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Palynomorphs from the Barakar Formation of Dhanpuri Open Cast Mine, Sohagpur Coalfield, Madhya Pradesh, India

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ABSTRACT

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Well preserved palynomorphs from the Barakar Formation of Dhanpuri Open Cast Mine, Sohagpur Coalfield, Shahdol District, Madhya Pradesh are reported for the first time. The palynomorphs include megaspores and spores/pollen grains. Dispersed megaspores are represented by 6 genera and 13 species comprising *Banksisporites indicus*, *B. utkalensis*, *Banksisporites* sp., *Barakarella shuklae*, *Barakarella* sp., *Biharisporites* sp. *Bokarosporites rotundus*, *Bokarosporites* sp., *Jhariatriletes baculosus*, *Jhariatriletes* sp., *Talchirella flavata*, *T. trivedii* and *Talchirella* sp. The microspore assemblage shows dominance of monosaccate pollen grains namely *Parasaccites obscures, P. korbaensis* and *Plicatipollenites indicus,* along with sub–dominance of non–striate bisaccate taxa *Scheuringipollenites barakarensis* and *S. maximus*. Other palynomorphs include trilete *Callumispora barakarensis*, striate bisaccate pollen grains *Faunipollenites* sp. and *Striatopodocarpites multistriatus*, non striate bisaccate genera *Ibisporites diplosaccus* and *Platysaccus ovatus,* along with *Tiwariasporis gondwanensis* and *Vitreisporites* sp.

Key–words—Palynomorphs, Barakar Formation, Sohagpur Coalfield, Madhya Pradesh.

भारत में मध्य प्रदेश के सोहागपुर कोयलाक्षेत्र की धनपुरी विवृत ढलवॉ खान के बराकार शैलसमूह से प्राप्त परागाणु संरूप

दीपा अग्निहोत्री, एस.एस.के. पिल्लै, नेहा अग्रवाल, रजनी तिवारी, एंड्रू जैस्पर एवं डाइटर उह्ल

सारांश

मध्य प्रदेश में जिला शहडोल के सोहागपुर कोयलाक्षेत्र की धनपुरी विवृत ढलवॉं खान के बराकार शैलसमूह से सुपरिरक्षित परागाणु संरूप पहली बार वर्णित किए गए हैं। परागाणु संरूप स्थूलबीजाणु एवं बीजाणु / पराग कण सन्निहित है। परिक्षिप्त स्थूलबीजाणु *बैंकीस्पोराइटिस इंडिकस, बी. उत्कलेन्सिस, बैकीस्पोराइटिस* जाति, *बराकरेल्ला शुक्ले, बराकरेल्ला* जाति, *बिहारीस्पोराइटिस* जाति, *बोकारोस्पोराइटिस रोटंडस, बोकारोस्पोराइटिस* जाति, *झरियाट्रिलेटीज बैकुलोसस, झरियाट्रिलेटीज* जाति, *तल्चीरेल्ला फ्लेवेटा, टी. त्रिवदायई* एवं *तल्चीरेल्ला* जाति, समावेशित 6 वंश 13 जाति से रूपायित हैं। सूक्ष्मजीवाणु समुच्चय गैर–रेखीय द्विसपुट *स्युरिंगीपॉल्लेनाइटिस बराकारेन्सिस* एवं *एस. मैक्सीमस* की उप–प्रभुत्वता के साथ एकल सपुट पराग कण नामतः *पैरासेक्काइटिस ऑब्सकर्स, पी. कोरबेन्सिस* एवं *प्लिकेटीपॉल्लेनाइटिस इंडिकस* का प्राबल्य दर्शाता है। अन्य परागाणुसंरूप त्रिअरीय *कल्लुमिस्पोरा बराकारेन्सिस,* रेखीय द्विसपुट पराग कण *फॉनीपॉल्लेनाइटिस* जाति एवं *स्ट्रिएटोपोडोकार्पाइटिस मल्टीस्ट्रिएटस, तिवारियास्पोराइटिस गोंडवानेन्सिस* व *विट्रीस्पोराइटिस* जाति के साथ गैर–रेखीय द्विसपुट वंश *इबीस्पोराइटिस डिप्लोसेक्कस* और *प्लेटीसेक्कस ओवेटस* शामिल हैं।

सूचक शब्द—परागाणु संरूप, बराकार शैलसमूह, सोहागपुर कोयलाक्षेत्र, मध्य प्रदेश।

INTRODUCTION

THE South Rewa Gondwana Basin occupies the central part of the Indian peninsula comprising Mand–Raigarh, Korba, Hasdo–Arand, Chirimiri, Bisrampur, Umaria, Johilla, Korar, Sohagpur, Tatapani–Ramkola, Sonhat, Jhilimili and Singarauli coalfields. The Sohagpur Coalfield is one of the major coal producing areas of Madhya Pradesh and lies between latitudes 23°05': 23°30' N and longitudes 81°13': 81°12' E (Fig. 1). The coalfield is mainly divided into three sub basins− Jhagrakhand–Bijuri, Kotma and Burhar–Amlai. Plant megafossils from the Sohagpur were recorded from the Talchir and Barakar formations by Hughes (1881, 1884), Feistmantel (1882), Chandra and Srivastava (1982), and Agnihotri *et al.* (2016). The first palynological study from the area was carried out by Navale and Tiwari (1967). Later, various workers have carried out palynological studies from the Permian and Triassic sediments of this coalfield (Bharadwaj & Srivastava, 1971; Ram–Awatar, 1993, 1996a, b, 1997, 2003; Ram–Awatar & Dutta, 2005; Ram–Awatar & Gautam, 2013; Ram–Awatar *et al.*, 2004; Gautam *et al*., 2014, 2016). Megaspore studies from the South Rewa Gondwana Basin have been carried out from the Barakar Formation of Sohagpur, Chirimiri, Korba (Bharadwaj & Tiwari 1970), Singrauli (Bharadwaj & Tiwari, 1970; Pant & Mishra, 1986) and Johilla (Pant & Mishra, 1986; Tewari & Maheshwari, 1992) coalfields. Records of megaspores from the Sohagpur Coalfield are rare. Besides, the records from the Barakar Formation by Bharadwaj and Tiwari (1970), Banerji *et al.* (1978) reported megaspores from the Tiki Formation of Shahdol District. In the present paper, mega and microspores are reported for the first time from the Barakar Formation of the Dhanpuri Open Cast Mine (DOCM), Sohagpur Coalfield, Shahdol District, Madhya Pradesh. The present microfloral study suggests the occurrence of Upper Karharbari/Lower Barakar palynoflora in the Barakar Formation of DOCM.

