The Palaeobotanist 62(2013): 199-209
0031-0174/2013

Further contribution to the mega- and microfossil assemblages from the Johilla-Ganjra Nala confluence, South Rewa Gondwana Basin, Madhya Pradesh, India

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(Received 13 August, 2013; revised version accepted 30 August, 2013)

ABSTRACT

Gautam S, Pillai SSK, Goswami S & Ram-Awatar 2013. Further contribution to the mega- and microfossil assemblages from the Johilla-Ganjra Nala confluence, South Rewa Gondwana Basin, Madhya Pradesh, India. The Palaeobotanist 62(2): 199-209.

The present paper deals with mega- and microfossils recovered from the Early Permian sediments of the Johilla-Ganjra Nala confluence of Johilla Coalfield, Madhya Pradesh. Megafossils include *Gangamopteris major, G. cyclopteroides, Glossopteris indica, G. gigas, G. conspicua*, *G. mohudaensis, Noeggerathiopsis hislopii*, *Samaropsis goraiensis, Cordaicarpus zeilleri, Alatocarpus indicus,* few platyspermic seeds and Equisetalean axes. The palynological studies reveal that coal-bearing beds contain dominance of monosaccate pollen (*Parasaccites, Plicatipollenites* and *Pachysaccus*) in association with *Callumispora gretensis*, *Crucisaccites monoletus, Barakarites indicus, Faunipollenites varius*, *Lunatisporites diffusus* and *Crescentipollenites fuscus* indicating an Early Permian age to the coal beds exposed near the confluence of Johilla River and Ganjra Nala. The mega- and microflora recorded from these beds indicate a transitional zone of the Upper Karharbari and Lower Barakar formations. The study further suggests that the climatic conditions of Son Valley were cooler than the Damodar Basin.

Key–words—Mega- and microfossils, Early Permian, Johilla-Ganjra Nala confluence, South Rewa Gondwana Basin.

भारत में मध्य प्रदेश के दक्षिण रीवा गोंडवाना द्रोणी के जोहिल्ला-गंजरा नाला संगम से प्राप्त स्थूल एवं सूक्ष्मजीवाश्म समुच्चयों का और योगदान

सौरभ गौतम, एस. सुरेश के. पिल्लई, श्रीरूप गोस्वामी एवं राम अवतार

सारांश

वर्तमान शोध-पत्र का संबंध जोहिल्ला कोयलाक्षेत्र, मध्य प्रदेश के जोहिल्ला-गंजरा नाला संगम के प्रारंभिक पर्मियन अवसादों से प्राप्त स्थूल एवं सूक्ष्मजीवाश्मों से है। सूक्ष्म जीवाश्मों में *गंगामाप्टेरिस मेजर, जी. सायक्लोप्टेरॉइड्स, ग्लाप्सोप्टेरिस इंडिका, जी. गीगाज़, जी. कॉन्सपिकुआ, जी. मोहुडेन्सिस, नोएग्गेराथिऑप्सिस हिस्लोपिआइ, समरॉप्सिस गोरिएन्सिस, कॉर्डेकार्पस ज़ील्लेरी, एलेटोकार्पस इंडिकस,* कुछ एक चिपिटबीजी बीज एवं *इक्वीसीटालीन* अक्ष समाहित हैं। परागाणविक अध्ययनों से खुलासा होता है कि कोयला दिकमान संस्तरें जोहिल्ला-गंजरा नाला संगम के निकट अनावरित प्रारंभिक पर्मियन से कोयला संस्तरें इंगित करते हुए *कल्लुमिस्पोरा ग्रेटेन्सिस, क्रुसिसेक्काइट्स मोनोलेटस, बराकाराइट्स इंडिकस, फॉनीपोलेनाइट्स वेरियस, लुनैटीस्पोराइट्स डिफ्यूजेज* एवं *क्रेसेंटीपॉलेनाइट्स फसकस* के साहचर्य में एकलसपुट पराग (*पैरासेक्काइट्स, प्लिकेटिपॉलेनाइट्स* व *पैचीसैक्कस*) की प्रभावित सन्निहित कोयला दिकमान संस्तरें हैं। इन संस्तरों से अभिलिखित स्थूल एवं सूक्ष्मवनस्पति ऊपरी करहरबाड़ी और निचली बराकार शैलसमूहों का संक्रमण क्षेत्र इंगित करते हैं। अध्ययन आगे सुझाता है कि सोन-घाटी का निक्षेपणीय पर्यावरण दामोदर द्रोणी की अपेक्षा शीतल था।

