

# MIOSPORE ASSEMBLAGE OF SEAM IX OF EAST RANIGANJ COALFIELD (INDIA)\*

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## ABSTRACT

The spore and pollen flora contained in seam IX (Upper Kajora seam at the Jaipuria Kajora colliery) of Raniganj coalfield consists of 32 genera and 72 species, out of which 11 species are new. The spore assemblage of this seam has also been compared with those of the underlying seams (Nos. VIII & VII in succession) and the important seam to seam, qualitative as well as quantitative differences have been discussed.

## INTRODUCTION

MIOSPORES contained in the coals of Raniganj Stage (Upper Permian) have been extensively worked out by Bharadwaj (1962) and Bharadwaj & Salujha (1965, a, b). Bharadwaj (*loc. cit.*) has described the various genera present in these coals whereas Bharadwaj & Salujha (1964) have delimited the various species represented in seam VIII of the Raniganj coalfield, India. This has been done after a detailed study of hundreds of specimens of each genus and ascertaining the value of different characters individually as well as in combination. In a subsequent publication (BHARAD. & SALUJHA, 1965 a) seam VIII has also been correlated from distantly situated collieries. In another paper Bharadwaj & Salujha (1965, b) have described the miospore assemblage of seam VII in Raniganj coalfield.

The present paper deals with a sporological study of seam IX (Upper Kajora) at the Jaipuria Kajora colliery of the Raniganj coalfield, Bihar. The spore and pollen flora recovered here has also been compared with the underlying seams (Nos. VIII & VII in succession) and the remarkable differences, both qualitative as well as quantitative, have been brought out.

The Upper Kajora seam (IX) is the uppermost workable seam of the Raniganj Stage in the eastern part of Raniganj coalfield. It lies about 220 ft. above the Jambad

Bowlah seam (VIII) and crops out to the east of the Kajora-Siduli strike-fault at Modhujori colliery and to the west of Khandra and Khas Kajora collieries. Further south it is worked at a depth in the pits of Central Kajora colliery. On the east of the fault the seam crops out again in the Parashkol tract and continues southwards across the eastern half of Kajora colliery area. The Khandra faults have affected the Upper Kajora seam in the area very profoundly. The seam outcrop south of Ukhra town becomes thinner very rapidly eastward so that its thickness is only 7 ft. in a number of bore holes located north-west of the Sarpi village. The Upper Kajora seam outcrop east of the Babuisol fault has been marked with the help of 2 bore holes located in the area to the north-west of Sokra. Below this seam is the typical sandstone succession of the thickness of 197 feet.

## MATERIAL AND METHODS

The material for the present study was provided by the Fuel Research Institute, Jealgora. The usual maceration procedure was adopted. The macerate used for qualitative study was passed through a sieve such that the wood shreds, cuticles, etc., were separated and a concentrated sporiferous material was obtained. In doing so some of the spores were lost, either by remaining sticking to the extenuous matter above or by passing down through the finer sieve. Thus for an exact quantitative analysis of the miospore assemblage the unsieved macerate was used.

The thickness of the Upper Kajora seam is about 21 feet, of which only the top 10' 4" has been sampled. The sampling details along with the maceration numbers of the samples collected have been given in the following table (TABLE 1).

\*Work carried out at the Birbal Sahni Institute of Palaeobotany, Lucknow, for the Scheme "Palaeobotanical Investigation of Indian Coals" (C.S.I.R.).

TABLE 1 — UPPER KAJORA SEAM, JAIPURIA KAJORA COLLIERY,  
RANIGANJ COALFIELD

Location of place of Sampling — No. 2 Pit, 27th level between 17th & 18th dip. N.E. Section  
Total thickness of the seam — 21 ft. (Working Section Top 8')

Section of the seam

DESCRIPTION OF STRATA	THICKNESS	SAMPLE NO.	MAC. NO.		
<i>Roof — Carb. Shale</i>					
Thickness 10'4"	Dull Coal with thin laminations of brights	1'4"	F.S. No. 10	141	10 Foot by Foot samples along a channel 3" x 2".
	Dull Coal with thin laminations of brights	0'6"	F.S. No. 9	140	
	Coal with brights	0'6"			
	Coal with brights	1'0"	F.S. No. 8	139	
	Coal with brights	0'9"	F.S. No. 7	138	
	Dull Coal with thin laminations of brights	0'3"			
	Dull Coal with thin laminations of brights	0'3"	F.S. No. 6	137	
	Coal with brights	0'9"			
	Coal with brights	1'0"	F.S. No. 5	136	
	Coal with brights	0'7"	F.S. No. 4	135	
	Dull Coal with thin laminations of brights	0'5"			
	Dull Coal with thin laminations of brights	1'0"	F.S. No. 3	134	
	Dull Coal with thin laminations of brights	1'0"	F.S. No. 2	133	
	Dull Coal with thin laminations of brights	1'0"	F.S. No. 1	132	

*Floor — Carb. Shale*

SYSTEMATIC DESCRIPTION OF  
SPORAE DISPERSAE

The miofloral assemblage of the Upper Kajora seam consists of 32 genera and 72 species. Qualitatively spore and pollen flora of the present seam is almost the same as those of the Jambad Bowlah and Bonbahal seams (BHARADWAJ & SALUJHA 1964, 1965 b) but for few species which are described below. Quantitative differences are rather very marked and perhaps very important to differentiate various strata in the same basin. The already known species recovered from the present assemblage have been listed here whereas the new species are described in detail.