GEOLOGY OF THE AREA

The Sohagpur Coalfield is the biggest coal–producing area of South Rewa Gondwana Basin, Shahdol District, Madhya Pradesh and covers an area of 3100 km^2. The coalfield has 1000 m thick sedimentary strata and the Gondwana rocks strike WNW–ESE to E–W and dip upto 5° towards the north (Pareek, 1987). The Gondwana sediments in the area are known as Talchir (early Permian), Barakar

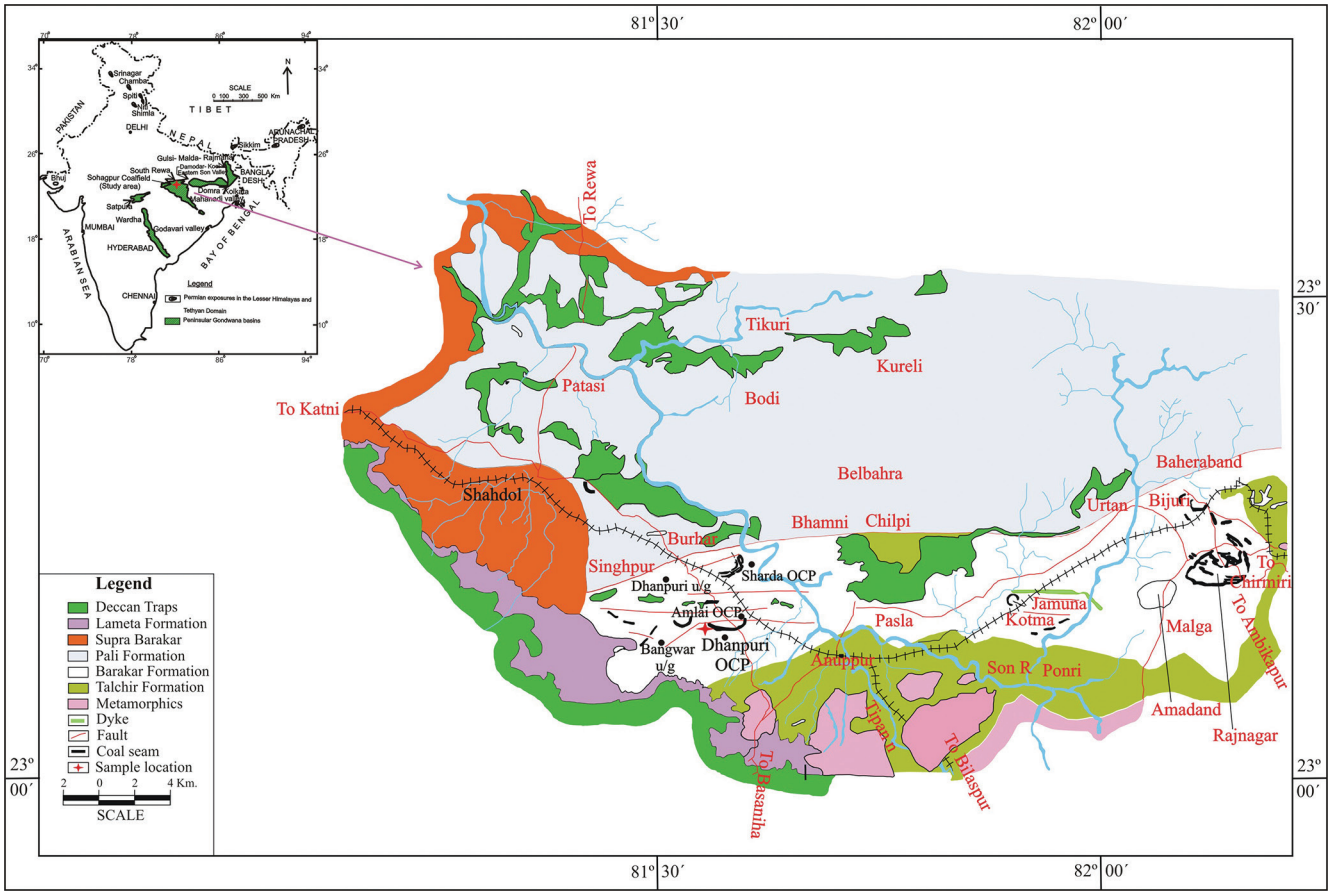

Fig. 1—Geological and location map of Sohagpur Coalfield showing the fossil locality. Inset map showing the location of Sohagpur Coalfield in India.

(early Permian), Pali (middle Permian–middle Triassic) and Parsora (early Jurassic) formations as well as Lameta beds (late Cretaceous) (Raja Rao, 1983) (Fig. 1) (Table 1). The Talchir Formation unconformably overlies the basement rocks and contains shale, siltstone and boulder beds. The Barakar Formation overlies the Talchir Formation and is approximately 450 m thick. The Barakar Formation is the only coal bearing sequence and is divided into lower, middle and upper members. The lower member is composed of greyish–white feldspathic garnetiferous sandstone, siltstone and shale, the middle member comprises cross–bedded feldspathic sandstones with garnet, and thick workable coal seams in the lower portion while the upper member of the Barakar Formation contains ferruginous sandstones, shales, and siltstones. The Pali Formation is also divided into three members, lower, middle and upper and is about 350 m thick (Gautam *et al.,* 2016). The Parsora Formation comprises coarse–grained to pebbly ferruginous sandstones and shales and the Lameta beds include greenish and reddish, poorly consolidated sandstones and shales with nodular limestone at the top. An unconformity is marked between the Parsora Formation and Lameta beds. The coalfield is intruded by dykes and sills (Deccan Trap–late Cretaceous–Eocene). Dolerites are also placed along the faults (Dhanam *et al.*, 2013).

The present study area, the Dhanpuri Open Cast Mine (DOCM), is located within the Burhar–Amlai sub–basin and is situated between the latitudes 23°08'30"−23°10'30"N and longitudes 81°32'20"−81°37'10"E in Shahdol District, Madhya Pradesh (Fig. 1). Nine coal seams have been identified by the South Eastern Coalfields Limited (SECL), which is a government coal exploitation agency, working in the area. The coal seams are numbered as I–IX from bottom to top. In Dhanpuri Open Cast Mine (DOCM), only the seam VI is workable and divided into VI top and VI bottom.

MATERIAL AND METHODS

Well preserved micro–and megaspores have been recovered from the sample collected from carbonaceous shale, present between the seam VI top and VI bottom (Fig. 2) of Barakar Formation of Dhanpuri Open Cast Mine, Sohagpur Coalfield, Shahdol District, Madhya Pradesh. For the chemical treatment, approximately 50 gms of crushed sample was processed. The sample was kept in hydrofluoric acid (HF) for three days for the removal of silicates from the carbonaceous shale. Further, the acid–free residue was treated with concentrated nitric acid (HNO_3) followed by alkali treatment (10% KOH solution) to remove the humic contents. Slides were prepared for identification and percentage frequency distribution of palynomorphs (Fig. 3). For the study of megaspores, the sample was broken into small pieces, followed by treatment with hydrofluoric acid (40%) for 5 days.