संकेत-शब्द—स्थूल एवं सूक्ष्म जीवाश्म, प्रारंभिक पर्मियन, जोहिल्ला-गंजरा नाला संगम, दक्षिण रीवा गोंडवाना द्रोणी।

INTRODUCTION

JOHILLA Coalfield is situated (23º16' : 23º23' N lat.; 80º57' : 81º05' E long.) at about 33 km south-east of Umaria Railway Station on Katni-Bilaspur line of the Central Railway, Umaria District, Madhya Pradesh. During last four decades a number of geological as well as palaeobotanical studies were carried out by different workers to solve the age of the bed exposed near the confluence of Johilla River and Ganjra Nala Section. Hughes (1884) and Fox (1932) suggested that the coal-bearing beds are equivalent to the Barakar Formation, while Feistmantel (1882) considered these beds equivalent to the Karharbari Formation. Based on the palynological studies, Mehta (1945) and Virkki (1946) opined that these beds are equivalent to the Pali Formation. Basu (1964) carried out the chemical analysis of the coal beds of the area and assigned an Early Permian age corresponding to Karharbari Formation. Saksena (1952, 1971) and Maithy (1969) studied the plant mega- and microfossils from the Ganjra Nala beds and suggested an Early Permian age equivalent to the Karharbari Formation. Deshmukh (1971) grouped these beds within Barakar Formation after mapping the regional lithological details of the area. Chandra and Srivastava (1982, 1986) studied the plant mega- and microfossils from Coal Measures of Johilla Coalfield and assigned an Early Permian age equivalent to the Karharbari Formation. Anand–Prakash and Srivastava (1984) also reported the Karharbari / Upper Barakar palynoflora from the sediments at the confluence of Johilla-Ganjra Nala Section. In the present communication, plant mega- and microfossils have been described from the beds exposed along Johilla River, near Birsinghpur Pali Village.

Plant megafossils were reported for the first time from South Rewa Gondwana Basin by Medlicott in the year 1860. Hughes (1881, 1884) and Feistmantel (1879a, 1882) confirmed that the coal-bearing beds belong to the Karharbari Formation on the basis of plant fossil assemblages. Further investigation in the area was carried out by Fermor (1914) where he reported plant fossils from the Barakar Formation of Kurasia Coalfield. Biswas (1955) described *Gangamopteris cyclopteroides, G. kashmirensis, Glossopteris indica, Noeggerathiopsis hislopii*, *Samaropsis goraiensis* and *Cordaicarpus* sp. from the Karharbari Formation of Chirimiri Coalfield and compared the flora with the Karharbari Formation of different Lower Gondwana basins of India. Surange and Lele (1956) reported plant fossils from the Talchir Formation of Johilla Coalfield. Lele and Maithy (1964) and Maithy (1966, 1968) described plant fossils from Ganjra Nala beds of the Karharbari Formation. Chandra and Srivastava (1981) reported new species of *Arberia surangei* from Karharbari beds of Birsinghpur Pali area. Chandra and Srivastava (1982) reported plant fossils belonging to the Talchir and coal-bearing formations (Lower Permian) from Umaria, Birsinghpur Pali, Anuppur and Chirimiri coalfields of the South Rewa Gondwana Basin.