*Leiotriletes* sp.  
cf. *Concavisporites bankolensis* Bharad. & Salujha  
*Eupunctisporites gravis* Bharad. & Salujha

*Calamospora aplata* Bharad. & Salujha  
*Calamospora exila* Bharad. & Salujha  
*Retusotriletes diversiformis* (B. & H.) Bharad.  
*Cyclogranisporites gondwanensis* Bharad. & Salujha  
*Cyclogranisporites optimus* Bharad. & Salujha  
*Lophotriletes rectus* Bharad. & Salujha  
cf. *Lophotriletes rarus* Bharad. & Salujha  
*Apiculatisporis weylandii* Bharad. & Salujha  
*Horriditriletes curvibaculosus* Bharad. & Salujha  
*Horriditriletes* sp. A  
*Cyclobaculisporites indicus* Bharad. & Salujha  
*Cyclobaculisporites minutus* Bharad. & Salujha  
*Microfoveolatispora* sp.  
*Indospora clara* Bharad.  
*Indospora macula* Bharad. & Salujha

- Indospora* sp.  
*Gondisporites* sp.  
*Latosporites colliensis* (B. & H.) Bharad.  
*Latosporites* sp.  
*Punctatosporites* sp.  
*Thymospora gondwanensis* Bharad. & Salujha  
*Densipollenites indicus* Bharad.  
*Densipollenites invisus* Bharad. & Salujha  
*Densipollenites* sp.  
*Striomonosaccites circularis* Bharad. & Salujha  
*Platysaccus* sp.  
*Cuneatisporites* sp.  
*Striatites notus* Bharad. & Salujha  
*Striatites rhombicus* Bharad. & Salujha  
*Striatites subtilis* Bharad. & Salujha  
*Striatites solitus* Bharad. & Salujha  
*Striatites communis* Bharad. & Salujha  
*Verticipollenites finitimus* Bharad. & Salujha  
*Verticipollenites subcircularis* Bharad. & Salujha  
*Verticipollenites gibbosus* Bharad.  
*Lahirites singularis* Bharad. & Salujha  
*Lahirites incertus* Bharad. & Salujha  
*Lahirites parvus* Bharad. & Salujha  
*Hindipollenites oblongus* Bharad. & Salujha  
*Lunatisporites fuscus* Bharad.  
*Lunatisporites* sp. A  
*Lunatisporites* sp. B  
*Striatopodocarpites decorus* Bharad. & Salujha  
*Striatopodocarpites magnificus* Bharad. & Salujha  
*Faunipollenites varius* Bharad.  
*Faunipollenites* sp. A  
*Striapollenites saccatus* Bharad.  
*Striapollenites obliquus* Bharad. & Salujha  
*Striapollenites* sp.  
*Sulcatisporites ovatus* (B. & H.) Bharad.  
*Sulcatisporites* sp. A  
*Sulcatisporites* sp. B  
*Welwitschiapites tenuis* Bharad. & Salujha  
*Welwitschiapites extansus* Bharad. & Salujha  
 cf. *Gnetaceapollenites* sp.  
*Decussatisporites lucifer* Bharad. & Salujha

The new species are not included in the above list. They are systematically classified and described below. They are arranged according to the artificial system of classification put forward by Potonié & Kremp (1954) and subsequently elaborated by Potonié (1956, 1958, 1960).

**Anteturma — Sporites H. Pot. 1893**  
**Turma — Triletes (Reinsch) Pot. & Kr. 1954**  
**Subturma — Azonotriletes Luber 1935**  
**Infraturma — Laevigati (B. & K.) Pot. 1956**

*Calamospora* S.W. & B. 1944

*Calamospora rotata* sp. nov.

Pl. 1, Figs. 1-4

*Holotype* — Pl. 1, Fig. 1.

*Diagnosis* — Circular, 28-40  $\mu$ . Y-mark distinct, rays  $\frac{1}{2}$ - $\frac{2}{3}$  radius long, exine laevigate.

*Description* — Yellow, circular miospores, holotype 32  $\mu$ . Trilete mark clearly discernible, rays  $\frac{1}{2}$ - $\frac{2}{3}$  radius long, ray ends usually blunt, rarely pointed; exine and *extrema-lineamenta* smooth.

*Comparison* — *Calamospora aplata* is bigger in size with an infrapunctate exine. *C. exila* is also bigger in size and has a dark brown central body.

Almost similar specimens referred as *Calamospora* sp. have been illustrated by Bharadwaj & Salujha (1965 b; PL. 1, FIGS. 6-7). They may also belong to the present species.

**Infraturma — Apiculati (B. & K.) Pot. 1956**

*Cyclogranisporites* Pot. & Kr. 1954

*Cyclogranisporites* sp.

Pl. 1, Fig. 5

*Description* — Golden yellow, circular miospores, size  $\pm 62 \mu$ . Trilete mark clearly seen, rays  $\frac{1}{2}$ - $\frac{2}{3}$  radius long. Exine ornamented with  $\pm 1 \mu$  broad grana; grana closely set usually cohering to give a pseudoreticulate appearance; about 75 grana seen at the margin.

*Comparison* — *Cyclogranisporites gondwanensis* is much smaller in size and the Y-rays are  $\frac{3}{4}$  the radius or more long. *C. optimus*, though measuring as much as the present specimen differs in having an indistinct trilete mark and loosely arranged grana.

**Apiculatisporis Pot. & Kr. 1956**

*Apiculatisporis grandis* sp. nov.

Pl. 1, Figs. 6-8

*Holotype* — Pl. 1, Fig. 6.

*Diagnosis* — Circular, 50-60  $\mu$ . Y-mark distinct, rays  $\frac{1}{2}$ - $\frac{3}{4}$  radius long; exine ornamented with 1.5-3  $\mu$  long and  $\pm 1.5 \mu$  broad coni.

*Description* — Golden yellow, circular to subcircular miospores, holotype 50  $\mu$ . Trilete mark clearly seen, rays  $\frac{1}{2}$ – $\frac{3}{4}$  radius length, ray-ends usually pointed. Exine bearing closely spaced coni; coni 1.5–3  $\mu$  long and  $\pm$  1.5  $\mu$  broad (at the base). 40–50 coni seen on the periphery.

*Comparison* — *Apiculatisporis levis* B. & H., is smaller in size, has very sparsely set coni and the Y-rays almost reaching the periphery of the spore. *A. weylandii* Bharad. & Salujha, has an indistinct trilete mark and exine is covered with sparsely set, longer than broad coni.

