Morphographic study of Permian palynomorphs: *Callumispora, Parasaccites, Crucisaccites* and *Faunipollenites*

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Taxonomy is the primary requisite for biostratigraphy, and objective resolution of organisations as well as finer morphography leads to effective circumscription of taxa for taxonomy. Obviously, such an approach is critical for dispersed microfossils where *form* and *shape* remain the only tools for classification.

The palaeopalynology has come to its age and the inevitable discrepancies which had crept in during its initial stage, have been now identified in delimitation of taxa. In this catalogue, an attempt has been made to review the generic and specific groups in four Permian palynotaxa, viz., *Callumispora, Parasaccites, Crucisaccites* and *Faunipollenites*. On this line of approach, more taxa will be taken up subsequently, with a view to streamline their taxonomic treatment. The ultimate aim is to evolve a simplar, logical and practical system of identification based on major qualitative expressions of spore-poilen construction and exine characters.

The relative abundance of these four genera through Lower Gondwana formations of India has also been determined and their index-value discussed. As such, the distribution of species of these genera is not known from the earlier works. It is therefore hoped that the future workers would deal each genus up to the specific level for determination of their distribution which will prove very useful for finer correlation. Only the selected species of distinct identity and restricted range have real practical value in biostratigraphy.

Key-words—Morphography, Palynology, *Callumispora, Parasaccites, Crucisaccites, Faunipollenites*, Permian, Lower Gondwana (India).

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सारांश

परमी युगीन परागाणविकरूपकों का आकारिकीय अध्ययनः केल्यूमिस्पोरा, पैरासेक्काइटिस, क्रूसिसेक्काइटिस एवं फ़ॉनिपॉलिनाइटिस

रामशंकर तिवारी, सुरेश चन्द्र श्रीवास्तव, अर्चना त्रिपाठी एवं विजया

जैवस्तरविन्यास के लिए वर्गिकीय अध्ययन अत्यन्त आवश्यक है, वर्गिकीय अध्ययन हेतु वर्गकों के परिसीमन करने में सूक्ष्म-आकारिकीय अध्ययन एवं अंगविन्यास के उद्देश्यात्मक विश्लेषण की महत्वपूर्ण भूमिका है। ऐसा दृष्टिकोण स्पष्टतया विकीरित सूक्ष्म-पादपाश्मों के लिए समालोचना का विषय है विशेषतया जहां वर्गीकरण प्ररूप एवं आकार पर ही आधारित हो।

पुराएरागाणविक अध्ययन में अब पर्याप्त कार्य किया जा चुका है तथा प्रारम्भ में जो अपरिहार्य असंगतियाँ रह गई थीं वर्गकों के परिसीमन में उन सभी की पहचान कर ली गयी है। इस कैटलॉग में परमी युगीन चार परागाणविक-वर्गकों के प्रजातीय एवं जातीय समूहों की विवेचना करने का प्रयास किया गया है ये वर्गक **केल्यूमिस्पोरा, पैरासेक्काइटिस, क्रूसिसेक्काइटिस** एवं **फ़ॉनिपॉलिनाइटिस** हैं। इसी दृष्टिकोण को ध्यान में रखते हुए और वर्गकों की वर्गीकीय स्थिति स्पष्ट करने के लिए उनका अध्ययन किया जायेगा। उक्त अध्ययन का मुख्य उद्देश्य बीजाणु-परागकणों की संरचना सम्बन्धी मुख्य गुणात्मक व्याख्याओं एवं बाह्यचोल के लक्षणों पर आधारित अभिनिर्धारण की एक सरलतम, तर्कसंगत तथा व्यावहारिक प्रणाली विकसित करना है।

प्रस्तुत कैटलॉग में भारत के अधरि गोंडवाना शैल-समूहों में विद्यमान इन चार प्रजातियों की आपेक्षिक बाहुल्यता सुनिश्चित की गई है तथा इनके सूचक-मान की विवेचना भी की गई है। वास्तव में पहले किये गये शोध-कार्यों से इन प्रजातियों की जातियों के वितरण का पता नहीं चलता। अतएव ऐसी आशा है कि भविष्य में शोधकर्त्ता प्रत्येक प्रजाति के वितरण को सुनिश्चित करने के लिए इनका जातीय स्तर तक विवेचन करेंगे जो कि यथार्थ सहसम्बन्धन करने में बहुत उपयोगी सिद्ध होगा। जैवस्तरिक अध्ययन में केवल विशिष्ट पहचान एवं सीमित विस्तार वाली जातियों की ही वास्तविक उपयोगिता है।

PALYNOLOGICAL studies of the Permian sediments in India started in nineteen thirtees, and by the turn of seventies the taxa-boom reached its culmination.

Such a situation was, however, inevitable at those initial stages because new palynofloras were being handled which contained very widely diversified pollen and spores produced by Glossopteris Flora. The numerosity of proposals for new species, and their loose circumscription in some cases, have led to diminish the utility of species as stratigraphic markers. It is now felt that the time has come when important generic groups must be redefined in view of the accumulated data, and the vague species should be recircumscribed so as to make them effective for zonations. This catalogue is the result of such an approach. It includes an annotated account of four Permian genera—*Callumispora, Parasaccites, Crucisaccites* and *Faunipollenites*. To achieve a better understanding, the data gathered in course of our studies during the last several years have been incorporated in the generic descriptions. Various species have also been resolved and re circumscribed. Such resolution has been based on the re-examination of types, where available, and also on the study of several comparable forms. In case where holotypes were not traceable, the lectotypes are designated to represent the taxa; similarly, isotypes are also proposed for such species where they were not identified in the original protocol. In these four genera some species have been identified which do not find their place in the genera to which they were originally assigned. This has made the systematics more comprehensive.

Callumispora, a more or less circular spore with laevigate exine having intrapunctate structure, is a characteristic taxon in Permian and Triassic of India and Australia. It has been ascertained that the structure of the exine is not a secondary deformity; it is the basic regular and organised character, which differentiates it from *Punctatisporites*. The size-range of spores and peculiar exine thickness are considered as criteria for species circumscription.

Parasaccites is a well defined monosaccate pollen in which the saccus encroaches on to the body on both the faces equally, giving rise to the 'para' condition of attachment. Various species of this genus have been resolved and only six well-defined species have been retained. Similarly *Crucisaccites*, markedly identified on the basis of its 'cruciate' organization of saccus attachment, has been restudied for the resolution of its species. Many new characters have been recorded in this taxon and the additional features of exine saccus-folds and monolete mark have been brought to light.

The striate-disaccate pollen in Permian assemblages constitute a complex population. The prolific variation in striations, body shape and saccus attachment makes the striate group a difficult area of delimitation for clean species which could be effectively used in stratigraphy. In this account, the genus *Faunipollenites* has been taken for resolution. The ill-defined body nexine characterizes this disaccate pollen. It is relatively a simpler group. Earlier the species were proposed usually on the basis of overall size, which, however, do not stand in view of merging boundaries of various size-clusters. The width of distal saccus-free area also guides for species identification.

Scanning electron microscopy, utilized in some cases, deciphered significant surface characters and organization. The protosaccate fill of the saccus in the saccate pollen could be ascertained in the transmitted light by L-O analysis (Tiwari, 1981). Such analysis has otherwise also indicated that almost all the Permian saccate pollen possess protosaccate condition of the saccus.

The type specimens, referred to as slide no. BSIP, are stored in BSIP Museum.

MORPHOTAXONOMY

Genus—Callumispora Bharadwaj & Srivastava 1969

Type species—*Callumispora barakarensis* Bharadwaj & Srivastava 1969.

Original diagnosis—"Circular, dark brown miospores; exine laevigate with tendency to become punctate and microverrucose in inter-ray area and elsewhere intrapunctate; exine 2-7 μ thick; trilete mark present" (after Bharadwaj & Srivastava, 1969; p. 220).

Discussion—The circular, subcircular or roundly triangular spores bearing a trilete mark with punctate exine were described under the genus *Punctatisporites* Ibrahim 1933. In the year 1969, Bharadwaj and Srivastava distinguished a group of spores which were characteristically trilete, spherical with differentially structured exine to accommodate them under a new name *Callumispora*. Subsequently, Bharadwaj and Varma (1974) further distinguished the genus *Callumispora* from *Punctatisporites* on the basis of overall shape and nature of exine. They also emended the diagnosis of *Punctatisporites* which reads as follows: "Trilete bearing spores, amb triangular, exine finely punctate sculptured" (after Bharadwaj & Varma, 1974: p. 107).

The genus *Callumispora* is thus referable to spores with circular shape, and laevigate, but with intrapunctate structure in the exine (Pl. 1, fig. 1), while *Punctatisporites* is punctate sculptured. The basic difference between the two taxa lies in the structured exine *vis a vis* sculptured exine.

The reassessment of morphography evolved during the recent years, and also in view of its comparative variation in different species, the diagnosis of *Callumispora* needs an emendment.

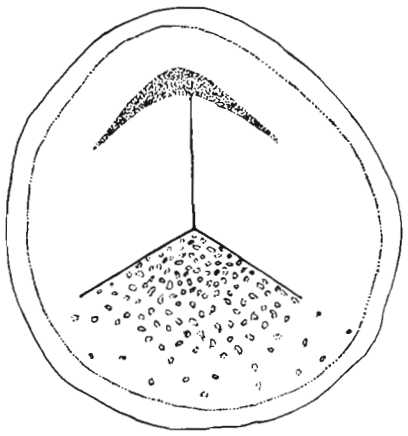
Emended diagnosis—Trilete spores with radial symmetry, spherical to sub-spherical in shape; trilete mark clear with distinct labra, arcuate rims absent; exine laevigate, intrapunctate structured, often exhibiting sharply defined exine thickness in optical section.

Description (elaborated)—Amb circular, trilete mark well-defined and never reduced or vestigial. Rays straight, traversing 3/4 spore radius or more, equal to each other in length and placed at equal angles. Ray-ends tapering. Labra thin and vertex slightly raised (Pl. 2, figs 1-3), but never associated with folds.

The exine thickness varying considerably (1-8 μm), the thickness demarcation line being distinctly visible in optical section along the amb margin in flattened specimens. The exine thickness in a group of spores appearing to be stratified, being divisible into two or more layers, the inner one thick and dark brown while the outer thin and yellowish brown (Pl. 1, fig. 1). In such cases, the concentric rings could be counted up to eight in number (Text-figs 2a, b). However, in another group of spores of this genus no such differentiation is perceptible even if the exine is considerably thick (Pl. 1, fig. 4).

Exine with various degrees of intrapunctate structure in different parts of specimen. In the inter-ray area the structure consisting of sparsely to closely distributed intrapuncta but elsewhere uniformly, hazily fine or distinctly fine. In certain cases the intrapuncta prominent, slightly sunken and densely set on the contact area but gradually reduced towards the margin (Pl. 1, fig. 5; Pl. 3, fig. 3). Between the puncta the exine surface simulating a microverrucose-like pattern, apparently differentiating a contact area (Pl. 1, figs 1, 2, 5). In other cases, the puncta uniformly distributed, being coarse to very fine in nature (Pl. 1, fig. 4).

Comparison—Callumispora compares closely with *Punctatisporites* Ibrahim 1933 emend. Bharadwaj & Varma 1974, but is distinguishable by its circular amb, and laevigate, structured exine. The exine in *Punctatisporites* is punctate sculptured. *Eupunctisporites* Bharadwaj 1962 reported from the Raniganj Stage (Upper Permian) of India is distinguishable by its circular shape and distinctly punctate (pitted) exine. *Ricaspora* Bharadwaj & Salujha 1964, also from Raniganj Stage of India, has a thin granulose perisporium all around. *Retusotriletes* Naumova 1953 bears a distinct, unstructured contact area.



Text-figure 1—Reconstruction of organisation of *Callumispora* Bharadwaj & Srivastava 1969, proximal view showing overall shape and thick intrapunctate exine.

Organisation (Text-fig. 1)—The overall shape of the spore is circular. However, subcircular to roundly triangular shapes may be assumed due to folding or flattening. The plane of flattening of the spore is not constant as is apparent from inconsistent position of the trilete mark with reference to the amb of the flattened spore. Trilete mark is distinct. Exine is intrapunctate structured.

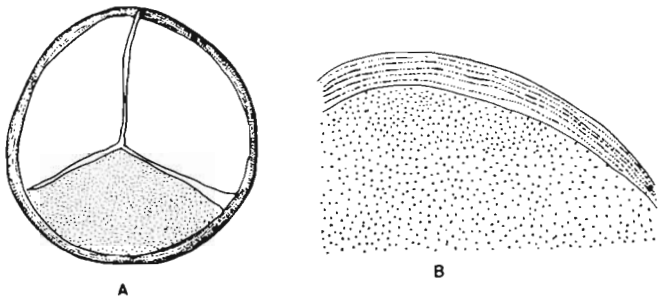
List of species on record:

Callumispora barakarensis Bharadwaj & Srivastava 1969
C. tenuis Bharadwaj & Srivastava 1969
C. tenuis var. *minor* Bharadwaj & Srivastava 1969
C. gretensis Balme & Hennelly 1956 emend. Bharadwaj & Srivastava 1969
C. fungosa (Balme) Bharadwaj & Srivastava 1969 emend. Bharadwaj & Tiwari 1977
C. adensa Bharadwaj, Kar & Navale 1976
C. uniformis (Tiwari) Chandra & Lele 1979
C. magna Kumaran & Maheshwari 1980
C. paliensis Tiwari & Ram-Awatar 1989
C. saksenae Tiwari & Ram-Awatar 1989

List of species resolved:

On the basis of exine structure, shape, overall size range, nature of trilete mark and exine thickness, the following species have been retained in this genus:

Callumispora barakarensis
C. magnifica (= *Callumispora paliensis*)
C. fungosa
C. gretensis (= *Punctatisporites lucidulus, P. subtritus, P. uniformis, P. ganjrensis, P. mukherjei, Callumispora tenuis, C. tenuis* var. *minor*)
C. adensa



Text-figure 2A—Line drawing of holotype of *Callumispora magnifica* (Bose & Maheshwari, 1968) comb. nov., showing overall shape and thick, uniformly intrapunctate structured exine; **2B**—Line drawing of part of Text-fig. 2A enlarged to show thick and stratified nature of exine.

Besides, the species of *Punctatisporites* which have been here considered under *Callumispora* are as follows:

Punctatisporites magnificus Bose & Maheshwari 1968
P. lucidulus Playford & Helby 1968
P. subtritus Playford & Helby 1968
P. ganjrensis Lele & Maithy 1969
P. lufupaensis Maheshwari 1969
P. mukherjei Mukherji & Ghosh 1972

The following species do not find their place under the genus *Callumispora*:

Punctatisporites punjabensis Pant & Srivastava 1964
P. pyramidicus Singh 1964
P. spathulatus Singh 1964
P. reticulatus Pant & Srivastava 1965
P. plicatus Bose & Kar 1966
P. indicus Tiwari 1968
P. foveolatus Maheshwari & Bose 1969
P. maiturensis Maheshwari & Banerji 1975
P. dejerseyi Foster 1979
P. priscus Bharadwaj & Salujha 1965
Callumispora magna Kumaran & Maheshwari 1980
C. saksenae Tiwari & Ram-Awatar 1989

The exine of the above species are not intrapunctate structured, and hence they cannot find their place in the genus *Callumispora*. In *Punctatisporites pyramidicus* and *P. spathulatus* the exine is described to be smooth while in *P. punjabensis* and *P. reticulatus* it is sculptured. *P plicatus* is a badly-preserved specimen, hence it is difficult to ascertain the characters. In *P. foveolatus* the exine is very thin and inter-ray area is almost foveolate. *P. priscus* also has very thin, folded exine which is smooth and does not appear to be structured. *P maiturensis* bears forked ray-ends. *Callumispora magna* bears verrucae-like sculpture over the exine. *C. saksenae* possesses flappy lacinate folds along the trilete rays; such a character is absent in *Callumispora*. Thus, most of these species bear supra-surface features; therefore, they even do not belong to the genus *Punctatisporites*.

Occurrence—Early Permian (Talchir Formation) to Early Triassic (Panchet Formation).

Prominence—Karharbari Formation (Early Permian).

Description of species resolved:

Callumispora barakarensis Bharadwaj & Srivastava 1969 emend.
Pl. 1, figs 1-3

Holotype—Bharadwaj and Srivastava, 1969; pl. 1, fig. 1; size 117 μm; Slide no. BSIP 2904; Nandira Colliery, Talchir Coalfield, Orissa; Barakar Formation, Permian.

Isotype—Bharadwaj and Srivastava, 1969; pl. 1, fig. 2; Slide no. BSIP 2978.

Original diagnosis—"Circular, thick-walled trilete, size range 88-140 μ but mostly 100 μ. Trilete mark distinct, rays equal, 30-40 μ in length. Exine golden brown, 4-6 μ in optical section, stratified and laevigate. Inter-ray area microverrucose sculptured. Exine faintly structured all over but showing sparsely distributed intrapunctation in inter-ray area" (after Bharadwaj & Srivastava, 1969, p. 222).

Discussion—The distribution of exine structure in the present species is not uniform. The intrapuncta are prominent and sparsely set in inter-ray area but they gradually get reduced in number

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PLATE 1 →

(Stage Co-ordinates are given as England Finder No. = EF:)

1 *Callumispora barakarensis* Bharadwaj & Srivastava 1969, holotype in proximal view showing intra-puncta in inter-ray area and thick stratified exine; Slide no. BSIP 2904, EF : M26/4, × 750.
2. *Callumispora barakarensis* Bharadwaj & Srivastava 1969, proximal view showing coarse intrapuncta and thick stratified exine; Slide no. BSIP 9907, EF : Q44/2, × 750.
3. *Callumispora barakarensis* Bharadwaj & Srivastava 1969, proximal view showing thick exine; Slide no. BSIP 9908, EF : P46/1, × 750.
4. *Callumispora gretensis* (Balme) Bharadwaj & Srivastava 1969 here emended. Specimen illustrated by Bharadwaj and Srivastava (1969) as Holotype of *C. tenuis* in proximal view showing uniform intrapuncta and thick non-stratified exine; Slide no. BSIP 2930, EF : V31/1, × 750.
5. *Callumispora barakarensis* Bharadwaj & Srivastava 1969, inter-ray area of holotype enlarged showing densely set intrapunctate structure. × 1,000.

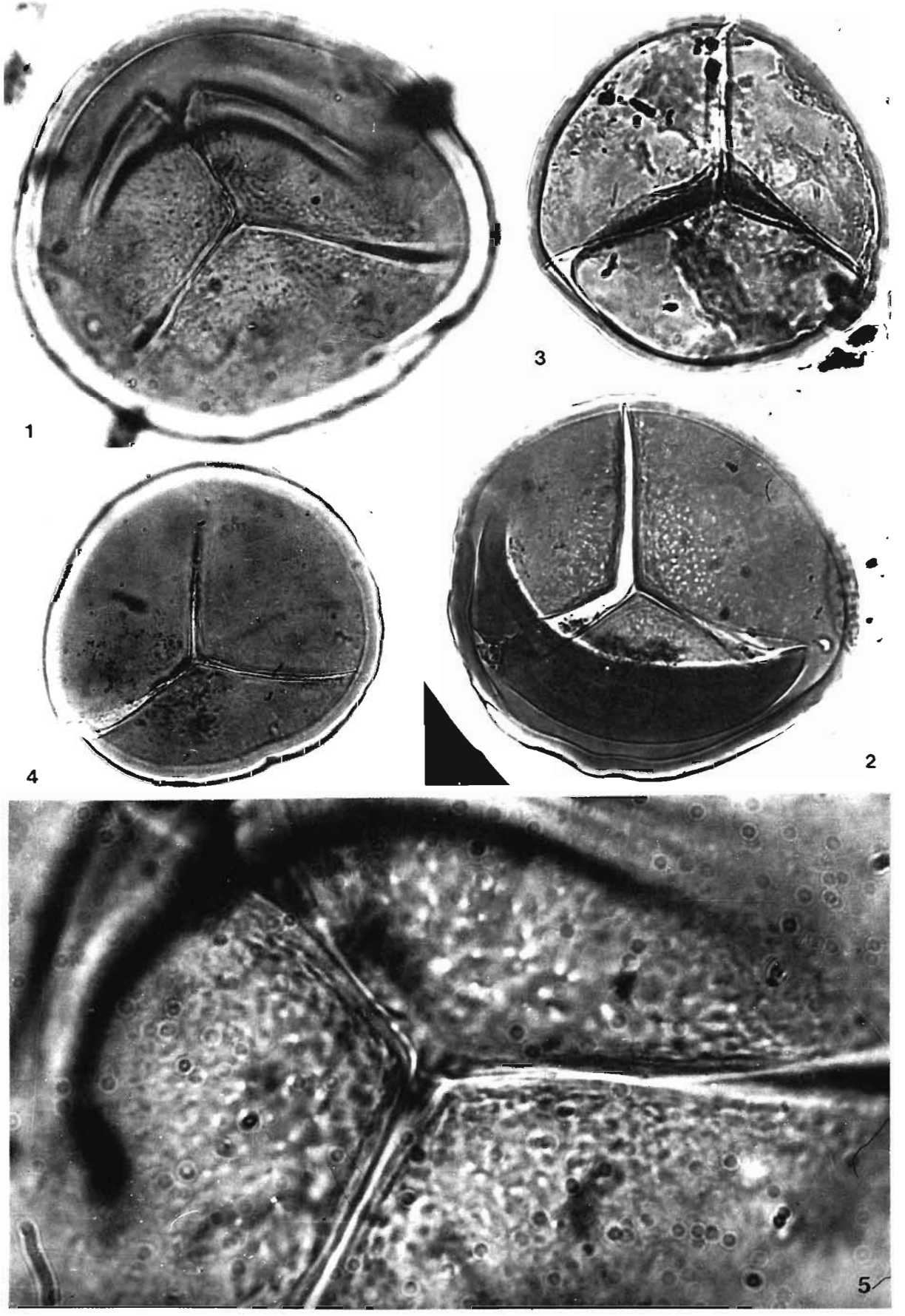
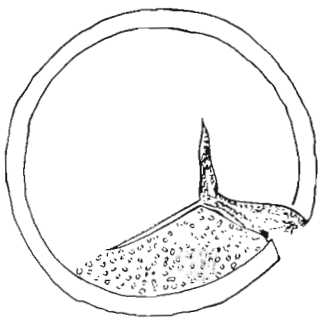


PLATE 1



Text-figure 3—Line drawing of holotype of *Callumispora fungosa* Balme 1973 showing thick and coarsely intrapunctate exine.

towards periphery and disappear thus simulating to differentiate a contact area (Pl. 1, fig. 1). The puncta are deep seated in the contact area and the exine between them are slightly scabrate (Pl. 1, fig. 5). Elsewhere, the exine is uniformly and faintly structured

Emended diagnosis—Circular, thick-walled trilete, size range 88-140 μm but mostly around 100 μm. Trilete mark distinct, rays equal, 3/4 radius in length. Exine in optical section up to 6 μm thick, stratified and laevigate. Inter-ray area marked with distinct sparsely set intrapuncta, apparently simulating an *area contagionis*. Exine beyond the contact area faintly structured. *Extrema lineamenta* smooth.

Description (elaborated)—Spores generally circular in overall shape. Trilete mark well-defined, with equal rays ending abruptly Labra thin and simple, never associated with secondary exinal folds. Vertex slightly raised. Exine fairly thick, 4-6 μm in thickness, 6 μm in holotype, slightly thicker along the rays than in inter-ray areas. In optical section exine appearing stratified, divisible into two layers, the inner thick and dark brown and the outer, thin, yellowish brown layer. Inter-ray area marked with sparsely set distinct intrapuncta apparently simulating an *area contagionis*. Exine beyond the contact area faintly structured. *Extrema lineamenta* smooth.

Callumispora magnifica (Bose & Maheshwari 1968) comb. nov.
Text-figs 2a, b

1968 *Punctatisporites magnificus* Bose & Maheshwari, pl. 3, figs 5-7, text-fig. 2.
1989 *Callumispora paliensis* Tiwari & Ram-Awatar, pl. 1, figs 7-9; text-fig. 1

Holotype—Bose and Maheshwari, 1968; pl. 3, fig. 5, size 102 μm, Slide no. RG 14191-8; Luanda, after the fall (about 2-5 ft thick exposure in river bed); Permian.

Original diagnosis—"Spores circular or subcircular; trilete distinct, rays 2/3-4/5 spore radius long; exine thick with concentric rings, intramicropunctate, equator smooth" (after Bose & Maheshwari, 1968, p. 19).

Discussion—The exine of the present species is 4-7 μm thick and shows distinct concentric rings (up to 6, Bose & Maheshwari, 1968, pl. 3, fig. 7). The surface of the exine is smooth but shows uniformly distributed fine intrapunctations all over. These two characters clearly indicate that this species must find its place in the genus *Callumispora*.

Description (elaborated)—Spores circular or subcircular in polar view, 58-130 μm in diameter; trilete rays distinct, sometimes slightly excentric, 2/3-4/5 spore radius long (22-56 μm), rarely attaining the spore equator, equal in length, tapering at the ends. Exine 4-7 μm thick, showing up to 6 concentric rings (Text-fig. 2a, b), the inner darker and the outer thin hyaline in colour; *extrema lineamenta* smooth. Intramicropunctate structure of exine uniformly distributed all over, intrapuncta fine, closely placed.

Comparison—The thickness of exine and size in this species is comparable with *C. barakarensis* and *C. fungosa*. However, *C. barakarensis* differs in having coarser intrapuncta in inter-ray area apparently differentiating a contact area while *C. fungosa* contains coarser, anastomosing intrapuncta all over the body.

Remarks—*C. paliensis* is identical in the nature of exine and extent of trilete rays with *C. magnifica*. Hence, it has been considered as synonym of the latter.

Callumispora fungosa (Balme) Bharadwaj & Tiwari 1977
Pl. 3, figs 1, 2; Text-fig. 3

1963 *Punctatisporites fungosus* Balme, pl 4, fig. 10.

Holotype—Balme, 1963; pl. 1, fig. 10, size 114

PLATE 2 →

1-3. *Callumispora* Bharadwaj & Srivastava 1969, SEM photomicrographs.
1 Showing raised trilete mark in a depressed contact area.
2. Showing shape, smooth exine and raised trilete mark.
3. Showing smooth surface and raised exine due to the presence of crescentic fold outside the inter ray area.

