by grooves or striations continuous with the adjacent ones nearer the equator; distal exine also intramicroreticulate but thinner, body wall frequently folded inwards in flattened specimens giving rise to two, vertical, semi-lunar or arcuate folds. Laterally sacci often coming together, distally inclined and forming a biconvex sulcus, zones of saccus attachment convex

Reconstruction — See Text-fig. 11A.

Lunatisporites fuscus sp. nov. (PL. 14, FIGS. 189-192).

Holotype — Pl. 14, Figs. 189, 190.

Locus Typicus — Poniati Seam, Poniati Mine, East Raniganj Coalfield, India.

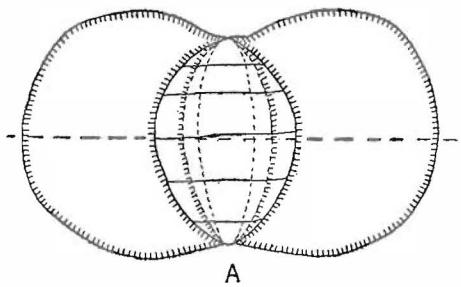
Diagnosis — Widely vertically oval, well differentiated central body with both ends pointed, 5-7 horizontal striations. Laterally sacci meeting together by narrow to wide ledge, distally sulcus 16-20 μ at its widest.

Description — Holotype 114 μ long, central body 56 × 42 μ; pollengrains bilateral,

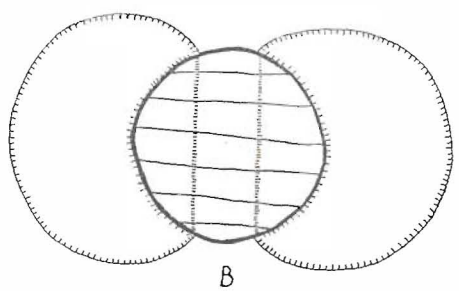
distinctly diploxylonoid and bisaccate. Known size range of length 114 μ-148 μ and biggest central body 78×50. Central body straw coloured, thin-walled bearing 5 simple horizontal striations in holotype but up to 7 in other specimens. Laterally an ingrowth or extension of one saccus meeting a 5 similar one from the opposite saccus — a characteristic feature. Distally saccus-free-zone forming a biconvex sulcus where body exine thin and granulose nearer its margin but laevigate in the centre. Sacci slightly more than hemispherical, intrareticulation small meshed.

Comparison — L. fuscus differs from the genotype in a number of characters, the chief diagnostic feature being its bigger size.

Other specimens referred to *Lunatisporites* — Pl. 14, Figs. 193-196, 199; Pl. 15, Figs. 200-208; Pl. 16, Figs. 209-217; Pl. 17, Figs. 218, 219.



TEXT-FIG. 11A — Organization of *Lunatisporites*.



TEXT-FIG. 11B — Organization of *Striatopodocarpites*, polar view with straight-edged sulcus.

Genus *Striatopodocarpites* (Soritsch. & Sedowa) emend.

Pl. 11, Figs. 155, 157; Pl. 13, Fig. 187; Pl. 14, Figs. 197, 198; Pl. 18, Figs. 235-237; Pl. 19, Figs. 238, 242-245, 247, 248.

Genotype — Striatopodocarpites antiquus (Leschik, 1956) Pot.

Remarks — The generic diagnosis of *Striatopodocarpites* given by Potonié (loc. cit.) on the basis of original description of the genotype by Leschik (loc. cit.) is very meagre with reference to present work and needs elaboration. Hence, through the kind co-operation of Prof. Dr. Kräusel and Dr. Leschik, I examined the diplotype which is bisaccate with a central body ± circular, body wall thickness uniform, equatorially folded apparently on flattening and simulating as if the body exine with a marginal ridge, 10, wavy, horizontal striations with a few forked ones on proximal face, exine coarsely intramicroreticulate, surface laevigate; distally zones of saccus attachment straight and widely separated laterally as well as near the pole; saccus very coarsely intrareticulate with big-sized meshes. Incorporating the observations on a large number of other forms from Raniganj coals and elsewhere it has become apparent that the elaborated generic diagnosis for *Striatopodocarpites* should run as follows: *Pollengrains bisaccate and bilateral. Bladders mostly more or less bigger in the height than the height of the central body in flattened grains. Central body circular to vertically oval. Central body exine bearing a number of horizontal striations on proximal face with the exine in between the striations intramicroreticulate. Distally sacci inclined with the zones of saccus attachment straight and full-length leaving a wide to narrow saccus-free area. Sacci subspherical.*

The diagnostic combination of characters for *Striatopodocarpites* as proposed here are a well-defined central body with intramicroreticulate structure of the exine and the mode of distal attachment of the sacci (TEXT-FIG. 11B). As compared to *Striatopodocarpites*, *Lueckisporites* has bands instead of striations on the exine of the body proximally; *Striatites*, *Verticipollenites*, *Lahirites* and *Hindipollenites*, all have nonintramicroreticulate exine on the proximal face of the central body. *Verticipollenites* and *Hindipollenites* possess differently shaped sacci in addition. *Kosankeisporites* has smooth exine proximally on the body.

Affinities — Striatopodocarpites, as the name suggests, might be consisting of pollengrains of Permian Podocarpaceae. Pl. 11, Fig. 157 shows close resemblance to the pollengrains of the living species *Podocarpus alpina* (BALME & HENNELLY, 1955, PL. 1, FIGS. 1-5).

Specimens referred to *Striatopodocarpites* — Pl. 11, Figs. 155, 157; Pl. 13, Fig. 187; Pl. 14, Figs. 197, 198; Pl. 18, Figs. 235-237; Pl. 19, Figs. 238, 242-245, 247, 248.

Genus *Kosankeisporites* Bhard., 1955

Pl. 19, Figs. 239-241, 246

Genotype — *Kosankeisporites elegans* (Kos.) Bhard.

Remarks — This is a spore genus with usually dense, smooth to verrucose body exine without any apparent structure. The distal attachment of bladder is convex to straight with a defined sulcus.

Specimens referred to *Lunatisporites* — Pl. 19, Figs. 239-241, 246.

Genus *Faunipollenites* gen. nov.

Pl. 17, Figs. 220-228; Pl. 18, Figs. 229-234

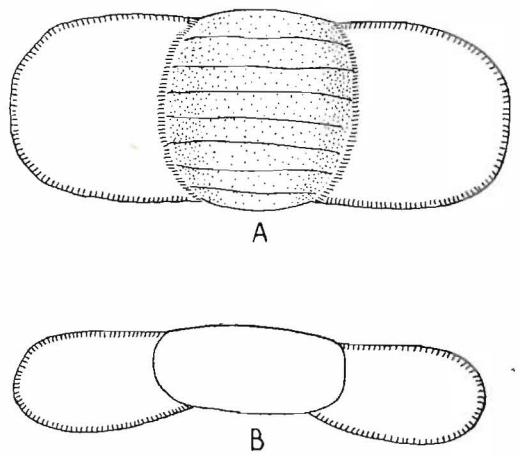
Genotype — *Faunipollenites varius* sp. nov.

Generic Diagnosis — Disaccate, bilateral, haploxylonoid pollengrains. Central body outline ill-defined, proximally exine intramicroreticulate and bearing a number of horizontal, simple or forked striations, rarely with vertical, connecting striations also; distally a uniformly wide to biconvex area free from saccus, where the exine is thin and sparsely granulose. Distal zones of saccus attachment ill-defined.

Generic Description — Bilateral grains with the bladders almost as much in height as the central body. Bladders distally inclined and laterally either separated from each other widely or narrowly. Central body with ill-defined outline and laterally having broad ends. Body exine thin and proximally intramicroreticulate with ± 8-12 horizontal striations some of which may be forked. Distally body free from the saccus in a biconvex or uniformly broad, ill-defined channel, exine faintly granulose. Sacci ± hemispherical, coarsely intrareticulate.

Reconstruction — See Text-figs. 12 A, B.

Comparison — *Striatopodocrapites* compares closely with *Faunipollenites* but for the fact that the central body in the former is well-defined and it consists of mostly diploxylonoid grains. Bolkovitina (1956) has referred organizationally similar pollengrains but lacking striations to *Protopinus* Bolkh., from the Upper Mesozoic of U.S.S.R. *Lunatisporites* Lesch., possesses smooth to microverrucose, indistinctly structured exine on the proximal, saccus-free face.



TEXT-FIG. 12 — Organization of *Faunipollenites* gen. nov. A, polar view. B, meridional section.

Faunipollenites varius sp. nov.

Holotype — Pl. 18, Fig. 230.

Locus Typicus — Samla Seam, Samla-Kendra Colliery, East Raniganj Coalfield, India.

Diagnosis — Central body apparently subcircular, 6-8 horizontal striations, distal channel wide, ill-defined. Sacci hemispherical.

Description — Holotype 106 μ long with central body 64 μ high; bilateral bisaccate grains. Central body apparently subcircular, the outline being hazy and apparent due to the striations ends or the laterally bladder-free margin. Striations normally simple, unforked. Distally sacci inclined but not much, the zones of saccus attachment ill-defined. Sacci hemispherical, coarsely intrareticulate.

Other specimens referable to *Faunipollenites* — Pl. 17, Figs. 220-228; Pl. 18, Figs. 229, 231-234.

SERIES — **Rectistriati** ser. nov.

Series Diagnosis — Bilateral pollengrains with a central body bearing vertical striations on proximal or distal, saccus-free regions.

Genus *Striapollenites* gen. nov.

Pl. 21, Figs. 273-275; Pl. 22, Figs. 276-280

Genotype — *Striapollenites saccatus* sp. nov.

Generic Diagnosis — Bilateral pollengrains with a vertically oval to subcircular central body bearing a number of obliquely vertical striations proximally. Sacci distally inclined on the body leaving an ill-defined, wide, saccus-free, distal area.

Generic Description — Grains usually bilateral, disaccate or imperfectly disaccate. Central body vertically oval to subcircular. Proximal, saccus-free exine intramicroreticulate and bearing a number of vertical striations running from one lateral side to the other frequently in a slightly oblique direction. Striations simple or forked. Occasionally a few horizontal, connecting striations may be apparent. Sacci hemispherical and usually finely intrareticulate, distally slightly inclined leaving a wide, biconvex ill-defined channel between the distal zones of saccus attachment.

Reconstruction — See Text-figs. 13A, B.

Comparison — The occurrence of vertical striations on the proximal face of central body is a feature not described from any horizon as far as known to me. The genus *Striapollenites* suggests a trend distinctly different from that of horizontally striated pollengrains if the former are taken to be elaborated from the horizontally striated, non-saccate pollengrains described here under *Gnetaceaepollenites*, bearing two parallel folds which can be considered as the pre-saccus manifestation.

The spores referable to *Striapollenites* are not so abundant in coals of Raniganj Stage as those grouped under other Series with the result that a final evaluation of the range of variation in the genus is not possible for the present.

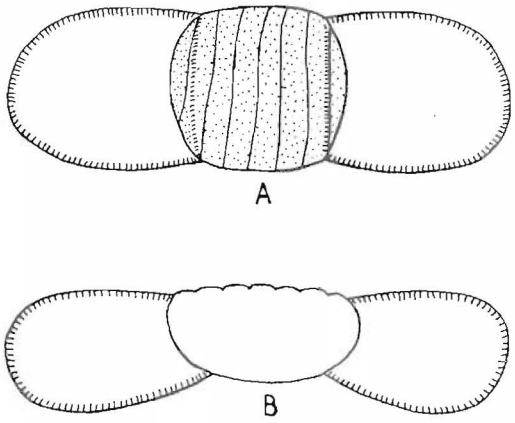
Striapollenites saccatus sp. nov. (Pl. 21, Figs. 273-275)

Holotype — Pl. 21, Fig. 273.

Locus Typicus — Poniati Seam, Poniati Mines, East Raniganj Coalfield, India.

Diagnosis — Disaccate, central body vertically fusoid, ± 6 vertical striations on proximal face. Laterally sacci meeting together on one side but widely separated on the other. Distally zone of saccus attachment ill-defined.

Description — Holotype 120 × 72 μ, central body 72 μ × 44 μ; grain distinctly bisaccate, central body longish vertically oval with one end acute and the other widely truncate as in a boat. Body outline distinct, proximally the exine bearing 5-6 vertical or vertically oblique, deep striations. Distally sacci distinctly inclined forming a boat-shaped channel free from the saccus, zones of distal saccus attachment ill-defined. Saccus ± hemispherical and finely intrareticulate.



Text-fig. 13 — Organization of *Striapollenites* gen. nov. A, polar view. B, meridional section.

Other specimens referred to *Striapollenites* — Pl. 20, Figs. 276-280.

Genus *Distriatites* gen. nov.

Pl. 22, Figs. 281-286

Genotype — *Distriatites bilateris* sp. nov.

Generic Diagnosis — Bilateral, pollengrains with a subcircular central body bearing a number of horizontal striations proximally and vertical striations distally in the saccus-free region. Sacci distally inclined on the body leaving an ill-defined wide, saccus-free, distal area.

Generic Description — Grains usually bilateral, mono- to tetrasaccate. Central body ovaloid or subcircular, thick- or thin-walled. Proximally body exine bearing in some species a number of horizontal striations and distally vertical striations, i.e. perpendicular to those borne proximally. Body exine proximally as well as distally in the saccus-free region fine to coarsely intramicroreticulate between the striations. Sacci distally inclined leaving a wide channel or an area free from the sacci, laterally widely separated. Sacci finely intrareticulate.

Reconstruction — See Text-figs. 13A, B for an idea of general organization.

Comparison — The only spore genus supposed to have comparable striations has been *Fastigatisporites* Leschik (1956) which as subsequently examined by Potonié (1958, p. 52) proved to be an observational mistake. In reality, as far as known to me, no genus similar to that circumscribed above, i.e. having horizontal and vertical striations on

proximal and distal faces of the central body respectively, has been described. These specimens present a case of singular organization as compared to the other conventionally known ones. *Striapollenites* differs from *Distriatites* by having striations on one face only. Unlike *Striapollenites*, the organization in *Distriatites* appears to be a direct variation from the other horizontally striated disaccate genera.

Distriatites bilateris sp. nov. (PL. 22, FIGS. 281-285)

Holotype — Pl. 22, Figs. 281, 282.

Locus Typicus — Chora Seam, Samla Dalurband Colliery, East Raniganj Coalfield, India.

Diagnosis — Bilateral, bisaccate with the sacci sometimes having an additional lobe, central body subcircular, larger than the sacci, thick-walled, exine on both faces intramicroreticulate appearing distinctly microfoveolate and bearing ± 7 horizontal striations proximally and 7 vertical striations distally.

Description — Holotype 120 μ long, central body 68 × 64 μ; grain bilateral and bisaccate, central body subcircular, exine thick and intrabaculate, proximal striations horizontal and distal striations vertical. Sacci slightly distally inclined leaving a very wide sacci-free distal area of the body-exine. Sacci ± hemispherical, finely intrareticulate.

Other specimens referable to *Distriatites* — Pl. 22, Fig. 286.

SERIES — **Disacciatrileti** (Lesch.) Pot., 1958

Genus *Vesicaspora* Schemel.

Pl. 20, Figs. 260, 261; Pl. 21, Figs. 265-269

Genotype — *Vesicaspora wilsonii* Schemel.

Specimens assigned to *Vesicaspora* — Pl. 20, Figs. 260, 261.

Comparable spores are referred by Balme and Hennelly (1955, PL. 6, FIGS. 62-64) as a species of *Vestigisporites*. *Parvisaccites* Couper (1958) also seems to be organizationally similar to these specimens.

Other specimens closely approaching *Vesicaspora* — Pl. 21, Figs. 265-269.

Genus *Sulcatisporites* (Lesch.) emend.

Pl. 19, Figs. 249-253; Pl. 20, Figs. 254-259

Genotype — *Sulcatisporites interpositus* Lesch., 1955.

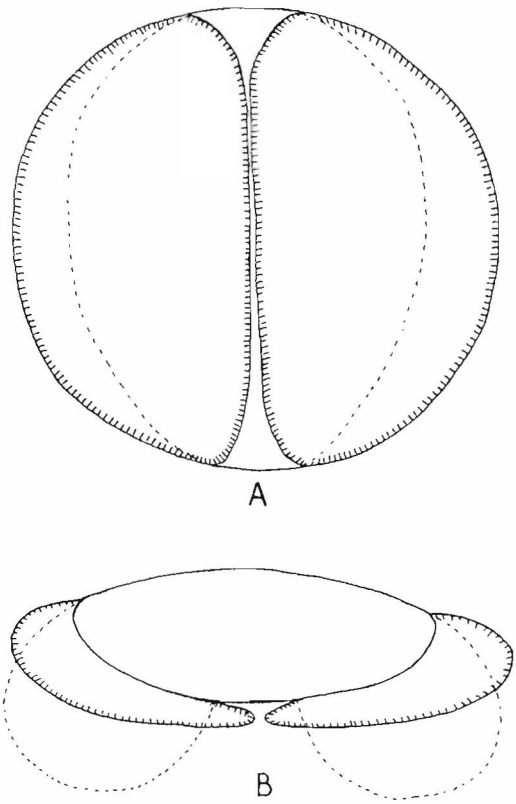
Remarks — Jansonius (1961) has merged *Sulcatisporites* into *Alisporites* Daugherty. He also gives a detailed diagnosis for *Alisporites*. However, a close study of the genotype figure of *Alisporites* suggests an organization different from that stipulated by Jansonius (l.c.). As apparent to me the generic diagnosis of *Alisporites* should run as follows — " Disaccate, bilateral pollen-grains, central body vertically oval, outline distinct, proximally exine laevigate, structured, not bearing striations, Y-mark or a monolete mark; distally sacci inclined, distal zones of bladder attachment straight to convex."

