PALYNOLOGY OF THE BARREN MEASURES SEQUENCE FROM JHARIA COALFIELD, BIHAR, INDIA—3. STUDIES ON THE MEGASPORES

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ABSTRACT

The present paper deals with the megaspores recovered from the surface samples of the Barren Measures Succession from Jharia Coalfield, Bihar. Four genera and 6 species have been described and compared with the other megaspore assemblages from the Lower Gondwanas.

INTRODUCTION

THE present paper deals with the systematic description of the megaspores recovered from the surface samples of the Barren Measures Succession of the Jharia Coalfield, Bihar, India (*see* KAR 1966, 1968b). The material consisting mostly of grey coloured shales was collected on both sides of the Katri Nala (for locality *see* KAR, 1968b).

The samples were macerated by the usual Schultz's method. The macerate remained over the sieve was collected and the megaspores were picked up by the help of binocular. To study the inner structure, the megaspores were treated with Potassium hydroxide solution (20 per cent) for 1-4 hours and observed under the microscope at regular intervals. The spores have been mounted in canada balsam. The slides, unused material have been deposited at the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

SYSTEMATIC PALYNOLOGY

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

Genus *Trileites* (Erdtman) ex Potonié, 1956

Type species — *Trileites spurius* (Dijkstra) Potonié, 1956.

Cf. *Trileites* sp.

Pl. 2, Fig. 8

Description — Triangular megaspore, 800 × 750 μ. Exine densely spinose, spines robustly built with pointed tip, closely placed and evenly distributed forming negative reticulum on surface view. Apices acutely rounded, interapical margins ± straight. Trilete not traceable, no mesosporium found.

Remarks — The present specimen is characterized by strongly built spines. Most of the species described under *Trileites* do not possess such strong spines as has been found here; hence the present specimen has been tentatively placed under *Trileites*.

Infraturma — *Duopelliti* Bose & Kar, 1966
Subinfraturma — *Duoalageniculati* subinfraturma nov.

Diagnosis — Azonate, alageniculate, trilete megaspore with exosporium and mesosporium. Exosporium laevigate or slightly ornamented; mesosporium granulose and intramicropunctate.

Genus *Pantiasporites* gen. nov.

Type species — *Pantiasporites flavatus* sp. nov.

Generic Diagnosis — Oval-subcircular megaspores; trilete ill-developed, not seen in most specimens; exosporium generally laevigate, thin, folded irregularly; mesosporium thin, granulose and intramicropunctate, seems to be attached to exosporium only at proximal pole.

Description — Megaspores mostly oval in overall shape, size range 450-600 μ × 550-800 μ. Exosporium thin, irregularly folded, sometimes folds concentrated more on margin; exosporium mostly laevigate, sometimes sparsely granulose probably due to granulose mesosporium. Trilete while present ill-developed, mostly seen in dry condi-

tion. In wet condition trilete rays not traceable in most specimens. Mesosporium well developed, more than half in size of exosporium, thin, translucent, granulose and intramicropunctate, grana not uniformly distributed (TEXT-FIGS. 1A & 1B).

Comparison — *Duosporites* Høeg, Bose & Manum (1955) resembles the present genus in possessing exosporium and mesosporium; the former can, however, be distinguished by it presence of very well developed trilete rays and ± granulose exosporium. *Mammilaespora* Pant & Srivastava (1961) can be distinguished by its mammillate exosporium with branched processes. *Dijkstraea* Pant & Srivastava (1962) approximates *Pantiasporites* by its presence of two coverings but can easily be differentiated by its lageniculate structure. *Carruthersiella* Pant & Srivastava (1962) is distinguished by its papillate exosporium. *Talchirella* Pant & Srivastava (1961) possesses exosporium, mesosporium and endosporium and thus can easily be differentiated from *Pantiasporites*.

Remarks — Pant and Srivastava (1961) described *Triletes utkalensis* from the Talchir Coalfield, Orissa (Lower Gondwanas). This species is comparable to *Pantiasporites* as it also possesses exosporium and endosporium, but can easily be distinguished by its very well developed trilete rays and papillate exosporium. It may be mentioned here that Pant and Srivastava (1961, p. 58) were not sure about the inclusion of the above mentioned species in *Triletes*. Perhaps it is better to transfer all the species from the said genus which are having definite exosporium and mesosporium (*see* SCHOPF, 1938; ERGÖNÜL, 1964).