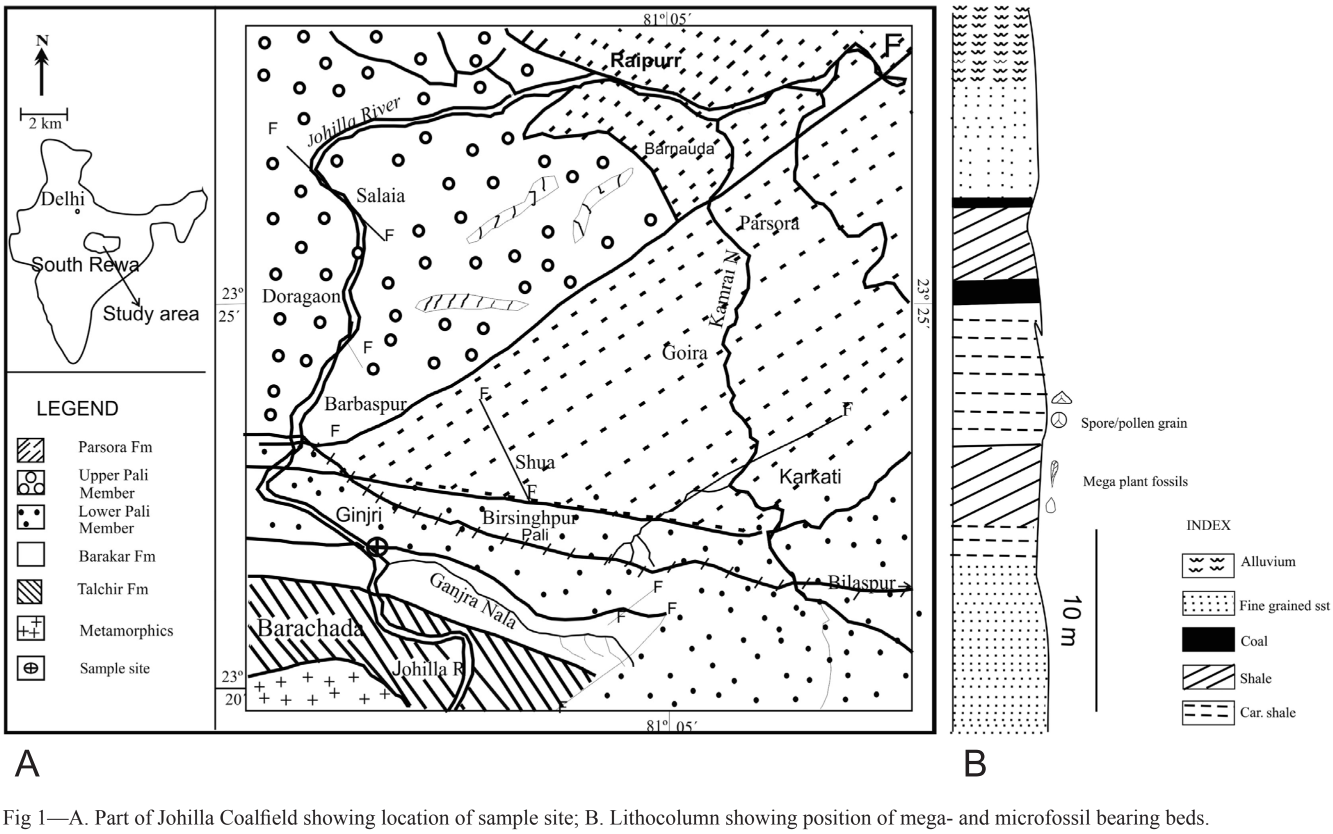

Fig 1—A. Part of Johilla Coalfield showing location of sample site; B. Lithocolumn showing position of mega- and microfossil bearing beds.

