PALYNOLOGY OF THE BARREN MEASURES SEQUENCE FROM JHARIA COALFIELD, BIHAR, INDIA. 2. GENERAL PALYNOLOGY

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ABSTRACT

The present paper deals with the palynological studies of the Barren Measures Succession of Jharia Coalfield through a bore-core of 3926 ft. The spores and pollen grains obtained from the material have been placed into 38 genera. The striated bisaccate pollen grains are dominating in the present preparation. The assemblage has also been compared with the various stages of the Lower Gondwana of India. A conclusion has also been drawn regarding the paucity of the spores and pollen in the Barren Measures Succession.

INTRODUCTION

THE Permian palynological assemblage of the Lower Gondwana of India have been studied by quite a good number of workers. Virkki (1937, 1939, 1946); Sen (1944); Ghosh and Sen (1948); Goswami (1952, 1956); Surange, Prem Singh and Srivastava (1953a, 1963b); Datta (1957); Bhattacharya, Raychowdhury and Datta (1957); Banerjee (1958); Das (1958); Bharadwaj (1962); Bharadwaj and Salujha (1964, 1965a, 1965b); Bharadwaj and Tiwari (1964a, 1964b); Tiwari (1964, 1965); Venkatachala and Kar (1964a, 1964b, 1965) and others have contributed to the knowledge of Permian Palynology from the Barakar (Lower Permian) and the Raniganj (Upper Permian) Stages of the Damuda Series of the Lower Gondwana, India. Palynological studies of the Barren Measures Succession have also recently done by Bharadwaj, Sah and Tiwari (1965); Kar (1966) and Venkatachala and Kar (1966).

The present paper deals with the palynological studies of the Barren Measures Succession of the Jharia Coalfield through a bore-hole-core (No. J.K. 5) of 3926 ft., kindly supplied by the Geological Survey of India. The location of the bore-hole is 23°44′ N: 86°19′28″ E, sheet No. 4, Jharia Coalfield, district Dhanbad, Bihar.

General Geology — The relative position of the Barren Measures Succession is as follows:

Lower Gondwana	Damuda Series	Raniganj Stage Barren Measures Succession Barakar Stage

Fox (1930) subdivided the Barren Measures Succession as:

Barren Measures

4. Mahuda sandstone
3. Hariharpur shales
2. Petia sandstone
1. Shibbabudih shales

Blanford (1861) referred Barren Measures Succession as Ironstone Shales for the richness of iron in this Succession. He, however, excluded Mahuda sandstone from this and included it in the Raniganj Stage.

Gee (1932) restricted Barren Measures Succession to Hariharpur shales only. He included Petia sandstones and Shibbabudih shales into Barakar and Mahuda sandstone into Raniganj Stages.

Lithology of the bore-core — The information about the core as supplied by the Geological Survey of India is as follows:

G.S.I. Borehole No. J.K. 5

Location — 23°44′N: 86°19′28″E
Sheet No.—4 Jharia Coalfield
District — Dhanbad, Bihar.
(For the core-chart *see* KAR, 1966)

Maceration technique — In total 629 samples were macerated and out of these only 28 samples yielded spores and pollen grains. The samples were taken from the entire core at an interval of approximate 5 ft. Some parts of the core, however, lost in transit. The samples that yielded are mostly confined to the upper part of the core and after the depth of 1550 ft. all the samples turned barren or yielded negligibly.

The carbonaceous samples were first treated with commercial Nitric acid for few days. When the maceration was complete it was treated with 5 per cent Potassium

hydroxide solution. The arenaceous and argillaceous samples were treated first with Hydrofluoric acid (40 per cent) for 24 hours. After washing the material several times it was also treated with 5 per cent Potassium hydroxide solution. Acetolysis (after ERDTMAN, 1952) was also done when felt necessary. The slides were prepared in glycerine jelly. The type locality of all the specimens described here is Jharia Coalfield, Bihar; bore-hole No. J.K. 5, Barren Measures (Permian).

SYSTEMATIC PALYNOLOGY

Anteturma —*Sporites* H. Potonié, 1893
Turma — *Triletes* (Reinsch) Potonié & Kremp, 1954
Subturma — *Azonotriletes* Luber, 1935
Infraturma—*Laevigati* (Bennie & Kidston) Potonié, 1956

***Leiotriletes* (Naumova) Potonié & Kremp, 1954**

Type Species — *Leiotriletes sphaerotriangulatus* (Loose) Potonié & Kremp, 1954.

Leiotriletes erectus sp. nov.

Pl. 1, Figs. 1-2

Holotype — Pl. 1, Fig. 1. Size 33 μ. Slide No. 2158.

Diagnosis — Spores triangular, 25-33 μ, margins straight to slightly convex. Trilete mark prominent, rays extending up to equator; exine uniformly thick, laevigate.

Description — Spores triangular in polar view with broadly rounded apices. Trilete mark distinct, rays thin; commissure well defined. Exine laevigate, less than 1 μ thick; folds in the apical area generally present.

Comparison — *Leiotriletes erectus* shows some similarity in form to *Microfoveolatispora* (*Leiotriletes*) *directa* (Balme & Hennelly) Bharadwaj (1962) described from the Permian sediments of Australia. *L. directa* described originally by Balme and Hennelly (1956) has been transferred to *Microfoveolatispora* by Bharadwaj (1962). Balme and Hennelly described their specimens as having psilate to faintly granulose exine while Bharadwaj (*l.c.*) transferred the species for its microfoveolate exine. Spores Types D_1 and D_3 described by Ghosh and Sen (1948, PL. 4, FIGS. 19, 22) are also comparable to *L. erectus*. Virkki (1946) also figured similar spores from the Lower Gondwana rocks of India. It is possible that some of the spores figured by Ghosh and Sen (*l.c.*), Virkki (*l.c.*) may belong to this species. *Leiotriletes* sp. described by Bharadwaj and Salujha (1964, PL. 1, FIG. 1) also seems to belong to this species.

Leiotriletes sp. A

Pl. 1, Fig. 4

Description — Spore triangular in polar view, 46 μ; apices rounded, interapical margins straight to slightly concave. Trilete prominent, rays uniformly thick, slightly elevated, extending upto the equator; apex and vertex low, labra thin. Exine about 1 μ thick, infrapunctate.

Remarks — In its large size and infrapunctate exine this specimen shows close resemblance to the type species, i.e. *Leiotriletes sphaerotriangulatus* (Loose) Potonié & Kremp. The specimen described here, however, differs in possessing better developed and longer trilete mark.

cf. *Leiotriletes*

Pl. 1, Fig. 3

Description — Spore triangular in polar view, 21 μ, hemispherical, cushion-like bluntly rounded apices; interapical margins distinctly concave. Trilete not prominent, traceable upto three-fourth of radius, exine thin and folded.

Remarks — The shape of the spore with its bluntly rounded apices and the markedly concave interapical margins recalls very much the general appearance of the genus *Triquitrites* Wilson & Coe. This may, however, be arisen due to compression and subsequent foldings of the exine. Only a single grain of this type has been recovered and so it has been tentatively compared with *Leiotriletes*.

***Punctatisporites* (Ibrahim) Potonié & Kremp, 1954**

Type Species — *Punctatisporites punctatus* Ibrahim, 1933.

Punctatisporites sp.

Pl. 1, Fig. 5

Description — Spore subcircular, 53 μ; trilete prominent, rays slightly elevated and extend upto three-fourth of radius. Exine 2 μ thick, infrapunctate.

Remarks — *Punctatisporites* constitutes one of the major genera in the Carboniferous

coals of Northern hemisphere. The genus is, however, scantily represented in the Lower Gondwana Succession of India. Spore types described as F_1 and F_2 by Ghosh and Sen (1948, PL. 5, FIGS. 47-49) seems to belong to *Punctatisporites*.

Aulisporites (Leschik) Klaus, 1960

Type Species — *Aulisporites canalis* Leschik, 1955.

Aulisporites rarus sp. nov.

Pl. 1, Figs. 6-7

Holotype — Pl. 1, Fig. 6. Size 35 μ. Slide No. 2204.

Diagnosis — Spores subcircular, 28-35 μ. Trilete faint, exine 2-3 μ thick possessing irregularly distributed upto 2 μ wide puncta.

Description — Subcircular-circular, folds rarely present. Trilete mostly obscure, sometimes faintly discernible; rays hardly traceable. Exine 2-3 μ thick, ornamented with puncta, irregularly distributed, varying in size and shape; exine in between puncta laevigate.

Comparison — *Aulisporites* are originally described from the Triassic rocks. *Aulisporites canalis* Leschik and *A. astigmosus* Klaus have finer punctations. *Eupunctisporites* Bharadwaj although comparable has well organized trilete apparatus with closely spaced circular — vermicular pits (puncta) for its decoration. *Aulisporites* differs from *Eupunctisporites* in possessing small, or ill-defined trilete mark (*see* TEXT-FIG. 1).

Infraturma—*Apiculati* (Bennie & Kidston) Potonié, 1956

***Cyclogranisporites* Potonié & Kremp, 1954**

Type Species — *Cyclogranisporites leopoldi* (Kremp) Potonié & Kremp, 1954.

Cyclogranisporites gondwanensis Bharadwaj & Salujha, 1964

Pl. 1, Fig. 21

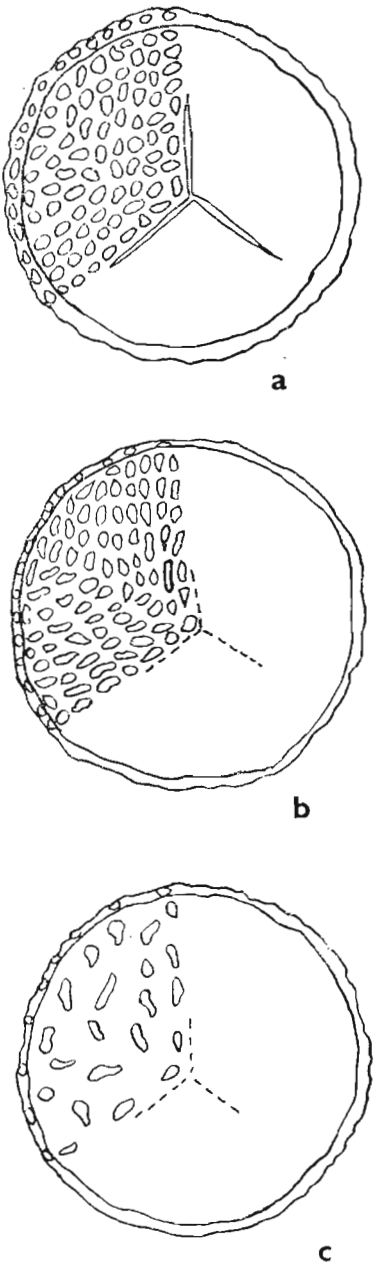
***Verrucosisporites* (Ibrahim) Smith *et al.*, 1964**

Type Species — *Verrucosisporites verrucosus* Ibrahim, 1932.

Verrucosisporites ambiplicatus sp. nov.

Pl. 1, Figs. 9-10

Holotype — Pl. 1, Fig. 10. Size 55 μ. Slide No. 2178.

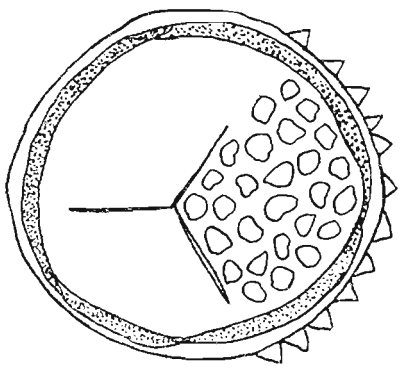


TEXT-FIG. 1 — a, *Eupunctisporites poniatiensis* Bharadwaj; b, *Aulisporites astigmosus* (Leschik) Klaus; c, *Aulisporites rarus* sp. nov.

Diagnosis — Size range 36-55 μ, trilete extending upto three-fourth of radius; exine folded regularly along equatorial margin; in surface view verrucae form a delicate negative reticulum.

Description — Spores subcircular to circular in polar view. Trilete fairly distinct, sometimes obscured by sculptural elements, rays of unequal length, not elevated, commissure distinct. Exine about 1 μ thick, ornamented with fairly numerous rounded to sometimes pointed verrucae; verrucae 2-2·5 μ long and 80-100 along margin (*see* TEXT-FIG. 2).

Comparison — The presence of fold along equatorial region is very characteristic and by this character alone it can be differentiated from the other species of this genus.



TEXT-FIG. 2—*Verrucosisporites ambiplicatus* sp. nov.

Lophotriletes (Naumova) Potonié & Kremp, 1954

Type Species — *Lophotriletes gibbosus* (Ibrahim) Potonié & Kremp, 1954.

General remarks on *Lophotriletes* — A general survey of the various specimens of *Lophotriletes* that have been studied here reveals an interesting fact. Every character shows much variation mostly within the limitation; but in some cases a character may be so emphasized or neglected that the very inclusion of the specimen within the genus may, however, easily be questioned. Let us anatomize this one by one. The trilete rays may well developed or obscure, extending from half of the radius to the equator, exaggerating the commissural development in some species and utterly neglecting on the other. The apices may be acutely rounded with well marked concave inter-radial margin or they become obtusely rounded making a ± convex inter-radial margin. Moreover, in the zenith of this mode of development the apices become so broad and obtuse that they hardly allow to form an inter-radial margin proper except a slight constriction in the middle part of the margin.

A further fillip towards the same kind of development essentially provides a subspheroidal shape with trilete mark and coni furnishing the sufficient ground to include the specimens in *Apiculatisporis* than *Lophotriletes* and thus confusing the demarcation of the said two genera.

Bearing in mind, however, that the spore genera are not water tight compartments and at a particular stage such kind of dilemma would always be there; all the specimens even with slight constriction at the interradial margin have been placed in *Lophotriletes* assuming the fact that they are in process of development from the triangular to subspheroidal form.

Lophotriletes novus sp. nov.

Pl. 1, Figs. 13-14

Holotype — Pl. 1, Fig. 13. Size 30 μ. Slide No. 2206.

