

Megaspore assemblage from Pench Valley Coalfield, Madhya Pradesh, India

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The carbonaceous shale samples of Barakar Formation (Lower Gondwana) collected from different collieries of Rawanwara area of Pench Valley Coalfield, Satpura Gondwana Basin have yielded a well preserved megaspore assemblage. Morphological and structural studies of megaspores under dry and wet conditions with controlled maceration revealed the presence of following megaspores: *Barakarella pantii*, *Banksisporites utkalensis*, *Bokarosporites rotundus*, *Duosporites congoensis*, *Duosporites multipunctatus*, *Talchirella trivedii* and *Singhisporites radialis*. The distribution of megaspores in the Barakar Formation is discussed in relation to structural features.

Key-words—Megaspore, Pench Valley, Satpura Gondwana Basin, Permian

INTRODUCTION

PENCH Valley Coalfield of Satpura Gondwana Basin is a major coal producing area of the Central India. The Coalfield is situated about 30 km north-

west of Chhindwara district (22° 03' : 79° 56') and lies between latitudes 22°09' and 22°14' and longitudes 78°21' and 78° 55'. The following geological sequence is known in the area (Raja Rao 1983):

Age	Formation	Lithology (Thickness)
Recent		Alluvium
Upper Cretaceous To Eocene	Deccan Traps basic flows, dykes & sills	Basalt
Upper Cretaceous	Lameta	Conglomerate, limestones and clays.
Lower Cretaceous	Jabalpur	Massive sandstones with jasper conglomerates, white clays, red clays, carbonaceous shales and coal lenses (50 m to 100 m)
-----Unconformity-----		
Rhaetic (?)	Bagra	Predominantly coarse conglomerates with bands of calcareous sandstones, variegated clays, limestone and dolomite (180 m to 240 m)
-----Unconformity-----		
Upper part of Lower Triassic to Middle Triassic	Denwa	Soft variegated clays interbedded with sandstone bands, conglomerate at places (about 350 m)
Lower Triassic	Panchmarhi	White, coarse grained cross-bedded sandstones with lenses of sub-angular quartz pebbles (about 750 m)
Upper Permian	Bijori	Micaceous, flaggy sandstones and shales, at places micaceous (180 m to 250 m)
Lower Permian	Motur	Buff, green and variegated clays with coarse to very coarse grained sandstones (about 600 m).
	Barakar	Coarse to medium grained sandstones, shales, carbonaceous shales and coal seams (250 m to 450 m)
Upper Carboniferous (?)	Talchir	Diamictites, sandstones, grey and olive green needle shales, varves and rhythmites (about 490 m)
-----Unconformity-----		
Precambrian		Gneiss, schists, quartzites, limestones, etc.

Western Coalfields Limited has divided the Pench Valley Coalfield into different areas for the purpose of coal exploration. Four Barakar coal seams numbered as I, II, III and IV from top to bottom with frequent splitting of seams are exposed in different collieries. The samples collected from III and IV seams attaining a thickness of 2.5 to 4.0 metres in Rawanwara and Pench East areas are found to contain well preserved plant fossils of *Gangamopteris*, *Euryphyllum*, *Rubidgea*, *Glossopteris*, *Noeggerathiopsis*, *Buriadia*, *Samaropsis*, *Cordaicarpus*, scale leaves, *Vertebraria* and equisetalean – axes.

The carbonaceous shale samples have yielded a number of megaspores including some new forms (Srivastava & Tewari 2002a, b) The present assemblage represented by six genera and seven species indicates variety and richness of megaspores in Pench Valley Coalfield.

MATERIAL AND METHOD

The bulk maceration samples for the study of megaspores were collected from the carbonaceous shale bands exposed in open cast mines of Rawanwara, Pench East (Rawanwara Khas) and 14/15 incline mine of Rawanwara. The samples belong to nos. III and IV seams (lower) of Barakar Formation, Pench Valley Coalfield, Satpura Gondwana Basin.