Formation & thickness	Lithology	Age
Deccan Trap	Basalt flow and dolerite Dykes.	Upper Cretaceous to Eocene
Lameta Bed (30 m)	White impure marlstone, pinkish to white sandstone.	Upper Cretaceous
Hartala Hill (300 m)	White coloured medium- to coarse-grained sandstone with Lower clay clast having siliceous matrix; often with ferruginous cement with medium-grained white coloured cross-bedded sandstone.	Early Jurassic
---------- Gradational contact ----------		
Parsora (200 m)	Pink, red and lavender coloured mudstone and minor brownish silty shale with interbeds of medium- to fine-grained arenite or sandstone containing clasts of various sizes.	Late Noric to Rhaetic
Tiki (200 m)	Red clay, buff coloured fine- to medium-grained sandstone with calcareous cement sandstone with partly or fully ferruginised clay clast.	Late Triassic
---------- Gradational Contact ----------		
P Upper Pali (300 m)	Coarse-grained arkosic sandstone. The granules and pebbles, and fresh quartz felspars occur as clast with siliceous matrix.	Early to Middle Triassic
A Middle Pali	White to grey coloured medium- to coarse-grained arkosic sandstone, grey shale, carbonaceous shale and coal seams.	Late Permian
L Lower Pali	Alternate band of red and green clay with medium- to coarse-grained arkosic sandstone.	Middle Permian
I		
---------- Unconformity ----------		
Barakar (+280 m)	Coarse-grained, calcareous sandstone, thin shale and siltstone bands, seven regionally distributed coal beds (Seams I to V; L 1 and L 2); fine-grained calcareous sandstone, interlaminated rippled sandstone, shale, and thin discontinuous coal beds.	Late Early Permian
Talchir (+275 m)	Matrix supported conglomerate, medium- to coarse-grained cross bedded sandstones containing rounded quartz pebbles and rock fragments, green to buff coloured very fine- to fine-grained sandstones.	Early Permian
Pre-Cambrian	Surguja Complex Crystalline Basement.	Early Proterozoic

Table 1—The general lithological succession of the South Rewa Gondwana Basin.

GEOLOGY

The pioneer worker Medlicott (1860) surveyed the central part of the Nerbudda area, South Rewa Gonwana Basin. Later, Hughes (1881, 1884) systematically studied and mapped the area. Fox (1934) gave a brief geological account of the Johilla Coalfield and designated Talchir, Barakar and Supra-Barakar formations in this area. The Supra-Barakar formations encompass - Pali, Tiki and Parsora formations. The general lithological succession in the area is given below (after Raja Rao, 1983; Mitra, 1993).

Metamorphic rocks cover an area of 20.72 km^2 lying in the southern part of the coalfield. In the northern part, the basement rocks are overlain by the Talchir Formation and partly by alluvium. In Johilla Coalfield, Barakar sediments are exposed in south and south-west of Birsinghpur Pali township. These rocks are also exposed north-east of Mangthar Village and at the junction of Ganjra Nala with Johilla River about 4.5 km south west of Pali. The Barakar sediments consist of yellowish to greyish feldspathic siliceous sandstone, shale, carbonaceous shale and coal seams. The Supra-Barakar sediments are highly ferruginous in composition and characterized by different shades of colours (buff, lilac, green and red).

The Lameta rocks unconformably overlie the Supra-Barakar formations and exposed at the fringes, near Ponri Village. These are limestone, mostly gritty and rarely crystalline. The trap-flows exposed in the area are mostly continuation of the Deccan Traps (Hughes, 1884).

MATERIAL AND METHODS

The material for the present investigation was collected by two of us (R.A. & S.G.), about 100 m north of Shiv Temple (between 23º20'52.3" N lat.: 81º01'25.6" E long.) along the right bank of Johilla River near the confluence of Johilla with Ganjra Nala, Umaria District, Madhya Pradesh (Figs 1A & B). The specimens are mostly preserved as impressions on fine-grained grey carbonaceous shales and coal. The mega plant fossils are preserved on the shales below the coal seams exposed along the Johilla River Section. The palynological samples were collected from the bottom carbonaceous shale and coal samples shown in Fig. 1. For the recovery of spores and pollen grains, samples were crushed into smaller pieces (2-3 mm in size) and treated with hydrofluoric acid (40% concentration) to dissolve the siliceous component, followed by nitric acid to digest the organic matter and finally 5-10% alkali to remove the humus. The samples were thoroughly washed with distilled water and the residue was mixed with polyvinyl alcohol and smeared over cover glass and kept for drying at room temperature. After complete drying, the cover glasses were mounted with canada balsam. The samples were studied and photographed with the help of high power Olympus Microscope (B.H. 2 Model, No. 216294).