*Apiculatisporis inconspicuus* sp. nov.

Pl. 1, Figs. 9–12

*Holotype* — Pl. 1, Fig. 9.

*Diagnosis* — Circular to subcircular, 16–28  $\mu$ . Y-mark faintly seen, rays  $3/4$  radius or more long. Exine beset with  $\pm$  1  $\mu$  long and equally broad coni.

*Description* — Yellow coloured, circular to subcircular miospores, holotype 22  $\mu$ . Trilete mark present but hardly seen, its rays being  $3/4$  the radius or more long. Exine covered with  $\pm$  1  $\mu$  long and equally broad (at the base) coni; 8–12 coni observed on the *extrema-lineamenta*.

*Comparison* — *Apiculatisporis levis* B. & H., is bigger in size, has sparsely set coni and a very clear trilete mark. *A. grandis* differs in being bigger in size and in having bigger coni. *A. weylandii* Bharad. & Salujha, is also bigger in size and has an indistinct trilete mark. The present species distinguishes in being smallest in size, in having a faintly discernible trilete mark and comparatively smaller coni.

*Lophotriletes* (Naum.) Pot. & Kr. 1954

*Lophotriletes minimus* sp. nov.

Pl. 1, Fig. 13–14

*Holotype* — Pl. 1, Fig. 13.

*Diagnosis* — Triangular, 26–34  $\mu$ . Y-mark distinct, rays almost reaching the periphery; exine beset with small  $\pm$  1  $\mu$  long and equally broad coni.

*Description* — Golden yellow, triangular to roundly triangular miospores, holotype 30  $\mu$ . Y-mark prominently seen, rays appearing slightly wavy, as long as the spore radius. Exine ornamented with coni; coni  $\pm$  1  $\mu$  long and equally broad; 50–60 of them counted at the *extrema-lineamenta*.

*Comparison* — *Lophotriletes rectus* has comparatively bigger and sparsely arranged coni. cf. *L. rarus* differs in having distinct inter-radial area.

*Cyclobaculisporites* Bharad. 1955

*Cyclobaculisporites bharadwajii* sp. nov.

Pl. 1, Fig. 15–18

*Holotype* — Pl. 1, Fig. 15.

*Diagnosis* — Circular, 58–90  $\mu$ , Y-mark faintly seen; rays  $\frac{1}{2}$ – $\frac{3}{4}$  radius long. Exine covered with round headed, irregular sized bacula.

*Description* — Golden yellow, circular miospores; holotype 78  $\mu$ . Trilete mark faintly discernible due to irregular size of the bacula which sometimes fuse to give a pseudoreticulate appearance; Y-arms  $\frac{1}{2}$ – $\frac{3}{4}$  radius long. Bacula usually 2–4  $\mu$  long and 1.5–2  $\mu$  broad, with rounded heads, some of them bend back to look like hooks at the margin; 60–75 bacula can be counted on the *extrema-lineamenta*.

*Comparison* — *Cyclobaculisporites indicus* has smaller, closely set bacula and a hardly perceptible trilete mark. *C. minutus* has very small bacula with a clearly seen Y-mark. The present species distinguishes in having bigger, sparse but irregular sized bacula with an hardly discernible Y-mark.

**Turma — Monoletes Ibr. 1933**

**Subturma — Azonomoletes Luber 1935**

**Infraturma — Laevigatomonoleti Dybova and Jachowitz 1957**

*Latosporites* Pot. & Kr. 1954

*Latosporites striatus* sp. nov.

Pl. 1, Fig. 19

*Holotype* — Bharadwaj & Salujha 1964; Pl. 3, Fig. 64.

*Diagnosis* — Oval to subcircular, longer axis 96–120  $\mu$ . Monolete mark  $\frac{1}{2}$ – $\frac{3}{4}$  spore length; exine laevigate with 4–6 striations parallel to monolete mark.

*Description* — Golden yellow, oval to subcircular miospores; holotype 120  $\mu$ . Monolete mark clearly seen, being  $\frac{1}{2}$ – $\frac{3}{4}$  the spore length. Exine smooth, proximally bearing 4–6 striations running parallel to the monolete mark.

*Comparison* — The present species differs from the earlier described species of *Latosporites*, *L. colliensis* in bearing striations on

its exine. Bharadwaj has illustrated one specimen (1962, PL. 4, FIG. 74) as *Latosporites* sp., which may be referred to the present species.

**Anteturma** — *Pollenites* Pot. 1931  
**Turma** — *Saccites* Erdt. 1947  
**Subturma** — *Disaccites* Cookson 1947  
**Infraturma** — *Podocarpoiditi* Pot. Thoms. & Thierg. 1950

***Cuneatisporites* Lesch. 1955**

*Cuneatisporites exiguus* sp. nov.

Pl. 1, Figs. 20-21

*Holotype* — Pl. 1, Fig. 20.

*Diagnosis* — Overall size 105-122  $\mu$ . Central body vertically oval, marginal ridge thin; exine finely intramicroreticulate. Bladders hemispherical, intrareticulation medium sized; distal sulcus 16-24  $\mu$  broad.

*Description* — Golden yellow, bisaccate, bilateral pollen grains, holotype 120  $\mu$ . Central body vertically oval, 44-60  $\mu \times$  78-86  $\mu$ , with a thin  $\pm$  2  $\mu$  wide marginal ridge all round; exine finely intramicroreticulate without any striations on it. Bladders hemispherical with mostly medium sized meshwork, attaching distally leaving a 16-24  $\mu$ , wide, thin bladder free area.

*Comparison* — This is the first species of *Cuneatisporites* being described from the Permian of India. It distinguishes in having a vertically oval central body with a thin marginal ridge all round, medium sized meshwork of the bladders and 16-24  $\mu$  broad sulcus distally.

**Infraturma** — *Striatiti* (Pant) Bharad. 1962

***Lahirites* Bharad. 1962**

*Lahirites kajorensis* sp. nov.