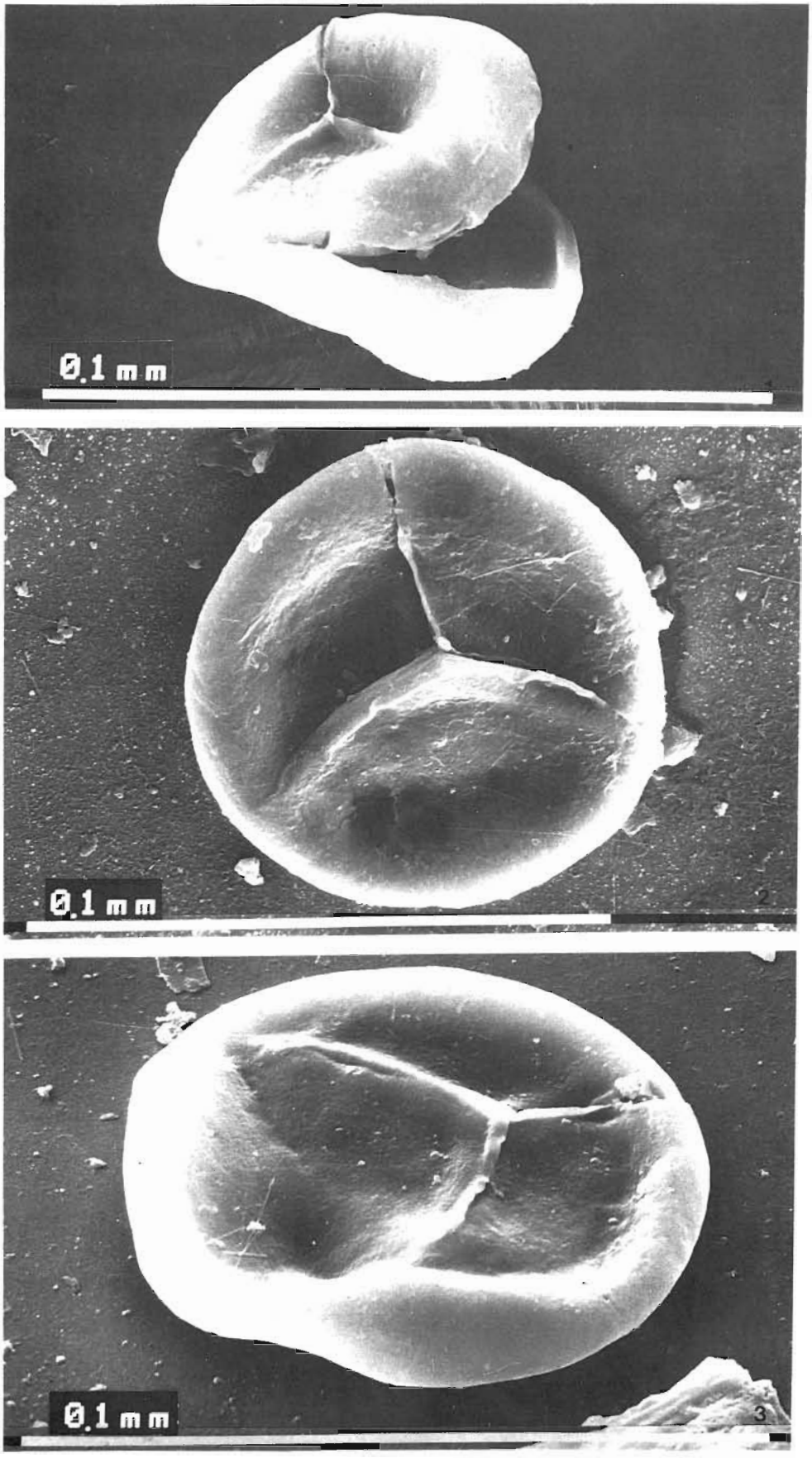


PLATE 2

μm, slide no. 47544, Well at Point 217, Upper Greenough River area (Sample 44070), Western Australia; Kockatea Shale, Early Triassic.

Paratype—Balme, 1963; pl. 1, fig. 11; slide no. 47545.

Original diagnosis—"Amb circular, periphery smooth, off-polar compressions common and exine frequently ruptured. Trilete, scar distinct, laesurae straight and often of unequal length but seldom extending more than about half-way to the equatorial margin. Groove of commissure visible in some specimens. Exine very thick, with fine irregularly distributed pits visible under oil immersion. Narrow anastomosing pits and channels sometimes developed, particularly in the area of the proximal pole (pl. 4, fig. 11). These channels are probably due to partial destruction of the exine, either during fossilisation or as result of the maceration process" (after Balme, 1963, p. 16).

Discussion—Bharadwaj and Tiwari (1977) considered that the exine of the above specimens is coarsely intrapunctate and emended the diagnosis of species to accommodate under the genus *Callumispora*. In such specimens the puncta are coarse and show anastomosing pattern as observed by Balme (1963). The anastomosing channels appear to be natural and are not developed during fossilisation or maceration process. Similar characters have also been observed by Bharadwaj and Tiwari (1977) from Permo-Triassic sediments of India. Therefore, *Punctatisporites fungosus* (Balme, 1963) was assigned to the genus *Callumispora*. The exine also is very thick in this species and exhibits concentric layers similar to the type species

Emended diagnosis—"Circular; trilete rays straight, half to two-third radius long, exine 4-7 μm thick with distinctly visible, somewhat coarse intrapunctation all over the body" (after Bharadwaj & Tiwari, 1977, p. 35).

Description (elaborated)—Exine 6-7 μm thick showing distinct concentric rings in optical section. Intrapuncta coarse, shallow, less than 1 μm in diameter, irregularly dispersed and showing anastomosing channels; structure more pronounced in the vicinity of proximal pole.

Comparison—The thickness of exine is comparable with that of *Callumispora barakarensis* and *C. magnifica* but the uniformly distributed coarser intrapuntation distinguishes *C. fungosa* from the above two species.

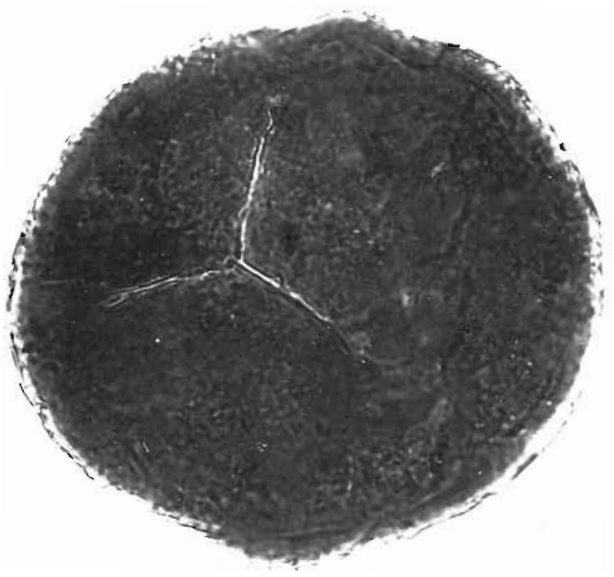
Callumispora gretensis (Balme & Hennelly) Bharadwaj & Srivastava 1969 emend.
Pl. 1, fig. 4; Pl. 3, figs 4, 5

1956 *Punctatisporites gretensis* Balme & Hennelly, pl. 2, figs 11-13.
1968 *Punctatisporites lucidulus* Playford & Helby, pl. 9, fig. 1.
1968 *Punctatisporites subtritus* Playford & Helby, pl. 9, fig. 1.
1969 *Punctatisporites uniformis* Tiwari, pl. 1, fig. 4.
1969 *Callumispora tenuis* Bharadwaj & Srivastava, pl. 1, fig. 3.
1969 *Callumispora tenuis* var. *minor* Bharadwaj & Srivastava, pl. 1, fig. 5.
1969 *Punctatisporties ganjrensis* Lele & Maithy, pl. 1, fig. 2
1969 *Punctatisporites lufupaensis* Maheshwari, pl. 1, fig. 2.
1972 *Punctatisporites mukherjei* Mukherji & Ghosh, pl. 2. figs 2a, b.

Holotype—Balme and Hennelly, 1956; pl. 2, fig. 11; size 110 μm (ca.), (designated in Bharadwaj & Tiwari, 1977, p. 34); Main Greta Seam, Hebburn no. 2 Colliery, New South Wales; Greta Coal Measures, Early Permian.

PLATE 3 →

1, 2. *Callumispora fungosa* (Balme) Bharadwaj & Tiwari 1977:
1. specimen illustrated by Bharadwaj & Tiwari 1977 as *C. fungosa* in proximal view showing thick exine; Slide no. BSIP 4669-5, EF : P21, × 750.
2. A part of specimen in fig. 1 enlarged to show thick stratified nature of exine, and coarser intrapuncta, × 1,000.
3. *Callumispora* Bharadwaj & Srivastava 1969, SEM photomicrograph of inter-ray area showing depressed nature of exine due to intrapuncta. The exine in between intrapuncta simulate verrucae-like pattern.
4, 5. *Callumispora gretensis* (Balme & Hennelly) Bharadwaj & Srivastava 1969 here emended.
4. Specimen illustrated by Lele and Maithy 1969 as holotype of *Punctatisporites ganjrensis* in proximal view; Slide no. BSIP 2823, EF : U43/4, × 750.
5. Proximal view of specimen illustrated by Tiwari, 1968 as Holotype of *Punctatisporites uniformis*; Slide no. BSIP 2764, EF : O32, × 750.
6, 8. *Callumispora magnifica* (Bose & Maheshwari) comb. nov. showing uniform intrapunctate exine structure and extent of trilete rays up to equator.
6. Specimen illustrated by Tiwari and Ram-Awatar, 1989 as holotype of *Callumispora paliensis* in proximal view; Slide no. BSIP 9308, EF : O32, × 500.
8. Slide no BSIP 9308, EF : H15/4, × 500.
7. *Callumispora adensa* Bharadwaj, Kar & Navale 1976, Isotype in proximal view; Slide no. BSIP 5157/7, EF : X47, × 750.



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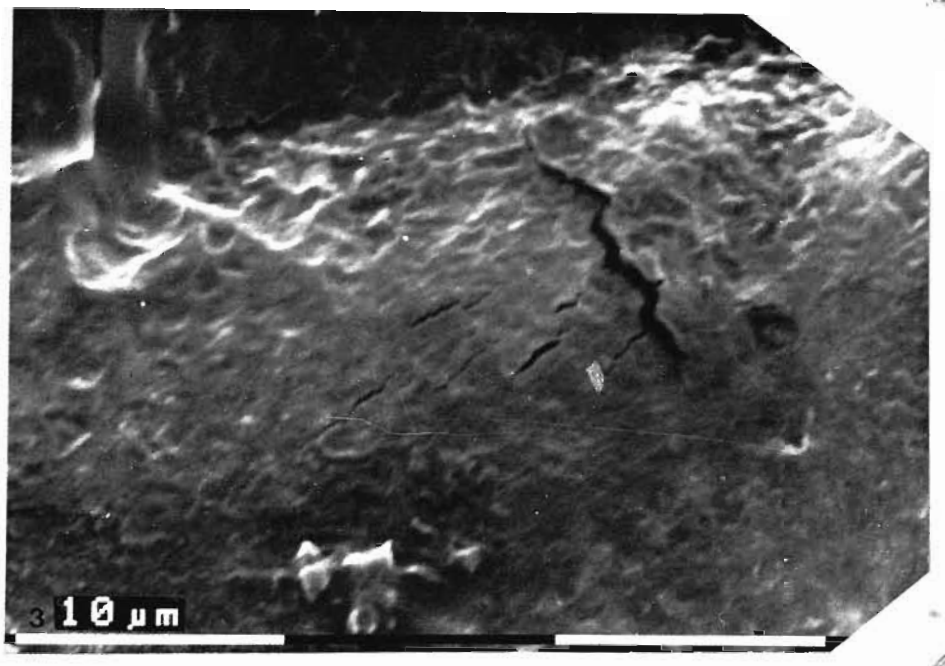

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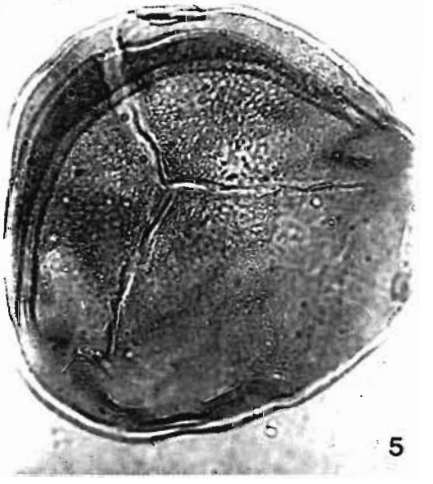

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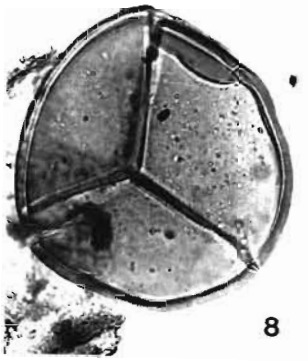

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PLATE 3

Text-figure 4—Line drawing of *Callumispora gretensis* (Balme & Hennelly) Bharadwaj & Srivastava here emended. Specimen illustrated by Balme and Hennelly, 1956 as *Punctatisporites gretensis*, Pl. 2, fig. 11 (Holotype), showing uniformly finely intrapunctate exine.

Original diagnosis—"Amb circular. Trilete, sutures straight and clearly defined extending about three quarters of the spore radius, lips prominent, sometimes slightly raised, short arcuate concentric folds occasionally present at the extremities of the rays. Exine about 4 μm thick, psilate or finely granulate" (after Balme & Hennelly, 1956, p. 245).

Discussion—Balme and Hennelly (1956) described *Punctatisporites gretensis* from the Lower Permian of New South Wales and considered its exine to be smooth or finely granulate. Later, Bharadwaj and Srivastava (1969) suggested that exine of these spores is intrapunctate structured, hence, this species was accommodated in *Callumispora*. The exine of the first illustrated specimen by Balme and Hennelly (1956, pl. 2, fig. 11) appears to be finely intrapunctate in structure; it is not sculptured (Text-fig. 4). The exine is fairly thick but does not show concentric rings as is evident in the type specimen. Several other species have been described in subsequent years, which possess similar nature of exine, the only difference being in size ranges. These characters are, however, overlapping. The resolution through bimetric analyses appears to be difficult in normal practice. Therefore, it has been concluded that they represent one species.

The characters considered here to be significant are:

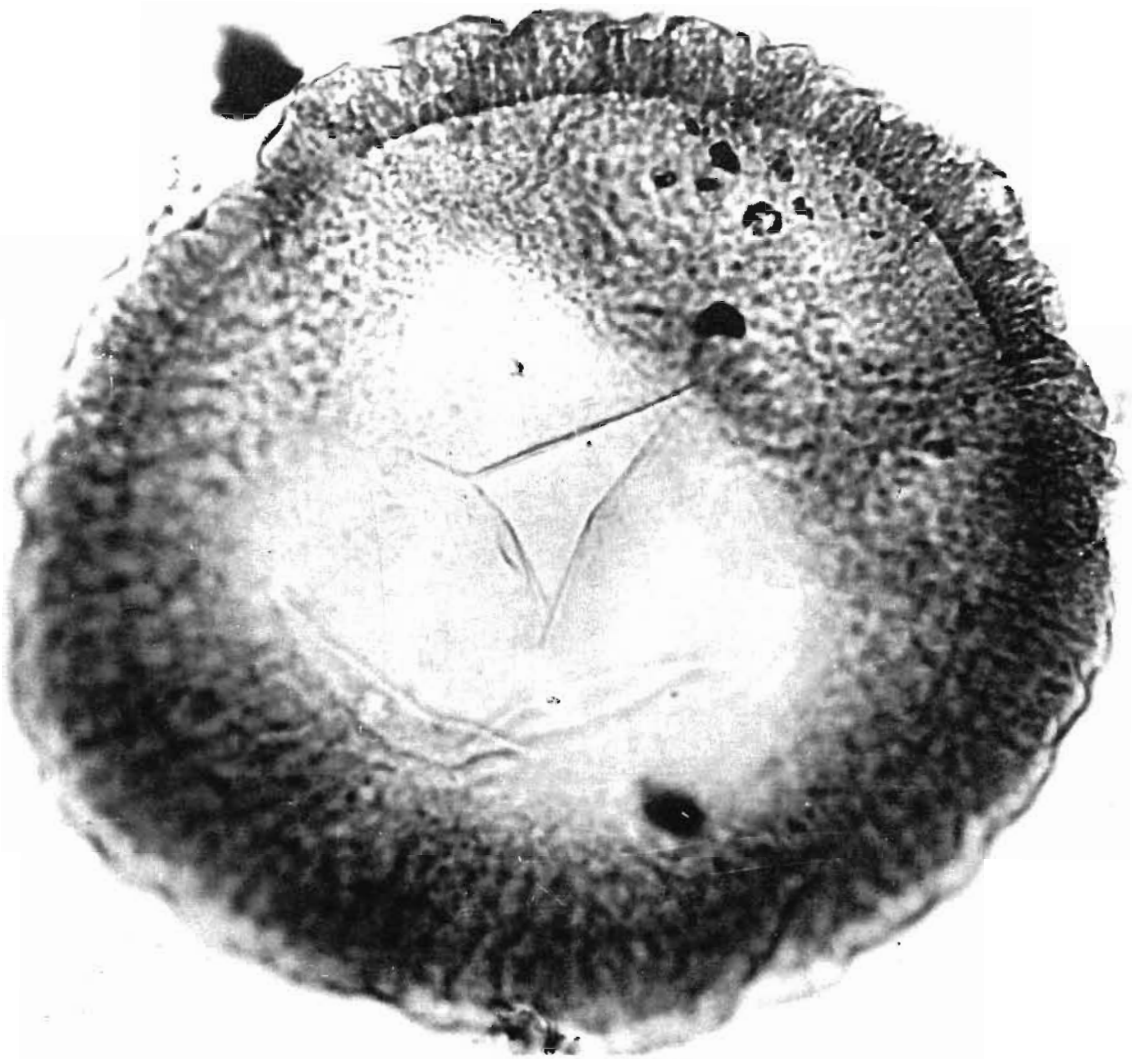
1. Finely uniformly intrapunctate structured exine.
2. Thick to thin exine showing no concentric rings.

The bases for considering the synonymy of various species are described below:

1. *Punctatisporites gretensis* Balme & Hennelly 1956—The specimens described by Balme and Hennelly (1956) appear to be heterogeneous with respect to the nature of exine. The first illustrated specimen (Balme & Hennelly, 1956; pl. 2, fig. 11) appears to be uniformly intrapunctate (Text-fig. 4) and not psilate or finely granulate. Such trilete spores from the Lower Gondwana sediments, by and large, have been observed to have a structured exine, and are not sculptured. On this basis, this species was considered by Bharadwaj and Srivastava (1969) under the genus *Callumispora*. Considering this similarity, Bharadwaj and Tiwari (1977, p. 34) have already designated the first specimen of Balme and Hennelly (1956, pl. 2, fig. 11) as its holotype which was not done earlier.
2. *Punctatisporites lucidulus* Playford & Helby 1968—Playford and Helby (1968, p. 107) described this species as "laevigate, but with distinct to perceptible fine, dense intragranulation" which is similar to *P. subtritus*. These two species were not compared by the authors but the apparent differentiation was based on size and the exine thickness. The overall size and exine thickness was 42-67 μm and 2-4 μm in *P. lucidulus* and 65-126 μm and 3.5-4.5 μm in *P. subtritus*, respectively. Such an overlap in overall size-ranges as well as thickness of exine is, however, not practicably differentiable and, hence, these species should be considered as junior synonym of *C. gretensis* (Balme & Hennelly) Bharadwaj & Srivastava 1969.
3. *Punctatisporites subtritus* Playford & Helby 1968—This species was considered by Playford and Helby (1968) to be similar to *Punctatisporites gretensis* in respect to size, shape and apertural features but was differentiated because it was understood that the nature of exine in *P. gretensis* is non-structured. However, this is not tenable now because the exine in both the species is uniformly intrapunctate in structure and, hence

PLATE 4 →

1, 2. *Parasaccites korbaensis* Bharadwaj & Tiwari 1964:
1. Holotype—proximal face showing the distinct central body outline, ruptured trilete mark and radiating folds in saccus; Slide no. BSIP 9898, EF : R11/3, × 1000.
2. Distal face of specimen in fig. 1 showing intrareticulate structure of central body, × 1000.



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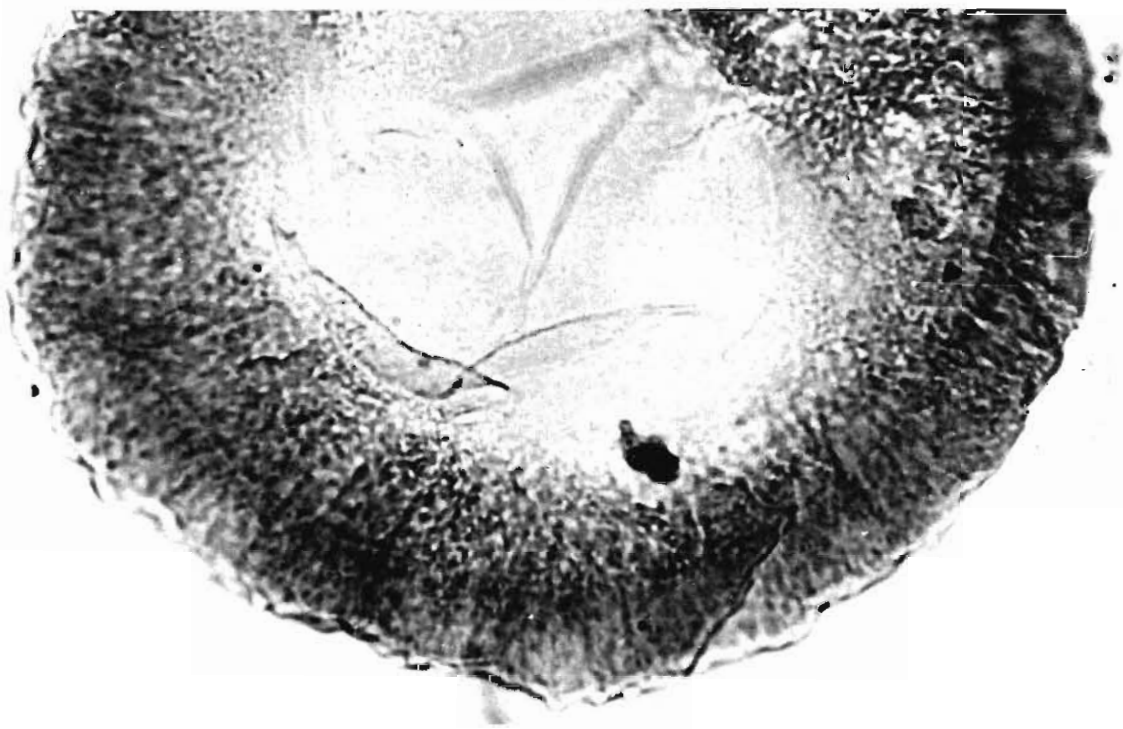

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PLATE 4

P. subtritus should be considered as a junior synonym of *Callumispora gretensis* (Balme & Hennelly) Bharadwaj & Srivastava 1969.

4. *Punctatisporites uniformis* Tiwari 1968—Chandra and Lele (1979) have transferred this species to the genus *Callumispora* on the basis of exine structure. The overall size and exine structure of *P. uniformis* (Pl. 3, fig. 5) compare closely to *Callumispora gretensis*, except the thickness of exine which is again not well-marked. Hence, *P. uniformis* is treated to be a junior synonym of *C. gretensis*.
5. *Callumispora tenuis* Bharadwaj & Srivastava 1969—The specimens described under *C. tenuis* (Pl. 1, fig. 4) were differentiated from *C. barakarensis* in being slightly smaller in size, having nonstratified exine and undifferentiated contact area. These characters encompass the specifications designated for *C. gretensis* and hence, *C. tenuis* is considered here to be a junior synonym of *C. gretensis*.
6. *Callumispora tenuis* var. *minor* Bharadwaj & Srivastava 1969—This variety was statistically differentiated from *C. tenuis* in having smaller size (66-90 μm) and much thinner exine (2 μm). However, spores having a uniformly distributed intrapunctate structured exine have been observed to vary greatly in their over-all size range and it seems impracticable to differentiate such taxa on the basis of their size variations. Therefore, *C. tenuis* var. *minor* has been merged here alongwith *C. gretensis*.
7. *Punctatisporites ganjrensis* Lele & Maithy 1969—The specimens described by Lele and Maithy (1969) were differentiated from *P. gretensis* Balme & Hennelly in having circular to circular-triangular outline and marginal thickenings. The type specimen has been re-examined (Pl. 3, fig. 4) and no marginal thickening has been observed. The uniform intrapunctation in exine is similar to *C. gretensis* (Balme & Hennelly) Bharadwaj & Srivastava 1969, apart from the overall size and exine thickness.
8. *Punctatisporites mukherjei* Mukherji & Ghosh 1972—Two specimens illustrated by the authors, however, do not conform with the description. They are larger than the size range prescribed. Holotype is also not designated. The illustrations as well as the descriptions taken together suggest that this species also conforms to *C. gretensis*.
9. *Punctatisporites lufupaensis* Maheshwari 1969—The spores included in this species, though badly preserved, show uniformly intrapunctate exine and thus are not appreciably different from *C. gretensis* except their smaller size (50-71 μm) and thinner exine (1-2 μm).

Emended diagnosis—Circular spores. Trilete distinct, rays straight extending 3/4 radius long, tapering, lips prominent, sometimes raised. Exine 2-5 μm thick without showing concentric rings at the equatorial margin, finely and uniformly intrapunctate structured, surface smooth.

Description (elaborated)—Circular to subcircular, dark brown spores. Size range 50-154 μm. Trilete mark well-defined, rays equal in length and placed at equal angles, traversing generally 2/3 body radius; ray ends tapering, labra thin and simple, frequently ruptured, and vertex slightly raised. Short arcuate fold occasionally present at the extremity of the rays. Exine fairly thick, 2-5 μm at the margin, nonstratified, without any recognisable differentiation into layers, sparsely intrapunctate but more pronounced along the rays and in the angles. Contact area not delimited. Exine elsewhere finely intrapunctate. *Extrema lineamenta* smooth.

Comparison—*Callumispora gretensis* (Balme & Hennelly) Bharadwaj & Srivastava 1969 is differentiable from *C. barakarensis* and *C. fungosa* in having thinner exine without showing any concentric layers in the exine thickness. Besides, *C. barakarensis* shows conspicuous intrapuncta between trilete rays apparently differentiating a contact region. In *C. fungosa*, the exine is coarsely intrapunctate. *C. adensa* is smaller in size range (34-36 μm) having thinner exine although the exine is uniformly and finely intrapunctate.