For the recovery of megaspores approximately 10 gm of sample was treated with conc. HF for 10-15 days and after repeated washing with water, single megaspore was picked under binocular. Individual megaspore was photographed at this stage in dry condition for shape and exine ornamentation. Again each megaspore was treated with conc. HNO₃ with KClO₃ for 1-2 days. When the megaspore turned brown it was washed several times with water and treated with 2-5% KOH solution. Differential treatment in acid and alkali revealed the presence of mesosporium (inner body). The megaspores were photographed in dry and wet conditions to examine the external morphology and structural features of mesosporium.

All the slides and negatives of figured megaspores are preserved in the museum of Birbal Sahni Institute of Palaeobotany, Lucknow.

DESCRIPTION OF MEGASPORES

Barakarella pantii Lele & Srivastava 1983

Pl. 1, Figs. 1-3

Megaspores trilete, circular to subcircular in proximo-distal orientation, tri-radiate ridges straight to wavy, uniformly broad throughout, reaching almost up to the margin, ending up at contact ridges, faint in dry condition, well defined in macerated stage, exosporium baculate, baculae thin, slender, uniformly distributed, more prominent at margins; mesosporium thin, hyaline smooth, globular, semicircular with a number of cushions arranged in multiseriate rows trigonally along tri-radiate mark.

Dimension in (a) dry condition: Overall size 360 – 550 x 350 – 480 µm, size of tri-radiate ridges 130-250 x 20-25 µm, width of contact ridges 10-25 µm, size of baculae 5-20 x 5-30 µm. (b) *wet condition:* overall size: 600 x 500 µm, size of tri-radiate ridges 200-250 x 10-30 µm, width of contact ridges 10-25 µm, size of mesosporium 450-500 µm, diameter of cushions 10 µm.

Comparison - The megaspores are comparable with *Barakarella pantii* (Lele & Srivastava 1983) in exosporium and mesosporium characters.

Banksisporites utkalensis (Pant & Srivastava, 1961) Tewari & Maheshwari, 1992

Pl. 1, Figs. 8,9

Megaspores trilete, azonate, circular in proximo-distal orientation, tri-radiate ridges straight, more than ¾ spore radius long, tapering towards end, end up at distinct contact ridges, contact area prominent, exosporium granulate, mesosporium (inner body), distinct, spherical, hyaline, smooth, big, almost as large as spore radius, devoid of cushions.

Dimensions in (a) dry condition : overall size 450 x 400 µm, size of tri-radiate ridges 150-180 x 31-40 µm, width of contact ridges 20 µm, size of grana 5 x 5 µm. (b) *wet condition:* overall size 500 x 500 µm, size of tri-radiate ridges 180-200 x 30-40 µm, size of