Derivation of name — After Professor D. D. Pant of Allahabad University, India.

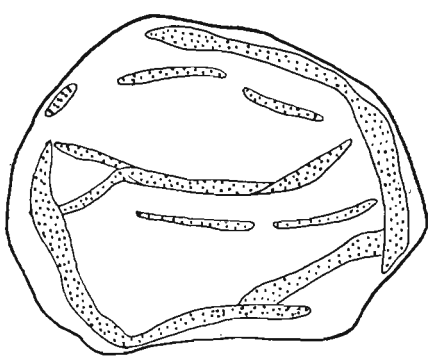
Pantiasporites flavatus sp. nov.
Pl. 1, Figs. 1, 2

Holotype — Pl. 1, Fig. 1, Size 590 × 450 μ.

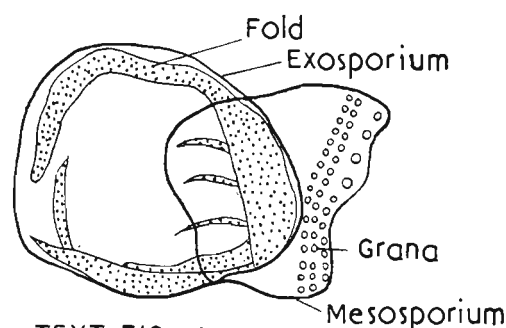
Type Locality — Katri Nala, Jharia Coalfield, Bihar; Barren Measures Succession (Permian).

Diagnosis — Megaspores oval-subcircular; trilete hardly perceptible; exosporium ± laevigate, irregularly folded; mesosporium more than half in size of exosporium, thin, granulose and intramicropunctate, seems to be attached to exosporium only at proximal pole.

Description — Megaspores mostly oval, sometimes subcircular; size range 450-600 μ × 550-800 μ. Exosporium mostly laevigate, sometimes sparsely granulose, thin, ± translucent, irregularly folded throughout, sometimes folds are more concentrated on margins. Trilete not seen in most specimens in dry as well as in wet condition; rays while present are hardly traceable and not extending more than half radius of exosporium. Mesosporium well developed, easily distinguishable in wet condition, mostly confronting with general shape of megaspores, thin, translucent, irregularly folded, granulose and intramicropunctate. Grana not uniformly distributed, seem to be arranged in rows in some specimens, perhaps bordering depressed mark of trilete



TEXT-FIG. 1A



TEXT-FIG. 1B

TEXT-FIGS. 1A, 1B — *Pantiasporites flavatus* gen. et sp. nov.

rays. Attachment of mesosporium to exosporium not clear in most specimens; however, it seems to be attached only at proximal pole.

Genus *Duosporites* Høeg, Bose & Manum, 1955

Type species — *Duosporites congoensis* Høeg, Bose & Manum, 1955.

Duosporites congoensis Høeg, Bose & Manum, 1955

Pl. 2, Fig. 1

Remarks — The specimen referred here to *Duosporites congoensis* is slightly smaller in size than those described by Høeg, Bose and Manum (*l.c.*) from Congo. The mesosporium as well as the grana are smaller in size in the present specimen. It may be mentioned here that the genus *Duosporites* seems to be present in most of the Lower Gondwanas. It was first described by Høeg, Bose and Manum from Congo and subsequently reported by Pant and Srivastava (1962) from Brazil and India.

Duosporites vulgatus (Dijkstra) Pant & Srivastava, 1962

Pl. 2, Figs. 2, 3

Remarks — The present specimens referred to *Duosporites vulgatus* (Dijkstra) Pant & Srivastava (1962) are possessing smaller mesosporium than those originally figured by Dijkstra (1955a, PL. 1, FIGS. 1-4). The holotype of *D. vulgatus* prescribed by Dijkstra (1955a, PL. 1, FIG. 3) is having rather ill-developed trilete rays which, however, extending up to the equator of the exosporium. The photographs illustrated by Pant and Srivastava (1962, PL. 17, FIGS. 19-21) of this species closely resemble with the present ones; but the mesosporium is granulose bordering the depression mark of the trilete rays in the present specimens while according to Pant and Srivastava (1962) it is pitted.

