STUDIES IN THE TALCHIR FLORA OF INDIA—9. MEGASPORES FROM THE TALCHIR FORMATION IN THE JOHILLA COALFIELD, (M.P.), INDIA

K. M. LELE & ANIL CHANDRA

Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

Megaspores belonging to the genera *Duosporites*, *Trilaevipillitis*, *Srivastavaesporites* and *Trileites* are for the first time described from the Talchir Formation of India. The fossils have been found associated with seed cuticles and miospores in typical Talchir siltstones exposed near Birsinghpur-Pali in the Johilla Coalfield, Madhya Pradesh. The assemblage is dominated by the genus *Duosporites*. The megaspores indirectly suggest the existence of Lycopsid plants at least towards the later part of the Talchir times.

External characters as well as the details of the inner sac have been carefully studied. It is suggested that the extent of the trilete trace and the bordering cushions in relation to the inner sac radius constitutes a charcter of taxonomic significance in delimiting megaspore species.

INTRODUCTION

STUDIES on the Lower Gondwana megaspores of India have begun comparatively recently. A significant start was made by Surange *et al.* (1953) followed by Srivastava (1954). However, these studies were mainly based upon external morphology of the transparent specimens. The importance of structures of different spore walls in the taxonomy of megaspores was particularly realized when Høeg *et al.* (1955) described the double wasll structure of *Duosporites* from the Lower Gondwana of Congo. A notable advance in this direction was made in India by Pant and Srivastava (1961, 1962) on Indian and Tanganyikan material. They created four new genera. Studies on similar lines have been recently carried out in other countries by Balme and Hassel (1952), Dettmann (1961), Trindade and Sommer (1966) and Spinner (1968, 1969). More recently Kar (1968) added some new genera of megaspores from India. The latest work on the morphology, systematics and distribution of Indian megaspores by Bharadwaj and Tiwari (1970) provides a very comprehensive treatment of the known taxa together with the erection of six new genera on the basis of external morphological details as well as the internal structure of the megaspore walls. Evidently a number of previously described species and even genera have found new places in the scheme of Bharadwaj and Tiwari (1970).

Our knowledge of the megaspores from the Lower Gondwana of India was so far confined to the Karharbari, Barakar and Raniganj Formations (Bharadwaj & Tiwari, 1970). Goswami (1950-51, 1956) and Saksena (1971) recorded some megaspores from the Karharbari or Barakar beds of South Rewa Gondwana Basin. However, from the Talchir Formation (Basal-Lower Gondwana unit), megaspores were not known until Lele and Chandra (1967) briefly reported them from Barachada locality, Birsinghpur-Pali of South Rewa Basin, M.P. In that communication three types were recorded including one strongly recalling Duosporites. The megaspores were found in association with a number of seed cuticles and a rich mioflora. Stem impression of equisetalean type were sometimes encountered.

In the present study megaspores from the above locality have been investigated in detail both in dry as well as in wet conditions following a procedure of controlled, progressive overmaceration. The details of the external spore-coat and the inner body have been critically examined. The scheme suggested by Bharadwaj and Tiwari (1970) has been followed for the systematic description of megaspores. The assemblage has revealed the genera: *Trilaevipillitis* (1 new species), *Duosporites* (2 species), *Srivastavaesporites* (1 species) and *Trileites*. As these findings are entirely new, it is considered appropriate to describe all the forms in detail.

PROBLEMS OF MEGASPORE SYSTEMATICS

From an appraisal of the recent trends in megaspore studies, the impression gained is that while some workers (especially those working on the Gondwanas) lay emphasis on the external and internal studies under dry and wet conditions of the megaspores, there are several others who still adhere to the orthodox method of studying the megaspores only in dry state. In between, are also workers who have preferred to study megaspores in transparent conditions but have not necessarily gone into the details of the controlled maceration procedures or other techniques for isolating the inner body for detailed study. Nor is there any general agreement between different workers as to the value of the internal characters in the taxonomy of megaspores. This has led to very controversial determinations of one and the same species under widely different genera.

As an illustration of this state of affairs *Trileites* (al *Trilets*) *tenuis* may be cited as an example. This species was originally described in dry state by Dijkstra (1955) from Brazil but was transferred to *Banksisporites* by Dettmann (1961) and to *Duosporites* by Pierart (1959) and Spinner (1969). The same species has been retained under *Triletes* by Pant and Srivastava (1962) but transferred to the new genus *Srivastavaesporites* by Bharadwaj and Tiwari (1970). It is interesting to note that the above genera which have claimed *Trileites tenuis* are widely different from each other. *Banksisporites* and *Srivastavaesporites* have noncushioned inner bodies while *Duosporites* has cushioned inner body. Similarly while *Banksisporites* is externally laevigate, *Duosporites* and *Srivastavaesporites* are apiculate. Spinner (1969) also refers to this taxonomic problem.