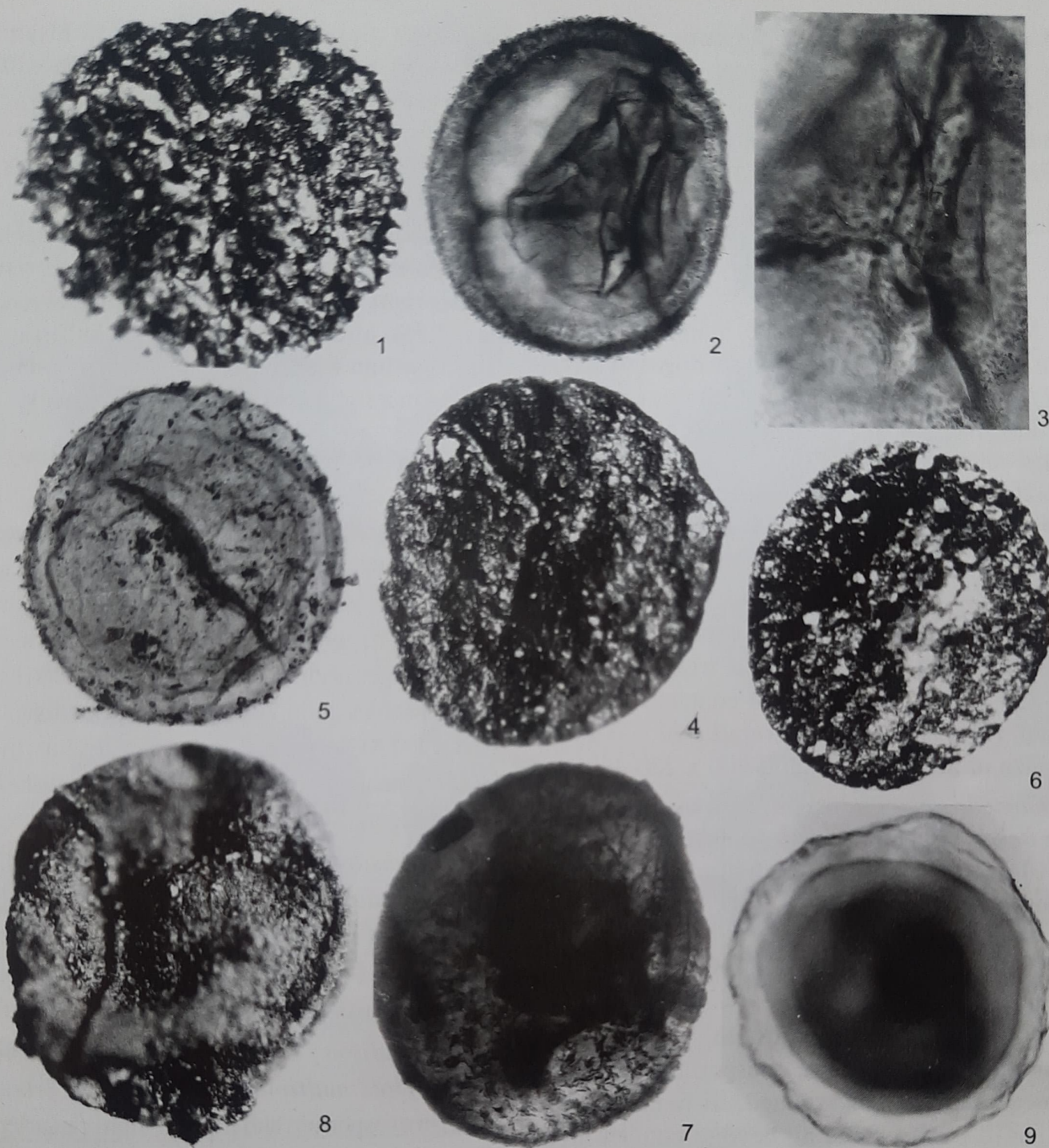


PLATE 1

Barakarella pantii Lele & Srivastava, 1983.

1. Megaspore in dry condition showing tri-radiate ridges and baculae on margins. x 100.
2. Same megaspore in wet condition showing exosporium, tri-radiate and arcuate ridges and mesosporium x 86. BSIP slide no. 12835.
3. Megaspore in fig. 2 enlarged to show numerous cushions arranged trigonally along triradiate mark. X 200.

Bokarosporites rotundus (Singh) Bharadwaj & Tiwari, 1970.

4. Megaspore in dry condition showing psilate exosporium and tri-radiate ridges. X91.

5. Megaspore of fig. 4 after maceration showing smooth exosporium and circular mesosporium. X 84. BSIP slide no. 12836.
6. Another megaspore in dry condition. X 100.
7. Same megaspore in wet condition showing smooth exosporium and circular mesosporium. X 120. BSIP slide no. 12837.

Banksisporites utkalensis (Pant & Srivastava, 1961) Tewari & Maheshwari, 1992

8. Megaspore in dry condition showing granulate exosporium and tri-radiate ridges. X 128.
9. Same megaspore after maceration showing exosporium and a small spherical mesosporium x 104. BSIP slide no. 12838.

grana 10 x 10 µm, size of mesosporium 450 x 450 µm.

