

# MIOFLORAL INVESTIGATIONS IN SOME COALS OF TALCHER COALFIELD (ORISSA) INDIA

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## ABSTRACT

The present paper contains a systematic description of miospore assemblage recovered from the Lower Gondwana Coals of Talcher coalfield. The mioflora has been referred to 36 genera and 71 species out of which 11 species are new. The new species have been described and illustrated and bimetric analyses of the morphographic characters, wheresoever necessary, have been done.

## INTRODUCTION

THE palynological studies have been done by Das (1958) and Navale and Tiwari (1966) in the coal bearing areas of Talcher coalfield belonging to Barakar Stage (Lower Gondwana), India but the knowledge of mioflora still remains incomplete as their descriptions are very limited and preliminary. The present investigation consists of an exhaustive taxonomic study of a large number of miospores dispersed in the above coals. The results of the investigation in part, including the correlation aspect, has been published separately (see BHARADWAJ & SRIVASTAVA, 1969a & 1969b) while a complete account of *Sporae dispersae* has been given here.

The material for the present investigation consists of 19 bore hole coal samples (for sampling details see BHARADWAJ & SRIVASTAVA, 1959a; TABLE 1) and 18 channel samples collected from the working horizons of Dera, Deulbera, Nandira and South Belanda collieries and 2 samples collected from the exposed coal bed near the village Gopalprasad in Talcher coalfield (TABLE 1).

## SYSTEMATIC DESCRIPTION

The *Sporae dispersae* of Talcher coalfield includes a number of trilete, monolete, monosaccate and disaccate miospores. A large number of specimens were studied and the degree of importance of more usual characters were taken into consideration. The species referred to the spore genera are almost similar to those already discussed by Bharadwaj (1962) and Bharadwaj and Salujha (1964). The various genera and species have been arranged according to

TABLE 1

LAB. SAMPLE No.	LITHOTYPE SAMPLES	COLLIERY
1	Vitrain — ( $V_3 + V_5 + V_6$ )	Dera colliery (Top Seam)
2	Fibrous Durain — ( $FD_2 + FD_3 + FD_6 + FD_8 + FD$ )	do
3	Durain — ( $D_1 + D_4 + D_{11} + D_{13}$ )	do
4	Vitrain — ( $V_1 + V_4$ )	Dera colliery (Bottom Seam, Bottom portion)
5	Fibrous Durain — ( $FD_3 + FD_5 + FD_6 + FD_7$ )	do
6	Durain — ( $D_2 + D_4$ )	do
7	Vitrain — (V)	Dera colliery (Bot. Seam, Top portion)
8	Fibrous Durain — ( $FD_1 + FD_2 + FD_3 + FD_4 + FD_5 + FD_6$ )	do
9	Durain — $D_8$	do
10	Vitrain	Nandira colliery (Bottom Seam)
11	Fibrous Durain	do
12	Durain	do
13	Vitrain	Deulbera colliery (Bottom Seam)
14	Fibrous Durain	do
15	Durain	do
16	Vitrain	South Belanda colliery
17	Fusain	do
18	Durain	do
19	Coal	Gopalprasad — Upp. Seam, mid. portion
20	Coal	Gopalprasad — Upp. Seam-1 bot. portion

the scheme of Potonié (1956, 1958, 1960). All the 36 genera and 71 species encountered in the present investigation have been listed here. The species marked with asterisk are new and have been described in detail.

*Leiotriletes* sp.

*Callumispora barakarensis* Bharad. & Sriv.

*Callumispora dubius* Bharad. & Sriv.

- Hennellysporites diversiformis* (B. & H.) Tiw.  
*Calamospora aplata* Bharad. & Sal.  
 \**Cyclogranisporites barakarensis* sp. nov.  
 \**Verrucosia sporites gondwanensis* sp. nov.  
*Lophotriletes rectus* Bharad. & Sal.  
*Brevitriletes communis* Bharad. & Sriv.  
*Brevitriletes unicus* (Tiw.) Bharad. & Sriv.  
*Brevitriletes levis* Bharad. & Sriv.  
*Horriditriletes curvibaculosus* Bharad. & Sal.  
*Horriditriletes novus* Tiw.  
*Microbaculispora barakarensis* Tiw.  
*Microbaculispora indica* Tiw.  
*Microbaculispora tentula* Tiw.  
*Cyclobaculisporites minutus* Bharad. & Sal.  
*Pseudoreticulatispora barakarensis* Bharad. & Sriv.  
*Indotriradites korbaensis* Tiw.  
*Indotriradites sparsus* Tiw.  
*Laevigatisporites minimus* (Wil. & Coe) Schopf, Wil. & Bent.  
*Laevigatisporites minor* (Loose) Pot. & Kr.  
 \**Tiwariasporis indicus* sp. nov.  
 \**Tiwariasporis gondwanensis* sp. nov.  
*Tiwariasporis* sp.  
*Densipollenites indicus* Bharad.  
*Densipollenites densus* Bharad. & Sriv.  
*Plicatipollenites indicus* Lele  
*Plicatipollenites diffusus* Lele  
*Plicatipollenites trigonalis* Lele  
 \**Plicatipollenites densus* sp. nov.  
*Cannanoropollis mehtae* (Lele) Bose & Mahesh.  
*Cannanoropollis densus* (Lele) Bose & Mahesh.  
*Cannanoropollis orientalis* (Tiw.) Bose & Mahesh.  
 \**Cannanoropollis talcherensis* sp. nov.  
*Parasaccites korbaensis* Bharad. & Tiw.  
*Parasaccites obscurus* Tiw.  
 \**Crucisaccites indicus* sp. nov.  
*Divarisaccus lelei* Venkat. & Kar.  
*Divarisaccus strengeri* Bose & Kar.  
 \**Cahentiasaccites indicus* sp. nov.  
*Potonieisporites barrelis* Tiw.  
 \**Potonieisporites talcherensis* sp. nov.  
*Platysaccus papilionis* Pot. & Kl.  
*Striatites obtusus* Bharad. & Sal.  
*Striatites tentulus* Tiw.  
*Striatites rhombicus* Bharad. & Sal.  
*Striatites irregularis* Tiw.  
*Striatites multistriatus* (B. & H.) Tiw.  
 \**Striatites indicus* sp. nov.  
*Verticypollenites gibbosus* Bharad.  
*Lahirites singularis* Bharad. & Sal.  
*Lahirites rarus* Bharad. & Sal.
- Lunatisporites fuscus* Bharad.  
*Gondwanipollenites decorus* (Bharad. & Sal.) Bose & Mahesh.  
*Gondwanipollenites magnificus* Bharad. & Sal.  
*Gondwanipollenites venustus* Bharad. & Sal.  
*Gondwanipollenites copiosus* (Bharad. & Sal.) Bose & Mahesh.  
*Strotersporites indicus* Tiw.  
*Faunipollenites varius* Bharad.  
*Faunipollenites goraiensis* (Pot. & Lele) Maithy  
*Illinites unicus* Kos.  
*Illinites delasaucei* (Pot. & Kl.) Gr. & Schw.  
*Illinites dissectus* (Hart) comb. nov.  
*Illinites novus* (Tiw.) comb. nov.  
*Vesicaspora ovata* (B. & H.) Wil. & Venkat.  
*Vesicaspora distincta* Tiw.  
*Sulcatisporites maximus* (Hart) Singh  
*Sulcatisporites tentulus* Tiw.  
*Pilasporites* sp. cf. *P. plurigenus* B. & H.  
*Ginkgocycadophytus novus* sp. nov.
- Anteturma** — *Sporites* H. Pot., 1893  
**Turma** — *Triletes* (Reins.) Pot. & Kr., 1954  
**Subturma** — *Azonotriletes* Lub., 1935  
**Infraturma** — *Laevigati* (Benn. & Kidst.) Pot., 1956
- Genus** — *Leiotriletes* (Naum.) Pot. & Kr. 1959
- Genotype* — *Leiotriletes sphaerotriangulatus* (Loose) Pot. & Kr.
- Leiotriletes* sp.  
 Pl. 1, Fig. 1
- Description* — Miospores are triangular; size ranges from 39-50  $\mu$ ; sides are slightly convex and angles are rounded. Trilete mark is distinctly defined; the rays are equal, more than 3/4 of the radius length and end shortly before the equator in the angles. Apex and vertex are slightly raised, often accompanied by folds; labra are thin. Exine is thin, laevigate and *extrema lineamenta* is smooth.
- Remarks* — These specimens resemble *Leiotriletes* sp. Bharadwaj and Salujha (1964) in overall characters. *L. virkkii* Tiwari (1965), however, differs from the present species in having much thicker exine.
- Genus** — *Hennellysporites* (Naum.) Tiw., 1968
- Genotype* — *Hennellysporites diversiformis* (B. & H.) Tiw., 1968.