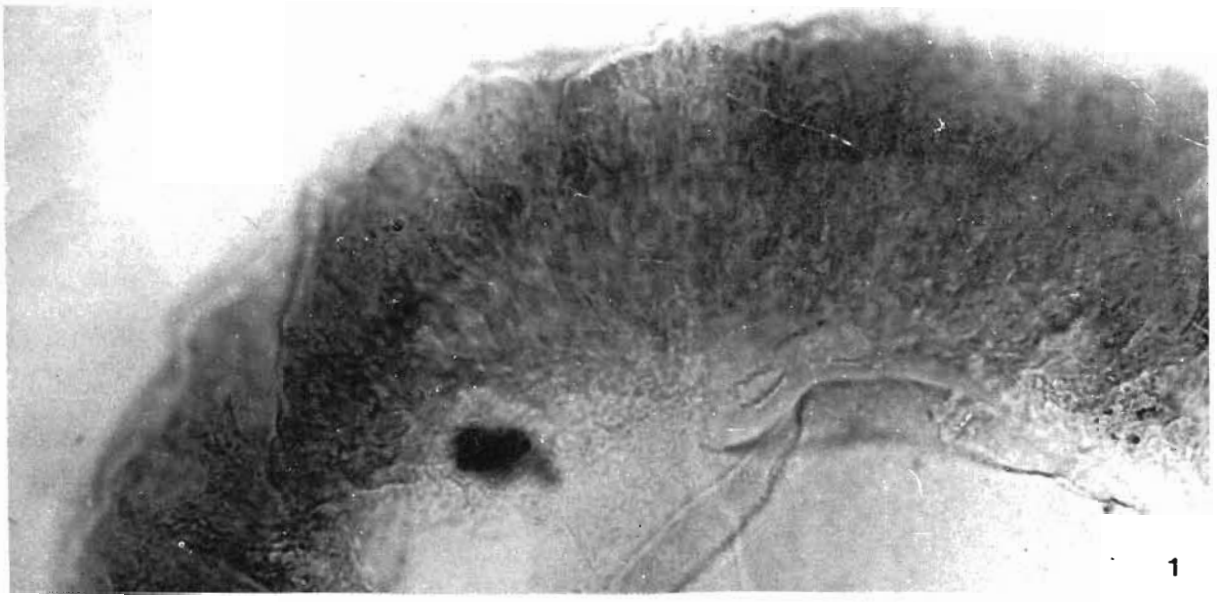
Callumispora adensa Bharadwaj, Kar & Navale 1976 emend.
Pl. 3, fig. 7

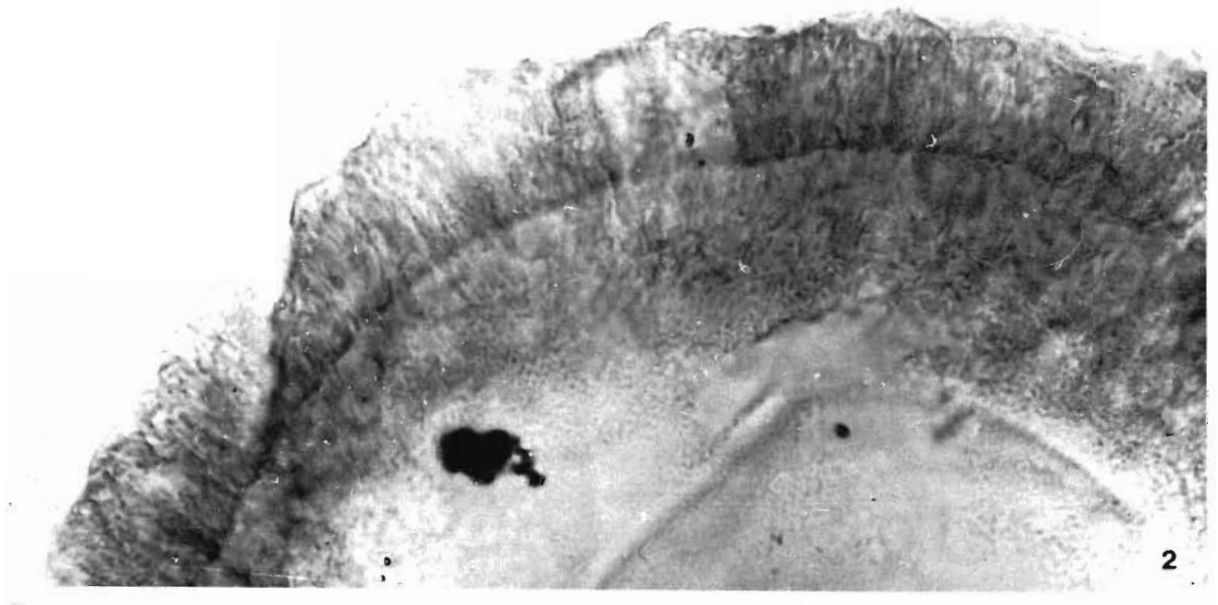
Holotype—Bharadwaj, Kar and Navale 1976; pl. 3, fig. 43; size 42 μm; Slide no. BSIP 5159/6;

PLATE 5 →

1-3. *Parasaccites korbaensis* Bharadwaj & Tiwari 1964, in L-O analysis showing para-condition of the saccus attachment; Slide no. BSIP 9898. EF : R11 3, × 1500.

1. Top focus—saccus attachment on proximal view.
2. Median focus—distinct central body outline, exine structure finely intrareticulate.
3. Deep focus—saccus attachment on distal face.





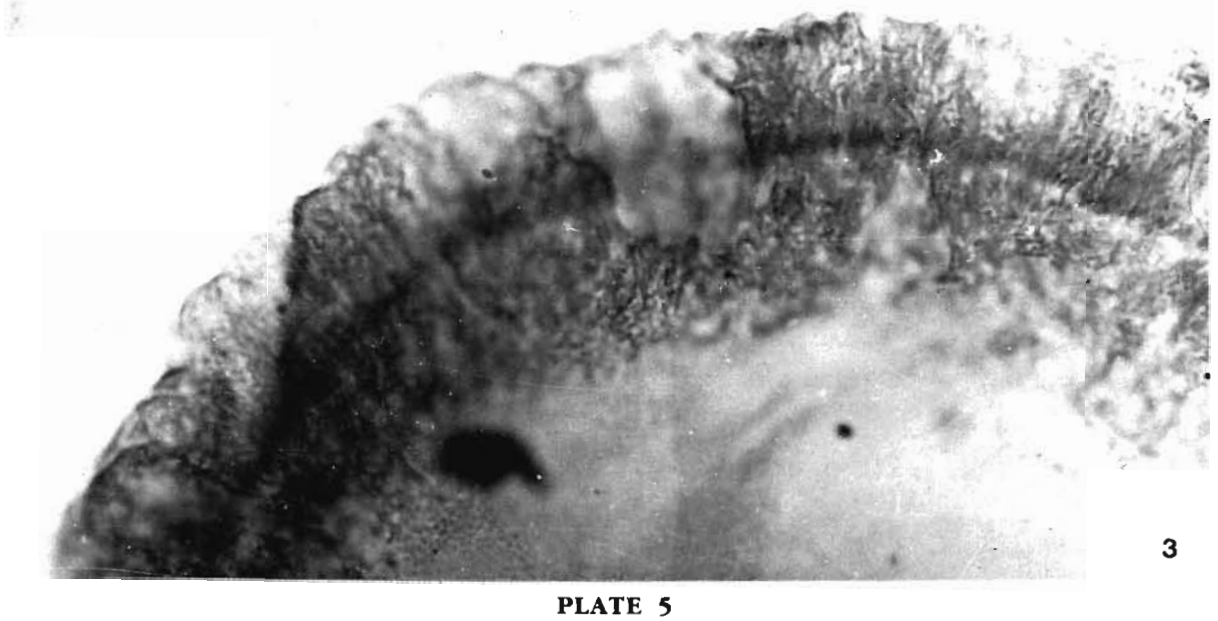
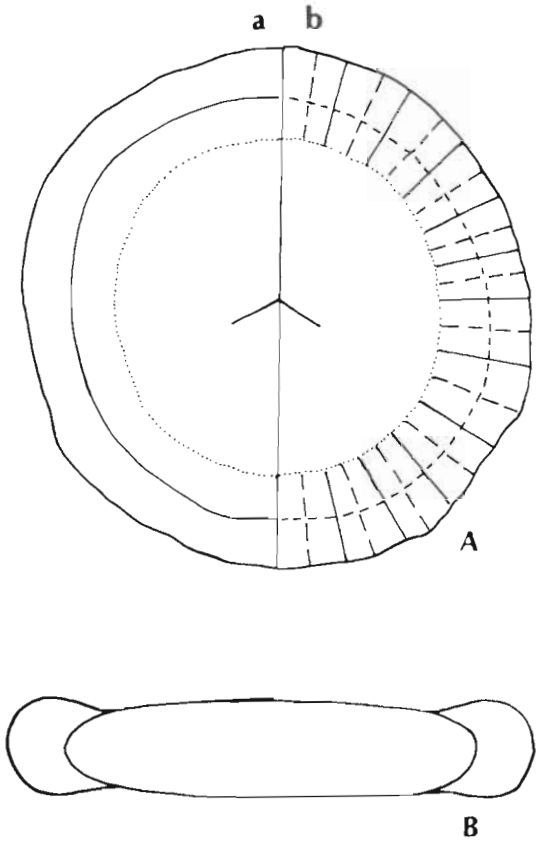


PLATE 5



Text-figure 5—Reconstruction of organisation of *Parasaccites* Bharadwaj & Tiwari 1964. **A**, In proximo distal plane, **a**—showing details of central body, **b**—showing proximal saccus attachment (solid line) and distal saccus attachment (broken line). **B**, Meridional section.

Maranhao Basin, Brazil, Palermo-Irati Formation, Permian.

Isotype—Bharadwaj, Kar & Navale, 1976; pl. 3, fig. 44, Slide no. BSIP 5157-7 (here designated)

Original Diagnosis—"Spores subcircular, 34-36 μ Trilete not extending more than three-fourth radius. Exine laevigate" (after Bharadwaj, Kar & Navale, 1976, p. 74).

Discussion—The type specimen of *Callumispora adensa* Bharadwaj, Kar & Navale 1976 has been re examined which shows faint intrapunctation all over the exine. Since the size range of the specimens assigned to this species is very small (34-36 μm), hence their identity as a species remains unaffected

In view of the observation that the exine in this species is intrapunctate the specific diagnosis is being emended here.

Emended diagnosis—Circular to subcircular spores; size range 34-36 μm. Trilete distinct, rays equal traversing not more than 3/4 body radius. Exine thin, 1-2 μm; surface smooth, uniformly and finely intrapunctate in structure

Description (elaborated)—Spores circular to subcircular. Trilete mark distinctly defined, rays equal in length, extending not more than 3/4 body radius, ends tapering, placed at equal angles, labra thin and simple. Exine thin, nonstratified without any perceptible differentiation into layers, uniformly and finely intrapunctate structured all over the body of spore.

Comparison—The uniform intrapunctate structured and nonstratified nature of exine in *C. adensa* is comparable to *C. gretensis* but the former is distinguishable in being distinctly smaller in size.

Genus—*Parasaccites* Bharadwaj & Tiwari 1964

Type species—*Parasaccites korbaensis* Bharadwaj & Tiwari 1964.

Original diagnosis—"Circular to bilaterally oval miospores with a saccus, attached subequatorially both on proximal as well as on distal face of the spore-body, leaving almost circular, equal bladder-free areas on both faces, i.e., para-condition of saccus attachment Body distinct or diffused, exine intramicroreticulate. Proximally sometimes a weak trilete mark present Saccus intrareticulate" (after Bharadwaj & Tiwari, 1964, p. 143).

Discussion—Re-examination of the type-specimens of several species of this genus has revealed the presence of following characters:

1. Saccus is more or less frilled in nature at the peripheral region in most of the cases.
2. Saccus attachment with the central body is not sharp but gradually merging.
3. Saccus is of protosaccate nature, i.e., filled with coarse and fine alveoli as determined by L-O analysis.

The SEM studies exhibited the following additional characters and also confirmed the observations earlier made under light microscope:

1. Frilled nature of the saccus is noticed in almost all the specimens suggesting swollen nature of saccus in living condition (Pl. 13, figs 1, 2, 4)
2. Saccus surface is generally smooth but in some cases puncta-like structures seen in high magnification (Pl. 13, figs 7, 8).
3. Central body surface is not smooth but shows low elevations of internal muri which appear to project out from within the sexine surface due to compression of the specimens (Pl. 13, figs 6, 9).

Description (elaborated)—Pollen circular, subcircular or bilaterally oval. Central body (nexine) circular, subcircular, subtriangular or bilaterally oval, with distinct or diffused outline, being thin or thick with or without microfolds. Sexine finely intramicroreticulate. Trilete mark weakly developed or ill-defined, distinct when ruptured, simple rays

PLATE 6

1-3. *Parasaccites korbaensis* Bharadwaj & Tiwari 1964:
1 Isotype showing ruptured trilete mark and distinct central body; Slide no. BSIP 9898, EF : K20/1, × 1000.
2. Slide no. BSIP 2816, EF : F40/3, × 500.
3. Slide no. BSIP 2816, EF : O30/4, × 500.

1/2 to 2/3 radius long, labra thin, vertex low. Saccus usually uniformly broad from body equator, 1/2-2/3 body radius wide in circular to subcircular forms but in bilateral forms it is narrower along the lateral sides. Zones of saccus attachment not sharply defined, sometimes being difficult to make out as the saccus gradually merge with the body. In L-O analyses para-condition of saccus attachment revealed distinctly, i.e., the extent of saccus invasion being more or less equal both on proximal and distal surfaces (Pl. 4, figs 1-3). Saccus strongly or weakly-frilled with radially oriented pleats, protosaccate, i.e., filled with alveoli, intramicroreticulate, muri generally polygonal and becoming radially elongated towards the periphery.

Comparison—*Parastriopollenites* Maheshwari 1967, although has para-condition of the saccus attachment, differs from the present genus in having reticuloid pattern of groves on both the faces of the central body.

Organisation (Text-fig. 5A, B)—So far, no specimen of *Parasaccites* has been found in lateral condition of preservation; the central body has also not been seen shifted from its central position. This suggests that the pollen had a wheel-like or disc-like construction in original condition. The para-condition of saccus attachment has already been established (Bharadwaj & Tiwari, 1964, text-fig. 4). The organisation of genus *Parasaccites* is deduced after studying number of specimens. The invasion of the saccus on both proximal and distal faces of central body is up to the same extent which was termed as para-condition by Bharadwaj and Tiwari (1964) suggesting an equatorial girdling nature. The frilled nature of saccus suggests that it was not flat but a swollen stucture in original condition before flattening.

List of species on record:

Parasaccites korbaensis Bharadwaj & Tiwari 1964
P. bilateralis Tiwari 1965
P. diffusus Tiwari 1965
P. distinctus Tiwari 1965
P. obscurus Tiwari 1965
P. karharbarensis Maithy 1965
P. radiplicatus Maithy 1965
P. densus Maheshwari 1967
P. longus Kar & Bose 1967
P. rimosus Venkatachala & Kar 1968
P. bellus Venkatachala & Kar 1968
P. ovatus Kar 1968
P. perfectus Bose & Maheshwari 1968
P. fimbriatus Maheshwari 1969
P. radialis Lele & Maithy 1969
P. gondwanensis (Balme & Hennelly) Segroves 1969
P. irregularis Sinha 1972
P. singrauliensis Sinha 1972
P. talchirensis Lele & Makada 1972
P. plicatus Lele & Makada 1972
P. densicorpus Lele 1975
P. lacinatus Chandra & Lele 1979

List of species resolved:

The criteria for retaining the species are para-condition of saccus attachment, intramicroreticulate exine of central body and simple trilete mark. On re-examination of the available type specimens of various species and critical analyses of the illustrations and descriptions of species, where the types are not available, only 6 species out of 22 species described so far have been retained in this genus. Rest of the species are either synonymous with the presently recognised species of *Parasaccites* or need placement in other genera on the basis of morphographic similarities (such transfers will be published elsewhere). Species retained in *Parasaccites* after present analysis are:

Parasaccites korbaensis (= *P. distinctus, P. karharbarensis, P. fimbriatus, P. singrauliensis*)
P. obscurus (= *P. diffusus*)
P. bilateralis (= *P. longus*)
P. ovatus
P. perfectus
P. densicorpus

Species which do not find their place under *Parasaccites* are: *Parasaccites radiplicatus, P. densus, P. rimosus, P. bellus, P. radialis, P. gondwanensis, P. irregularis, P. talchirensis, P. plicatus* and *P. lacinatus*.

The species *P. radiplicatus* and *P. radialis* show verrucoid sculpture on the central body and the distinct intrareticulation in the true sense of *Parasaccites* is not present. The holotype of *P.*

PLATE 7 →

1, 2. *Parasaccites obscurus* Tiwari 1965; Slide no. BSIP 9902, EF : Y35/1:
1. Lectotype showing indistinct central body outline and distinct trilete mark, × 1000.
2. Enlargement of specimen in fig. 1 showing intrareticulate pattern of central body, × 1500.

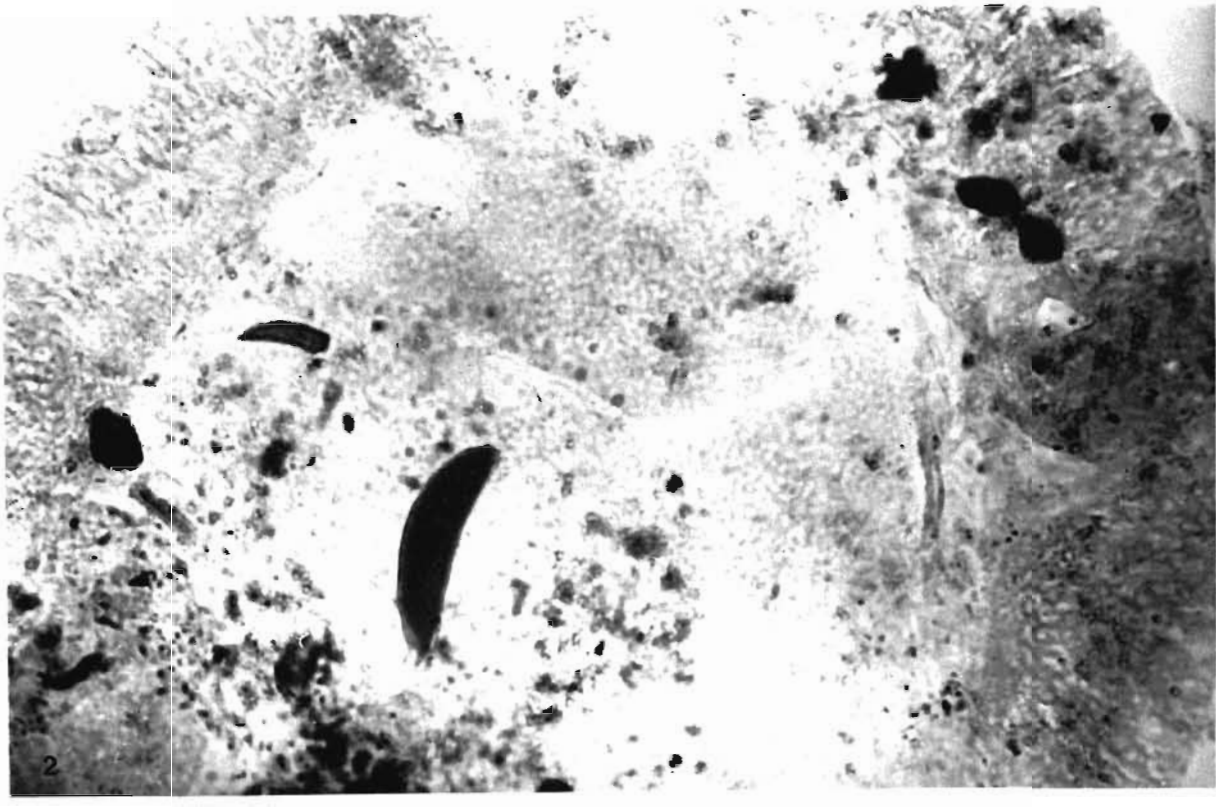


PLATE 7

densus although possesses intrareticulate exine shows mud crack pattern on the proximal side and loose exinal folds on the distal side hence, differs from *Parasaccites*. The species *P rimosus* and *P bellus* are nearer to genus *Potonieisporites* Bhardwaj 1956 because of body infold system. The species *P gondwanensis* is based on the holotype of *Nuskoisporites gondwanensis*. This has already been transferred to the genus *Plicatipollenites* by Lele (1964) because of the presence of body infold system. *P. irregularis* is disaccoid in nature and possesses 4-5 faint horizontal striations, the distal zone of saccus attachment being bilateral. *Parasaccites talchirensis* shows verrucoid nature of central body. The saccus attachment is more on distal face of central body, thus the para-condition of saccus attachment is absent. In *P. plicatus* the central body is intramicroreticulate but the para-condition of saccus attachment is absent. *P. lacinatus* possesses lacinate folds along the trilete rays; such a character is absent in *Parasaccites*.

Occurrence—Early Permian (Talchir Formation) to Early Triassic (Panchet Formation).

Prominence—Talchir and Karharbari formations (Early Permian), and Late Permian-Early Triassic transition.

Description of species resolved:

Parasaccites korbaensis Bharadwaj & Tiwari 1964

Pl. 4, figs 1, 2; Pl. 6, figs 1-3; Pl. 8, fig. 2; Pl. 13, figs 1, 2, 4

1964 *Parasaccites korbaensis* Bharadwaj & Tiwari, pl. 2, figs 7, 8.

1965 *Parasaccites distinctus* Maithy, pl. 3, fig. 19.

1969 *Parasaccites fimbriatus* Maheshwari, pl. 3, fig. 10.

1972 *Parasaccites singrauliensis* Sinha, pl. 2, fig. 34.

Holotype—Bharadwaj & Tiwari, 1964; pl. 2, fig. 7; size 130 μm; Slide no. BSIP 9898; Ghordewa Sector (Bore-hole no. G-101), Korba Coalfield; Barakar Formation, Permian.

Isotype—Bharadwaj and Tiwari, 1964; pl. 2, fig. 8; Slide no. BSIP 9898 (here designated).

Original diagnosis—"± Circular miospores, 128-147 μm in size; central body distinct, 105-119 μ in size, circular, with mediumly thick intramicroreticulate exine. Trilete mark distinct, rays small, up to ½ the body radius long; labra thin, vertex low. Saccus 24-38 μ, uniformly wide all around the equator, zones of saccus attachment somewhat irregular, finely intrareticulate with apparently radially elongated muri" (after Bharadwaj & Tiwari, 1964, p. 145).

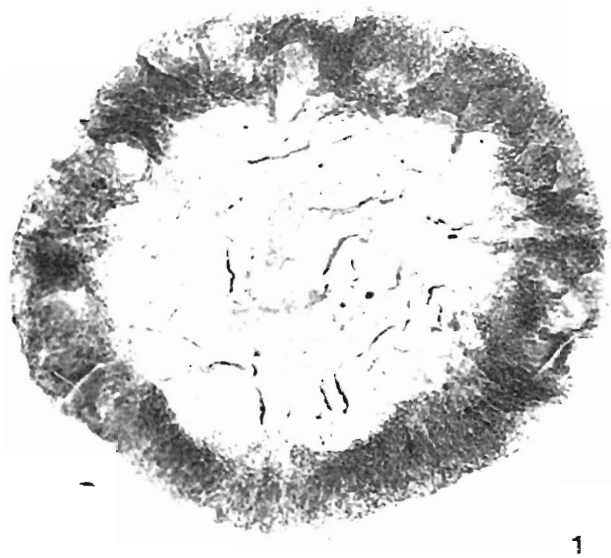
Discussion--On re-examining the type specimen following additional observations are made:

1. The saccus margin is not smooth but wavy, with weak pleats on the surface.
2. Saccus shows protosaccate condition.
3. Saccus attachment is merging with body without forming a sharp line.

The species listed in the synonymy have been found to be inseparable from *P. korbaensis*. The reassessment of the characters of the types or description and illustration of specimens have been made:

1. *P. distinctus* was originally distinguished from *P korbaensis* because of wrinkled exine of the body. However, this character is considered here as a secondary feature of *P. korbaensis*; all other features are common.
2. *P. karharbarensis* was differentiated from type species by ± thick body and distinct zone of saccus attachment. However, a re-examination of the type specimen of this species revealed that the body is thin and the saccus attachment is not sharply defined.
3. *P. fimbriatus* was distinguished by the frilled nature of saccus and fimbriate roots. However, this feature is also noticed in *P. korbaensis*, may be the degree of frilling is relatively less pronounced. In all the frilled saccus the "roots" of saccus are fimbriate, only varying in degree of prominence. Also a reassessment of the illustration and description of this species suggest a distinct nature of central body and that the dark colour of muri is because of the preservation somewhat concealing the central body outline.
4. *P. singrauliensis* is shown to have smaller size range (65-110 μm) than *P. korbaensis* (128-147 μm). The data from subsequent studies indicate a wide range in size in the population of this kind encompassing both the species.

Description (elaborated)—Circular to subcircular pollen, 65-147 μm in size; central body outline sharply defined, conforming to the overall shape of pollen, thin to mediumly thick, with or without microfolds or wrinkles, finely intramicroreticulate. Trilete mark generally distinct, sometimes weakly developed or obscure, simple, sometimes open, ray length not more than half of the body radius. Saccus almost uniformly broad not exceeding 1/4 of body radius (30 μm wide in holotype), finely intramicroreticulate, polygonal at the base becoming radially elongated towards periphery; protosaccate, muri thick, saccus margin wavy, frilled with pleats of various degree. Zone of saccus attachment subequatorial proximally as well as distally, merging with the central body, not forming a sharp line of attachment.



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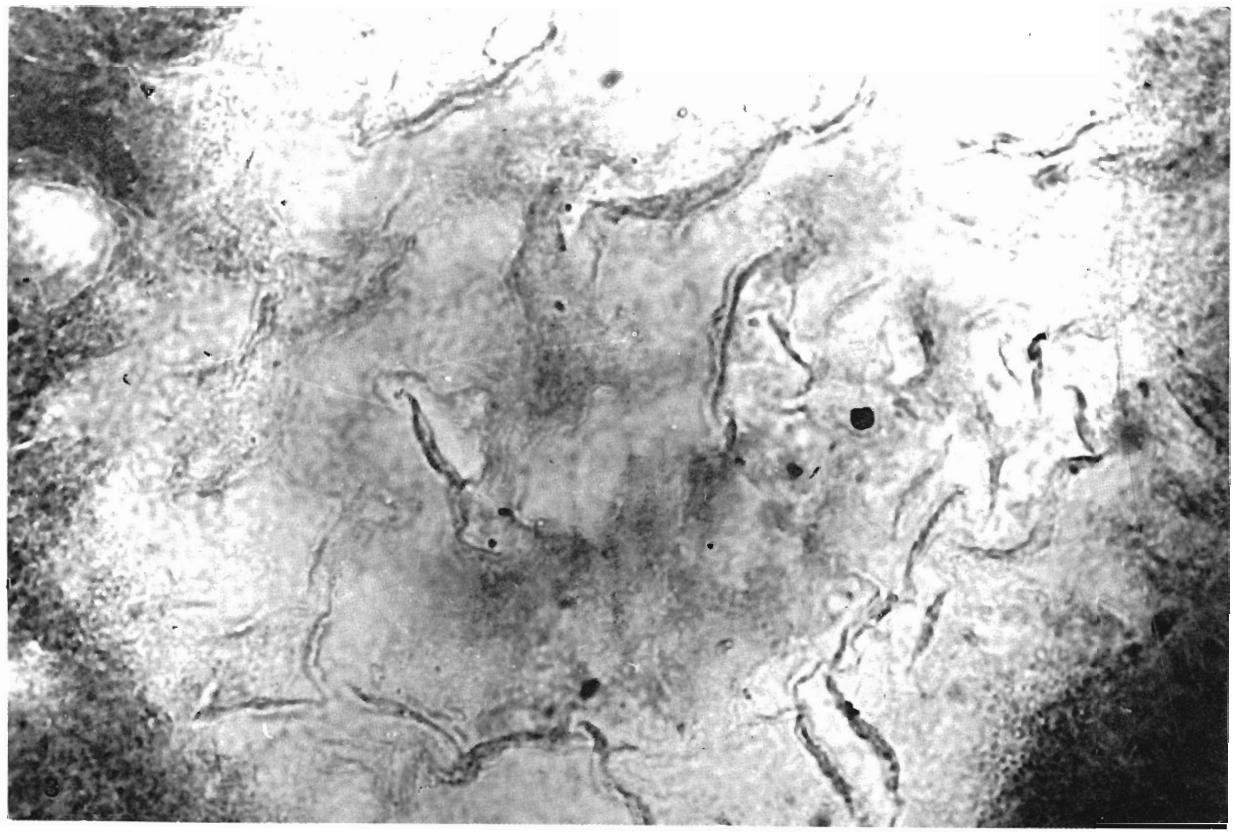


PLATE 8

1, 3. *Parasaccites obscurus* Tiwari 1965; Slide no. BSIP 9899, EF J26/2:

1 Specimen illustrated by Tiwari (1965) as Holotype of *P. diffusus* showing indistinct central body outline, radiating folds on the saccus, and irregular saccus attachment, × 500.

3. Enlargement of specimen in fig. 1 showing the intrareticulate exine structure and the micro-ruptures in the body exine, × 1500.

2. *Parasaccites korbaensis* Bharadwaj & Tiwari 1964 showing proximal saccus attachment; Slide no. BSIP 9900, EF : K 14/4, × 500.

Parasaccites obscurus Tiwari 1965

Pl. 7, figs 1, 2; Pl. 8, figs 1, 3; Pl. 10, figs 4, 5

1965 *Parasaccites obscurus* Tiwari, pl. 4, figs 74, 75.
1965 *Parasaccites diffusus* Tiwari, Holotype in Bharadwaj & Tiwari 1964, pl. 2, fig. 11.