Organizationally the diplotype of *Alisporites* approaches the polar view of pollen-grains illustrated by Potonié (1958, PL. 8, FIG. 75) for *Pinuspollenites* Raatz and *Podocarpidites* Cookson (POTONIÉ 1958, PL. 8, FIG. 85) but for the sacci being slightly bigger than the body in the latter genera. The overall shape in the genotype of *Sulcatisporites* and also in some specimens referred to it by me is almost circular which is very characteristic in addition to the thinness of the central body wall so much so as to be hardly perceptible, in contrast to *Alisporites*.

In *Sulcatisporites splendens* Lesch. (1956) and in *Sulcatisporites* (as *Florinites*) *ovatus* (Balme & Henn.) comb. nov., the overall shape is more oval than circular although in all other characters these are unmistakably referable to *Sulcatisporites*. It is thus apparent that in its overall shape *Sulcatisporites* exhibits the tendency to vary from oval to circular form.

In my opinion *Sulcatisporites* with its diagnosis as emended and elaborated here should be easily identifiable as well distinguishable from *Alisporites* which is so different from it in a number of features.

Labiisporites Lesch. (1956) from Europe appears to be a variant of *Sulcatisporites*. *Vesicaspora* Schemel. from N. America has a distinctly outlined central body and the saccus is continuous round the body laterally. In view of the copious representation of the specimens referable to *Sulcatisporites* in the coals of Raniganj Stage as well as in Gondwana horizons of Australia (Balme & Henn. 1955, PL. 5, FIGS. 46, 47, 49-52). I have emended the genus *Sulcatisporites* accordingly. In the diplotype, examined by me through the kindness of Dr. Leschik, the distal, biconvex structure referred by Leschik (1955) as '*Spalt*', is really made up



TEXT-FIG. 14 — Organization of *Sulcatisporites* (Leschik) emend. A, polar view. B, meridional sections of flattened and unflattened specimens.

of two arcuate folds in the body-exine without any split.

Generic Diagnosis (emend.) — Pollengrains with an oval to circular overall shape in polar view. Central body faintly discernible, outline not defined. Distally, the median vertical region of the grain showing vertical folds frequently. Sacci distally inclined and mostly infolded in a characteristic way, saccus exine mediumly coarse, intrareticulate.

Reconstruction — See Text-figs. 14A, B.

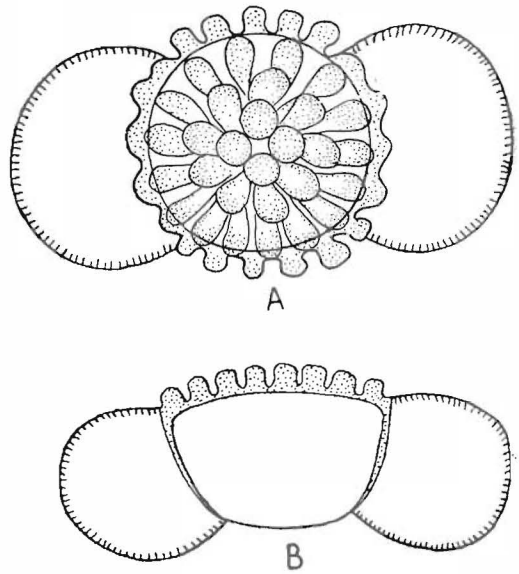
Specimens referred to *Sulcatisporites* — Pl. 19, Figs. 249-253; Pl. 20, Figs. 254-259.

Genus *Tumoripollenites* gen. nov.

Pl. 21, Figs. 270-272

Genotype — *Tumoripollenites baculatus* sp. nov.

Generic Diagnosis — Haploxylonoid, bisaccate, bilateral grains with circular to horizontally oval central body having prioximally tuberculate, thick exine. Saccic finely intrareticulate and distally inclined.



TEXT-FIG. 15 — Organization of *Tumoripollenites* gen. nov. A, polar view. B, meridional section.

Generic Description — The sacci are usually smaller than the central body and laterally widely separated. Central body circular or horizontally oval, proximally thick-walled bearing close and uniformly spaced bacula with rounded or truncate heads apparently arranged radially with the inner bacula smaller and the outer bigger. Ditals exine of the central body thin and granulose. Sacci finely intrareticulate, and appear to be attached distally for most of their extent.

Reconstruction — See Text-figs. 15A, B.

Comparison — But for its haploxylonoid organization and large bacula *Tumoripollenites* could as well have been merged with *Platysaccus*. The bladders in *Tumoripollenites* suggest a tendency towards reduction in size as in *Phyllocladidites* (Cookson) Couper.

Tumoripollenites baculatus sp. nov. (PL. 22, FIG. 270)

Holotype — Pl. 22, Fig. 270.

Diagnosis — Central body circular, bacula up to 6 μ and 4 μ broad with rounded heads. Distally wide, circular area free from sacci.

Description — Holotype 78 μ long, central body circular, 40 μ in diameter; grains bilateral, sacci smaller than the central body in height, central body bearing bacula-like tubercles with rounded heads and more in

number nearer the equator but less as well as smaller nearer the centre. Distally sacci slightly inclined leaving most of the body exine free from them. Distally body-exine granulose. Bladders finely intrareticulate.

Other specimens referred to *Tumoripollenites* — Pl. 22, Figs. 271, 272.

DIVISION — **Polyplicates** Erdtm.

Genus *Gnetaceaepollenites* Thiergart, 1938

Pl. 5, Figs. 84-87, 92

Genotype — *Gnetaceaepollenites ellipticus* Thierg.

Generic Diagnosis — See Potonié, 1958, p. 88.

Remarks — The specimens from Raniganj coals referable to this genus agree in all essential characters of organization with the genotype and other species listed by Potonié (loc. cit.). Quite like the genotype my specimens show two arcuate folds running along the longest axis of the pollengrains. The only important difference between the genotype and some of my specimens is that the latter have characteristically intrapunctate exine whereas the former seem to have had only smooth exine. Considering the disparity in the age of my specimens of Upper Permian age with the others exclusively from Tertiary horizons such a morphographical difference may be plausible among members which are otherwise organizationally similar. However, considering this important difference some of my specimens are referred here as cf. *Gnetaceaepollenites* — Pl. 5, Figs. 84-87.

Gnetaceaepollenites sinuosus (Balme & Henn.) comb. nov. (PL. 5, FIG. 92.)

Syn.— *Marsupipollenites sinuosus* B. & H. 1956b.

Holotype — Balme & Henn., 1956b, Pl. 2, Fig. 25.

Diagnosis (emend.) — Oval to fusiform, characterized mostly by two longitudinal, slightly crescentic folds extending almost the full length of the grain and converging at their extremities. Exine about 2 μ thick, smooth and longitudinally, sparsely striated. Striations running full height of the grains and occassionally branched.

Comparison — *Gnetaceaepollenites ellipticus* is from Tertiary horizon and *Ephedripites mediolobatus* Bolkhow., is a species described from Northern Hemisphere as well as from Cretaceous strata.

Genus *Welwitschiapites* Bolchowit., 1953

Pl. 5, Figs. 88-91

Genotype — *Welwitschiapites magniolobatus* Bolchowitina.

Generic Diagnosis — See Potonié, 1958, p. 88.

Remarks — The specimens from Raniganj coals referred here agree in most of the organizational details with the genotype. They differ among themselves in the ornamentation of the exine. Some (PL. 5, FIGS. 88-90) have intrabaculate exine and Pl. 5, Fig. 91 has verrucose sculpture on the exine. None of these specimens shows any sign of reduced or vestigial sacci or even the slight protrusion of the exoexine at the two ends as is the case in some *Welwitschiapites* Bolchowitina.

Till Wilson's (1959) discovery from Mid. Permian of northern hemisphere (now JANSONIUS, 1961 also) and mine from the Raniganj Stage in India the genus was not known to be represented before the Cretaceous. The inclusion of Permian forms in *Welwitschiapites* is warranted on grounds of morphographical similarity.

Specimens referable to *Welwitschiapites* — Pl. 5, Figs. 88-91.

DIVISION — **Monocolpates** Iversen & Troel-Smith

SUB-DIVISION — **Intortes** (Naum.) Potonié, 1958.

Genus *Vittatina* Luber, 1940

Pl. 5, Figs. 93, 94

Remarks — Lower Gondwana spores referable to *Vittatina* have been described by Balme & Hennelly (1956b) under *Marsupipollenites*, a new genus created by them. The genotype of *Marsupipollenites*, *M. triradiatus* B. & H. consists of oval to subcircular grains bearing a trilete mark, the body wall vertically folded very much like in *Entylissa* and exhibiting verrucose ornamentation of the exine with a few horizontal striations (*see* B. & H. 1956b, PL. 2, FIG. 31) and distinctly striated exine together with a trilete mark in a *forma* of the same species described as *M. triradiatus* forma *striatus*. *Vittatina*, as far as known to me, has never been described to show a trilete mark as is the case in genotype of *Marsupipollenites*, although the striated exine, its generic character, occurs also in *Marsupipollenites triradiatus* forma *striatus*. *Vittatina* also shows

vertical folding of the grain very similar to that in *M. triradiatus*. It is apparent that *Vittatina* is very close to *Marsupipollenites*. Morphographically it is possible to recognize both these genera, *Marsupipollenites* bearing a trilete mark and *Vittatina* without a trilete mark.

Potonié (1958, p. 90) groups *Vittatina* in Polyplicates with *Gnetaceaepollenites, Ephedripites*, etc., but I have preferred to group *Vittatina* as well as *Marsupipollenites* along with *Entylissa* in Monocolpates. The folding over of the grains in *Vittatina* and *Marsupipollenites* is in the same manner as in *Entylissa* and thus suggestive of nearness. In these genera the folds always run perpendicular to the striations whereas in Polyplicates the folds lie parallel to the striations.

Following species of *Vittatina* are referred here —

1. *Vittatina scutata* (Balme & Henn.) comb. nov.

Syn. — *Marsupipollenites scutatus* B. & H. 1956b.

Holotype — Balme & Hennelly, 1956b, Pl. 2, Fig. 39

Diagnosis (emend.) — Longitudinally 43-52 μ (mean 46 μ), transversely 34-58 μ (mean 48 μ), circular or oval with one or two folds directed inwards and partly overlapping. Exine fairly thick, up to 4 μ in optical section in the region of folds, bearing transverse striations irregularly connected by small, vertical striations thereby enclosing flattened verrucae, 1-3 μ in diameter.

Comparison — Samoilowitz (1953) describes irregularly criss-cross striated as well as regularly, horizontally striated forms in *V. vittifer* Lub., and *V. striata* Lub. which are slightly bigger and are described from the Lower Permian of northern hemisphere.

2. *Vittatina fasciolata* (Balme & Henn.) comb. nov.

Syn. — *Marsupipollenites fasciolatus* B. & H. 1956b.

Holotype — Balme & Hennelly, 1956b, Pl. 3, Fig. 42.

Diagnosis (emend.) — Oval to subcircular with one or two folds at right angles to the plane of striations. Exine transversely striated mostly without any vertical, connecting striations.

Comparison — *V. scutata* shows regularly criss-cross striated exine resulting into verrucose appearance and is slightly bigger in size. *V. vittifer* and *V. striata* from Northern Hemisphere are still bigger in size.

DISCUSSION

Raniganj Stage is considered to be uppermost Permian in age in India, the Panchet Series which overlies it being held as of Triassic age. The miospore assemblage of Raniganj Stage as evidenced here is rich and diversified, represented by 18 trilete genera, 3 monolete genera, 19 genera of saccate pollengrains and 3 genera of nonsaccate pollengrains. In its richness it easily compares with any spore assemblage of the Upper Carboniferous age such as that of the Westphalian where nearly similar number of spore genera usually constitute a spore assemblage. In the qualitative diversification, Raniganj miospore assemblage with its preponderating disaccate pollengrains manifests equitably its age where, comparing with Carboniferous times, seed plants had become richer and more diversified. In spite of this the Cryptograms do not appear to have lagged very much behind at least qualitatively.

Although most of the trilete and monolete genera from Raniganj Stage are the same as those in European Upper Carboniferous strata, they are quantitatively meagrely represented and the new trilete genera such as *Eupunctisporites, Microbaculispora, Microfoveolatispora, Indospora* and *Gondisporites* as well as the richly represented cf. *Acanthotriletes* (*see* also BALME & HENNELLY, 1956b) and *Cyclobaculisporites* lend this assemblage a distinctive character. The saccate pollengrains which really constitute a very large portion of this spore assemblage are to a significant degree qualitatively different as compared to those recorded from contemporary strata of Northern Hemisphere thus again lending a distinctive character to it. Thus, generally speaking, the miospore assemblage from Raniganj Stage varies markedly from that of contemporary strata in Europe.

The detailed taxonomic study of the dispersed miospores from Raniganj Stage has revealed a number of distinctive spore organizations.

Among the trilete spores four new organizations have been discerned.

Eupunctisporites gen. nov. has thick exine marked with roundish to irregularly shaped, averagely spaced pits. In flattened specimens the margin appears smooth in places but it is broken where it passes through the pits lending there an appearance very much

like *Cyclobaculisporites*. As compared to *Cyclobaculisporites* this genus has the same shape and has similar disposition of the trilete mark. These correspondences suggest that *Eupunctisporites* might be closely related to *Cyclobaculisporites*.

Microbaculispora gen. nov., and *Microfoveolatispora* gen. nov., are organizationally very similar to each other as well as to *Acanthotriletes* in possessing the ornamentation progressively pronounced from proximal to distal side. These genera might be representing three parallel tendencies emanating from one or a number of closely related groups.

Indospora gen. nov. represents a morphographical set up which was difficult to resolve but for careful microscopic examination. The muri though ensuing from the proximal side are mostly distal. Organizationally it resembles some forms of *Triquitrites* on one hand and *Dictyotriletes* on the other.

Gondisporites gen. nov. represents slight modification from the organizationally similar, genera *Cirratriradites* and *Endosporites* from the northern hemisphere combining some characters of one with the remaining of the other genus.

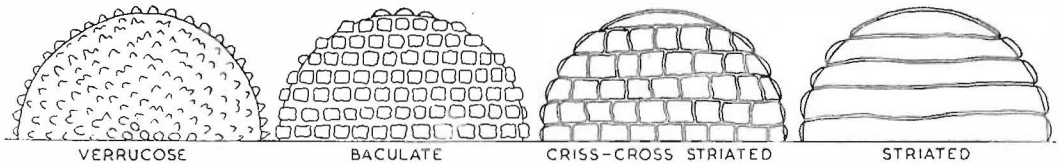
Among saccate pollengrains a number of new morphographic features have been discovered. These relate mostly to the characters exhibited by the central body itself or how the saccus separates from it.

In *Striomonosaccites* gen. nov., and *Distriomonosaccites* gen. nov., the central body bears striations on one of the faces or on both faces respectively. These genera are typically monosaccate.

Platysaccus and *Cuneatisporites* lack striations though have sculptured exine on the central body. In *Striatopodocarpites* the body-exine on proximal face is horizontally striated and intramicroreticulate structured.

In *Striatites*, *Verticipollenites* gen. nov., *Lahirites* gen. nov., and *Hindipollenites* gen. nov., the central body bears horizontal striations with some species bearing vertical connecting striations in between, the like of which have never been described from elsewhere. In extreme cases these vertical striations are ill-defined closely approaching the conditions of simple, horizontally striated grains. Taking this fact to be on one extreme and the verrucose sculpture of *Platysaccus* and *Cuneatisporites* on the other leads me to venture the suggestion that possibly the striated exine is a successor to verrucose exine. That this relationship is more probable is substantiated by the specimens of *Marsupipollenites* illustrated by Balme and Hennelly (1956a, Pl. 2, Figs. 29-37) where, in the case of *M. triradiatus* the verrucose sculpture (Pl. 2, Figs. 29, 30, 32-35) and verruco-baculate sculpture (Pl. 2, Figs. 31, 36, 37) are evident. In my opinion the specimens possessing verruco-baculate sculpture and thus considered only as a forma of *M. triradiatus*, should be raised to a specific rank as *M. striatus* comb. nov., *M. scutatus* (Balme & Hennelly, 1956a, Figs. 38-41), now transferred to *Vittatina* —a genus morphographically close to *Marsupipollenites* (cf. p. 100), shows the baculo-striated sculpture, very similar to criss-cross striated surface of the central body in some of the disaccate genera, and in *M. fasciolatus* (Balme & Hennelly 1956a, Pl. 3, Figs. 42-45) a simple striated sculpture is seen. The same relationship between verrucose and striated ornamentations is also apparent in the specimens of *Welwitschiapites* referred to in this paper (p. 99). In view of these observations I suppose that the condensation of verrucae resulted into densely baculate sculpture and gradual alignment of bacula in ± horizontal rows apparently led to baculo-striated ornamentation wherefrom gradual fusion of the adjacent bacula resulted into criss-cross striated and thence into simple, horizontally or vertically striated exines as depicted in Text-fig. 16. Thus, the verrucose, baculate, and the criss-cross striated exines of the central body in saccate pollengrains seem to have been the intermediate stages respectively in the evolution of simple striated exines. The occurrence of striations is the characteristic feature in pollengrains mostly of Permian age. Such grains really started appearing timidly in the uppermost Carboniferous and disappeared some time in the Mesozoic. The non-sculptured, non-striated, structured exine of the modern saccate pollengrains has existed along side the striated ones. The structure in the proximal exines of central bodies in saccate pollengrains seems to have developed from ± non-structured exines normally found in the saccate and non-saccate pollengrains of Upper Carboniferous age. The evolution seems to have been from non-structured to intrapunctate and intramicroreticulate exine.

In *Striapollenites* gen. nov., another new tendency observed is the occurrence of



TEXT-FIG. 16 — Probable derivation of striated exines from verrucose exines.

vertical striations, i.e. running perpendicular to the long axis of the grain. In some specimens, such striations occur on the proximal face and in the others on the distal face. In *Distriatites* gen. nov. striations occur on both faces of the central body but those of one face are usually oriented at right angles to those of the other.

