UPPER TRIASSIC SPORAE DISPERSAE FROM THE TIKI FORMATION: MEGASPORES FROM THE JANAR NALA SECTION, SOUTH REWA GONDWANA BASIN

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ABSTRACT

Twentyone different types of megaspores belonging to 10 genera are recorded from the plant-bearing bed in the upper part of the Tiki Formation exposed in a stream section in Bijouri-Harai area, Shahdol District, Madhya Pradesh (South Rewa Gondwana Basin). Five species are new. The genus Banksisporites Dettmann has been emended and enlarged. On the basis of megaspore study an Upper Triassic age for the plant-bed of the Tiki Formation is supported.

INTRODUCTION

In the last two decades the taxonomic classification of megaspores has undergone a change. Whereas in the beginning surface study of dry megaspores was carried out by reflected light, later more emphasis was given to the structural studies of wet megaspores in transmitted light. A balanced approach where equal importance is given to surface studies as well as to structural studies has recently found much acceptance with megaspore workers. Of necessity this type of study has resulted in the creation of several new genera of megaspores (Høeg, Bose & Manum, 1955; Pant & Srivastava, 1961, 1962; Bharadwaj & Tiwari, 1970; Maheshwari & Banerji, 1975).

As in the case of dispersed microspores and pollen, in megaspores too, it would be farfetched to suggest that all species referred to a particular genus of megaspores are phylogenetically related. For example, the genus Biharispores is reported right from the Devonian of Arctic Canada (Chaloner, 1958) to at least up to the Upper Triassic of India (present work) but there is no evidence from the megafossil record of the occurrence of a plant which flourished from Devonian to Upper Triassic. Thus, Biharispores presumably includes megaspores of different and may be phylogenetically widely separated plants. This could be true for several other genera too. In the same way it is also likely that megaspores of phylogenetically related plants are placed under different genera.

Thus the taxonomic classification of megaspore taxa has so far been arbitrary and no relationship is implied by placing together similar looking megaspores.

MATERIAL AND METHODS

The megaspores described in the present study were obtained from a grey, argillaceous shale and associated micaceous sandy shale collected by one of us (H.K.M.) from a small exposure on the south bank of Janar stream, about 2·5 km south-east of Bijouri Village (Survey of India toposheet no. 64E/2, see Map 1), Shahdol District, Madhya Pradesh (South Rewa Gondwana Basin). Both the shales are fossiliferous and have yielded carbonized compressions of certain fronds which outwardly look like Dicrotium but their cuticle is more of Lepidopteris type.

Plant fossils from this locality were also reported by C. nageswara Rao (see Krishnan, 1958, pp. 11, 12) who placed this exposure in the Tiki Group to which he assigned a Lower Triassic age.

The Tiki Formation has been shown by Roy Chowdhury et al. (1975, p. 151) as ranging from Anisian to Norian. The Janar Nala plant-bearing bed represents the upper part of the Tiki Formation. A rich vertebrate fauna of Carnian-Norian age has been obtained from beds near Tiki which presumably overlie the plant bearing bed and on that basis Roy Chowdhury et al. (1975) date the plant-bearing bed as Late Carnian-Norian in age. The flora of the Parsora Formation is supposed to be an extension
MAP 1 — Map of Bijouri-Harai area showing the sampling site along Janar Nala near Bijouri, Shahdol District, Madhya Pradesh.
of the Tiki flora and the combined Tiki-Parsora flora (Flora IV of Roy Chowdhury et al.) is dated as Late Carnian-Rhaetian in age.

Megasporas were processed for study in the same way as outlined in an earlier work by Maheshwari and Banerji (1975, p. 151).

**Anteturma — Sporites Potonié, 1893**

**Turma — Triletes (Reinsch) Potonié & Kremp, 1954**

**Subturma — Azonotriletes Luber, 1935**

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

**Genus — Trileites Erdtman ex Potonié, 1956**

*Type Species — Triletes spurius (Dijkstr.) Potonié, 1956.*

**Trileites sp.**

*Pl. 1, fig. 1*

**Description** — Megaspore spherical, trilete. Trilete laesurae open, rays extend more or less up to half spore radius, inter-radial areas show three distinct subtriangular regions each with a central dense portion; contact area indistinct. Exosporium rough, laevigate, 10 \( \mu m \) thick; mesosporium indistinct.

**Dimensions** — Equatorial diameter — dry condition: 360 \( \mu m \); wet condition: 900 \( \mu m \).

**Remarks** — The only specimen found from the sandstone sample shows a peculiar thickening in the inter-radial areas which has not been reported so far in any of the megaspore species.

**Genus — Bokarosporites Bharadwaj & Tiwari, 1970**

*Type Species — Bokarosporites psilatus Bharadwaj & Tiwari, 1970.*

**Bokarosporites janarensis** sp. nov.

*Pl. 1, fig. 2; Text-fig. 1*

**Diagnosis** — Megaspores circular to subcircular, trilete. Trilete laesurae distinct, rays extend up to 2/3rd of spore radius, rays broader toward ends, sometimes with funnel-shaped endings; curvaturnae indistinct. Exosporium laevigate to rough, 10-15 \( \mu m \) thick; mesosporium distinct, circular, thin, without cushions.

**Dimensions** — Equatorial diameter — dry condition: 550-700 \( \mu m \); wet condition: 650-900 \( \mu m \). Diameter of mesosporium: 500-650 \( \mu m \).

**Comparison** — Bokarosporites janarensis is easily distinguished from the two known species of the genus Bokarosporites, viz., *B. psilatus* Bharadwaj & Tiwari, 1970 and *B. rotundus* (Singh) Bharadwaj & Tiwari, 1970 by its trilete rays which are slightly broader at the ends and in the possession of a well-defined mesosporium, whereas, in both the known species the rays are with tapering, pointed or blunt ends and the mesosporium is not as distinct as in the present species.