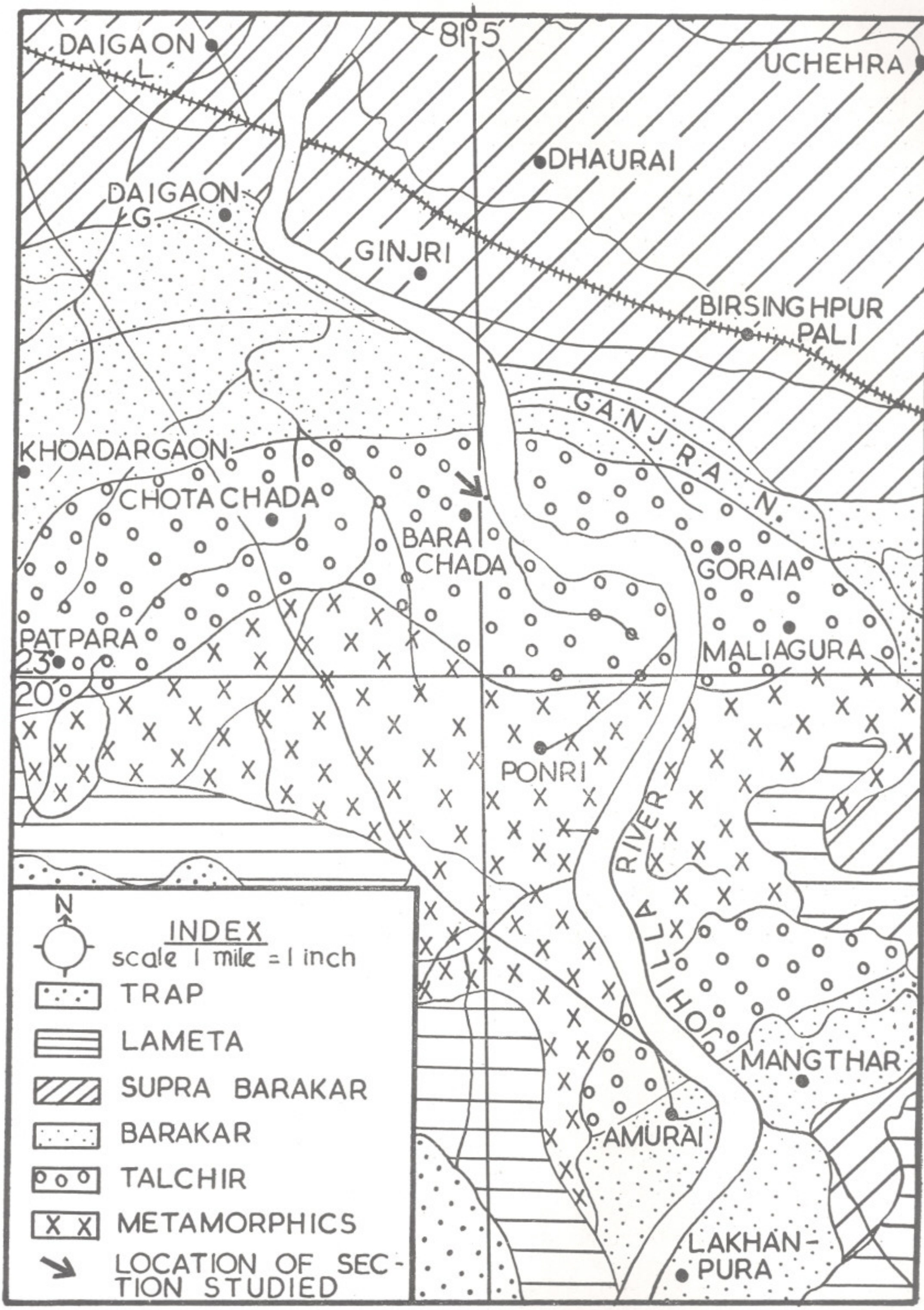
A similar interesting controversy exists around the circumscription of *Duosporites* Høeg, *et al.* (1955) which occurs in the present material. Since the genus was erected, there have been three emendations of it; first by Pierart (1959), second by Spinner (1969) and third by Bharadwaj and Tiwari (1970). All these emendations only express the underlying divergence of opinion on taxonomic procedures. Naturally during the present treatment, it was not very easy to make assignments for the megaspore specimens. However, we have found the procedure of Bharadwaj and Tiwari (1970) more suitable for systematic descriptions. We earnestly feel that the time has come for all interested workers on megaspores to resolve and standardize the methods of study and systematic procedure of describing the megaspores. Without that, the purpose of megaspore studies can have no real application.

MATERIAL AND METHODS

The megaspore material is recovered from the following section (Bed no. 5 and 6) of the Talchir Formation exposed near the village Barachada (Text Fig. 1), approximately two and a half miles south east of Birsinghpur Pali (M.P.) along Johilla River. In several beds of the section, fragmentary impressions of equisetalean stems were encountered.

	Thickness	Field nos.
7. Yellow silty sandstone (poor in miospores)	6 ft	B42
6. Yellowish laminated sandstone (poor in miospores and rich in megaspores)	10 ft	BC11-F
5. Greenish silty sandstone (containing plant fossils, rich in miospores and megaspores)	4 ft	BC10-F
4. Yellowish laminated sandstone	1 ft	BC9-F
3. Yellowish silty sandstones (containing plant fossils, rich in miospores)	4 ft	BC8F
2. Laminated sandstone (Poor in miospores)	3 ft	BC7F
1. Laminated yellowish greenish sandstone	30 ft	BC6
Total thickness	58 ft	

The beds dip average 10° gently towards north



TEXT-FIG. 1 — Geological Map of Birsinghpur- Pali (M.P.) India. After Hughes (1884).

The silty shales were macerated by treating them with hydrochloric acid for a short period followed by hydrofluoric acid treatment for about two weeks. The residue was washed and passed through 100 mesh sieve to separate the larger megaspores, seeds and cuticles from the fine miospore material. Residues left over the 100 mesh sieve were examined for picking up the megaspores. These megaspores were dried under room temperature and types were selected under the binocular and placed in separate cavity slides. Photographs of the megaspores in dry state were taken under the Panphot using brilliant reflected light of the arc lamp. FP_4, FP_3 plates and cut films were used for photography. The plates gave better results. Alternatively strong normal light was also used to directly illuminate the megaspores from one side. Illumination was properly balanced by manipulating a small mirror at a suitable distance on the other side of the megaspore opposite the source of illumination. In this way shadow effects could be toned down and desired relief could be obtained. In some cases the megaspores were placed on a tiny soft base which could be adjusted to obtain the maximum plane of uniform focus. A number of photographs were obtained in this way for the external morphological details and notes with regard to these features were simultaneously completed.