Among the non-saccate pollengrains the recovery of specimens referred to *Gnetaceaepollenites* and *Welwitschiapites* is of significance. These specimens show remarkably close resemblance to living species, mostly those of *Ephedra* and *Welwitschia*, in organization. If morphographic resemblance can be deemed to reflect phylogenetic nearness, this find extends the fossil history of the Gnetales to Permian as is also the opinion of Wilson (1959).

Recently, Steeves and Barghoorn (1959) have published a comprehensive account of the pollengrains of *Ephedra*. They have recognized four morphological types of pollengrains in the genus. From Raniganj coals, some *Gnetaceaepollenites* (PL. 5, FIGS. 84, 85) have unmistakable resemblance to the pollen of *Ephedra distachya* (STEEVES & BARGHOORN 1959, PL. 1, FIG. 3) and specimens of *Welwitschiapites* (PL. 5, FIGS. 88-90) resemble *E. trifurca*. The other specimens of *Gnetaceaepollenites* illustrated by me here exhibit organizational similarity with pollengrains of *Welwitschia* in general.

The close morphographical nearness between the species of *Gnetaceaepollenites* and *Welwitschiapites* from the Upper Permian of Raniganj with the Cretaceous and subsequent fossil as well as living representatives of Gnetales (*Ephedra*, *Welwitschia*) extends the fossil history of Gnetales to the late Palaeozoic. Some years back, Tchigouriaeva (1954) suggested that the ancestral form of *Ephedra* had evolved from the striated disaccate pollengrains of Permotriassic. According to him, from the Permian onwards the sacci in the disaccate, striated pollengrains were progressively reduced during Triassic until probably by Jurassic the sacci were either vestigial or completely absent as is the case in the pollengrains of living *Welwitschia* and *Ephedra*. However, the discovery of *Ephedra*-like, nonsaccate pollengrains from the same strata where striated, disaccate pollengrains abound, raises the doubt if the latter could be direct ancestors of ephedralean pollen. With this discovery, even the mode of the morphographic evolution of ephedralean pollen as suggested by Tchigouriaeva (loc. cit.) seems questionable. In my opinion it is preferable to avoid a positive statement on the question of the origin of ephedralean pollen till we know how the saccate and the nonsaccate, striated pollengrains are related to each other in still older miospore assemblages.

In the taxonomic treatment of disaccate pollengrains considerable significance has been attached by me to the sculpture and structure of exine in the central bodies and the mode of attachment of sacci with their resultant shape. The varied types in these characters occur also in the pollengrains of living coniferous genera but associated in a way different than what is found in the Permian types. This, in my opinion, is due to the fact that the modern coniferous genera are remnants of a one time much diversified and dominant class now on wane and thus are supposedly either groupings of elements from different, originally independent, evolutionary tendencies in which some characters show agreement due to parallel evolution or exhibit a mixing up of originally, differently associated characters on account of their parallel passage through considerable period of evolution, whereas the disaccate pollengrains of Raniganj coals represent the young and well defined, vigorously evolving gymnospermous plant groups. It is for this reason that I have not gone utterly by what we find in modern conifers and instead relied more upon the constancy of the association of characters as evident in the Permian miospores which provide overwhelming ease in classifying them.

Another interesting find is the remarkable organizational similarity of the species of *Striatites* and *Striatopodocarpites*, with some living species of *Podocarpus*. The members of *Verticipollenites*, *Lahirites* and *Hindipollenites* also, on the basis of their overall similarity with *Striatites* and *Striatopodocarpites*, appear to be similar to the pollengrains of Podocarpaceae. But the species of the fossil genera possess striations on their central bodies which the modern, podocarpaceous pollengrains lack.

However, besides the organizational similarity another fact which cannot be lost sight of is that Podocarpaceae, as its fossil history shows, is mainly a family of Southern Hemisphere (FLORIN, 1940,1 958) including India and, according to Florin (1940), *Podocarpus* probably originated in the south in early Mesozoic time because he has been able to evidence the presence of podocarpaceous fossil remains as far back as the Triassic age in the southern continents. So far as I know, Triassic was no period of great floral amplification in southern continents. On the contrary it was a period of lull after the maximum floral diversification of Upper Permian as apparent from the comparison of the flora of Raniganj Stage and Panchet Series from India. Thus, it is probable that the roots of Podocarpaceae actually date back to Raniganj Stage or even earlier and the Podocarpaceae-like pollengrains found there represent the earliest Podocarpaceae. But no podocarpaceous remains have so far been recognized in the megaflora of Raniganj Stage. This, however, may be due firstly to the fact that what we know of the megaflora of this Stage is far from complete so that out of the many, narrow, lanceolate leaves found in *Glossopteris*-assemblage some might have belonged to the early podocarpaceous plants, yet on the basis of superficial examination these are being passed off as juvenile leaves of *Glossopteris* or secondly that the earliest Podocarpaceae were quite unlike the modern ones in some respects. The possibility that these podocarpaceous-like pollengrains had no relation with Podocarpaceae, their likeness being superficial, should also not be excluded. There is apparently need for a study of *Glossopteris* megaflora in considerable detail especially now, when we know from the mioflora that it appears to have been much more diversified than hitherto supposed.

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EXPLANATION OF PLATES

(All figures unless otherwise stated are 500 ×)

Plate 1

1-3. *Leiotriletes*, Ph. Nos. 154, 56/30, 109/14.
4, 5. *Eupunctisporites poniatiensis* gen. et sp. nov., Ph. Nos. 94/6 (Holotype), 133/14.
6, 7. *Eupunctisporites*, Ph. Nos. 131/23, 94/10.
8. *Punctatisporites*, Ph. No. 6/24.
9, 10. *Retusotriletes diversiformis* (Balme & Henn.) comb. nov., Ph. Nos. 79/11. 149.
11-14. *Cyclogranisporites*, Ph. Nos. 9/11, 135/22, 83/16, 77/34.
15. *Verrucosisporites*, Ph. No. 151.
16, 17. *Anapiculatisporites ericianus* (Balme & Henn.) comb. nov., Ph. Nos. 109/16, 76/18.
18-21. *Lophotriletes*, Ph. Nos. 82/37, 61/5, 150, 121/35.
22-24. *Acanthotriletes*, Ph. Nos. 152, 135/18, 84/6.
25-28. Cf. *Acanthotriletes*, Ph. Nos. 147/23, 109/21, 76/3, 16/13.
29, 30. Cf. *Lophotriletes*, Ph. Nos. 135/6, 139/14.
31, 32. Cf. *Acanthotriletes*, Ph. Nos. 72/5, 85/19.

Plate 2

33-35. *Microbaculispora gondwanensis* gen. et sp. nov., Ph. Nos. 109/7 (Holotype), 123, 6/22.
36-38, 41-42. *Cyclobaculisporites*, Ph. Nos. 58/21, 134/2, 4/6, 14/34, 6/17.
39, 40. *Cyclobaculisporites trisecatus* (Balme & Henn.) comb. nov., Ph. Nos. 146, 5/2.
43, 44. *Microfoveolatispora pseudoreticulata* (Balme & Henn.) comb. nov., Ph. Nos. 89/22, 89/25.
45-47. *Microfoveolatispora directa* (Balme & Henn.) comb. nov., Ph. Nos. 120, 121, 109/13.
48, 49. *Microfoveolatispora raniganjensis* gen. et sp. nov., Ph. Nos. 109/8 (Holotype), 109/9.

Plate 3

50-53. *Microfoveolatispora trisina* (Balme & Henn.) comb. nov., Ph. Nos. 109/6, 109/3, 109/4, 141/12.
54, 56, 57. *Indospora clara* gen. et sp. nov., Ph. Nos. 109/33 (Holotype), 109/32, 109/30.
55, 58-60. *Indospora*, Ph. Nos. 152/17, 81/12, 180/7, 176/33.
61. *Gravisporites*, Ph. No. 6/9.
62, 63. *Lycopodiumsporites*, Ph. Nos. 10/27, 163/5.
64. *Reticulatisporites*, Ph. No. 110/3.
65. Cf. *Cirratriradites*, Ph. No. 110/4.

Plate 4

66, 67. *Gondisporites raniganjensis* gen. et sp. nov., Ph. Nos. 155, 128 (Holotype).
68-71. *Gondisporites*, Ph. Nos. 5/11, 107/4, 62/34, 62/17.
72, 73. *Latosporites colliensis* (Balme & Henn.) comb. nov., Ph. Nos. 94/1, 10.
74. *Latosporites*, Ph. No. 85/27.

Plate 5

75, 76. *Latosporites*, Ph. Nos. 83/9, 90/3.
77-79. *Punctatosporites*, Ph. Nos. 69/2, 147/16, 147/17.
80-83. *Verrucososporites*, Ph. Nos. 135/19, 92/9, 108/15, 43/13, 110/6.
84-87. Cf. *Gnetaceaepollenites*, Ph. Nos. 151/1, 151/3, 8/9, 148/4.
88-91. *Welwitschiapites*, Ph. Nos. 106, 110/7, 135/29, 151/44.
92. *Gnetaceaepollenites sinuosus* (Balme & Henn.) comb. nov., Ph. No. 147/22.
93. *Vittatina scutata* (Balme & Henn.) comb. nov., Ph. No. 58/25.
94. *Vittatina fasciolata* (Balme & Henn.) comb. nov., Ph. No. 53/7.
95. Cf. *Nuskoisporites*, Ph. No. 106/28.

Plate 6

96-98 Cf. *Nuskoisporites*, Ph. Nos. 126/20, 75/20, 147/10.
99-102. *Densipollenites*, Ph. Nos. 143/5, 56/9, 115, 58/8.
103, 104. *Densipollenites indicus* gen. et sp. nov., Ph. Nos. 118/13 (Holotype), 118/15.

Plate 7

105-106B. *Densipollenites*, Ph. Nos. 147/6, 147/9, 147/7 (proximal), 147/8 (distal).
107-109. *Striomonosaccites ovatus* gen. et sp. nov., Ph. Nos. 132/9, 8 (Holotype), 132/5.
110-114. *Striomonosaccites*, Ph. Nos. 108/8, 126/3, 48/20, 106/30, 131/1.

Plate 8

115, 116. *Distriomonosaccites rotatus* gen. et. sp. nov., Ph. Nos. 147/3, 147/2 (Holotype).
117, 118. *Distriomonosaccites*, Ph. Nos. 147/4, 5.
119-121. *Striatites*, Ph. Nos. 131/9, 8, 106/2.
122. *Hindipollenites*, Ph. No. 146/31.
123, 124. *Striatites*, Ph. Nos. 146/32, 131/14.

Plate 9

125. *Striatites*, Ph. No. 146/28.
126,127. *Verticipollenites*, Ph. Nos. 106/10, 11.
128. *Striatites*, Ph. No. 108/6.
129-136. *Verticipollenites*, Ph. Nos. 118/23, 146/33, 131/12, 73/29, 4/4, 110, 107/25, 107/24.

Plate 10

137-139. *Verticipollenites*, Ph. Nos. 146/25, 119/4, 117/24, 13.
140. *Striatites*, Ph. No. 8/1.
141, 142. *Hindipollenites*, Ph. Nos. 117/38, 132/12.
143-146. *Verticipollenites*, Ph. Nos. 131/16, 131/15, 120/20, 21.
147, 148. *Striatites*, Ph. Nos. 106/23, 13/11.

PLATE 11

149-151, 154, 156. *Striatites*, Ph. Nos. 107/35, 108/9, 10, 108/19, 103/6.
152, 153. *Lakhirites*, Ph. Nos. 148/5, 146/34.
155, 157. *Striatopodocarpites*, Ph. Nos. 58/17, 107/34.
158, 159. *Verticipollenites*, Ph. Nos. 121/20, 81/3.

PLATE 12

160. *Verticipollenites secretus* gen. et sp. nov., Ph. No. 146/22 (Holotype).
161. *Hindipollentes*, Ph. No. 119/16.
162-165. *Verticipollenites*, Ph. Nos. 129/31, 132/24, 94/18, 7/23.
166, 167. *Striatites*, Ph. Nos. 121/11, 117/8.
168 171, 173. *Verticipollenites*, Ph. Nos. 133/21, 22, 57/14, 64/27, 57/5.
172. *Lakhirites raniganjensis* gen. et sp. nov. Ph. No. 146/24 (Holotype).
174. *Verticipollenites gibbosus* sp. nov., Ph. No. 106/36 (Holotype).
175, 176. *Verticipollenites*, Ph. Nos. 49/33, 131/28.

PLATE 13

177, 178. *Verticipollenites*, Ph. Nos. 67/29, 133/32 (sacci partly retouched).
179. *Striatites*, Ph. No. 142/12.
180. *Verticipollenites obloogas* sp. nov., Ph. No. 112/17 (Holotype).
181. *Lakhirites*, Ph. No. 143/14.
182. *Hindipollentes*, Ph. No. 61/23.
183. *Lakhirites*, Ph. No. 146/29 (sacci partly retouched).
184. *Platysaccus*., Ph. No. 13/17.
185. *Cuneatisporites* Ph. No. 57/4.
186. *Verticipollenites*, Ph. No. 132/22.
187. *Striatopodocarpites*, Ph. No. 129/33.
188. *Lakhirites*, Ph. No. 148/6.

PLATE 14

189-192. *Lunatisporites fuscus* sp. nov., Ph. Nos. 146/13, 14 (Holotype), 81/10, 7/17.
193-196. *Lunatisporites*, Ph. Nos. 59/12, 63/35, 73/9, 59/27.
197, 198. *Striatopodocarpites*, Ph. Nos. 48/30, 39/25.
199. *Lunatisporites*, Ph. No. 7/8.

PLATE 15

200-208. *Lunatisporites*, Ph. Nos. 108/2, 108/12, 146/11, 8/4, 7/22, 6 6/34, 108/22, 125/25, 26

PLATE 16

209-217. *Lunatisporites*, Ph. Nos. 126/14, 106/27, 107/21, 62/6, 65/10, 146/12, 125/19, 88/33, 142/22.

PLATE 17

218, 219. *Lunatisporites*, Ph. Nos. 7/6, 7/9.
220-228. *Faunipollentes*, Ph. Nos. 146/15, 49/34, 146/16, 53/28, 57/19, 57/11, 128/20, 128/18, 131/29.

PLATE 18

230. *Faunipollenites varius* gen. et sp. nov., Ph. No. 113 (Holotype).
229, 231-234. *Faunipollentes*, Ph. Nos. 23/5, 32/17, 128/33, 83/24, 115/11.
235,-237. *Striatopodocarpites*, Ph. Nos. 59/23, 146/10, 61/11.

PLATE 19

239-241, 246. *Kosankeisporites*, Ph. Nos. 112/11, 60/8, 62/13, 111.
238, 242, 245. *Striatopodocarpites*, Ph. Nos. 120/2, 120/29, 6/4.
243, 244, 247-248. cf. *Striatopodocarpites*, Ph. Nos. 107/9, 118/19, 106/19, 55/2.
249-251. *Sulcatisporites ovatus* (Balme & Henn.) comb. nov., Ph. Nos. 118, 109/12, 87/3.
252, 253. *Sulcatisporites*, Ph. Nos. 125/6, 125/4.

PLATE 20

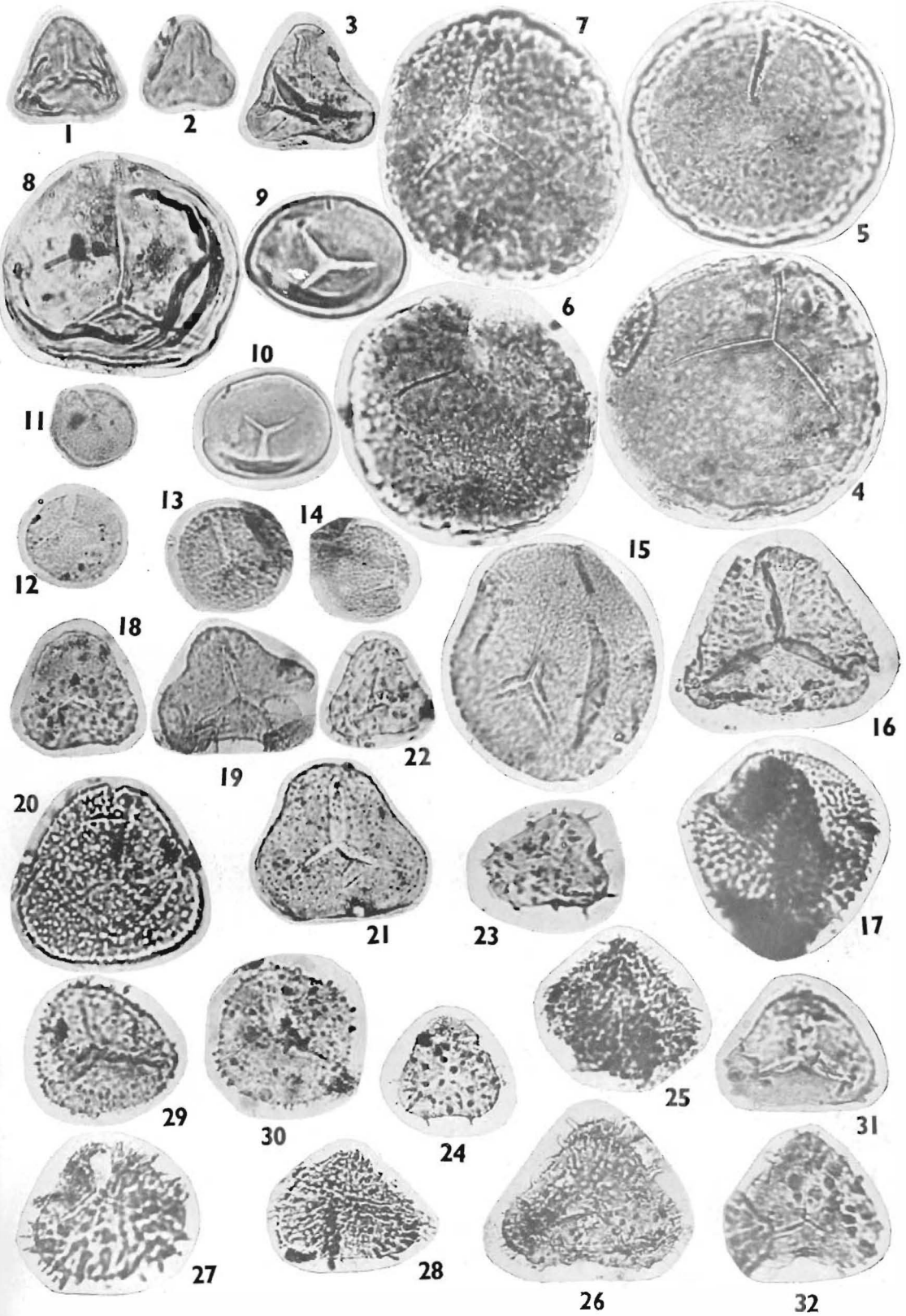
254-259. *Sulcatisporites*, Ph. Nos. 119, 8/5, 11/27, 92/13, 78/10, 77/30.
260, 261. *Vesicaspora*, Ph. Nos. 92/7, 61/20.
262-264. *Cuneatisporites*, Ph. Nos. 62/14, 7/19, 132/1.