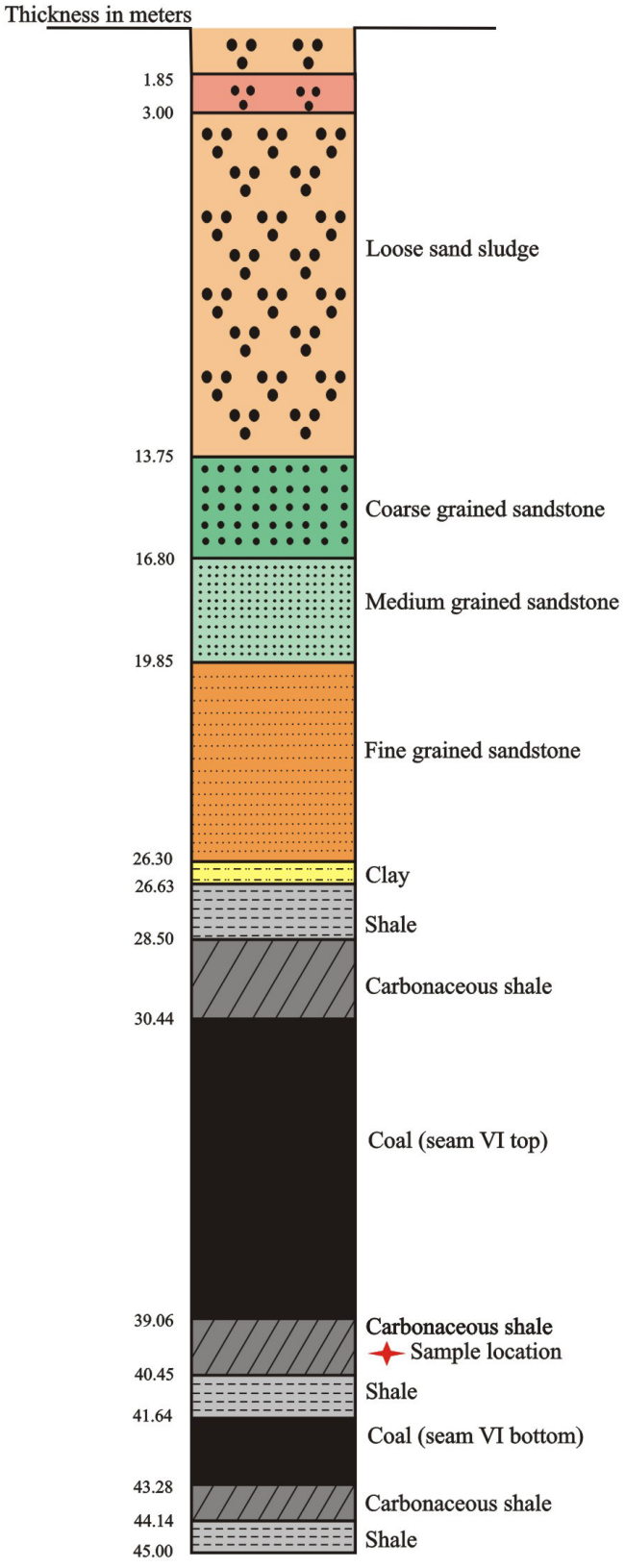

Fig. 2—Litholog of Dhanpuri OCM showing the location of fossil horizon.

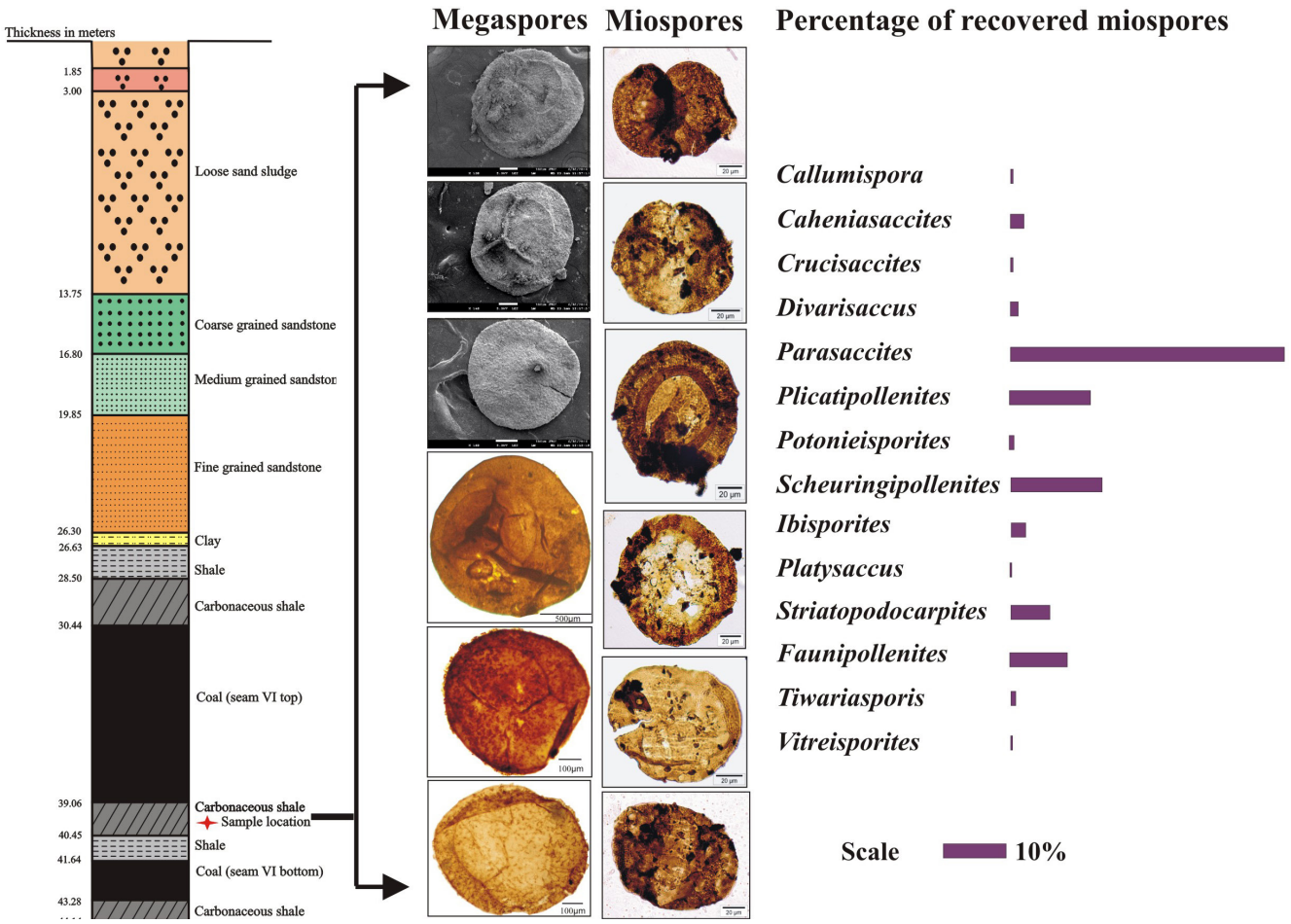

Fig. 3—Figure showing the megaspores and micro–spores containing horizon with frequency distribution of palynoassemblage.