In the next phase the individual megaspore specimens were placed in watch glass and carefully subjected to remaceration in commercial nitric acid. In the case of opaque megaspores potassium chlorate was used with advantage to accelerate oxidation. Observations were made from time to time to check up the progress of oxidation. When the desired oxidation was achieved the megaspore was washed carefully in the watch glass by adding water successively. These specimens were then progressively cleared in 5% KOH. In between, the specimens could be carefully washed free of alkali for taking photographs. The alkali process was controlled and manipulated in such a way that the progressive dissolution of the outer coat could be verified before the inner body emerged out clearly. Generally the inner-body appeared to be attached to the exoexine along a small area proximally. Drastic alkali treatment sometimes, automatically released the inner body but at other times it was separated by fine needles. The inner-body though generally thin and more or less hyaline showed a very resistant membrane. It could be mounted in glycerine jelly or in more permanent media like canada balsam using a polyvinyl alcohol base. During course of the wet treatment, all photographs were taken in Olympus microscope using 35 mm 10 Din microfilm. The material and preparations are preserved in the Museum, Birbal Sahni Institute of Palaeobotany, Lucknow (Locality no. 854C, Registered slide nos. 4452-4456).

SYSTEMATIC DESCRIPTION

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

Genus — *Trilaevipillitis* (Kar) Bharadwaj & Tiwari, 1970

Type species — *Trilaevipillitis psilatus* Kar, 1968.

Trilaevipillitis talchirensis sp. nov.

Pl. 1, Figs. 1-6

DIMENSIONS

Dry specimens untreated with alkali

Spore size	380×600 μ
Triradiate rays	200-240 μ
	30-40 μ wide

Specimens treated with alkali

Spore size	400-640 μ×
	500-700 μ
Inner-sac	400-450 μ
Triradiate rays	200-240 μ long
Outer spore-coat	10-15 μ
Cushions (diameter)	20-y-30 μ
Trilete trace	
(inner sac)	140-160 μ long

DIAGNOSIS

Trilete megaspore, circular to sub-triangular. Trilete mark distinct, rays not extending beyond arucate ridges. Contact area ± trilobed. Spore wall two layered, exosporium ± smooth, inner sac rounded to sub-rounded, thin, possessing single row of prominent rounded cushions bordering a weak triradiate trace; cushion-rows and trilete trace do not reach inner sac margin, length about 2/3 of inner sac radius.

DESCRIPTION

Dry specimens untreated with alkali — Trilete megaspore, circular to sub-triangular. Exosporium 10-15μ thick, surface ± smooth. Triradiate rays distinct, raised, thick, about 2/3 spore radius. Contact area trilobed. Occasionally cushion marking of the inner sac detectible on the surface (Pl. 1, Fig. 1).

Specimens treated with alkali — Overall size increases. Megaspores sub-circular to sub-triangular. Triradiate rays distinct to weakly developed. Spore wall two layered. Exosporium ± smooth. Inner sac 400-450 μ large, thin, hyaline, circular to sub-circular, frequently folded; traces of triradiate rays ± weakly developed on the inner sac, single row of conspicuous round cushions on either side of a triradiate trace. Rows of cushions and trilete trace extend up to about 2/3 radius of the inner sac (Pl. 1, Figs. 2, 3).

COMPARISON

The nearest comparable species *Trilaevipillitis nitens* (Dijkstra) Bharadwaj and Tiwari, 1970 is distinguishable by the following features:

Specimen studied — 6.

Holotype — Pl. 1, Figs. 1-3.

Locality — Barachada, Birsinghpur Pali, M.P.

Horizon — Talchir Formation (Lr. Perm.)

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

Genus — *Duosporites* (Höeg, Bose & Manum) Bharadwaj & Tiwari, 1970

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

Duosporites dijkstrae Bharadwaj & Tiwari, 1970

Pl. 1, Figs. 7-10

Synonymy (after Bharadwaj and Tiwari, 1970) —
Triletes endosporitiferous Singh in Dijkstra, 1955,
Triletes endosporitiferous (Singh) in Trindade, 1957;
Duosporites endosporitiferous (Singh) Pant & Srivastava, 1962;
Duosporites endosporitiferous (Singh) Pant & Srivastava in Canduro & Zingano, 1965;
Duosporites dijkstrae Bharadwaj & Tiwari, 1970.

DIMENSIONS

Dry specimen untreated with alkali

Spore size	380-440 μ× 390-530 μ
Triradiate rays widening from	180-240 μ in length 15-50 μ towards extremity

T. talchirensis sp. nov.	*T. nitens*
1. Overall size range smaller 380-600 μ	1. Spores large, size range 450-900 μ (Bharadwaj & Tiwari, 1970)
2. Contact area trilobed	2. Contact area ± circular
3. Inner sac 400-450 μ	3. Inner sac large, 800 μ asmeasured from photo (Pant & Srivastava, 1962)
4. Cushions on inner sac conspicuous and large, 20-30 μ in diameter, rounded. Trilete trace and rows of cushions do not reach the inner sac margin.	4. Cushions indistinct as judged from the photo (Pant & Srivastava, (1962), 10-25 μ in diameter, other details not known.
5. Inner sac thin, 1 μ, frequently folded.	5. Inner sac comparatively thicker, 2 μ, folding not described, perhaps uncommon.

Specimens treated with alkali

Spore size	460-540 μ× 480-680 μ
Triradiate rays	160-400 μ long widening from 20-60 μ towards extremity
Inner sac	220-290 μ
Cushions (diameter)	15-30 μ

DESCRIPTION

Dry specimens untreated with alkali — Trilete megaspores, rounded, sub-triangular or triangular. Triradiate rays conspicuous, raised, ± equal in lenght, reaching margin, usually becoming wider towards extremity. Arcuate ridges ± clear. Exosporium thick smooth or finely granular.