*Hennellysporites diversiformis* (B. & H.)  
Tiw., 1968

*Remarks*—The specimens studied here compare very closely with the original ones. Centre of the miospore generally exhibits a small, darker triangular area with the vertices usually located at the ray ends. In some of my specimens the triangular area is sharply defined suggesting of an inner body but in others this outline is not sharply delimited. Similar triangular area is also visible in some specimens described by Balme and Hennelly (1956b, PL. 2, FIGS. 14-16).

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

**Subinfraturma** — *Granulati* Dyb. & Jach., 1957

**Genus** — *Cyclogranisporites* Pot. & Kr., 1954

*Genotype* — *Cyclogranisporites leopoldii*  
(Kr.) Pot. & Kr., 1954.

*Cyclogranisporites barakarensis* sp. nov.

Pl. 1, Figs. 2-4

*Holotype* — Pl. 1, Fig. 2. Size 22 $\mu$ ;  
Reg. No. 2962.

*Locus Typicus* — India (Orissa); Talcher coalfield, Gopalprasad coal bed.

*Stratum Typicum* — Upper Barakar.

*Diagnosis* — Circular trilete, sometimes subcircular, overall size 18-32  $\mu$  (mean 24  $\mu$ ), exine thin, microgranulose.

*Description* — Majority of the specimens range up to 22  $\mu$ . Grana are closely set and are usually less than 1  $\mu$  in size. Trilete mark is distinctly defined, arms are equal and extend more than half the body radius.

*Comparison* — *Cyclogranisporites barakarensis* sp. nov. resembles *C. gondwanensis* Bharad. & Sal. (1964) but differs comparatively in overall size. *C. gondwanensis* is a species reported from Raniganj Stage of Lower Permian, India and occurs there as a subdominant stratigraphic unit. Its overall size ranges from 22-36  $\mu$  with the maximum at 30  $\mu$  (graph 1). *C. barakarensis* ranges in size from 18 to 32  $\mu$  with the maximum at 22  $\mu$  (graph 1) and occurs as the most dominant biostratigraphic unit in Upper Barakar coal seams of Talcher coalfield.

**Subinfraturma** — *Verrucati* Dyb. & Jach., 1957

**Genus** — *Verrucosisporites* (Ibr.) Pot. & Kr.,  
1954

*Genotype* — *Verrucosisporites verrucosus*  
Ibr.

*Verrucosisporites gondwanensis* sp. nov.

Pl. 1, Figs. 5, 6

*Holotype* — Pl. 1, Fig. 5. Size 93  $\mu$ ; Reg. No. 2888.

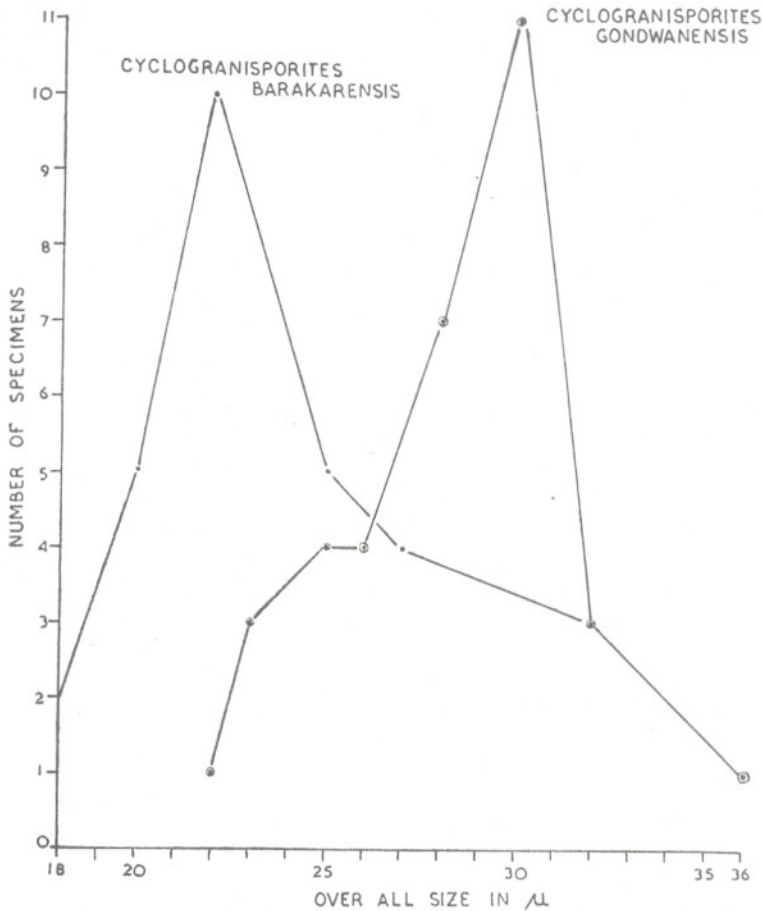
*Locus Typicus* — India (Orissa); Talcher coalfield, Dera colliery.

*Stratum Typicum* — Lower Barakar Stage.

*Diagnosis* — Subcircular miospore, size range 75-118  $\mu$ ; trilete mark weakly defined; exine finely microverrucose.

*Description* — Majority of spores measure 93  $\mu$ . Sometimes spores assume other shapes also due to irregular flattening. Rays are  $\frac{1}{2}$ - $\frac{2}{3}$  of the body radius long and equal. In some specimens one of the arms is weakly developed and short (PL. 1, FIG. 5). Exine 1-2  $\mu$  thick in cross section and set with closely spaced fine verrucae which are weakly developed but can be well defined in L-O analysis and are less than 1  $\mu$  in size. Secondary exinal folds occur irregularly distributed. Verrucae are compactly and uniformly arranged on both the faces of exine. Sometimes, in some specimens (PL. 1, FIG. 6), a thin membranous structure set with larger verrucae (1 $\mu$  × 1  $\mu$ ) is found scattered irregularly over the exine. This appears to be a part of perinous covering which is never found occurring uniformly and thus is not a constant character.