Diagnosis — Size range 27-32 μ, apices bluntly rounded, trilete distinct, pyramic area raised, exine thin, covered by sparse coni.

Description — Spores distinctly triangular in polar view, apices broadly rounded, occasionally truncated, inter-apical margins ± straight — concave, sometimes straight. Trilete rays fairly long, extending upto equator, laesurae raised, commissure well defined. Exine thin, less than 1 μ, often irregularly folded, ornamented with sparsely distributed coni, coni less than 1 μ, about 15-23 coni along the margin.

Comparison — *Lophotriletes rectus* Bharadwaj & Salujha (1964) differs from the present species in the presence of blunt-tipped coni and the extension of the trilete rays upto three-fourth of the radius.

Remarks — *Lophotriletes* sp. described by Bharadwaj and Salujha (1964, PL. 2, FIG. 29) is characterized by sparse coni and the extension of the trilete rays upto the equator. It seems that this specimen also belongs to *L. novus*.

Lophotriletes latiangulatus sp. nov.

Pl. 1, Figs. 11-12

Holotype — Pl. 1, Fig. 11. Size 41μ. Slide No. 2165.

Diagnosis — Size-range 37-41 μ, equatorial outline broadly triangular, apices very broadly rounded, sides concave, rays of Y-mark unequal, extending form three-fourth of radius to almost upto equator, exine sculptured with minute coni.

Description — Spores tetrahedral, triangular in polar view. Trilete distinct, laesurae thin, usually widely gaping. Commissure well marked. Exine thin, often folded, coni less than 1 μ; 20-40 coni along margin.

Comparison — *Lophotriletes novus* resembles the present species in possessing bluntly rounded apices and more or less similar size range but can be differentiated by the distinct trilete mark extending upto equator and raised pyramic area *L. rectus* Bharadwaj & Salujha is distinguished in possessing blunt, sparsely distributed coni.

***Apiculatisporis* Potonié & Kremp, 1956**

Type Species — *Apiculatisporis* (al. *Apiculatisporites*) *aculeatus* (Ibrahim) Potonié & Kremp, 1956.

Apiculatisporis levis Balme & Hennelly, 1956

Pl. 1, Fig. 8

Lectotype — Balme & Hennelly (1956a, Pl. 2, Fig. 19).

Apiculatisporis sp. A

Pl. 1, Fig. 15

Description — Spore circular in polar view, 27 μ. Trilete ill-developed extending upto three-fourth of radius. Commissure indistinct. Coni sparse, 3-4 μ long, about 15 coni present on margin.

Comparison — The species differs from the other species of this genus in having sparse but long coni and ill-developed trilete rays.

***Acanthotriletes* (Naumova) Potonié & Kremp, 1954**

Type Species — *Acanthotriletes ciliatus* (Knox) Potonié & Kremp, 1954.

Acanthotriletes jhariaensis sp. nov.

Pl. 1, Figs. 16-17

Holotype — Pl. 1, Fig. 17. Size 30 μ. Slide No. 2161.

Diagnosis — Known size-range 28-30 μ; trilete distinct, fairly long; exine thin, ornamented with spines and also a few bacula.

Description — Miospores triangular in polar view, apices broadly rounded, interapical margin ± concave. Trilete usually clearly seen, sometimes obscure, extending upto three-fourth of radius, laesurae slightly elevated, lips usually open. Exine about 1 μ thick, spines 2·5-3·5 μ long, with pointed or blunt ends; 18-25 spines along margin.

Comparison — The spores belonging to the genus *Acanthotriletes* are not so abundant in the Lower Gondwana rocks of India. Only a few solitary specimens have been figured by Bharadwaj (1962, PL. 1, FIGS. 20-28, pp. 79-80). Bharadwaj has, however, given no detailed description; but from his illustration and remarks it is quite apparent that the present specimens differ considerably in the form and disposition from those. The spores types D_{10} and D_{11} figured by Ghosh and Sen (1948, PL. 4, FIGS. 30-31) appear almost identical to present specimens. *Acanthotriletes ericianus* Balme & Hennelly (1956, PL. 3, FIGS. 30-33) differs in having bigger size-range, trilete rays extending upto equator with the associated folds of the exine along the contact area.

***Horriditriletes* Bharadwaj & Salujha, 1964**

Type Species — *Horriditriletes curvibaculosus* Bharadwaj & Salujha, 1964.

Horriditriletes curvibaculosus Bharadwaj & Salujha, 1964

Pl. 1, Fig. 18

***Cyclobaculisporites* Bhardwaj, 1955**

Type Species — *Cyclobaculisporites grandiverrucosus* (Kosanke) Bhardwaj, 1955.

Cyclobaculisporites minimus sp. nov.

Pl. 1, Fig. 19

Holotype — Pl. 1, Fig. 19. Size 27 μ. Slide No. 2207.

Diagnosis — Miospores circular, 25-27 μ. Trilete indistinct, exine covered with bacula.

Description — Miospores circular-subcircular in polar view. Trilete indistinct, extending upto half to three-fourth radius. Exine often folded, beset with bacula; bacula as high as broad, closely placed, 50-60 bacula along margin.

Comparison — *Cyclobaculisporites minutus* is distinguished by larger size range and very well developed trilete extending upto half of the radial distance. *C. indicus* Bharadwaj & Salujha (*l.c.*) differs in posses-

sing broad bacula forming negative reticulum in surface view and larger size range.

Cyclobaculisporites minutus Bharadwaj & Salujha, 1964

Pl. 1, Fig. 20

Infraturma — *Varitrilete* Venkatachala & Kar, 1965

***Microfoveolatispora* Bharadwaj, 1962**

Type Species — *Microfoveolatispora raniganjensis* Bharadwaj, 1962.

Microfoveolatispora sp.

Pl. 1, Fig. 22

Description — Spore triangular in polar view, 36 μ. Trilete distinct extending up to equator. Commissure well defined. Exine about 1 μ thick, folded along contact area; microfoveolate, foveolae small; closely placed forming a faintly pitted reticulum in surface view.

Comparison — The present species differs from the other well established species of this genus in its comparatively smaller size and in the sculpturing pattern of the exine; microfoveolate reticulum being very delicate and faint.

Infraturma—*Murornati* Potonié & Kremp, 1954

***Indospora* Bharadwaj, 1962**

Type Species — *Indospora clara* Bharadwaj, 1962.

Indospora cf. *I. clara* Bharadwaj, 1962

Pl. 1, Figs. 23-24

Description — Spores distinctly triangular in polar view, 36-46 μ. Apices sharply rounded, interapical margins straight to slightly convex. Trilete distinct, well developed, laesurae extending beyond equatorial contour, raised between ridges. Exine thin, sparsely baculate, bacula 2·5-3·5 μ long.

Remarks — The specimens are smaller in size than those described by Bharadwaj (1962) and lacking polygonal mesh-work at the contact area. Further differentiation is not possible as only a few specimens have been recovered.

Indospora sp.

Pl. 1, Fig. 25

Description — Spore triangular in polar view, 32 μ. Apices sharply rounded, interapical margins concave. Trilete distinct, rays slightly elevated, projecting beyond equatorial contour. Exine laevigate, appears to be infra-structured.

Comparison — The present specimen differs from the others in being comparatively smaller in size and possessing laevigate to infra-structured exine.

Turma — *Zonales* (Bennie & Kidston) Potonié, 1956
Subturma — *Zonotriletes* Waltz, 1936
Anteturma—*Zonati* Potonié & Kremp, 1954

***Gondisporites* Bharadwaj, 1962**

Type Species — *Gondisporites raniganjensis* Bharadwaj, 1962.

Gondisporites raniganjensis Bharadwaj, 1962

Pl. 1, Fig. 26

Remarks — The specimens described by Bharadwaj (*l.c.*) from the Raniganj Stage are smaller in size range than the present specimens. The other characters are, however, more or less same and hence they have been regarded to be of the same species.

Turma — *Monoletes* Ibrahim, 1933
Subturma — *Azonomonoletes* Luber, 1935
Infraturma—*Psilamonoleti* V. D. Hammen, 1955

***Laevigatosporites* (Ibrahim) Schopf, Wilson & Bentall, 1944**

Type Species — *Laevigatosporites vulgaris* Ibrahim, 1933.

Laevigatosporites vulgaris forma *colliensis* Balme & Hennelly, 1956

Pl. 1, Fig. 27

Remarks — The Australian specimens described by Balme and Hennelly (*l.c.*) are also having more or less same size range. Bharadwaj (1962) transferred this into *Latosporites* without stating any cause for it. *Laevigatosporites vulgaris* forma *colliensis* is well within the circumscription of *Laevigatosporites* and hence they have been kept in the above mentioned genus.

Laevigatosporites plicatus sp. nov.

Pl. 1, Figs. 28-29

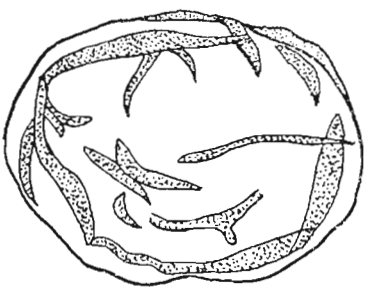
Holotype — Pl. 1, Fig. 28. Size 41 μ. Slide No. 2169.

Diagnosis — Size range 41-55 μ; monolete obscure, sometimes appear to be extended

up to three-fourth of longitudinal axis. Exine thin, folded regularly along the margin.

Description — Subcircular — circular in lateral view. Monolete while discernible slightly elevated, uniformly broad, often obscure by folds. Exine laevigate, thin and regularly folded, exo-exinous layer ± 1 μ thick, translucent (*see* TEXT-FIG. 3).

Comparison — *Laevigatosporites vulgaris* forma *colliensis* Balme & Hennelly and *L. scissus* Balme & Hennelly are distinguished from the present species in the absence of numerous folds along the margin.



TEXT-FIG. 3 — *Laevigatosporites plicatus* sp. nov.

Laevigatosporites sp.

Pl. 1, Fig. 30

Description — Elliptical, 64-92 μ. Monolete, well developed, lip slightly elevated extending three-fourth of longer axis. Exine thin, folded longitudinally, sculptureless, few longitudinal striations present.

Remarks — Bharadwaj (1962, PL. 3, FIG. 64) referred one specimen to *Latosporites* sp. which resembles to the present specimens in having horizontal striations; but differs in size range and infrapunctate exine.

Anteturma—*Pollenites* Potonié, 1931
Turma — *Saccites* Erdtman, 1947
Subturma — *Monosaccites* (Chitaley) Potonié & Kremp, 1954
Infraturma—*Apertacorpiti* Lele, 1964

***Plicatipollenites* Lele, 1964**

Type Species — *Plicatipollenites indicus* Lele, 1964

Plicatipollenites giganticus sp. nov.

Pl. 2, Fig. 38

Holotype — Pl. 2, Fig. 38. Size 216 × 202 μ. Slide No. 2196.

Diagnosis — Size-range 197-216 μ, equatorial outline circular; central body and saccus ± equal in size, body subcircular, trilete not traceable, body infold system circular.

Description — Monosaccate pollen grains, radially symmetrical. Circular; central body circular, size range of central body 130-140 μ. Exine of body thin, imperfectly intramicroreticulate. Saccus equatorially attached on the proximal surface, distal attachment inclined, body infold system circular, occasionally other minor folds may also be present, saccus denser than body, coarsely intrareticulate, mesh size 1-3 μ.

Comparison — Morphologically the present species seems to be similar to the genotype: *P. indicus* Lele except for being comparatively much larger in size. The range is sufficiently larger to justify its specific separation.

Plicatipollenites indicus Lele, 1964

Pl. 2, Fig. 39

Plicatipollenites gondwanensis Lele, 1964

Pl. 2, Fig. 40

Plicatipollenites ovatus sp. nov.

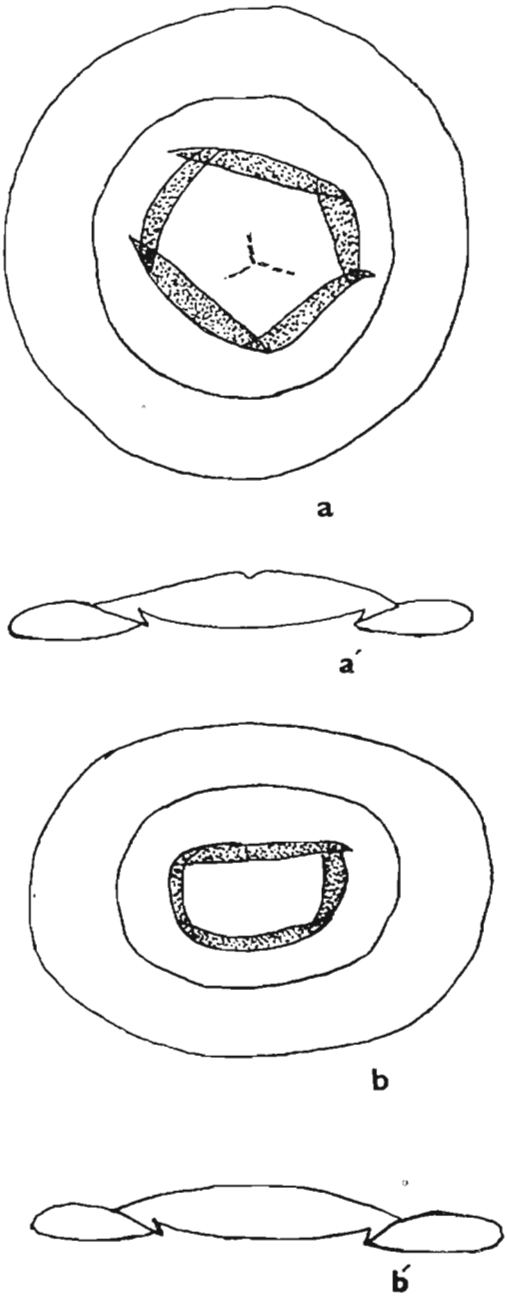
Pl. 2, Figs. 41-42

Holotype — Pl. 2, Fig. 41. Size 165 × 115 μ. Slide No. 2198.

Diagnosis — Elliptical-oval pollen, central body oval-subcircular, well defined, distal attachment associated with oval-subcircular folds.