**Holotype** — Pl. 1, fig. 2; Slide no. B.S.I.P. 5300.

**Type Locality** — Janar Nala near Bijouri, Shahdol District, Madhya Pradesh.

**Age & Horizon** — Upper Triassic, Tiki Formation.

**Genus — Banksisporites Dettmann emend.**

*Type Species — Banksisporites pinguis (Haris) Dettmann, 1961.*

**Emended Diagnosis** — Megaspores subcircular to subtriangular, trilete. Trilete laesurae distinct, straight to sinuous with lips; curvaturnae ill-defined to distinct. Exosporium smooth to granulose; mesosporium indistinct to well-defined, thin, usually covering more than half radius of spore cavity, without cushions.

**Remarks** — The genus Banksisporites was instituted by Dettmann (1961) from Lower Mesozoic strata of Tasmania for cavate trilete megaspores with smooth to granular nexine and sexine and straight or sinuous laesurae with or without lips. She designated *Triletes pinguis* Harris (1935) as the type species of her genus. Besides describing a new species, *Banksisporites sinuosus* from Tasmania, she also ascribed to this genus another specie earlier known as *Triletes tenuis* Dijkstra (1955), from the Permian of Brazil. Bharadwaj and Tiwari (1970) created a new genus *Srivastavae sporites* for cavate trilete megaspores, diagnostic characters of this genus being almost similar to those of the earlier *Banksisporites*.
Text-Figs. 1-4 — 1, Bokarospirites janarensis sp. nov.: holotype in optimum stage of maceration showing trilete rays and distinct subcircular mesosporium \( \times 75 \). 2, Banksisporites dettmaniae sp. nov.: holotype in translucent stage of maceration showing trilete laesurae extending up to contact ridges and a well-defined mesosporium \( \times 100 \). 3, Banksisporites sinuosus Dettmann.: macerated megaspore showing sinuous laesurae and subcircular mesosporium \( \times 150 \). 4, Banksisporites sp. cf. B. gondwanensis Maheshwari & Banerji: macerated megaspore showing trilete rays up to contact ridges, and a distinct mesosporium with minute folds \( \times 100 \).

except for well-defined contact areas delimited by prominent curvatures in Sri- 
vastavaesporites. However, Dettmann has figured one specimen of B. sinuosus (1961, 
pl. 1, fig. 14) where one could observe the presence of clearly developed arcuate ridges. 
Probably the previous author did not attach any importance to this character. 
In the present assemblage megaspores with both indistinct as well as well-defined 
contact areas delimited by clearly developed arcuate ridges have been found. 
Therefore, it seems that not much importance can be attached to the prominence of the arcuate ridges. Hence, the 
diagnosis of the genus Banksisporites is
accordingly emended. *Srivastavaesporites* is treated as a junior synonym.

**Banksisporites dettmannae** sp. nov.
Pl. 1, figs. 3-6; Text-fig. 2

Diagnosis — Megaspores subcircular, tri­
lete. Trilete laesurae distinct, extend nearly
up to equator, straight, lips 20-25 µm
broad, uniformly thickened, contact area
well-defined, delimited by distinct arcuate
ridges which almost merge with equator.
Exosporium 5-10 µm thick, folded, finely
granulose, grana uniformly distributed all
over surface; mesosporium distinct, sub­
circular, large.

Dimensions — Equatorial diameter — dry
condition: 300-900 µm; wet condition: 350-
600 µm. Diameter of mesosporium: 250-
400 µm.

Comparison — *Banksisporites dettmannae*
differs from *B. pinguis* (Harris) Dettmann,
1961 in having large contact areas
delimited by arcuate ridges which sit
almost at the equator. *Banksisporites sinuosus* Dettmann, 1961 can be readily
distinguished by its sinuous laesurae.

**Banksisporites panchetensis** Maheshwari & Banerji, 1975
along with some more specimens from the
present assemblage clearly shows that these
specimens conform to the diagnosis of the
genus *Banksisporites* and hence the species
is transferred to the latter genus.

**Banksisporites pinguis** (Harris) Dettmann,
1961
Pl. 2, figs. 11-14

1935 *Triletes pinguis* Harris, Meddr. Grønland,
112, p. 166, pl. 25, fig. 3.
1935 *Triletes persimilis* Harris, Meddr. Grønland,
112, p. 165, pl. 25, fig. 2.
1950 Megaspore of *Selaginellites hallei* Lund­
blad, K. svenska VetenskAkad. Handl.,
4, p. 9, pl. 1, figs. 6-15.
1950 Megaspore of *Selaginella hallei* Lund­
blad, Svensk bot. Tidskr., 44, p. 484,
pl. 2, figs. 1-4.
1956 *Triletes pinguis* (Harris) Potonie, Beih.
1960 *Triletes pinguis* (Harris) Potonie: Jung,
Palaeontographica, B107, p. 133, pl. 36,
figs. 6-8.
1961 *Banksisporites pinguis* (Harris) Dett­
mann, Micropaleontology, 7, p. 74,
pl. 1, figs. 1-8.
1962 *Triletes pinguis* (Harris) Marcinkiewicz,
Pr. Inst. geol., 30, pl. 1, figs. 5-7.
1963 *Banksisporites pinguis* (Harris) Rein­
hardt, Freiberger Forsch Hft, 164, pl. 2,
figs. 9, 11.
1971 *Triletes pinguis* (Harris) Potonie: Marcinkiewicz,
Pr. Inst. geol., 65, pp.
30-31, pl. 1, figs. 1-5.

Description — Megaspores subtriangular,
trilete. Laesurae extend up to 3/4th of
spore radius, lips broad, 30-40 µm thick,
straight to slightly wavy; contact area
indistinct. Exosporium finely granulose, 10-
20 µm thick, mesosporium well-defined,
subtriangular in shape, without cushions.