*Comparison* — *Verrucosisporites* (Ibr.) Pot. & Kr. (1952) described from northern hemisphere possesses coarser and irregularly distributed ornamentation and are much larger in size. Among the species described from Gondwana mioflora, *V. pseudoreticulatus* B. & Henn. (1956b; PL. 4, FIGS. 42-44) and Hart (1960; PL. 3, FIG. 36) have now been described as *Pseudoreticulatispora* Bharad. & Sriv. (1969b) on realization of its punctatoreticulate character. However, *V. distinctus* Tiw. (1965; PL. 1, FIGS. 10-12) compares very closely to *V. gondwanensis* sp. nov. in view of its ornamentation but on detailed examination, it has been found to be different in size range (graph 2). *V. distinctus* Tiw. (1965) has a distinct mode at 61  $\mu$  while *V. gondwanensis* sp. nov.



GRAPH - I

peaks at 93  $\mu$ . Mention may be made here, that the ornamentation observed in *V. gondwanensis* sp. nov. does not agree with that described from the northern hemisphere.

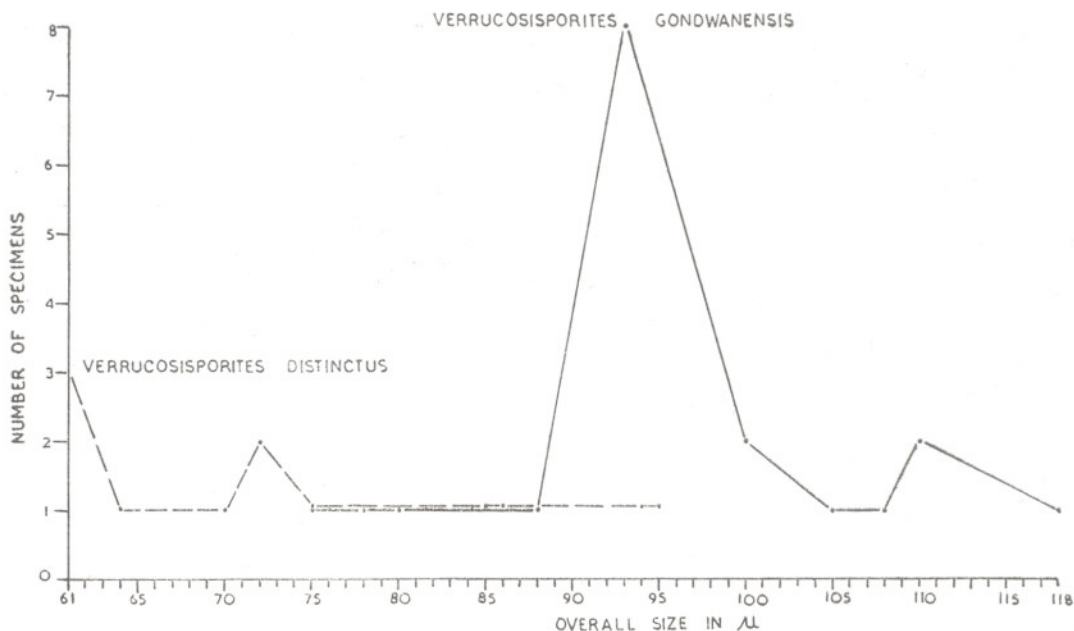
Turma — *Monoletes* Ibr. 1933  
 Subturma — *Azonomoletes* Lub. 1935  
 Infraturma — *Ornati* Pot. 1956

Genus — *Tiwariasporis* Mahesh. & Kar 1967

Genotype — *Tiwariasporis flavatus* Mahesh. & Kar. 1967.

Remarks — The pollen grains referred to *Tiwariasporis* Mahesh. & Kar were so far described as *Vittatina* (Lub.) Jan. (1962) from the Lower Gondwanas which apparently show near resemblance to the genotype. However, a close examination of such specimen in the present investigation

reveals a greater degree of dissimilarities. The proximal striations running parallel to the equator appears to be a common factor among all the forms of *Vittatina* while the distal surface of the specimens studied by me is marked with irregular striations rendering a reticuloid-verrucoid appearance of the surface. Similar observations have also been made by Balme and Hennelly (1956a; p. 62) in *Vittatina* (*Marsupipollenites*) *scutata* (Balm. & Henn.) Bharad. (1962). *Vittatina permegna* Tiw. (1965) also possesses similar distal reticuloid striations (l.c.; p. 207). *Welwitschiapites simplex* Tiw. (1965; p. 206; PL. 8, FIG. 50) are also described to have similar organization. The distal ornamentation of the genotype, *Vittatina subsaccata* and other species has not been described by Samoilovich (1953). However, Jansonius (1962) mentions in the



GRAPH - 2

emended diagnosis that the distal side, excluding the more or less inflated bladder-like structure, is without ornamentation, smooth or roughened. If this holds good for the type material from U.S.S.R. my specimens from the Lower Gondwanas are different from it. The specimens described by Wilson (1962; pp. 25, 26) and Klaus (1963; pp. 339-343) differ from the type of the genus in having distal ribs placed perpendicular to the proximal striations. These spores answer better to the circumscription of *Aumancisporites* (Alp.) Jan. (1962; p. 76). In view of the above reported variations associated with one common feature of longitudinally striated, non-saccate pollen grains and the fact that the description of the genotype gives no clear indication of any one of the above mentioned variations being normally associated with it, the Lower Gondwana forms have been described as *Tiwariasporis* by Maheshwari & Kar (1967).

The specimens studied in the present investigation show a regular orientation of the sculptural elements in linear rows on one face thus forming pseudo-striations. On the other face of the pollen grains these pseudo-striations become irregular rendering it a reticuloid-verruroid appearance of the surface.

*Tiwariasporis indicus* sp. nov.

Pl. 2, Figs. 20, 21

*Holotype* — Pl. 2, Fig. 20. Size  $100 \times 78 \mu$ ; Reg. No. 2890.

*Locus Typicus* — India (Orissa); Talcher coalfield; Dera colliery.

*Stratum Typicum* — Lower Barakar Stage.

*Diagnosis* — Pollen grains oval in shape, known size  $60-110 \mu \times 45-82 \mu$ , mostly  $70 \mu$  long (along the longer axis); thick, finely intrapunctate, puncta being less than  $0.5 \mu$  in size; monolete mark present; proximally 12-24 pseudo-striations present, distally exine reticuloid-verruroid; equatorial rim distinct.

*Description* — Exine is usually thick, as is perceptible along the margin, dark brown to yellow in colour and is uniformly intrapunctate. Proximally pseudo-striations are present, 22 in holotype, parallel to the equatorial axis dividing the whole surface into equal number of ribs which are  $2-3 \mu$  in width. Pseudo-striations are simple, also locally dichotomized, slightly converging and end at or near the poles and tend to merge with reticuloid striations surrounding small to large verrucae similar to those on the distal surface. Vertical striations interconnecting the horizontal ones are absent. Monolete mark is distinct in most of the

specimens and lies in between the horizontal striations. Labra are usually thick, slightly raised and simple. Distal side is marked with irregular striations forming a reticuloid-verrucoid pattern all over the surface (Pl. 2, Fig. 21). Verrucae are medium to small in size (usually 2-4  $\mu$ ), generally uniform but are sometimes larger in the middle decreasing gradually in size towards the pole. Distally the exine is thin and depressed widely around the pole. Nearer the lateral ends the depressed area is flanked by flap-like folds oriented at right angle to the longer axis. Equatorial rim is distinctly defined, usually 2-5  $\mu$  thick, slightly more thickened at the polar ends, surface of which is wavy and irregularly notched.

*Comparison* — *Tiwariasporis flavatus* Mahesh. & Kar differs from *T. indicus* in being smaller in size apart from other details. *T. simplex* (Tiw.) Mahesh. & Kar compares in overall size with the present species but differs in the absence of equatorial thickening and has numerous vertical partitions.