Description — Large-sized pollen grains, size range 115-138 × 165-197 μ. Central body intramicroreticulate, haptotypic mark absent. Proximal attachment of saccus to central body equatorial, distal attachment inclined; folds distinct, saccus strongly built, coarsely intrareticulate, mesh size 2-3 μ, lumina shallow (*see* TEXT-FIG. 4).

Comparison — *Plicatipollenites indicus* and *P. gondwanensis* resemble the present species in having distinct attachment zone; but can be differentiated by its circular shape. *P. diffusus* is characterized by diffused attachment zone and circular shape. *P. ovatus* is distinguished from all the known species of this genus in its oval-elliptical shape and oval-subcircular folds along with the distal attachment.



TEXT-FIG. 4 — a, *Plicatipollenites gondwanensis* Lele (polar view); a', *P. gondwanensis* (meridional section); b, *Plicatipollenites ovatus* sp. nov.; b', *P. ovatus* (meridional section).

***Virkkipollenites* Lele, 1964**

Type Species — *Virkkipollenites* (*Hymenozonotriletes*) *triangularis* (Mehta) Lele, 1964.

Virkkipollenites latisaccus sp. nov.

Pl. 1, Figs. 33-34

Holotype — Pl. 1, Fig. 33. Size 142 × 128 μ. Slide No. 2192.

Diagnosis — Size range 142-178 μ; equatorial outline circular, monosaccate; saccus bigger or at least equal in size to central body; body circular enclosed by a saccus except for a small part on the distal side, trilete not traceable, body exine not well defined, laevigate to faintly intramicroreticulate.

Description — Large-sized monosaccate, radially symmetrical pollen grains with a well defined central body measuring 142-150 × 142-174 μ. Exine thin, laevigate intramicroreticulate. Saccus attachment distinct, proximal attachment equatorial, distal attachment subequatorial; body folds rare. Exine of the saccus denser than body, coarsely intrareticulate, mesh size 1-3 μ (*see* TEXT-FIG. 5).

Comparison — *Virkkipollenites mehtae* Lele is comparable to the present species in general shape and well defined attachment zone; but can be distinguished in the presense of trilete mark and size of the saccus. *Virkkipollenites densus* Lele is characterized by dense central body.

Virkkipollenites astericus sp. nov.

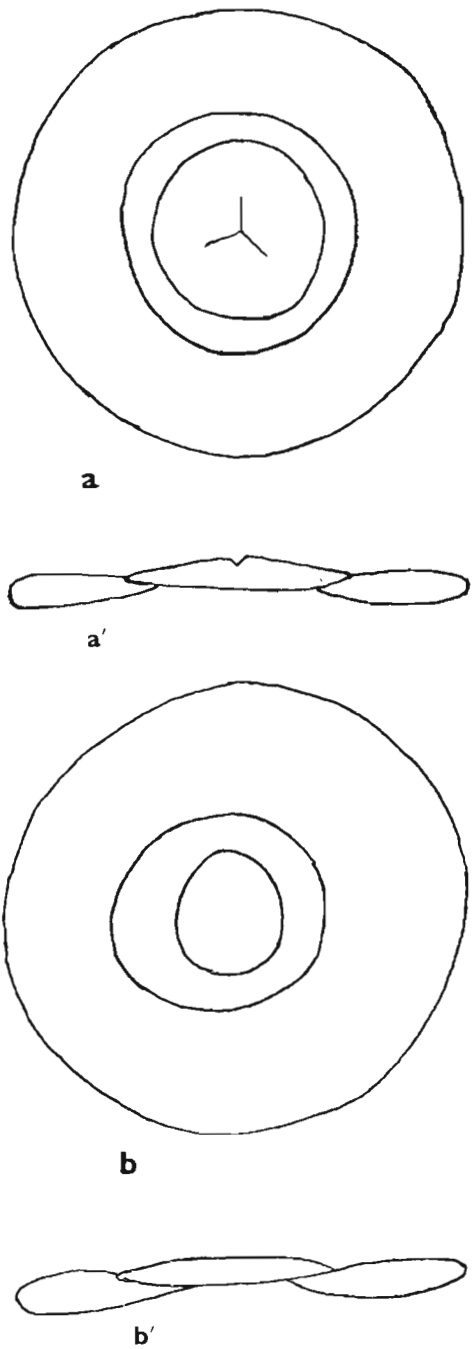
Pl. 1, Figs. 35-36

Holotype — Pl. 1, Fig. 35. Size 170 × 147 μ. Slide No. 2192.

Diagnosis — Size range 147-174 μ, central body well defined, ± equal in size to that of saccus, exine thin, folded many times in middle part of central body. Body and saccus circular, trilete not traceable.

Description — Monosaccate, ± radially symmetrical grains with a well defined central body; exine of central body ± laevigate to imperfectly intramicroreticulate; exine numerously folded in the middle part of the central body. Proximal attachment equatorial, distal attachment subequatorial, saccus denser than central body, coarsely intrareticulate, mesh size 1-3 μ.

Comparison — *Virkkipollenites latisaccus* closely resembles the present species in general shape and proportion of size of central body and saccus. *V. astericus* can, however, be distinguished by its star-shaped infold system of the exine of the central body.



TEXT-FIG. 5 — a, *Virkkipollenites mehtae* Lele (polar view); a', *V. mehtae* (meridional section); b, *V. latisaccus* sp. nov. (polar view); b', *V. latisaccus* (meridional section).

Virkkipollenites obscurus Lele, 1964

Pl. 2, Fig. 37

Virkkipollenites katriensis sp. nov.

Pl. 2, Figs. 47-48

Holotype — Pl. 2, Fig. 48. Size 142 × 133 μ. Slide No. 2198.

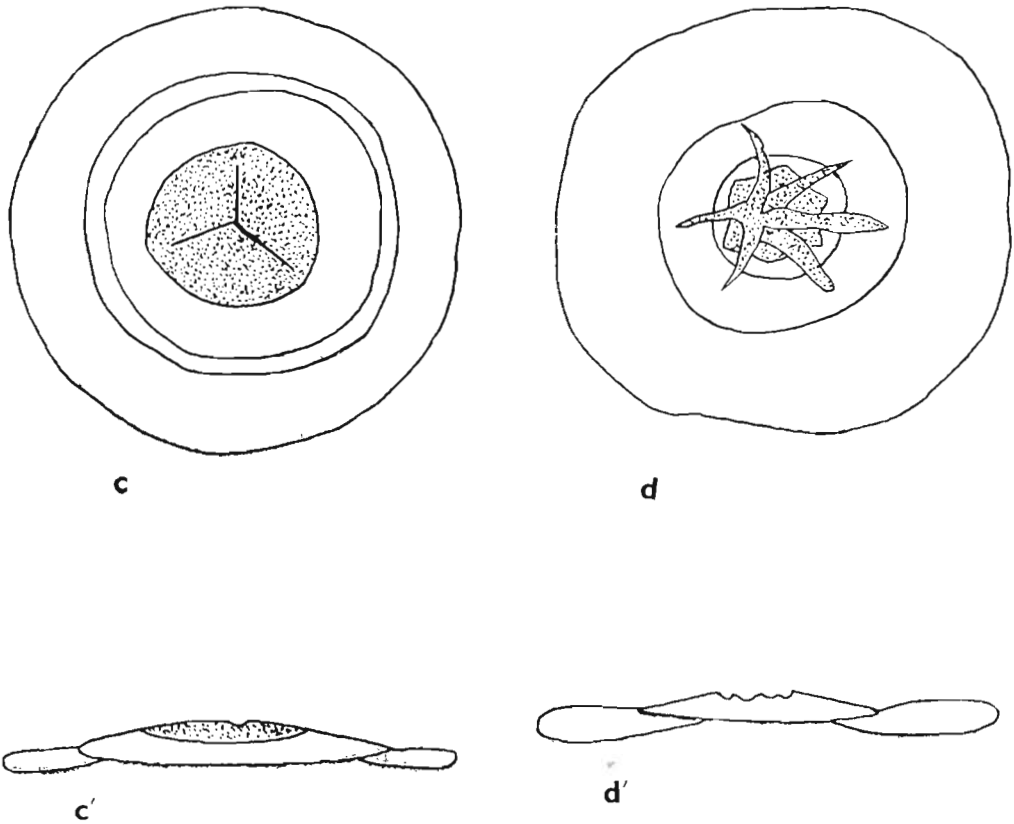
Diagnosis — Circular-subcircular pollen grains. Size range 96-197 × 119-220 μ. Central body circular-subcircular, distinct, possessing an inner body. Saccus dense, coarsely intrareticulate.

Description — Large sized pollen grains. Central body finely intramicroreticulate except the inner body; which may be circular, subcircular or semilunar in shape with strongly built meshes; in some cases inner body is more thickened in one part or may be incipient. Trilete mostly absent; while present (PL. 2, FIG. 48) it extends more or less up to the inner body; rays equal and tapering at ends; commissure well defined. Proximal attachment of saccus to central body equatorial, distal attachment subequatorial, attachment zone well marked. Saccus strongly built, same or slightly smaller in size than central body; meshes apparently radially arranged, lumina shallow.

Comparison — *Virkkipollenites mehtae* Lele and *V. densus* Lele resemble the present species in possessing circular — subcircular overall shape and the distinct zone of saccus attachment. *V. katriensis* can, however, be distinguished in the presence of inner central body.

Remarks — The occurrence of inner central body seems to be common in the various genera of monosaccate pollen described from the Permian sediments of the Lower Gondwana. Bharadwaj and Tiwari (1964) recorded it while instituting *Barakarites* and *Parasaccites* (vide BHARADWAJ & TIWARI 1964, PL. 1, FIGS. 4, 5; PL. 2, FIG. 9) from the Barakar Stage of India. *Virkkipollenites katriensis*, however, differs from the *Barakarites* in the absence of pseudoreticuloid grooves in the central body. *Parasaccites* Bharadwaj & Tiwari is organizationally different from *Virkkipollenites* Lele.

The occasional presence of inner body among the pteridophytic spores have also been reported. Schopf, Wilson and Bentall (1944); Bharadwaj and Venkatachala (1964) reported inner body in *Calamospora microrugosa* and *Calamospora densa* respectively. Hartung (1933, PL. 9, FIGS.



TEXT-FIG. 5 — c, *Virkkipollenites katriensis* sp. nov. (polar view); c', *Virkkipollenites katriensis* (meridional section); d, *Virkkipollenites astericus* sp. nov. (polar view); d', *Virkkipollenites astericus* (meridional section).

9-12) also reported inner body in the spores recovered from *Hultonia spicata*.

The function of the inner body seems to be, however, different among the pteridophytic and monosaccate pollen. In the latter kind the presence of inner body was perhaps an approach to be utilized for better flight.

Infraturma—*Triletesacciti* Leschik, 1955

***Parasaccites* Bharadwaj & Tiwari, 1964**

Type Species — *Parasaccites korbaensis* Bharadwaj & Tiwari, 1964.

Parasaccites sp.

Pl. 2, Fig. 44

Description — Pollen grains mostly elliptical. Central body well defined, subcircular-circular; intramicroreticulate; trilete not seen. Proximal and distal attachment subequatorial. Saccus dense, intrareticulate, mesh size 1-3 μ.

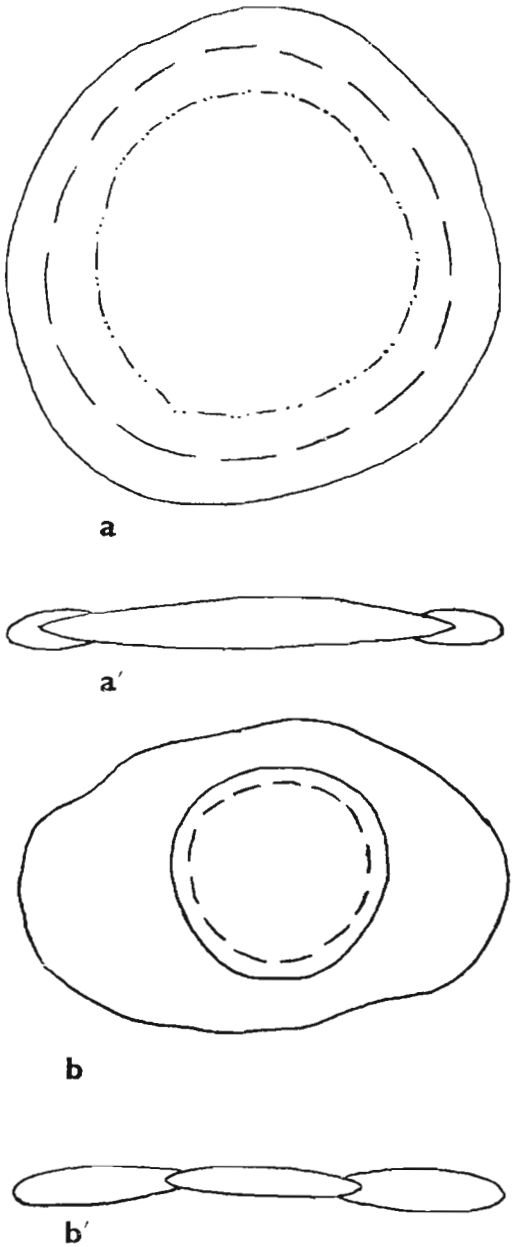
Parasaccites ovatus sp. nov.

Pl. 2, Figs. 45-46

Holotype — Pl. 2, Fig. 46. Size 125 × 73 μ. Slide No. 2202.

Diagnosis — Oval — elliptical pollen, central body well defined, circular-subcircular, intramicroreticulate. Proximal and distal attachment of saccus to central body subequatorial and ± in para condition.

Description — Medium-sized pollen; size range 64-115 × 110-166 μ. Central body lighter than saccus; exine thin; haptotypic mark not seen. Proximal and distal attachment zone mostly distinct, often tilted. Saccus dense, coarsely intrareticulate, mesh size 1·5-2·5 μ, lumina shallow (*see* TEXT-FIG. 6).



TEXT-FIG. 6 — a, *Parasaccites korbaensis* Bharadwaj & Tiwari (polar view); a', *P. korbaensis* (meridional section); b, *P. ovatus* sp. nov. (polar view); b', *P. ovatus* (meridional section).