Holotype—Tiwari, 1965; pl. 4, fig. 75; size 130 μm; holotype now not traceable; 207 (II Seam): Bore-hole G-1, Korba Coalfield, Madhya Pradesh, Barakar Formation, Permian.

Lectotype—Tiwari, 1965; pl. 4, fig. 74 (here designated), Slide no. BSIP 9902.

Original diagnosis—"Subcircular; central body outline not distinguishable; exine thick, without wrinkles or folds, Y-mark generally distinct, closed or open into a triangular window, rays ½ to 2/3 radius long; saccus narrow, finely intrareticulate with radially arranged muri" (after Tiwari, 1965, p. 182).

Discussion—The species *Parasaccites diffusus* was distinguished from *P. obscurus* by the presence of microfolds on the central body. However, on re-examining the holotype of *P. diffusus* it is observed that the microfolds are of secondary nature. They are formed by the microruptures of the exine. Hence, *P. diffusus* is treated as synonym of *P. obscurus*.

Description (elaborated)—Circular to subcircular pollen grain, 107-165 μm in size. Central body outline indistinct, thin to mediumly thick with or without microfolds, finely intramicroreticulate, at times muri may be thick simulating a punctate appearance. Trilete mark obscure to distinct, when present rays 1/2 to 2/3 radius long, simple with thin labra and low vertex, may be open leaving a triangular vent. Saccus with protosaccate-fill, uniformly broad, 28 μm in holotype; saccus outline wavy, attachment subequatorial on both faces leaving subcircular area free, merging with central body, zone of attachment diffused, not forming a distinct line, saccus intrareticulation fine with polygonal meshes at the attachment zone becoming medium-sized and radially elongated towards periphery, muri thick or thin sometimes giving a leathery appearance to the saccus.

Comparison—Parasaccites obscurus is differentiated from *Parasaccites korbaensis* on the basis of diffused central body, i.e., without a distinct outline.

Parasaccites bilateralis Tiwari 1965

Pl. 9, figs 1, 2; Pl. 10, figs 1-3; Pl. 13, fig. 3

1964 *Parasaccites* Bharadwaj & Tiwari, pl. 2, fig. 12.
1965 *Parasaccites bilateralis* Tiwari, pl. 4, fig. 7.
1967 *Parasaccites longus* Kar & Bose, pl. 5, fig. 7.

Holotype—Bharadwaj and Tiwari, 1964; pl. 2, fig. 12; size 148 × 90 μm; Slide no. BSIP 9901; Topa Village Quarry West Bokaro Coalfield, Bihar; Barakar Formation, Permian.

Isotype—Tiwari, 1965, pl. 4, fig. 73 (here designated), Slide no. BSIP 9901.

Original diagnosis—"Central body subcircular, faintly visible; exine thin, Y-mark not seen. Zones of saccus attachment ill-defined. Saccus broader at the terminal sides while narrower at the lateral sides, finely intrareticulate with ± radial arrangement of muri" (after Tiwari, 1965, p. 183).

Discussion—The additional observations made during re-examination of the type specimen are: Saccus intrareticulation fine and polygonal at the base and progressively increases in size to become mediumly coarse and radially elongated towards the periphery. Saccus weakly pleated in appearance, and with slightly wavy outline.

Basis for considering the synonyms are: *P. longus* was differentiated from *P. bilateralis* on the basis of length/width ratio of pollen having more length than double the width. This is not tenable because such a minor variation has been found to show a gradational incidences in the population of bilateral specimen of *Parasaccites*.

Description (elaborated)—Pollen grains bilaterally oval in outline, size range 124-192 (horizontal axis) × 68-128 μm (vertical axis). Central body thin, outline ill-defined, apparently oval to subcircular, finely intramicroreticulate. Sometimes thin microfolds present. Trilete mark not seen. Saccus with wavy outline, narrower along the lateral sides of the central body and broader at the terminal sides. Saccus attachment subequatorial on both the faces, diffused, leaving almost equal subcircular areas free. Saccus intrareticulation fine at the attachment zone and progressively becoming coarser towards the periphery, muri thick, meshes polygonal at base getting elongated with radially arranged muri towards the margin.

PLATE 9 →

1, 2. *Parasaccites bilateralis* Tiwari 1965 showing bilateral contour of pollen, indistinct central body outline and nature of body exine, × 1000.

1. Holotype; Slide no. BSIP 9901, EF : S23/4.
2. Isotype: Slide no. BSIP 9901, EF T32.

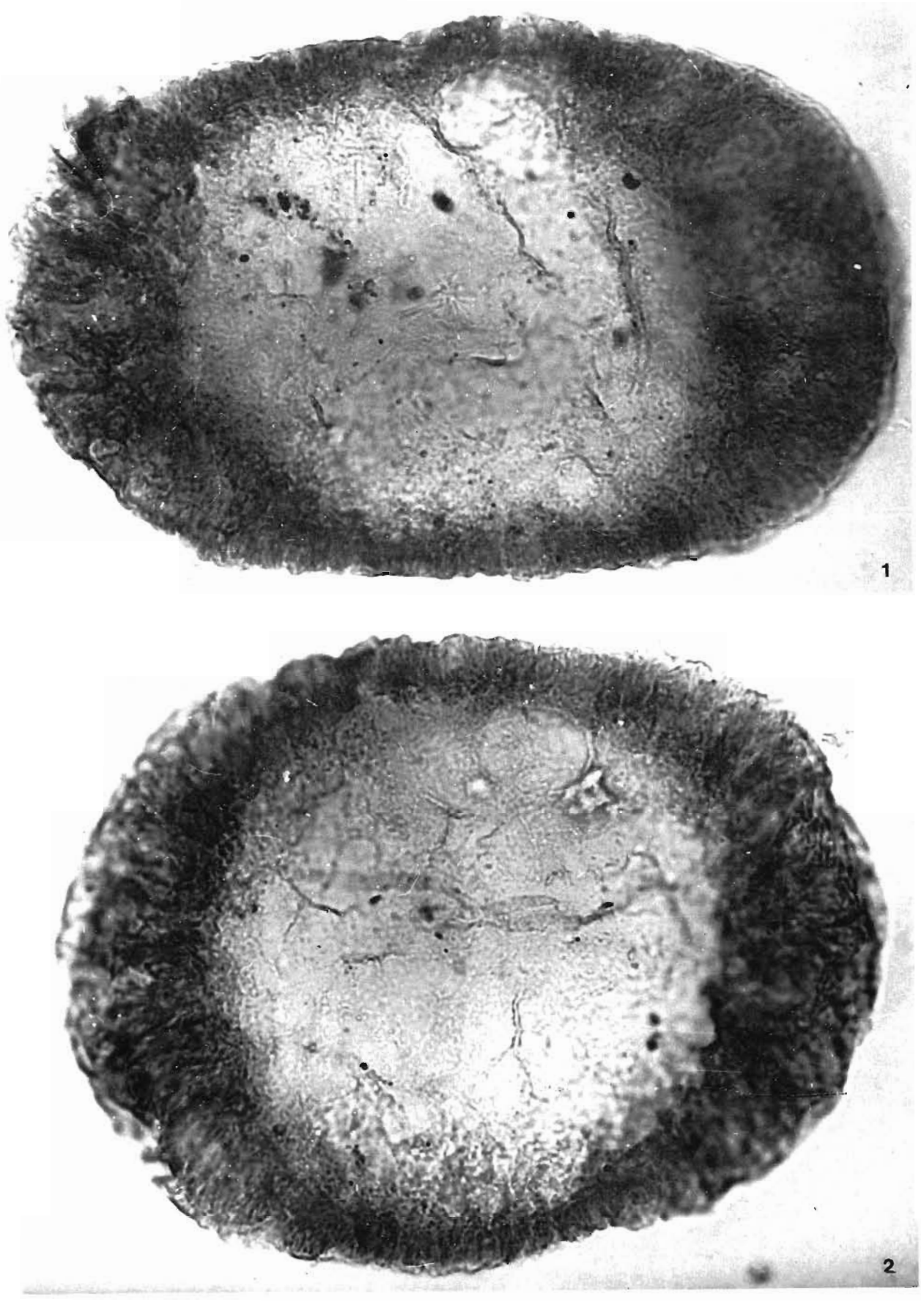


PLATE 9

Comparison—The present species differs from *P korbaensis* Bharadwaj & Tiwari 1964 and *P obscurus* Tiwari 1965 in having a bilateral symmetry.

Parasaccites ovatus Kar 1968

Pl. 11, fig. 1

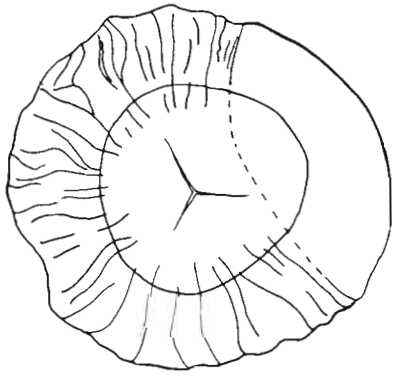
Holotype—Kar, 1968; Pl 2, fig. 46; size 125 × 73 μm; Slide no. BSIP 2202; Bore-hole no. J. K. 5, Jharia Coalfield; Permian, Kulti (Barren Measures) Formation.

Original diagnosis—"Oval-elliptical pollen, central body well-defined, circular to subcircular, intramicroreticulate. Proximal and distal attachment of saccus to central body subequatorial and ± in para-condition" (after Kar, 1968, p. 124).

Discussion—On re-examination of the type specimen following additional information is recorded:

1. Saccus protosaccate, outline wavy, intrareticulation fine with polygonal meshes at the saccus root becoming slightly coarser, radially arranged towards periphery, muri thick giving leathery appearance
2. Saccus attachment line is of diffused and merging type.

Description (elaborated)—Pollen bilateral, oval to elliptical, 64-115 × 110-166 μm in size. Central body circular to subcircular, thin, outline distinct, finely intramicroreticulate, sometimes microfolds present. Trilete mark not seen. Saccus with protosaccate fill having wavy outline, weakly pleated, narrower along the lateral sides and broader at terminal sides. Saccus attachment subequatorial on both faces, diffused leaving a subcircular saccus free area. Saccus intrareticulation fine with polygonal meshes at the attachment zone gradually becoming coarse with radially arranged muri towards periphery.



Text-figure 6—Line drawing of holotype of *Parasaccites perfectus* Bose & Maheshwari 1968 showing roundly triangular nature of central body and the radiating folds in saccus.

Remarks—The combination of the characters—bilateral shape and distinct central body, suggests an assignment of these forms to a separate species; otherwise in all other characters it resembles *P bilateralis*. This species is very sporadic in the Gondwana assemblages.

Comparison—*P. ovatus* distinguishes itself from *P bilateralis* in having distinct central body. *P korbaensis* and *P obscurus* are differentiated from *P ovatus* in having circular to subcircular shape.

Parasaccites perfectus Bose & Maheshwari 1968

Text-fig. 6

Holotype—Bose & Maheshwari, 1968; pl. 9, fig. 1, size 98 μm; Slide no. RG. 14191-7; Luanda, after the fall (about 2.5 ft thick exposure in river bed), Early Permian.

Isotype—Bose and Maheshwari, 1968; pl. 9, fig. 2 (here designated); Slide no. R.G. 14194-4

Original diagnosis—"Miospores monosaccate, subcircular to circular; central body distinct, roundly triangular to subcircular; trilete weakly-developed, saccus extent more than ½ body radius" (after Bose & Maheshwari, 1968, p. 41).

Description (elaborated)—Pollen grains circular to subcircular in shape, 78-98 μm. Central body outline distinct, roundly triangular in shape with broad angles and convex sides (Text-fig. 6), intramicroreticulate. Trilete mark weak to distinct, simple, rays equal, reaching 1/2 central body radius. Saccus with wavy outline, frilled, uniformly wide, subequatorially attached proximally as well as distally, finely intramicroreticulate, meshes fine and polygonal at the base progressively becoming elongated with radially arranged muri towards periphery.

Comparison—The present species differs from all the species in having a characteristic roundly triangular body

Parasaccites densicorpus Lele 1975

Pl. 12, figs 1-6

Holotype—Lele, 1975; pl 3, fig. 42; size 80 μm; Slide no. BSIP 4762; sample B9/662, Dudhi River Section, West Bokaro Coalfield, Bihar; Talchir Formation, Permian.

Isotype—Lele, 1975; pl. 3, fig. 45 (here designated), Slide no. BSIP 4762

Original diagnosis—"Circular-oval or roundly triangular miospore. Size 50-100 μm. Central body intramicropunctate to intramicroreticulate, 1.5-2 μm thick, outline distinct and smooth. Shape circular to roundly triangular, generally conforming with overall outline. Size 45-60 μm. Tetrad mark simple,

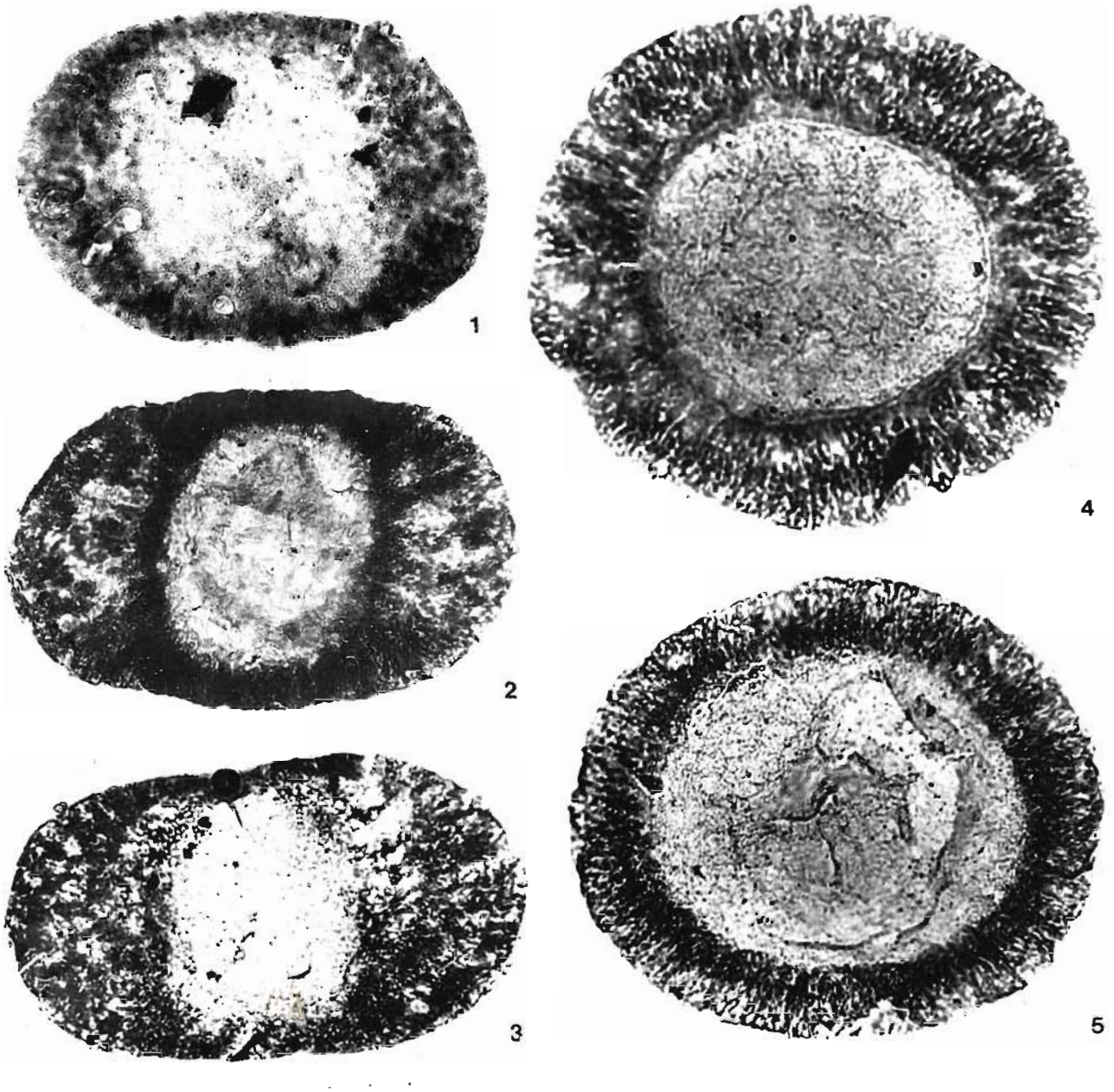


PLATE 10

1-3. *Parasaccites bilateralis* Tiwari 1965 showing indistinct central body outline and saccus attachment leaving sub-circular saccus free area, × 500.
1. Slide no. BSIP 1983, EF : G60/3.
2. Slide no. BSIP 1983, EF : I27/3.
3. Slide no. BSIP 1984, EF : O48/2.
4. *Parasaccites obscurus* Tiwari 1965; Slide no. BSIP 1983, EF : G61/3, × 500.
5. *Parasaccites obscurus* Tiwari 1965; Slide no. BSIP 1986, EF : S42/3, × 500.

weak to ± clear, rays 1/2 to 2/3 of body radius in length, with a tendency to become bilete or rarely monolete. Saccus width about 1/2 of body radius or more, prominently frilled by radial pleats arising from saccus roots, especially distally. Distal saccus overlap deep (about 2/3-1/3 of body radius), ± clear, root ± fimbriate and may be associated with partial exine folds of thickening (compressional); proximal saccus overlap narrow and relatively indistinct" (after Lele, 1975, p. 224).

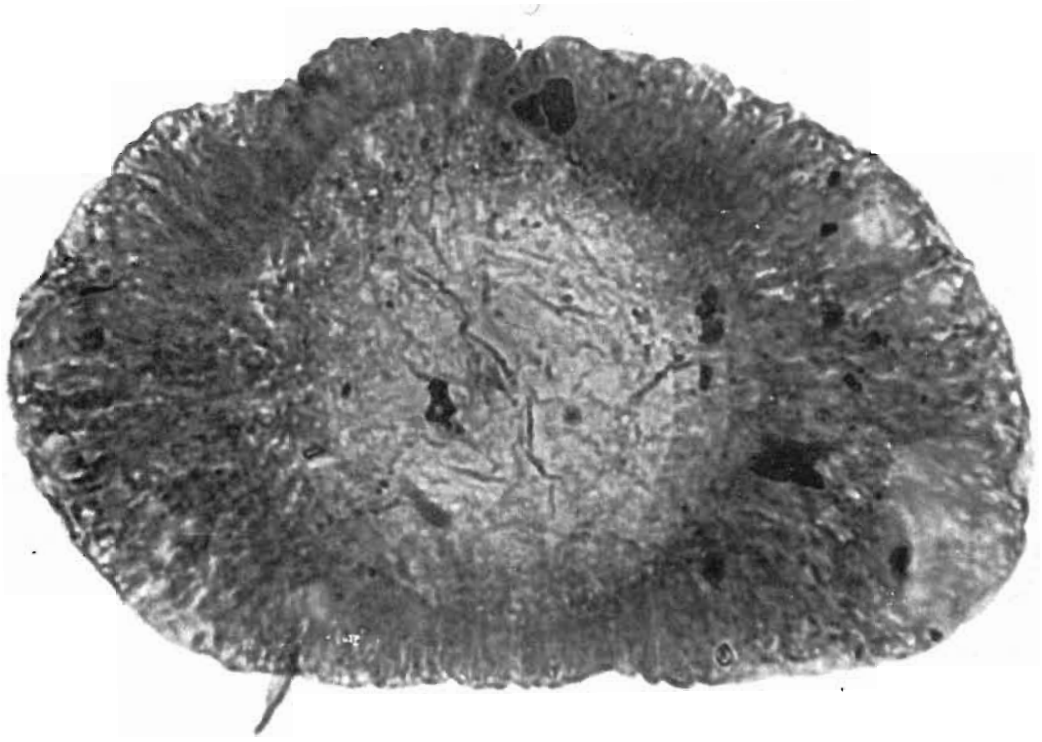


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PLATE 11

1. *Parasaccites ovatus* Kar 1968, Holotype showing distinct central body outline; Slide no. BSIP 2202, EF : K40/3, × 1000.

Discussion—After re-examining the type and similar forms some more details were recorded which are given below:

1. Central body exine and saccus structure are intrapunctate to intramicroreticulate.
2. The central body is dark, dense and mostly circular to subcircular; however, roundly triangular shape of body has also been included by the original author in this species. Their illustrations do not suggest that there exists a condition where typical triangular shape of the body is attained. It is, therefore, concluded that some specimens might show a tendency for triangularity of body, the overall shape remains circular.

Description (elaborated)—Pollen grains circular, subcircular, 50-120 μm in size. Central body dense, dark coloured with distinct outline, mostly conforming to the overall shape of pollen, finely intramicroreticulate; muri thick giving a punctate appearance. Trilete mark distinct or represented by a triradiate folds. Saccus with protosaccate fill, wavy

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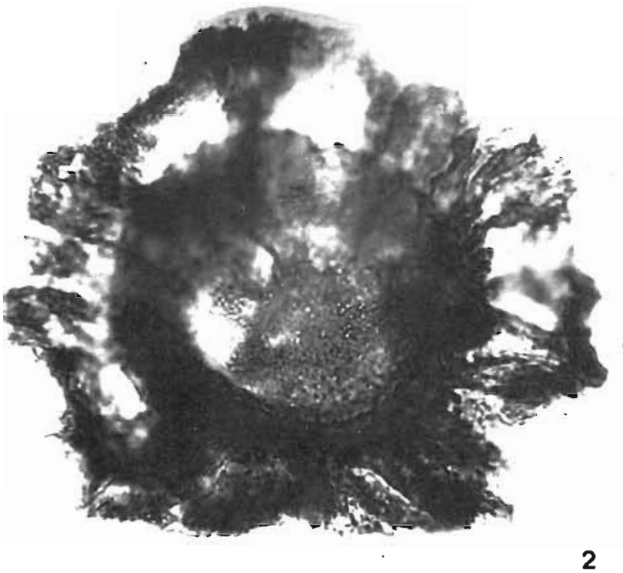
PLATE 12 →

1-6. *Parasaccites densicorpus* Lele 1975.

1. Holotype showing thick and leathery nature of saccus intrareticulation; Slide no. BSIP 4762, EF : T11/4, × 1000.
2. Specimen in fig. 1 showing distinct outline and intrareticulate structure of central body.
3. Isotype; Slide no. BSIP 4762, EF S16/1, × 850.
4. Slide no. BSIP 4757, EF : N10/2, × 1000.
5. Enlargement of specimen in fig. 6 showing trilete mark, intrareticulate structure and central body outline, × 1000.
6. Specimen showing distinct central body outline; Slide no. BSIP 4762, EF : N11/2, × 500.

1



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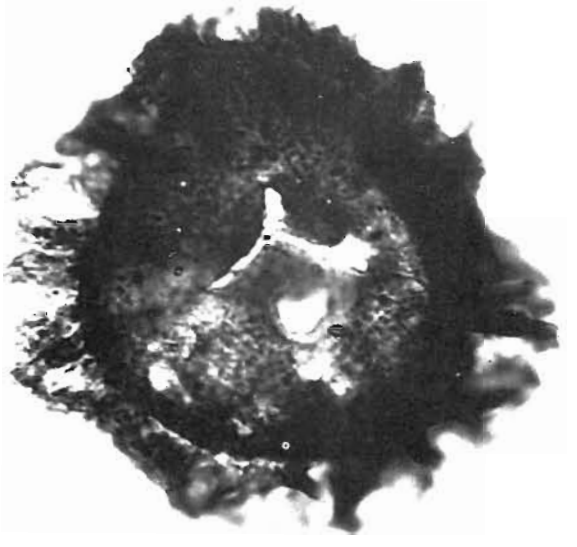

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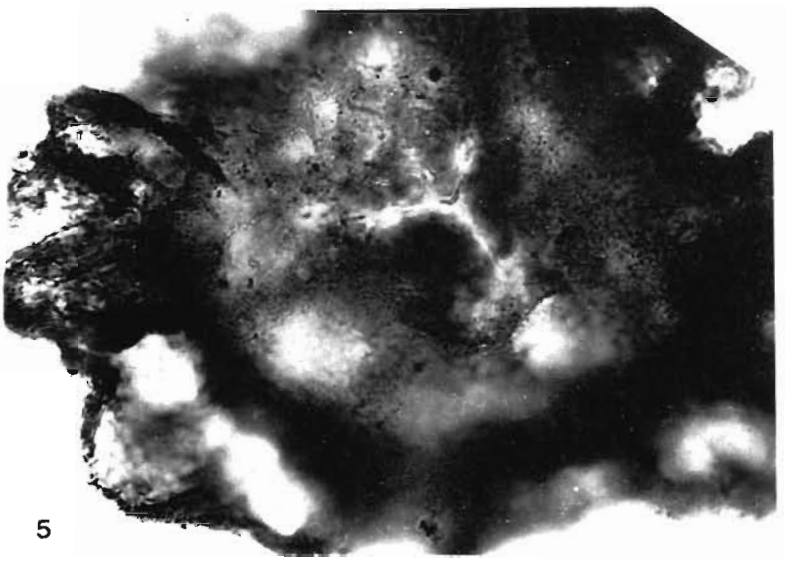

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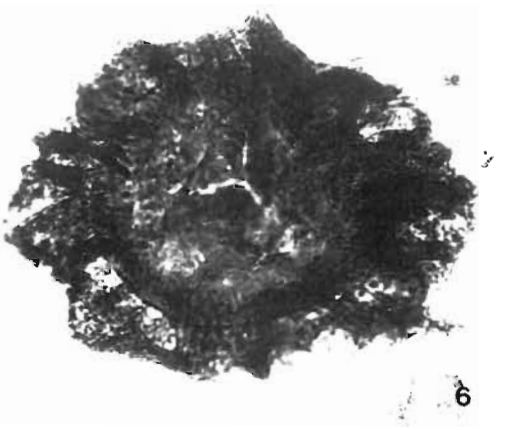

6

PLATE 12

outline, strongly frilled, finely intramicroreticulate with thick muri imparting leathery and punctate nature. Saccus attachment subequatorial.

Comparison—*Parasaccites densicorpus* Lele 1975 differs from all other species in having a distinct, thick and dark coloured central body.

Genus—*Crucisaccites* Lele & Maithy 1964

Type species—*Crucisaccites latisulcatus* Lele & Maithy 1964.

1946 Specimens in Virkki, pl 5, fig. 49; pl. 10, figs 135, 136; pl. 11, figs 137, 138.

Original diagnosis—"Monosaccate grain, circular to oval in outline, body distinct to indistinct, circular to ellipsoid; saccus encloses most of the body but leaves free a bilateral zone on both sides of the body along which it is attached, saccus-free areas on the two sides of the body lie at right angles to each other; monolete mark present but inconsistantly developed; body exine in the saccus-free areas apparently thinner, with a tendency to rupture; body infolds near saccus attachment may be strongly developed or absent; saccus structure intrareticulate" (after Lele & Maithy 1964, p. 307, 308).

Discussion—It has been noticed that the central body in such pollen grains is mostly distinct (and not indistinct as mentioned in the diagnosis); however, it is a possibility that the central body is lost in some specimens where only the cruciate saccus remains in the macerate. The shape of the nexine is variable being elongately oval with smooth curved outline to flat lateral and terminal side walls. The exine of the body is finely intramicroreticulate which could be best seen in the high power objective. The monolete mark is an inconsistent feature and the body exine usually ruptures along such weaker zone. In certain specimens this is also represented by a thinner linear area. The body infolds near saccus attachment have been found to occur in most of the specimens. They may be well-developed or, at times, less pronounced or even partially so. When the folds are prominent, they are ± lunar in outline with convex line towards the outer side. The saccus is frilled type, protosaccus with usually thick muri and very narrow, sometimes puncta-like lumen. At the periphery of saccus in flattened condition, a narrow, denser zone is demarcated which exhibits thicker nature of muri.