Pl. 2, Figs. 22-25

*Holotype* — Pl. 2, Fig. 22.

*Diagnosis* — Overall size 58-78  $\mu$ . Central body circular to subcircular with a broad marginal ridge, bigger than the bladders in height; exine uniformly intrapunctate, bearing 6-8 horizontal striations proximally, vertical partitions absent. Bladders subspherical with small to medium sized intrareticulation, distal sulcus 12-16  $\mu$  broad.

*Description* — Golden yellow, bisaccate, bilateral pollen grains, holotype 74  $\mu$ . Central body circular to subcircular, 32-44  $\mu \times$  24-40  $\mu$  with a 2-3  $\mu$  broad marginal ridge; bigger

than the bladders in vertical height; exine coarsely but uniformly intrapunctate, proximally bearing 6-8 horizontal striations without any vertical connectives. Bladders subspherical, attached laterally and distally leaving a 12-16  $\mu$  wide, thin bladder free area; bladder intrareticulation small to medium sized.

*Comparison* — All the known species of *Lahirites* are *diploxylooid* in nature, i.e. the central body is smaller in vertical height than the bladders. The present species distinguishes in being haploxylooid with very small bladders, central body with a thick marginal ridge, proximally bearing 6-8 horizontal striations without any vertical connectives. Samoilovich (1961) has referred an apparently similar specimen (PL. 4, FIGS. 1 a & b) to *Protodiploxylinus bullaeformis* which has been transferred to *Striatosaccites bullaeformis* by Jizba (1962). In the description of this species she gives the exine ornamentation to be finely reticulate, a character which differentiates these from the specimens illustrated here. Hart has also illustrated two specimens (1960, PL. 1, FIGS. 3 & 4) under disaccate '*Striatiti*' type which may probably belong to the present species.

***Lunatisporites* (Lesch.) Bharad. 1962**

*Lunatisporites sellingsii* sp. nov.

Pl. 2, Figs. 26-29

*Holotype* — Pl. 2, Fig. 26.

*Diagnosis* — Overall size 94-110  $\mu$ ; central body thin, circular to subcircular, marginal ridge thick, exine intramicroreticulate with 6-9 horizontal striations. Bladders subspherical, intrareticulation medium sized, sulcus 11-16  $\mu$  broad distally.

*Description* — Golden yellow, bisaccate, bilateral pollen grains, holotype 100  $\mu$ . Central body circular to subcircular, 44-52  $\mu \times$  44-54  $\mu$ ; marginal ridge 3-5  $\mu$  thick; exine intramicroreticulate, proximally bearing 6-9 horizontal striations without any vertical partitions in between them. Bladders subspherical with medium sized intrareticulation, attaching distally leaving a 11-16  $\mu$  wide, bladder free area.

*Comparison* — *Lunatisporites fuscus*, the genotype, has a vertically oval central body with two bladder ledges at the lateral sides. *L. latisulcatus* Bharad. & Salujha, also has a vertically oval central body and the widest

(25-35  $\mu$ ) bladder free area distally. *L. sp. A* has a boat-shaped sulcus. The present species distinguishes in having a circular to subcircular central body with a thick marginal ridge and a narrower (11-16  $\mu$ ) bladder free area distally.

**Faunipollenites Bharad. 1962**

*Faunipollenites minor* sp. nov.

Pl. 2, Figs. 30-32

*Holotype* — Pl. 2, Fig. 30.

*Diagnosis* — Overall size 36-62  $\mu$ . Central body indistinct, exine intramicroreticulate, 5-7 horizontal striations; distal sulcus 8-12  $\mu$  broad, bladder intrareticulation small sized.

*Description* — Yellow, bisaccate, bilateral pollen grains, holotype 46  $\mu$ . Central body vertically oval, outline indistinct made out by striation ends; exine intramicroreticulate, proximally bearing 5-7 horizontal striations without any vertical partitions in between them. Bladders hemispherical with small sized meshwork, attaching distally leaving a 8-12  $\mu$  wide bladder free, thin area.

*Comparison* — *Faunipollenites varius*, the genotype, and *F. sp. A*, are much bigger in size and have a very wide bladder free area distally. The present species distinguishes in being smallest in size and in having a narrower bladder free area distally.

**Infraturma—Disaccitrileti (Lesch.) Pot. 1958**

**Vesicaspora (Schemel) Wilson & Venk. 1963**

*Vesicaspora luteus* sp. nov.

Pl. 2, Figs. 33-35

*Holotype* — Pl. 2, Fig. 33.

*Diagnosis* — Overall size 56-80  $\mu$ . Central body broadly oval to subcircular, marginal ridge distinct but thin, seen all round; bladder oval, intrareticulation medium sized, distal sulcus 20-38  $\mu$  broad.

*Description* — Golden yellow pollen grains, holotype 80  $\mu$ . Central body broadly oval to subcircular, 36-50  $\mu \times 34-48 \mu$ ; exine finely intragranulose. Bladder oval with 2-4  $\mu$  wide lateral attachment; distal sulcus 20-38  $\mu$  broad and medium sized bladder intrareticulation.

*Comparison* — Bharadwaj has illustrated two apparently similar specimens (1962, PL. 20, Figs. 260, 261) as *Vesicaspora* sp. which may belong to the present species. Other specimens illustrated and referred to

*Vesicaspora* sp. by Bharadwaj (PL. 21, Figs. 265-269) appear to be different because of the vertically oval shape of the central body and a comparatively narrower bladder free area distally.

*Vesicaspora* sp.

Pl. 2, Fig. 36

*Description* — Golden yellow pollen grains. Overall size  $\pm 150 \mu$ . Central body vertically oval,  $\pm 90 \times 114 \mu$ ; exine coarsely intragranulose; bladder oval, 3-5  $\mu$  wide at the lateral sides; distal sulcus  $\pm 70 \mu$  wide; bladder intrareticulation big sized.