Comparison — *Parasaccites korbaensis* Bharadwaj & Tiwari differs from the present species in possessing circular overall shape.

Infraturma—*Aletesacciti* Leschik, 1956

***Vestigisporites* (Balme & Hennelly) Hart, 1960**

Type Species — *Vestigisporites rudis* Balme & Hennelly, 1955.

General Remarks on Vestigisporites — Apprehending the difficulties in distinguishing *Vestigisporites* Balme & Hennelly, *Limitisporites* Leschik and *Sahnities* Pant from each other, Hart (1960) emended *Vestigisporites* and to emphasize disaccate condition of this genus subsequently commented on the genotype *Vestigisporites rudis* (BALME & HENNELLY, 1955, PL. 6, FIG. 54) that " the monosaccate condition is the exception rather than the rule." The description given by Hart in connection with the specimens is unfortunately not emancipated from the tendency of monosaccism as in the words of Hart most of the species are " monosaccate in construction." Moreover, his opinion that *Sahnites* does " not show the monosaccate construction " is also not commendable. Because *Sahnites* (*Pityosporites*) *gondwanensis* according to Mehata (1944) " has. . . . .densely webbed bladders which are continuous over the poles and arise intra-marginally all round the body."

Besides, the species *Vestigisporites methoris*, instituted by Hart 1960 (PL. 2, FIG. 20) shows very close resemblance to *Sahnites* (*Pityosporites*) *gondwanensis* from the diagram as well as from the photograph supplied by Mehta by its ± continuous sacci on lateral sides and presence of two body folds running parallel to each other, perpendicular to the longitudinal axis.

Bharadwaj (1964) merged *Vestigisporites* to *Potonieisporites* Bharadwaj. *Vestigisporites* has been maintained by Venkatachala and Kar (1968) and the same practice has also been followed here.

Vestigisporites monosaccatus sp. nov.

Pl. 1, Figs. 31-32

Holotype — Pl. 1, Fig. 31. Size 142 × 105 μ. Slide No. 2203.

Diagnosis — Central body horizontally oval, exine of the central body ± laevigate to intramicroreticulate; saccus continuous and not compressed laterally.

Description — Pollen grains oval. Size range 142-165 × 105-120 μ. Central body well defined, exine thin, monolete well marked, slightly elevated, tapering at ends, extends half of central body along longitudinal

axis. Saccus shows no constriction on the lateral sides; often frilled at margin, denser than body, coarsely intrareticulate, mesh size 1-2·5 μ.

Comparison — *Vestigisporites monosaccatus* differs from the other species in having monosaccate construction without any constriction on the lateral sides except *V. methoris* Hart; but the latter is characterized by two parallel body folds along the entire length of the body, perpendicular to the longitudinal axis.

***Densipollenites* Bharadwaj, 1962**

Type Species — *Densipollenites indicus* Bharadwaj, 1962.

Densipollenites indicus Bharadwaj, 1962

Pl. 2, Figs. 49

Infraturma—*Decussati* Lele & Maithy, 1964
***Crucisaccites* Lele & Maithy, 1964**

Type Species — *Crucisaccites latisulcatus* Lele & Maithy, 1964.

cf. *Crucisaccites*

Pl. 2, Fig. 43

Description — Elliptical pollen grain; size 207 × 161 μ. Central body ill defined, exine thin, imperfectly intramicroreticulate. Saccus attachment bilateral and on both sides of the central body, zones of attachment on two sides at right angles to each other. Saccus coarsely intrareticulate, mesh size 1-3 μ, lumina shallow.

Remarks — The attachment zone is not associated with body infold system; so it has only been compared to *Crucisaccites*.

Subturma — *Disaccites* Cookson, 1947
Infraturma—*Podocarpoiditi* Potonié, Thomson & Thiergart, 1950
***Platysaccus* (Naumova) Potonié & Klaus, 1954**

Type Species — *Platysaccus papilionis* Potonié & Klaus, 1954.

Platysaccus katriensis sp. nov.

Pl. 2, Figs. 52, 58

Holotype — Pl. 2, Fig. 52. Size 21 × 52 μ. Slide No. 2156.

Diagnosis — Size range 21-26 × 52-60 μ. Central body and sacci both well developed, exine of central body ± thin, microverrucose, distal attachment of sacci to central body ± straight.

Description — Pollen grains rather small in size, bisaccate and diploxylonoid. Central body dense, vertically oval; exoexinous layer not seen. Proximal attachment of sacci to central body equatorial. Sacci semicircular, leathery to finely intrareticulate, muri thin, lumina shallow, 1-1·5 μ in size (*see* TEXT-FIG. 7).

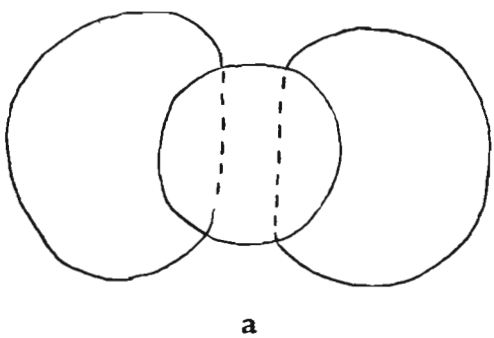
Comparison — *Platysaccus papilionis* Potonié & Klaus is distinguished from the present species in having a very thick exoexinous layer. In *P. leschiki* Hart the central body is comparatively much smaller in size that the sacci.

Platysaccus densus sp. nov.

Pl. 2, Figs. 50-51

Holotype — Pl. 2, Fig. 50. Size 36 × 82 μ. Slide No. 2154.

Diagnosis — Central body horizontally oval, well developed, exine microverrucose; sacci comparatively less developed.



TEXT-FIG. 7 — a, *Platysaccus katriensis* sp. nov.; b, *Platysaccus densus* sp. nov.

Description — Pollen grains biwinged and bilaterally symmetrical. Size range 35-40 × 75-87 μ. Exine of central body thin. Proximal attachment of sacci to central body equatorial, distal attachment ± straight. Sacci semicircular, leathery, muri thick, lumina shallow, 1-1·5 μ in size.

Comparison — *Platysaccus katriensis* differs from the present species in possessing circular central body. *P. densus* differs from the other known species in having horizontally oval and well developed, central body with microverrucose ornamentation.

Cuneatisporites Leschik, 1955

Type Species — *Cuneatisporites radialis* Leschik.

Cuneatisporites rarus sp. nov.

Pl. 2, Figs. 53-54

Holotype — Pl. 2, Fig. 53. Size 36 × 60 μ. Slide No. 2172.

Diagnosis — Size range 27-35 × 50-60 μ. Central body vertically oval, exine of the central body thin and intramicroreticulate; distal attachment of the sacci to the central body ± straight.

Description — Bisaccate, medium sized pollen grains. Central body distinct, exine of the central body about 1 μ thick, central body as light as the sacci. Proximal attachment of the sacci to central body equatorial, distal attachment ± straight; sulcus ± uniformly broad. Sacci hemispherical, intrareticulate, mesh size 1-1·5 μ.

Comparison — *Cuneatisporites radialis* Leschick is characterized by granulated exine on the central body. Moreover, the distal attachment of sacci to the central body is also ± convex.

Infraturma—_Striatiti_ Pant, 1955
Striatites (Pant) Bharadwaj, 1962

Type Species — *Striatites sewardii* (Virkki) Pant, 1955.

Striatites varius sp. nov.

Pl. 2, Figs. 55-56

Holotype — Pl. 2, Fig. 55. Size 41 × 77 μ. Slide No. 2155.

Diagnosis — Central body subcircular to vertically oval, exine thick without any lateral ridges, horizontal striations present; distal attachment of sacci diverging on lateral sides.

Description — Pollen grains bisaccate, bilateral, diploxylonoid, overall shape elongate-elliptical. Size range 41-46 × 77-87 μ. Central body well defined, exine uniformly thick (2-2·5 μ), microverrucose. Horizontal striations 9-12 in number, mostly unbranched and ± parallel to each other. Proximal attachment of sacci to central body equatorial, distal attachment ± convex and diverging each other on lateral sides; sacci hemispherical, intrareticulate, mesh size 1-2 μ (*see* TEXT-FIG. 8).

Comparison — *Striatites sewardii* (Virkki) Pant differs in having vertical striations and comparatively much smaller central body. *S. solitus* Bharadwaj & Salujha (1964) is characterized by prominent ridges on the lateral sides of the central body. *S. communis* Bharadwaj & Salujha (*l.c.*) differs from the present species in having converging distal attachment on the lateral sides.

Striatites sp. A

Pl. 2, Fig. 57

Description — Bilateral, bisaccate, diploxylonoid pollen grain measuring 23 × 60 μ. Central body ill-defined, exine thin, microverrucose; horizontal striations 3 in number, ill-developed and often branched. Proximal attachment of the sacci to central body equatorial, distal attachment ± straight; sacci ± hemispherical, intrareticulate, mesh size 1-2 μ.

Comparison — The present specimen differs from all of the known species of *Striatites* in having ill-defined central body and weakly developed horizontal striations.

Verticipollenites Bharadwaj, 1962

Type Species — *Verticipollenites secretus* Bharadwaj, 1962.

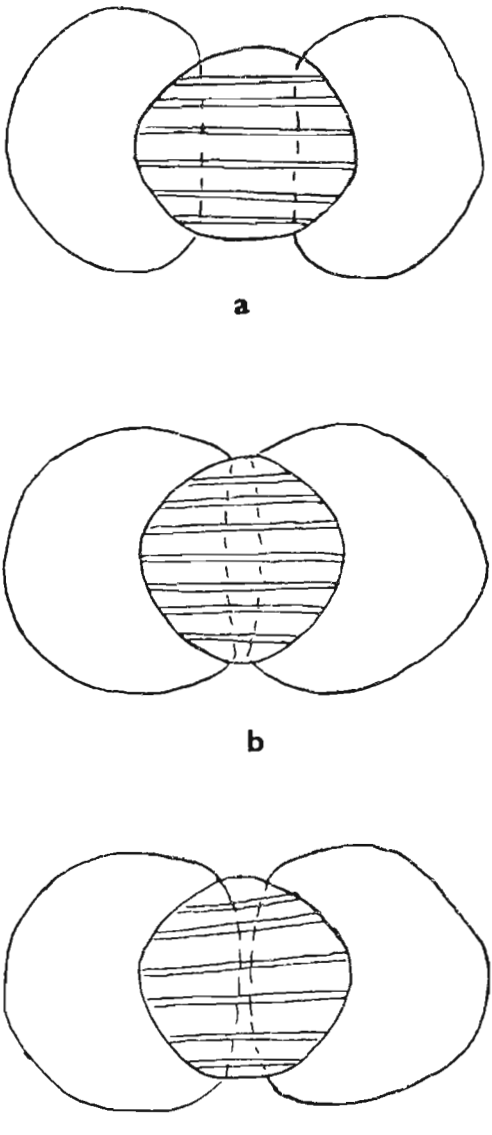
Verticipollenites mineosus sp. nov.

Pl. 3, Figs. 59-60

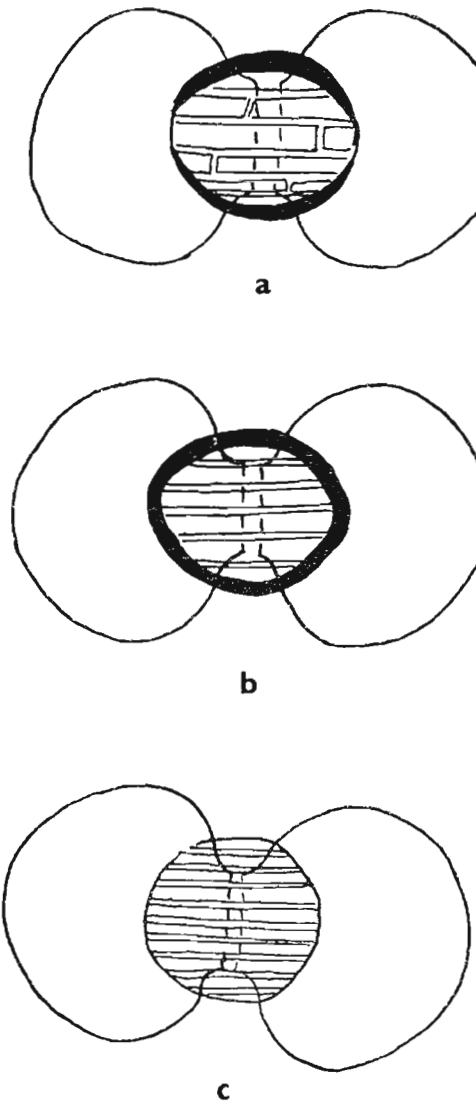
Holotype — Pl. 3, Fig. 59. Size 46 × 101 μ. Slide No. 2174.

Diagnosis — Size range 32-46 × 87-101 μ. Central body vertically oval to subcircular, exine thick, only horizontal striations present, distal attachment of sacci to central body ± striaght; sacci free area of central body forms a narrow uniform sulcus.

Description — Bisaccate, diploxylonoid, pollen grains. Central body denser than



TEXT-FIG. 8 — a, *Striatites solitus* Bharadwaj & Salujha; b, *S. communis* Bharadwaj & Salujha; c, *S. varius* sp. nov.



TEXT-FIG. 9 — a, *Verticipollenites subcircularis* Bharadwaj & Salujha; b, *V. gibbosus* Bharadwaj, 1962; c, *V. mineosus* sp. nov.

sacci, exine of central body up to 2 μ thick, faintly microverrucose; horizontal striations 6-10, unbranched, ± parallel to each other. Proximal attachment of sacci to central body equatorial, distal attachment ± juxtaposed; sacci ± pitcher-shaped, intrareticulate, mesh size 1-2 μ (*see* TEXT-FIG. 9).

Comparison — *Verticipollenites crassus* Bharadwaj & Salujha (1964), *V. finitimus* Bharadwaj & Salujha (1964), *V. subcircularis* Bharadwaj & Salujha (1964) differ from the present species in having both horizontal and vertical striations. *V. gibbosus* Bharadwaj (1962) shows similarity in possessing only horizontal striations, but can be distinguished in its horizontally oval central body with 5-7 horizontal striations.