Duosporites nitens (Dijkstra) Pant & Srivastava, 1962

Pl. 2, Fig. 4

Remarks — Goswami (1956, FIG. 2) described a megaspore from the South Rewa Gondwana basin which very much resembles *Duosporites nitens* (Dijkstra) Pant & Srivastava (1962). *Triletes rotundus* described by Prem Singh (*in* SURANGE, SINGH & SHRIVASTAVA, 1953, PL. 2, FIG. 9) from the Pindra coal seam (Permian) also seems to be belong to this species. The present specimens resemble the megaspores described by Pant and Srivastava (1962) except that the mesosporium which is granulose in the present specimens is pitted according to Pant and Srivastava (1962). Mention may be made here that none of the mesosporium of the various genera studied here possess pits on the contrary, they are grana arranged mostly along the depression of the haptotypic mark.

Infraturma — *Tripelliti* infraturma nov.

Diagnosis — Trilete, azonate megaspore with three coverings viz. exosporium, mesosporium and endosporium. Exosporium laevigate or ornamented, mesosporium mostly granulose and intrapunctate, endosporium laevigate or ornamented.

Subinfraturma — *Trilaevipelliti* subinfraturma nov.

Diagnosis — Trilete, azonate megaspore with laevigate exosporium, granulose and intrapunctate mesosporium and ± laevigate endosporium.

Genus *Trilaevipellitis* gen. nov.

Type species — *Trilaevipellitis psilatus* sp. nov.

Generic Diagnosis — Circular-oval, trilete, azonate megaspore; exosporium ± laevigate; mesosporium thin, folded, subcircular-oval, granulose along trilete rays, intramicropunctate; endosporium thin, translucent; mesosporium and endosporium attached to exosporium only at proximal pole.

Description — Megaspore mostly subcircular in overall shape, but spores with typical circular or oval forms also met with, size range (mounted in Canada balsam) 594-650 μ × 600-700 μ. Exosporium well developed, thick, opaque in dry condition, mostly laevigate and intramicropunctate in wet condition. Trilete hardly visible in dry state but in wet condition rays ± equal, not extending beyond outer margin of mesosporium. In some specimens, however,

trilete hardly perceptible even in wet condition. Commissure mostly not recognizable. Mesosporium seen only in wet condition, mostly subcircular-oval, thin, transulcent and ± half in size of mesosporium; grana generally arranged in two rows bordering depression of haptotypic mark, rest part intramicropunctate. Mesosporium attached with exosporium only at proximal pole. In Potassium hydroxide solution (20 per cent) mesosporium usually clearly seen. In some cases exosporium dissolves or broken in parts showing mesosporium. Endosporium never seen in dry condition, even in wet conditions not visible in most cases. Endosporium very thin usually disappearing even in mild treatment of Potassium hydroxide solution. Endosporium probably adpressed with mesosporium but seems to be constricted while treated with Potassium hydroxide solution. Endosporium very thin, irregularly folded, ± laevigate (TEXT-FIGS. 2A & 2B).

Comparison — *Talchirella* Pant & Srivastava (1961) closely resembles the present genus in the presence of three coverings, but the latter can easily be distinguished by its laevigate exosporium, granulose mesosporium and ± laegivate endosporium. Moreover, the trilete rays are also not so well developed in *Trilaevipellitis* as found in *Talchirella*. *Duosporites* Høeg, Bose & Manum (1955) is comparable to the present genus in having ± psilate exosporium but can easily be distinguished by its very well developed trilete rays and presence of mostly exosporium and mesosporium. *Mammilaespora* Pant & Srivastava (1961) is also only two walled and the exosporium is mammillate. *Dijkstraea* Pant & Srivastava (1962) is lageniculate.

Trilaevipellitis psilatus sp. nov.

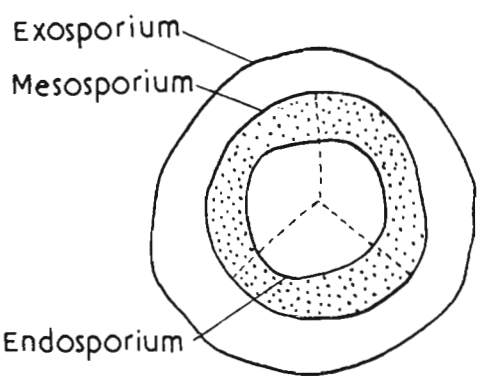
Pl. 1, Figs. 3, 4

Holotype — Pl. 1, Fig. 3, Size 610 × 600 μ.