PLATE 21

265-269. *Vesicaspora*, Ph. Nos. 13/22, 59/24, 61/8, 118/21, 84/4.
270. *Tumoripollenites bacculatus* sp. nov., Ph. No. 105 (Holotype).
271, 272. *Tumoripollenites*, Ph. Nos. 64/18, 106/26.
273-275. *Striapollenites saccatus* gen. et sp. nov., Ph. Nos. 129/21 (Holotype), 133/13, 129/2.

PLATE 22

276-280. *Striapollenites*, Ph. Nos. 132/3, 64/14, 11/31, 126/29, 128/8.
281-285. *Distriatites bilateris* gen. et sp. nov., Ph. Nos. 146/3, 5 (Holotype), 146/6, 7, 78/33.
286. *Distriatites*, Ph. No. 148/8.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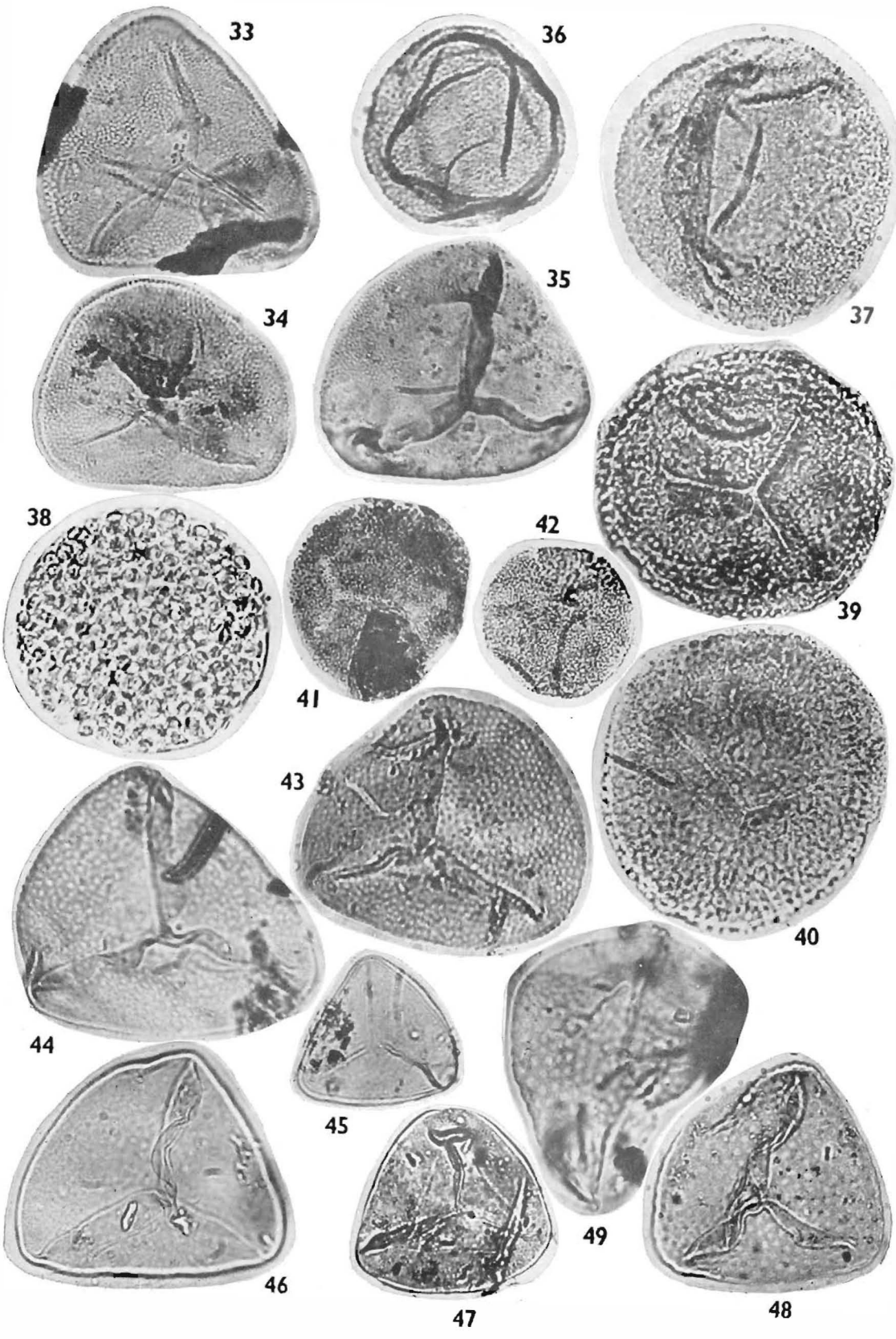
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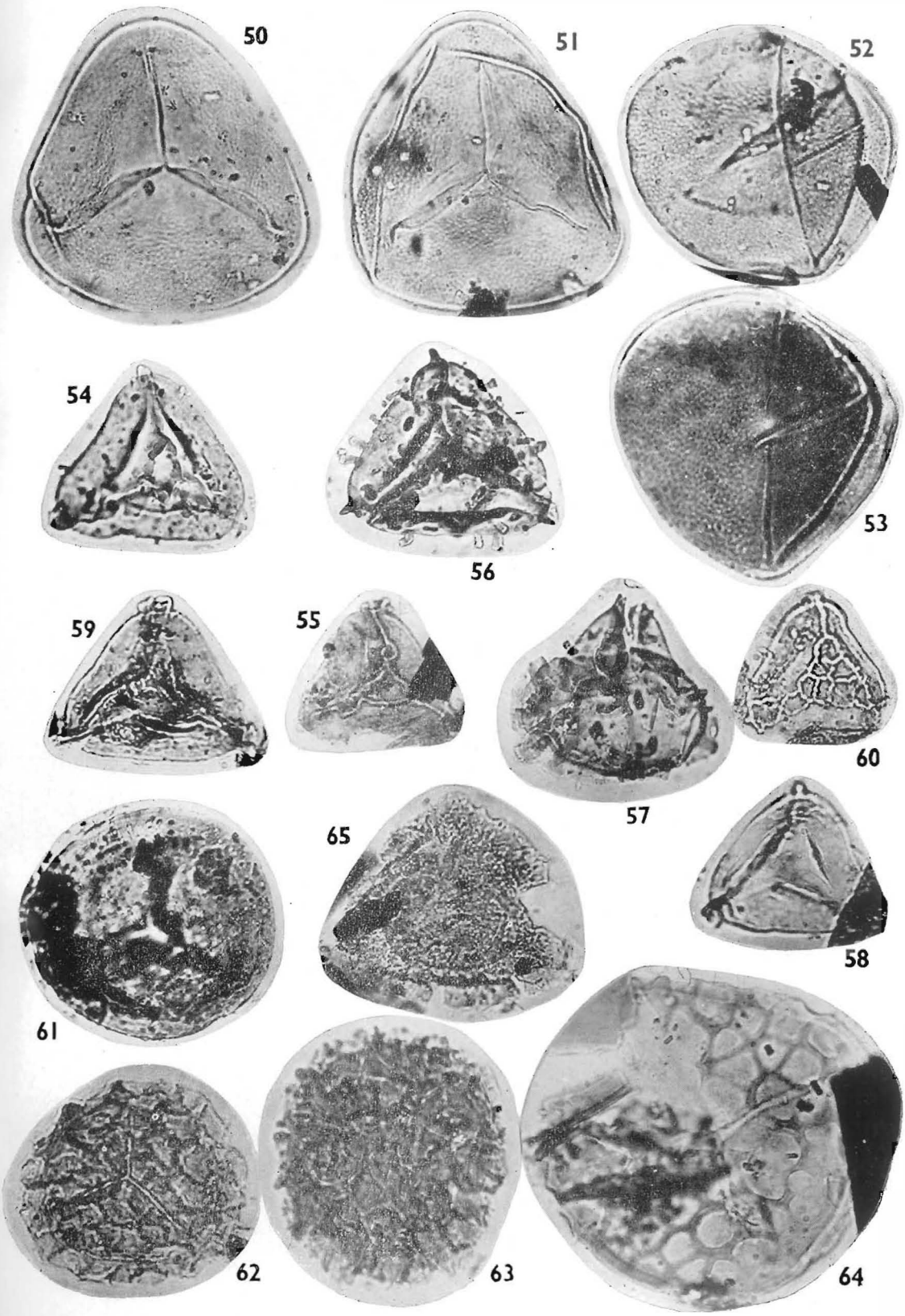
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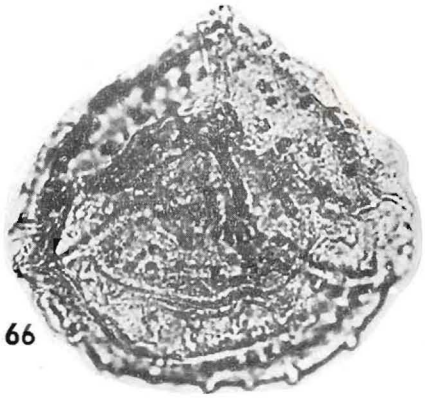
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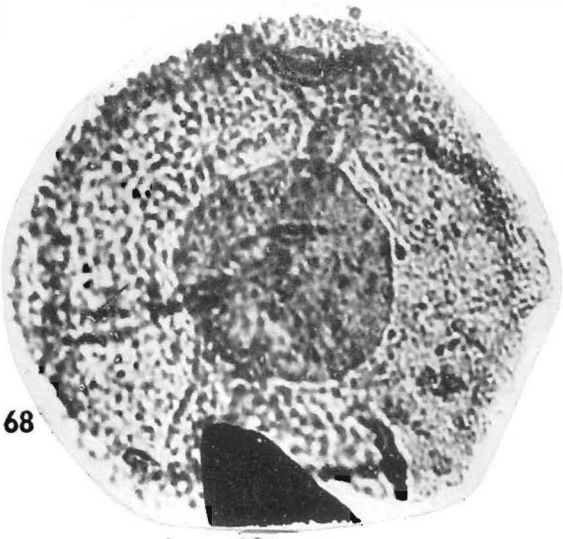
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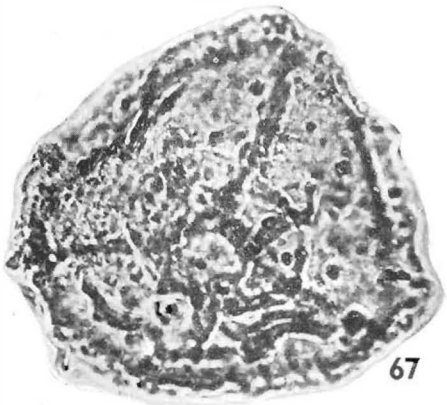
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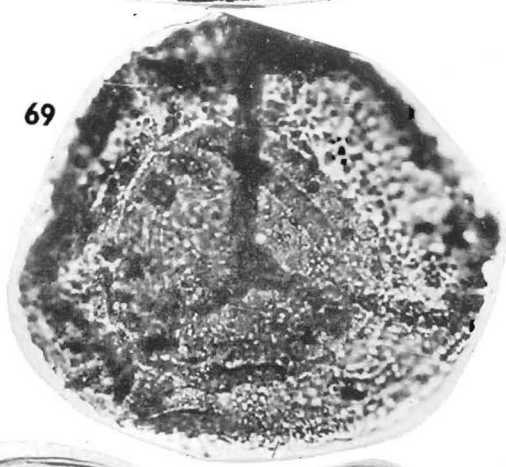
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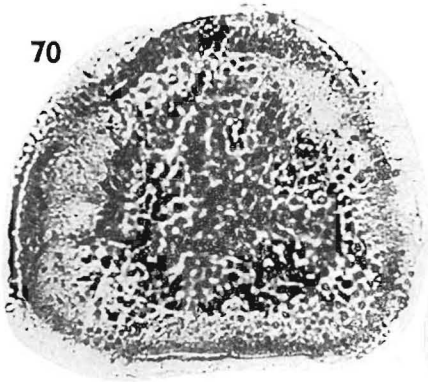
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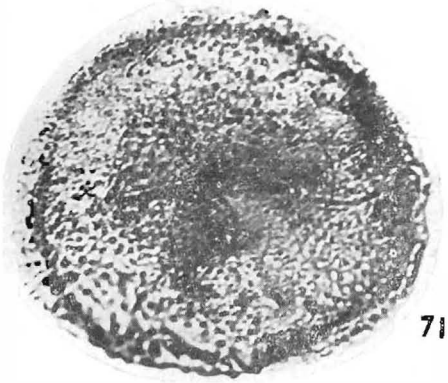
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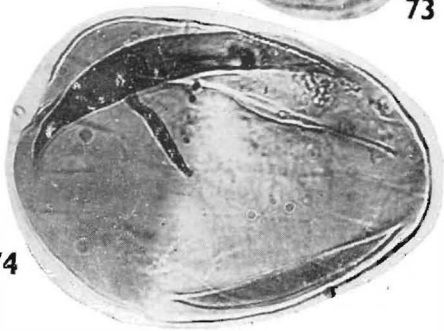
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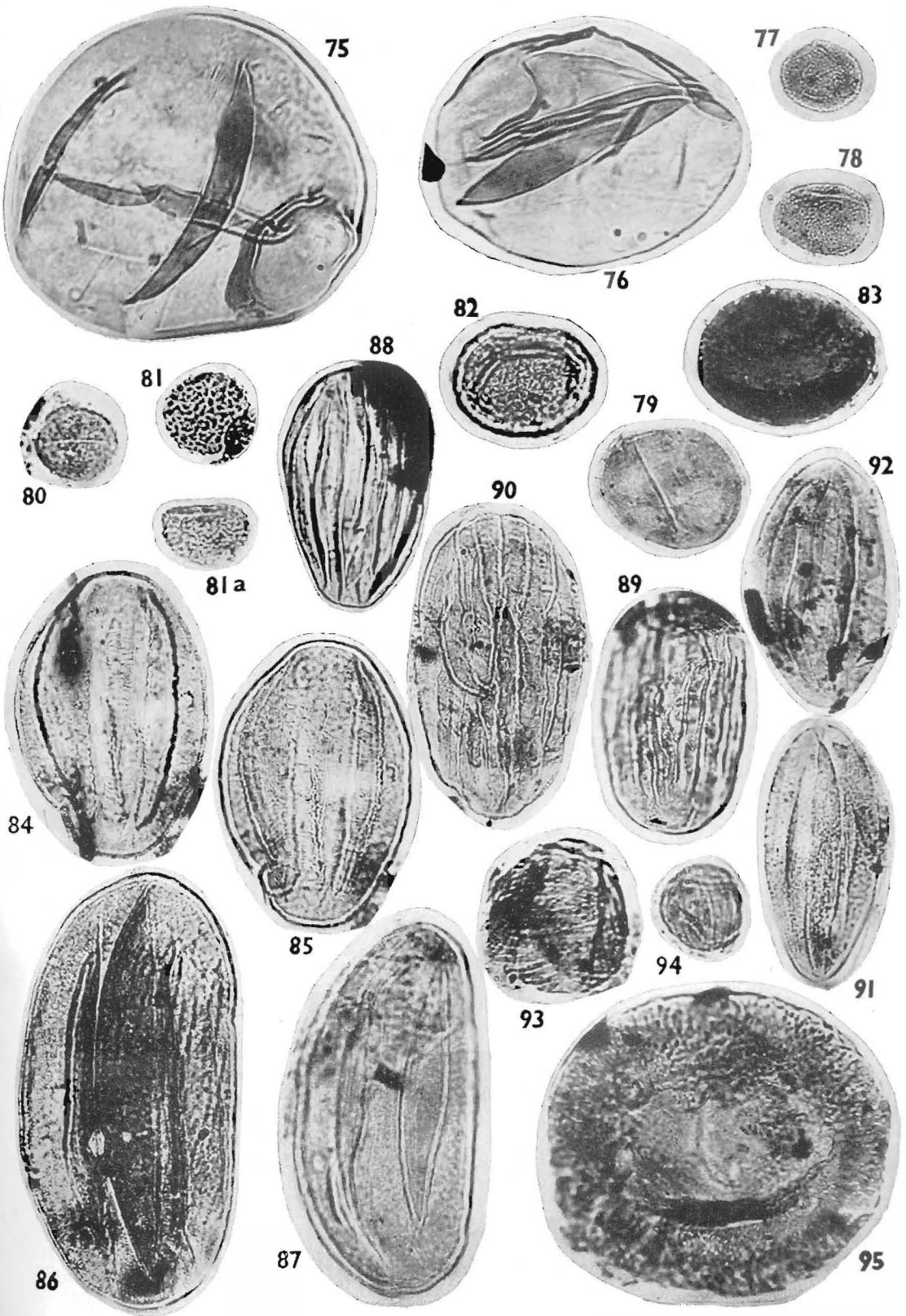
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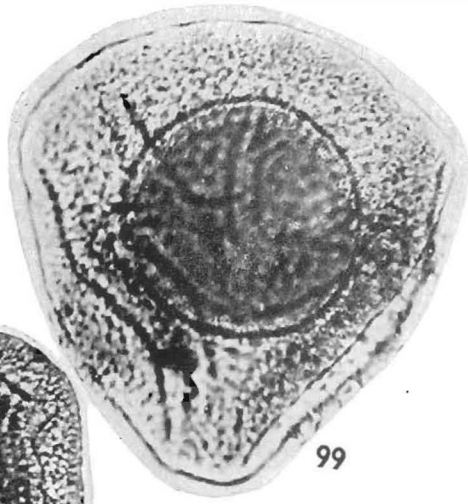