Later, it was thoroughly washed with water. The megaspores were picked up individually under a low power binocular microscope and treated with nitric acid (40%). Subsequently, a pinch of potassium chlorate was added to catalyze the reaction. The megaspores were washed with water again. Henceforth, they were treated with potassium hydroxide (5%) to reveal details of exosporium (outer wall), *viz.* shape, nature of triradiate and contact ridges and ornamentation, and mesosporium (inner wall–presence and absence of cushions and their arrangement along the tri–radiate mark) characters. Thereafter, individual megaspores were placed on a slide, and photographed under transmitted light using a high power Olympus VANOX AHBS3 microscope. For SEM study, individual megaspores were picked and mounted on stubs with double–sided adhesive carbon tape, coated with gold palladium and examined using a LEO–430 Scanning Electron Microscope. In SEM studies, some megaspores could be identified at generic level only, on the basis of exosporium features. These belong to the taxa *Banksisporites*, *Barakarella, Biharisporites, Bokarosporites* and *Talcheriella*. Since, all the megaspores are well known and have been described by earlier workers, a detailed description of these is not provided here. The slides have been deposited in the repository of BSIP Museum vide BSIP Statement No. 1495 (BSIP Museum Slide No. 16358−16368).

PLATE 1

1. *Callumispora barakarensis*, BSIP Museum Slide No. 16363.
2. *Parasaccites obscurus*, BSIP Museum Slide No. 16363.
3. *Parasaccites korbaensis*, BSIP Museum Slide No. 16364.
4. *Plicatipollenites indicus,* BSIP Museum Slide No. 16365.
5. *Potonieisporites gondwanensis*, BSIP Museum Slide No. 16366.
6. *Caheniasaccites ovatus*, BSIP Museum Slide No. 16363.
7. *Divarisaccus lelei*, BSIP Museum Slide No. 16363.
8. *Scheuringipollenites barakarensis*, BSIP Museum Slide No. 16365.
9. *Ibisporites diplosaccus*, BSIP Museum Slide No. 16365.
10. *Platysaccus ovatus*, BSIP Museum Slide No. 16366.
11. *Striatopodocarpites multistriatus*, BSIP Museum Slide No. 16367.
12. *Tiwariasporis gondwanensis*, BSIP Museum Slide No. 16368.

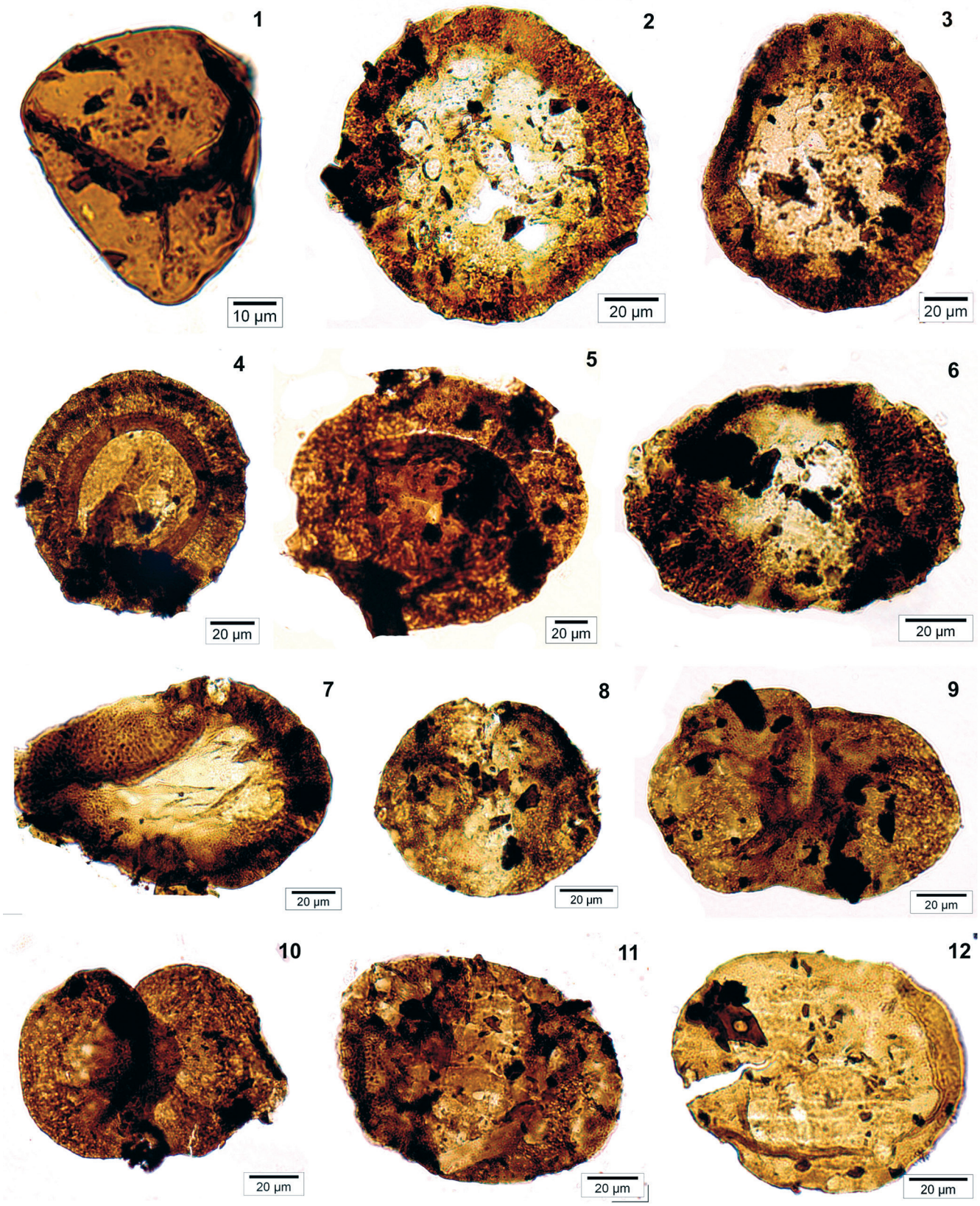
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PLATE 1

Table 1—Generalized stratigraphical column of the Sohagpur Coalfield, South Rewa Basin, Madhya Pradesh (modified after Raja Rao, 1983; Pareek, 1987; Dhanam *et al.*, 2013; Gautam *et al.*, 2016).