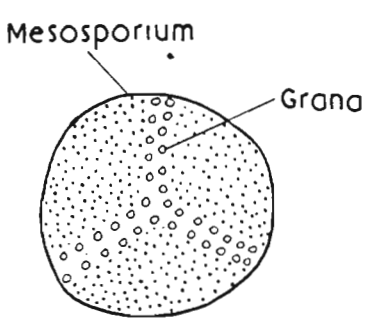
Type Locality — Katri Nala, Jharia Coalfield, Bihar; Barren Measures Succession (Permian).

Diagnosis — Megaspores circular-oval, trilete, with three coverings; exosporium laevigate; mesosporium subcircular-circular, thin, granulose along border of trilete rays, otherwise intramicropunctate; mesosporium attached to exosporium only at proximal pole; endosporium thin, ± laevigate, adpressed to mesosporium.

Description — Megaspores mostly subcircular in overall shape. Size range 594-650 μ × 600-700 μ. Exosporium thick, opaque in dry condition, laevigate and intramicropunctate. Mesosporium seen only in wet condition, about half in size of exosporium, granulose, grana arranged in rows bordering depression mark of trilete rays. Trilete not seen in dry stage and seems to be extended up to outer margin of mesosporium in wet condition; rays equal, uniformly broad, not well developed; commissure not distinct. Mesosporium attached to exosporium only at commissure. Endosporium thin, not recognizable in most cases, ± of same size of endosporium.



TEXT-FIG. 2 A



TEXT-FIG. 2 B

TEXT-FIGS. 2A, 2B — *Trilaevipellitis psilatus* gen. et sp. nov.

Subinfraturma — *Triapipelliti* subinfraturma nov.

Diagnosis — Trilete, azonate megaspore with apiculate exosporium, granulose and intrapunctate mesosporium and ± laevigate endosporium.

Genus *Triapipellitis* gen. nov.

Type species — *Triapipellitis baculatus* sp. nov.

Generic Diagnosis — Oval-subcircular, megaspores with three coverings; exosporium baculate, bacula very long; trilete rays mostly extending three-fourths of exosporium; mesosporium oval-subcircular, thin, granulose and intrapunctate; attached with exosporium only at proximal pole; endosporium thin, laevigate, adpressed to mesosporium.

Description — Megaspore mostly oval, sometimes subcircular or almost circular. Size range 500-650 μ × 550-800 μ. Exosporium thick, opaque, vermiculate in dry condition. Mesosporium and endosporium not visible in dry stage. Trilete mostly observed in wet condition, rays not very well developed, ± uniformly broad and not extending more than three-fourths the radius; commissure ± recognizable. Exosporium baculate, bacula uniformly broad, sometimes interspersed with spinules; bacula ± closely placed and evenly distributed, occasionally found in pairs; bacula mostly straight, sometimes curved, tip generally lacerated, rarely dichotomising, sometimes blunt, mostly dissolve in strong Potassium hydroxide solution (15 per cent). Exosporium may sometime irregularly folded. Mesosporium mostly oval or subcircular and confronting with exosporium in most of cases. Mesosporium thin, laevigate, much folded, translucent, granulose; grana are arranged in rows along the depression mark of trilete rays. Mesosporium seems to be attached with exosporium only at proximal pole. Endosporium thin, not traceable in most specimens, can only be seen after standing in weak alkali solution in some cases. Endosporium very thin, ± of same size of mesosporium and tightly adpressed to it (TEXT-FIG. 3A & 3B).

Comparison — *Talchirella* Pant & Srivastava (1961) is comparable to the present genus in the presence of three coverings but the latter can be distinguished by its long baculate exosporium, granulose and intrapunctate mesosporium and laevigate endosporium. *Trilaevipellitis* approximates *Triapipellitis* in the presence of three coverings; granulose and intrapunctate mesosporium and laevigate endosporium; but can easily be differentiated by its laevigate exosporium.

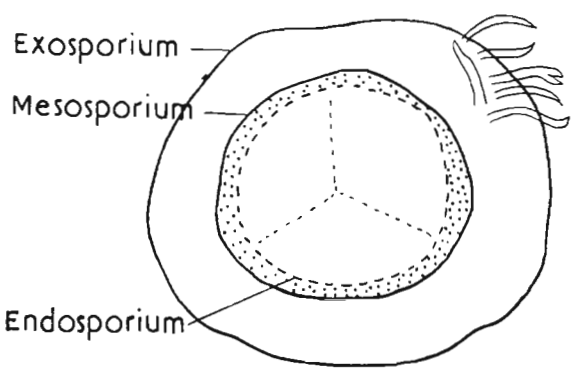
Triapipellitis baculatus sp. nov.