Remarks — *Banksisporites pinguis* is a characteristic megaspore species widely known from almost all Rhaetic or Rhaet-Liassic beds of the world. It was first described by Harris (1935) from Rhaetic (Lepidopteris zone) of East Greenland. Later on Lundblad (1950) reported similar megaspores from *Selaginella hallei* type of fructification. Some of our specimens differ slightly in the nature of trilete laesurae from those figured by Harris (1935) and Dettmann (1961). However, specimens included by Marcinkiewicz (1971, pl. 1, figs. 4-5) under this species are quite similar.

*Banksisporites simtos~s* Dettmann, 1961
Pl. 2, figs. 15-18; Text-fig. 3

Description — Megaspore subcircular, trilete. Trilete laesurae distinct, extend up to 2/3rd of spore radius, slightly wavy, lips 20-50 μm broad; contact areas provided with a few apical folds. Exosporium scabrate-granulose, mesosporium indistinct.

Dimensions — Equatorial diameter — dry condition: 430 μm; wet condition: 500 μm.

Remarks — Similar forms were first described as *Triletes tenuis* by Dijkstra (1955) from Permian of Brazil. Later, Dettmann (1961) renamed the forms as *Banksisporites tenuis*, but she did not give any illustration. Pant and Srivastava (1962) restudied the material of Dijkstra and observed that the megaspores increase in size after alkali treatment and that the exosporium is scabrate. Bharadwaj and Tiwari (1970) transferred previously recorded *Triletes tenuis* to their new genus *Srivastavaesporites* but they did not make any reference to *Banksisporites tenuis* which was already existing. As observed in previous pages *Srivastavaesporites* is hardly distinguishable from *Banksisporites* and hence the species *tenuis* should be referred to the genus *Banksisporites*.

Solitary specimen of *Banksisporites tenuis* observed in the present assemblage is rather more comparable to the specimens figured by Dijkstra (1955, pl. 1, figs. 6-8). All the specimens show granulose exine and contact areas with distinct apical folds.

*Banksisporites sp. cf. B. gondwanensis* Maheshwari & Banerji, 1975
Pl. 3, figs. 19, 20; Text-fig. 4

Description — Megaspore subcircular, trilete. Trilete laesurae distinct, extend up to 3/4th of spore radius, rays straight, 30-40
µm broad, slightly broader towards ends; arcuate ridges not very distinct. Exosporium granulose, 10-15 µm thick; mesosporium well-defined, circular, with minute folds, without cushions.

**Dimensions** — Equatorial diameter — dry condition: 510 µm; wet condition: 660 µm. Diameter of mesosporium: 430 µm.

**Comparison** — The specimen is closely comparable with Banksisporites gondwanensis Maheshwari & Banerji (1975) in size, shape etc., but differs in having granulate ornamentation, whereas, the earlier specimens show closely set low verrucae.

**Banksisporites sp.**

**Description** — Megaspore subtriangular, trilete. Trilete laesurae extend nearly up to margin, narrow, uniformly 10-15 µm high, straight. Exosporium finely granulose, peripheral folds present; mesosporium faintly perceptible.

**Dimensions** — Equatorial diameter — dry condition: 380 µm; wet condition: 410 µm.

**Comparison** — The specimen differs from all the known species of Banksisporites by its uniformly developed narrow trilete rays which reach nearly up to the margin.

Infraturma — Apiculati (Bennie & Kidston, 1886) Potonie, 1956

**Genus — Biharisporites** Potonie 1956 emend. Bharadwaj & Tiwari, 1970

**Type Species** — Biharisporites spinosus (Singh, in Surange, Singh & Srivastava) Potonie, 1956.

**Biharisporites sparsus sp. nov.**

**Description** — Megaspores circular to subcircular, trilete. Rays extend nearly up to equator, 10-20 µm broad, 20-60 µm high, tectum possessing small spinate projections at its margin. Commissures indistinct probably due to well-developed tectum. Exosporium conate, coni ± 10-20 µm high as well as broad, sparsely distributed all over surface, surface scabrate to granulate; mesosporium generally indistinct, sometimes faintly visible, filling almost whole spore cavity.

**Dimensions** — Equatorial diameter — dry condition: 500-600 µm; wet condition: 600-700 µm.

**Comparison** — Biharisporites sparsus differs from B. spinosus (Singh) Potonie, 1956 emend. Bharadwaj & Tiwari, 1970 in having sparsely placed sculpture elements and a large mesosporium. B. distinctus Bharadwaj & Tiwari, 1970 can be distinguished by its differentially developed ornamentation of low coni. B. arcuatus Bharadwaj & Tiwari, 1970 resembles the present species in shape, size and indistinctly seen mesosporium but differs by its highly developed arcuate ridges, well-defined contact areas and closely placed setae. B. scaber Marcinkiewicz (1960) differs in having well-defined coni, distinct mesosporium and is smaller in size.

**Holotype** — Pl. 3, figs. 24, 25; Slide no. B.S.I.P. 5313.

**Type Locality** — Janar Nala near Bijouri, Shahidol District, Madhya Pradesh.

**Age & Horizon** — Upper Triassic, Tiki Formation.

**Biharisporites sp.**

**Description** — Megaspores circular to subcircular, trilete. Trilete rays extend nearly up to margin, ± straight, 20-25 µm broad, contact areas well-defined by low, 15-20 µm broad arcuate ridges. Exosporium covered with small spines or setae, 10-20 µm thick, 10-20 µm broad at base, apices of spines slightly curved, pointed or rounded, by gradual disappearance of ornamentation exosporium seems to be laevigate-verrucate; at optimum stage of maceration mesosporium faintly visible, almost filling whole of spore cavity.