Formation	Member	Thickness	Lithology	Age
Deccan Traps			Basalt flow and dolerite dykes	Late Cretaceous–Eocene
Lameta beds		30 m	Greenish and reddish, poorly consolidated sandstone and shales with nodular limestone	Late Cretaceous
Parsora		200 m	Coarse–grained to pebbly ferruginous sandstone and shale; at places red clay stone	Early Jurassic
Pali	Upper	350 m	Coarse grained arkosic sandstone, granules and pebbles of quartz and fresh feldspars occur as a clast with siliceous matrix	Early to middle Triassic
	Middle		White to grey coloured, medium to coarse grained, arkosic sandstone, grey shale, carbonaceous shale and coal seams	Late Permian
	Lower		Alternate band of red and green clay with medium to coarse grained arkosic sandstone	Middle Permian
Barakar	Upper	450 m	Greyish–white felspathic garnet sandstone, siltstone and devoid of coal seams	Early Permian
	Middle		Cross bedded felspathic sandstone with garnet and thick workable coal seams	
	Lower		Sandstone, shales and siltstone	
Talchir		430 m	Diamictite, sandstone, siltstone, needle shale, boulder beds	Early Permian
Precambrian			Granite, gneisses and quartzite	Early Proterozoic

MICROSPORES

The palynoassemblage recovered from the VI seam of Barakar Formation of Dhanpuri Open Cast Mine is characterized by the dominance of monosaccate pollen grains namely, *Parasaccites obscurus*, *P. korbaensis* (45.6%), *Plicatipollenites indicus* (13.5%) along with sub–dominance of non–striate bisaccate genus *Scheuringipollenites barakarensis* and *S. maximus* (15.2%). Other palynomorphs recovered from this palynoassemblage are the trilete genus *Callumispora barakarensis* (0.4%); the monosaccate pollen taxa *Caheniasaccites ovatus* (2.26%), *Divarisaccus lelei* (1.3%), *Potonieisporites gondwanensis* (0.8%) and *Crucisaccites monoletus* (0.4%); the non–striate bisaccate grains: *Ibisporites diplosaccus* (2.41%) and *Platysaccus ovatus* (0.3%); the striate bisaccate genera: *Faunipollenites*

PLATE 2

1. *Banksisporites indicus* (Singh, 1953) Tewari & Maheshwari, 1992, BSIP Museum Slide No. 16358.
2. *Banksisporites indicus* (Singh, 1953) Tewari & Maheshwari, 1992, BSIP Museum Slide No. 16359.
3. *Banksisporites utkalensis* (Pant & Srivastava, 1961) Tewari & Maheshwari, 1992, BSIP Museum Slide No. 16361.
4. *Barakarella shuklae* Tewari & Maheshwari, 1992, BSIP Museum Slide No. 16359.
5. Enlargement of *Barakarella shuklae* Tewari & Maheshwari, 1992, to show the inner body with cushions, BSIP Museum Slide No. 16359.
6. *Bokarosporites rotundus* Bharadwaj & Tiwari, 1970, BSIP Museum Slide No. 16360.
7. *Jhariatriletes baculosus* Bharadwaj & Tiwari, 1970, BSIP Museum Slide No. 16361.
8. *Jhariatriletes* sp., BSIP Museum Slide No. 16359.
9. *Talchirella flavata* (Kar, 1968) Bharadwaj & Tiwari, 1970, BSIP Museum Slide No. 16362.
10. *Talchirella trivedii* (Pant & Srivastava, 1961) Bharadwaj & Tiwari, 1970, BSIP Museum Slide No. 16358.
11. *Talchirella trivedii* (Pant & Srivastava, 1961) Bharadwaj & Tiwari, 1970, BSIP Museum Slide No. 16359.
12. Enlargement of *Talchirella trivedii* (Pant & Srivastava, 1961) Bharadwaj & Tiwari, 1970, BSIP Museum Slide No. 16359.

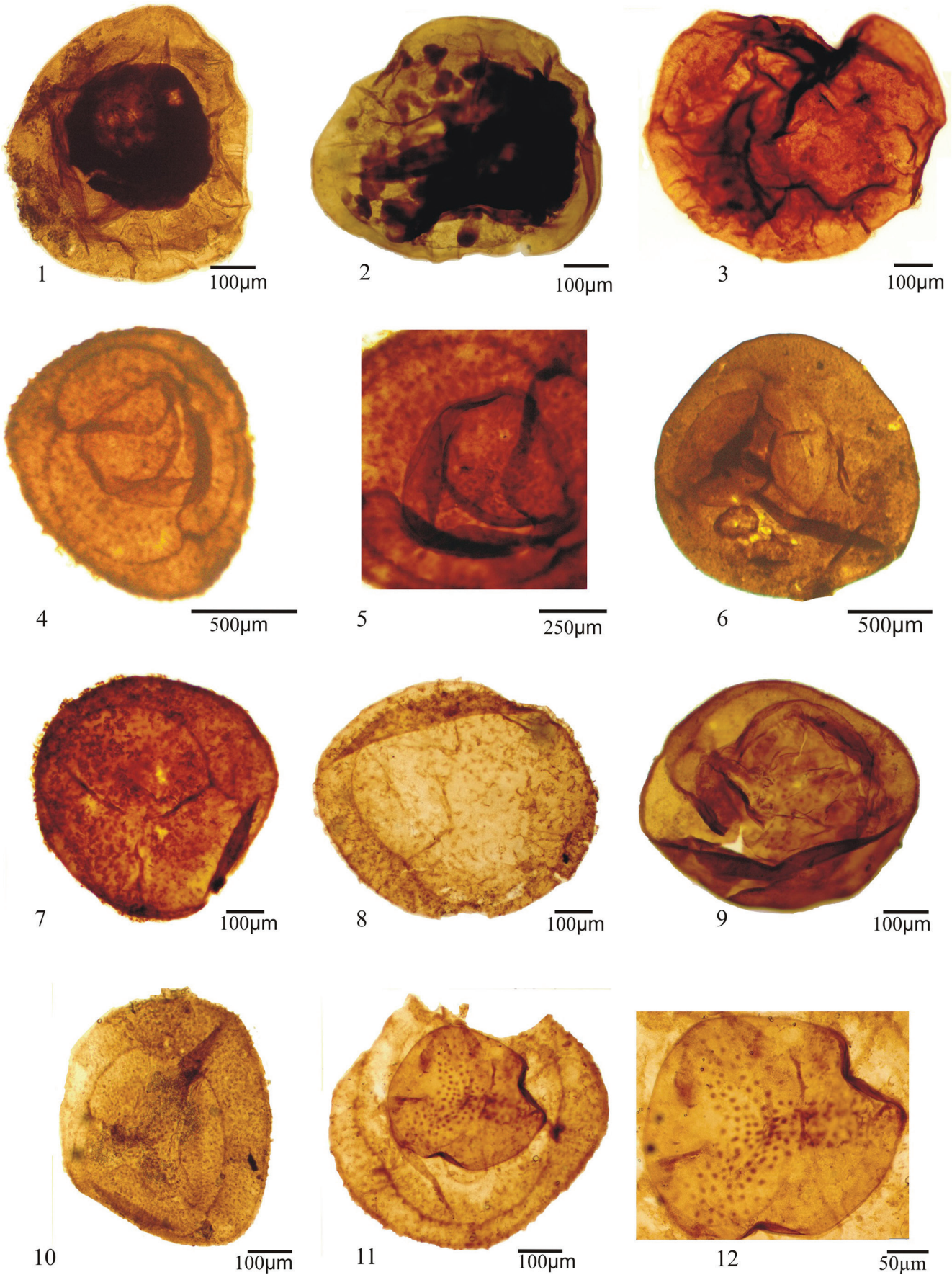
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PLATE 2

Table 2—Megaspores from the Barakar Formation of different coalfields of South Rewa Gondwana Basin, India.