The original generic diagnosis given by Lele and Maithy (1964) broadly encompasses the variability of species under *Crucisaccites*. The above mentioned characters are additional observations and are incorporated in elaborated description.

Description (elaborated)—Normally big monosaccate pollen with well-developed sexine enclosing a thin, oval, ellipsoid to flat sided hexagonoid central body (nexine) (Pl. 15, figs 1, 2). No sulcus or tenuitas seen, except a thin, weak, elongated area being present in the body centre on one of its faces, which sometime rupturing to form a vent; a short monolete slit rarely seen. The central body is indistinctly to distinctly intramicroreticulate in structure. The cross attachment of saccus with the body very peculiar and distinctive; folds of nexine along the saccus attachment zone generally prominent. Saccus with protosaccate fill, alveoli of very minute size having thick walls of muri. Muri thickness increasing at the peripheral region of the saccus forming thicker zone. Width of saccus with relation to central body equator may be uniform or trending towards a wider span at the terminal sides on the longer axis.

Comparison—*Crucisaccites* is identifiable from other monosaccate genera on the basis of its cruciate nature of saccus attachment.

Organization—The crucisaccate mode of saccus attachment with the central body is the characteristic feature of organization in this genus (Text-fig. 7). Lele and Maithy (1964) have already given a detailed account of mode of saccus attachment, with crossed saccus-free areas on the body. The monolete mark appears to be a variable character. The body folds along the zone of saccus attachment normally

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PLATE 13 →

1-9. *Parasaccites* Bharadwaj & Tiwari 1964, SEM photomicrographs:

1, 2, 4. *Parasaccites korbaensis* Bharadwaj & Tiwari 1964 showing radiating folds of saccus and the nature of central body and saccus in surface view.

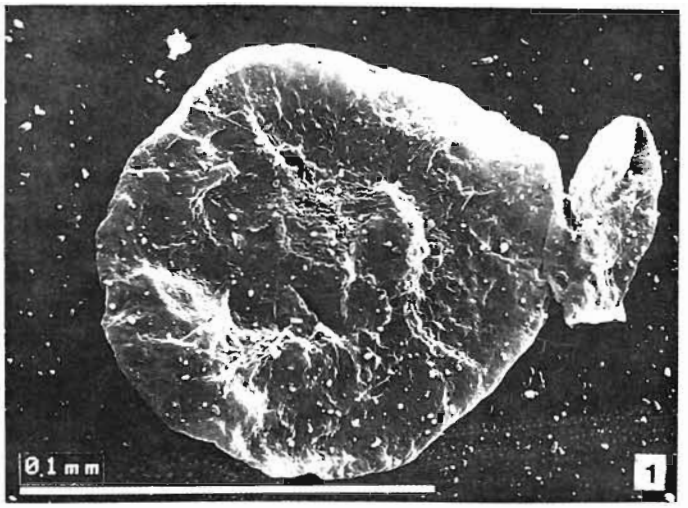
3. *Parasaccites bilateralis* Tiwari 1965 showing radiating folds of saccus and subcircular saccus free area.

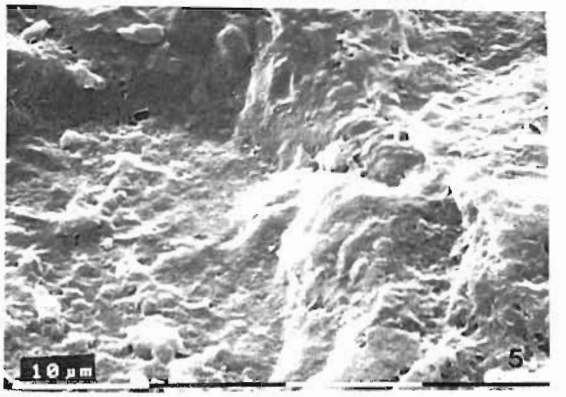
5. Enlargement of a portion of pollen at the saccus attachment zone showing the leathery nature of saccus—fine reticulation with thick muri, and the nature of central body.

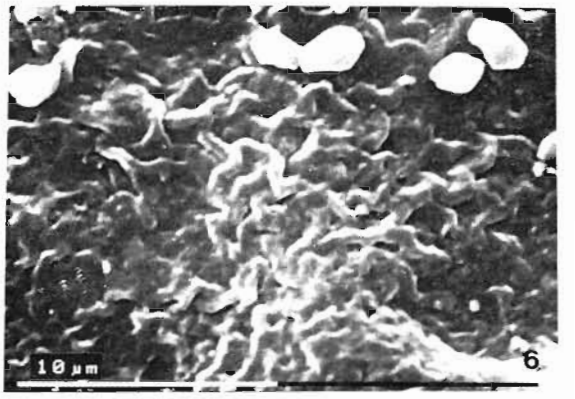
6. Enlargement of pollen showing intrareticulate structure of central body in surface view with irregular and anastomosing muri.

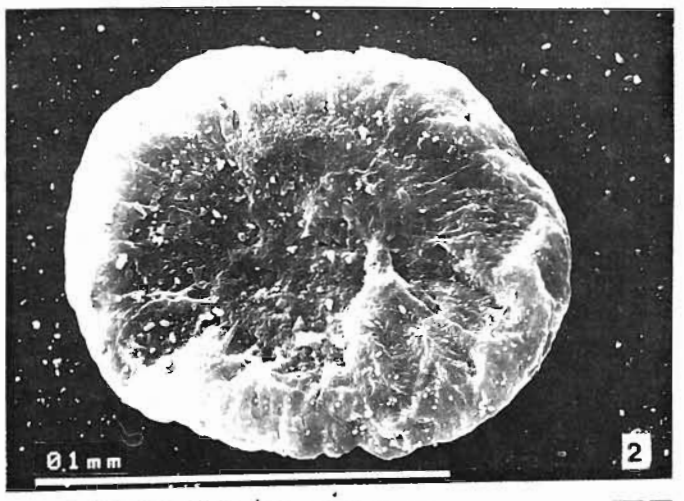
7, 8. Portion of saccus enlarged to show small puncta-like holes in surface view.

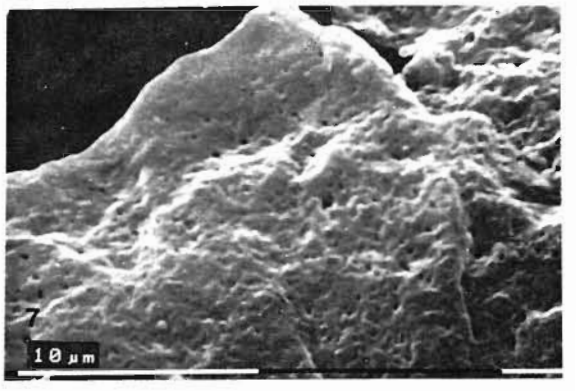
9. Portion of pollen showing intrareticulate nature of central body, and radiating folds on the saccus attachment zone.

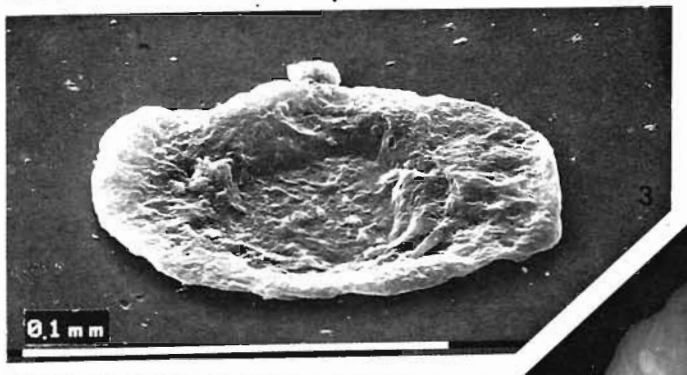


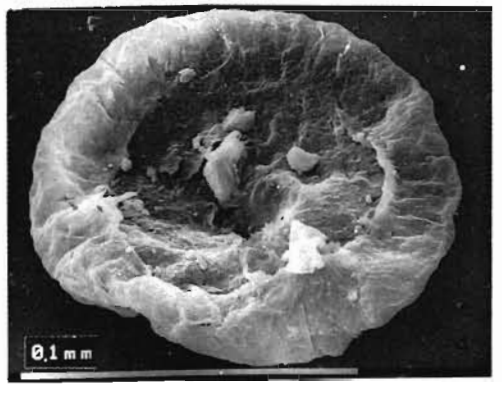


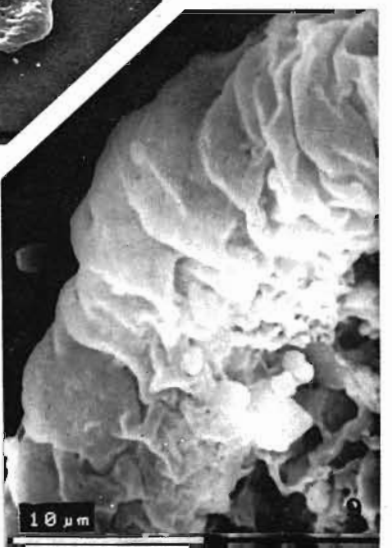












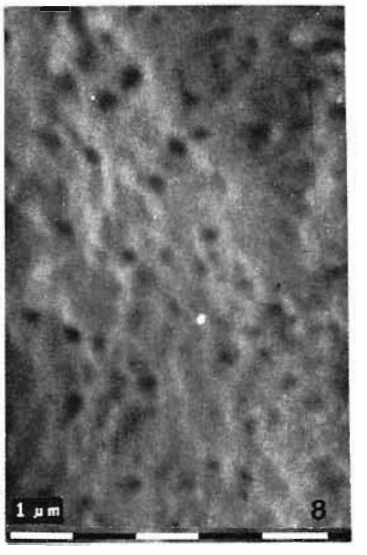
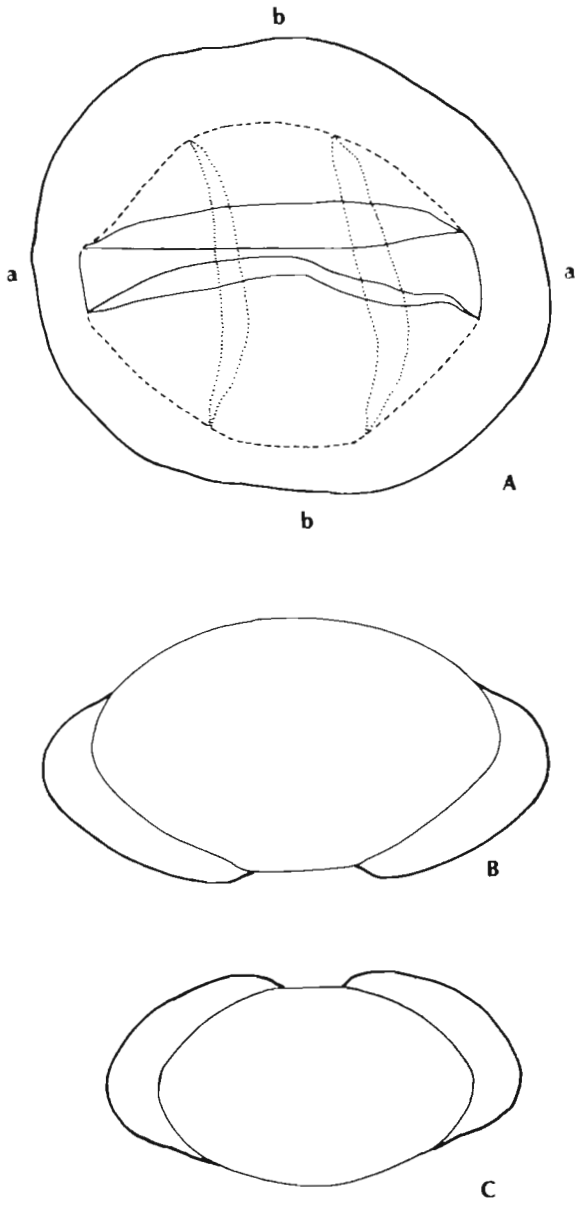


PLATE 13



Text-figure 7—Reconstruction of organisation of *Crucisaccites* Lele & Maithy 1964: **A**, Proximo-distal plane; **B**, Meridional section at aa plane; and **C**, Meridional section at bb plane.

develop prominently; sometimes, however, all are not pronounced due to flattening angle of the pollen or body orientation. The nexine (central body) is thin, elliptical to globoid which flattens to adjust its vertical plane.

Occurrence—Permian (Upper Talchir to Raniganj).

Prominence—Karharbari Formation.

List of species on record :

Crucisaccites latisulcatus Lele & Maithy 1964
C. monoletus Maithy 1965
C. medius Lele & Maithy 1969
C. indicus Srivastava 1970

List of species resolved :

The type specimens wherever available or other specimens from the type material, were examined and following species were retained in the genus.

1. *Crucisaccites latisulcatus*
2. *C. monoletus*
3. *C. indicus*

Crucisaccites medius Lele & Maithy 1969 does not find its place under this genus.

Remarks—Only three species, viz., *Crucisaccites latisulcatus, C. monoletus* and *C. indicus* have been retained in this genus. *C. latisulcatus* has generally a smaller body with relation to the overall pollen size, while in *C. monoletus* and *C. indicus* the body is bigger occupying most of the pollen area. The most distinguishing character is the body shape in *C. latisulcatus*. Only those forms have to be included here which exhibit the presence of a trapezoid, ellipsoid body with flat sides or hexagonoid rhomboidal configuration. In *C. indicus* the forms with subcircular body should be included. In *C. monoletus* the cruciate arrangement is not typical but the monolete mark is well-defined.

Other species of Crucisaccites—*Crucisaccites medius* Lele & Maithy 1969 does not show a cruciate construction of saccus. The type as well as other specimens illustrated by Lele and Maithy (1969, pl. 3, figs 25, 26) possesses the distorted configuration of *Plicatipollenites* in having a radially symmetrical saccus attachment rather than the cruciate-type. Evidently these pollen belong to the genus *Plicatipollenites*.

Description of species resolved :

Crucisaccites latisulcatus Lele & Maithy 1964

Pl. 14, figs 1, 2; Pl. 16, figs 1, 2; Pl. 17, figs 1, 2; Pl. 18, figs 1, 2; Pl. 24, figs 1-6

PLATE 14 →

1, 2. *Crucisaccites latisulcatus* Lele & Maithy 1964 showing trapezoid nature of central body and cruciate nature of saccus attachment, × 500:

1. Holotype; Slide no. BSIP 1584, EF : S29/1.
2. Slide no. BSIP 1586, EF : N43.

1

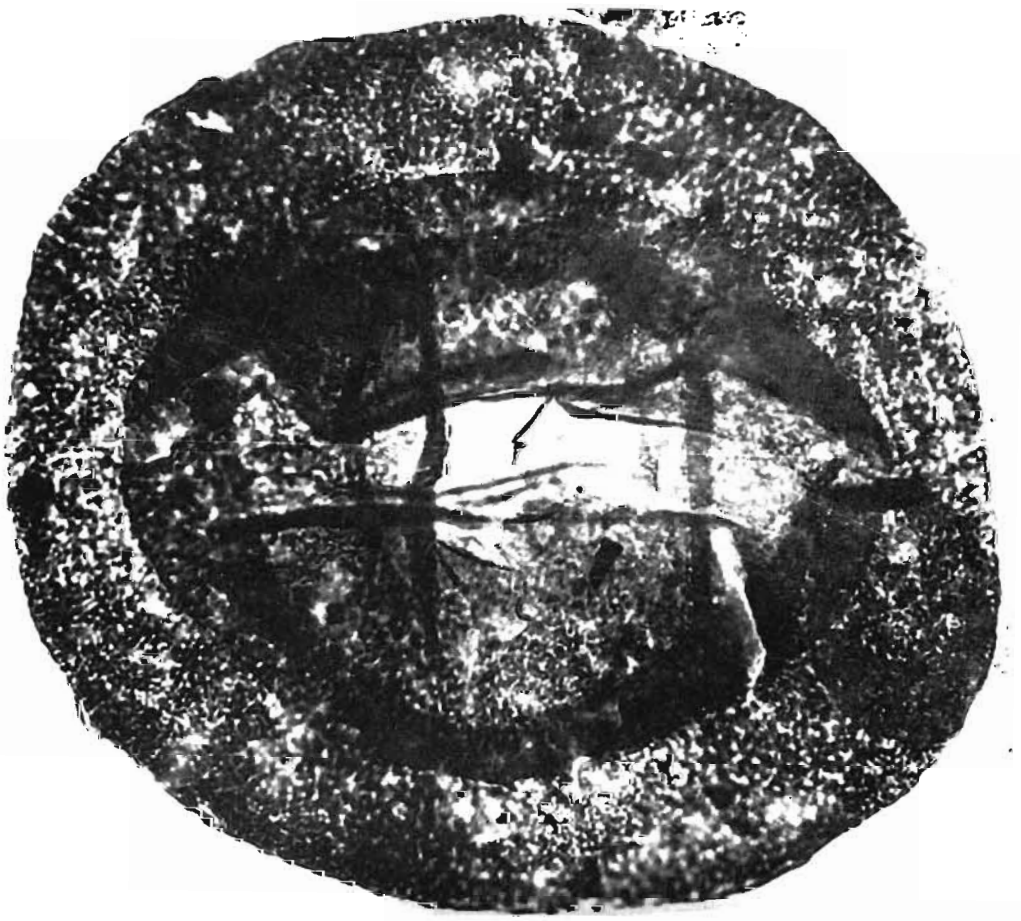


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PLATE 14

Holotype—Lele and Maithy, 1964; pl. 1, fig. 1; size 207.5 × 240 μm; Slide no. BSIP 1584/3; Central Pit, Srirampur Colliery, Giridih Coalfield; Karharbari Formation, Early Permian.

Isotype—Lele and Maithy, 1964; pl. 1, fig. 2; Slide no. BSIP 1587 (here designated).

Original diagnosis—"Size range about 200-260 microns (along longer axis), outline ± circular to oval, body 160-190 microns (along the longer axis), mediumly thick, clear, subcircular to ellipsoid in shape, exine structure or sculpture obscure, saccus outside the body narrow, more or less uniformly wide; zones of attachment nearly reaching the body periphery, bilateral, cruciate with respect to each other on the two sides, saccus free areas of body ± wide, thinner, sulcus-like; body-infolds near saccus roots strongly developed; monolete mark rarely visible, body exine in the saccus free area may often rupture to simulate a monolete horizontal slit; saccus structure fine intrareticulate" (after Lele & Maithy, 1964, p. 309).

Discussion—On re-examination of the type specimen as well as other specimens in the type material, following additional observations are made for this species:

1. Central body thin, squarish, trapezoid or ellipsoid with ± hexagonal rhomboid appearance, infrareticulate. The structure is visible more clearly when seen under high power objective rather than under immersion oil.
2. Saccus has thick irregularly wide muri and very narrow, at times puncta-like or fine reticulum, with protosaccate filling.

Description (elaborated)—Central body thin, distinct, squarish to trapezoid generally with flat ends. Monolete mark not distinct but a rupture is generally visible. Exine smooth, folds in body prominent, mostly lunar in shape with pointed ends joining with the angles of the body contour in the cruciate set-up of folds; horizontal folds more prominent than the vertical. Sacci with thick irregularly wide muri and intrapunctate to intrareticulate (lumen less than 1 μm); ± 10 μm wide thicker zone in the peripheral region of the saccus seen; rest of the area relatively lighter. Saccus structure doubly intrareticulate, coarse framework of muri enclosing finer meshes; protosaccate.

Crucisaccites monoletus Maithy 1965 emend.

Pl. 19, figs 1, 2; Pl. 20, figs 1, 2

Holotype—Maithy, 1965; pl. 3, fig. 18; size 142 × 108 μm; Slide no. BSIP 1983; Central Pit, Srirampur Colliery, Giridih Coalfield, Bihar; Karharbari Formation, Early Permian.

Original diagnosis—"Size range about 120-160 μ (along longer axis), outline ± oval to circular, body 110-130 μ (along longer axis), thin, distinct, circular or oval in outline, body ornamentation intramicroreticulate, saccus outside the body extremely narrow, more or less uniformly wide; zone of attachment nearly reaching to the body periphery, bilateral, cruciate with respect to each other on the two sides, saccus free areas of body ± wide, thinner, sulcus-like; body infolds absent; an undoubted monolete mark demonstrable, sometimes the body exine in the saccus-free area may often rupture to a broad horizontal slit; saccus structure fine intra-reticulate" (Maithy, 1965, p. 295).

Discussion—The above given original diagnosis is too loose to circumscribe this species. Therefore, after the examination of the holotype following emended diagnosis is given.

Emended diagnosis—Horizontally oval pollen with monosaccoid construction of saccus having wider span at terminal sides. Folds not typical of cruciate, having prominent, long vertical pair of folds and short, insignificant horizontal folds leaving rectangular saccus-free area. Monolete mark distinct. Muri thick, meshes fine; protosaccate.

Description (elaborated)—Typical cruciate infold system of the type species not seen. Body exine indistinctly structured. Horizontally rectangular saccus-free space bearing well-defined straight monolete mark. Saccus having a tendency to be wider at the terminal sides with fairly thick muri and doubly intrareticulate structure, meshes less than 1 μm wide.

Comparison—This species differs from *C latisulcatus* in having a bigger oval central body bearing a distinct monolete mark.

Crucisaccites indicus Srivastava 1970

Pl. 21, fig. 1; Pl. 22, figs 1, 2

Holotype—Srivastava, 1970; pl. 2, fig. 18; size 138 μm; Slide no. BSIP 2935; Nandira Colliery, Talchir Coalfield; Barakar Formation, Permian.

Isotype—Srivastava, 1970; pl. 2, fig. 19; Slide no. BSIP 2899.

Original diagnosis—"Overall size range 110-188 μ (along the longer axis), roundly subcircular to sub-rectangular with wide angles in overall shape; central body weakly defined, monolete mark not discernible; saccus attachment well-defined" (after Srivastava, 1970, p. 161).

Discussion—The following additional characters have been observed in this species:

1. The central body is big, filling most of the pollen area, subcircular and very thin. In some

PLATE 15

1, 2. *Crucisaccites latisulcatus* Lele & Maithy 1964 showing trapezoid nature of central body and prominent lunar folds on the body, × 500:

1 Isotype; Slide no. BSIP 1587, EF : V27/2.
2. Slide no. BSIP 1587, EF : L35/4.

cases it appears as if the body has been lost, but it is apparent rather than real, the structure of body ascertains its presence and its very thin nature.

2. Saccus beyond equator is narrow, muri short, thick, meshes narrow, protosaccate.
3. Folds of body are present at attachment zone.

Description (elaborated)—Big circular to oval pollen 100-130 μm. Central body thin, outline generally very faint but can be traced through L-O analysis occupying more than 3/4 of the pollen area, faintly structured; sometimes body appears to be missing because of highly thin nature; however, its presence can be ascertained because of the structured exine and microfolds in the central region. No mark or thinner area representing the monolete mark seen. Typical cruciate infold system generally not well-developed, encroachment of sacci cruciate type; in holotype horizontal folds are better represented; in other specimens studied, only narrow and short pleats in body exine noticed; in sacci also folding can be marked at the attachment zone. Saccus well-developed, with intrareticulate structure having thick muri and narrow meshes of ± 1 μm size; protosaccate fill ascertained; no peripheral zone in saccus.

Comparison—*C. latisulcatus* and *C. monoletus* differ from the present species in having distinct central body, the latter also has a well-defined monolete mark.

Genus—*Faunipollenites* Bharadwaj 1962

Type species—*Faunipollenites varius* Bharadwaj 1962.

Original diagnosis—"Disaccate, bilateral, haploxylonoid pollen grains. Central body outline ill-defined, proximally exine intramicroreticulate and bearing a number of horizontal, simple or forked striations, rarely with vertical, connecting striations also; distally a uniformly wide to biconvex area free from saccus, where the exine is thin and sparsely granulose. Distal zones of saccus attachment ill-defined" (after Bharadwaj, 1962, p. 95).

Discussion—Re-examination of the type specimens of several species of *Faunipollenites* has revealed the presence of following additional characters as well as variability:

1. The pollen, in most cases, are haploxylonoid but slightly diploxylonoid construction of sacci has also been noted in some cases.
2. The grooves are the "striations" in nature, i.e., they are uniformly wide, linear furrow-like structure; they are not taeniae bound by irregularly wide pathways.
3. The central body has no defined outline; only sometimes it is apparent, or visually delimited by free ends of striations.
4. The sacci are protosaccate.
5. The proximal body surface is finely intrareticulate and distal saccus free area is smooth, chagrinate or incipiently structured.

Description (elaborated)—Pollen disaccate, bilaterally oval, mostly haploxylonoid with hemispherical sacci broadly attached with body at lateral sides, rarely showing incipient tendency for diploxylonoid construction. Central body (nexine) not clearly demarcated, apparently oval or subcircular. Proximally bearing a number of simple or branched striations, vertical partitions in between them not observed. Striations linear, uniformly wide along their full length deciphering the limits of central body extension (Pl. 27, figs 6-8). Sexine in between striations finely intramicroreticulate. Sacci protosaccate, hemispherical or less than that, laterally rarely close to each other, merging with body, distally inclined to leave narrow to wide, generally ill-delimited, saccus-free area, which being thin and incipiently intramicroreticulate structured. No folds along zones of sacci attachment. Intrareticulation of sacci fine to coarse or even double in having coarser areas enclosing finer reticulation; saccus with protosaccate fill.

Comparison—Genus *Faunipollenites* Bharadwaj 1962 has been equated with *Protohaploxypinus* Samoilovich 1953 by Hart (1964) and Balme (1970) and to *Striatopiceites* Zoricheva & Sedova 1954 emend. Sedova 1956 by Venkatachala and Kar (1968) and Kar (1968). However, a critical review of the original description for those taxa has revealed the following morphotaxonomic differences.