**Dimensions** — Equatorial diameter — dry condition: 500-600 µm; wet condition: 600-700 µm.

**Comparison** — The specimens are closely comparable with Biharisporites arcuatus Bharadwaj & Tiwari, 1970 in size, shape and ornamentation but the latter species differs in having sinuous trilete laesurae. B. spinosus (Singh) Potonie, 1956 and B.
TEXT-FIGS 5-8 — 5, _Biharisporites sparsus_ sp. nov.: holotype in macerated condition showing exosporium with sparsely distributed coni ×75. 6, _Bacutriletes_ sp.: megaspore in macerated condition showing baculate exosporium ×100. 7, _Horstisporites areolatus_ (Harris) Potonie: megaspore showing reticulate exosporium and a subcircular mesosporium ×100. 8, _Hughesisporites variabilis_ Dettmann: translucent specimen showing granulate exosporium and with prominent verrucae in the inter-radial areas ×200.

_B. distinctus_ Bharadwaj & Tiwari, 1970 are distinguished by a distinct inner body. _B. echinatus_ (Miner) Potonie, 1956 differs in having well-developed conate-spinate sculpture. _B. scaber_ Marcinkiewicz, 1960 differs by its smaller size.
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**?Biharisporites sp.**

Pl. 4, figs. 28, 29

**Description** — Megaspore subcircular, trilete. Trilete laesurae small and indistinct. Exosporium conate-spinate, 5 \( \mu m \) thick, spines distantly placed, 10-20 \( \mu m \) long, after maceration it gives a pseudoreticulate appearance; mesosporium indistinct.

**Dimensions** — Equatorial diameter — dry condition: 350 \( \mu m \); wet condition: 380 \( \mu m \).

**Comparison** — The present specimen can well be compared with *Biharisporites* sp. described by Maheshwari and Banerji (1975) in its exine ornamentation but the trilete laesurae, and the mesosporium are not discernible in the present specimen.

**Genus — Verrutriletes van der Hammen ex Potonie, 1956**

**Type Species** — *Verrutriletes compositopunctatus* (Dijkstra) Potonie, 1956.

**Verrutriletes distinctus** (Maheshwari & Banerji) comb. novo


**Description** (after Maheshwari & Banerji) — Trilete megaspore, amb subtriangular, laesurae strongly developed, straight, almost uniformly broad throughout, about two-thirds of spore radius long, contact area not marked, arcuate ridges absent. Exine cavate, exosporium 10-20 \( \mu m \) thick, ornamented with closely placed verrucae elements with broad bases and gradually narrowing towards rounded or blunt apices. In wet specimens verrucae 10-25 \( \mu m \) high and 10-20 \( \mu m \) broad; mesosporium distinct, large and subtriangular.

**Dimensions** — Equatorial diameter — dry condition: 280 \( \mu m \); wet condition: 320-380 \( \mu m \). Diameter of mesosporium: 250-280 \( \mu m \).

**Comparison** — Some of the megaspore types from the Lower Triassic earlier reported under the genus *Jhariateiletes* are now considered to be representative of the genus *Verrutriletes* as these have a verrucae exosporium instead of a baculate exosporium which is characteristic of the former genus. In shape and ornamental elements *Verrutriletes distinctus* comes closest to *V. dubius* (Dijkstra) Potonie. However, the ornamentation elements are not so sparsely distributed as in the latter species and the mesosporium is distinct.

**Verrutriletes minuticorpus** sp. nov.

Pl. 4, figs. 31, 32; Pl. 5, fig. 33

**Description** — Megaspore subspherical, trilete. Trilete laesurae extend up to 3/4th of spore radius, uniformly 20-25 \( \mu m \) broad, ± straight, arcuate ridges not well-defined. Exosporium with well-developed, about 20-30 \( \mu m \) long and equally broad verrucae, ends slightly conate, surface in between verrucae finely granulate, after prolonged maceration verrucae dissolve to give granulate surface; mesosporium subcircular to oval, small, darker in colour, granulate.

**Dimensions** — Equatorial diameter — dry condition: 600-700 \( \mu m \); wet condition: 700-800 \( \mu m \); diameter of mesosporium: 450-500 \( \mu m \).

**Comparison** — *Verrutriletes minuticorpus* is comparable with *Verrutriletes litchi* (Harris) Potonie described by Marcinkiewicz (1971) from Rhaeto-Liassic beds of Poland in size and exospore ornamentation. However, it differs in possessing a smaller mesosporium as compared to that of the Polish specimens. In the Greenland specimens a mesosporium has not been found (Harris, 1935, p. 159).

**Holotype** — Pl. 4, figs. 31, 32; Pl. 5, fig. 33; Slide no. B.S.I.P. 5316.

**Type Locality** — Janar Nala near Bijouri, Shahdol District, Madhya Pradesh.

**Age & Horizon** — Upper Triassic, Tiki Formation.

**Verrutriletes obscurus** (Maheshwari & Banerji) comb. novo

Pl. 5, figs. 34, 35

1975 *Jhariateiletes obscurus* Maheshwari & Banerji, *Palaeontographica*, B152, p. 171, pl. 7, figs. 101-102; pl. 8, figs. 103-107; text-fig. 4.

**Description** — Megaspores subcircular, trilete. Laesurae distinct, extend up to 3/4th of spore radius, straight or slightly sinuous,
20-30 μm broad, occasionally broader at trijunction, gradually tapering towards ends, sometimes laesurae open, with distinct lips; contact area clearly demarcated, but arcuate ridges not prominent. Exine cavate, exosporium ornamented with hemispherical warts or verrucae, 15-35 μm high, closely distributed except in contact area, surface in between verrucae finely granulate; mesosporium hardly perceptible, subcircular, almost filling the whole cavity.

**Dimensions** — Equatorial diameter — dry condition: 400-600 μm; wet condition: 600-800 μm.

**Remarks & Comparison** — The present specimens largely agree with *Bacutriletes tylotus* described from the *Lepidopteris* bed of East Greenland (Harris, 1935). The Greenland specimens, however, characteristically have cylindrical bacula with transversely truncate ends.