Megaspore taxa	Name of coalfields				
	Sohagpur Coalfield	**Johilla Coalfield**	**Korba Coalfield**	**Chirimiri Coalfield**	**Singrauli Coalfield**
Ancorisporites binaensis (Pant & Mishra, 1986)					+
Aneuletes sp. A Pant & Mishra, 1986					+
Banksisporites dijkstrae (Bharadwaj & Tiwari, 1970) Tewari & Maheshwari, 1992			+		
Banksisporites endosporitiferus (Bharadwaj & Tiwari, 1970) Tewari & Maheshwari, 1992			+		+
**Banksisporites indicus* (Bharadwaj & Tiwari, 1970) Tewari & Maheshwari, 1992	+	+			
**Banksisporites utkalensis* (Pant & Srivastava, 1961) Tewari & Maheshwari, 1992	+	+	+	+	+
Banksisporites linearis (Pant & Mishra, 1986) Tewari & Maheshwari, 1992		+	+	+	+
**Banksisporites* sp.	+				
Barakarella churulaiensis Lele & Srivastava, 1983					+
**Barakarella shuklae* Tewari & Maheshwari, 1992	+				
**Barakarella* sp.	+				
**Bokarosporites rotundus* Bharadwaj & Tiwari, 1970	+	+	+		+
**Bokarosporites* sp.	+				
Biharisporites arcuatus Bharadwaj & Tiwari, 1970			+	+	
Biharisporites distinctus Bharadwaj & Tiwari, 1970			+		
Biharisporites spinosus Bharadwaj & Tiwari, 1970	+	+	+		+
**Biharisporites* sp.	+				
Canaliculites triangulatus Pant & Mishra, 1986					+
Duosporites inaqualis Pant & Mishra, 1986		+			
Duosporites multipunctatus Høeg & Bose, 1960			+	+	
Dijkstraea indica Tripathi & Mishra, 2001		+			
Hughesisporites varibilis Dettmann, 1961					+
**Jhariatriletes baculosus* Bharadwaj & Tiwari, 1970	+	+			+

Jhariatriletes binaensis (Pant & Mishra, 1986) Tewari & Maheshwari, 1992					+
Jhariatriletes srivastavae Bharadwaj & Tiwari, 1970			+		
**Jhariatriletes* sp.	+				
Lagenicula gondwanensis Pant & Mishra, 1986					+
Maithyspora ovalis Tripathi & Mishra, 2001				+	
Manumisporites distinctus Høeg & Bose, 1960	+		+		+
Mammalispora grandis Pant & Mishra, 1986		+			
Manumisporites høegii (Srivastava, 1954), Bharadwaj & Tiwari, 1970			+		+
Pilatriletes mirzapurensis Pant & Mishra, 1986					+
Ramispinatispora indica Pant & Mishra, 1986					+
Ramispinatispora nautiyalii Pant & Mishra, 1986					+
Saksenasporites rewaensis Tripathi, 1998		+			
Shahdolia chalonerii Pant & Mishra, 1986					+
Singhisporites indica Pant & Mishra, 1986					+
Singhisporites insignis Pant & Mishra, 1986					+
Singhisporites obesus Tripathi, 1998		+			
Singhisporites surangei (Singh, 1953) Bharadwaj & Tiwari, 1970					+
**Talchirella flavata* (Kar, 1968) Bharadwaj & Tiwari, 1970	+	+			
**Talchirella trivedii* (Pant & Srivastava, 1961) Bharadwaj & Tiwari, 1960	+	+	+	+	
**Talchirella* sp.	+				
Triconia sp.					+
Triletes sp. A Pant & Mishra, 1986					+

Note: Megaspores with * are recorded in the present study.

sp. (9.66%); *Striatopodocarpites multistriatus* (6.49%) and others including *Tiwariasporis gondwanensis* (0.8%) and *Vitreisporites* sp. (0.3%). Stratigraphically significant taxa of the recovered palynoflora have been shown in Pl. 1.

Comparison—The palynoassemblage is comparable with palynoflora of Korba Coalfield (Zone–2; Bharadwaj & Srivastava, 1973); Umrer Quarry, Nagpur (Biozone–II and III; Bharadwaj & Anand–Prakash, 1974); Johilla Coalfield (Zone–2; Anand–Prakash & Srivastava, 1984); Umaria Coalfield (Zone–2; Srivastava & Anand–Prakash, 1984); Shobhapur block, Pathakhera Coalfield (Zone–1; Srivastava & Sarate, 1989); Wardha Coalfield (Assemblage–A; Bhattacharyya, 1997); Umrer Coalfield (Jha *et al.*, 2007). Besides, this palynoassemblage is also akin to palynoflora of different areas of Godavari Graben, *viz.* Manuguru (palynoassemblage–2; Srivastava & Jha, 1992); Mamakannu (Palynoassemblage–II; Jha & Aggarwal, 2010), Gundala (Palynoassemblage–C; Jha & Aggarwal, 2011); Mailaram

(Palynozone–2; Jha & Aggarwal, 2012), Lingala–Koyagudem Coalbelt (Palynozone–3; Aggarwal & Jha, 2013) and Chintalapudi sub basin (Palynoassemblage–III; Jha *et al.,* 2018).

The recovered palynoflora shows close resemblance with the Upper Karharbari palynoflora of the Godavari Graben in having the abundance of *Parasaccites* and subdominance of *Scheuringipollenites* (Jha *et al.,* 2018). It also shows close resemblance with the upper part of *Crucisaccites monoletus* zone (*Parasaccites* + *Callumispora*) of Damodar Basin in the presence of *Crucisaccites monoletus*, *Callumispora barakarensis, Parasaccites obscurus, Parasaccites korbaensis* and *Tiwariasporis gondwanensis.* This mioflora closely resembles with Palynozone IV of South Rewa Basin in the presence of *Crucisaccites*, *Parasaccites* and *Callumispora* (Ram Awatar, 1996c) and Palynozone V of South Rewa Basin in presence of *Scheuringipollenites*, *Parasaccites* and *Plicatipollenites*. As the palynoflora is distinguished by the dominant occurrence of *Parasaccites* along with *Scheuringipollenites*, it broadly resembles with the Upper Karharbari/Lower Barakar palynozones of the South Rewa Basin (Ram Awatar, 1996c).