*Tiwariasporis gondwanensis* sp. nov.

Pl. 2, Figs. 22, 23

*Holotype* — Pl. 2, Fig. 22. Size  $92\mu \times 70\mu$ ; Reg. No. 2935.

*Locus Typicus* — India (Orissa); Talcher coalfield, Deulbera colliery.

*Diagnosis* — Overall size range 65-120 $\mu \times$  45-90  $\mu$ , mostly 85  $\mu$  (along the longer axis); proximal pseudo-striations 11-26 (11 in holotype), vertical partitions numerous, distally reticuloid-verrucoid; equatorial rim well defined (2-3  $\mu$  thick), slightly more thickened at poles.

*Description* — The spores are mostly oval to barrel-shaped with broadly rounded poles. Exine is usually thin, light yellow in colour and is finely intrapunctate, puncta being more distinct in thinner specimens. Proximal pseudo-striations are parallel to the longer axis, entire, simple or locally dichotomized, usually slightly converging and ending near the poles to form reticuloid pattern similar to that on the distal surface. Horizontal pseudo-striations are vertically crossed by many vertically connecting partitions. Ribs are broad, 3-5  $\mu$  wide in the middle. A monoete mark is perceptible in most of the specimens observed. Distally the striations are very much irregular

forming a reticuloid-verrucoid pattern. The verrucae are large to medium size (3-5  $\mu$ ) being usually larger in the polar region and smaller towards the equator. Distally the exine is depressed near the pole and is associated with flap-like infolds placed perpendicular to the long axis. *Extrema lineamenta* is vertically notched and irregular.

*Comparison* — *Tiwariasporis flavatus* Mahesh. & Kar differs being smaller in size. *T. indicus* distinguishes itself in having thicker exine and lacks vertical partitions.

*Tiwariasporis* sp.

Pl. 2, Fig. 24

*Description* — Pollen grain is bilaterally elongated, oval in outline with broad round lateral ends and overall size is 98-60  $\mu$ . Exine is thin and finely intrapunctate. 18 horizontal striations run all over the body on one surface which are simple or bifurcated and are interconnected with numerous vertical striations. Some horizontal striations extend to the other face at the terminal ends and run perpendicularly to the horizontal striations. A dark inner body is also enclosed within the grain which measures 75  $\mu \times$  46  $\mu$ . No germinal aperture is visible and the outline is irregular. The sculpture of the distal exine is masked by the inner body.

*Comparison* — Only one specimen of the above organization has been found and is distinctly preserved. The pollen grain is characterized by having a thick inner body which is not known in most of the described species.

*Anteturma* — *Pollenites* R. Pot. 1931

*Turma* — *Saccites* Erdt. 1947

*Subturma* — *Monosaccites* (Chit.) Pot. & Kr. 1954

*Infraturma* — *Apertacorpiti* Lele 1964

*Genus* — *Plicatipollenites* Lele, 1964

*Genotype* — *Plicatipollenites indicus* Lele, 1964.

*Plicatipollenites densus* sp. nov.

Pl. 1, Figs. 7, 8

*Holotype* — Pl. 1, Fig. 7. Size 84  $\mu$ ; Reg. No. 2886.

*Locus Typicus* — India (Orissa); Talcher coalfield, Dera colliery.

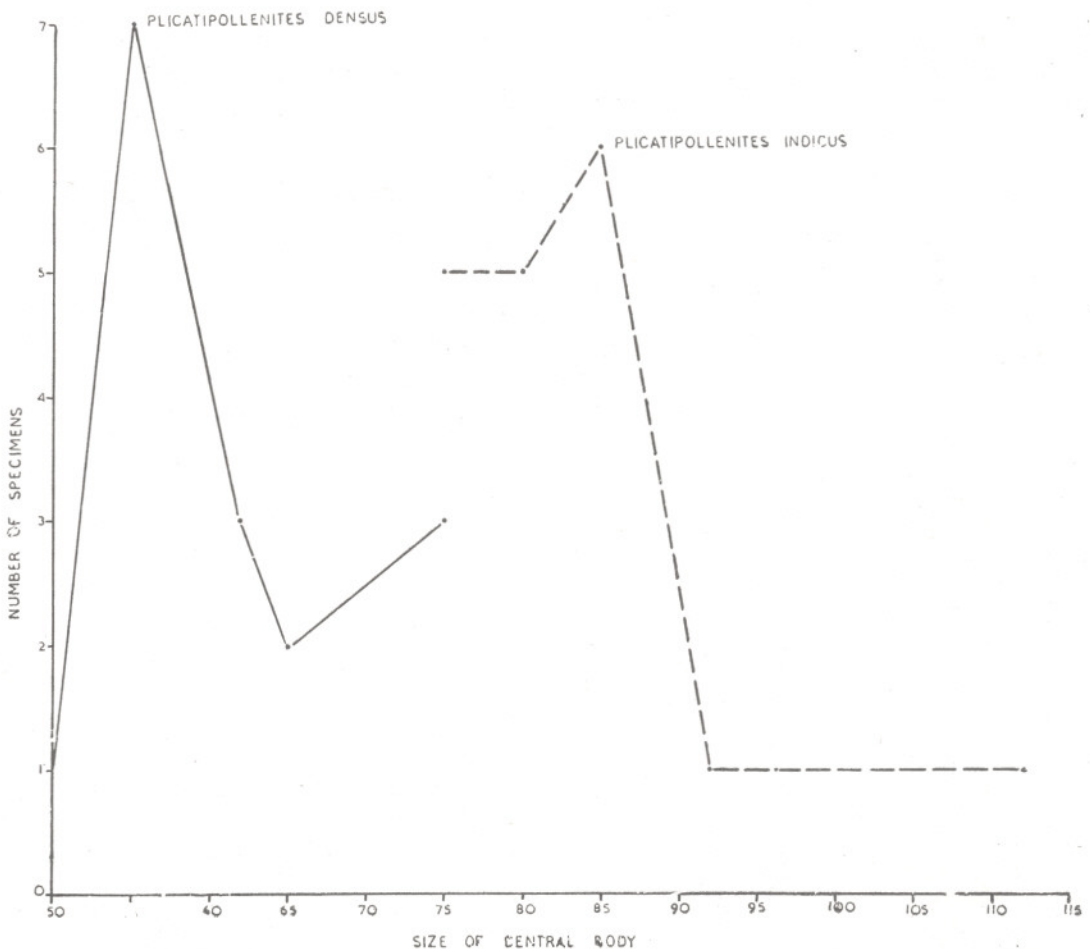
*Stratum Typicum* — Lower Barakar Stage.

*Diagnosis* — Known size range  $80-108\mu \times 85-103\mu$ , outline circular, undulated; central body circular, distinct, dense,  $50-63\mu$  in size ( $48\mu$  in holotype). Trilete mark distinct, rays  $\frac{1}{2}-\frac{3}{4}$  body radius, equal and placed at equal angles; exine thick, finely intramicroreticulate.

*Description* — Central body is circular, sometimes subcircular. Holotype is  $48\mu$  in diameter and is distinctly defined, dense and dark brown in colour. Saccus width is usually more than  $\frac{3}{4}$  of the body radius; attached equatorially over the proximal face, width almost  $20\mu$ , and distally subequatorial, slightly away from the body equator, almost  $23\mu$  wide. Saccus encroachment on the distal side does not exceed

$\frac{1}{4}$  of body radius and is always associated with a circular,  $2-5\mu$  thick body fold system which is placed slightly away from the body equator. Saccus is mediumly coarse, intrareticulate, muri are disposed radially; meshes do not exceed  $2\mu$  in size. Outline is frilled and undulated.