Specimens treated with alkali — Trilete megaspore, rounded, sub-rounded or triangular. Overall size increases conspicuously. Triradiate rays distinct, thick, sinuate, raised, reaching the margin. Prolonged alkali treatment obliterates rays beyond the area of inner sac; in some specimens individual rays fork beyond the inner sac. Spore wall two layered; exosporium ± smooth to verrucose (elements varying from conical to baculate), inner sac thin, smooth, roundly triangular, size about 1/2-1/3 of spore diameter, proximally having a triradiate mark bordered with one row of distinct dark cushions, trilete trace and row of cushions reaching inner sac margin.

Specimen studied — 12

Locality — Barachada, Birsinghpur, Pali, M.P.

Horizon — Talchir Formation (Lr. Perm.)

Duosporites congoensis Høeg, Bose & Mannum 1955

Pl. 2, Figs. 11-13

Holotype — Hφeg, Bose & Manum, 1955, Pl. 1, Figs. 1,2.

DIMENSIONS

Dry specimens untreated with alkali

Spore size	420-600 μ% 430-640 μ
Triradiate rays	190-240 μ long 20-40 μ wide, wider at extremity

Specimens treated with alkali

Spore size	400-800 μ× 480-800 μ
Triradiate rays	20-30 μ with up to 70 μ wide at extremity
Inner sac	240-400 μ% 300-420 μ
Cushions (diameter)	15-20 μ
Trilete trace (inner sac)	150-200 μ long

DESCRIPTION

Dry specimens untreated with alkali — Trilete megaspore, circular or sub-circular. Triradiate rays conspicuous, thick, raised, ± uniformly wide for most part but wider at extremity, sinuate, reaching ± up to margin. Exosporium granular, arcuate ridges seen in some specimens.

Specimens treated with alkali — Trilete megaspore, circular, sub-circular or roundly triangular. Overall size increases significantly. Trilete mark distinct, rays thick, ± uniformly wide, straight, sometimes sinuate. Spore wall two layered, exosporium granular, inner sac thin, translucent, smooth, rounded, sometimes sub-rounded, proximal side shows vague impression of triradiate mark bordered with one row of distinct dark cushions. Trilete trace and cushions do not extend up to inner sac margin, length about 2/3-3/4 of inner sac radius. Diameter of inner sac about half of the spore diameter or less.

COMPARISON AND REMARKS

The specimens figured earlier by Lele and Chandra (1967, p. 76, Figs. 1 & 2) may be taken as very good examples of *Duosporites congoensis*. The inner body in their figure 2 is almost identical with that of Hφeg, Bose and Manum (155, Pl. 1, Fig. 3). In both cases it is striking to note that the trilete trace as well as the row of cushions do not extend up to the inner body margin. In the transparent specimen (Pl. 2, Fig. 12) the inner body is well seen beneath the outer coat. A single row of cushions is also decipherable along the trilete trace. The rows, as revealed by microscopic examination, are again shorter than the inner sac radius. The illustrations of Hφeg, *et al.*

(1955, Pl. 1, Figs. 1-3), Bharadwaj and Tiwari (1970, Text-fig. 30) and Pant and Srivastava (1962, Pl. 17, Fig. 25) also exhibit similar features. We, therefore, contend that the shorter extent of the trilete trace as well as the cushion rows may serve as additional character in distinguishing *D. congoensis*.

From what we know so far, the differences between *D. congoensis* and *D. dijkstrae* are not sharp enough and the criteria used appear to be rather contradictory, when one compares the views of Pant and Srivastava (1962) with those of Bharadwaj and Tiwari (1970) on this issue, especially with regard to the size of cushions and the inner sac. The few other differences between the species as suggested by Bharadwaj and Tiwari (1970, pp. 17, 18) are that the spore coat is verrucose in *D. congoensis* and its inner margin is well-defined; whereas the spore coat of *D. dijkstrae* is finely granular and its inner margin is obscure. From our studies, we can now add a more reliable point of difference, i.e. in *D. congoensis* the trilete trace and bordering cushions are shorter ($+2/3$) than the inner-sac radius while in *D. dijkstrae* they are as long as the inner sac radius.

Specimens Studied — 10.

Locality — Barachada, Birsinghpur Pali, M.P.

Horizon — Talchir Formation (Lr. Perm.)

Genus — *Srivastavaesporites* Bharadwaj & Tiwari, 1970

Type species — *Srivastavaesporites karanpurensis* Bharadwaj & Tiwari, 1970.

Srivastavaesporites indicus (Singh) Bharadwaj & Tiwari, 1970

Pl. 2, Figs. 14, 15

Synonymy (after Bharadwaj & Tiwari, 1970) —

Triletes indica Singh, 1953;

Talchirella endonigra, Pant & Srivastava, 1961.

DIMENSIONS

Specimen untreated with alkali

Spore size	470-540 μ× 600-660 μ
Triradiate rays	180-240 μ long 20-30 μ wide wider at extremity

Specimens treated with alkali

Spore size	510-600 μ× 640-820 μ
Triradiate rays	Not seen
Cushions	Not seen

DESCRIPTION

Dry specimens untreated with alkali — Trilete megaspores. Circular to sub-circular, sometimes oval. Triradiate rays conspicuous, thick, raised, 3/4 radius, not reaching margin, contact area marked by ridges. Exosporium ± granular.

Specimens treated with alkali — Overall size increases. Round to sub-circular. Triradiate mark obscure. Exosporium granular; inner sac dark and dense. Circular to subcircular; triradiate trace or cushions not seen.

Specimen studied — 6.

Locality — Barachada, Birsinghpur Pali, M.P.

Horizon — Talchir Formation (Lr. Perm.)

Genus — *Trileites* (Erdtman) ex. Potonié 1956

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

Triletes sp.