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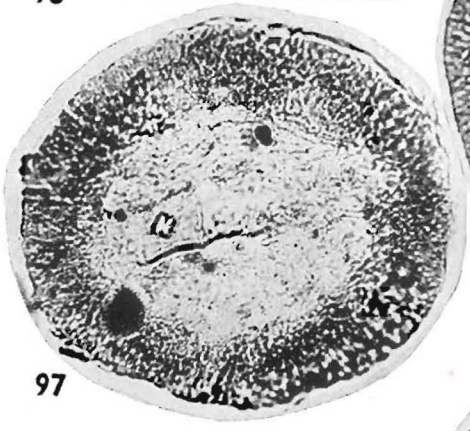

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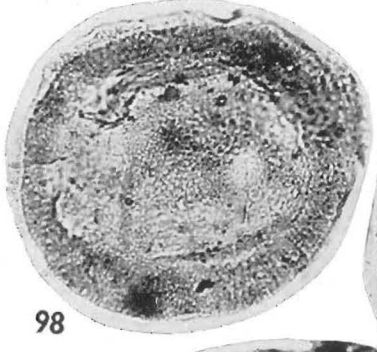

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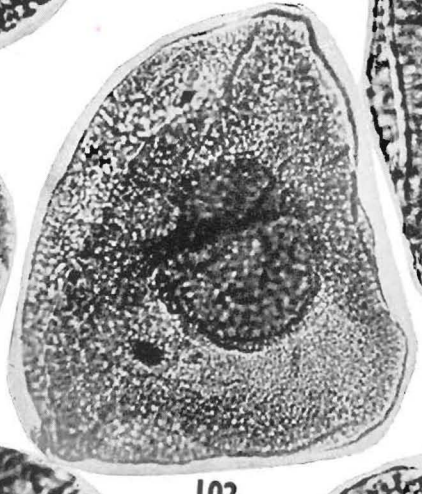

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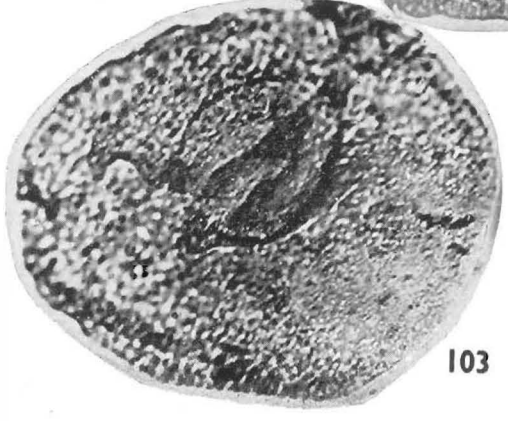

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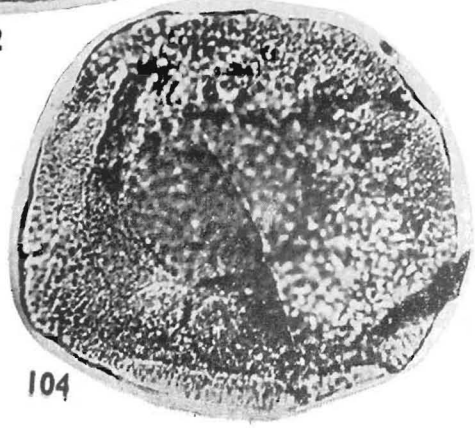