Lahirites Bharadwaj, 1962

Type Species — *Lahirites raniganjensis* Bharadwaj, 1962.

Lahirites rarus Bharadwaj & Salujha, 1964

Pl. 3, Fig. 65

Lahirites sp. A

Pl. 3, Fig. 66

Description — Pollen grain measuring 55 × 78 μ. Exine of central body about 2 μ thick with prominent lateral ridges, unsculptured, uniformly intrapunctate. Horizontal striations 8 in number, unbranched, parallel to each other. Vertical striations absent. Proximal attachment of sacci to central body equatorial, distal attachment ± concave. Sacci leathery, meshes not clear.

Comparison — In the absence of vertical striation, the present species is comparable to *Lahirites rarus* Bharadwaj & Salujha (1964) and *L. parvus* Bharadwaj & Salujha (1964). But *L. rarus* is devoid of lateral ridges in the ± subcircular central body and *L. parvus* is characterized by sporadic intrapunctate exine of central body.

Hindipollenites Bharadwaj, 1962

Type Species — *Hindipollenites indicus* Bharadwaj, 1962.

Hindipollenites globosus sp. nov.

Pl. 3, Figs. 61, 64

Holotype — Pl. 3, Fig. 64. Size 46 × 101 μ. Slide No. 2177.

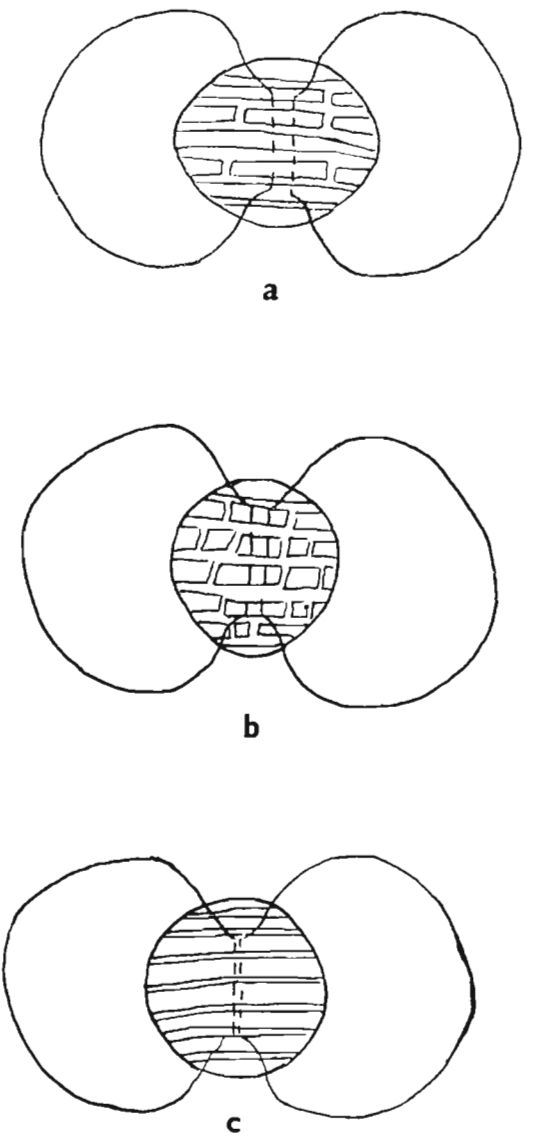
Diagnosis — Size range 41-46 × 73-101 μ. Central body ± circular to vertically oval, exine thin, horizontal striations only present.

Description — Bilateral, bisaccate, diploxylonoid pollen grains. Central body well defined, exine about 1·5 μ thick, laevigate and intrapunctate. Horizontal striations 7-10, unbranched. Proximal attachment of sacci to central body equatorial, distal attachment closely placed. Sacci pitcher shaped, intrareticulate, mesh-size 1·5-2·5 μ (*see* TEXT-FIG. 10).

Comparison — *Hindipollenites globosus* differs from *H. indicus* Bharadwaj & Salujha (1964) and *H. oblongus* Bharadwaj & Salujha (1964) in the absence of vertical striation on central body.

Lunatisporites (Leschik) Bharadwaj, 1962

Type Species — *Lunatisporites acutus* Leschik, 1955.



TEXT-FIG. 10 — a, *Hindipollenites indicus* Bharadwaj; b, *H. oblongus* Bharadwaj & Salujha; c, *H. globosus* sp. nov.

Lunatisporites amplus sp. nov.

Pl. 3, Figs. 67-68

Holotype — Pl. 3, Fig. 68. Size 124 × 170 μ. Slide No. 2199.

Diagnosis — Size range 105-124 × 161-170 μ, central body vertically oval with broad ends; horizontal striations 10-15.

Description — Pollen grains large in size, bisaccate, diploxylonoid. Central body well defined, exine of central body up to 1·5 μ thick, finely intramicroreticulate. Horizontal striations mostly unbrached, ± parallel to each other. Proximal attachment of sacci to central body equatorial, distal attachment inclined, ± parallel to body fold; sulcus narrow, often fully covered by folds. Sacci hemispherical, coarsely intrareticulate, muri moderately thick, lumina shallow, 1-3 μ in size (*see* TEXT-FIG. 11).

Comparison—*Lunatisporites fuscus* Bharadwaj (1962) differs from the present species in having pointed, vertically oval central body and less number of horizontal striations. *Lunatisporites* sp. 'A' of Bharadwaj and Salujha (1964) is distinguished by the smaller size range and elliptical central body. *Lunatisporites* sp. 'B' of Bharadwaj & Salujha (1964) can be easily differentiated from this species in possessing a boat-shaped sulcus.

Lunatisporites hirsutus sp. nov.

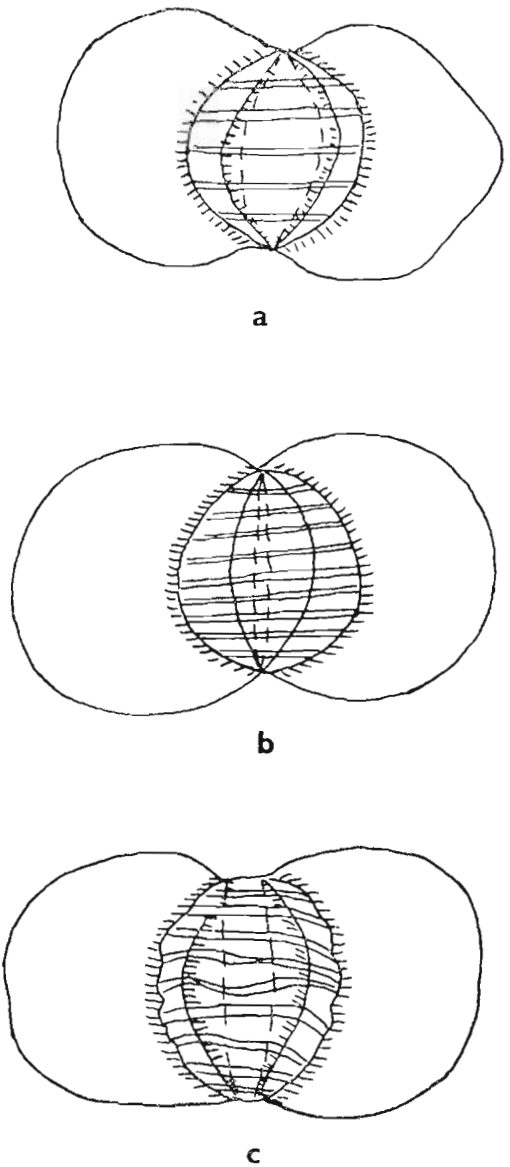
Pl. 3, Figs. 62-63

Holotype — Pl. 3, Fig. 63. Size 115 × 170 μ. Slide No. 2200.

Diagnosis — Size range 115-119 × 161-170 μ. Central body vertically oval to subcircular; horizontal striations zig-zag, exine of central body ledged at attachment region.

Description — Fairly large-sized, bisaccate, diploxylonoid pollen grains. Central body distinct, exine up to 1·5 μ thick, intramicroreticulate. Horizontal striations 6-10, deep, mostly not parallel to each other. Proximal attachment of sacci to central body equatorial, distal attachment ± inclined, body fold along with the distal attachment, sulcus narrow. Sacci hemispherical, intrareticulate, muri ± thick, lumina shallow, 1-2·5 μ in size.

Comparison — *Lunatisporites hirsutus* differs from the other species of this genus in having zig-zag horizontal striations and ledge-like process at the attachment region.



TEXT-FIG. 11 — a, *Lunatisporites fuscus* Bharadwaj; b, *L. amplus* sp. nov.; c, *L. hirsutus* sp. nov.

Strotersporites (Wilson) Klaus, 1963

Type Species — *Strotersporites communis* Wilson, 1962.

Remarks — Venkatachala and Kar (1964) transferred the hitherto known species of *Striatopodocarpites* (Sedova) Bharadwaj (1962) of Bharadwaj and Salujha (1964) to *Strotersporites* Wilson pointing out the invalidity of *Striatopodocarpites* on nomenclatural ground. Klaus (1963) emended *Strotersporites* and also included the pollen grains possessing distinct fissure in between the two striations. Such condition is, however, not met with in the present material.

Strotersporites lentisaccatus sp. nov.

Pl. 3, Fig. 69

Holotype — Pl. 3, Fig. 69. Size 46 × 92 μ. Slide No. 2208.

Diagnosis — Size range 41-46 × 92-105 μ; central body and sacci are of same height, only horizontally striated, spindle-shaped, distal attachment straight, sulcus broad, sacci leathery.

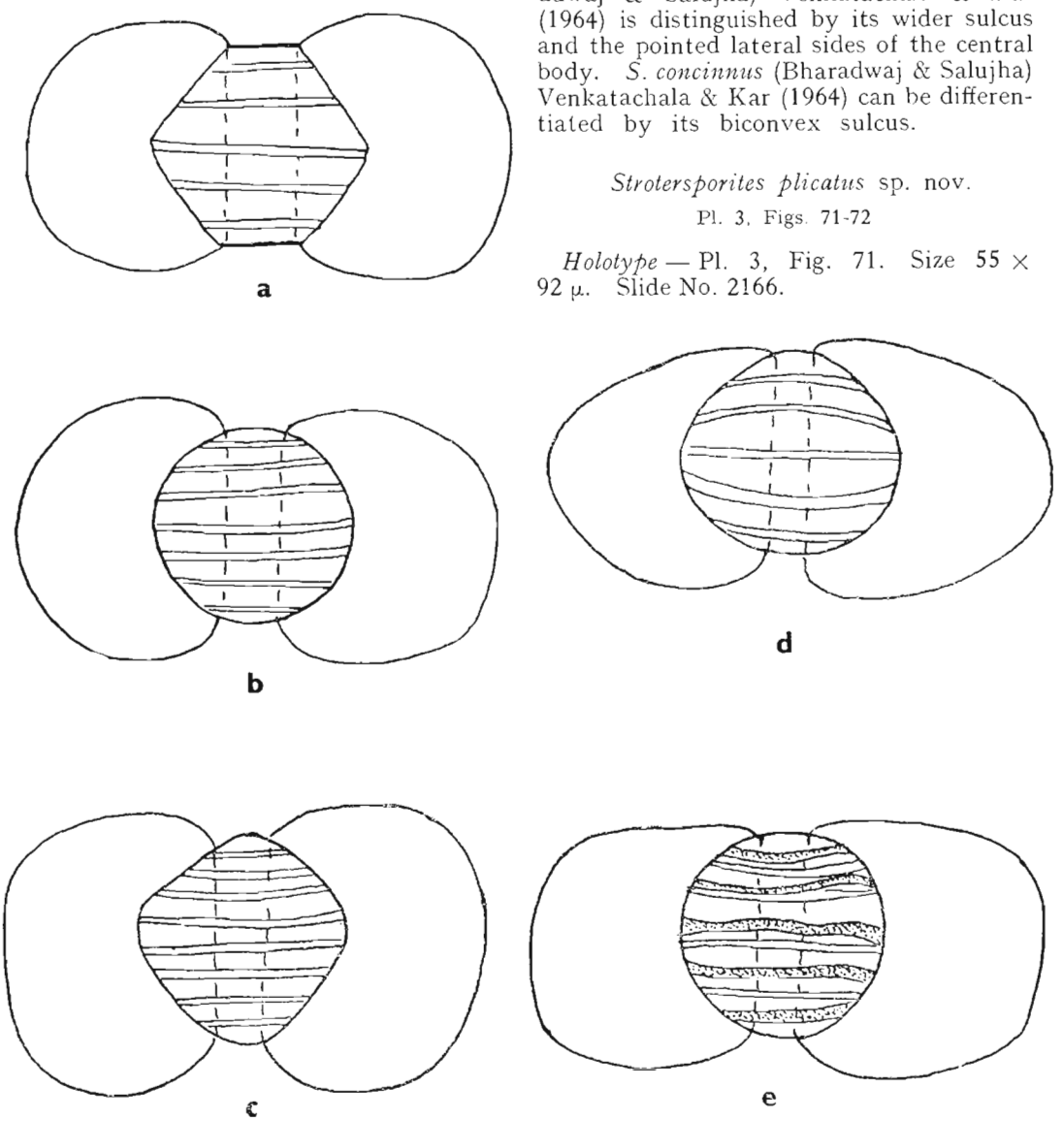
Description — Pollen grains bilateral, bi-winged. Central body circular, well defined; exine of central body about 2 μ thick, intramicroreticulate; horizontal striations 6-10, unbranched. Proximal attachment of sacci to central body equatorial; distal attachment slightly inclined. Sacci hemispherical, tough and leathery, ornamentation not clearly seen (*see* TEXT-FIG. 12).

Comparison — *Strotersporites fuscus* (Bharadwaj & Salujha) Venkatachala & Kar (1964) is distinguished by its wider sulcus and the pointed lateral sides of the central body. *S. concinnus* (Bharadwaj & Salujha) Venkatachala & Kar (1964) can be differentiated by its biconvex sulcus.

Strotersporites plicatus sp. nov.