Pl. 2, Figs. 16, 17

DESCRIPTION

Trilete megaspores, size range 500-620 μ; sub-circular to roundly triangular, triradiate rays distinct, raised, nearly reaching the margin, straight to sinuate. Contact area broad, ill defined.

On maceration an inner body did not separate out from the exo-exine (outer layer) as in the foregoing species. The outer layer enlarged about one third of original diameter becoming thinner but still showing fine papillae (coni to baculate elements), up to 8 μ long and 4 μ broad on its surface as well as along its margin (Pl. 2, Fig. 17).

REMARKS

As the nature of the inner body and its details are not known, it is not possible to place these few specimens under other genera recognized on the basis of internal and external morphology. We, therefore, prefer to provisionally accommodate these megaspores under *Trileites sensu* Pant & Srivastava, 1961 without assigning them to any species. Comparison with *T. utkalensis*, *T. tenuis* and *T. labiosus* described by Pant and Srivastava (1961, 1962 is precluded as these species have now been transferred to *Srivastavaesporites* by Bharadwaj and Tiwari (1970) on the basis of additional material.

Specimens studied — 3.

Locality — *Barachada*, Birsinghpur Pali, M.P.

Horizon — Talchir Formation (Lr. Perm.)

DISCUSSION

Composition of the Megaspore Assemblage: Following genera and species are present in the Talchir material of the Johilla Coalfield: 1. *Trilaevipillitis talchirensis* sp. nov.; 2. *Duosporites dijkstrae* Bharadwaj & Tiwari, 1970; 3. *Duosporites congoensis* Höeg, Bose & Manum, 1955; 4. *Srivastavaesporites indicus* (Singh) Bharadwaj & Tiwari (1970); 5. *Trileites* sp.

Among the above genera *Duosporites* seems to be dominant, followed by *Trilaevipillitis* and *Srivastavaesporites*. It may be interesting to note that the assemblage contains mostly laevigate to finely apiculate megaspores. According to the known distribution of the megaspore genera in the Lower Gondwana (Bharadwaj & Tiwari, 1970), *Trilaevipillitis* was so far known only from the Barren Measures. Its presence in the Talchir Formation is, therefore, interesting. The other genus *Duosporites*, was so far believed to be characteristic of the Karharbari and Barakar Formations. We find now that this genus is quite common in the Talchir Formation as well, being represented by two species. The third genus *Srivastavaesporites* was hitherto confined to the Barakar Formation. The present findings extend down its range to the Talchir Formation.

The discovery of megaspores has also a bearing on the floristics of the Talchir Formation. The meagre Talchir Flora is strikingly devoid of pteridophytes except for some fragmentary equisetalean remains. The finding of megaspores now indirectly suggests that in all probability some lycopsid plants existed at least during the later part of the Talchir times when the impact of glaciation had dwindled out giving way to more hospitable conditions for plant development.

Taxonomic aspect of the Inner Sac

The importance of the inner sac in the taxonomy of megaspores has become clear by the contributions of Pant and Srivastava (1961, 1962) and Bharadwaj and Tiwari (1970). However, there are certain features which have not received enough attention from the standpoint of specific delimitation. One such feature pertains to the extent of the trilete trace and the bordering cushion rows in relation to the inner sac radius. The other relates to the degree of prominence of the trilete trace.

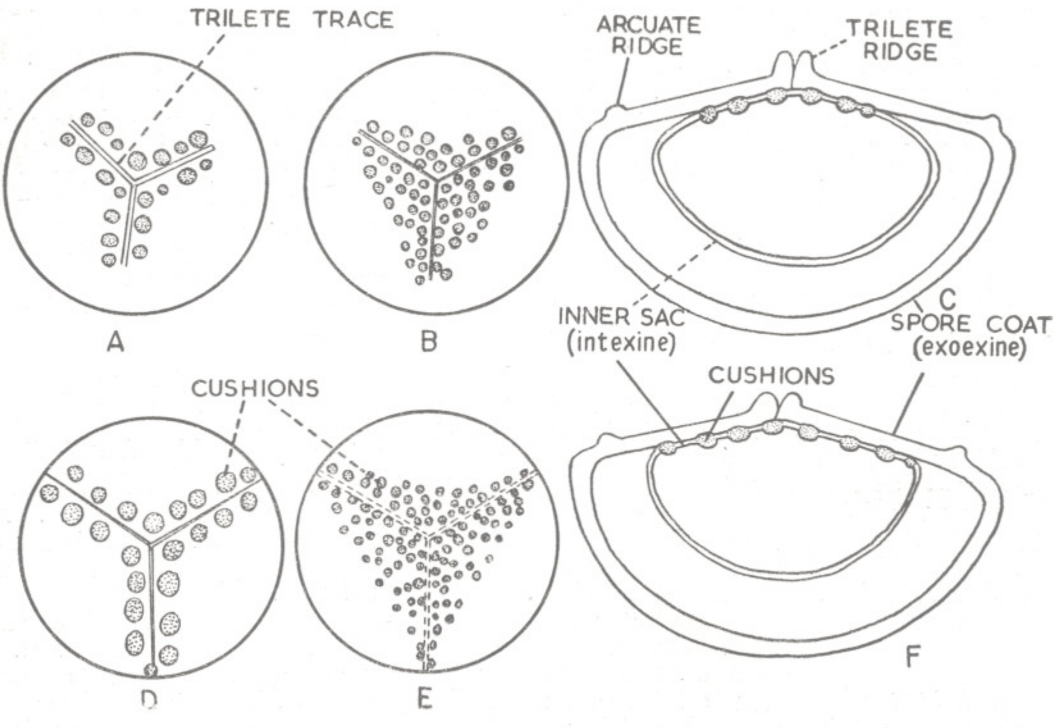
To illustrate the above point we may take some examples. In some species the trilete trace and the bordering cushion rows extend up to the inner sac margin. *Duosporites dijkstrae* is a good example. The holotype of the species (Pant & Srivastava, 1962, Pl. 17, Figs. 23-25) as well as our specimens demonstrate this feature. Similarly in *D. multipunctatus* Høeg & Bose (1960, Pl. 31, Fig. 11) the trigonally arranged cushions extend right up to the inner sac margin.