Pl. 1, Figs. 5, 6

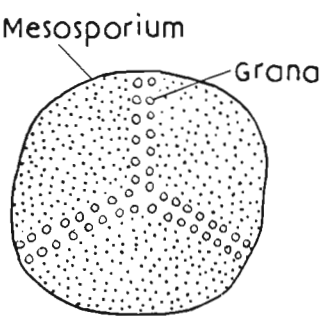
Holotype — Pl. 1, Fig. 5, Size 750 × 650 μ.

Isotype — Pl. 1, Fig. 6, Size 800 × 620 μ.

Type Locality — Katri Nala, Jharia Coalfield, Bihar; Barren Measures Succession (Permian).



TEXT-FIG 3A



TEXT-FIG 3B

TEXT-FIGS. 3A, 3B — *Triapipellitis baculatus* gen. et sp. nov.

Diagnosis — Megaspore, oval-subcircular with three coverings; exosporium with long bacula, closely placed and evenly distributed; trilete rays extending up to three-fourths of radius; mesosporium oval-subcircular, granulose and intrapunctate; mesosporium seems to be attached only at proximal pole; endosporium very thin, laevigate, adpressed to mesosporium.

Description — Megaspores mostly oval, sometimes subcircular, size range 500-650 μ × 550-800 μ. Exosporium thick, opaque, seems to be vermiculate due to long bacula in dry condition. After strong alkali treatment, exosporium becomes somewhat transparent showing trilete and sculptural elements more clearly. Bacular elements, however, dissolve in strong alkali treatment. Bacula very long, 6-10 μ × 50-100 μ, uniformly broad, sometimes interspersed with spinules, tip of bacula mostly serrated, sometimes blunt or dichotomising; bacula in some specimens placed in pairs; interbacular space laevigate and intramicropunctate. Trilete rays not very well developed, rays not extending more than three-fourths radius; commissure not distinct. Mesosporium seen only in wet condition, mostly confronting with general shape of exosporium, very thin, translucent, irregularly folded, granulose, grana found in rows along depression mark of trilete rays; rest part is intramicropunctate. Endosporium not seen in most specimens. It is not detachable in dry condition and dissolves even in weak alkali treatment (3 per cent). Endosporium thin, laevigate, tightly adpressed to mesosporium.

Remarks — It may be mentioned here that the holotype was possessing the endosporium, but while kept in alkali solution the bacula of the exosporium and some part of the mesosporium and the endosporium dissolved and finally the megaspore was broken in two parts.

The megaspore described by Goswami (1951, PL. 5, FIG. 3) from the Pali beds in the South Rewa Gondwana basin is comparable to the present species in size and overall shape but the exosporium seems to be spinose. The other megaspore described by Goswami (1956, FIG. 1) from the same basin, however, closely resembles in sculptural elements and shape and size of the megaspores; but the trilete rays extend up to the margin of the exosporium and whether it possesses mesosporium and endosporium is not known. *Triletes surangei* described by Prem Singh (*in* SURANGE, SINGH & SRIVASTAVA, 1953, PL. 2, FIGS. 7-8) from the Pindra coalseam (Permian) is also comparable to the present species in its nature of the bacula and their serrated or dichotomising tips. *T. litchi* Harris, *T. datmensis* and *Triletes* sp. described by Srivastava (*l.c.*, PL. 4, FIGS. 16-18) from the Datma and Mangardaha coal seams (Permian) are also comparable to the present species in size, shape and sculptural elements; but cannot be definitely included in the present species as the presence of mesosporium and endosporium has not been reported from those above mentioned species.