The species *tylotus* has also been reported from Rhaeto-Lias boundary of Franconia (Jung, 1960), Rhaeto-Lias beds of Poland (Marcinkiewicz, 1962, 1971), and from Upper Cretaceous of Alberta (Gunther & Hills, 1972). It is, however, extremely doubtful if any of these specimens actually belongs to the species *tylotus*.

**Infraturma** — *Murornati* Potonie & Kremp, 1954

**Genus** — *Horstisporites* Potonie, 1956

**Type Species** — *Horstisporites* (Triletes) *areolatus* (Harris) Potonie, 1956.

**Horstisporites areolatus** (Harris) Potonie, 1956

*Pl. 6, figs. 39, 40; Text-fig. 7*


1961 *Triletes areolatus* Harris: Harris, *Yorkshire Jurassic Flora*, 1, text-fig. 19 E.


**Description** — Megaspores spherical, trilete. Trilete laesurae distinct, extend up to 3/4th of spore radius, straight, 20-25 μm broad, contact area ill-defined. Exosporium 15-20 μm broad, reticulate, reticulation irregular-polygonal in shape, muri of reticulum 15-20 μm broad, lumina 30-60 μm broad, surface of exosporium finely granulate; mesosporium faintly visible, thin, almost filling two-thirds of spore cavity.
On prolonged maceration the exosporium gradually dissolves and the muri of the reticulation stand out very clearly and look like bacula.

**Dimensions** — Equatorial diameter — dry condition: 350-500 \( \mu \)m; wet condition: 500-700 \( \mu \)m. Equatorial diameter of mesosporium: 425-450 \( \mu \)m.

**Comparison** — The present specimens are closely comparable to *Horstisporites areolatus* described from Rhaetic beds of Greenland (Harris, 1935) in having more or less regular development of reticulate pattern on the exosporium. *H. reticuliferus* (Dijkstra) Potonie can be distinguished from the present one in having smaller trilete laesurae and larger areolae. *H. rexargentus* (Harris) Potonie and *H. harrisii* (Murray) Potonie differ in possessing smaller and irregular meshes of the reticulation. *H. semireticulatus* Jung, 1960 is distinguished by larger meshes of the reticulum. *H. cavernatus* Marcinkiewicz, 1971 is distinguished by its triangular to subtriangular shape. *H. planatus* (Marcinkiewicz) Marcinkiewicz, 1971 and *H. foeranus* Marcinkiewicz, 1971 differ in having a fine and delicate reticulum.

This species is widely known from Rhaeto-Liassic beds of the world and has been recorded by Harris (1935) from Rhaeto-Liassic Bed of East Greenland, Harris (1961) from Jurassic of Yorkshire, Jung (1960) from Rhaeto-Liassic of Franconia and Marcinkiewicz (1962, 1971) from Liassic of Poland.

### Genus — Erlansonisporites Potonie, 1956

**Type Species** — *Erlansonisporites erlansonii* (Miner) Potonie, 1956.

*Erlansonisporites triassicus* sp. nov.

Pl. 6, figs. 42-47; Text-fig. 9

**Description** — Megaspores subcircular, trilete. Trilete rays raised, reaching nearly up to equatorial margin, 20-30 \( \mu \)m broad; contact areas indistinct. Exine proximally having appendages which form imperfect reticulum on a finely granulate surface, which generally forms 20-25 \( \mu \)m broad equatorial flange; distally exine without appendages.

**Dimensions** — Equatorial diameter — dry condition: 200-400 \( \mu \)m; wet condition: 300-500 \( \mu \)m.


**Holotype** — Pl. 6, figs. 46, 47; Slide no. B.S.I.P. 5325.

**Type Locality** — Janar Nala near Bijouri, Shahdol District, Madhya Pradesh.

**Age & Horizon** — Upper Triassic, Tiki Formation.

*Erlansonisporites singhii* nom. nov.


**Description** (after Singh, 1964) — Trilete megasporone, outline of the spore completely circular; in some specimens trilete mark entirely covered by strong reticulation and partially or not at all visible; faint trilete crack about 1/3rd the length of the spore radius visible where the high membraneous lamellae on the muri of the reticulum destroyed by oxidative maceration; arcuate lamellae absent; contact faces not distinguishable; a coarse network of muri 4 to 7 micron wide, forming circular to elongate lumina, 34 to 60 micron in diameter, present all over the spore surface, muri of the reticulum transformed into thin and membraneous lamillae about 60 micron high, equally well developed all over the exine, but better preserved around the periphery due to flattening of the spherical body.

**Dimensions** — Equatorial diameter — including the lamillae: 580-660 \( \mu \)m; excluding the lamillae: 480-550 \( \mu \)m.

**Remarks** — *Erlansonisporites reticulatus* described by Singh, 1964 is an invalid species as the name was pre-occupied having been used by Marcinkiewicz (1960) for *Triletes reticulatus* Zerndt, 1938. Therefore, a new specific name has been given by us for *E. reticulatus* described by Singh, 1964.

*E. reticulatus* (Zerndt) Marcinkiewicz can be distinguished from the present species...
Text-Figs. 9-11 — 9, *Erlansonisporites triassicus* sp. nov.: holotype showing laevigate distal exosporium and proximal exosporium with imperfect reticulum comprising thick muri × 200. 10, *Nathorstisporites* sp.: specimen showing high appendages in inter-radial areas. × 200. 11, *Nathorstisporites hopliticus* Jung: specimen showing branched and unbranched capilli-like exoexinous projections × 150.

by its well-defined contact areas and less-developed muri of the reticulum.

*Holotype* — Singh, C., 1964, pl. 22, fig. 1.

*Type Locality* — Fort Augustus no. 1 Well, East-Central Alberta, Canada.