*Comparison* — The specimen illustrated here distinguishes in being bigger in size, coarse intragranulation on the body exine and a very wide bladder free area distally.

**Turma — Monocolpates Iverson & Troels-Smith 1950**

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

**Decussatisporites**

*Decussatisporites* sp.

Pl. 1, Fig. 37

*Description* — Golden yellow, oval pollen grains; size  $\pm 38 \times 80 \mu$ . Exine bearing  $\pm 10$  striations on one side and  $\pm 7$  striations on the other side running perpendicular to each other.

*Comparison* — *Decussatisporites lucifer* Bharad. & Salujha, is smaller in size, subcircular in shape and the striations are comparatively closely spaced. Wilson has illustrated a similar specimen (1962, PL. 3, FIG. 10) under *Vittatina* sp.

**MIOFLORAL DISTRIBUTION**

The spore flora of the Upper Kajora seam at the Jaipuria Kajora colliery consists of 32 genera and 72 species.

*Leiotriletes* is represented by a single species, *L. sp.* and has the average distribution percentage of 1.3 per cent.

cf. *Concavisporites* is rather poor in its distribution. Its occurrence averages to 0.4 per cent and the species met with is cf. *C. bankolensis*.

*Eupunctisporites* has the average frequency of 0.36 per cent and is represented by only one species, *E. gravis*.

*Calamospora* as *C. aplata*, *C. exila* and *C. rotata* are met with as rare and scattered

specimens. The genus averages in its distribution to 0.88 per cent.

*Cyclogranisporites* has the average frequency of 8.0 per cent and is represented by 3 species:

- Cyclogranisporites gondwanensis*
- C. optimus*
- C. sp.*

*C. gondwanensis* is abundantly represented as compared to the other two species and thus constitutes bulk of the percentage.

*Lophotriletes* is represented by 3 species:

- Lophotriletes rectus*
- L. minimus*
- cf. *L. rarus*.

Out of these the first species is comparatively richly represented than the other two. The total frequency of the genus is 2.05 per cent.

*Apiculatisporis* is fairly represented with an average distribution percentage of 1.88 per cent. The species of the genus represented here are:

- Apiculatisporis grandis*
- A. inconspicuus*.

The later species, *A. inconspicuus* is comparatively richly represented than the former.

*Horriditriletes* has the average distribution percentage of 16.9 per cent. The species of the genus met with here are:

- Horriditriletes curvibaculosus*
- H. brevis*
- H. sp.*

Out of these species *H. curvibaculosus* and *H. brevis* constitute bulk of the average percentage. *H. sp.* is recorded as stray specimens.

*Cyclobaculisporites* averages to 3.5 per cent in its distribution and is represented by as many as 3 species which are:

- Cyclobaculisporites indicus*
- C. minutus*
- C. bharadwajii*.

Here all the three species are almost equally distributed.

*Microfoveolatispora* is rather poorly represented. It has the average distribution percentage of 0.45 per cent and is represented by 2 species:

- Microfoveolatispora trisina*
- M. directa*

*Indospora* ranges in its frequency from 3.0 per cent to 5.5 per cent. The genus is represented by three species:

- Indospora clara*
- I. laevigata*
- I. macula*.

All the species are almost equally distributed throughout the seam.

*Gondisporites* is met with as stray specimens and has the average distribution of 0.16 per cent. It is represented by only a single species *G. sp.*

*Latosporites* is fairly represented with an average percentage of 1.26 per cent. It is almost uniformly represented throughout the vertical height of the seam. The genus is represented by 2 species here:

- Latosporites collicensis*
- L. striatus*

*Latosporites striatus* is comparatively poorer in occurrence.

*Punctatosporites* averages to 1.6 per cent in its distribution. Only one species of the genus, *P. sp.* has been recorded here.

*Thymospora* is represented in the form of a single species *T. gondwanensis*. It has the average frequency of 3.48 per cent.

*Densipollenites* averages in its occurrence to 1.01 per cent and is represented by 3 species:

- Densipollenites indicus*
- D. invisus*
- D. sp.*

All these species are almost uniformly represented along the whole of vertical height of the seam.

*Striomonosaccites*, represented by a single species *S. circularis*, is very poorly encountered and has the average frequency of 1.0 per cent.

*Cuneatisporites* has the average frequency of 0.5 per cent and is represented by a single species, *C. exiguus*.

*Striatites* has the average percentage of 6.2 per cent and is represented by 5 species which are listed below:

- Striatites notus*
- S. rhombicus*
- S. subtilis*
- S. solitus*
- S. communis*.

*Striatites notus*, *S. rhombicus* and *S. communis* are comparatively richly represented than the remaining species.

*Verticypollenites* ranges in its distribution from 1.0 to 3.0 per cent. Here the following 3 species are recorded:

- Verticypollenites finitimus*
- V. subcircularis*
- V. gibbosus*

All the above listed species are almost uniformly represented in the various samples of the seam.

*Lahirites* has the average distribution percentage of 2.95 per cent. Here the genus is represented by 4 species:

- Lahirites singularis*
- L. incertus*
- L. parvus*
- L. kajorensis*

Bulk of the percentage is constituted by first two species, i.e. *L. singularis* and *L. incertus*.

*Hindipollenites* is very poorly represented, the average frequency being 0.45 per cent. Only one species of the genus *H. oblongus* is recorded here.

*Lunatisporites* has the average distribution percentage of 2.25 per cent and is represented by the following species:

- Lunatisporites fuscus*
- L. sellingii*
- L. sp. A*
- L. sp. B*

Out of these species *L. sellingii*, *L. sp. A* and *L. sp. B* form the bulk of the percentage.

*Striatopodocarpites* has the distribution percentage as 11.21 per cent and is represented by 2 species:

- Striatopodocarpites decorus*
- S. magnificus*

Both the species are almost uniformly represented throughout the seam.