Pl. 3, Figs. 71-72

Holotype — Pl. 3, Fig. 71. Size 55 × 92 μ. Slide No. 2166.



TEXT-FIG. 12 — a, *Strotersporites decorus* (Bharadwaj & Salujha) Venkatachala & Kar; b, *S. magnificus* (Bharadwaj & Salujha) Venkatachala & Kar; c, *S. diffusus* (Bharadwaj & Salujha) Venkatachala & Kar; d, *Strotersporites lentisaccatus* sp. nov.; e, *S. plicatus* sp. nov.

Diagnosis — Size range 50-55 × 92-101 μ. Central body subcircular, exine of central body thin, folded along horizontal striations; only horizontally striated, distal attachment straight, widely placed.

Description — Medium-sized pollen grains, bilateral, biwinged. Central body well defined, exine of central body about 1·5 μ thick, intramicroreticulate. Horizontal striations 6-12, unbranched, parallel to each other. Proximal attachment of sacci to central body equatorial, distal attachment slightly inclined. Sacci semicircular, intrareticulate, mesh size 1-2 μ.

Comparison — The presence of horizontal folds on the central body along with striations apparently seem to be restricted to the present species and hence this character alone may be used for the specific discrimination from the other known species of *Stroterspories*.

Stroterspories sp. A

Pl. 3, Fig. 70

Description — Pollen grain biwinged, comparatively small in size (34 × 61 μ), bilaterally symmetrical. Central body distinct, subcircular, possessing 10 horizontal striations on both proximal and distal surfaces. Exine of central body thin, irregularly folded, finely intramicroreticulate. Sacci semicircular; distal attachment straight, sulcus wide, sacci intrareticulate, meshes apparently radially arranged, mesh-size 1-2 μ.

Comparison — The specimen differs from other species of *Stroterspories* in having striations on both surfaces of the central body.

Striatopiceites **(Zoricheva & Sedova, 1954) Sedova, 1956**

Type Species — *Striatopiceites suchonensis* Sedova, 1956.

Remarks — Zoricheva and Sedova (1954) proposed the name *Striatopiceites* without proper generic diagnosis or description. They also did not designate any type species. Sedova (1956), however, validated this genus and included the haploxylonoid disaccate pollen grains with horizontal striations and finely reticulate (? intramicroreticulate) central body. She did not, however, mention the nature of the central body. The text-figure illustrated by her and the photograph published by Hart point out that the central body has an ill-defined outline. Potonié (1958) rejected this name as invalid taking into account only the publication of Zoricheva and Sedova (1954). He perhaps did not have the access to Sedova's (1956) paper. Bharadwaj (1962) instituted *Faunipollenites* to include bisaccate, bilateral haploxylonoid pollen grains with ill-defined, intramicroreticulate central body having a number of horizontal striations with a distal sulcus area.

Hart (1964) emended *Protohaploxypinus* Samoilovich (1953) and included *Striatopiceites* along with *Striatopinites* Sedova, *Lueckisporites* Potonié & Klaus (in parts), *Lunatisporites* Leschik, *Striatites* Pant, *Taeniaesporites* Leschik (in parts), *Faunipollenites* Bharadwaj and a host of other genera in it. *Protohaploxypinus* in the sense defined by Hart (*l.c.*) is not acceptable to the present author.

Striatopiceites digredius sp. nov.

Pl. 3, Figs. 73-74

Holotype — Pl. 3, Fig. 73. Size 65 × 101 μ. Slide No. 2180.

Diagnosis — Size range 46-65 × 96-101 μ, central body horizontally oval, ill-defined horizontal striations only present; distal attachment closely placed at one end while diverging on other.

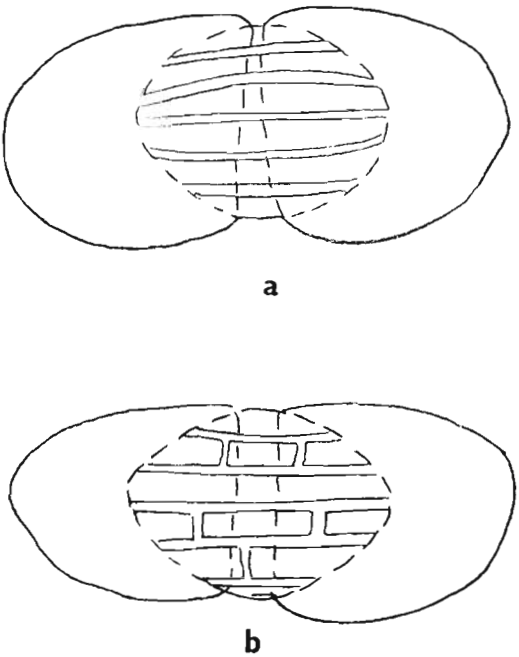
Description — Medium-sized pollen-grains, bilaterally symmetrical and haploxylonoid. Central body ill-defined, exine of central body about 2 μ thick, intramicroreticulate. Horizontal striations 6-10, unbranched, converging at ends. Proximal attachment of sacci to central body equatorial, distal attachment entire, sulcus faintly discernible. Sacci hemispherical, intrareticulate, meshes narrow (*see* TEXT-FIG. 13).

Comparison—*Faunipollenites varius* Bharadwaj (1962) is comparable to the present species in possessing only horizontal striations, but can be distinguished by its straight distal attachment. *S. digredius* differs from other species of this genus in having diverging distal attachment on one of the lateral sides of the central body and converging on the other.

Striatopiceites granulatus sp. nov.

Pl. 3, Figs. 75-76

Holotype — Pl. 3, Fig. 75. Size 36 × 78 μ. Slide No. 2167.



TEXT-FIG. 13 — a, *Striatopiceites digredius* sp. nov.; b, *S. granulatus* sp. nov.

Diagnosis — Size range 36-41 × 73-78 μ; central body horizontally oval, ill-defined, horizontal and vertical striations present, exine of central body proximally intramicroreticulate, distally granulate.

Description — Pollen grains small in size, haploxylonoid, bilaterally symmetrical. Exine of central body about 2 μ thick, often folded along horizontal striations. Horizontal striations 5-8, unbranched; vertical striations ill-developed, only few in number. Proximal attachment of sacci to central body equatorial, distal attachment straight; sulcus narrow, uniformly broad. Sacci semicircular, intrareticulate, meshes narrow, lumina broad, mesh-size 1-2 μ.

Comparison — *Striatopiceites digredius* differs from the present species in having only horizontal striations. *S. granulatus* is distinguished from the other known species in having distinct granular exine on the distal surface of the central body.

Vittatina (Luber) ex Samoilovich, Wilson, 1962

Type Species — *Vittatina subsaccata* Samoilovich, 1953.

Vittatina lata Wilson, 1962

Pl. 4, Figs. 77-78

Infraturma — _Disaccitrilete_ (Leschik) Potonié, 1958

Vesicaspora (Schemel) Wilson & Venkatachala, 1963

Type Species — *Vesicaspora wilsonii* Schemel, 1951.

cf. *Vesicaspora*

Pl. 4, Fig. 79

Description — Pollen grain elliptical in overall shape, 101 × 188 μ. Central body subcircular to oval. Sulcus narrow, elliptical in shape. Sacci hemispherical, intrareticulate, meshes narrow, 1-2 μ.

Comparison — *Vesicaspora ovata* (Balme & Hennelly) Wilson & Venkatachala (1963) differs from the present species in having oval shape and smaller size.

Sulcatisporites (Leschik) Bharadwaj, 1962

Type Species — *Sulcatisporites interpositus* Leschik, 1955.

cf. *Sulcatisporites*

Pl. 4, Figs. 80-81

Description — Oval to elliptical pollen grains, often slightly constricted in one of the lateral sides of central body. Size range 46-55 × 78-90 μ. Central body ill-defined, seems to be subcircular; exine about 2 μ thick, intramicroreticulate. Proximal attachment zone of saccus to central body ill-defined; distal attachment inclined and obscure. Sacci semicircular, coarsely intrareticulate, mesh size 1-2·5 μ, lumina shallow.

Turma — _Monocolpates_ Iversen & Troels-Smith, 1950

Subturma — _Intortes_ (Naumova) Potonié, 1958

Ginkgocycadophytus Samoilovich, 1953

Type Species — *Ginkgocycadophytus caperatus* (Luber) Samoilovich, 1953.

Ginkgocycadophytus (al. *Entylissa*) *cymbatus* (Balme & Hennelly) Potonié & Lele, 1960

Pl. 4, Fig. 82

Ginkgocycadophytus micropunctatus sp. nov.

Pl. 4, Figs. 83-84

Holotype — Pl. 4, Fig. 84. Size 57 × 32 μ. Slide No. 2164.

Diagnosis — Overall shape elliptical, size range 22-32 × 40-57 μ; exine ± intramicroreticulate, colpus ± uniformly broad.

Description — Bilateral, elliptical pollen grains. Exine thin, less than 2 μ, mostly intramicropunctate; exine often folded without any regular pattern. Colpus extends from one end to other.

Comparison — *Ginkgocycadophytus cymbatus* Potonié & Lele (1960) differs from the present species in having infragranular exine.

cf. *Ginkgocycadophytus*

Pl. 4, Fig. 85

Description — Oval pollen grain measuring 35 × 24 μ. Exine thin, laevigate, intrapunctate. Colpus funnel shaped, extends from one end to other.

Marsupipollenites Balme & Hennelly, 1956

Type Species — *Marsupipollenites triradiatus* Balme & Hennelly, 1956.

Marsupipollenites sp.

Pl. 4, Fig. 86

Description — Pollen oval measuring 36μ. Exine thin, up to 1·5 μ thick, imperfectly granular. Horizontal and vertical striations present; colpus wide, unequally broad, extending from one end to other. Trilete mark ill-developed, rays unequally long.

Turma — _Polyplicates_ Erdtman, 1952

Gnetaceaepollenites (Thiergart) Jansonius, 1962

Type Species — *Gnetaceaepollenites ellipticus* Thiergart, 1940.

Gnetaceaepollenites biplicatus sp. nov.

Pl. 4, Figs. 87-88

Holotype — Pl. 4, Fig. 87. Size 92 × 32 μ.

Diagnosis — Spindle-shaped pollen grains with blunt or truncated ends, size range 23-32 × 59-92 μ; groove uniformly wide.

Description — Medium-sized, bilaterally symmetrical pollen grains. Exine moderately thick (1·5 μ), finely intramicropunctate; exo-exinous layer while preserved translucent, well marked. Groove narrow, extends from one end to other, accompanied by one major fold parallel to longitudinal axis on each side. Longitudinal striations present on both surfaces running parallel to each other (*see* TEXT-FIG. 14).

Comparison — The present specimen is distinguished from *G. ellipticus* Thiergart (1940) by its intramicropunctate exine.

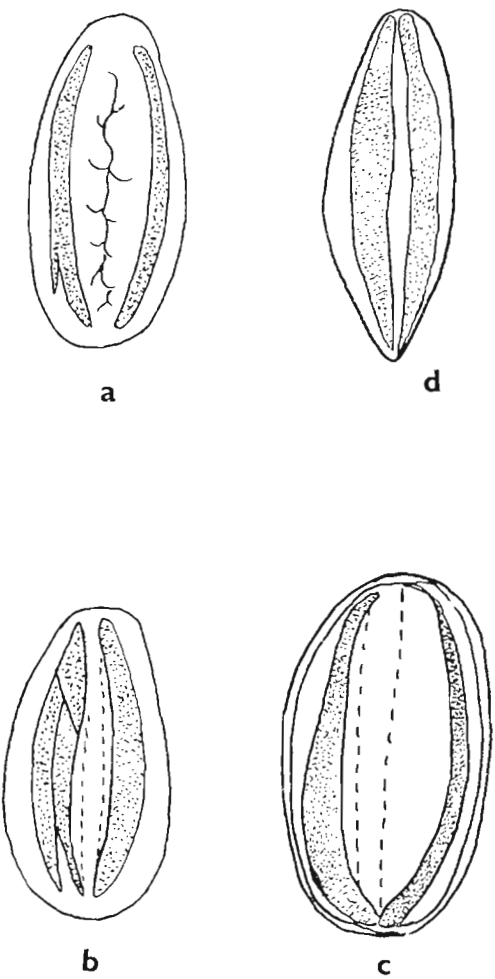
Gnetaceaepollenites pachydermatus sp. nov.

Pl. 4, Fig. 89

Holotype — Pl. 4, Fig. 89. Size 46 × 27 μ. Slide No. 2176.

Diagnosis — Oval, size range 25-27 × 46-70 μ, exine thick, groove ± dentate.

Description — Medium to small sized pollen grains. Exine uniformly thick (2·5-



TEXT-FIG. 14 — a, *Gnetaceaepollenites ellipticus* Thiergart; b, *G. biplicatus* sp. nov.; c, *G. pachydermatus* sp. nov.; d, *G. acutus* sp. nov.

3·5 μ), intramicroreticulate; exo-exinous layer thin, translucent. Groove uniformly wide, extends from one end to other; longitudinal fold running parallel to groove is not well developed.

Comparison — *Gnetaceaepollenites pachydermatus* differs from *G. biplicatus* in having thick exine, ill-developed longitudinal fold and dentate margin of the groove.

Gnetaceaepollenites acutus sp. nov.

Pl. 4, Fig. 90

Holotype — Pl. 4, Fig. 90. Size 92 × 32 μ. Slide No. 2160.

Diagnosis — Spindle-shaped pollen grains with or without pointed ends. Size range 25-32 × 60-92 μ. Groove deep, margin smooth accompanying by one major fold on each side.

Description — Medium-sized pollen grains. Exine 1·5-2 μ thick, infrastructured, exo-exinous layer translucent, occasionally preserved. Groove ± straight, extending one end to other. One major fold always associated with the groove on each side.

Comparison — *Gnetaceaepollenites biplicatus* is distinguished from the present species by blunt or truncated ends. *G. pachydermatus* is possessing thick exine and the margin of the groove is dentate.

Welwitschiapites Bolkhovitina, 1953

Type Species — *Welwitschiapites magnilobatus* Bolkhovitina, 1953.