PALYNOLOGICAL ASSEMBLAGE

The palynoflora recovered from the Johilla River Section near the Johilla-Ganjra Nala confluence has yielded the palynotaxa *Parasaccites* (21%), *Plicatipollenites* (15%), *Potonieisporites* (5%), *Virkkipollenites* (7%), *Pachysaccus* (18%), *Callumispora* (3%), *Cyclogranisporites* (1%), *Microbaculispora* (1%), *Crucisaccites* (4%), *Barakarites* (2%), *Caheniasaccites* (5%), *Faunipollenites* (3%), *Crescentipollenites* (3%), *Striatopodocarpites* (2%), *Striatites* (1%), *Lunatisporites* (1%), *Sahnites* (3%), *Tiwariasporis* (4%) and *Vesicaspora* (1%). The palynofloral assemblage indicates an Early Permian age.

PALYNOLOGICAL CORRELATION

The *Parasaccites* dominated palynoflora in association with other monosaccate genera, namely–*Plicatipollenites, Caheniasaccites, Pachysaccus* and *Crucisaccites* along with poor representation of nonstriate bisaccate pollen, is comparable with Upper Karharbari palynoflora of Damodar Basin (Srivastava, 1973; Bharadwaj, 1974); Godavari Basin (Srivastava & Jha, 1995; Jha & Sarate, 2001; Jha & Aggarwal, 2010) and Satpura Basin (Srivastava & Sarate, 1989). The present record of palynoassemblage shows the dominance of high percentage of *Parasaccites* while trilete and striate bisaccate taxa are low. Similar palynoflora is known from Umaria Coalfield (Maithy, 1966; Chandra & Srivastava, 1986), Johilla Coalfield (Srivastava & Anand-Prakash, 1984; Tiwari & Ram-Awatar, 1989) and Chandra & Srivastava, 1986 from Anuppur and Chirimiri coalfields.

SYSTEMATICS

Division—Gymnospermous

Order—Glossopteridales

Genus—*Gangamopteris* McCoy, 1847

Type species—***Gangamopteris angustifolia*** McCoy, 1847

Species—***Gangamopteris major*** Feistmantel 1879a

(Pl. 2.1)

Description—There are two incomplete leaf impressions. The leaves are medium to large in size. The preserved leaves are 8-11.5 cm long and 3-4.5 cm broad. The length/width ratio is 4 : 1. The leaves are narrow, lanceolate with margin entire, midrib absent. The secondary veins arch, dichotomize and anastomose to form narrow elongated meshes. Meshes are 4.5 mm long and 0.5 mm broad. Vein density is 18-20 per cm throughout the lamina.

Specimen No.—BSIP Museum Specimen No. 40133.

Horizon—Barakar Formation (Lower).

Remarks—The present leaves are comparable with *Gangamopteris major* described by Feistmantel 1879a (pl. 14, fig. 3; pl. 16, fig. 16), Maithy (1965a, pl. 1, fig. 7) and Singh *et al.* (2006, pl. 1, fig. 3) in their narrow, elongate shape and linear mesh pattern.

Gangamopteris cyclopteroides Feistmantel 1879a

(Pl. 2.2, 4, 5)

Description—There are four leaf impressions in the present collection. Leaves measure 10-15 cm in length and 2.2-6.6 cm in width. Leaves spathulate, margin entire and midrib absent. The middle portion of the leaves has thick and sub–parallel veins in the lower part; during upward course they diverge to form secondary veins. Lateral veins emerge at an angle of 10°-14°, arch backwards and meet the margin at about 50°. The concentration of veins is 18-24 per cm near the base, 22-28 per cm in the middle and 26-32 per cm in the apical part of the leaf. Veins dichotomize and anastomose to form linear oblong and polygonal meshes in the middle part and linear narrow meshes towards the margin of the leaves.

Specimen No.—BSIP Museum Specimen No. 40134, 40136, 40137.

Horizon—Barakar Formation (Lower).