Incertae sedis

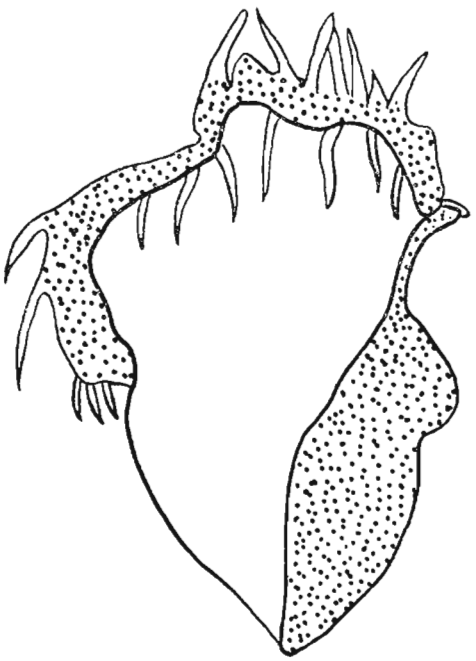
SPORE TYPE I

Pl. 2, Fig. 9

Description — Megaspore 'cephaliculate', measuring 770 × 400 μ. The anterior part is broader than the posterior one. The former possesses spinules only at the fringes, spinules 8-15 μ × 100-150 μ; the rest part of the spore is laevigate and intramicropunctate. The posterior part is heart-shaped, folded; the middle portion joining the anterior and posterior ends is slightly constricted (TEXT-FIG. 4).

Remarks — The term 'cephaliculate' is introduced here for those megaspores which are longer than broad with unequally broad ends; the broader head forming the 'head' the narrower one forming the 'body' and joined to each other by a 'neck' like structure.

The lageniculate megaspore (*see* SCHOPF, 1938) can easily be distinguished from the present specimen in the presence of neck-like protuberance. *Cystosporites* Schopf (1938) resembles the present specimen in possessing longer than broad axis. It may, however, be mentioned here that *Cystosporites* seems to be seed megaspore with distinct fertile and abortive forms. The various species of *Cystosporites* described by Schopf (1938), Chaloner (1953), Chaloner and Petitt (1963, 1964), Dijkstra (1955c), Dijkstra and Piérart (1957), Piérart (1961) do not show spinules only at one end. Moreover, Schopf (1938), Chaloner (1953), Chaloner and Pettit (1964) believe that most of the *Cystosporites* represent Lepidocarp seed megaspores.



TEXT-FIG. 4 — *Spore type* I. Note the 'cephaliculate' structure.

DISCUSSION

The present megaspore assemblage is comparable to that of the Pindra coal seam described by Prem Singh (in SURANGE, PREM SINGH & SRIVASTAVA, 1953) and the Datma and the Mangardaha coal seams (Barakar stage) described by Srivastava (in Surange, Prem Singh & Srivastava, *l.c.*). *Triletes surangei* Prem Singh (*l.c.*) and *T. litchi* Harris, *T. datmensis* and *Triletes* sp. described by Srivastava (*l.c.*) closely resemble *Triapipellitis baculatus* described here.

The megaspore assemblage described by Pant and Srivastava (1961) from the Talchir Coalfield (Lower Gondwanas) is quite distinct from that of the Barren Measures Succession as *Talchirella* and *Mammilaespora* are conspicuous by their absence in the present assemblage.

The megaspores described by Dijkstra (1955a, 1955b), Trindade (1954, 1959a, 1959b) and Pant and Srivastava (1962) from the Lower Gondwanas of Brazil are mostly lageniculate representing the genus *Dijkstraea* Pant & Srivastava (1962). It may be mentioned here that this genus is not found in the present assemblage. *Duosporites* Høeg, Bose & Manum (1955) is, however, found in both the assemblages while *Carruthersiella* Pant & Srivastava (1962) is confined only to the Lower Gondwanas of Brazil.

The Palaeozoic megaspores from Congo described by Høeg, Bose and Manum (1955), Høeg and Bose (1960) and Bose and Kar (1966) share only in common the occurrence of *Duosporites* with the present assemblage.

Mention may here be made that the megaspores belonging to the genus *Trileites* (Erdtman) ex Potonié (1956) are believed to be of lycopodian in origin (*see* SURANGE, PREM SINGH & SRIVASTAVA, 1953). Most of the megaspore genera described so far from the Lower Gondwanas of Brazil (PANT & SRIVASTAVA, 1961); Congo (HØEG, BOSE & MANUM, 1955; HØEG & BOSE, 1960; BOSE & KAR, 1966); India (PANT & SRIVASTAVA, 1961) and Tanganyika (PANT & SRIVASTAVA, 1962) are mostly possessing either exosporium and mesosporium (e.g. *Duosporites*, *Dijkstraea*, *Carruthersiella*, *Mammilaespora* and *Pantiasporites*) or exosporium, mesosporium and endosporium (e.g. *Talchirella*, *Trilaevipellitis* and *Triapipellitis*). These two or three walled nature of the megaspores of the Lower Gondwanas perhaps point out that all of them are not of lycopodian in origin as heterospory is known in other groups also (*see* ARNOLD, 1944, 1950). It may be mentioned here that the lycopods is represented in the Barren Measures Succession only by *Cyclodendron leslii* (Seward) Kräusel (1961) which produced megaspores in tetrad. *Cyclodendronoisporites* Bose & Kar (1966), the dispersed tetrad megaspores of *C. leslii* is, however, not found in the present assemblage. This perhaps strengthen the supposition that at least some of the megaspores were produced other than lycopodian group.