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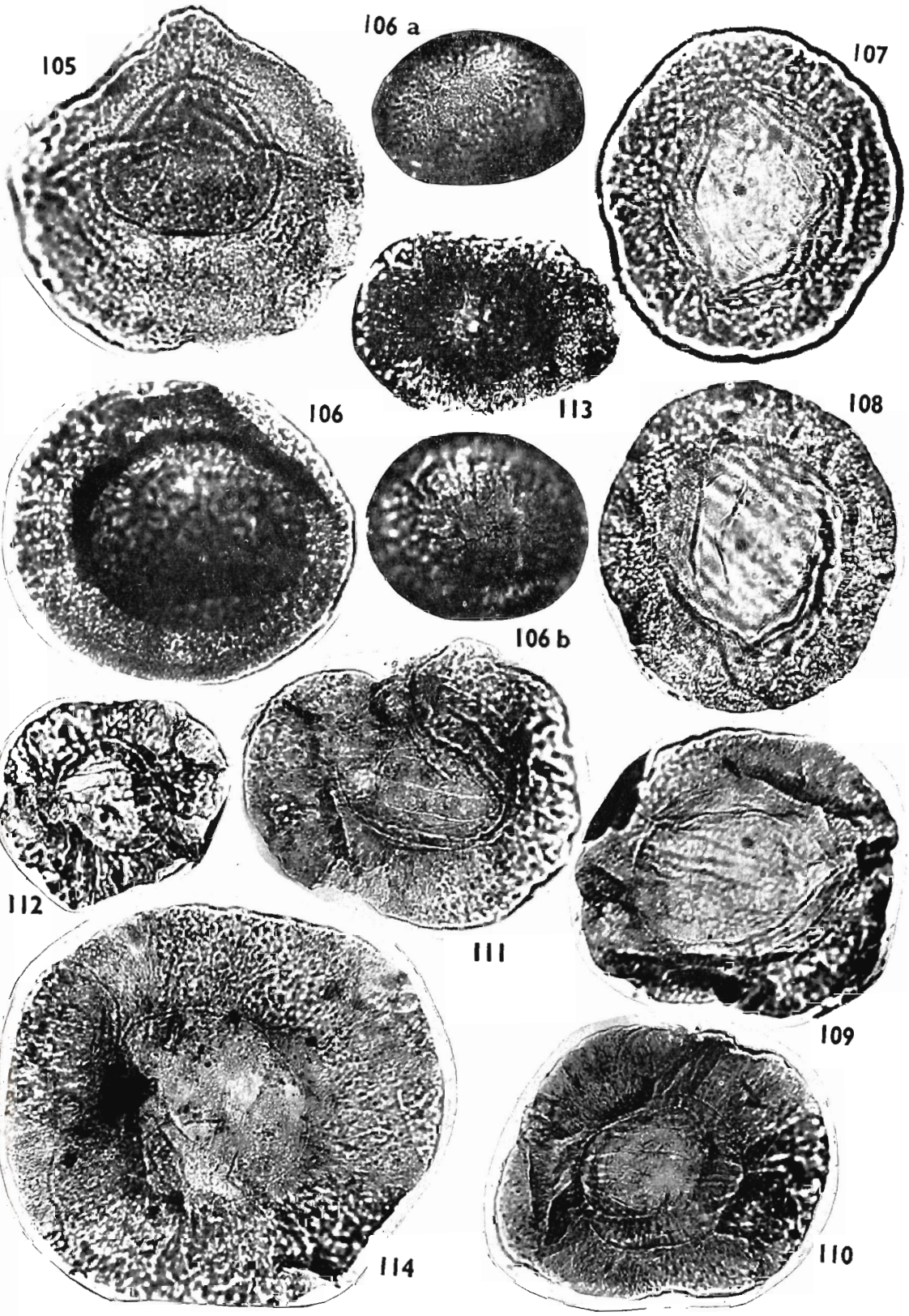
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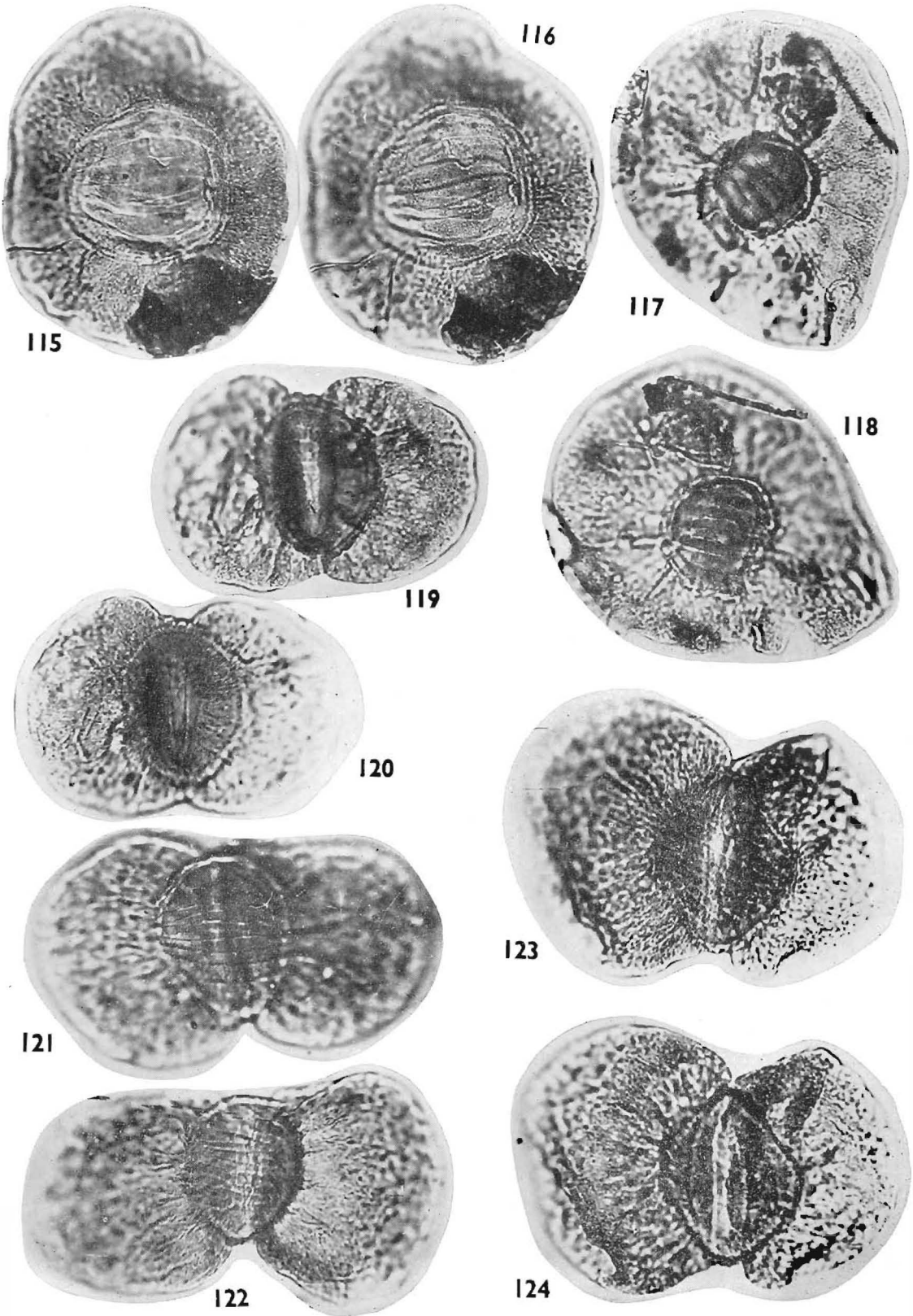
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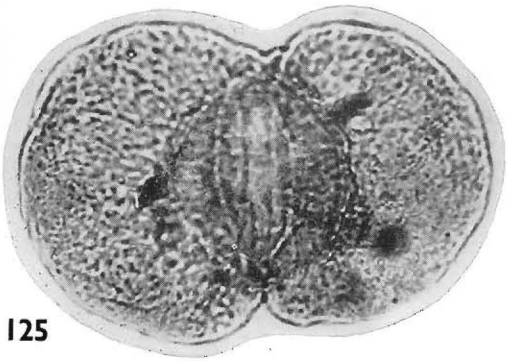
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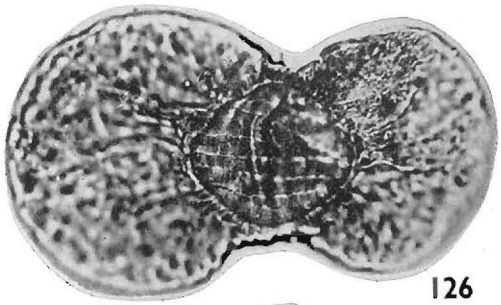
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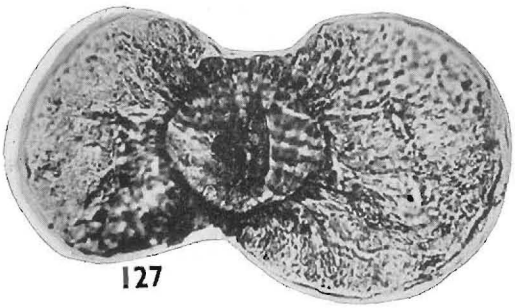
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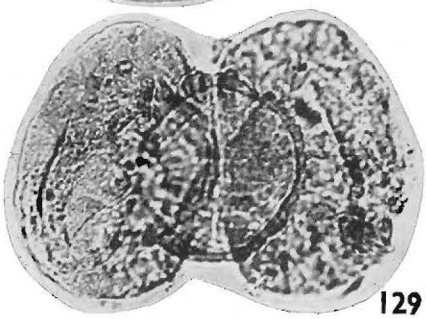
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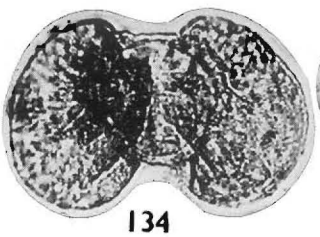
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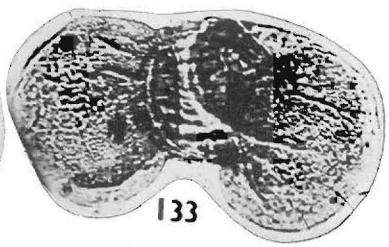
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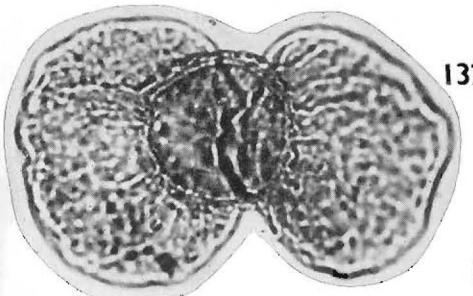
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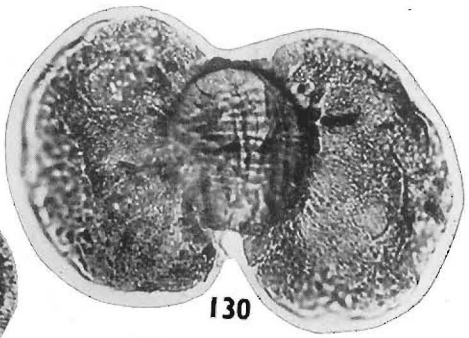
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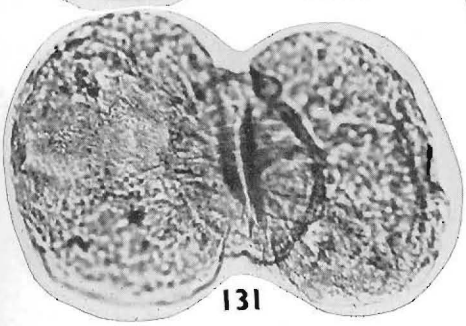
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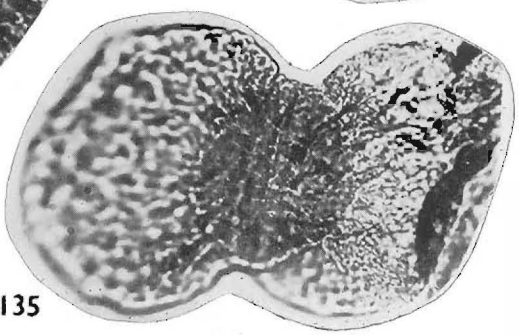
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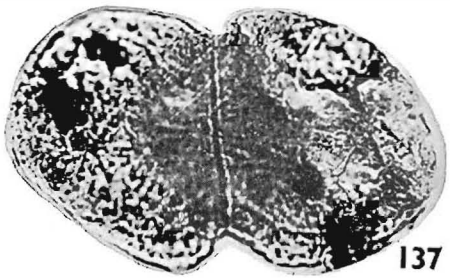
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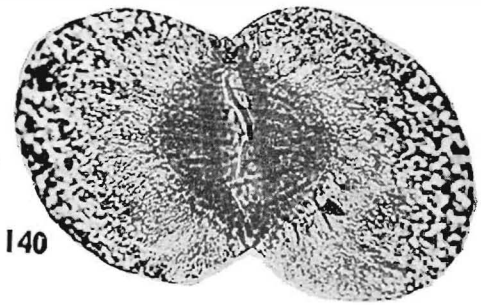
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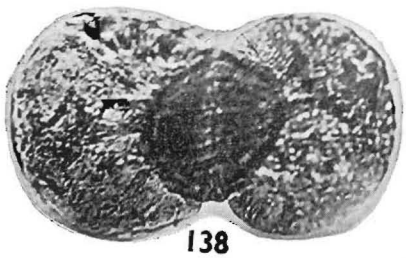
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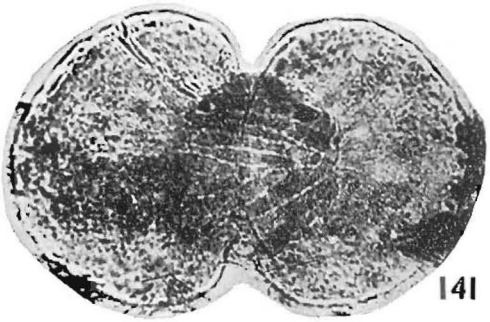
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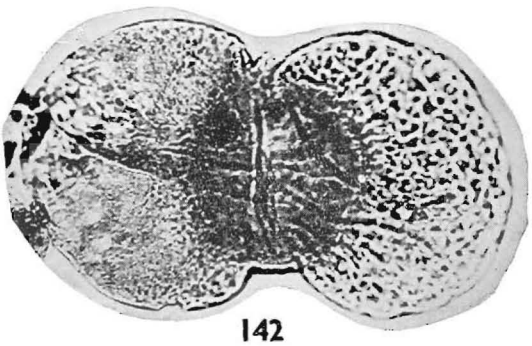
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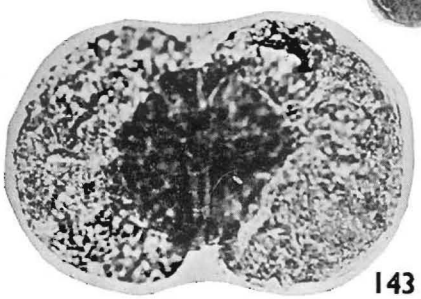
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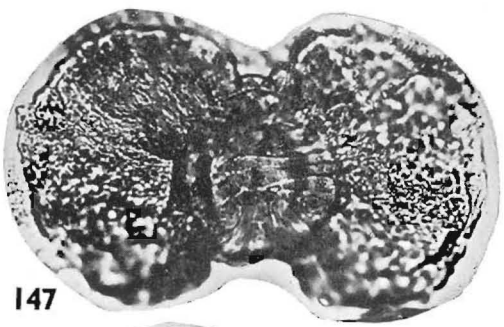
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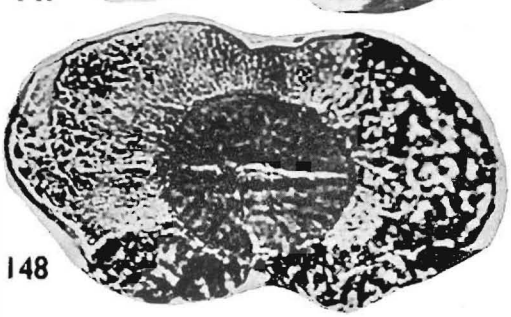
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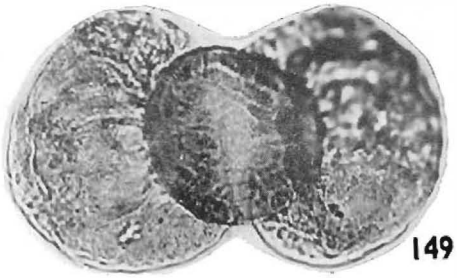
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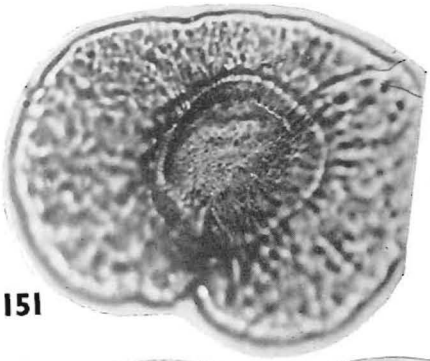
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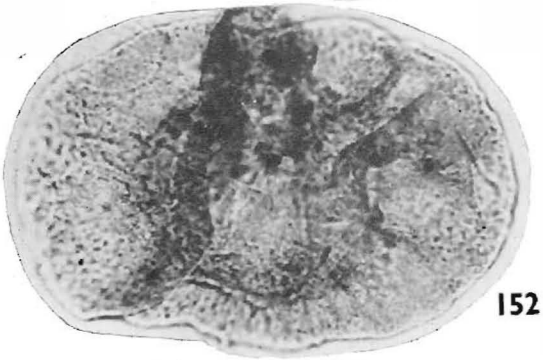
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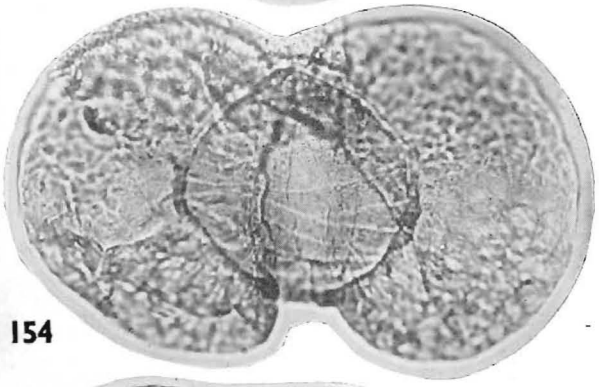
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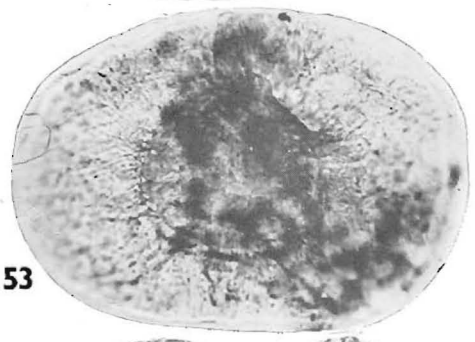
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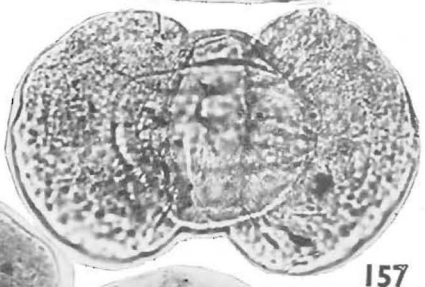
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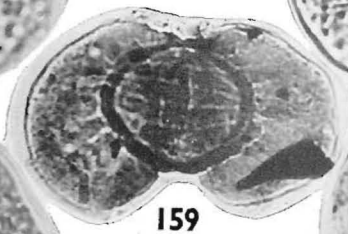
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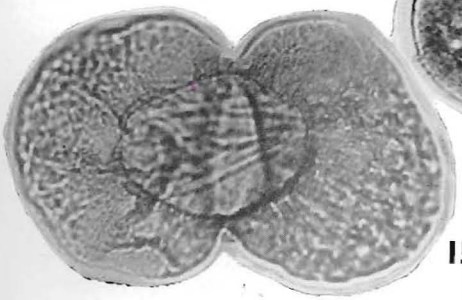
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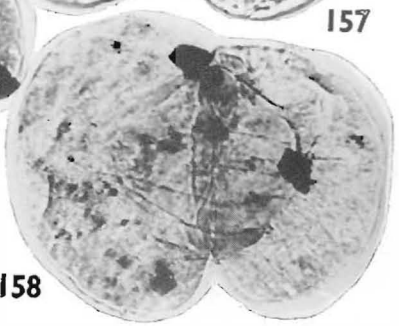
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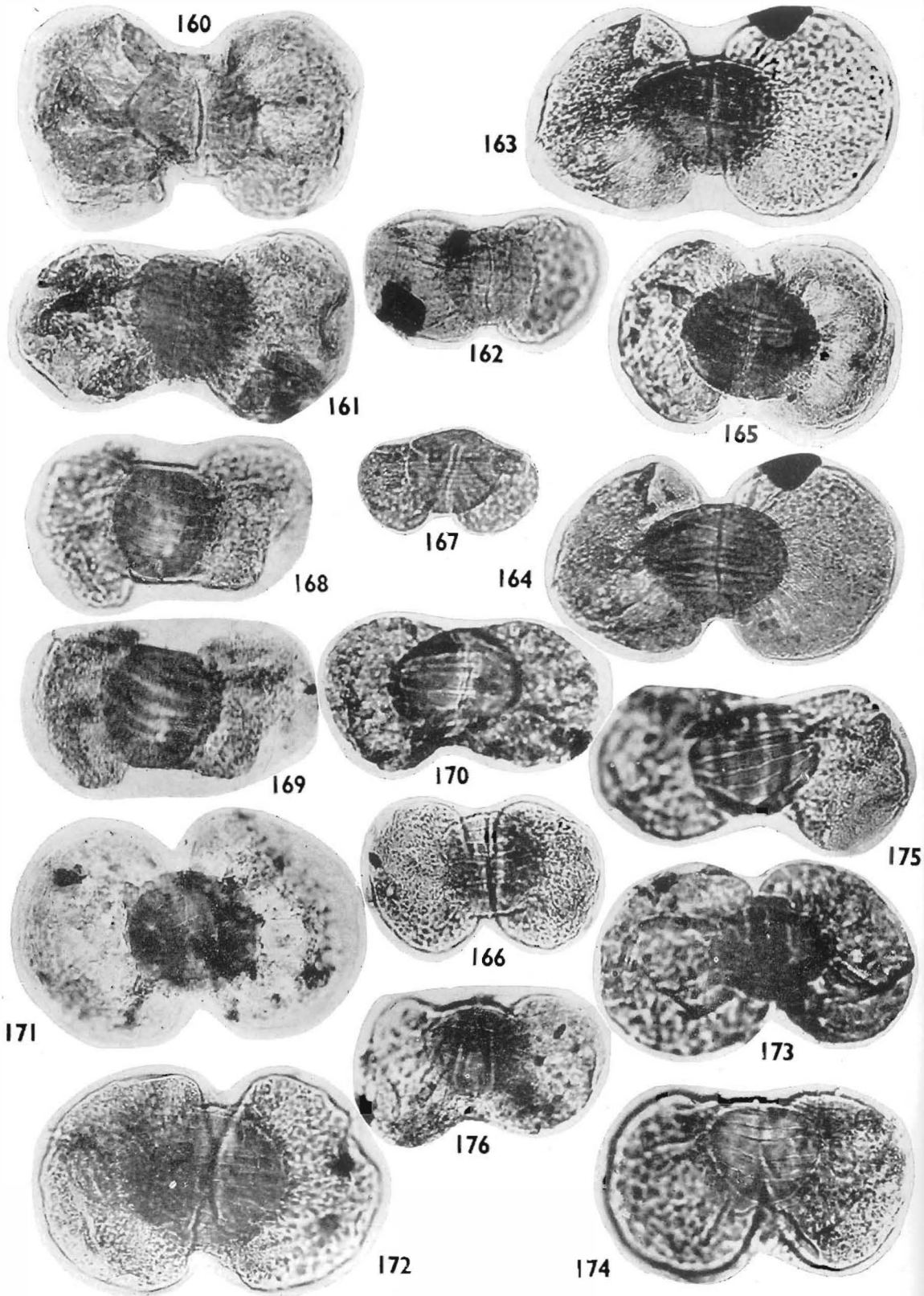
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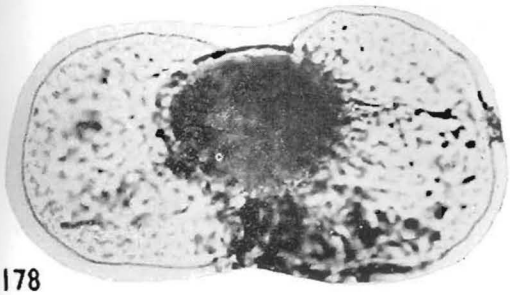
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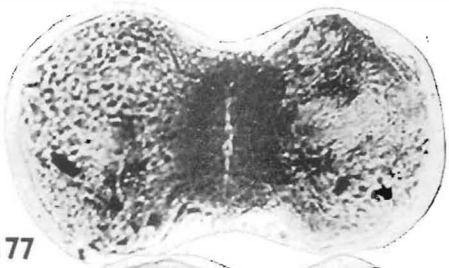
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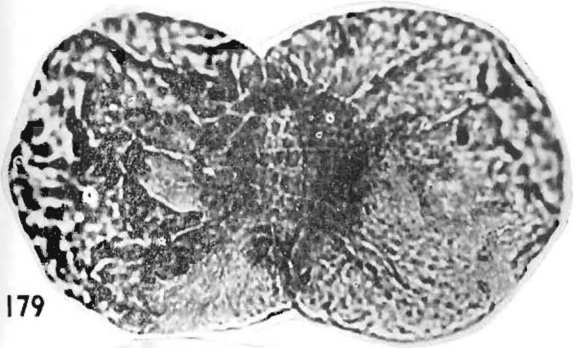
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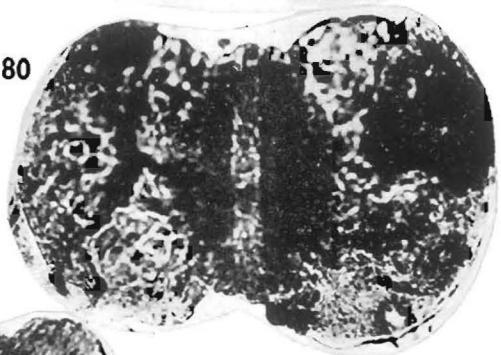
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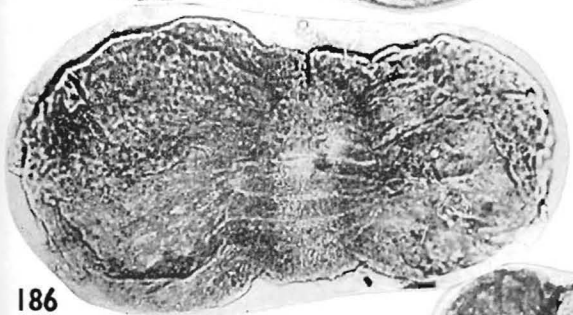
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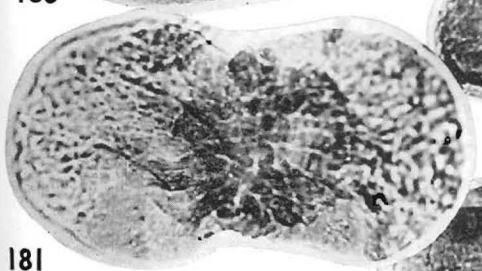
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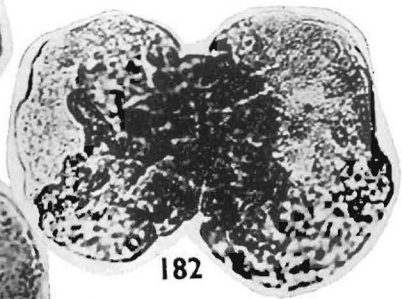
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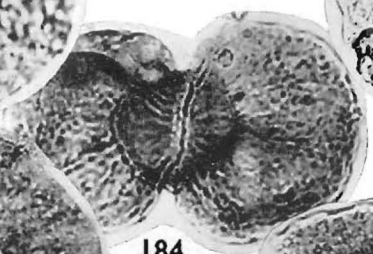
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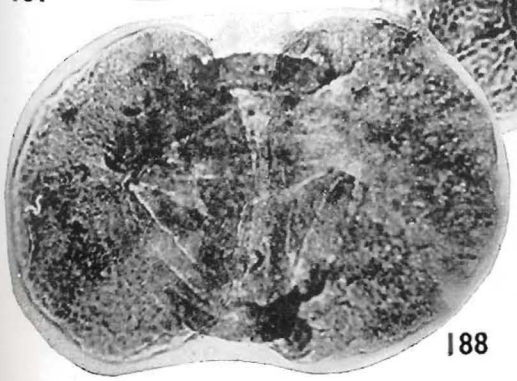
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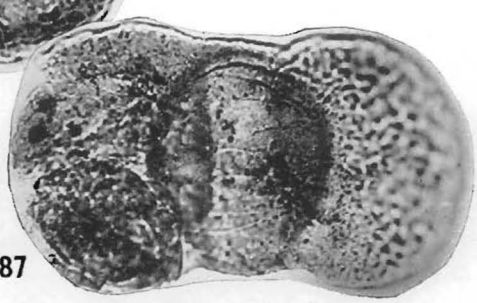
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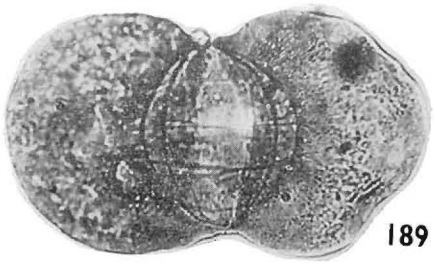
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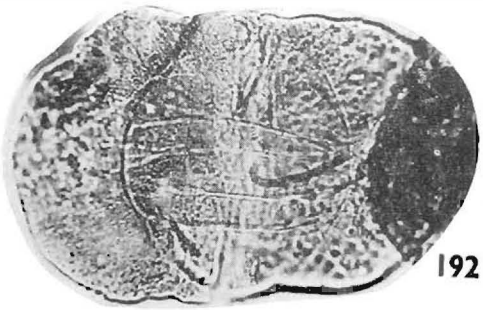
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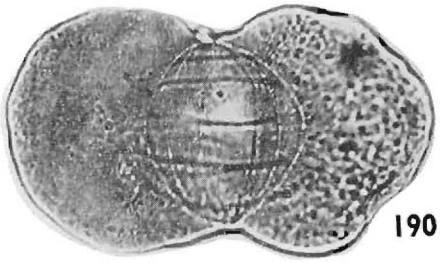
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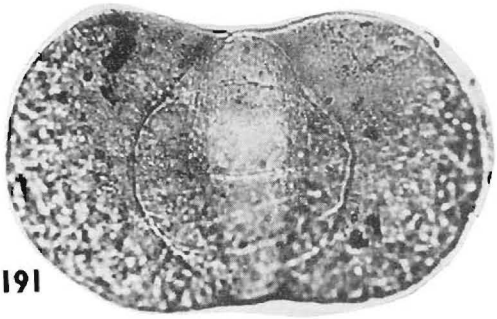
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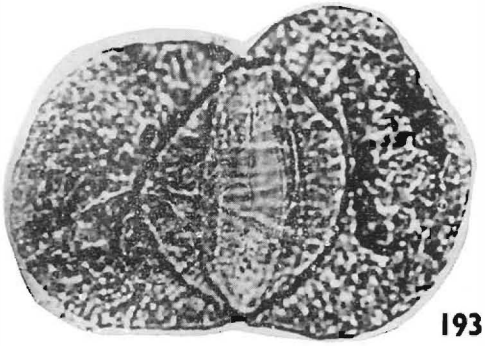
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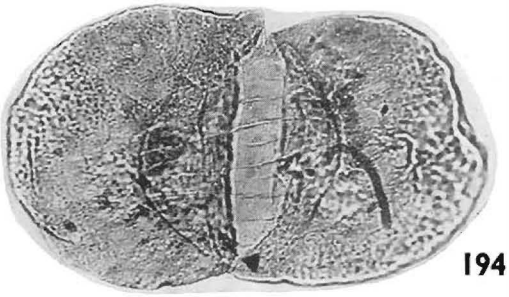
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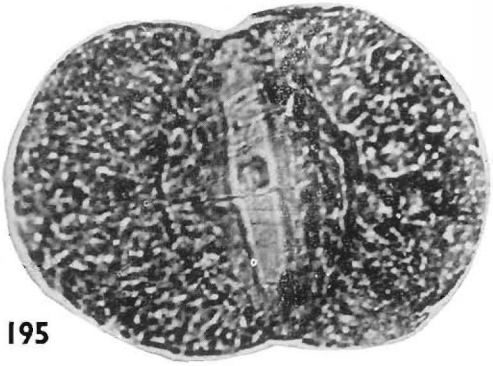
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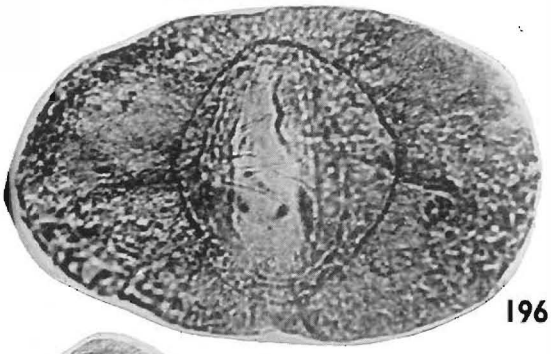
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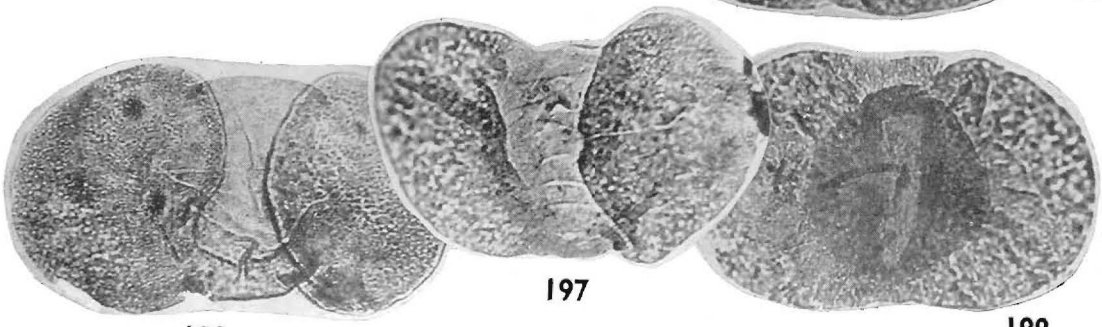
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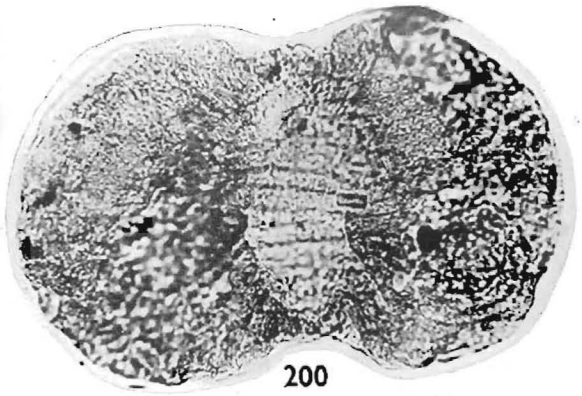
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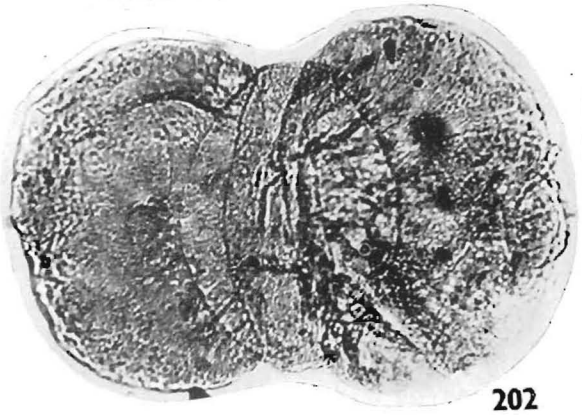
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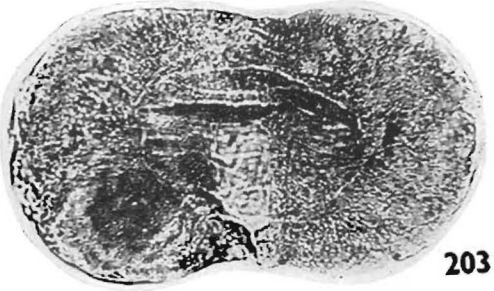
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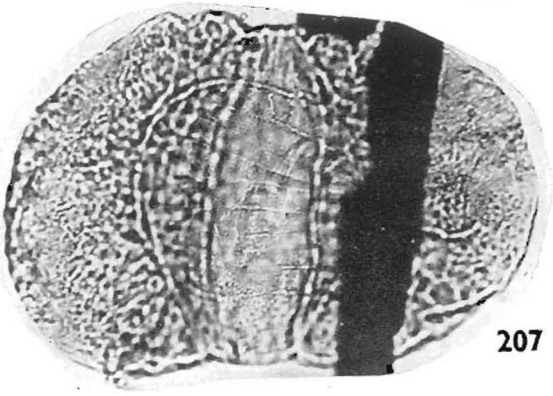
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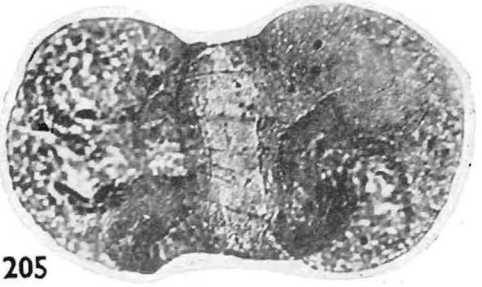
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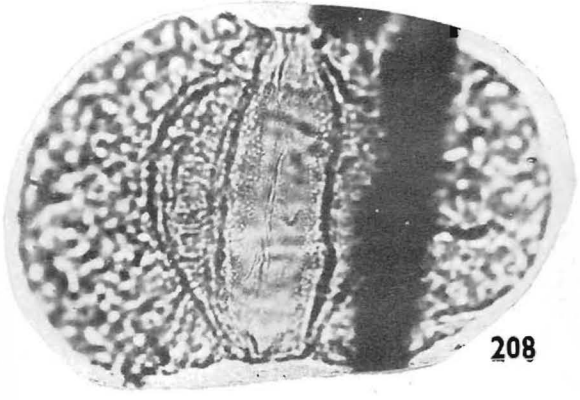
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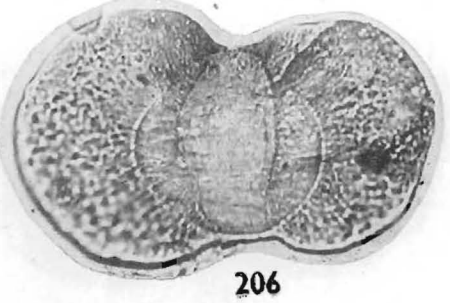
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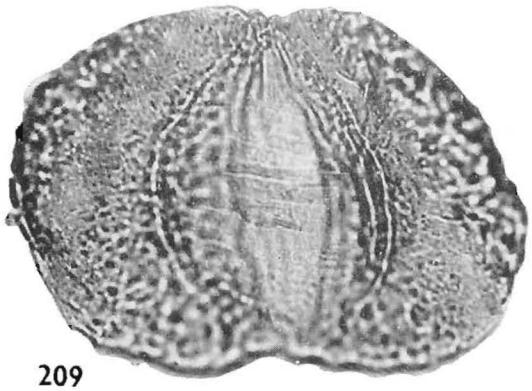