Comparison - The megaspore is comparable with *Banksisporites utkalensis* (Tewari & Maheshwari 1992) in exosporium and mesosporium features.

Bokarosporites rotundus (Singh) Bharadwaj & Tiwari 1970
Pl. 1, Figs. 4-7

Megaspores trilete, azonate, more or less circular in proximo-distal view, tri-radiate ridges straight to wavy, up to $\frac{3}{4}$ spore radius long, ending up at contact ridges, contact area faintly marked, contact ridges almost merged with margin, exosporium psilate-scabrate. Differential maceration in conc. HNO₃ and KOH dissolves exosporium and reveals, thin, spherical, smooth, brownish mesosporium, devoid of cushions.

Dimensions in (a) dry condition - overall size 280 - 550 x 250 - 500 µm, size of tri-radiate ridges 150-250 x 10-30 µm, width of contact ridges 10-20 µm. (b) *wet condition*: overall size 570 x 450 µm, size of mesosporium 300-400 x 220-400 µm.

Comparison - The megaspores are comparable with *Bokarosporites rotundus* (Bharadwaj & Tiwari 1970) in laevigate exosporium and smooth mesosporium.

Duosporites congoensis Høeg, Bose & Manum 1955
Pl. 2, Figs. 1, 2

Megaspore trilete, azonate, triangular in proximo-distal orientation; exosporium verrucate; verrucae uniformly distributed, tri-radiate ridges straight, distinct extending beyond contact area, reaching up to margins, broad at ends; contact ridges well marked, contact area triangular, exosporium dissolves during differential maceration, measurement of exosporium were taken in wet condition before it dissolved, contact ridges indistinct in wet condition, mesosporium thin, semitriangular, hyaline with circular cushions arranged in a row along triradiate mark.

Dimensions in (a) dry condition - overall size 500 x 450 µm, size of triradiate ridges 150-180 x 10

µm, width of tri-radiate ridges at ends 12-15 µm, width of contact ridges 10 µm, size of verrucae 5-10 x 5-8 µm. (b) *wet condition*: overall size 500 x 450 µm, size of triradiate ridges 150-180 x 20-30 µm, size of verrucae 5 x 5 µm; width of contact ridges 140-150 x 120-130 µm, size of cushions 10 x 12-15 µm.

Comparison : The megaspore is comparable with *Duosporites congoensis* in triangular shape, verrucate exosporium, tri-radiate ridges extending beyond contact area and a subcircular to subtriangular mesosporium with one row of circular cushions arranged in a single row along tri-radiate mark.

Duosporites multipunctatus Høeg & Bose 1960
Pl. 2, Figs. 8, 9

Megaspores trilete, azonate, triangular in proximo-distal orientation, exosporium verrucate, verrucae uniformly distributed; tri-radiate ridges distinct, straight, extending beyond contact ridges up to the margins; contact ridges distinct, contact area triangular; exosporium dissolves during differential maceration in conc. HNO₃ and KOH; mesosporium thin, hyaline, triangular in shape with a number of small dark cushions arranged trigonally along tri-radiate mark.

Dimensions in (a) dry condition - overall size: 500 x 400 µm, size of triradiate ridges 120-150 x 10 µm, width of contact ridges 10 µm, width of verrucae 10 x 10 µm. (b) *wet condition*: size of mesosporium 220 x 220 µm, size of cushions 5-10 x 5-10 µm.

Comparison : The megaspore is comparable with *Duosporites multipunctatus* (Pant & Srivastava 1961) in exosporium and mesosporium characteristics. However, triangular mesosporium of present specimen has pointed angles. This may be due to folding of mesosporium from sides.