MEGASPORES

The megaspores recorded from the Barakar Formation of Dhanpuri Open Cast Mine, Sohagpur Coalfield, Shahdol District, Madhya Pradesh (Pls. 2, 3) are listed below.

Genus—BANKSISPORITES (Dettmann) Banerji *et al.*, 1978

Banksisporites indicus (Singh, 1953) Tewari & Maheshwari, 1992 (Pl. 2.1, 2.2)

Banksisporites utkalensis (Pant & Srivastava, 1961) Tewari & Maheshwari, 1992 (Pl. 2.3)

Banksisporites sp. (Pl. 3.3, 3.4, 3.5, 3.8, 3.9)

Genus—BARAKARELLA Lele & Srivastava, 1983

Barakarella shuklae Tewari & Maheshwari, 1992 (Pl. 2.4, 2.5)

Barakarella sp. (Pl. 3.7, 3.11, 3.12)

Genus–BIHARISPORITES Potonié emended. Bharadwaj & Tiwari, 1970

Biharisporites sp. (Pl. 3.1)

Genus—BOKAROSPORITES Bharadwaj & Tiwari, 1970

Bokarosporites rotundus Bharadwaj & Tiwari, 1970 (Pl. 2.6)

Bokarosporites sp. (Pl. 3.2, 3.6)

Genus—JHARIATRILETES Bharadwaj & Tiwari, 1970

Jhariatriletes baculosus Bharadwaj & Tiwari, 1970 (Pl. 2.7)

Jhariatriletes sp. (Pl. 2.8)

Remark—Although the megaspore is similar to *Jhariatriletes filiformis* (Tewari & Maheshwari, 1992, Pl. 5, Figs 2, 5) in having hair like filiform appendages on the exosporium and other characters, the triradiate ridges and mesosporium are not distinct. Therefore, we refrain to assign it to *Jhariatriletes filiformis*.

Genus—TALCHIRELLA (Pant & Srivastava, 1961) Bharadwaj & Tiwari, 1970

Talchirella flavata (Kar, 1968) Bharadwaj & Tiwari, 1970 (Pl. 2.9)

Talchirella trivedii (Pant & Srivastava, 1961) Bharadwaj & Tiwari, 1970 (Pl. 2.10, 2.11, 2.12)

Talchirella sp. (Pl. 3.10)

DISCUSSION

Dispersed fossil megaspores are well known from the Talchir, Karharbari, Barakar, Barren Measures and Raniganj formations of different lower Gondwana basins of India namely, Damodar (Tewari, 1991; Tewari & Maheshwari, 1992), Satpura (Srivastava & Tewari, 2001, 2002, 2004), Mahanadi (Tewari *et al.*, 2009), South Rewa (Tewari & Maheshwari, 1992; Tripathi, 1997, 1998a, b, 1999; Tripathi & Mishra, 1997, 2001), Wardha (Tewari *et al.,* 2004; Murthy *et al.*, 2017) and Godavari (Patil & Premchand, 2001; Jha & Tewari, 2003; Jha *et al.,* 2006; Tewari *et al.,* 2007; Joshi & Tewari, 2015). Earlier records of megaspores from the

PLATE 3

1. *Biharisporites* sp.
2. *Bokarosporites* sp.
3–5. *Banksisporites* sp.
6. *Bokarosporites* sp.
7. *Barakarella* sp.
8–9. *Banksisporites* sp.
10. *Talchirella* sp.
11. *Barakarella* sp.
12. Enlargement of *Barakarella* sp.

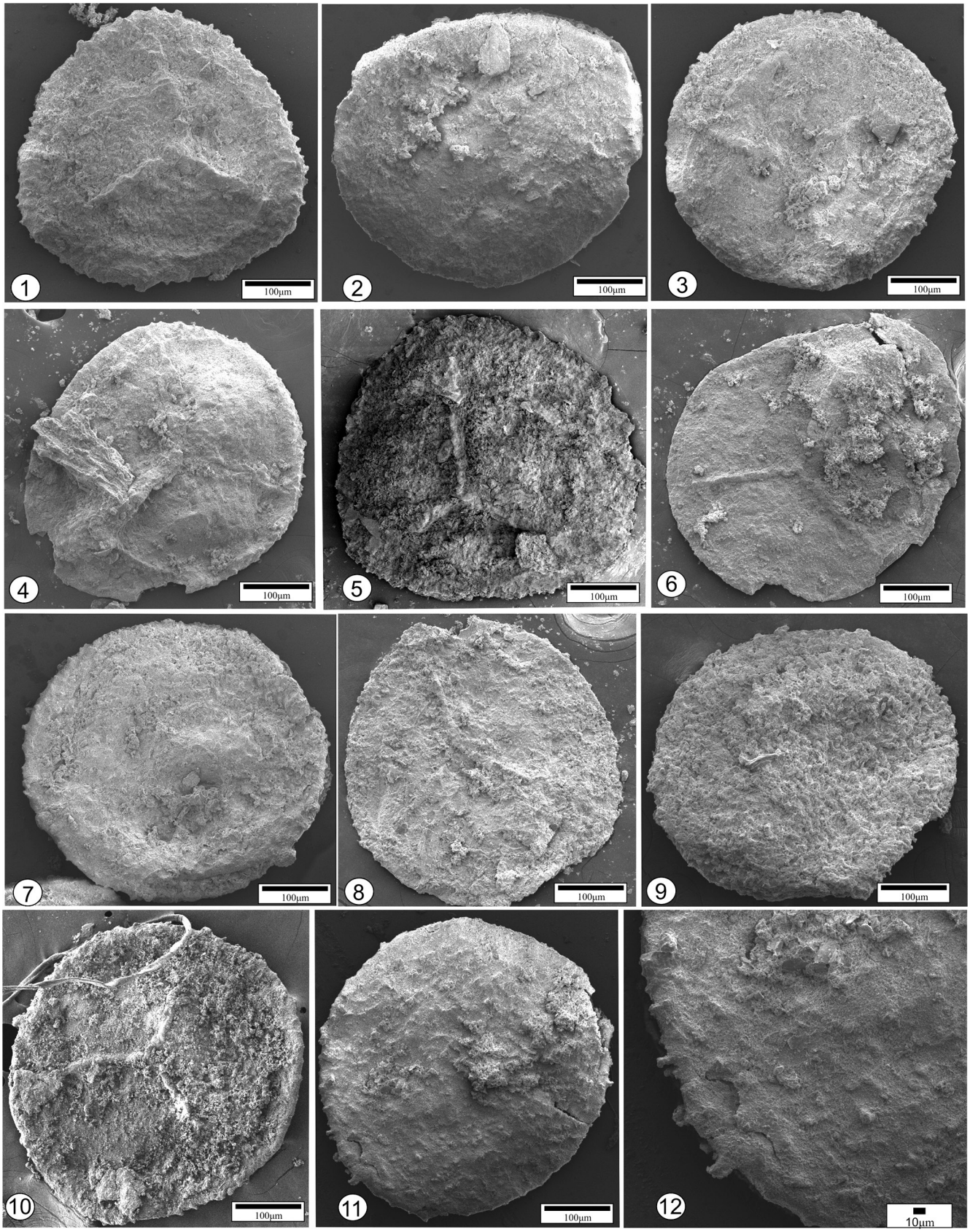
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PLATE 3

Table 3—Distribution of megaspores of present study in the Barakar Formation of different lower Gondwana basins of India.