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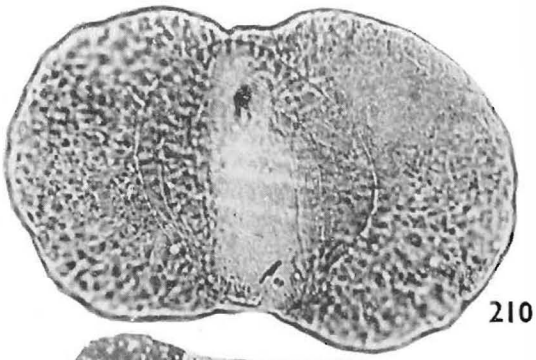

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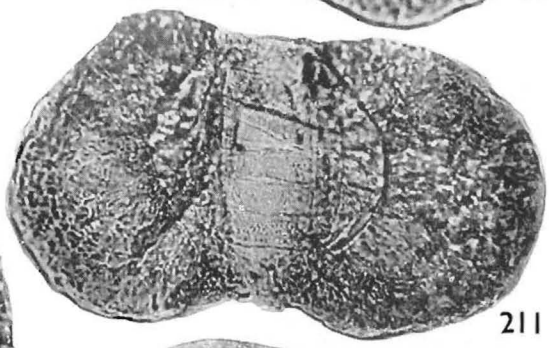

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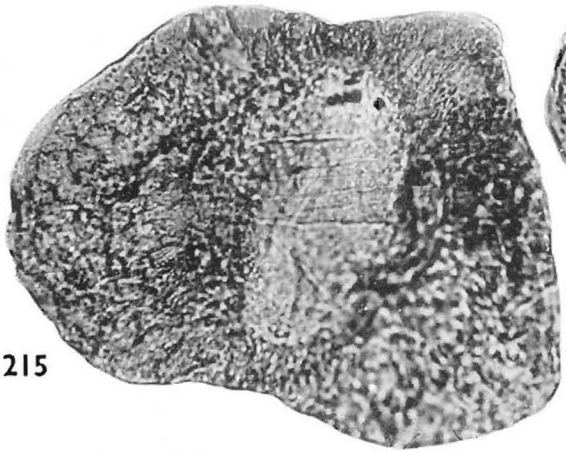

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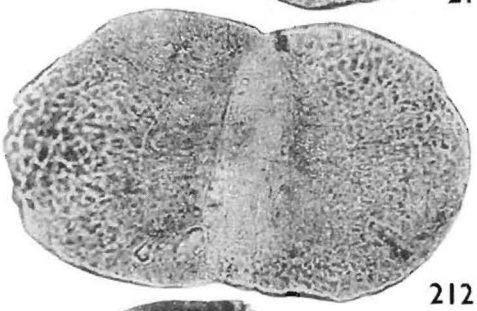

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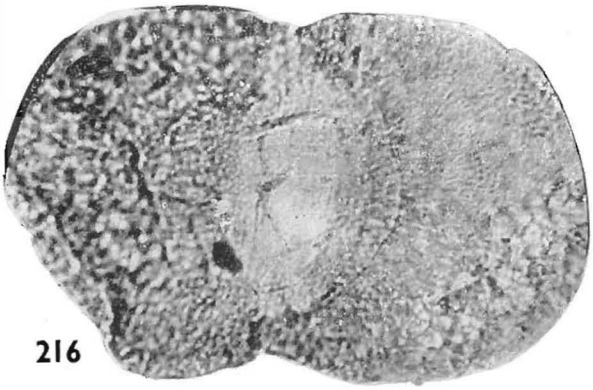

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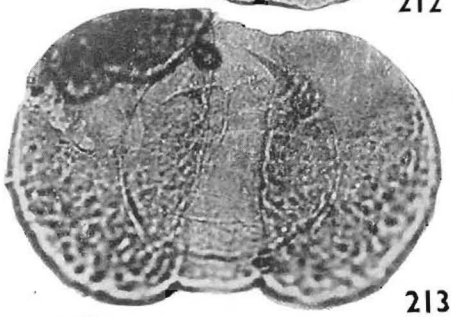

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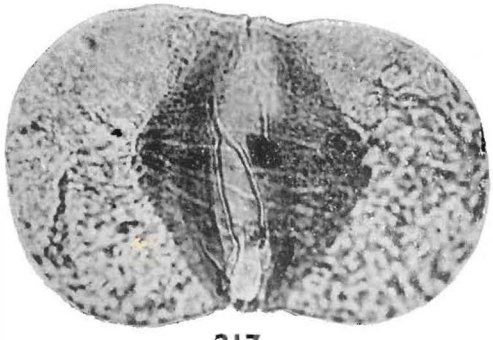

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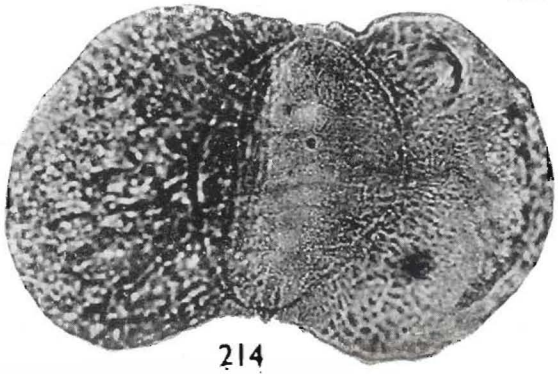

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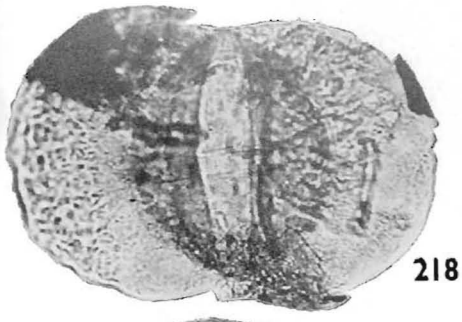
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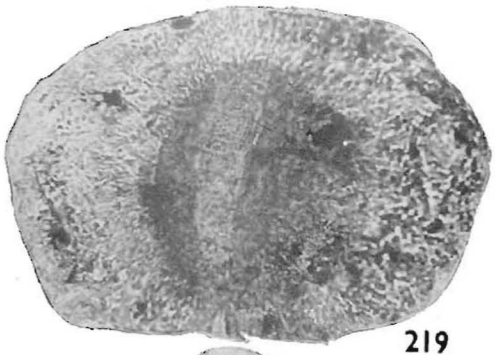
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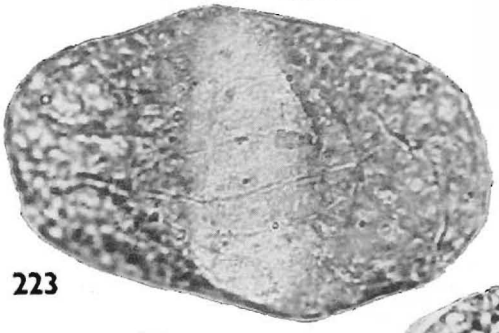
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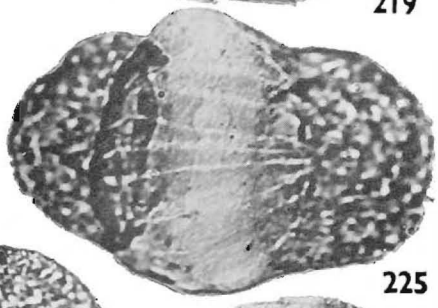
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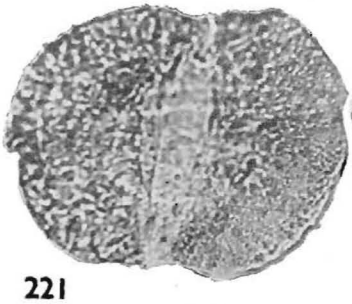
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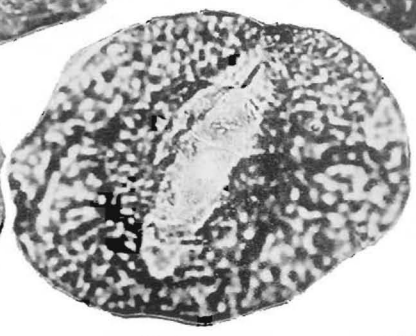
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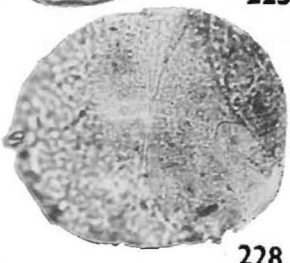
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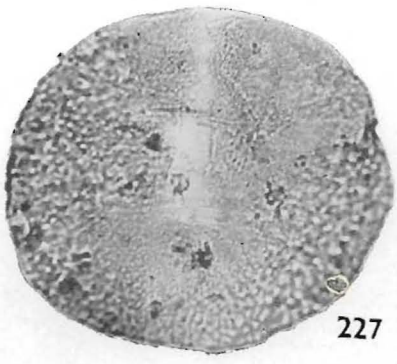
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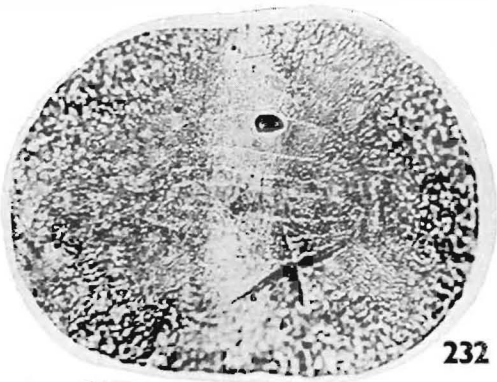