On the contrary, in *Duosporites congoensis*, the cushion rows as well as the trilete trace are distinctly shorter ($\pm 2/3$ to 3/4) than the inner sac radius. The holotype of the species (Høeg, Bose & Manum, 1955, Pl. 1, Figs. 1, 2) shows identical features. All other good examples of *D. congoensis* including those described by us also confirm this (vide pp. 243-244).

The shorter extent of the trilete trace and the cushion rows is also met with in other genera. In the present material *Trilaevipillitis talchirensis* sp. nov. shows it. The same is true for the species *Talchirella trivedii* (Pant & Srivastava), Bharadwaj & Tiwari (1970, Pl. 4, Fig. 3) and *Surangaeasporites rangiganjensis* Bharadwaj & Tiwari (1970, Pl. 15; Fig. 2, 3) which have trigonally arranged cushions. In several of the aforesaid examples the inner sac develops characteristic secondary folds surrounding the trilete trace extremities. Generally the trilete trace and the cushion rows are coextensive but exceptions may be found (e.g. Høeg, Bose and Manum, 1955, Pl. 2, Fig. 7).

Bharadwaj and Tiwari, (1970) have mentioned that the trilete trace on the inner sac varies in its length. However, the taxonomic value of this feature was hitherto not realized. The evidence at hand clearly points out that the extent of the trilete trace and the cushions is a feature of consistent development in a particular species, much like the tetrad mark on the spore coat, We are, therefore, inclined to recognize it as a useful criterion for specific delimitation. In addition we have also noted that the trilete trace varies in sharpness, Often it is weakly developed or is almost invisible but in some other cases it is very distinctly marked (e.g. *Surangaeasporites raniganjensis* Bharadwaj & Tiwari, 1970; Pl. 15, Fig. 3). These differences are also likely to be useful in determining a species.

It is well known that the trilete trace and the cushions (wherever present) play a vital role in the mechanism of attachment between the inner sac (intexine) and the outer spore coat (exoexine). There is also evidence to believe (e.g. *Duosporites congoensis*) that the border of the attachment area runs around the trilete trace and cushion rows (Høeg, Bose & Manum, 1955, p. 102, Pl. 1, Figs. 3-5). This means that at least two modes of attachment can be recognized. In the first case, the attachment of the inner sac is confined to a small proximal area (Text-figs. 2A-C), while in the other case the entire proximal face of the inner sac is attached to the exoexine (Text-figs. 2D-F).



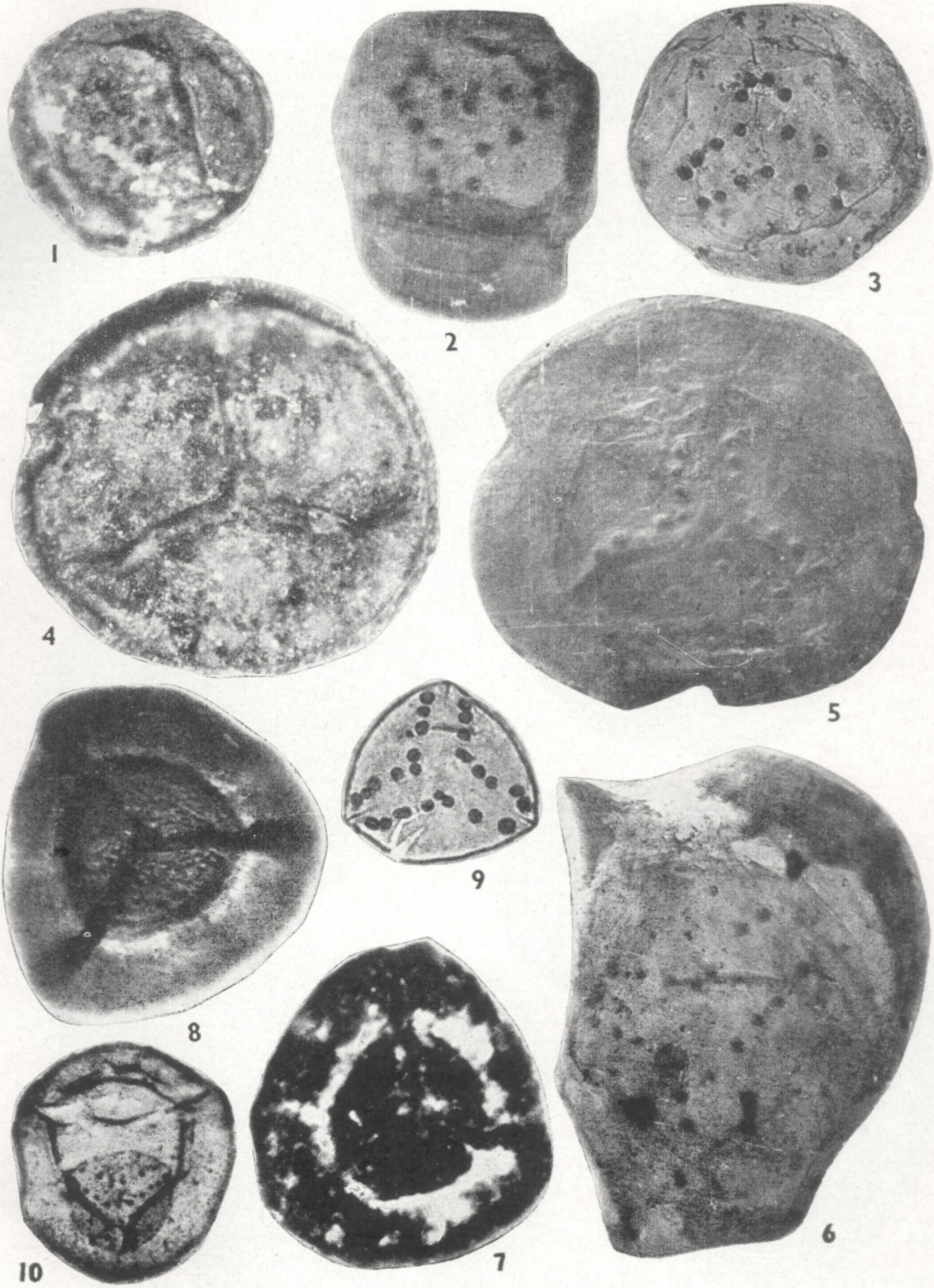
TEXT-FIG. 2 — Morphological aspects of the inner sac (intextine). All figures are semi-diagrammatic.