*Horizon & Age* — Grand Rapids Formation, Lower Cretaceous.
**Description** — Megaspore oval, ?trilete. Exosporium reticulate, reticulum irregular comprising high muri, surface finely granulate; mesosporium indistinct.

**Dimensions** — Equatorial diameter — dry condition: 525 μm; wet condition: 590 μm.

**Comparison** — The specimen is doubtfully referred to *Erlansonisporites* as the trilete mark has not been seen. The specimen is somewhat comparable with *Erlansonisporites sparassis* (Murray) Potonié emend. Harris (1961) in its coarsely developed reticulate pattern but does not show such high ridges as are characteristic of *E. sparassis*.

**Remarks** — The specimen is somewhat comparable with *Erlansonisporites* but does not show such high ridges as are characteristic of *E. sparassis*.

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**Genus — Hughesisporites Potonié, 1956**

**Type Species** — Hughesisporites galericulatus (Dijkstra) Potonié, 1956.

**Hughesisporites variabilis** Dettmann, 1961

**Description** — Megaspores subtriangular to subcircular in shape, cavate, trilete. Trilete laesurae wavy, extend up to three-fourths of spore radius, lips about 40 μm broad, contact area well-defined, delimited by mediumly developed arcuate ridges. Exosporium 10 μm thick, granulate, inter-radial areas with prominent verrucae; mesosporium distinct, small, subtriangular to subcircular in shape, without cushions.


**Comparison** — In all the characteristic features the present specimens resemble *Hughesisporites variabilis* Dettmann, 1961 reported from the Lower Mesozoic beds of Tasmania. The species differs from *H. galericulatus* and *H. ionthus* (Harris) Potonié, 1956 by its cavate nature and well-defined contact areas. *H. novus* Sah & Jain, 1968 probably represents the genus *Verrutritelles* as the exosporium is verruicate all over. *H. pustulatus* Marcinkiewicz (1962) from the Liassic of Poland is distinguishable by the rugulate exine sculpture in the inter-ray areas. *H. tumulosus* Marcinkiewicz (1976) from the Middle Bundsandstein of Poland differs in having characteristic folds and swellings in the contact areas.

**Genus — Nathorstisporites Jung, 1958**

**Nathorstisporites hopliticus** Jung, 1958.

**Description** — Megaspores subcircular, trilete. Trilete laesurae with raised lips associated with 20-50 μm long branched or unbranched capilli-like exoexinous projections, inter-ray areas also show prominent spine-like outgrowths. Exine granulate-spinate, after maceration it gives spongy texture due to gradual disappearance of ornamentation.

**Dimensions** — Equatorial diameter — dry condition: 400-650 μm; wet condition: 500-700 μm.

**Remarks** — The specimens compare rather well with those described and figured by Marcinkiewicz (1971, p. 40, pl. 22, figs. 5-9) from the Hettangian (Liassic) of Poland.

The species is of wide occurrence in Rhaeto-Liassic sediments of Greenland (Harris, 1935), Sweden (Lundblad, 1956), Germany (Jung, 1960), Poland (Marcinkiewicz, 1960, 1971), Australia (Dettmann, 1961) and Salt Range (Sah & Jain, 1968). Recently Maheshwari and Banerji (1975) have also reported a doubtful specimen from Lower Triassic of India. But, the present record of *N. hopliticus* gives a sufficient ground to show its definite occurrence in the Upper Triassic sediments of India.

**Nathorstisporites hopliticus**

**Nathorstisporites hopliticus**

**Nathorstisporites sp.**

**Description** — Megaspore subcircular, trilete. Trilete laesurae indistinct due to folds. Exine laeivigate, infragranulate, proximally with 20-50 μm high appendages in inter-ray areas.

**Dimensions** — Diameter — dry condition: 330 μm; wet condition: 350 μm.
Comparison — The solitary specimen recovered can best be placed in the genus Nathorstisporites Jung. However, it differs from all the known species, viz., Nathorstisporites hopliticus Jung, 1958; N. pellasticus Jung, 1958; N. reticulatus Dettmann, 1961; N. flagellatus Dettmann, 1961; N. pulcherrima Helby, 1966; N. nammalensis Sah & Jain, 1968; and N. imprimus Reinhardt & Fricke, 1969 in having smooth, infragranulate exine and leaf-like appendages in proximal inter-ray areas.

PLANTAE INCERTAE SEDIS

Genus — Spermatites Miner, 1935

Spermatites sp. cf. S. indicus Srivastava, 1955

Pl. 4, fig. 30; Text-fig. 13

Description — Probably a seed-coat, oval-elliptical in shape, sessile, apex obtuse, size 1.9×0.9 mm. Cellular structure seen only at few places comprising square to rectangular, straight-walled cells. Prominent rib-like structures seen at two extremities.

Comparison — The overall appearance of the specimen is like that of a seed. In its shape and size the specimen compares somewhat with Spermatites indicus Srivastava, 1955 known from the Barakar Formation of West Bokaro Coalfield, India. However, in the species a dense and more or less circular nucellus is reported whereas in the present specimen it has not been observed.

Spermatites sp. cf. S. orbicularis Miner, 1935

Pl. 5, fig. 36; Text-fig. 12

Description — Seed-coat, sub-circular in shape, sessile, apex obtuse, base broadly rounded, 2 mm long, 1.8 mm wide, cells usually rectangular, near apical region...
somewhat polygonal, at base comparatively elongated than elsewhere.

Remarks — Though in this specimen, too, a nucellus has not been observed, it has the looks of a seed. Due to insufficient information available about its structure, it is referred to the non-commital genus Spermatites. The nearest comparable species is S. orbicularis Miner, 1935 reported from the Upper Cretaceous of Greenland.