*Comparison* — The specimens included in *Plicatipollenites densus* sp. nov. compare closely with the genotype, *Plicatipollenites indicus*, but the former differs from the latter in having denser central body and comparatively smaller overall size (graph 3) of central body. *P. gondwanensis* Lele (1964) and *P. trigonalis* Lele (1964) are different in having polygonal and trigonal nature of body folds respectively. *P. diffusus* Lele (1964) has a diffused infold system. *P. magnus* Tiw.



GRAPH - 3

(1965) is comparatively very large in size and has roundly trigonal folds.

**Genus** — *Cannanoropollis* Pot. & Sah, 1960

*Genotype* — *Cannanoropollis janakii* Pot. & Sah, 1960.

*Cannanoropollis talcherensis* sp. nov.

Pl. 1, Figs. 9, 10

*Holotype* — Pl. 1, Fig. 9. Size 106  $\mu$ ; Reg. No. 2937.

*Locus Typicus* — India (Orissa); Talcher coalfield, South Belanda colliery.

*Stratum Typicum* — Lower Barakar Stage.

*Diagnosis* — Subcircular to roundly subtriangular, sometimes circular pollen grains, known overall size 100-135  $\mu$ ; central body triangular to sub-triangular, distinct, 55-85  $\mu$  in size (65  $\mu$  in holotype); trilete mark distinct, proximal attachment of saccus equatorial, distal attachment of saccus subequatorial approaching up to  $\frac{1}{2}$  the body radius and form a circular sulcus.

*Description* — Central body is distinctly defined, thin walled. Exine is very thin and finely microgranulose. Trilete mark is usually open, arms equal extending up to  $\frac{1}{2}$  the body radius; labra are thin and vertex is slightly raised. Saccus on the proximal surface is attached to the equator (12-22  $\mu$  wide) but on the distal surface it approaches up to half of the body leaving a circular saccus free area (25-34  $\mu$  wide). Zone of saccus attachment is distinct proximally while distally it thins out and becomes diffused as it approaches towards the centre of the body. Saccus is intramicroreticulated, meshes are disposed radially and are 2-3  $\mu$  in size.

*Comparison* — *Cannanoropollis triangularis* (Mehta) Bose & Mahesh. 1968 and *C. mehtae* (Lele) Bose & Mahesh. 1968 compare very closely with *C. talcherensis* in overall shape and organization. The specimens figured and descriptions given by Mehta (1944; pp. 129, 130; TEXT-FIG. 1(1); PL. 1, FIG. 1) and reinvestigations carried out by Lele (1964; pp. 157-159; TEXT-FIG. 8, PL. 2, FIGS. 15, 16) clearly indicate that the central body remains circular in the former two species. Distal inclination of the saccus in *C. talcherensis* is also comparable to that described in *C. orientalis* (Tiw). Bose & Mahesh. (1968) but in the latter species it is more sharply defined and is slightly irregular

due to radial nature of muri. However, *C. talcherensis* is also distinguishable from *C. orientalis* by its distinct trilete mark. Thus, it can be differentiated from the rest of the species of the genus by the combination of a subtriangular overall shape, subtriangular central body, distinct trilete mark and distally much inclined saccus leaving a circular sulcus.

**Infraturma** — *Amphisacciti* Lele, 1965

**Genus** — *Crucisaccites* Lele & Maithy, 1964

*Genotype* — *Crucisaccites latisulcatus* Lele & Maithy, 1964.

*Crucisaccites indicus* sp. nov.

Pl. 2, Figs. 18, 19

*Holotype* — Pl. 2, Fig. 18. Size 138  $\mu$ ; Reg. No. 2935.

*Locus Typicus* — India (Orissa); Talcher coalfield, Nandira colliery.

*Stratum Typicum* — Lower Barakar Stage.

*Diagnosis* — Overall size range 110-188  $\mu$  (along the longer axis), roundly subcircular to subrectangular with wide angles in overall shape; central body weakly defined, mono-lete mark not discernible; saccus attachment well defined.

*Diagnosis* — Central body outline is distinguishable in differential focus and is 120  $\mu$  in the holotype. Exine is thin and is finely intramicroreticulate. Outside the body saccus is very narrow (8-12  $\mu$ ) and encroaches the body cruciately for more than  $\frac{1}{2}$  the body radius. Zones of saccus attachment are slightly concave, thus leaving medianly a narrow saccus-free-area on both sides of the central body. Body-infolds near the zones of saccus attachment are absent. Saccus is coarsely and uniformly intrareticulate.

*Comparison* — *Crucisaccites latisulcatus*, the genotype, differs from the present species in having a thick central body and distinct body-infolds along the zone of saccus attachment. *C. monoletus* Maithy (1965) possesses a distinct monolete mark and a well defined central body. *C. indicus* sp. nov. distinguishes itself by its weakly defined central body, thin exine and distinct zones of saccus attachment without accompanying body-infolds.



**Infraturma** — *Caheniasacciti* Bose & Kar, 1966

**Genus** — *Caheniasaccites* Bose & Kar, 1966

**Genotype** — *Caheniasaccites indicus* sp. nov.

Pl. 2, Figs. 16, 17

**Holotype** — Pl. 2, Fig. 16. Size  $130 \times 86 \mu$ ; Reg. No. 2938.

**Locus Typicus** — India (Orissa); Talcher coalfield, South Belanda colliery.

**Stratum Typicum** — Lower Barakar Stage.

**Diagnosis** — Known size range  $100-130 \mu$  (along the horizontal axis)  $\times 67-70 \mu$  (along the vertical axis); central body circular to subcircular,  $58-63 \mu$  ( $64 \times 62 \mu$ ); monolete mark indistinct; sacci laterally continuous.

**Description** — Pollen grains are bilaterally symmetrical. Central body is circular to subcircular and distinctly defined. Exine is thin walled, finely intramicroreticulate and is usually accompanied with microfolds rendering a wrinkled appearance of exine. Sacci are larger than the central body, slightly swollen at the horizontally terminal ends. Laterally saccus is slightly notched and continuous,  $\pm 5-10 \mu$  wide. Proximal and distal attachment of saccus is subequatorial, the zone of saccus attachment is diffused and sacci in this region are slightly undulated giving a pleated appearance. Sacci intrareticulation is fine.

**Comparison** — The three described species by Bose and Kar (1966) compare with the present species in overall size and general organization but *Caheniasaccites flavatus* Bose & Kar differs in having horizontally oval central body and sulcus. *C. elongatus* Bose & Kar differs in possessing strongly developed, unfrilled lateral ridges and rectangular sulcus. The circular to subcircular central body of *C. ovatus* Bose & Kar is comparable to *C. indicus* sp. nov. but the latter species distinguishes itself in having larger overall size, diffused zone of saccus attachment and weakly developed undulations in the zone of saccus attachment.

**Infraturma** — *Vesiculomonoraditi* (Pant) Bhard. 1955

**Genus** — *Potonieisporites* (Bhard.) Bharad. 1964

**Genotype** — *Potonieisporites novicus* Bhard. 1954.

*Potonieisporites talcherensis* sp. nov.

Pl. 1, Figs. 11, 12

**Holotype** — Pl. 1, Fig. 11. Size  $98 \times 78 \mu$ ; Reg.No. 2860.

**Locus Typicus** — India (Orissa); Talcher coalfield, Dera colliery.

**Stratum Typicum** — Lower Barakar Stage.

**Diagnosis** — Bilaterally oval,  $88-123 \mu \times 64-78 \mu$  in overall size; central body subcircular to roundly rectangular,  $78-103 \mu \times 56-78 \mu$  ( $72 \times 70 \mu$  in holotype), mediumly thick and distinct, monolete mark well developed; exine finely microverrucose; saccus narrower at lateral sides, zones of saccus attachment ill defined.