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EXPLANATION OF PLATES

(All photomicrographs are enlarged *ca.* × 100)

PLATE 1

1-2. *Pantiasporites flavatus* gen. et sp. nov. Slide nos. 2220, 2219.

3-4. *Trilaevipellitis psilatus* gen. et sp. nov. Slide no. 2227.

5-6. *Triapipellitis baculatus* gen. et sp. nov. Slide nos. 2239, 2229.

PLATE 2

1. *Duosporites congoensis* Høeg, Bose & Manum. Slide no. 2232.

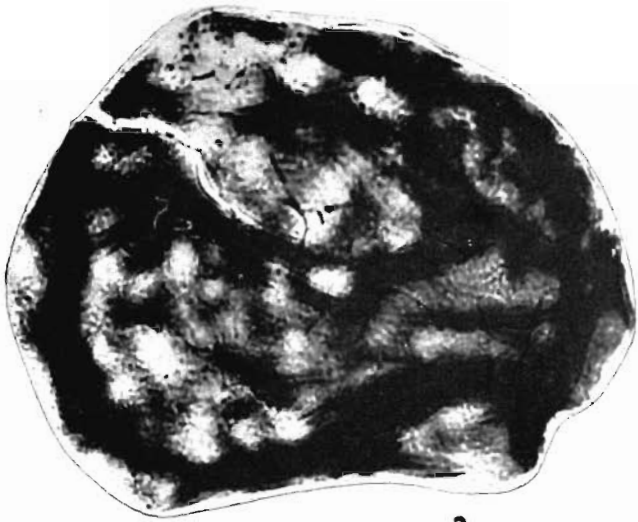
2-3. *Duosporites vulgatus* (Dijkstra) Pant & Srivastava. Slide nos. 2233, 2220.

4. *Duosporites nitens* (Dijkstra) Pant & Srivastava. Slide no. 2232.

5-7. Mesosporium of *Duosporites* Høeg, Bose & Manum. Slide nos. 2235, 2233, 2220.

8. Cf. *Triletes* sp. Slide no. 2234.

9. Spore type I. Slide no. 2221.



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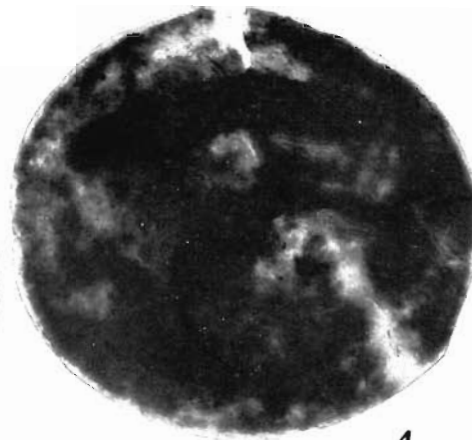

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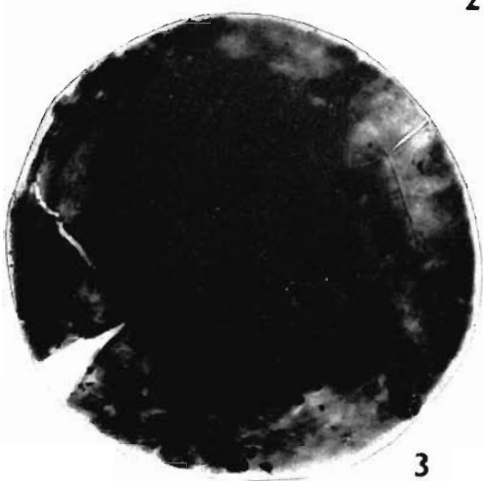