The genus *Protohaploxypinus* as described and illustrated by Samoilovich (1953, pp. 42, 43; pl. 4, fig. 4), is not supplemented by the photomicrograph of the type specimen; only a semidiagrammatic figure of the same is given, wherein no distinct striations are depicted. The horizontal lines drawn by Samoilovich (1953) do not appear to be striations. As they are shorter than the body horizontal axis, they in all probability represent small folds. The central body appears to be distinct as in other species of the genus illustrated by Samoilovich (1953, pl. 6, figs 1-3; pl. 12, figs 1, 2; compare photographs with line drawings). In the generic description it has been mentioned that the central body is ellipsoidal and airsacks embrace the body deeply. It follows that the central body exine has been described as granular or granular-ribbed; as such, this is an ambiguous taxon. Later, Hart (1964) restudied the type designated to *P. latisimus*

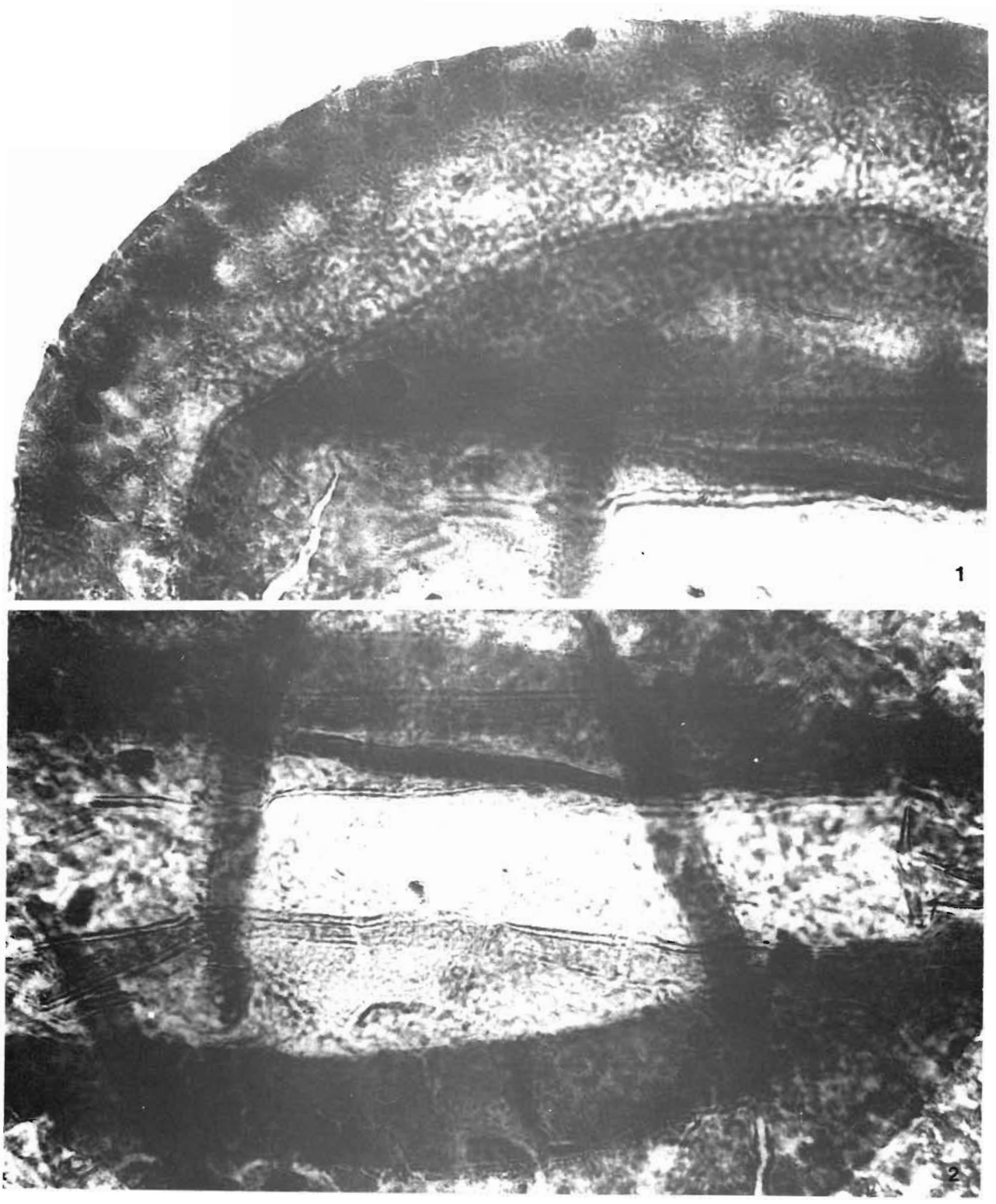
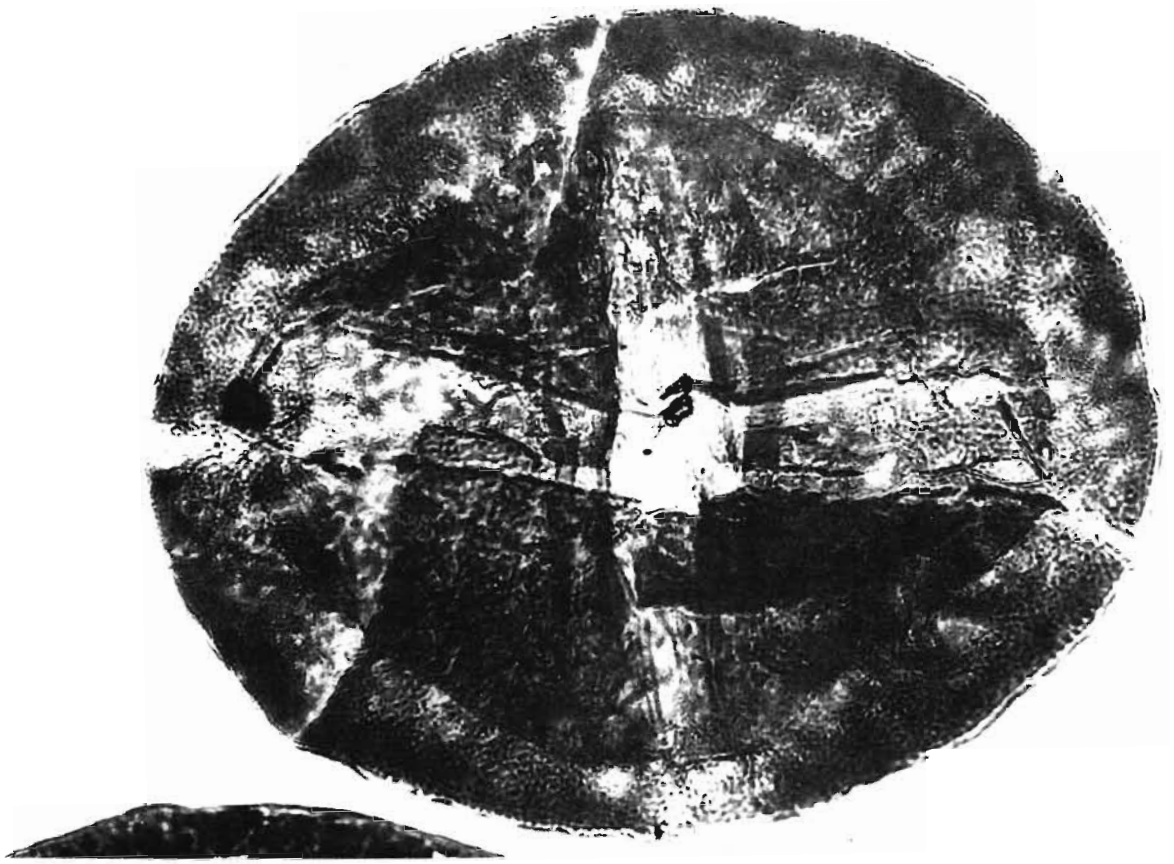


PLATE 16

1, 2 *Crucisaccites latisulcatus* Lele & Maithy 1964, × 1500.
1 Portion of specimen in Plate 15, fig. 1 showing saccus reticulation with thick muri
2 Portion of specimen in Plate 15, fig. 1 showing the nature of folds and intrareticulation of central body



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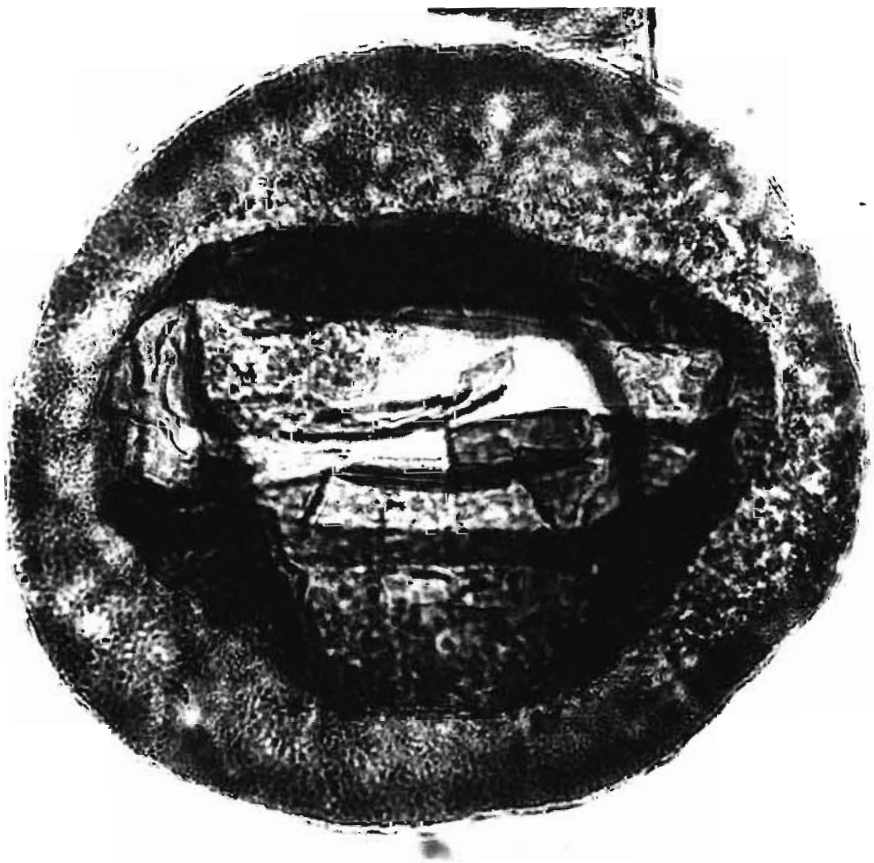

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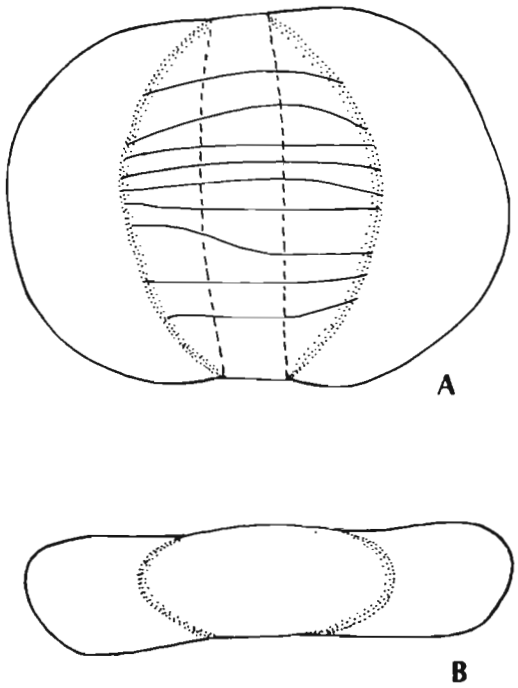
PLATE 17



Text-figure 8—Reconstruction of organisation of *Faunipollenites* Bharadwaj 1962: **A**, In proximodistal plane; **B**, Meridional section.

by A. A. Luber in 1941. He excluded non-striate grains and emended the diagnosis for the genus accordingly; he described the shape of the central body, meaning thereby the distinctness of the same. Thus, if the presence of striations is doubtful in the type specimen, the exclusion of non-striate forms from this genus is not justified. In any case, the central body is very well defined in *Protohaploxypinus* and exine structure could be different than the reticulation. This genus, therefore, does not compare with *Faunipollenites*.

Similarly, in the genus *Striatopiceites* as described and illustrated by Sedova (1956; Trans. Hart, 1964, pp. 6, 7; pl. XLI, fig. 7), the central body is thick with a distinct outline. Body is ribbed with a fine reticulation between the ribs. Besides, in few grains germinal furrow is seen varying in its direction either longitudinal or perpendicular to the air sacs. Such situations are not encountered in *Faunipollenites*.

In view of these observations, Tiwari (1974) commented that both the above mentioned genera have distinct central body, apart from other details, which make them different from *Faunipollenites*.

Hence, the present authors do not agree with the views of Hart (1964), Balme (1970), Venkatachala and Kar (1968) and Kar (1968) to consider the genus *Faunipollenites* Bharadwaj 1962 as synonym of *Protohaploxypinus* Samoilovich 1953 or *Striatopiceites* Sedova 1956 at any level of morphography.

The diffused nature of intramicroreticulate central body, common haploxylonoid organization of sacci, merging zones of sacci attachment on distal side, the free ends of striations simulating the body limit and the protosaccate nature of sacci remain the distinguishing features of the genus *Faunipollenites*.

Organization—The main character of the genus is a diffused central body, without marked outline (Text-fig. 8). The sacci are generally half of the sphere or subspherical with haploxylonoid construction. The zone of saccus attachment is also diffused without any body infold accompanying them. These features suggest that the central body did not have much area along proximo-distal line; it could be of lensoid rather than spheroid in sectional view. The sacci also do not appear to incline distally to a greater extent. There is no prominent blowing up of sacci as normally radially oriented pleats emerging from saccus roots are absent.

List of species on record:

Faunipollenites varius Bharadwaj 1962
F. perexiguus Bharadwaj & Salujha 1965
F. copiosus Bharadwaj & Salujha 1965
F. parvus Tiwari 1965
F. minor Salujha 1965
F. goraiensis (Potonié & Lele) Maithy 1965
F. bharadwajii Maheshwari 1967
F. circumstriatus Maheshwari 1969
F. enigmatus Maheshwari 1969
F. gopadensis Bharadwaj & Srivastava 1969
F. singrauliensis Sinha 1972
F. multistriatus Srivastava 1979

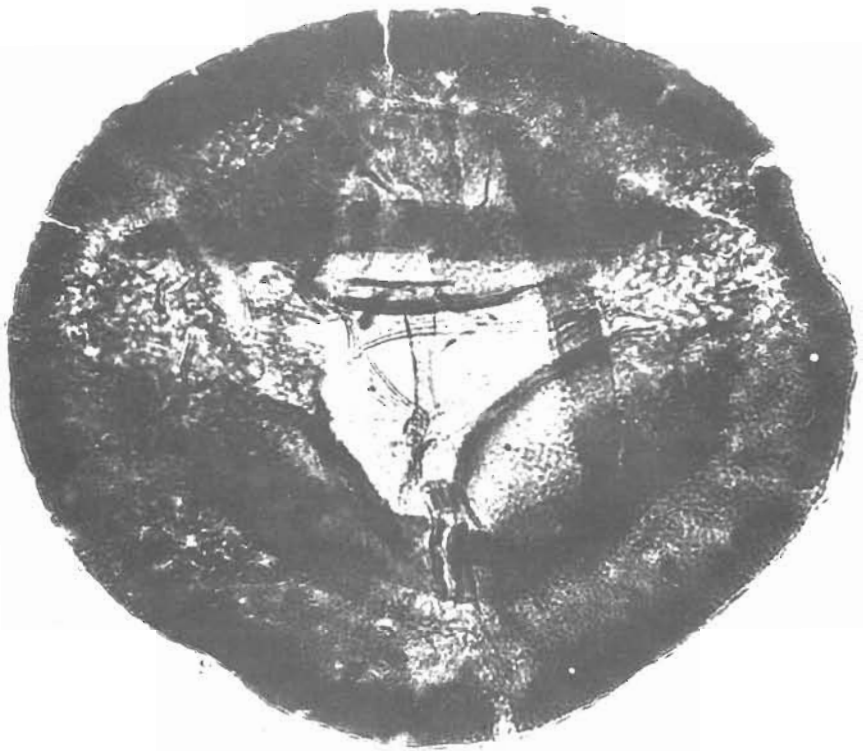
Some species assigned to *Striatopiceites* Zorich. & Sedova 1954 emend. Sedova 1956, have resemblance with *Faunipollenites*, hence considered here for resolution.

Striatopiceites magnus Bose & Kar 1966
S. congoensis Bose & Kar 1966

← **PLATE 17**

1, 2. *Crucisaccites latisulcatus* Lele & Maithy 1964 showing trapezoid nature of central body, ruptured exine and cruciate nature of saccus attachment, × 500:

1. Slide no. BSIP 1587/1, EF : N31/4.
2. Slide no. BSIP 1588/1, EF : E44/1.



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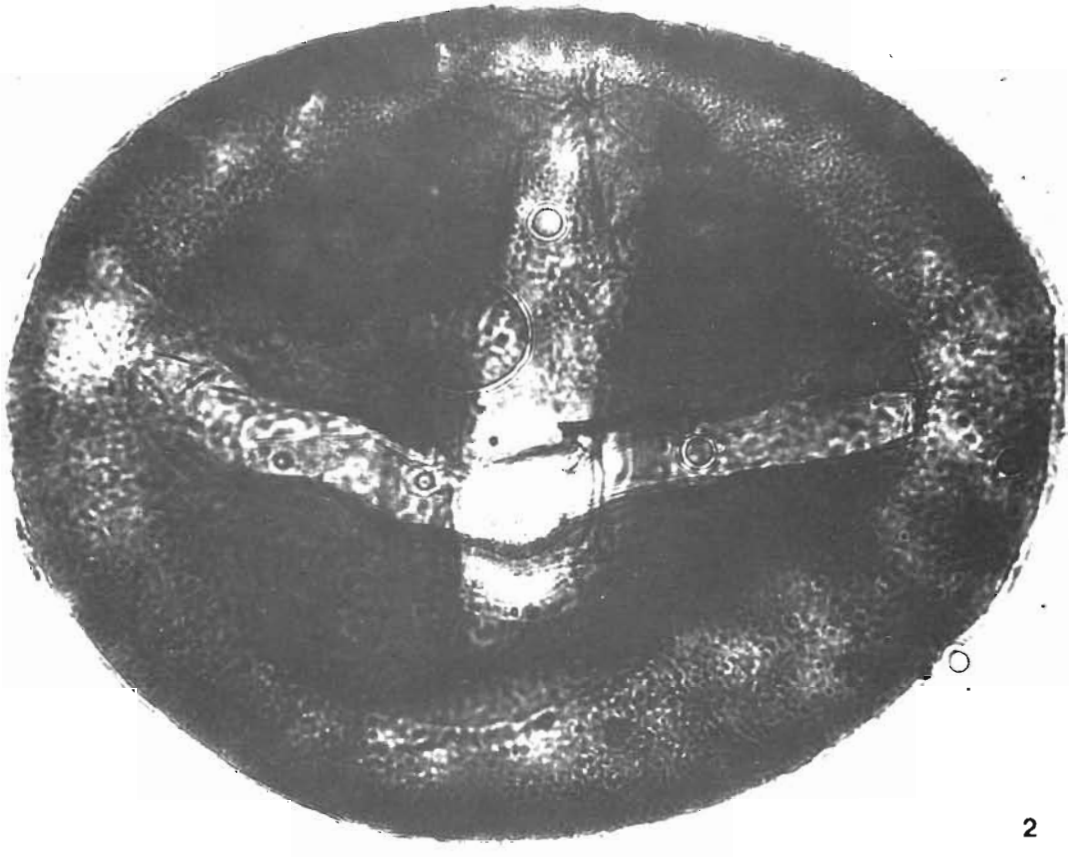

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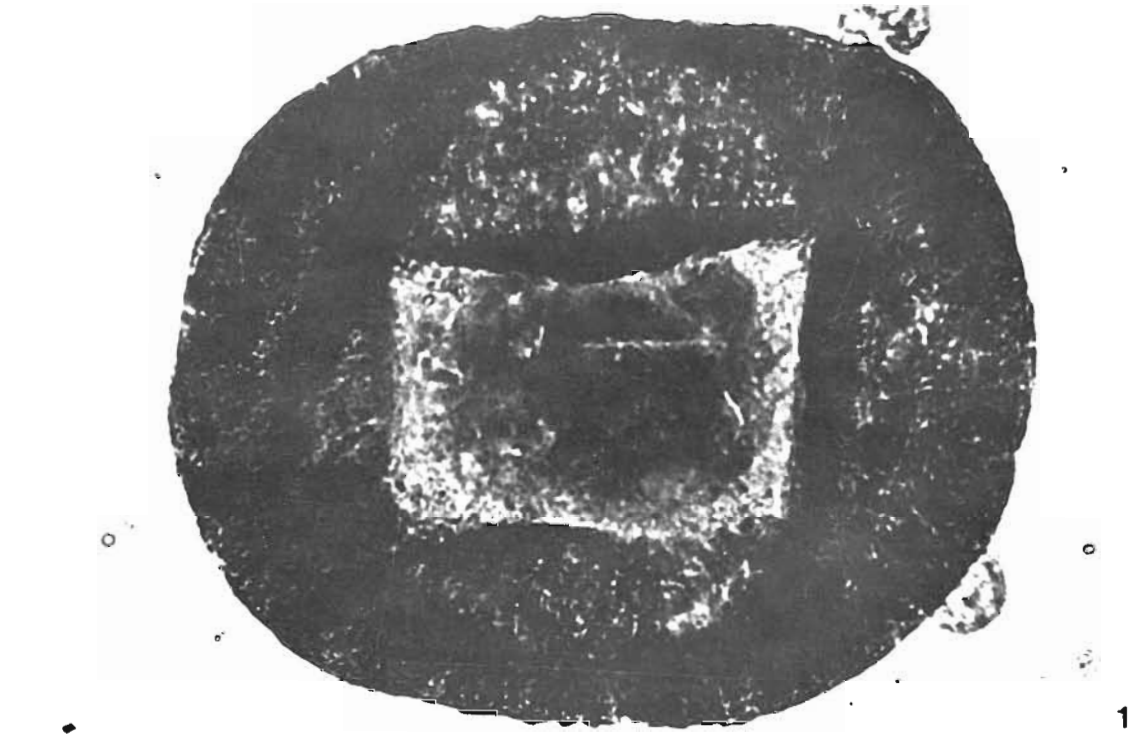
PLATE 18

1, 2. *Crucisaccites latisulcatus* Lele & Maithy 1969.

1 Showing the trapezoid nature of central body and fold system; Slide no. BSIP 1588, EF : O38/3, × 500.

2. Showing trapezoid nature of central body, cruciate saccus attachment and saccus intrareticulation with thick muri; Slide no. BSIP 1585/2, EF : K44/1, × 500.



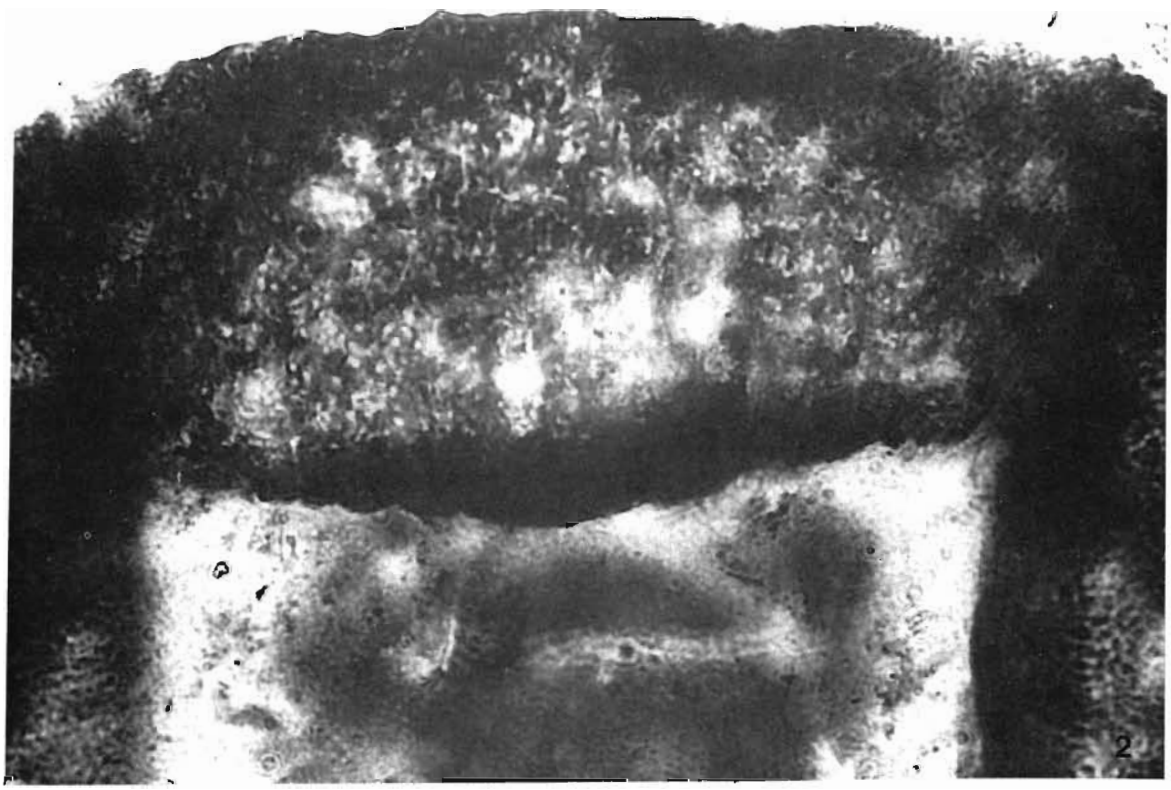


PLATE 19

1, 2. *Crucisaccites monoletus* Maithy 1965 here emended:
1. Holotype showing monolete mark on the central body and cruciate nature of saccus attachment; Slide no. BSIP 1984, EF : Q51/2, × 800.
2. Enlargement of a portion of holotype to show the nature of central body and saccus intrareticulation with thick muri, × 2000.

S. minutus Venkatachala & Kar 1968
S. digradius Kar 1968
S. rimosus Venkatachala & Kar 1968
S. granulatus Kar 1968
S. clarus Kar 1970
S. delicatus Kar & Bose 1976

List of species resolved:

Re-examination of available type specimens and allied specimens of various species, and analysis of range of characters have led to circumscribe the following species under this genus. Consequently, out of 20 species, only five species have been retained in this genus. Rest of the species have either been treated as synonym or transferred to other genera.

Species retained in *Faunipollenites* after present analysis are:

Faunipollenites varius (= *F. bharadwajii, Striatopiceites digredius, Striatopiceites clarus*)
F. perexiguus (= *F. parvus, F. minor, Striatopiceites granulatus, Striatopiceites minutus, Striatopiceites delicatus*)
F. singrauliensis
Faunipollenites congoensis (= *Striatopiceites rimosus*)
Faunipollenites magnus

Species which do not find their place under *Faunipollenites* are:

Faunipollenites copiosus
F. circumstriatus
F. enigmatus
F. gopadensis
F. goraiensis
F. multistriatus

Faunipollenites copiosus, F. gopadensis and *F. goraiensis* possess distinct central body with well-defined outline. *F. circumstriatus* and *F. enigmatus* exhibit the arrangement of striations similar to that described for the genus *Circumstriatites* Lele & Makada 1972. *F. multistriatus* is a badly-preserved, over-macerated specimen and the structure of the exine could not be determined.

Occurrence—Early Permian to Early Triassic.

Prominence—Upper Barakar and Lower Raniganj.

Description of species resolved:

Faunipollenites varius Bharadwaj 1962 emend.
Pl. 25, figs 1-4; Pl. 26, figs 4, 5; Pl. 27, figs 1-4, 6-8

1967 *Faunipollenites bharadwajii* Maheshwari, pl. 8, fig. 63.
1968 *Striatopiceites digradius* Kar, pl. 3, figs 73, 74.
1970 *Striatopiceites clarus* Kar, pl. 2, fig. 40.

Holotype—Bharadwaj, 1962; pl. 18, fig. 230 (not traceable); Samla seam, Samla Kendra Colliery, East Raniganj Coalfield; Raniganj Formation, Permian.

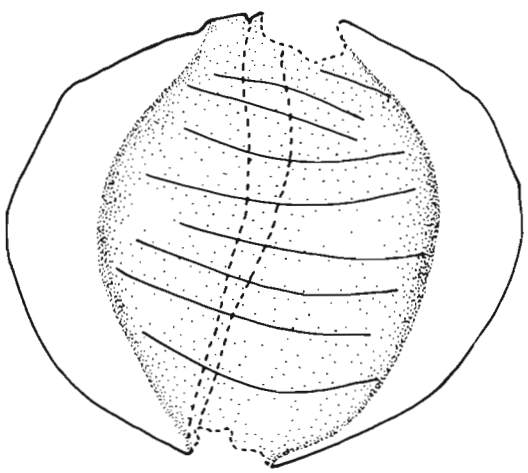
Lectotype—Bharadwaj, 1962; pl. 18, fig. 232; size 64 × 106 μm; Slide no. BSIP 9903.

Original diagnosis—"Central body apparently subcircular, 6-8 horizontal striations, distal channel wide, ill-defined. Sacci hemispherical" (after Bharadwaj, 1962, p. 95).

Discussion—The "apparent" shape of the central body cannot be taken as a criterion for delimiting this species as it may be deceptive. The width of the distal channel and the number of striations show a wide range, hence do not make an effective ground for defining this species. Therefore, the diagnosis is being altered here.