*Faunipollenites* dominates all the bisaccate forms in its distribution which is 16.9 per cent. The following 3 species of the genus are recorded:

- Faunipollenites varius*
- F. minor*
- F. sp. A*

Out of these species *F. varius* and *F. sp. A* are abundantly and almost uniformly distributed whereas the remaining species *F. minor* is rather poorly represented.

*Striapollenites* is poorly represented and constitutes only 0.63 per cent of the present spore assemblage. The species of the genus recorded here are:

- Striapollenites saccatus*
- S. obliquus*
- S. sp.*

*S. saccatus* and *S. obliquus* are comparatively richly represented than *S. sp.* for which only 1-2 specimens are recorded.

*Distriatites* is a very poorly represented genus and very few specimens of the genus scattered here and there are met with, the average percentage of the genus being 0.16 per cent. It is represented by a single species *D. pulcher*.

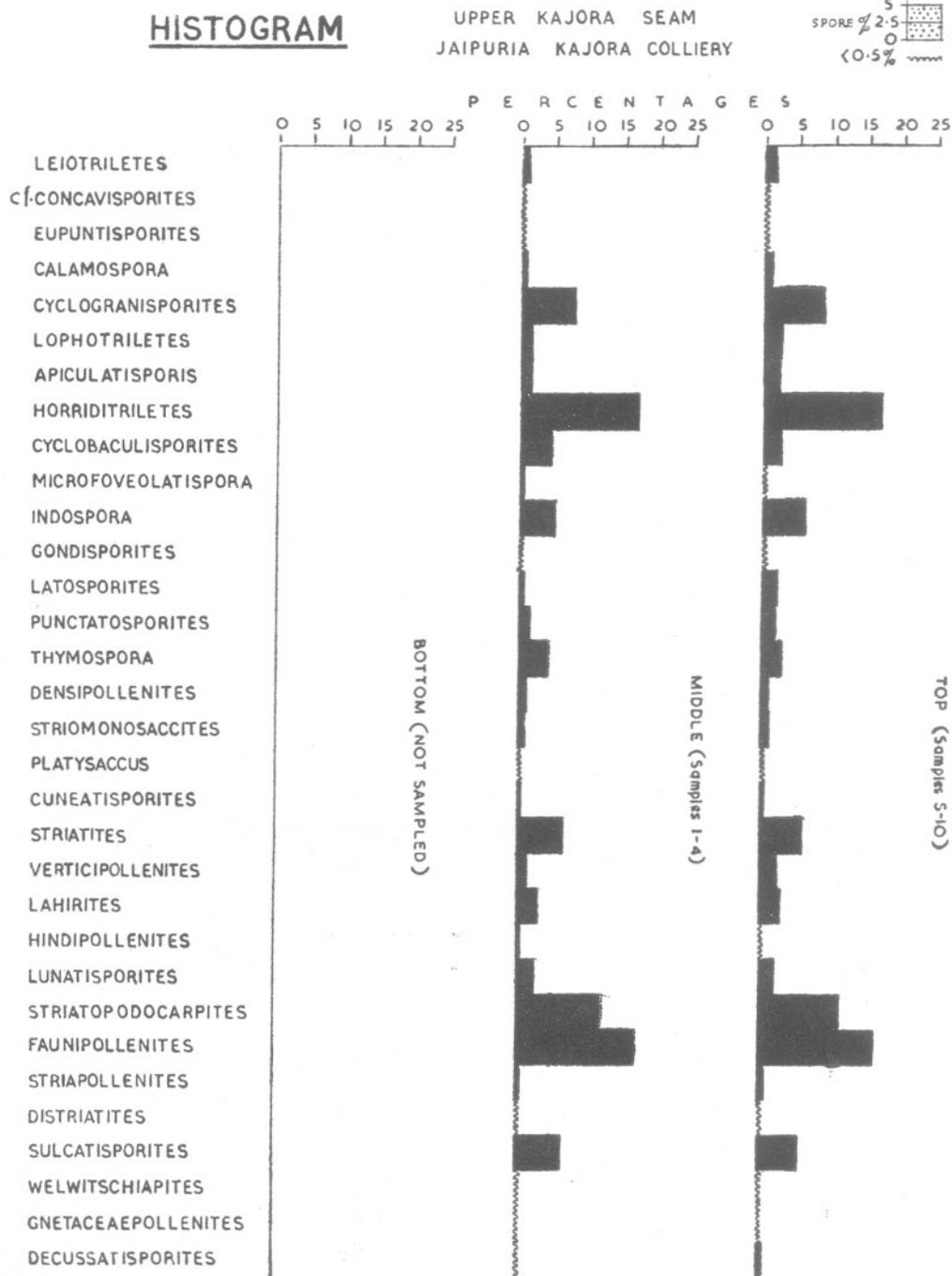
*Sulcatisporites* has the average percentage of 6.11 per cent and is met with as 3 species:

- Sulcatisporites ovatus*
- S. sp. A*
- S. sp. B*

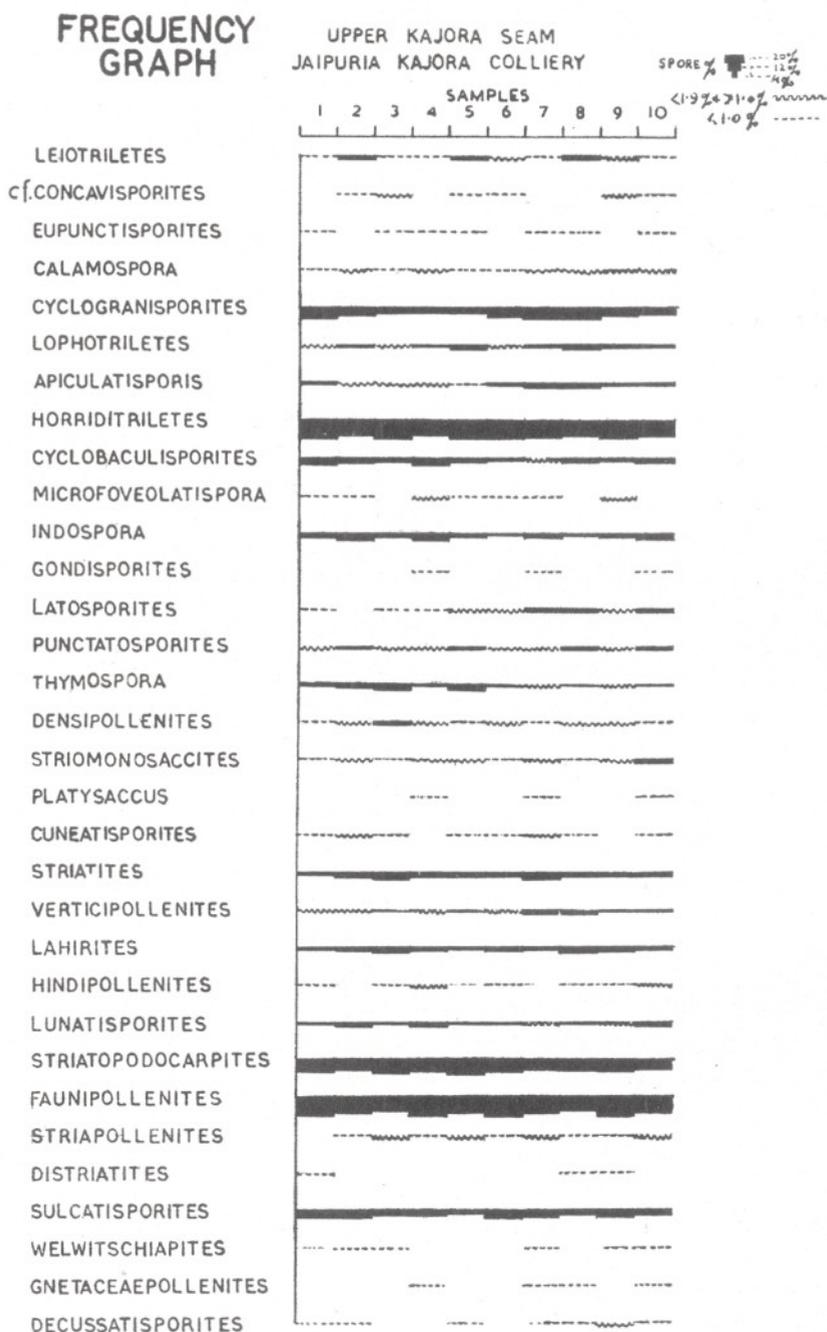
*S. ovatus* is abundantly represented as compared to the other two species and constitutes bulk of the total percentage of the genus.

TABLE 2

GENUS	BONBAHAL SEAM	JAMBAD BOWLAH SEAM	UPPER KAJORA SEAM
(1)	(2)	(3)	(4)
<i>Leiotriletes</i>	4.5	2.45	1.3
<i>Concavisporites</i>	+	0.1	0.4
<i>Eupunctisporites</i>	0.6	0.35	0.36
<i>Ricaspora</i>	—	+	—
<i>Punctatisporites</i>	0.13	—	—
<i>Calamospora</i>	0.23	0.37	0.88
<i>Retusotriletes</i>	0.02	+	+
<i>Cyclogranisporites</i>	3.8	7.66	8.0
<i>Verrucosisporites</i>	+	+	—
<i>Lophotriletes</i>	2.5	2.6	2.05
<i>Apiculatisporis</i>	0.1	—	1.88
<i>Horviditriletes</i>	16.2	14.22	16.9
<i>Cyclobaculisporites</i>	3.7	1.67	3.5
<i>Microfoveolatispora</i>	4.3	0.04	0.45
<i>Microbaculispora</i>	0.5	—	+
<i>Indospora</i>	4.8	2.7	5.5
<i>Dictyotriletes</i>	—	+	—
<i>Lycopodium-sporites</i>	0.16	0.02	+
<i>Gondisporites</i>	0.5	0.25	0.16
<i>Latosporites</i>	3.9	2.65	1.26
<i>Punctatosporites</i>	1.5	2.03	1.6
<i>Thymospora</i>	7.03	10.83	3.48
<i>Spinososporites</i>	0.03	—	—
<i>Nuskoisporites</i>	0.1	0.01	+
<i>Densipollenites</i>	1.3	2.0	1.01
<i>Striomonosaccites</i>	0.7	0.9	1.0
<i>Platysaccus</i>	0.1	+	0.16
<i>Cuneatisporites</i>	0.2	0.01	0.5
<i>Limitisporites</i>	0.3	—	—
<i>Striatites</i>	4.5	7.9	6.2
<i>Verticipollenites</i>	1.7	2.66	2.05
<i>Lahirites</i>	2.5	3.8	2.95
<i>Hindipollenites</i>	0.6	1.46	0.45
<i>Lunatisporites</i>	2.1	5.3	2.25
<i>Striatopodocarpites</i>	10.5	4.4	11.21
<i>Faunipollenites</i>	15.5	15.74	16.9
<i>Striapollenites</i>	0.5	0.5	0.63
<i>Distriatites</i>	+	0.04	0.16
<i>Sulcatisporites</i>	3.5	5.96	6.11
<i>Welwitschiapites</i>	0.7	0.7	0.25
<i>Gnetaceapollenites</i>	0.2	0.1	0.18
<i>Decussatisporites</i>	0.5	0.53	0.37



TEXT-FIG. 1 — Showing the frequency of various genera in each of the samples of the seam.



TEXT-FIG. 2 — Showing the average representation of various genera from top, middle and bottom sectors of the seam.

*Welwitschiapites* has the average frequency of 0.25 per cent and is represented by two species:

*Welwitschiapites tenuis*  
*W. extansus*

*W. tenuis* is comparatively more frequently encountered than *W. extansus*.

*Gnetaceapollenites* is very poorly represented with a meagre percentage of 0.18 per cent. The specimens referable to this genus have been put as *G. sp.*

*Decussatisporites* is represented by two species *D. lucifer* and *D. sp.*, with an average distribution percentage of 0.37 per cent.