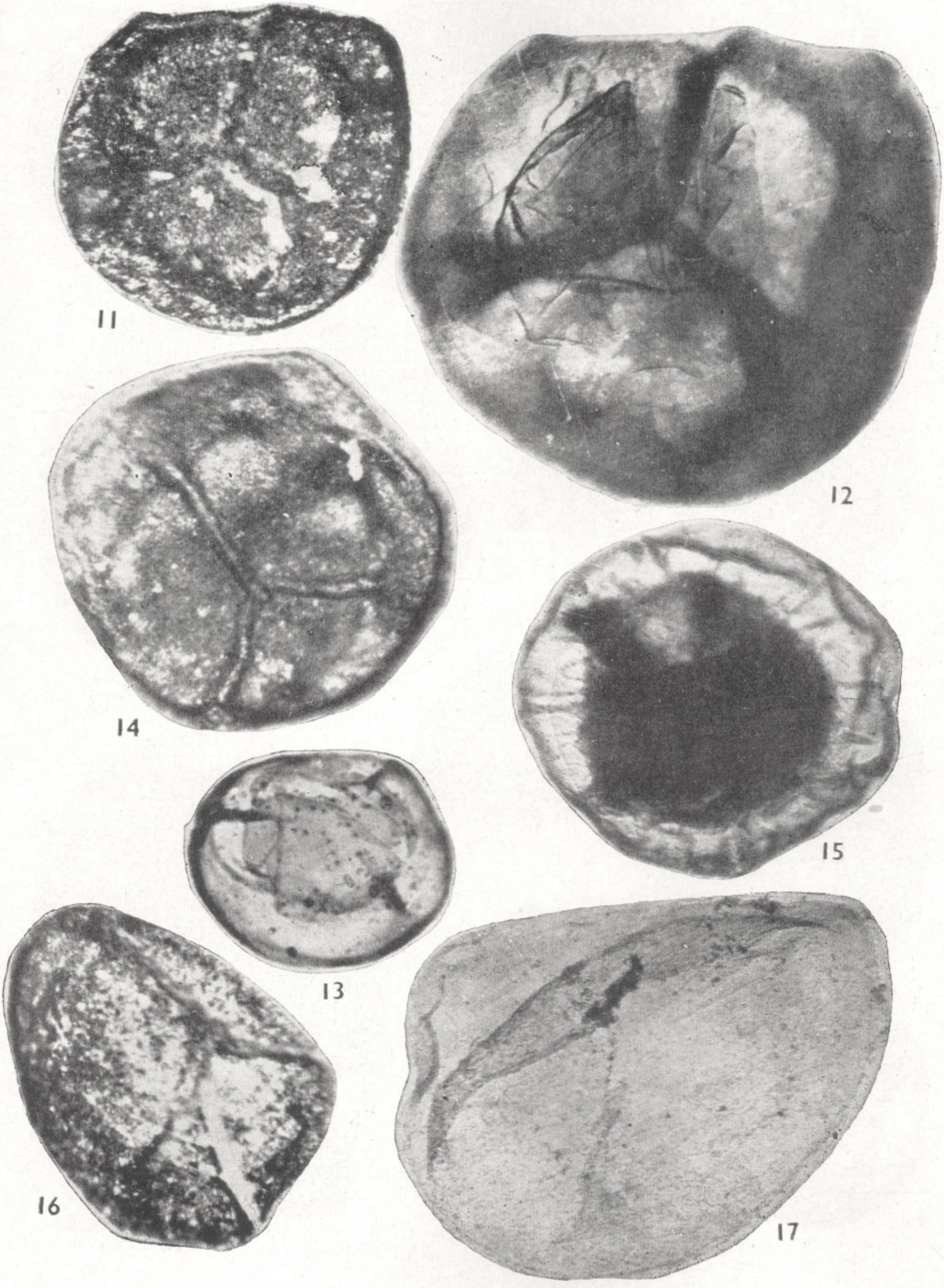
A-B — Proximal view of two types of inner sacs in which the trilete trace and bordering cushion rows do not extend up to the inner sac margin: (A) *Duosporites congoensis*-type, (B) *Talchirella trivedii*-type.

C — Interpretation of the attached inner sac (as in A and B) with the outer coat (exoexine) in meridional section of a megaspore.

D-E — Proximal view of two types of inner sacs in which the trilete trace and bordering cushion rows extend up to the inner sac margin: (D) *Duosporites dijkstrae*-type, (E) *Duosporites multipunctatus*-type.

F — Interpretation of the attachment of the inner sac (as in D and E) with the outer coat (exoexine) in meridional section of a megaspore.


1
2
3
4
5
8
9
6
10
7


11
12
14
15
13
16
17

REFERENCES

BALME, B. E. & HASSEL, C. W. (1962). Upper Devonian spores from the Canning Basin, Western Australia. *Micropalaeontology*. 8: 1-28.