Welwitschiapites tenuis Bharadwaj & Salujha, 1964

Pl. 4, Figs. 91-93

Ephedripites Bolkhovitina, 1953

Type Species — *Ephedripites mediolobatus* Bolkhovitina, 1953.

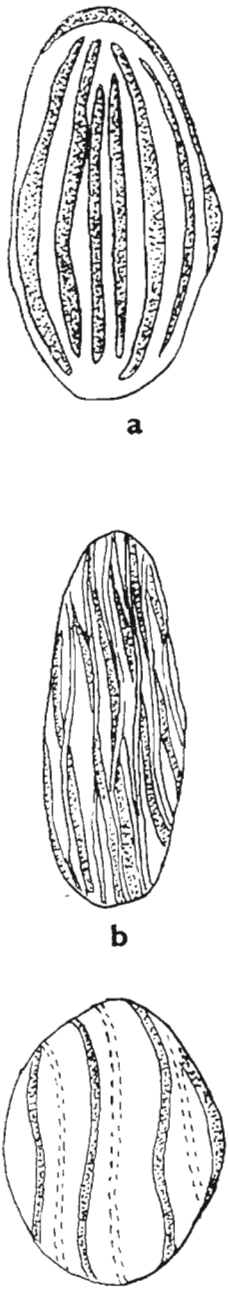
Ephedripites dentatus sp. nov.

Pl. 4, Figs. 96-97

Holotype — Pl. 4, Fig. 97. Size 45 × 35 μ. Slide No. 2173.

Diagnosis — Subcircular-oval, exine thick, grooves broader in middle, dentate at margin.

Description — Size range 35-38 × 45-52 μ. Exine uniformly thick (1·5-2·5 μ), finely intramicroreticulate. Exo-exinous layer thin, well marked. Grooves 5-7, present on both sides (*see* TEXT-FIG. 15).



TEXT-FIG. 15 — a, *Ephedripites mediolobatus* Bolchovitina; b, *E. ellipticus* sp. nov.; c, *E. dentatus* sp. nov.

Comparison — *Ephedripites dentatus* is distinguished from the other known species of this genus in its dentate margin of the grooves.

Ephedripites ellipticus sp. nov.

Pl. 4, Figs. 94-95

Holotype — Pl. 4, Fig. 95. Size 65 × 35 μ. Slide No. 2173.

Diagnosis — Elliptical, grooves 6-10 in number, margin of the groove smooth and unbranched.

Description — Medium-sized pollen grains, size range 27-35 × 65-75 μ. Exine thin, intramicroreticulate; exo-exinous layer 1 μ thick, well marked. Grooves parallel along longitudinal axis.

Comparison — *Ephedripites dentatus* is distinguished from the present species in possessing dentate margins of the grooves.

Subturma — *Monoptyches* (Naumova) Potonié, 1958

***Decussatisporites* Leschik, 1955**

Type Species — *Decussatisporites delineatus* Leschik.

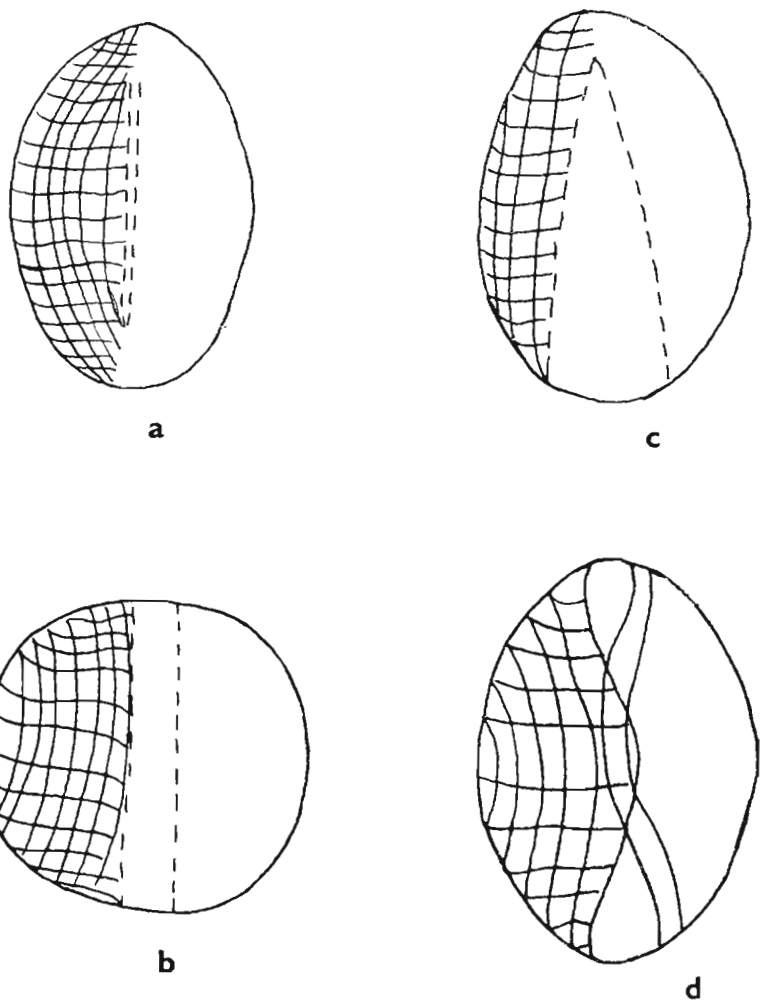
Decussatisporites ovatus sp. nov.

Pl. 4, Figs. 98-100

Holotype — Pl. 4, Fig. 98. Size 46 × 36 μ. Slide No. 2160.

Diagnosis — Oval pollen grains, size range 20-25 × 27-30 μ, colpus funnel-shaped, extends from one end to other, striated.

Description — Pollen grains small in size, bilaterally symmetrical. Exine thin, laevi-



TEXT-FIG. 16 — a, *Decussatisporites delineatus* Leschik; b, *D. lucifer* Bharadwaj & Salujha; c, *Decussatisporites ovatus* sp. nov.; d, *D. constrictus* sp. nov.

gate; horizontal striations 15-20 in number, vertical striations 5-8, ill-developed, parallel to each other (*see* TEXT-FIG. 16).

Comparison — *Decussatisporites ovatus* differs from *D. lucifer* Bharadwaj & Salujha (1964) by its oval shape, ill-developed vertical striations and funnel-shaped colpus.

Decussatisporites constrictus sp. nov.

Pl. 4, Fig. 101

Holotype — Pl. 4, Fig. 101. Size 32 × 26 μ. Slide No. 2168.

Diagnosis — Oval pollen grains, horizontal and vertical striations well developed, colpus constricted in middle.

Description — Size range 26-32 × 32-46 μ. Exine thin, less than 2 μ, laevigate, horizontal and vertical striations about 15 in number. Colpus extends from one end to other.

Comparison — In *Decussatisporites ovatus* the vertical striations are few in number and ill-developed. *D. lucifer* Bharadwaj and Salujha (1964) is having well developed horizontal and vertical striations; but the colpus is not constricted in the middle.

Decussatisporites lucifer Bharadwaj & Salujha

Pl. 4, Figs. 102-103

DISCUSSION

The Damuda Series of the Lower Gondwana system of India represents a panorama of sedimentary deposition. The strata in the Barakar and the Raniganj Stages consist mostly of sandstones containing kaolinized feldspars followed by shales and finally coal. The Barren Measures Succession differs from this general rule in the absence of coal-bearing strata in the whole Sequence. This feature naturally points out that the vegetation was not so luxurious as was in the Barakar and the Raniganj Stages.

The qualitative as well as the quantitative analyses of the spore-pollen spectrum recovered from the bore-core also substantiate this supposition. The spore-pollen genera are less in number in comparison to Barakar and Raniganj assemblages. The spore-pollen have also always been found in meagre number in all the macerated samples in the present material (*see* KAR, 1966).

A comparative study on the proportion of coal to other strata in the Damuda Series is approximately 1 to 8-10 in the Barakar Stage; while in the Raniganj Stage it varies from 1 : 20-35 (vide Krishnan 1956, p. 306). This naturally indicates that the climate was gradually becoming unfavourable for luxurious vegetation. The succeeding Panchet Stage is practically devoid of any carbonaceous matter and thus obviously indicate a change in climate.

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EXPLANATION OF PLATES

(*All photomicrographs are enlarged ca.* × 500 *except otherwise mentioned*)

PLATE 1

1-2. *Leiotriletes erectus* sp. nov. Photo Nos. 1/1, 1/5.

3. cf. *Leiotriletes*. Photo No. 1/2.

4. *Leiotriletes* sp. A. Photo No. 1/6.

5. *Punctatisporites* sp. Photo No.
6-7. *Aulisporites rarus* sp. nov. Photo Nos. 1/7, 1/8.
8. *Apiculatisporis levis* Balme & Hennelly. Photo No. 2/8.
9-10. *Verrucosisporites ambiplicatus* sp. nov. Photo Nos. 1/24, 1/25.
11-12. *Lophotriletes latiangulatus* sp. nov. Photo Nos. 1/23, 1/18.
13-14. *Lophotriletes novus* sp. nov. Photo Nos. 1/15, 1/19.
15. *Apiculatisporis* sp. A. Photo No. 2/12.
16-17. *Acanthotriletes jhariaensis* sp. nov. Photo Nos. 1/28, 1/33.
18. *Horriditriletes curvibaculosus* Bharadwaj & Salujha Photo No. 2/4.
19. *Cyclobaculisporites minimus* sp. nov. Photo No. 1/11.
20. *Cyclobaculisporites minutus* Bharadwaj & Salujha Photo No. 2/5.
21. *Cyclogranisporites gondwanensis* Bharadwaj & Salujha Photo No. 2/5.
22. *Microfoveolatispora* sp. Photo No. 2/14.
23-24. *Indospora* cf. I. *clara* Bharadwaj Photo No. 2/15, 2/17.
25. *Indospora* sp. Photo No. 2/16.
26. *Gondisporites raniganjensis* Bharadwaj Photo No. D_1.
27. *Laevigatosporites vulgaris* forma *colliensis* Balme & Hennelly Photo No. 2/20.
28-29. *Laevigatosporites plicatus* sp. nov. Photo Nos. 2/28, 2/19.
30. *Laevigatosporites* sp. Photo No. 2/25.
31-32. *Vestigisporites monosaccatus* sp. nov. Photo Nos. N28, G12. × 250.
33-34. *Virkkipollenites latisaccus* sp. nov. Photo Nos. N22, N21. × 250.
35-36. *Virkkipollenites astericus* sp. nov. Photo Nos. N18, N25. × 250.

Plate 2

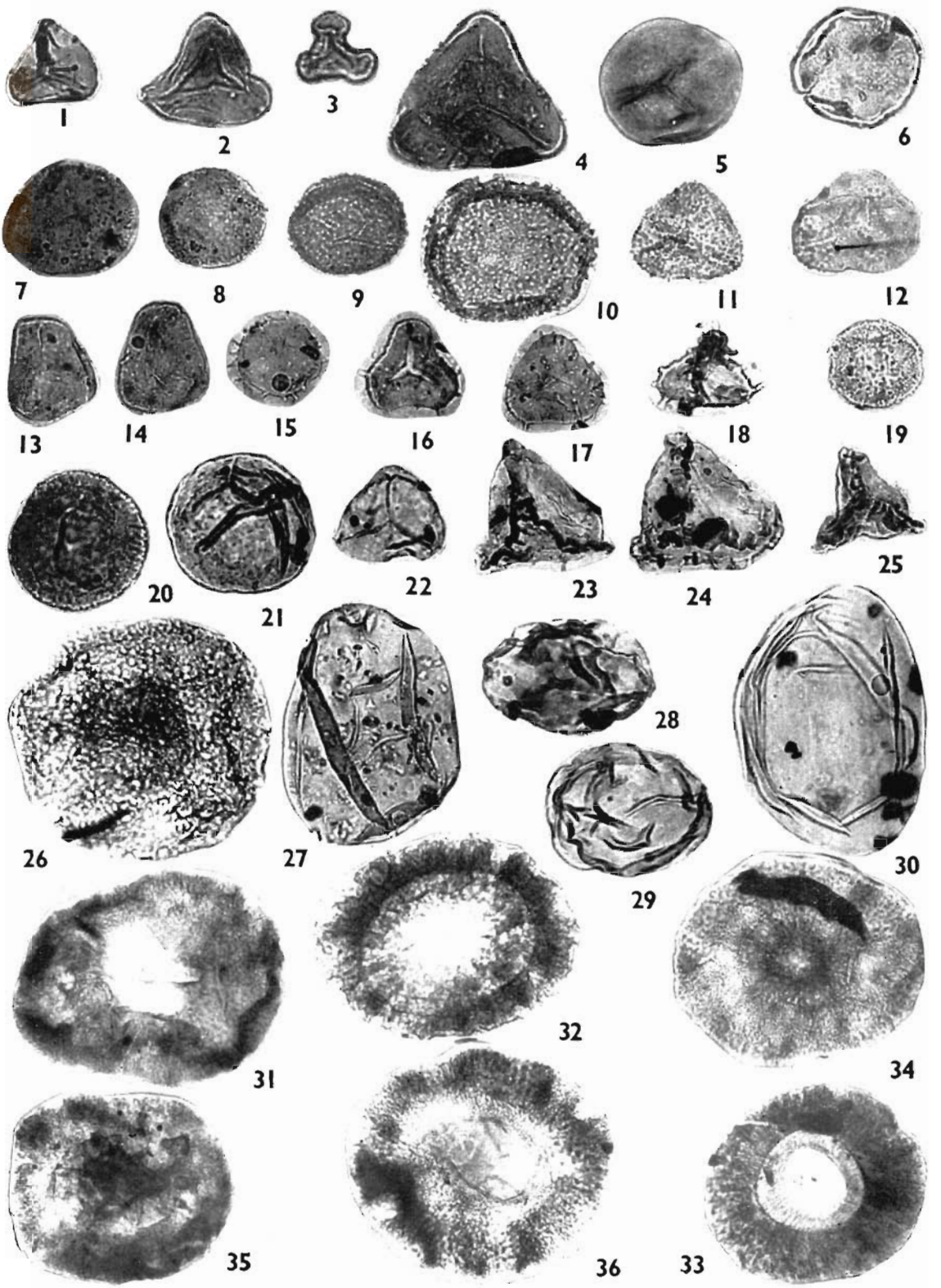
37. *Virkkipollenites obscurus* Lele Photo No. N19. × 250.
38. *Plicatipollenites giganticus* sp. nov. Photo No. N1. × 250.
39. *Plicatipollenites indicus* Lele Photo No. N13. × 250.
40. *Plicatipollenites gondwanensis* Lele Photo No. V20. × 250.
41-42. *Plicatipollenites ovatus* sp. nov. Photo Nos. Vl2, Vl10. × 250.
43. cf. *Crucisaccites* Lele & Maithy Photo No. V3. × 250.
44. *Parasaccites* sp. Photo No. N6. × 250.
45-46. *Parasaccites ovatus* sp. nov. Photo Nos. Vi4, Vi5. × 250.
47-48. *Virkkipollenites katriensis* sp. nov. Photo Nos. Vl5, N7. × 250.
49. *Densipollenites indicus* Bharadwaj Photo No. G9. × 250.
50-51. *Platysaccus densus* sp. nov. Photo Nos. P7, P16.
52, 58. *Platysaccus katriensis* sp. nov. Photo Nos. P6, Vt6.
53-54. *Cuneatisporites rarus* sp. nov. Photo Nos. C3, C8.
55-56. *Striatites varius* sp. nov. Photo Nos. S7, S8.
57. *Striatites* sp. A Photo No. S13.