Talchirella trivedii (Pant & Srivastava) Bharadwaj & Tiwari, 1970
Pl. 2, Figs. 5-7

Megaspores trilete, azonate, subcircular in outline in proximo-distal view; tri-radiate ridges distinct, straight to curved, ending up at contact ridges, con-

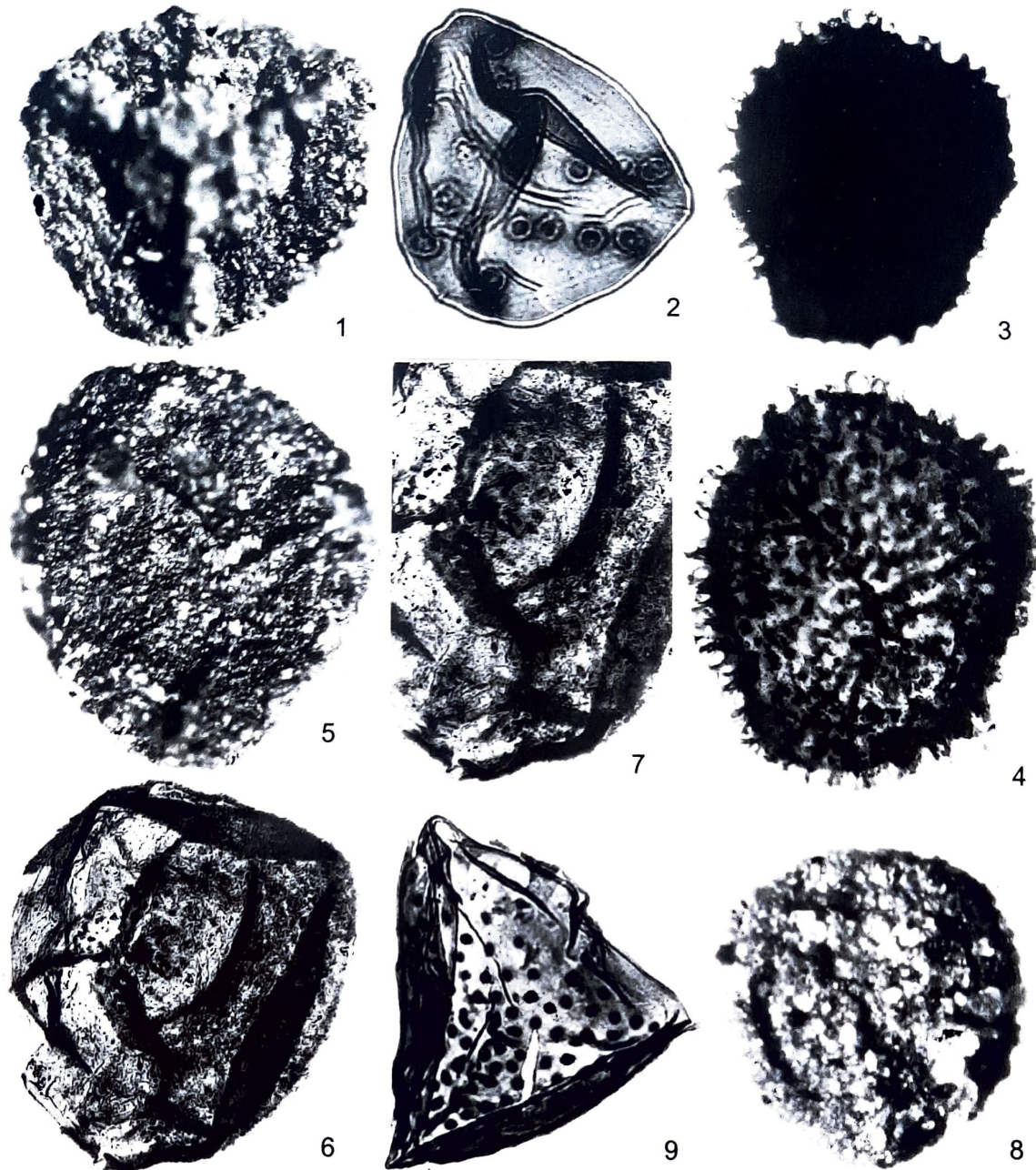


PLATE 2

Duosporites congoensis Høeg, Bose & Manum, 1955

1. Megaspore in dry condition showing triangular shape, verrucate exosporium and triradiate ridges extending beyond the contact area. X 100.
2. Mesosporium of same megaspore after maceration showing one row of cushions. x 300. BSIP slide no. 12839.