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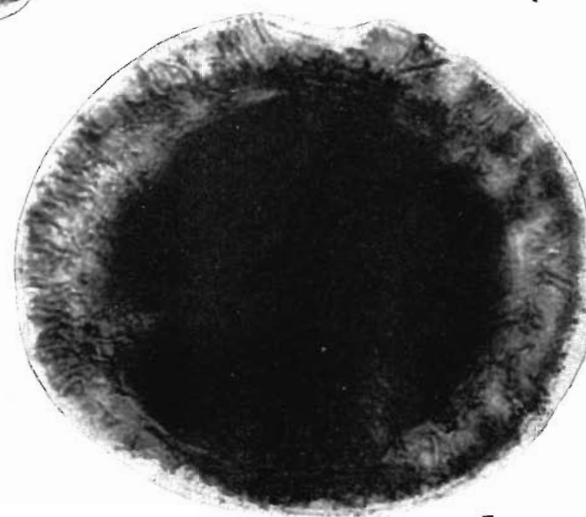

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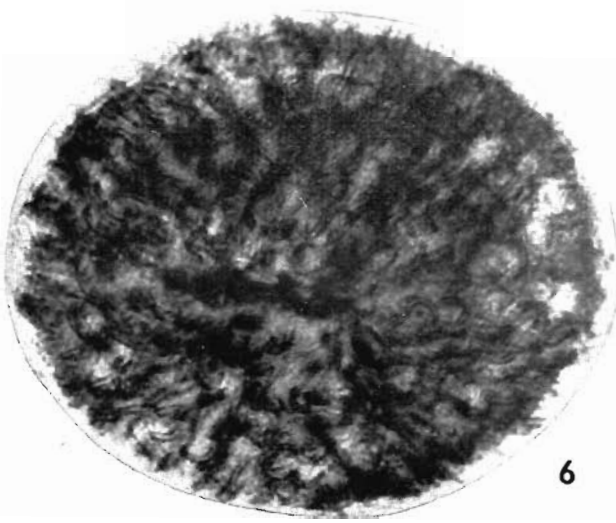

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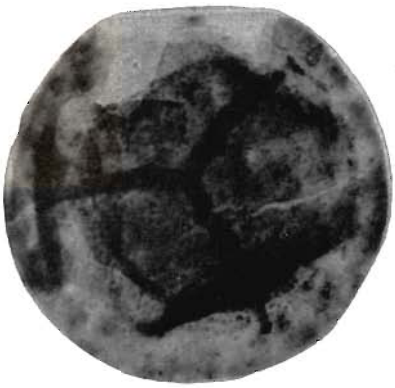

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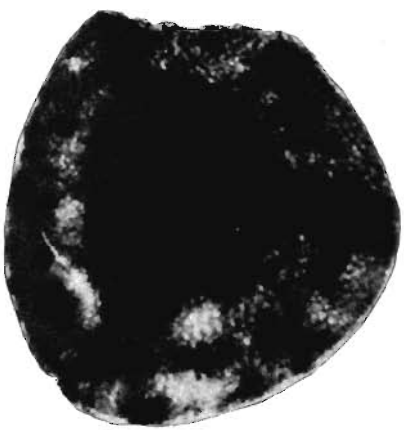

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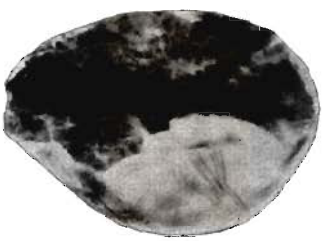

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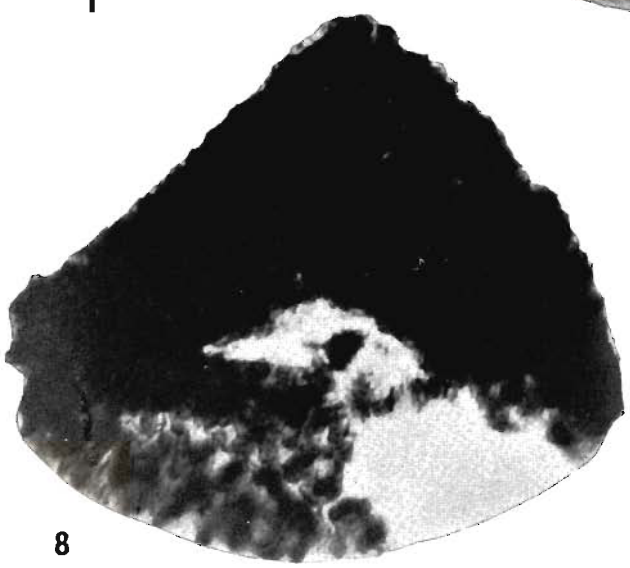

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