	Name of the basins					
Name of taxa	**South Rewa**	**Damodar**	**Satpura**	**Mahanadi**	**Wardha**	**Godavari**
Banksisporites indicus (Singh 1953) Tewari & Maheshwari, 1992	+	+		+	+	
Banksisporites utkalensis (Pant & Srivastava 1961) Tewari & Maheshwari, 1992	+	+	+	+	+	+
Banksisporites sp. (present study)	+					
Barakarella shuklae Tewari & Maheshwari, 1992	+	+				
Barakarella sp. (present study)	+					
Biharisporites sp. (present study)	+					
Bokarosporites rotundus Bharadwaj & Tiwari, 1970	+	+	+	+	+	+
Bokarosporites sp. (present study)	+					
Jhariatriletes baculosus Bharadwaj & Tiwari, 1970	+	+			+	+
Jhariatriletes sp. (present study)	+					
Talchirella flavata (Kar 1968) Bharadwaj & Tiwari, 1970	+					
Talchirella trivedii (Pant & Srivastava 1961) Bharadwaj & Tiwari, 1960	+	+	+	+	+	+
Talchirella sp. (present study)	+					

Sohagpur Coalfield include three taxa, namely *Biharisporites spinosus*, *Manumisporites disticntus* and *Talchirella trivedii*. The megaspores recorded in the present study are represented by six genera and thirteen species including *Banksisporites indicus*, *B. utkalensis*, *Banksisporites* sp., *Barakarella shuklae*, *Barakarella* sp., *Biharisporites* sp., *Bokarosporites rotundus, Bokarosporites* sp., *Jhariatriletes baculosus, Jhariatriletes* sp., *Talchirella flavata*, *T. trivedii, Talchirella* sp. The taxa *Banksisporites indicus*, *B. utkalensis*, *Banksisporites* sp., *Barakarella shuklae, Barakarella* sp., *Biharisporites* sp., *Bokarosporites rotundus, Bokarosporites* sp., *Jhariatriletes baculosus, Jhariatriletes* sp., *Talchirella flavata* and *Talchirella* sp. are recorded for the first time from the area. Apart from the Sohagpur Coalfield, *Banksisporites indicus* is known from the Johilla Coalfield; *Banksisporites utkalensis* from the Singrauli Coalfield; *Bokarosporites rotundus* from the Johilla, Korba and Singrauli coalfields; *Jhariatriletes baculosus* from the Singrauli Coalfield, *Talchirella flavata* from the Johilla Coalfield, *Talchirella trivedii* from the Johilla, Korba, and Chirmiri coalfields. *Banksisporites* sp., *Barakarella shuklae*, *Barakarella* sp., *Biharisporites* sp., *Bokarosporites* sp., *Jhariatriletes* sp. and *Talchirella* sp. found in the present study are not known from any other coalfield of South Rewa Gondwana Basin (Table 2). Table 3 reveals that megaspore taxa *Banksisporites utkalensis*, *Bokarosporites rotundus* and *Talchirella trivedii* of present study are commonly known from the Barakar Formation of Damodar, Satpura, Mahanadi, Wardha, Godavari and South Rewa Gondwana basins of India. *Banksisporites indicus* also shows its common occurrence in all the basins except Satpura Gondwana Basin. *Barakarella shuklae* and *Jhariatriletes baculosus* are known from the South Rewa and Damodar basins. However, *Talchirella flavata* is only recorded from the South Rewa Basin.

The palynoassemblage recorded in the present study, is comparable with the early Permian palynoassemblages of Korba (Bharadwaj & Srivastava, 1973), Johilla (Anand–Prakash & Srivastava, 1984) and Umaria (Srivastava & Anand–Prakash, 1984) coalfields of South Rewa Gondwana Basin; Umrer Quarry, Nagpur (Bharadwaj & Anand–Prakash, 1974), Wardha Coalfield (Bhattacharyya, 1997) and Umrer Coalfield (Jha *et al.*, 2007) of Wardha Basin, Shobhapur block, Pathakhera Coalfield (Srivastava & Sarate, 1989) of Satpura Gondwana Basin; and Manuguru (Srivastava &

Jha, 1992), Mamakannu (Jha & Aggarwal, 2010), Gundala (Jha & Aggarwal, 2011), Mailaram (Jha & Aggarwal, 2012) and Lingala–Koyagudem (Aggarwal & Jha, 2013) areas of Godavari Graben. Besides, it shows resemblance with the upper Karharbari palynoassemblage of the Damodar Basin. The present palynoflora closely resembles with the pollen taxa of the Godavari Graben showing the Upper Karharbari affinity in dominance of *Parasaccites* and subdominance of *Scheuringipollenites* (Jha *et al.*, 2018). It also shows resemblance with the upper part of *Crucisaccites monoletus* zone (*Parasaccites* + *Callumispora*) of Damodar Basin in presence of *Crucisaccites monoletus*, *Callumispora barakarensis, Parasaccites obscurus, Parasaccites korbaensis* and *Tiwariasporis gondwanensis.* Due to the predominance of *Parasaccites* alongwith *Scheuringipollenits*, the recovered palynoflora shows broad resemblance with the Upper Karharbari/Lower Barakar palynoflora of South Rewa Basin (Ram-Awatar, 1996c)

CONCLUSION

Presence of megaspores in the Barakar Formation of Dhanpuri Open Cast Mine indicates the presence of lycopsids, which are absent in the megafloral records. Different kind of exosporia, e.g. laevigate, granulate,verrucate, baculate and spinate indicate that the lycopsid source plants were diversified. Wide distribution of some megaspores like *Bokarosporites rotundus*, *Banksisporites utkalensis* and *Talchirella trivedii* in the Barakar Formation of different lower Gondwana basins of India (Table 2) indicate presence of common ancestral lycopsids in these basins. Occurrence of spinate megaspores like *Biharisporites* though rare, points toward aquatic conditions. Presence of diversified megafossils in the area (collected by Rajni Tewari, Suresh K. Pillai and Deepa Agnihotri) including pteridophytes and gymnosperms (also confirmed by macro charcoal records, Jasper *et al.*, 2017), particularly glossopterids with large leaves along with the palynomorphs of the present study, indicate the occurrence of a luxuriant vegetation during deposition of Barakar Formation of Sohagpur Coalfield, which was responsible for the formation of thick coal seams in the area.

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