The sample to sample distribution of the various genera represented in the seam is shown in the frequency chart (TEXT-FIG. 1) and the average frequencies of the different genera from the top, middle and bottom sectors have been plotted in a histogram (TEXT-FIG. 2).

#### Comparison with Jambad Bowlah and Bonbahal Seams

A thorough and detailed sporological study of the Upper Kajora, Jambad Bowlah and Bonbahal seams shows that they differ from each other both qualitatively as well as quantitatively. The qualitative differences are not as marked as the quantitative differences. Qualitative differences occur in the rare and very rare genera and species in a way that some of them may be present in one seam and absent in the other and vice versa. Such genera show a meagre representation and sometimes they are not encountered in the countings. The

differences in the relative percentage of various genera and species presented in the different seams are quite significant to show up their differential nature. The qualitative and quantitative representation of the various genera in all the seams studied has been shown in Table 2.

In the above table (—) denotes total absence and (+) denotes presence but not encountered in the countings.

In the above table it is observed that both qualitative as well as quantitative differences occur in the miospore assemblage of all the 3 seams under comparison. Qualitatively there are some genera which are present in one seam and absent in the other two whereas some others are present in two of the above seams and absent in the third. Such qualitatively important genera are:

*Ricaspora*  
*Punctatisporites*  
*Verrucosisporites*  
*Apiculatisporis*  
*Microbaculispora*  
*Dictyotriletes*  
*Spinosisporites*  
*Limitisporites*

In addition to the above genera there are some other genera which show a significant difference in their average frequencies in Bonbahal, Jambad Bowlah and Upper Kajora seams. Such differences among the various genera may either be in all the seams studied or at least in two of them. The genera showing marked quantitative differences are:

*Leiotriletes*  
*Cyclogranisporites*

TABLE 3

UPPER KAJORA SEAM	JAMBAD BOWLAH SEAM	BONBAHAL SEAM
<i>Calamospora rotata</i>	<i>Ricaspora granulata</i>	<i>Punctatisporites priscus</i>
<i>Apiculatisporis grandis</i>	<i>Calamospora exila</i>	<i>Cyclogranisporites optimus</i>
<i>Apiculatisporis inconspicuus</i>	cf. <i>Lophotriletes pseudogranus</i>	<i>Verrucosisporites diversus</i>
<i>Lophotriletes minimus</i>	<i>Dictyotriletes invisus</i>	<i>Apiculatisporis weylandii</i>
<i>Cyclobaculisporites bhara dwajii</i>	cf. <i>Nuskoisporites triangularis</i>	<i>Horriditriletes elegans</i>
<i>Latosporites striatus</i>	<i>Distriomonosaccites ovalis</i>	<i>Horriditriletes splendidus</i>
<i>Cuneatisporites exiguus</i>	<i>Lahirites rarus</i>	cf. <i>Anapiculatisporis longispinosus</i>
<i>Lahirites kajorensis</i>	<i>Hindipollenites oblongus</i>	<i>Cyclobaculisporites proprius</i>
<i>Lunatisporites selligii</i>	<i>Striatopodocarpites diffusus</i>	<i>Limitisporites disectus</i>
<i>Faunipollenites minor</i>		<i>Lahirites lepidus</i>
<i>Vesicaspora luteus</i>		<i>Lunatisporites latisulcatus</i>
		<i>Striatopodocarpites venustus</i>
		<i>Faunipollenites copiosus</i>
		<i>Faunipollenites perexiguus</i>

*Cyclobaculisporites*  
*Microfoveolatispora*  
*Latosporites*  
*Thymospora*  
*Hindipollenites*  
*Lunatisporites*  
*Striatopodocarpites*  
*Sulcatisporites*  
*Welwitschiapites*

It is not only the genera that show qualitative and quantitative differences, species also show distinct qualitative differences among the various seams. There are some of the species which are present in Upper Kajora seam and absent in the others, while some others are restricted to the Jambad Bowlah seam only and still another set of species is met within the Bonbahal seam and not in the other two seams. The species that are present and restricted to each of the

Upper Kajora, Jambad Bowlah and Bonbahal seams are shown in Table 3.

If not all, at least some of the species present in each of the seams are likely to constitute the association of index species for individual seam under study.

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#### EXPLANATION OF PLATES

(All magnifications × 500)

##### PLATE 1

- 1-4. *Calamospora rotata* sp. nov. Ph. Nos. 381/21, 381/26, 382/19, 382/9.
5. *Cyclogranisporites* sp. Ph. No. 351/7.
- 6-8. *Apiculatisporis grandis* sp. nov. Ph. Nos. 381/5, 383/3, 282/13.
- 9-12. *Apiculatisporis inconspicuus* sp. nov. Ph. Nos. 351/4, 381/22, 382/7, 382/37.
- 13-14. *Lophotriletes minimus* sp. nov. Ph. Nos. 351/2, 381/2.
- 15-18. *Cyclobaculisporites bharadwajii* sp. nov. Ph. Nos. 237/16, 236/16, 381/14, 351/12.
19. *Latosporites striatus* sp. nov. Ph. No. 382/30.

20-21. *Cuneatisporites exiguus* sp. nov. Ph. Nos. 237/21, 236/15.

##### PLATE 2

- 22-25. *Lahiritites kajorensis* sp. nov. Ph. Nos. 383/12, 351/15, 382/8, 383/7.
- 26-29. *Lunatisporites selligii* sp. nov. Ph. Nos. 237/29, 239/3, 43/21, 236/23.
- 30-32. *Faunipollenites minor* sp. nov. Ph. Nos. 381/16, 381/4, 381/8.
- 33-35. *Vesicaspora luteus* sp. nov. Ph. Nos. 238/3, 381/19, 381/17.
36. *Vesicaspora* sp. Ph. No. 236/4.
37. *Decussatisporites* sp. Ph. No. 240/27.