**Description** — Central body is slightly denser than the saccus. Monolete mark is distinct, more than  $\frac{1}{2}$  of the body length, lips are thick and the ray ends are pointed. Saccus is attached equatorially over the proximal face, while the distal attachment is subequatorial and ill defined. Secondary fold is usually absent along the zone of saccus attachment. Saccus is smaller than the body and the lateral continuations are very narrow. Saccus intrareticulations are mediumly coarse and have the mesh size of  $1-2 \mu$ .

**Comparison** — *Potonieisporites talcherensis* sp. nov. differs from other species of *Potonieisporites* in having a broadly rectangular central body, a monolete mark with thickened lips, narrowly lateral continuation of the saccus and lack of secondary folds on the distal side delimiting the monolete mark.

**Subturma** — *Disaccites* Cook. 1947

**Infraturma** — *Striatiti* Pant, 1954

**Genus** — *Striatites* (Pant) Bhard. 1962

**Genotype** — *Striatites seawardii* (Virki) Pant, 1955.

*Striatites gopalensis* sp. nov.

Pl. 1, Figs. 13-15

**Holotype** — Pl. 1, Fig. 13. Size  $108 \mu$ ; Reg. No. 2951.

**Locus Typicus** — India (Orissa); Talcher coalfield.

**Stratum Typicum** — Barakar Stage.

**Diagnosis** — Known size range  $83-123 \mu$  (along horizontal axis); central body circular to subcircular,  $38-48 \mu$  ( $38 \mu$  in holotype), thick with a distinct marginal ridge;  $5-9$

horizontal striations present, vertical partitions absent; sacci diploxylo-noid, distal saccus free area narrow and straight.

*Description* — Pollen grains are bilaterally symmetrical. Central body possesses a distinct frilled marginal ridge,  $\pm 2 \mu$  wide. Exine is thick, dark brown, evenly microverrucose and marked with 5-9 horizontal striations which are usually simple, rarely bifurcated. Sacci are  $\pm$  hemispherical, distally inclined coming closer together, leaving  $\pm$  a narrow, straight saccus free area. Saccus intrareticulation is fine to mediumly coarse.

*Comparison* — The proper description of the genotype *Striatites seawardii* is not available and hence its comparison has not been taken into account. The species described by Bharadwaj and Salujha (1964), viz. *S. novus*, *S. rhombicus*, *S. obtusus* and *S. subtilis*, and by Tiwari (1965), viz. *S. irregularis* and *S. reticuloides* differ from the present species in the presence of vertical partitions. *S. medius* Singh (1964), *S. parvus* Tiw. (1965) and *S. tentulus* Tiw. (1965) are too small in size to be compared with. *S. gopalensis* sp. nov. compares closely with *S. communis* Bharad. & Sal. (1964) and *S. solitus* Bharad. & Sal. (1964) but the latter two differ in having thinner body without any equatorial rim.

**Infraturma** — *Disaccitrileti* Lesch. 1955

**Genus** — *Illinites* (Kos.) Pot. & Kr. 1954

*Genotype* — *Illinites unicus* Kos. 1950.

*Remarks* — Grebe and Schweitzer (1962) have studied the pollen grains obtained from the cones of *Ullmannia frumentaria* and have assigned the various forms to a number of species. Pollen grains recovered in the present investigation, although show a certain degree of variation, answer broadly to the variations mentioned in the pollen grains of *U. frumentaria*. Recently Bharadwaj (1964) has made comparative study of *in situ* pollen grains of *Lebachia*, *Ernestiodendron*, *Walchianthus* and some species of *Potonieisporites*. He has given a complete account of the similarities and dissimilarities between *Potonieisporites*, *Vestigisporites*, *Sahnites* and *Illinites* and the author has expressed his opinion that the first three genera should be recognized as synonyms of *Potonieisporites* due to their almost similar plan of organization, whereas the smaller pollen grains with distinct disaccoid organi-

zation and a monolete-quasi trilete mark should be considered as species of *Illinites*.

However, in my opinion the distinction between *Potonieisporites* and *Illinites* is rather slender morphographically although the two can be distinguished in practice.

*Illinites unicus* Kos., 1950

*Remarks* — Specimens observed by me resemble to the holotype especially in the nature of trilete mark, shape of the body and nature of sacci. Similar specimens have also been described by Virkki (1946) as *Pityosporites* sp. (Spore 81, p. 142; Pl. 8, Figs. 120-122) which has been referred to *Vestigisporites hennellyi* by Hart (1960) but the specimens described by Virkki possess two vertical secondary folds along the zones of distal saccus attachment. This character is more akin to *I. unicus* than to *V. hennellyi* and hence the specimens of Virkki should be referred to *I. unicus*.

*Illinites disectus* (Hart) comb. nov.

1960 — *Vestigisporites disectus* Hart, Pl. 2, Fig. 28.

1960 — *V. hennellyi* Hart, Pl. 1, Fig. 18; Pl. 2, Figs. 23, 30.

1965 — *Limitisporites disectus* (Hart) Bharadwaj & Salujha, Pl. 1, Figs. 29-31.

1965 — *Illinites delasaucei* (Pot. & Kl.) Gr. & Schw.: Tiwari Pl. 7, Figs. 163-166.

1955 — *Vestigisporites* spm. A, Balme & Hennelly, Pl. 6, Figs. 60, 62-64.

*Holotype* — Hart, 1960; Pl. 2, Fig. 30.

*Emended Diagnosis* —  $\pm$  haploxylo-noid with sacci narrowly, laterally connected. Central body thin walled, subcircular and possessing usually an indistinct monolete mark.

*Description* — Broadly oval to bilaterally flattened miospores with a size range from  $70-80\mu \times 45-75 \mu$ . Body is sometimes circular and ranges in size from  $45-75\mu \times 40-63 \mu$ , distinct, thin walled and microverrucose. Monolete mark is weakly defined and is straight to slightly angular. Saccus is attached equatorially over the proximal surface and subequatorially on the distal one. Saccus attachment on the distal side sometimes encroaches up to centre of the body. Zones of saccus attachment are weakly defined. Saccus is narrow on the lateral sides, usually  $3-5 \mu$  wide.

*Remarks* — The specimens described here compare in many respects with those described by Hart (1960, p. 15; Pl. 2, Figs. 23, 28, 30). Such specimens are very common in the older assemblage of Talcher coalfield. Bharadwaj and Salujha (1965) described such pollen grains as species of *Limitisporites dissectus* (Hart) comb. nov. However, Bharadwaj (1964) has finally suggested to include *Limitisporites* in *Illinites*.

*Illinites novus* (Tiw.) comb. nov.

1960 — *Limitisporites* cf. *rectus* (Lesch.) Hart; Pl. 2, Fig. 26.

1965 — *Vestigisporites novus*; Tiwari, Pl. 8, Figs. 169, 170.

*Holotype* — Bharadwaj & Tiwari, 1964b; Pl. 2, Fig. 28.

*Diagnosis* — See Tiwari, 1965; p. 202.