DISCUSSION

The megaspores reported in the paper have been recovered both from the fine-grained grey shale and the associated micaeous coarse-grained sandy shale. The proportion of megaspore recovery is, however, comparatively more in the fine-grained shale. A detailed taxonomic study of the specimens recovered has revealed the presence of at least 21 different types of megaspores, probably representing as many species. These have been grouped under 10 genera. The total list of megaspore types described in the present paper is:

- Trileites sp.
- Bokarosporites janarensis sp. nov.
- Banksisporites dettmannae sp. nov.
- Banksisporites sp. cf. B. gondwanensis Maheshwari & Banerji
- Banksisporites panchetensis (Maheshwari & Banerji) comb. nov.
- Banksisporites pinguus (Harris) Dettmann
- Banksisporites sinuosus Dettmann
- Banksisporites tenuis (Dijkstra) Dettmann
- Biharisporites sparsus sp. nov.
- Biharisporites sp.
- ? Biharisporites sp.
- Verrutriletes minuticusporus sp. nov.
- Verrutriletes obscurus (Maheshwari & Banerji) comb. nov.
- Bacutriletes sp.
- Horstisporites arcolatus (Harris) Potonié
- Erlansonisporites triassicus sp. nov.
- ? Erlansonisporites sp.
- Hughesisporites variabilis
- Nathorstisporites hopliticus Jung
- Nathorstisporites sp.

A per cent frequency count of the occurrence of megaspores has not been attempted but a general survey shows that the megaspores referable to the genus Banksisporites dominate the assemblage. Horstisporites, Nathorstisporites and Verrutriletes are the other genera which are frequency-wise important in that order. The genera Horstisporites, Erlansonisporites, Hughesisporites and Nathorstisporites have not been found in the sandy shale samples.

Comparison with Gondwanan Megaspore assemblages — From the Gondwanaland provinces though the megaspores have been worked out from the Permian, Triassic, Jurassic and Cretaceous sediments, a proper biostratigraphical sequence built on them has not been worked out so far. This is probably due to scanty information available.

The Permian megaspore assemblages are known from India, Brazil, and Central Africa (see Høeg & Bose, 1960; Pant & Srivastava, 1961, 1962; Trindade, 1967; Bharadwaj & Tiwari, 1970). Most of these assemblages are characterized by the presence of trilete cavate megaspores in which the mesosporium has variously aligned 'cushions', e.g., the genera Duosporites, Talchirella, Dijkstraecia, Gulatriletes and Surangeaesporites. Out of these forms only Talchirella extends into the Lower Triassic (Maheshwari & Banerji, 1975). This genus is also reported from the Lower Triassic of Romania (Antonescu & Lantz, 1973) and Poland (Marcinkiewicz, 1976). However, none of these 'cushioned' forms is present in our assemblages.

The only well known Lower Triassic megaspore assemblage is from the Nonia Nala section in the West Raniganj Coalfield, India (Maheshwari & Banerji, 1975). This assemblage, besides having continuation of Permian forms such as Biharisporites and Talchirella, has several new elements, viz., Banksisporites, Pantiella, Maiturisporites, and Verrutrilates. Of these, only Banksisporites and Verrutrilates are common with our assemblage.

Only a few Middle-Upper Triassic megaspores are known, e.g. Nathorstisporites pulcherrima from New South Wales (Helby, 1966), Nathorstisporites and Horstisporites from western Australia (Dolby & Balme, 1976) and Talchirella, Triletes and Zeillerisporites from Salt Range (Pant & Srivastava, 1964).

Dettmann (1961) has described a few Rhaetic-Liassic megaspores from Australia. The following species are common with the present assemblage: Banksisporites pinguus,
B. sinuosus, Hughesisporites variabilis and Nathorstisporites hopliticus. Besides, the genera Horstisporites and Bacutriletes are also present in both.

The only probable Liassic megaspore assemblage known is from the Salt Range (Sah & Jain, 1968). From this assemblage only Banksisporites sinuosus and Nathorstisporites hopliticus are common with our assemblage. The Salt Range assemblage probably also has the genus Verrutriletes (Hughesisporites novus of Sah & Jain, 1968).

The Jurassic-Cretaceous megaspore assemblages known from India (Dev, 1961; Singh, Srivastava & Roy, 1964) are characterized by the presence of the genera Dijkstrastrisporites, Erlansonisporites, Saccharisporites, Verrutriletes, Bacutriletes, Horstisporites, Valvisporites, Umiaspora, Mineriisporites, Auriculoozonosporites and Thomsonia. Out of these, the genera Erlansonisporites, Bacutriletes, Horstisporites and Verrutriletes are also known from our assemblage. Hughesisporites and Horstisporites are also known from the Cretaceous of Argentina (Gamerrro, 1975).

Thus it is evident that our megaspore assemblage is more akin to the Rhaetic-Liassic assemblages rather than to the Permain-Lower Triassic ones. A comparative distribution in Indian sediments of the megaspore genera found in the present assemblage is shown in chart 1.

Comparison with European Rhaetic-Liassic Megaspore assemblages—The Rhaetic-Liassic megaspores in Europe have been extensively worked out from Poland (Marcinkiewicz, 1960, 1961, 1962, 1971), Germany (Jung, 1960), Greenland (Harris, 1935). The common elements between the Indian and Greenland megaspore assemblages are Banksisporites pinguis, Bacutriletes, Horstisporites areolatus and Nathorstisporites hopliticus. The same species are also known from Germany. Reinhardt and Fricke (1969) have reported the presence of Banksisporites pinguis, Verrutriletes, Biharisporites, Horstisporites and Nathorstisporites in the Keuper of Germany.