BHARADWAJ, D. C. & TIWARI, R. S. (1970). Lower Gondwana megaspores — a monograph. *Palaeontographica*. **129B**: 1-70.

DETTMAN, M. E. (1961). Lower Mesozoic megaspores from Tasmania and South Australia. *Micropalaeontology*. **7**: 71-76.

DIJKSTRA, S. J. (1955). Some Brazilian megaspores, Lower Permian in age and their comparison with Lower Gondwana spores from India. *Meded. geol. Sticht. New. Ser.* **9**: 5-10.

GOSWAMI, S. K. (1951). Microfossils from Coals from the Lower Gondwanas of Rewa (Vindhya Pradesh), India. *J. Sci. Res. B.H.U.* **1**: 153-156, (1950-51).

Idem (1956). Occurrence of megaspores in the coal from the South Rewa Gondwana Basin. *Curr. Sci.* **25**: 365-366.

HÖEG, O. A. & BOSE, M. N. (1960). The Glossopteris Flora of Belgian Congo with a note on some fossil plants from the Zambesi basin (Mozambique). *Annls. Mus. r. Congo belge Ser.* **8**. **32**: 1-109.

HÖEG, O. A., BOSE, M. N. & MANUM, S. (1955). On double walls in fossil megaspores with description of *Duosporites congoensis* n. gen., n. dp. *Nytt. Mag. Bot.* **7**: 101-107.

KAR, R. K. (1968). Palynology of the Barren Measures sequence from Jharia coalfield, Bihar, India 3. Studies on the megaspores. *Palaeobotanist*. **16**(3): 292-300.

LELE, K. M. & CHANDRA, A. (1967). Occurrence of megaspores, seeds etc. in the Talchirs of India. *Curr. Sci.* **36**(3): 75-76.

PANT, D. D. & SRIVASTAVA, G. K. (1961). Structural studies on Lower Gondwana megaspores. Part 1. Specimens from Talchir Coalfield of India. *Palaeontographica*. **109B**: 45-61.

Idem (1962). Structural studies on Lower Gondwana megaspores. Part II. Specimens from Brazil and Mhukuru Coalfield, Tanganyika. *Ibid.* **111B**: 96-111.

PIERART, P. (1959). Contribution a l'etude des spores et pollens de la flora a *Glossopteris* contenus dans les charbons de la Luena (Katanga). *Mem. Acad. r. Soc. Colon.* **8**: 1-10.

SAKSENA, S. D. (1971). On fossil flora of Ganjra Nalla Beds. Part II-Microflora (A) Dispersed Spores and Pollen grains. *Palaeobotanist*. **18**(3): 237-257.

SPINNER, E. (1968). Contribution on the Megasporegenus *Tuberculatisporites* (Ibrahim) Potonié and Kremp, 1954. *Pollen Spores*. **10**(2): 395-410.

Idem (1969). Preliminary study of the megaspores from the Tupe formation, Quebrada Del Tupe, La Rioje, Argentina. *Ibid.* **11**(3): 669-684.

SRIVASTAVA, P. N. (1954). On some Lower Gondwana megaspores and seeds from Mangardaha Coal, West Bokaro, Bihar. *Palaeobotanist*. **3**: 113-116.

SURANGE, K. R., SINGH, P. & SRIVASTAVA, P. N. (1953). Megaspores from the West Bokaro Coalfield (Lower Gondwanas) of Bihar. *Ibid.* **2**: 9-17.

TRINDADE, N. M. & SOMMER, F. W. (1966). Sinopse de sistematica dos Megasporos do Gondwana Brasiliero. *Anais Acad. bras. Cienc.* **38**(2): 305-314.

EXPLANATION OF PLATES

(All photomicrographs are magnified 100 times unless mentioned specifically)

PLATE 1

1-3. *Trilaevipillitis talchirensis* sp. nov. Dry megaspore (proximal view); Inner sac (wet) detaching from the main body during alkali treatment; and inner sac showing weak trilete trace and cushion rows which do not extend up to inner sac margin (Slide no. 4452, Holotype, Bed no. 5).

4-6. *Trilaevipillitis talchirensis* sp. nov. Dry megaspore (proximal view); Alkali treated (wet) specimen showing distinct inner sac with cushion rows; and strong alkali treated specimen (wet) which disintegrated after further alkali treatment (Bed no. 5).

7-9. *Duosporites dijkstrae* — Dry megaspore (proximal view); Alkali treated specimen (wet) showing inner sac; and detached inner sac showing cushions. Note the trilete trace and cushion rows extending up to the inner sac margin (Slide no. 4453, Bed no. 5).

10. *Duosporites dijkstrae* — Alkali treated megaspore showing distinct inner sac; detached inner sac still lying within the outer-coat. Note the trilete trace and cushion rows extending up to the inner sac margin (Slide no. 4454, Bed no. 6 × 50).

PLATE 2

11, 12. *Duosporites congoensis* — Dry megaspore (proximal view); and alkali treated megaspore (wet) showing inner sac. The cushion rows are discernible. (Slide no. 4455, Bed no. 6).

13. *Duosporites congoensis* — Alkali treated megaspore showing distinct inner sac with cushion rows. Trilete trace and cushion rows do not extend up to the inner sac margin. Specimen earlier figured by Lele & Chandra, (1967, fig. 1). (Slide no. 4454, Bed no. 6) × 50.

14, 15. *Srivastavaeasporites indicus* — Dry megaspore (proximal view); and alkali treated specimen showing dark inner body. The specimen disintegrated after further alkali treatment. (Bed no. 5).

16, 17. *Trileites* sp. Dry megaspore (proximal view); and alkali treated specimen showing exosporium. (Slide no. 4456, Bed no. 6).