*Description* — Pollen grains are usually small. Overall size ranges from 68-82 × 45-68  $\mu$ . Central body is circular to sub-circular, 43 × 58  $\mu$ , thick walled, dense and slightly brown to golden yellow in colour. Exine of the body is finely microverrucose. Monolete mark is distinct, narrow with thin lips usually about three quarter of the body radius in length and straight. Sacci are broader at the polar ends and narrow to absent at the lateral sides, so that a completely disaccoid organization becomes apparent in some cases. Zones of saccus attachment over the distal face are not well defined. Saccus intrareticulations are fine.

*Remarks* — Specimens studied here are very much similar to *Vestigisporites novus* (1965). Some of the specimens are slightly smaller in size as compared to the prescribed range but rest of the characters are similar in all respects. Hart (1960) described a similar specimen from Africa as *Limitisporites* cf. *rectus*. *Vestigisporites* spm. A (Pl. 6, Figs. 58, 59, 61) described by Balme and Hennelly (1955) from Australia compare very closely to this species.

**Turma** — *Aletes* Ibr., 1933

**Subturma** — *Azonaletes* (Lub.) Pot. & Kr., 1954

**Infraturma** — *Psilonapiti* Erdt., 1947

**Genus** — *Pilasporites* B. & H., 1956a

*Genotype* — *Pilasporites calculus* Balme & Hennelly, 1956a.

*Pilasporites* sp. cf. *P. plurigenus* B. & H., 1956a

Pl. 2, Fig. 27

*Holotype* — Balme & Hennelly, 1956a; Pl. 3, Fig. 57.

*Specific Description* — The spore is circular to subcircular in shape and range in size from 40-42  $\mu$  × 34-37  $\mu$ . Exine is fairly thick, 1-2  $\mu$  along the equator and is generally smooth. In the median region the exine is slightly thinner and sometimes ruptured. No haptotypic features are present.

*Remarks* — The specimen described above answer well to the circumscriptions of the holotype but for the size and the age. My specimens are slightly larger than the biggest specified for the species by Balme & Hennelly (1956a) and come from Lower Permian whereas *P. plurigenus* is reported from the Upper Permian of New South Wales.

**Turma** — *Plicates* (Naum.) Pot. 1960

**Subturma** — *Monocolpates* Iver. & Troels-Smith 1950

**Infraturma** — *Intortes* (Naum.) Pot. 1958

**Genus** — *Ginkgocycadophytus* Samoil., 1953

*Genotype* — *Ginkgocycadophytus caperatus* (Lub.) Samoil., 1953.

*Ginkgocycadophytus novus* sp. nov.

Pl. 2, Figs. 25, 26

*Ginkgocycadophytus cymbatus* (Balme & Hennelly); Pottonié & Lele; Pl. 3, Figs. 85-95.

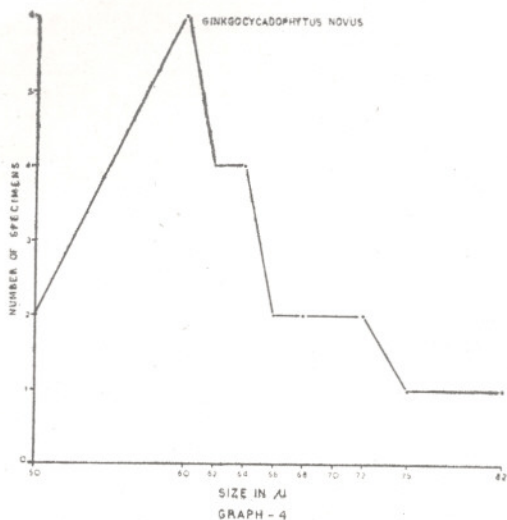
*Holotype* — Pl. 2, Fig. 25. Size 56  $\mu$ ; Reg. No. 2939.

*Locus Typicus* — India (Orissa); Talcher coalfield, South Belanda colliery.

*Stratum Typicum* — Lower Barakar Stage.

*Diagnosis* — Known size 50-82  $\mu$  × 25-40  $\mu$ ; exine finely intrapunctate; colpus narrow in the middle, wider at the ends.

*Description* — Pollen grains are elongated, spindle shaped with narrow, rounded ends. Exine is sometimes finely granulose sculptured. Colpus extends full length of the grain, 2-12  $\mu$  apart in the median region and slightly wider at either ends.



*Comparison* — *Ginkgocycadophytus vetus* and *G. cymbatus* described by Balme and Hennelly (1956a) resemble *G. novus* sp. nov. in the nature of colpus but differ in being distinctly smaller in size. The specimens described by Potonié and Lele (1959)

as *G. cymbatus* compare very closely to *G. novus*. The specimens included in *G. cymbatus* by Balme and Hennelly (*l.c.*) are much smaller in size range having a mean of 49  $\mu$  while most of the specimens studied by me and by Potonié and Lele (*l.c.*) too are of the size of 60  $\mu$  (graph 4). Also *G. cymbatus* is described from a younger horizon and is geographically widely separated from India. *G. korbaensis* Tiw. (1965) compares with the new species assigned here in possessing similar size of pollen grains but differs in having a uniformly narrow colpus.

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## EXPLANATION OF PLATES

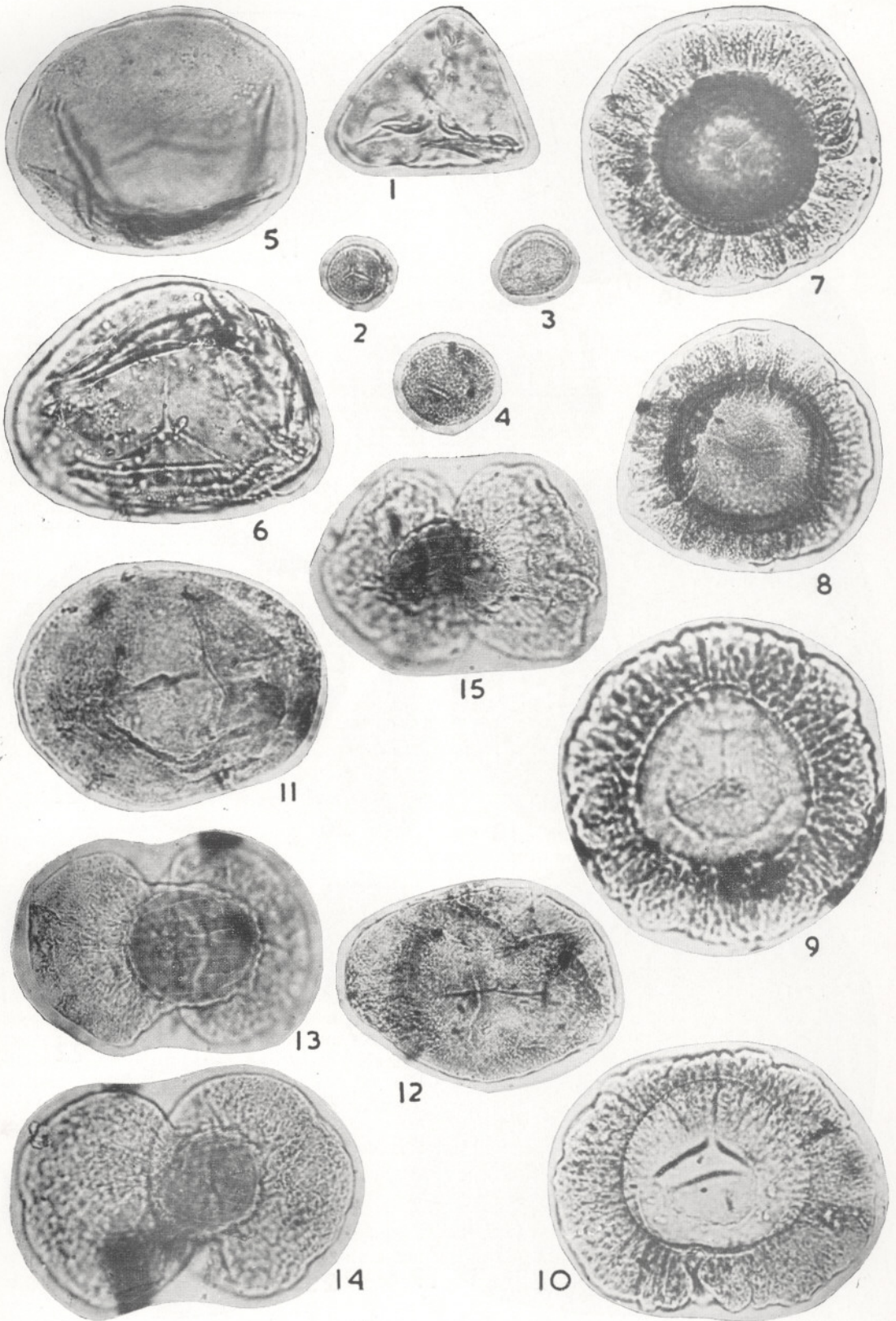
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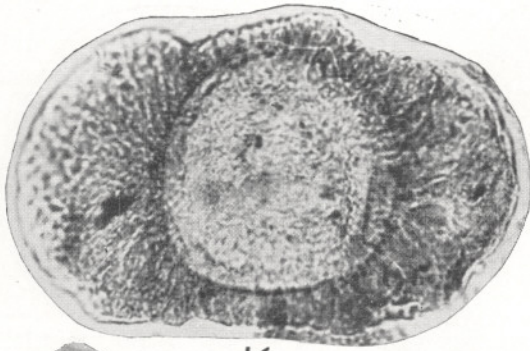
## PLATE 1