Singhisporites radialis Bharadwaj & Tiwari 1970

3. A megaspore in transmitted light showing furcate spines. x 83. BSIP slide no. 12841.
4. Same megaspore after differential maceration in acid and alkali, showing tri-radiate ridges, arcuate ridges and branched spines. x 113. BSIP slide no. 12841

Talchirella trivedii (Pant & Srivastava) Bharadwaj & Tiwari, 1970

5. Megaspore in dry condition showing verrucate exosporium and tri-radiate ridges. x 120.
6. Same megaspore in wet condition. X 102. BSIP slide no. 12840.
7. Megaspore shown in fig. 6 enlarged to show trigonally arranged cushions along triradiate mark. x 200. BSIP slide no. 12840.

Duosporites multipunctatus Høeg & Bose, 1960.

8. Megaspore in dry condition showing triangular shape, verrucate exosporium and triradiate ridges extending beyond arcuate ridges. x 97.
9. Triangular mesosporium of same megaspore after maceration showing a number of cushions arranged trigonally along tri-radiate mark. x 227. BSIP slide no. 12842.

tact ridges distinct, almost merged with margins; exosporium verrucate, verrucae uniformly distributed; differential maceration in conc. HNO_3 and KOH reveals thin, transparent almost circular mesosporium with numerous small circular cushions arranged trigonally along tri-radiate mark.

Dimensions in (a) dry condition : overall size $500 \times 350 \mu\text{m}$, size of triradiate ridges $150-180 \times 15-20 \mu\text{m}$, width of contact ridges $9-12 \mu\text{m}$, width of verrucae $5 \times 10-15 \mu\text{m}$. (b) *wet condition* : overall size $580 \times 500 \mu\text{m}$, size of tri-radiate ridges $250-300 \times 20 \mu\text{m}$, width of contact ridges $20 \mu\text{m}$, size of verrucae $10 \times 10 \mu\text{m}$, size of mesosporium $400 \times 350 \mu\text{m}$, size of cushions $5 \times 5-10 \mu\text{m}$.

Comparison : Megaspore resembles with *Talchirella trivedii* (Bharadwaj & Tewari 1970) in exosporium and mesosporium features.

Singhisporites radialis Bharadwaj & Tiwari 1970
Pl. 2, Figs. 3, 4

Megaspores trilete, azonate, subcircular in outline in proximo-distal orientation; triradiate ridges $\frac{3}{4}$ spore radius long, straight to wavy, ending up at contact ridges; contact area faint in dry condition, distinct in macerated condition, trilobed, exosporium spinate, spines simple and furcate, closely placed, more prominent at margins; mesosporium thin, indistinct, without cushions.

Dimensions in (a) dry condition - overall size $450 - 500 \times 400 - 550 \mu\text{m}$, size of triradiate ridges $140-200 \times 10-20 \mu\text{m}$, width of contact ridges $10-25 \mu\text{m}$, length of spines $10-25 \mu\text{m}$, width of spines at base $5 \times 25 \mu\text{m}$, width of spines at apex $2.5-10 \mu\text{m}$. (b) *wet condition* : overall size: $550-600 \times 450-600 \mu\text{m}$, size of triradiate ridges $200-280 \times 20 \mu\text{m}$, width of contact ridges $15-20 \mu\text{m}$; length of spines $40-60 \mu\text{m}$, width of spines at base $10 \times 20 \mu\text{m}$, width of spines at apex $5-10 \mu\text{m}$, size of mesosporium $400 \times 400 \mu\text{m}$.

Comparison - Megaspores resemble *Singhisporites radialis* (Bharadwaj & Tiwari 1970) in shape and exosporium characters. Mesosporium, however, is not very distinct in present specimens.