The Rhaeto-Liassic of Poland has the following genera common with our assemblage: Banksisporites, Biharisporites, Verrutriletes, Bacutriletes, Horstisporites, Erlansonisporites, Hughesisporites and Nathorstisporites. The Polish assemblage, however, also has Maexisporites, Minerisporites, Thomsonia, Aneuletes and Dictyothylakos which are not present in our assemblage.
REFERENCES


EXPLANATION OF PLATES

(All figures. X 100, unless otherwise mentioned)

PLATE 1

1. Triletes sp.—Translucent megaspore showing three subtriangular dense portions. Slide no. B.S.I.P. 5299.

2. Bokarasporites janarensis sp. nov.—Holotype in macerated condition showing a well-defined and thin mesosporium. Slide no. B.S.I.P. 5300.

3-6. Banksiosporites dettmannae sp. nov.—3, Holotype in dry condition showing trilete rays which extend almost up to the equator; 4, The same megaspore macerated showing distinct mesosporium and finely granulate exosporium. Slide no. B.S.I.P. 5301; 5, Another megaspore in dry condition showing distinct trilete rays; 6, Same in macerated condition. Slide no. B.S.I.P. 5302.

PLATE 2

7-10. Banksiosporites panchatensis (Maheshwari & Banerji) comb. nov.—7, Specimen in dry condition showing trilete rays which reach up to the contact ridges; 8, The same megaspore macerated, showing a distinct mesosporium. Slide no. B.S.I.P. 5303; 9, Another specimen in dry condition showing thick and raised trilete rays; 10, Same in macerated condition. Slide no. B.S.I.P. 5304. (An unfigured specimen on Slide no. B.S.I.P. 5307).

11-14. Banksiosporites pinguis (Harris) Dettmann —11, Megaspore in dry condition; 12, Macerated megaspore showing the mesosporium. Slide no. B.S.I.P. 5305; 13, Another specimen of the same species. Slide no. B.S.I.P. 5306; 14, A specimen of the same species showing a distinct mesosporium and trilete rays (Specimen dissolved during further maceration).

15-18. Banksiosporites simonos Dettmann —15, A macerated megaspore showing sinusuous trilete rays and the mesosporium. Slide no. B.S.I.P. 5308; 16, A megaspore in dry condition; 17, The same specimen macerated to show the granulate exosporium and the mesosporium; 18, Specimen further macerated. Slide no. B.S.I.P. 5309.

PLATE 3

19-20. Banksiosporites sp. cf. B. gondwanensis Maheshwari & Banerji — 19, A megaspore in dry condition showing granulate exine; 20, Same specimen in macerated condition showing a well-defined subcircular mesosporium. Slide no. B.S.I.P. 5310.

21. Banhsiosporites sp.—The specimen in macerated condition showing narrow trilete laesurae which extend almost up to the spore equator. Slide no. B.S.I.P. 5312.

22-23. Banksiosporites tenuis (Dijkstra) Dettmann —22, Megaspore in dry condition; 23, Specimen macerated to show the contact area with apical folds. Slide no. B.S.I.P. 5311.

24-25. Biharisporites sparsus sp. nov.—24, Holotype in dry condition showing highly developed trilete laesurae; 25, The type specimen macerated to show exosporium with sparsely developed conate-spinate exine. Slide no. B.S.I.P. 5313. (Another specimen, unfigured, on Slide no. B.S.I.P. 5318).

PLATE 4

26-27. Biharisporites sp.—26, Megaspore in dry condition showing exine ornamented with spines and setae; 27, Same in macerated condition. Slide no. B.S.I.P. 5314.


31-32. Verrutriletes minuticorpus sp. nov.—31, Holotype in dry condition showing verrucate exine; 32, Granulate mesosporium isolated from the exosporium of the holotype by maceration. Slide no. B.S.I.P. 5316.

PLATE 5

33. Verrutriletes minuticorpus sp. nov.—Megaspore in Pl. 4, fig. 31, in translucent condition showing verrucate exosporium and a distinct and dense mesosporium. Slide no. 5316 (Mesosporium later isolated and mounted on same slide).

34-35. Verrutriletes obscurs (Maheshwari & Banerji) comb. nov.—34, Megaspore in dry condition showing exine ornamented with closely placed verrucae except in the contact areas; 35, Macerated megaspore showing well-developed verrucae. (Lost during maceration in an attempt to isolate the mesosporium).


37. Bacutriletes sp.—Megaspore in dry condition showing baculate exine.
38. Bactritites sp.—Specimen in pl. 5, fig. 37 macerated to show well-developed baculate ornamentation of the exosporium. Slide no. B.S.I.P. 5320.


41. ?Erlansonisporites sp.—Translucent megaspore showing reticulate exosporium. Slide no. B.S.I.P. 5322.

42-47. Erlansonisporites triassicus sp. nov.— 42. Megaspore in dry condition; 43. Same specimen in macerated condition showing equatorial flange. Slide no. B.S.I.P. 5323; 44. Another specimen in dry condition; 45. The same spore macerated showing well-developed equatorial flange. Slide no. B.S.I.P. 5324; 46. Holotype in dry condition; 47. Same in macerated condition showing proximal imperfect reticulum and distal laevigate exosporium. Slide no. B.S.I.P. 5325.

48-49. Hughesisporites variabilis Dettmann — 48, Megaspore in dry condition showing well-developed trilete rays reaching almost up to equator; 49, The same megaspore macerated showing granulate exosporium and well-developed verrucae in the inter-radial areas just over the small mesosporium. Slide no. B.S.I.P. 5326.


51-54. Nathorstisporites hopliticus Jung— 51, Megaspore in dry condition showing branched or unbranched capilli-like exoexinous projections associated with trilete lips; 52, Same in macerated condition. Slide no. B.S.I.P. 5328; 53, Another specimen in dry condition; 54, Same in macerated condition; Slide no. B.S.I.P. 5329.

55-56. Nathorstisporites sp.— 55, Specimen in dry condition, 56, Macerated spore showing high appendages in inter-ray areas. Slide no. B.S.I.P. 5330.
Plate 2