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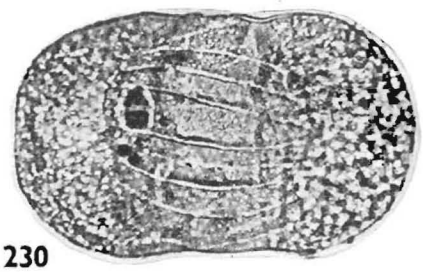

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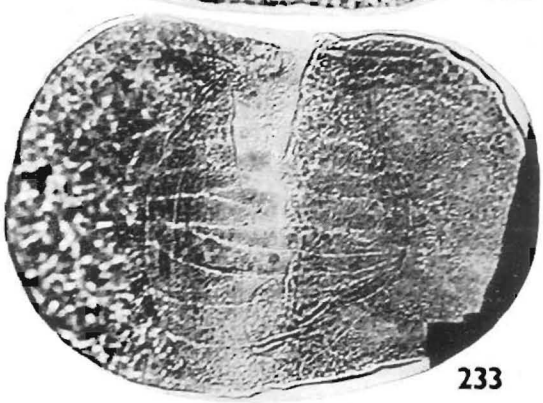

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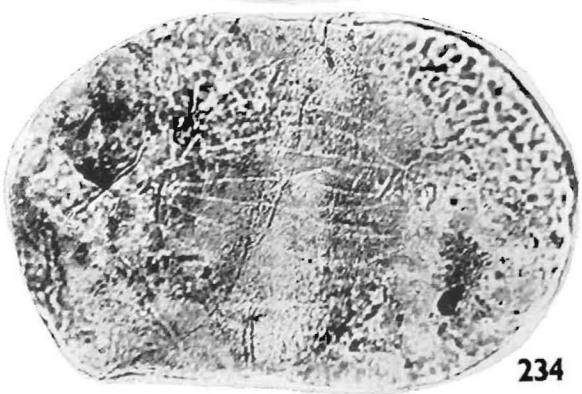

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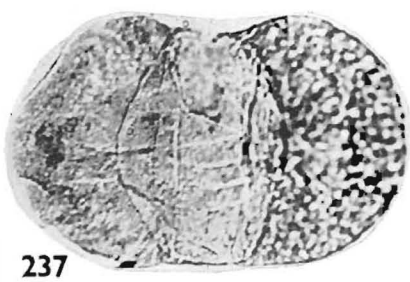

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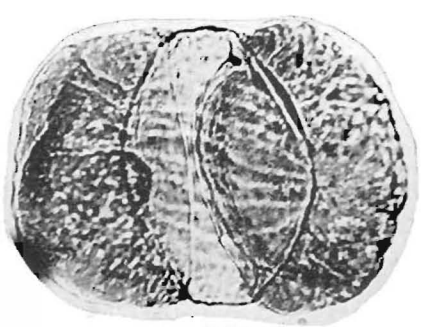

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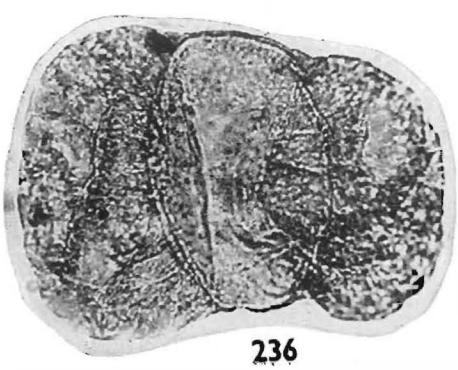

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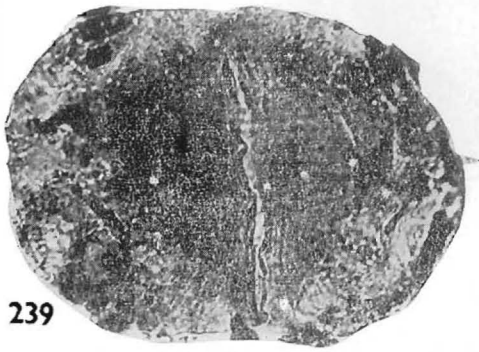
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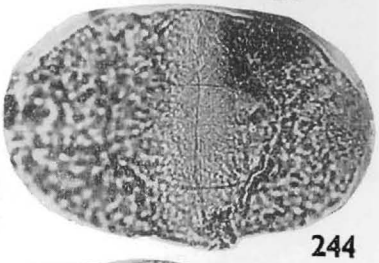
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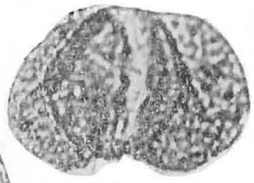
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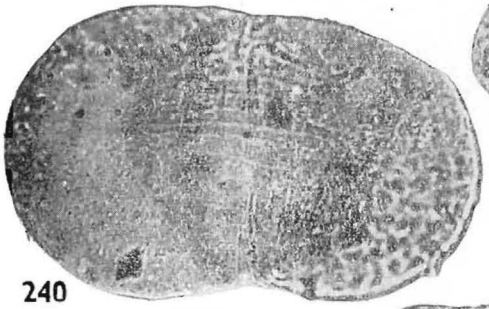
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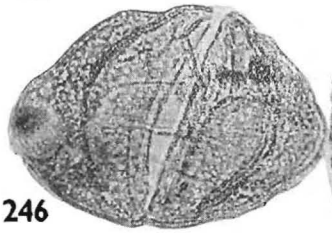
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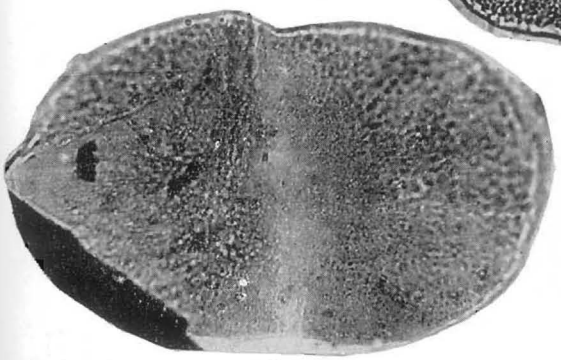
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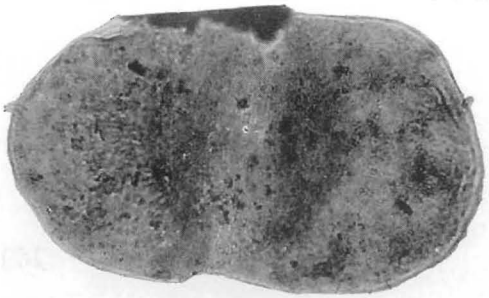
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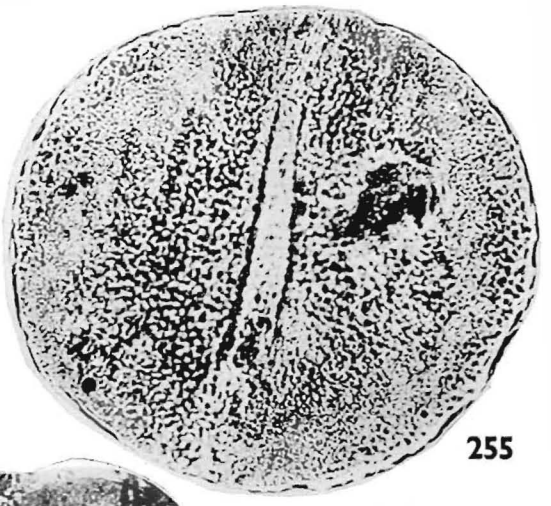
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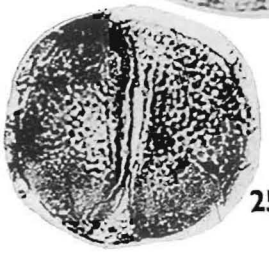
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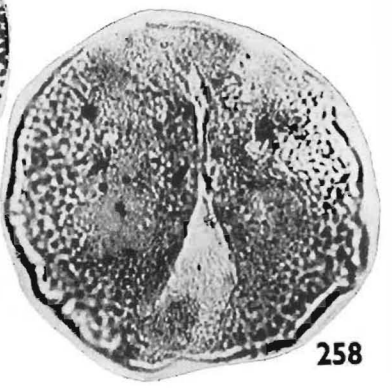
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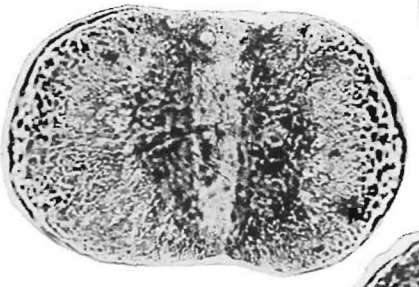
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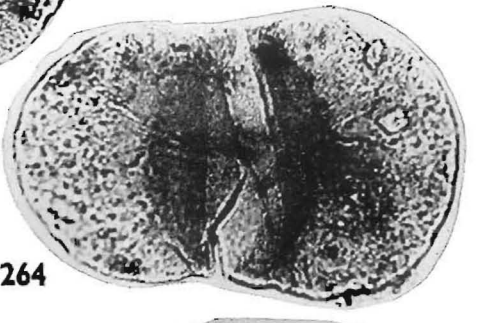
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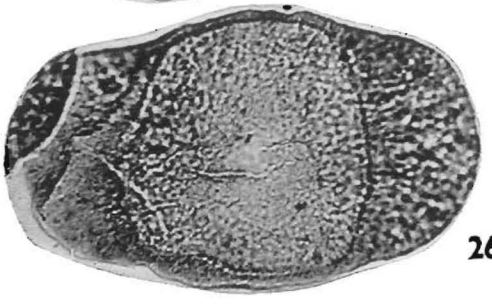
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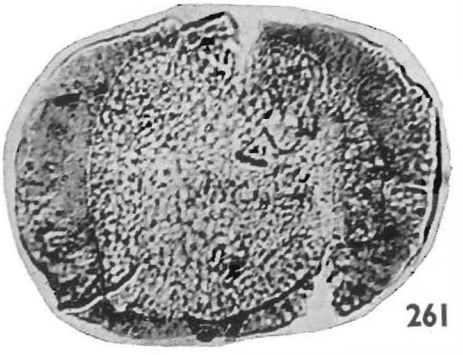
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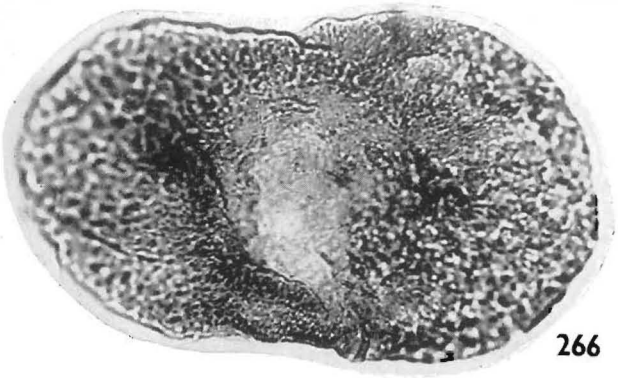
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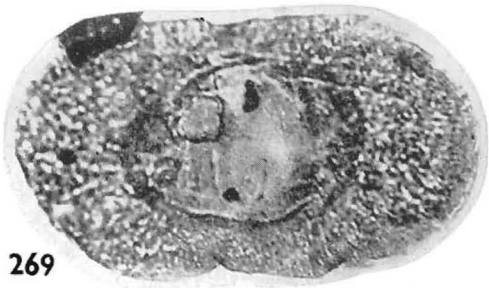
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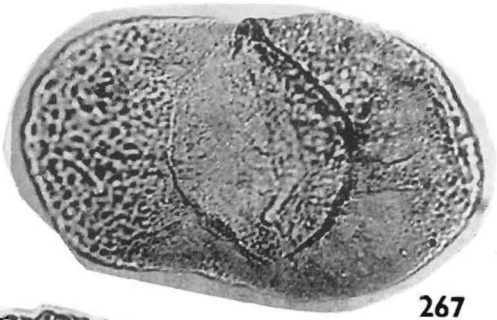
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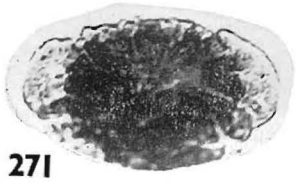
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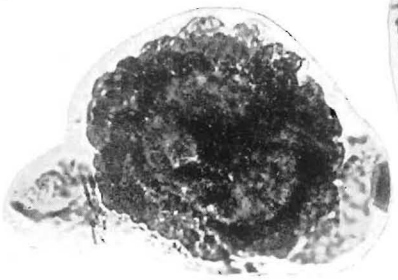
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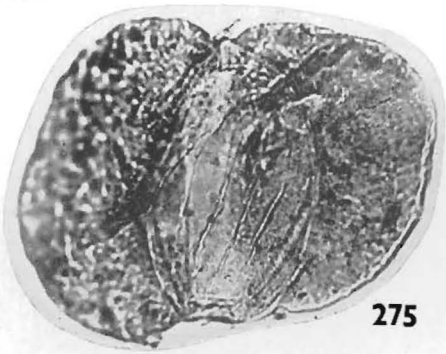
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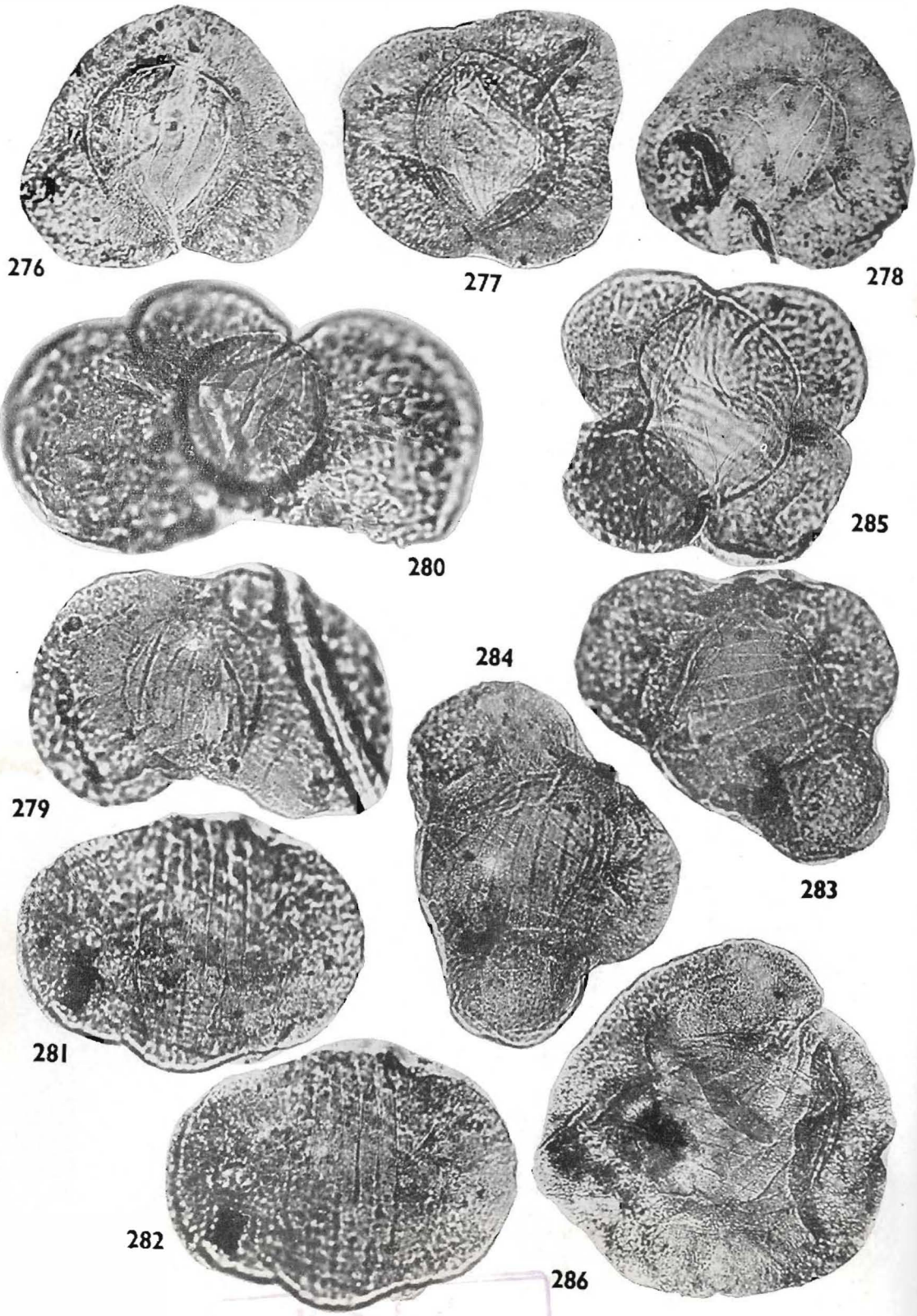
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