DISCUSSION

The megaspores in Gondwana sequence of India are known from almost all the horizons. However, it is interesting to note that Barakar Formation (Early Permian) of Lower Gondwana contains maximum number of genera and species and as such they are represented by variety of shape and their exosporium and mesosporium possess many types of characters. Nineteen genera viz., *Bokarosporites*, *Banksisporites*, *Duosporites*, *Talchirella*, *Barakarella*, *Biharisporites*, *Jhariatriletes*, *Singhisporites*, *Pilatriletes*, *Ramispinatispora*, *Umarispora*, *Singraulispora*, *Saksenasporites*, *Lagenicula*, *Manumisporites*, *Canaliculites*, *Cystosporites*, *Aneulites* (Pant & Srivastava 1961, Kar 1968, Bharadwaj & Tewari 1970, Lele & Srivastava 1983, Tewari & Maheshwari 1992) and three new genera recorded from Satpura Gondwana basin viz., *Satpuraspora*, *Penchiella*, *Sethiaspora* are reported from Barakar Formation (Srivastava & Tewari 2002a,b). Of these, *Lagenicula* and *Satpuraspora* are trilete gulate; *Manumisporites* is trilete zonate; *Canaliculites*, *Cystosporites*, *Aneuletes* are alete and rest of the megaspores are trilete azonate.

Shape of the megaspores varies from circular (*Bokarosporites*, *Barakarella*, *Jhariatriletes*, *Banksisporites*, *Ramispinatispora*, *Saksenasporites*, *Pilatriletes*) to triangular (*Duosporites*, certain species of *Talchirella* and *Ancorisporites*) or oval (*Cystosporites*). It may also be subcircular/subtriangular/roundly triangular (*Barakarella*, *Talchirella* and *Jhariatriletes*). Exosporium, besides being psilate and scabrate (*Bokarosporites*) shows a variety of ornamental processes viz., verrucae (*Talchirella*, *Duosporites*), grana (*Banksisporites*), baculae (*Barakarella*, *Jhariatriletes*), spines, conical setae (*Biharisporites*, *Singhisporites*). Spines are either simple (*Singraulispora*, *Lagenicula*), bifurcate (*Ancorisporites*) or multiple branched (*Ramispinatispora*, *Satpuraspora*). Exosporium exhibits different type of appendages, viz., mamillate

(*Mamillaespora* = *Singhisporites*), rods and ribbon like (*Manumisporites*), club shaped (*Pilatriletes*), tuberculate (*Saksenasporites*) and pilate (*Umarispora*). Mesosporium too, like the exosporium, shows variations in megaspores of Barakar Formation. It varies from spherical (*Talchirella*, *Barakarella*, *Banksisporites*, *Jhariatriletes*, *Lagenicula*) to triangular (*Mamillaespora* = *Singhisporites*, *Singraulispora*, *Duosporites*, *Biharisporites*). It may be thin, membraneous (*Ramispinatispora*, *Jhariatriletes*, *Lagenicula*), hyaline (*Barakarella*, *Jhariatriletes*, some species of *Ancorisporites*, *Lagenicula* and *Singhisporites*), translucent (*Talchirella*) or granulate (*Jhariatriletes*). Mesosporium is either devoid of cushions (*Bokarosporites*, *Banksisporites*, *Singraulispora*, *Ramispinatispora*, *Singhisporites*, *Manumisporites*, *Biharisporites*, *Jhariatriletes*) or with cushions. Cushions are variously arranged i.e. they are few and arranged in one row along the tri-radiate mark (*Duosporites congoensis*, *Talchirella nitens*) or numerous and arranged trigonally along the trilete mark (*Barakarella pantii*, *Duosporites multipunctatus*, *Talchirella trivedii*, *Ancorisporites binaensis*, *Pilatriletes mirzapurensis*). Sometimes cushions are few and are irregularly arranged (*Duosporites irregularis*, *Gulatriletes* = *Lagenicula barakarensis*). Indistinct mesosporium is observed in *Singraulispora indica*.

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