Emended diagnosis—Haploxylonoid, bisaccate, bilateral pollen grains. Central body ill-defined, proximally bearing 6-20 simple, rarely forked striations. Exine between the striations intramicroreticulate. Sacci hemispherical without radial pleats, distally leaving narrow to wide 5-20 μm ill-defined mostly unstructured saccus-free area. Saccus reticulation filling the cavity, hence protosaccate with variable sizes of the meshes.

Description (elaborated)—Basic shape of the pollen bilaterally oval, could be vertically oval to subcircular, 64-180 μm in size. Central body apparent, but thin and without marked outline so that its size cannot be measured. Apparent shape simulated due to ends of striations or structure differentiation. Distal attachment-lines of sacci



Text-figure 9—Line drawing of holotype of *Faunipollenites congoensis* (Bose & Kar) comb. nov. showing subcircular pollen outline and narrow saccus-free area.

merging with central body can be marked by structural differences; no folds along attachment line. Saccus-free area narrow to wide, straight to slightly convex. No pleating in sacci. Saccus medium to coarse with double network, protosaccate. Muri thickness may vary

Remarks—Faunipollenites bharadwajii Maheshwari 1967 does not have characteristic features which could separate it from *F. varius*. *Striatopiceites digredius* Kar 1968 is based on sublaterally preserved specimens, hence the distal attachment lines appear to go apart from each other; else, it is not different from *F. varius*.

Faunipollenites perexiguus Bharadwaj & Salujha 1965

Pl. 25, figs 5-8; Pl. 27, fig. 5

1965 *Faunipollenites parvus* Tiwari, pl. 6, fig. 125.
1965 *Faunipollenites minor* Salujha, pl. 2, fig. 30.
1968 *Striatopiceites granulatus* Kar, pl. 3, fig. 75.
1968 *Striatopiceites minutus* Venkatachala & Kar, pl. 8, fig. 135.
1976 *Striatopiceites delicatus* Kar & Bose, pl. 8, fig. 12.

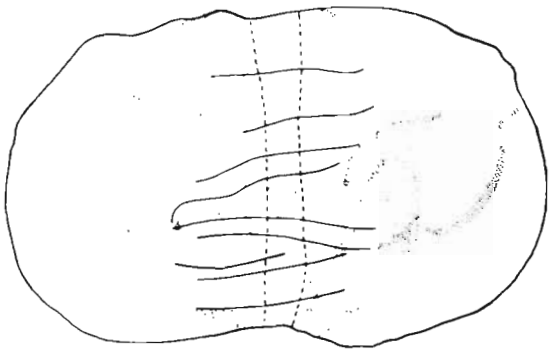
Holotype—Bharadwaj and Salujha 1965; pl. 2, fig. 42; size 43 × 54 μm; Slide no. BSIP 9904; VII (Bonbahal) Seam, Raniganj Coalfield, Bihar; Raniganj Formation, Late Permian.

Isotype—Bharadwaj and Salujha 1965; pl. 2, fig. 43 (here designated).

Original diagnosis—"Overall shape subcircular, size 54-74 μ; central body outline indistinct, horizontal striations 6-9; bladders with fine to medium intrareticulation, almost touching each other distally" (after Bharadwaj & Salujha, 1965, p. 37).

Discussion—There are several species enlisted above under "synonymy" which have been earlier separated on the basis of very minor differences. This group of species represents the smaller pollen with faint or completely diffused body and narrow to medium width of the distal saccus-free area.

F. perexiguus Bharadwaj & Salujha 1965, being the priority-bearer taxon, has been recognised. The type specimen of this species reveals that the body is completely ill-defined, hence no shape can be presumed. It is finely intrareticulate, the sacci are also finely intrareticulate but having slightly bigger meshes than those of body. Five unbranched striations are present. Sacci attachment lines are sharp as well as close to each other in the centre of the body distally. The type specimen is bilaterally ovoid while others are slightly circuloid. So also the distal saccus-free area varies in width in other specimens illustrated for this species.



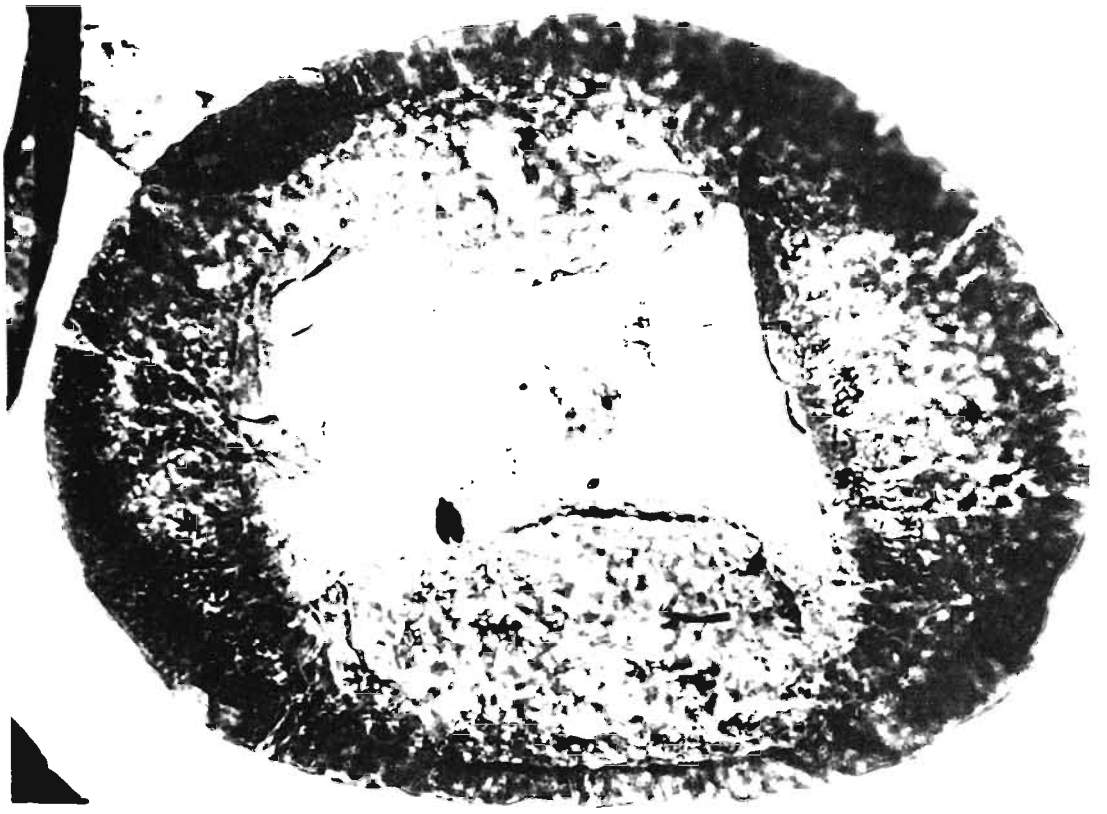
Text-figure 10—Line drawing of holotype of *Faunipollenites magnus* (Bose & Kar) comb. nov. showing indistinct outline of central body and bilateral saccus attachment.

1. In *F. parvus* Tiwari 1965 the distal saccus-free area is relatively wider than *F. perexiguus* but in all other characters they are indistinguishable.
2. The type of *F. minor* Salujha 1965 is unlike *Faunipollenites* in being diploxylonoid, having folds along one zone of attachment and body outline being somewhat clear. The isotype of *F. minor*, however, can not be distinguished from *F. perexiguus*.
3. *Striatopiceites minutus* Venkatachala & Kar 1968 and *S. granulatus* Kar 1968 have been differentiated from *F. perexiguus* on very minor differences. Types of both the former species are slightly sublaterally preserved, and hence overall shape is deceptive. The granulose sexine described for *S. granulatus* is not granulose; it is structureless. In all other characters they are similar to *F. perexiguus*.
4. *S. delicatus* Kar & Bose 1976 also does not differ from the present species; they fall under the range of smaller grains as discussed above.

On re-circumscription of the smaller group of pollen represented by *Faunipollenites perexiguus*, the following characters are to be taken as important for this species:

1. The pollen are generally small with a range along longer axis being 36-62 μm. They vary in shape from bilaterally oval to bilaterally subcircular.
2. Distal saccus-free area narrow.
3. Striations simple, rarely a few bifurcate.

Description (elaborated)—Overall shape of pollen bilaterally oval, sometimes vertical axis extended to impart a subcircular look. Size small, having haploxylonoid sacci. Body ill-defined, exine being finely intrareticulate. Distal saccus-free area very narrow (3-6 μm), lines of sacci attachment



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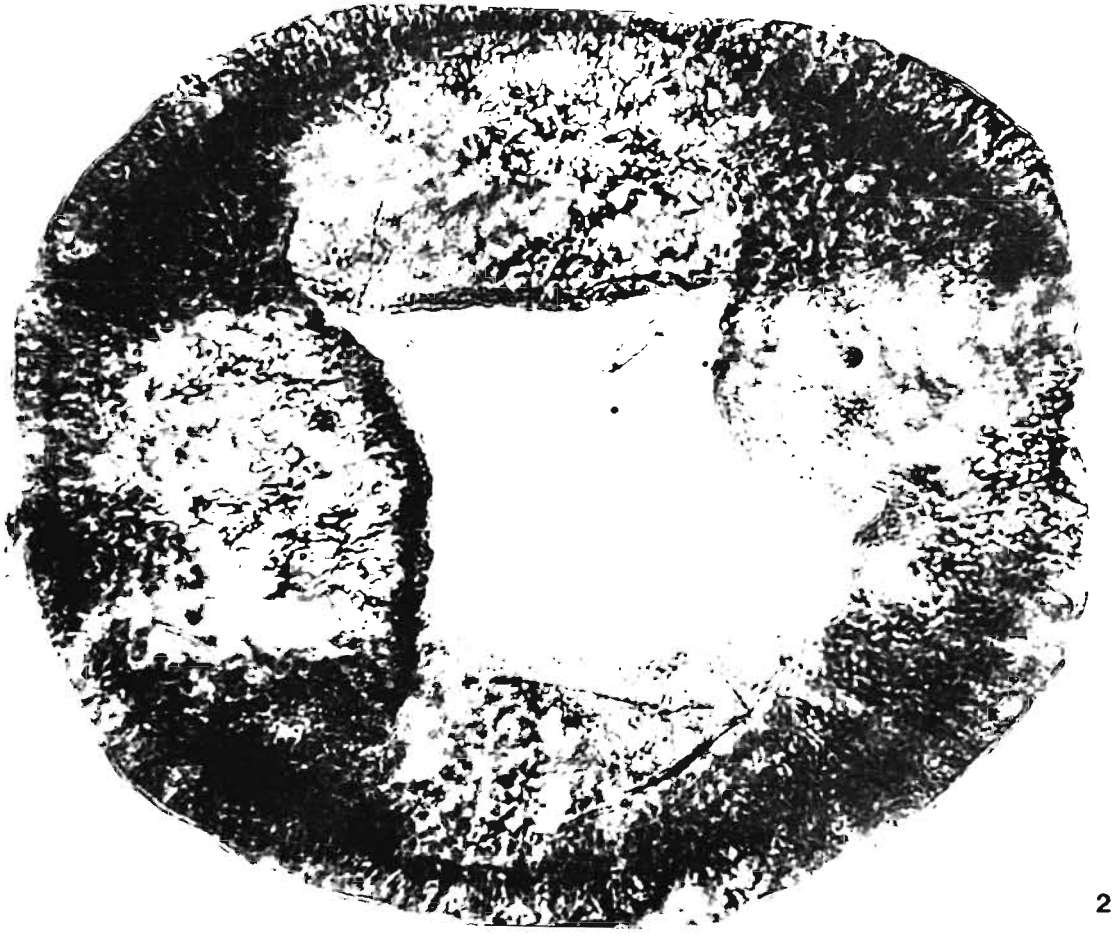


2

PLATE 20

PLATE 21

Crucisaccites indicus Srivastava 1970:
1 Holotype showing cruciate nature of saccus attachment; Slide no. BSIP 2935, EF: M19/1, × 950.

almost meeting in the centre, distinctly marked. Saccus also finely intrareticulate.

Comparison—*F. perexiguus* can be distinguished from *F. varius* by its much smaller size-range and narrow saccus-free area on the distal side.

Faunipollenites singrauliensis Sinha 1972 emend.
Pl. 26, figs 1-3, 6

Holotype—Sinha, 1972; pl. 7, fig. 105; size 67 × 95 μm, Slide no. BSIP 4160; Bore-hole NCSJ-4, Sample no. 126; Jhingurdah Seam, Singrauli Coalfield, Madhya Pradesh; Raniganj Formation, Late Permian.

Isotype—Sinha, 1972; pl. 7, fig. 10; Slide no. BSIP 4164 (here designated).

Original diagnosis—"Horizontally oval, bilateral pollen grains. Size 64 × 50-100 × 70 μ. Central body ill defined, proximally bearing well defined horizontal striations, 5-10 in number. Sacci haploxylonoid, zone of distal saccus attachment diffused, a median vertical groove or slit present" (after Sinha, 1972, p. 195).

Discussion—The observations made by re-examining the type specimen are:

1. Central body outline invisible, apparently horizontally oval as visualized by the free ends of striations.
2. Body exine with thick muri, fine meshes giving leathery look to the proximal surface.
3. Striations deeply-cut, some folded resulting

←

PLATE 20

1, 2. *Crucisaccites monoletus* Maithy 1965 here emended showing the distinct outline of the central body and cruciate nature of saccus attachment, × 750.

1. Slide no. BSIP 1584, EF: Y35/1.
2. Slide no. BSIP 1586, EF: F37/1.

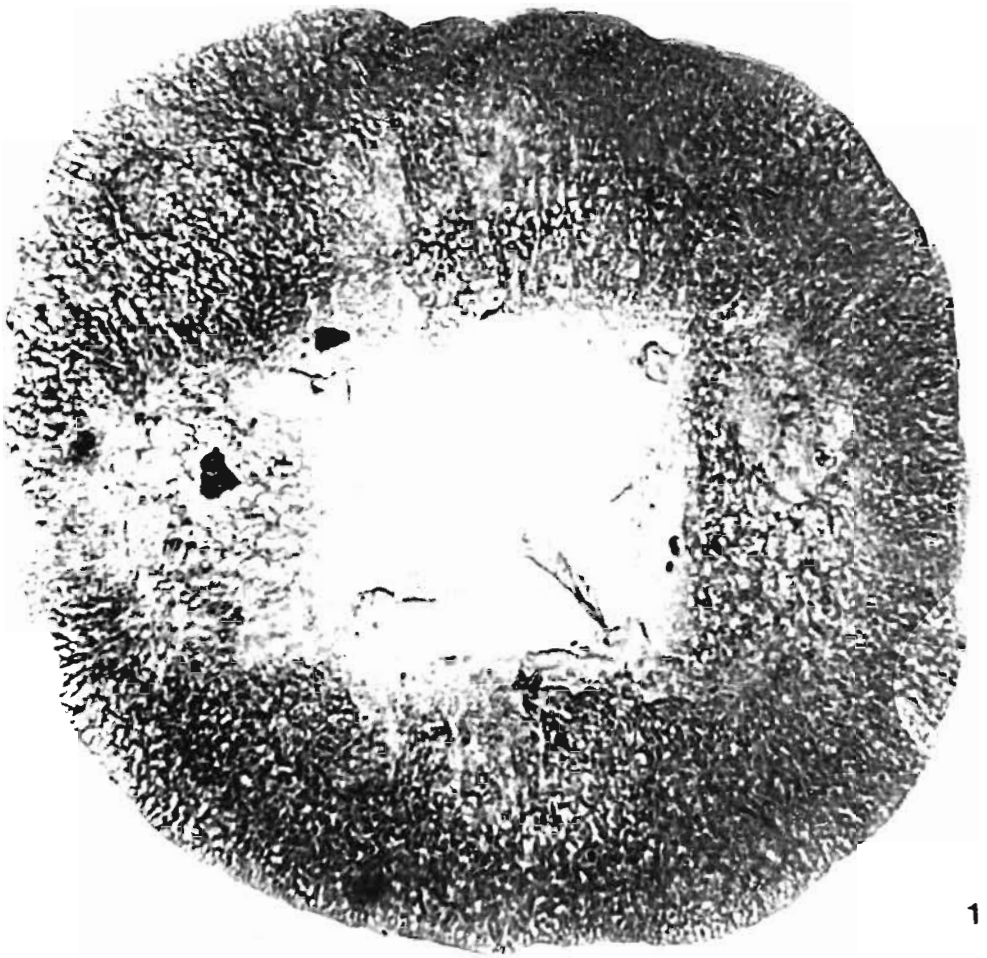


PLATE 22

1. *Crucisaccites indicus* Srivastava 1970:
Isotype showing indistinct nature of central body; Slide no. BSIP 2899, EF : O35/3, × 950.

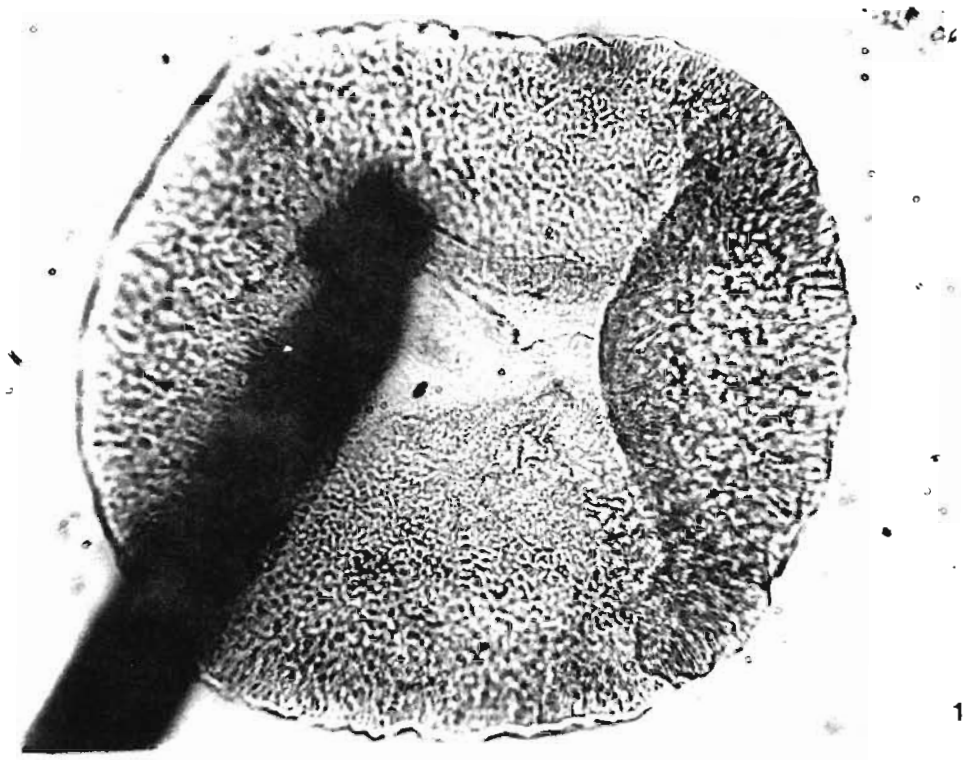
into narrow linear fold-like pleats after compression.

4. Sacci narrow beyond free ends of striations, protosaccate without double network.
5. Median vertical slit absent; sacci attachment zones close to each other, forming "slit-like" saccus-free area; separated apart from each other at one of their lateral sides.

Sinha (1972) separated *Faunipollenites singrauliensis* from *F. varius* on the basis of distal vertical slit in the centre; however, such a slit does not exist in the type specimen of the former species. On the other hand, a number of other characters, as enumerated above, have been observed which entitle this species to be a separate taxon from others. In view of these observations the diagnosis of *Faunipollenites singrauliensis* is being emended here.

Emended diagnosis—Bilateral, central body outline diffused, extent simulated through free ends of striations to be horizontally oval. Exine of central body finely intrareticulate with thick muri and fine meshes, imparting heavy leathery look; striations 5-10, deep-cut, some turning to be as liner narrow folds; sacci sub-hemispherical, narrow beyond free ends of striations, with medium-sized intrareticulations, distally inclined almost up to the centre. No slit on distal median region present.

Description (elaborated)—Size range 50-100 μm. Distally sacci close to each other so that a slit-like area simulated but these attachment lines separate apart from each other at one of the lateral sides. Striations being deep-cut in thick sexine on



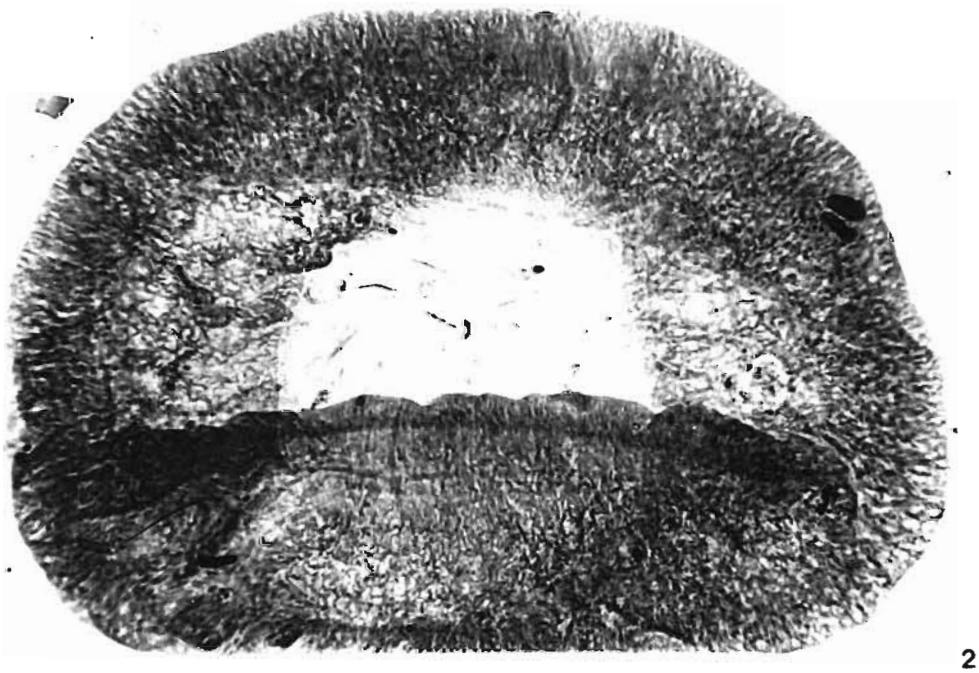


PLATE 23

1, 2. *Crucisaccites indicus* Srivastava 1970 showing indistinct nature of central body and saccus attachment.

1. Slide no. BSIP 2898, EF : W27/1, × 750.
2. Slide no. BSIP 2901, EF : N15/2, × 1000.

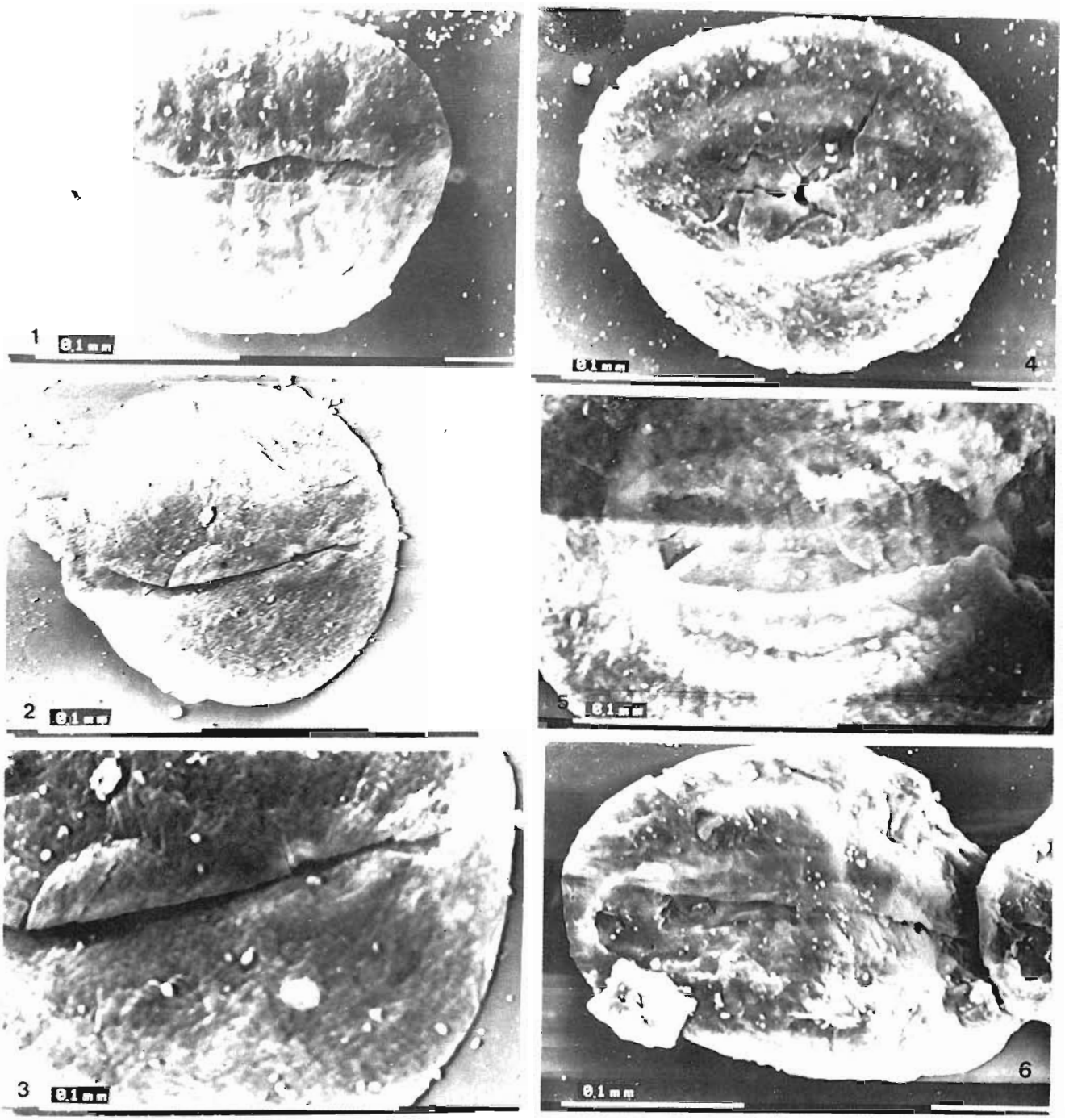


PLATE 24

1 6 Scanning electron photomicrographs of *Cruciaccites latisulcatus* Lele & Maithy 1964

1 2 Showing nature of saccus attachment

3 Enlargement of specimen of fig 2 showing the leathery nature of saccus structure with thick muri and small lumen

4 Showing nature of body folds

5 Showing the body folds and monolete mark

6 Showing the nature of saccus attachment

central body, get folded forming very narrow linear folds. Sacci peculiar in being narrow, laterally continuous, protosaccate having thick muri forming fine meshes.

Comparison—The nature of intrareticulation of the body with thicker muri, narrow sacci and deep-cut striations with folding tendency differentiate this species from the type species. The present species differs from *F. perexiguus*, apart from above characters, in being bigger in size.

Faunipollenites congoensis (Bose & Kar) comb. nov.
Text-fig. 9

1966 *Striatopiceites congoensis* Bose & Kar, pl. 13, fig. 1.
1968 *Striatopiceites rimosus* Venkatachala & Kar, pl. 2, fig. 23.

Holotype—Bose and Kar, 1966; pl. XIII, fig. 1; size 186 × 176 μm; Slide no. RG 14161-9; Elila River (right side, only 11) near Fundi Sadi, Congo; Permian.

Isotype—Bose and Kar, 1966; pl. 13, fig. 2; size 192 × 178 μm; Slide no. RG 14161-17.