1. *Leiotriletes* sp., Reg. No. 2929.
2. *Cyclogranisporites barakarensis* sp. nov., Holotype, Reg. No. 2962.
3. *C. barakarensis* sp. nov., Reg. No. 2949.
4. *C. barakarensis* sp. nov., Reg. No. 2970.
5. *Verrucosisporites gondwanensis* sp. nov., Holotype; Reg. No. 2888.
6. *V. gondwanensis* sp. nov., Reg. No. 2903.
7. *Plicatipollenites densus* sp. nov.; Holotype; Reg. No. 2886.
8. *P. densus* sp. nov., Reg. No. 2927.
9. *Cannanoropollis talcherensis* sp. nov., Holotype; Reg. No. 2937.
10. *C. talcherensis* sp. nov., Reg. No. 2935.
11. *Potonieisporites talcherensis*, sp. nov., Reg. No. 2888.
12. *P. talcherensis* sp. nov., Holotype; Reg. No. 2860.
13. *Striatites gopalensis* sp. nov., Holotype; Reg. No. 2949.
14. *S. gopalensis* sp. nov., Reg. No. 2951.
15. *S. gopalensis* sp. nov., Reg. No. 2951.

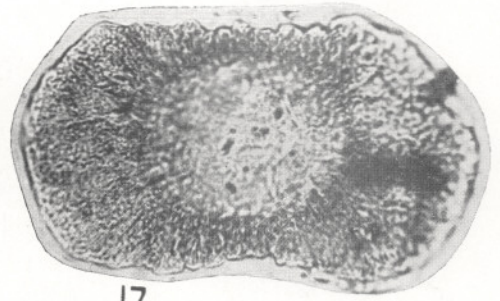
## PLATE 2

16. *Caheniasaccites indicus* sp. nov., Holotype; Reg. No. 2938.
17. *C. indicus* sp. nov., Reg. No. 2937.
18. *Crucissaccites indicus* sp. nov., Holotype; Reg. No. 2935.
19. *C. indicus* sp. nov., Reg. No. 2899.
20. *Tiwariasporis indicus* sp. nov., Holotype (Proximal view) Reg. No. 2890.
21. *T. indicus* sp. nov., Distal view; Reg. No. 2943.
22. *T. gondwanensis* sp. nov., Holotype (Proximal view); Reg. No. 2935.
23. *T. gondwanensis* sp. nov., Distal view; Reg. No. 2904.
24. *Tiwariasporis* sp., Reg. No. 2858.
25. *Ginkgocycadophytus novus* sp. nov., Holotype; Reg. No. 2939.
26. *G. novus* sp. nov., Reg. No. 2938.
27. *Pilasporites* sp. cf. *P. plurigenus* B. & H., Reg. No. 2938.





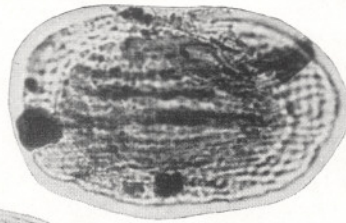
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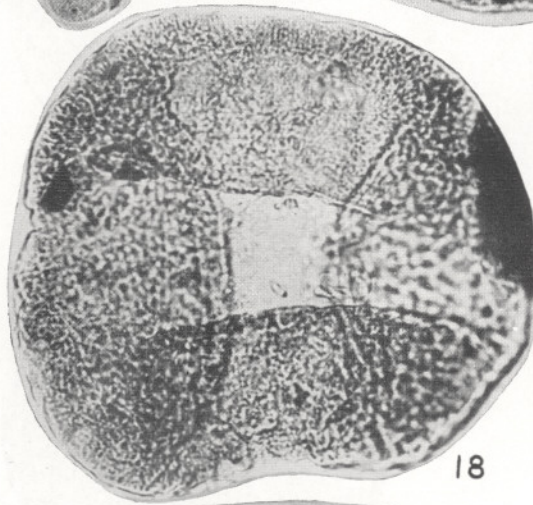
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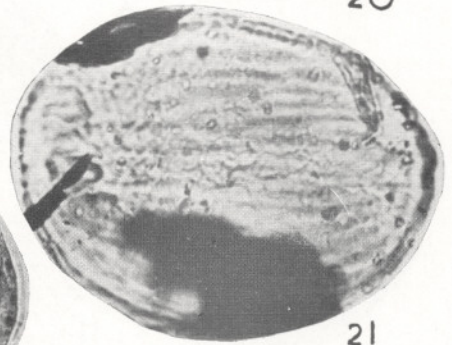
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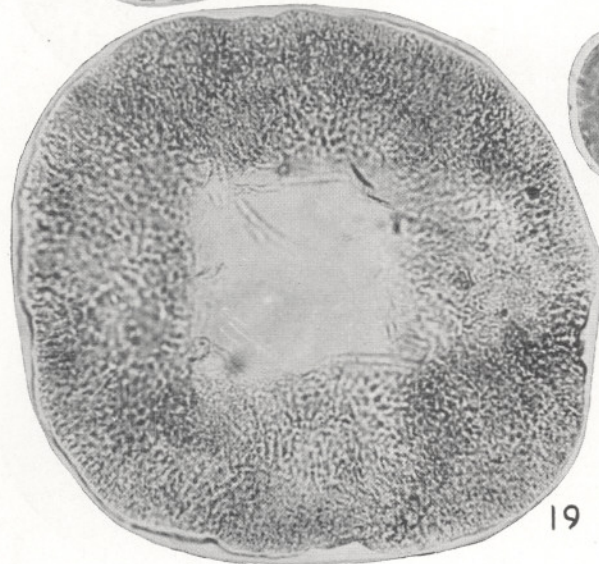
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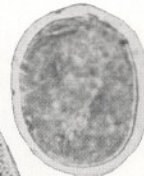
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