Plate 3

59-60. *Verticipollenites mineosus* sp. nov. Photo Nos. Vt4, Vt2.
61, 64. *Hindipollenites globosus* sp. nov. Photo Nos. H1, H3.
62-63. *Lunatisporites hirsutus* sp. nov. Photo Nos. Lu11, Lu8.
65. *Lahirites rarus* Bharadwaj & Salujha Photo No. St5.
66. *Lahirites* sp. A Photo No. S10.
67-68. *Lunatisporites amplus* sp. nov. Photo Nos. Lu15, Lu1.
69. *Strotersporites lentisaccatus* sp. nov. Photo No. St3.
70. *Strotersporites* sp. A Photo No. St8.
71-72. *Strotersporites plicatus* sp. nov. Photo Nos. St6, St12.
73-74. *Striatopiceites digredius* sp. nov. Photo Nos. F2, F3.
75-76. *Striatopiceites granulatus* sp. nov. Photo Nos. F11, F12,

Plate 4

77-78. *Vittatina lata* Wilson Photo Nos. 3/34, 2/3.
79. cf. *Vesicaspora* Photo No. Vi2.
80-81. cf. *Sulcatisporites* Photo Nos. Sl8, Sl7.
82. *Ginkgocycadophytus cymbatus* (Balme & Hennelly) Potonié & Lele Photo No. 2/30.
83-84. *Ginkgocycadophytus micropunctatus* sp. nov. Photo Nos. 2/29, 2/32.
85. cf. *Ginkgocycadophytus* Photo No. 2/33.
86. *Marsupipollenites* sp. Photo No. 2/35.
87-88. *Gnetaceaepollenites biplicatus* sp. nov. Photo Nos. 3/26, 3/13.
89. *Gnetaceaepollenites pachydermatus* sp. nov. Photo No. 3/22.
90. *Genetaceaepollenites acutus* sp. nov. Photo No. 3/11.
91-93. *Welwitschiapites tenuis* Bharadwaj & Salujha Photo Nos. 3/23, 3/18, 3/21.
94-95. *Ephedripites ellipticus* sp. nov. Photo Nos. 3/15, 3/17.
96-97. *Ephedripites dentatus* sp. nov. Photo Nos. 3/28, 3/19.
98-100. *Decussatisporites ovatus* sp. nov. Photo Nos. 3/3, 3/4, 3/33.
101. *Decussatisporites constrictus* sp. nov. Photo No. 3/9.
102-103. *Decussatisporites lucifer* Bharadwaj & Salujha Photo Nos. 3/6, 3/10.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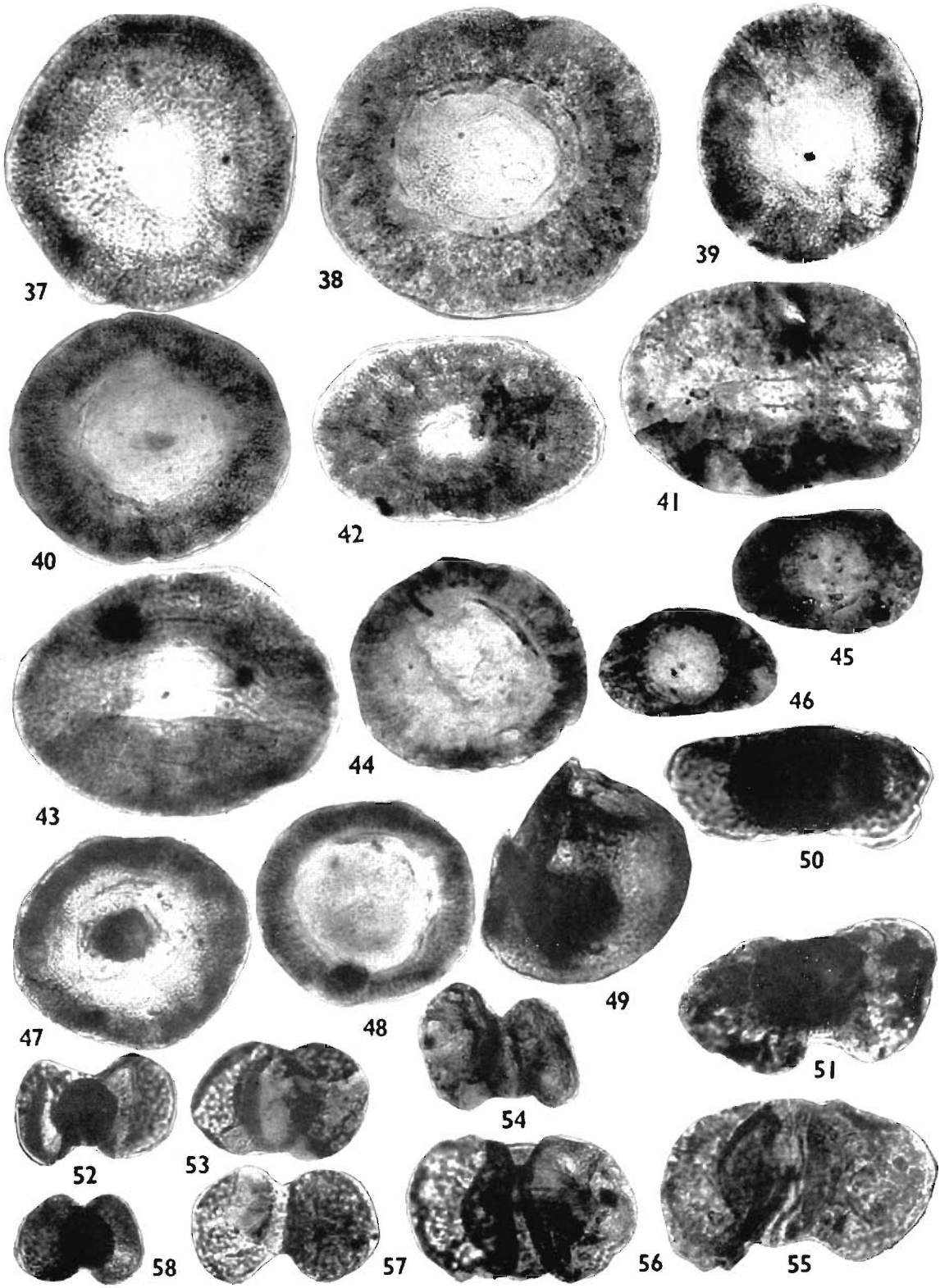
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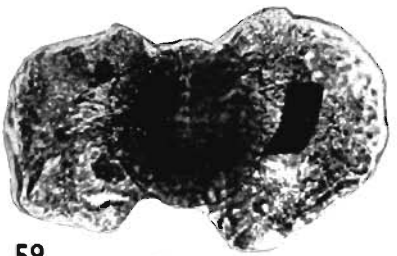
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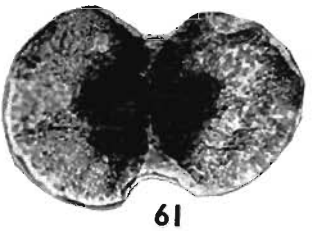
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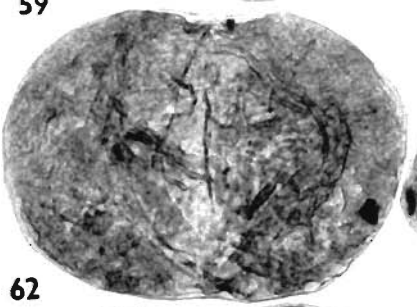
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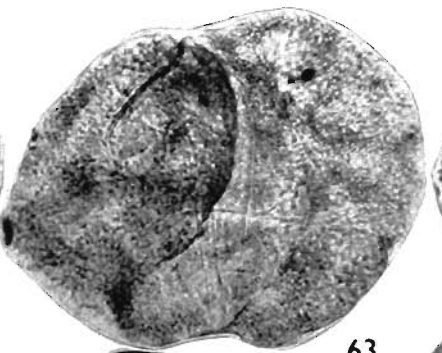
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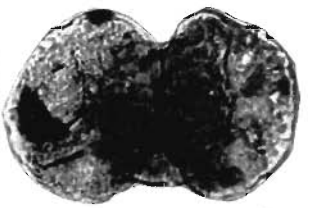
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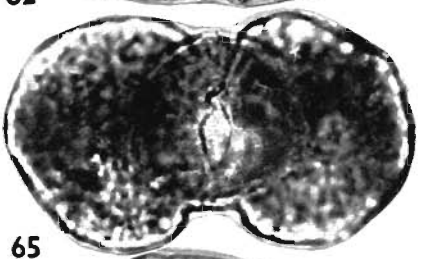
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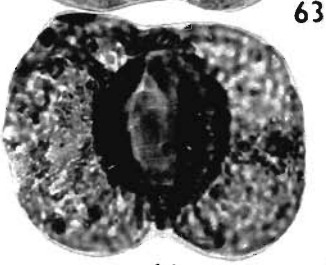
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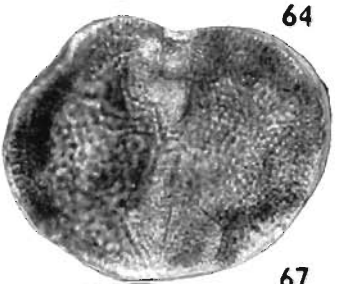
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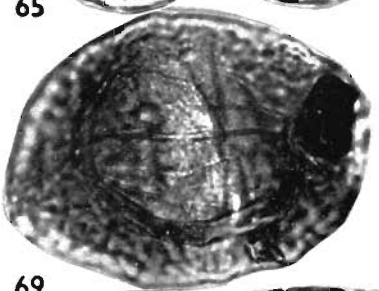
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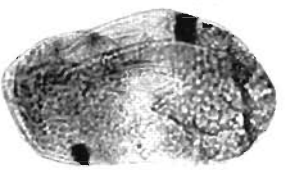
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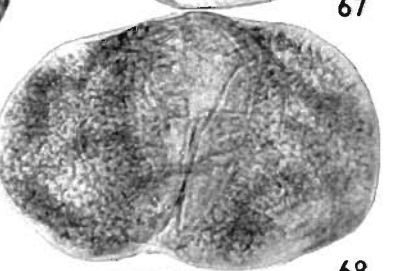
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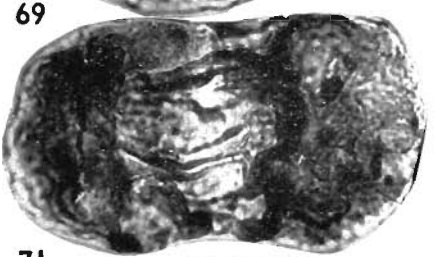
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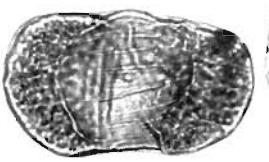
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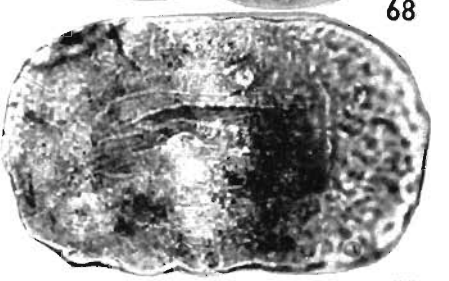
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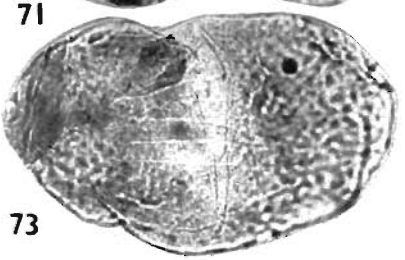
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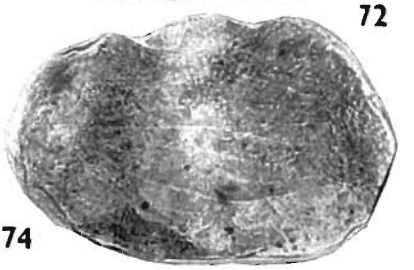
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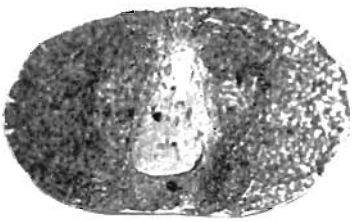
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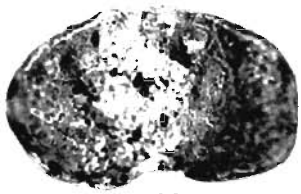
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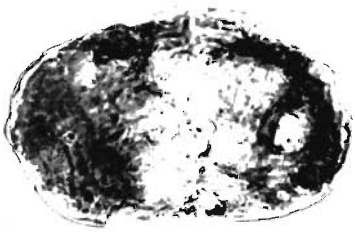
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