Original diagnosis—"Bisaccate, subcircular to circular pollen grains, 192-154 × 134-178 μm. Central body ill-defined, intramicroreticulate, horizontally striate. Proximal attachment of sacci to central body seems to be equatorial; distal attachment juxtaposed. Sacci intrareticulate" (after Bose & Kar, 1966, p. 48).

Discussion—The holotype was not available for re-examination. The description and illustration suggest that big circular pollen with diffused central body and juxtaposed zones of sacci attachment find their place in this species.

The transfer of the species *Striatopiceites congoensis* to *Faunipollenites*, as *Faunipollenites congoensis* (Bose & Kar) comb. nov. has been made here in keeping with the lines of approach discussed in the beginning of this account. *Striatopiceites rimosus* Kar 1968 does not differ from *F. congoensis*, hence included in synonymy.

The photomicrograph of the holotype reveals the nature of saccus intrareticulation being medium-sized with thick muri and distinct meshes. The zones of sacci attachment appear to meet each other in central region while get apart from each other at lateral region.

Comparison—This species includes big circular pollen having narrow distal saccus-free area. *F. varius* is different in having bilaterally oval shape and broader distal saccus-free area. Other species recognised here also differ in being mostly bilaterally oval or being much smaller in size.

Faunipollenites magnus (Bose & Kar) comb. nov.
Text-fig. 10

1966 *Striatopiceites magnus* Bose & Kar, pl. 14, fig. 1.

Holotype—Bose and Kar, 1966; pl. XIV, fig. 1; size 220 × 124 μm; Slide no. RG 14161-15; Elila River (right side, only 11) near Fundi Sadi, Congo; Permian.

Isotype—Bose & Kar, 1966; pl. XIV, fig. 2; size 232 × 124 μm; Slide no. RG 14161-10.

Original diagnosis—"Pollen bisaccate, elliptical, 222-232 × 126-128 μm. Central body indistinct, intramicroreticulate, horizontal striations ill-developed. Proximal attachment of sacci to central body not clear, distal attachment juxtaposed. Sacci intrareticulate" (after Bose & Kar, 1966, p. 49).

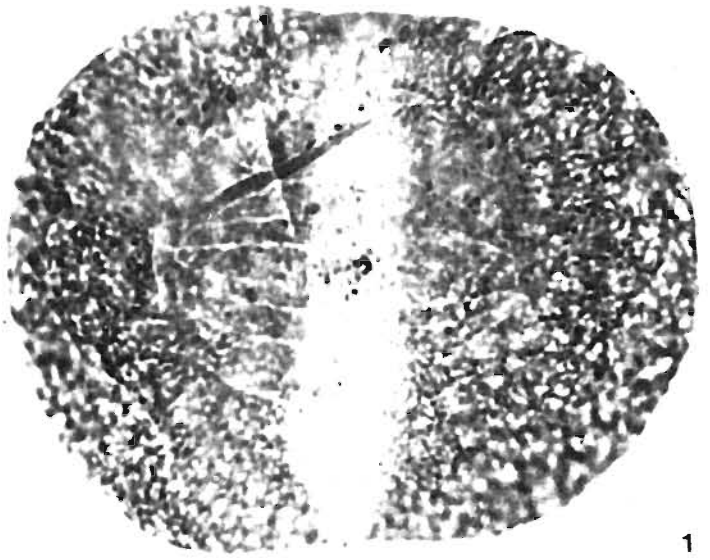
Discussion—The type specimen was not available for re-study. The species is circumscribed for big bilateral pollen with diffused body and big sacci. Distal zones of saccus attachments are close to each other or slightly apart. Intrareticulation of sacci appears to be distinct with thick muri. The pollen seems to have a tendency to rotate sublaterally during preservation—apparently due to its big size and subcylindrical organization.

Comparison—In general shape and nature of striation, *F. magnus* is closely comparable to *F. varius*; however, the former is much bigger in size having coarser intrareticulation of the sacci.

PLATE 25 →

1-4. *Faunipollenites varius* Bharadwaj 1962 showing indistinct outline of central body, nature of horizontal striations and intrareticulate structure of central body:
1. Lectotype; Slide no. BSIP 9903, EF : R40/4, × 750.
2. Slide no. BSIP 9906, EF : N35/4, × 500.
3. Slide no. BSIP 2337, EF : O30/2 × 750.
4. Slide no. BSIP 9906, EF : H34/2, × 500.

5-8. *Faunipollenites perexiguus* Bharadwaj & Salujha 1965:
5. Showing proximal striations; Slide no. BSIP 9905 EF : 518/2, × 1000.
6. Showing distal saccus attachment; Slide no. BSIP 9900, EF : H19/4, × 1000.
7. Holotype proximal face showing indistinct central body outline and proximal horizontal striations; Slide no. BSIP 9904, EF : P30/2, × 1000.
8. Distal face of specimen in fig. 7 showing distal saccus attachment, × 1000.



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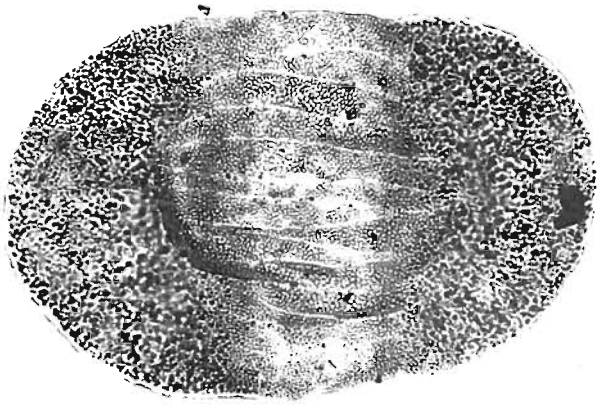

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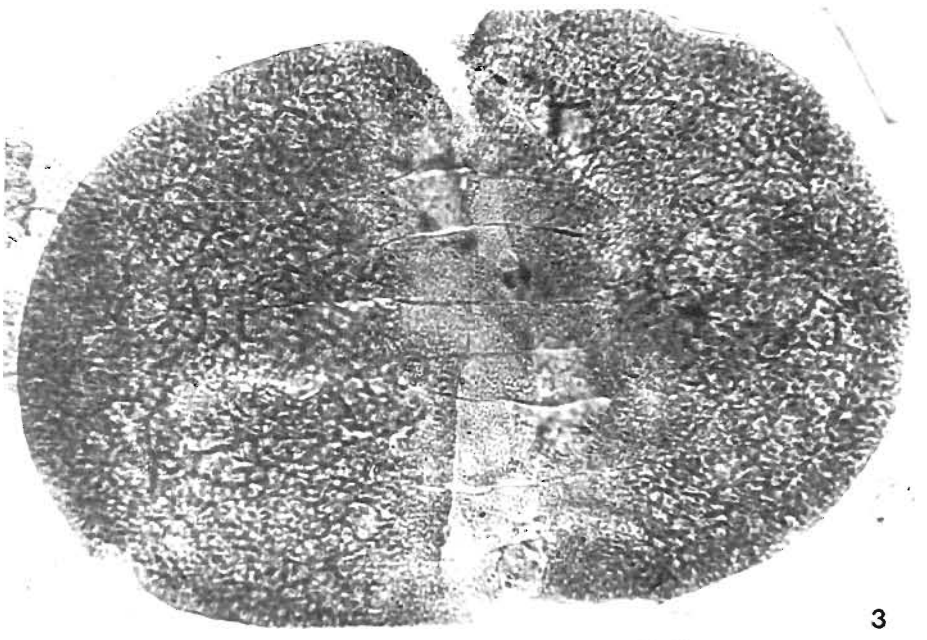

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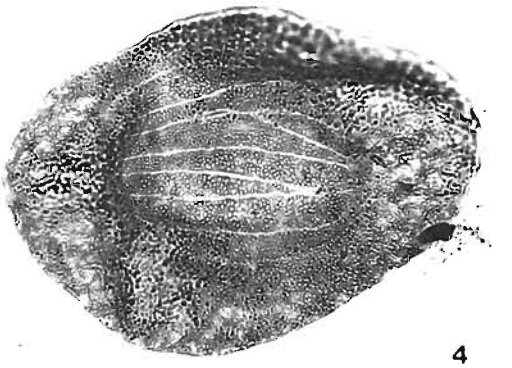

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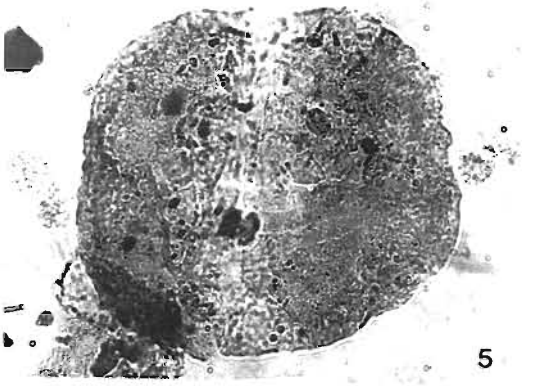

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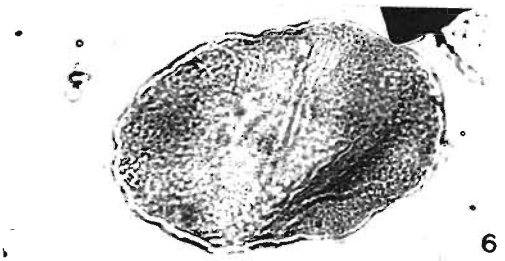

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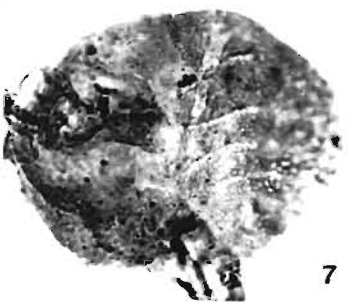

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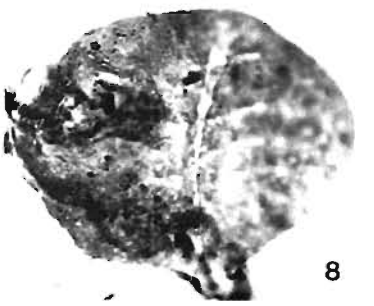

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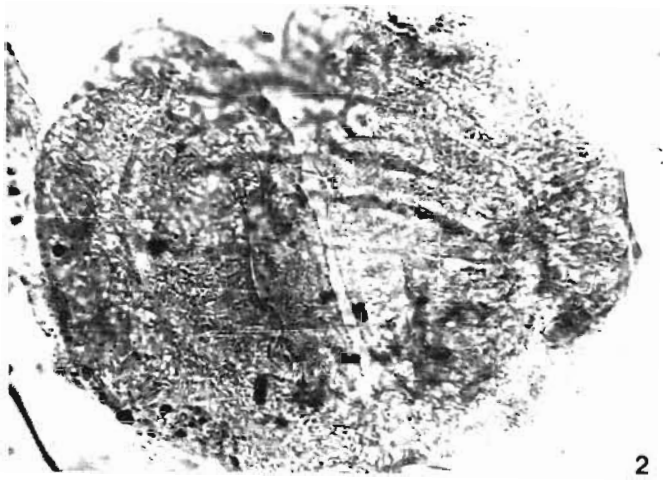
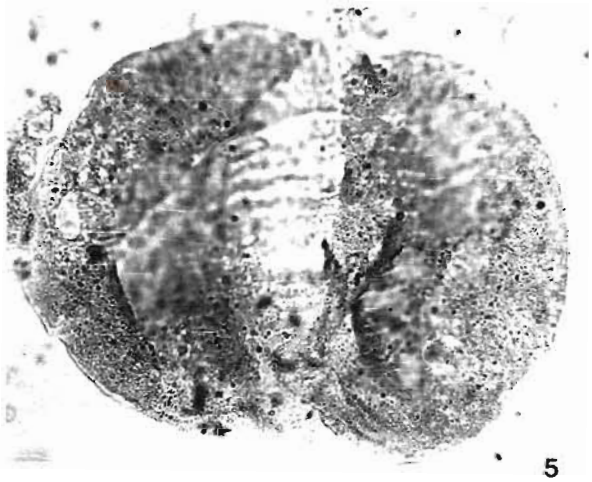
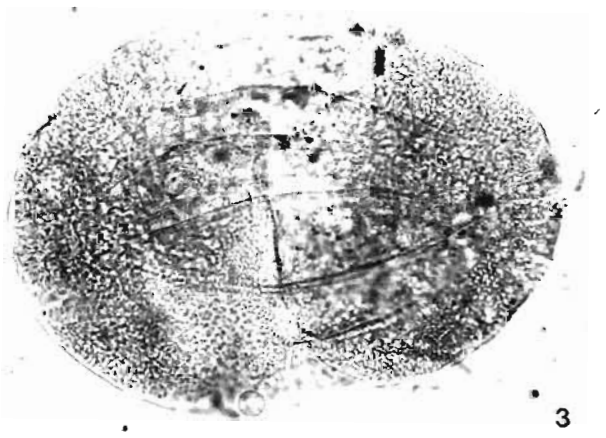
PLATE 25







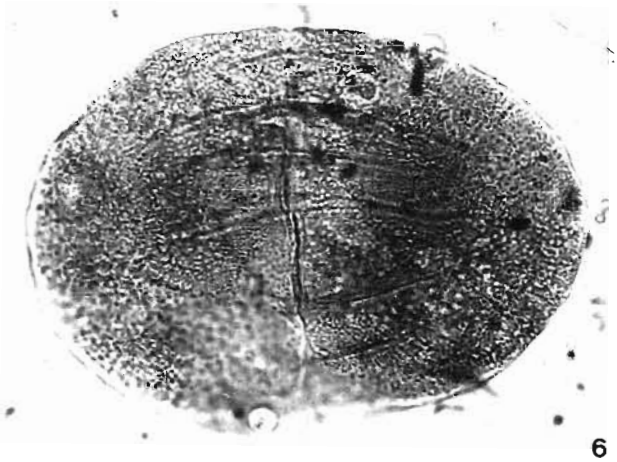


PLATE 26

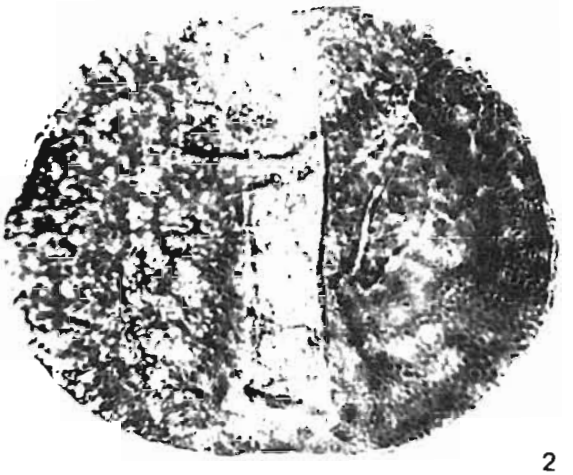
1-3, 6. *Faunipollenites singrauliensis* Sinha 1972.

1. Proximal view showing nature of striations and intrareticulate structure of central body exine, Slide no. BSIP 4160, EF : J22/4, × 750
2. Distal view of specimen in fig. 1 showing nature of saccus attachment.
3. Holotype in proximal view showing indistinct nature of central body outline and horizontal striations; Slide no. BSIP 4160, EF F15/1, × 750
6. Holotype in distal view showing bilateral, narrow saccus-free area.

4, 5. *Faunipollenites varius* Bharadwaj 1962 here emended. Specimen illustrated by Srivastava 1979 as holotype of *Faunipollenites multistriatus*; Slide no. BSIP 5032, EF : Z46/3, × 750.

4. Proximal view showing nature of striations and central body.
5. Distal view showing distal saccus attachment.

1



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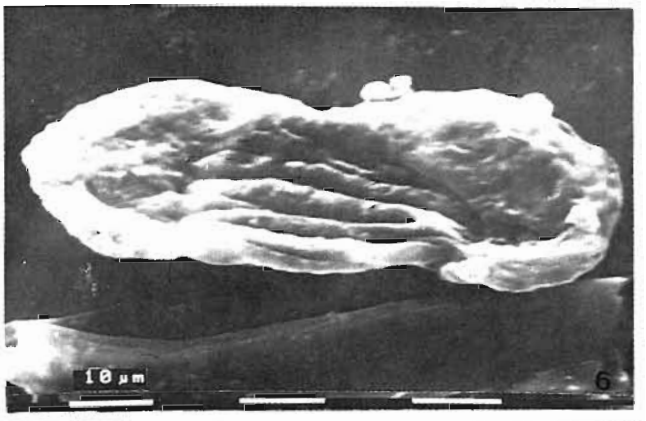

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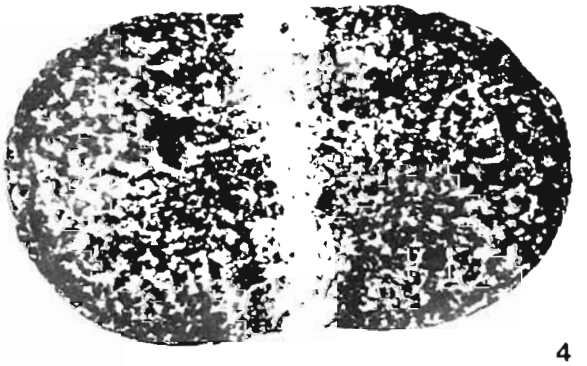

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PLATE 27

DISTRIBUTION

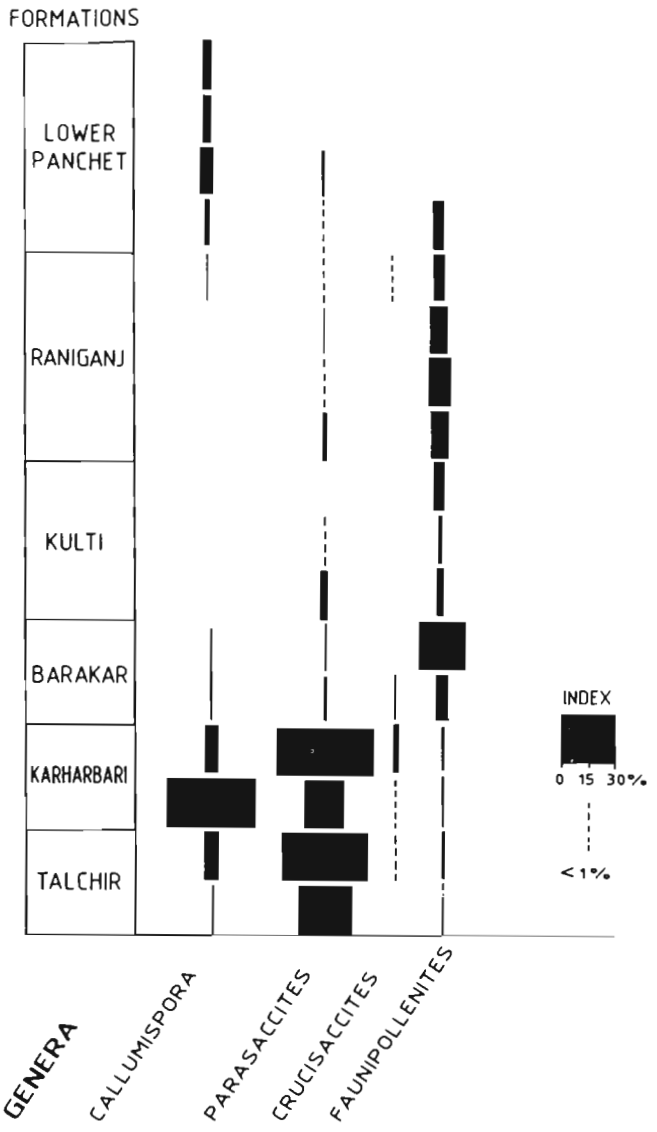
The four genera dealt here for their morphography and species delimitation have characteristic distribution through Lower Gondwana formations. The precise distribution of species is not on record from various basins, because most of the data is based on generic frequency. However, the relative abundance of these genera itself is diagnostic for different assemblages through Lower Gondwana formations of India.

The pattern of percentage frequency of *Callumispora, Parasaccites, Crucisaccites* and *Faunipollenites* is depicted in Text-figure 11.

The genus *Callumispora* is prominently represented in Early Permian; it is abundant in Talchir and prominent in Karharbari palynoflora. Within these formations, its frequency is recorded by maximum representation in the Lower Karharbari Formation. In the overlying Barakar Formation it dwindles out and ultimately in the Kulti and Raniganj assemblages, it is generally not recorded. This genus once again appears in Upper Raniganj and becomes fairly abundant in the Lower Panchet Formation. Obviously, some similarity of climatic condition is reflected in the Early Permian and Early Triassic time as has been discussed by Tiwari and Tripathi (1988).

The prominence of *Parasaccites*, as such, is confined to the Early Permian palynoflora. Along with other members of the radial monosaccate group (e.g. *Plicatipollenites, Virkkipollenites*) the genus *Parasaccites* is abundant in the Lower Talchir while in Upper Talchir it further increases in frequency. In the Lower Karharbari, the percentage of this genus declines but again in Upper Karharbari a maximum has been observed. In rest of the younger horizons of Lower Gondwana sequence the presence of the genus has been noticed but, by and large, it remains sporadic. It is interesting that its incidences continue up to the Lower Panchet; thereafter it ceases to exist.

The comparability of prominence between *Callumispora* and *Parasaccites* is very striking (Text-fig. 11) and this linkage is attributed to comparable climatic conditions.



Text-figure 11—Histogram showing distribution pattern of various genera through Lower Gondwana formations in India.

Numerically *Crucisaccites* is not a major element in the assemblages of Lower Gondwana formations. However, its typical construction signifies for a line of evolution diverted from the

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← **PLATE 27**

1-4. *Faunipollenites varius* Bharadwaj 1962 showing nature of horizontal striation, indistinct central body outline and distal saccus attachment:
1. Slide no. BSIP 1984, EF : M22/3, × 500.
2. Slide no. BSIP 1586, EF : Q38/1, × 500.
3. Slide no. BSIP 1983, EF : V42, × 500.
4. Slide no. BSIP 1984, EF : T26/4, × 500.

5. *Faunipollenites perexiguus* Bharadwaj & Salujha 1965, specimen illustrated by Venkatachala and Kar (1968) as Holotype of *Striatopiceites minutus* showing nature of central body and striations; Slide no. BSIP 2414/5, EF : U38/4, × 750.

6-8. *Faunipollenites varius* Bharadwaj 1962, SEM photomicrographs showing nature of striations on central body.
8. Enlargement of specimen showing merging nature of striations.

girdling radial monosaccates. *Crucisaccites* is fairly represented in Upper Karharbari. In Talchir, Barakar and Raniganj only sporadic and inconsistent presence has been recorded; elsewhere normally it is absent. The fair occurrence of this taxon is linked with the genera *Callumispora* and *Parasaccites*. Its diversification is an index for Karharbari Formation.

Faunipollenites is one of the important members of striate-disaccate pollen complex of Permian. The poorly defined nexine and general homo-(=equal) or haploxylonoid shape of sacci differentiate *Faunipollenites* from a scores of other striate genera. Besides, the ill-defined saccus attachment zones, mostly simple striations without vertical partitions, fine reticulation of body cappa and protosaccate fill of saccus further defines this genus. It is distributed throughout the Lower Gondwana and also occurs in Lower Panchets. The maximum incidences of *Faunipollenites* are recorded in Upper Barakar. In Raniganj palynoassemblages also this genus is abundantly present. Thus, in Talchir and Karharbari formations this genus is very meagre but from Barakar upwards it is one of the important constituents of the striate-disaccate population.

To conclude, it is emphasised that individually as well as jointly the genera *Callumispora, Parasaccites* and *Crucisaccites* identify various levels of stratigraphy in Talchir and Karharbari formations. *Faunipollenites*, however, can be of index value by virtue of its abundance only when pollen frequency of other disaccate pollen are determined.

ACKNOWLEDGEMENTS

The authors are grateful to Dr B. S. Venkatachala, Director, BSIP, Lucknow for encouragement to undertake this research project. His constant efforts to make this catalogue a reality, useful discussions and valuable suggestions are gratefully acknowledged. Thanks are also due to our colleagues in the PGGP Department, BSIP, for providing useful informations as and when needed.

KEY FOR IDENTIFICATION OF SPECIES

Genus—*Callumispora* Bharadwaj & Srivastava 1969 emend.

Trilete spores, radially symmetrical and spheroidal in shape. Exine thick, laevigate, intrapunctate in structure. Trilete mark prominent.

a. Exine stratified, mostly >4 μm thick.
   Inter-ray areas marked by coarse and distinct structure simulating contact areas.
   C. barakarensis Bharadwaj & Srivastava 1969 emend.
2. Intrapunctate structure fine, uniformly distributed all over the body.
   C. magnifica (Bose & Maheshwari) comb. nov.
3. Intrapunctate structure coarse, irregularly distributed all over the body.
   C. fungosa (Balme) Bharadwaj & Tiwari 1977

b. Exine non-stratified, mostly <4 μm thick.
4. Intrapunctate structure fine and uniformly distributed all over the body.
   C. gretensis (Balme & Hennelly) Bharadwaj & Srivastava 1969 emend.
5. Faint intrapunctation all over; spore size very small (34-36 μm).
   C. adensa Bharadwaj, Kar & Navale 1976 emend.

Genus—*Parasaccites* Bharadwaj & Tiwari 1964

Monosaccate pollen, circular to bilateral; discoidal shape; trilete mark generally present. Saccus girdling type, attached with body in para-condition. Central body intrareticulate.

a. Central body distinct.
1. Circular; central body circular, thin; trilete mark distinct.
   P. korbaensis Bharadwaj & Tiwari 1964
2. Bilateral, oval or elliptical; central body circular to subcircular, thin; trilete mark indistinct.
   P. ovatus Kar 1968
3. Circular; central body roundly triangular; trilete mark generally distinct.
   P. perfectus Bose & Maheshwari 1968
4. Circular-circulo-triangular; central body generally conforming to overall outline, thick; intrareticulate, trilete mark distinct.
   P. densicorpus Lele 1975

b. Central body indistinct
5. Circular; central body outline ill-defined, apparently circular; trilete mark obscure, faint.
   P. obscurus Tiwari 1965
6. Bilaterally oval; central body ill-defined, apparently circular to oval; trilete mark obscure.
   P. bilateralis Tiwari 1965

Genus—*Crucisaccites* Lele & Maithy 1964

Circular to oval monosaccate pollen; monolete mark obscure to distinct. Central body oval to hexagonal, intramicroreticulate. Saccus attachment cruciform. Zone of saccus attachment generally accompanied with secondary folds.

1. Circular; central body thin, trapezoid to rhomboid.
   C. latisulcatus Lele & Maithy 1964
2. Oval; central body oval, thin, monolete mark prominent.
   C. monoletus Maithy 1965 emend.
3. Circular to oval; central body weakly-defined, thin, apparently circular, infold not developed.
   C. indicus Srivastava 1970

Genus—*Faunipollenites* Bharadwaj 1962

Bisaccate pollen mostly bilaterally oval; central body not marked, apparently oval to subcircular, intramicroreticulate, proximally simple or branched horizontal striations; distally saccus-free area not sharply delimited.

1. Oval; central body thin, 6-20 striations, distally saccus-free area 5-20 μm; size 64-180 μm.
   F. varius Bharadwaj 1962 emend.
2. Oval; 6-9 striations, distally saccus almost touching each other (5-7 μm apart); size 36-62 μm.

F. perexiguus Bharadwaj & Salujha 1965

3. Oval; central body thick, 5-10 striations, distally sacci meet each other.

   F. singrauliensis Sinha 1972

4. ± Circular, big, 5-13 striations, distally sacci close to each other

   F. congoensis (Bose & Kar) comb. nov.

5. Elliptical to oval, striations faint and few, distally sacci close to each other; size 222-232 μm.

   F. magnus (Bose & Kar) comb. nov.

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