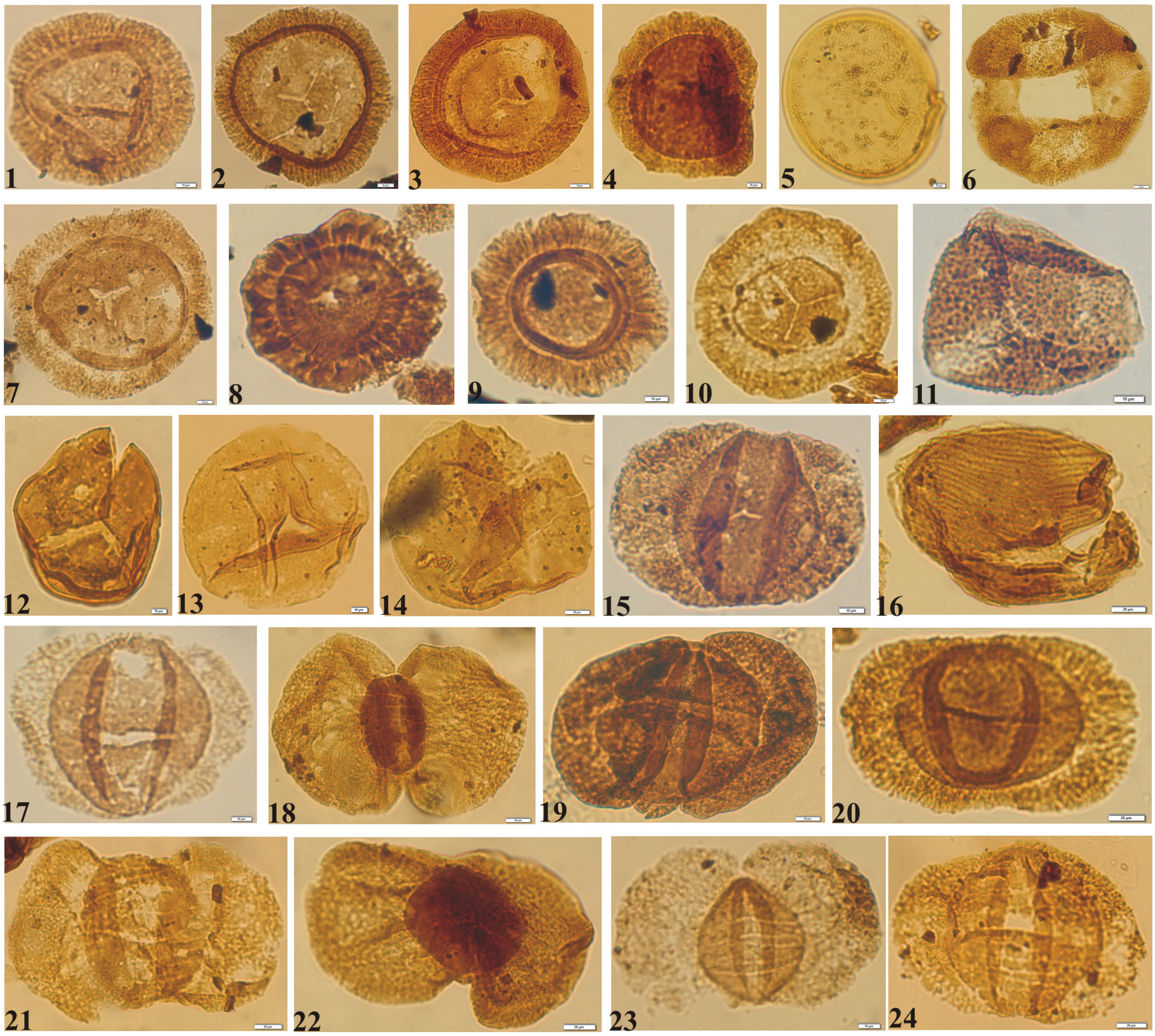

PLATE 1

1. *Plicatipollenites trigonalis*
2. *Pachysaccus radialis*
3. *Plicatipollenites angularis*
4. *Parasaccites densicorpus*
5. *Punctatisporites uniformis*
6. *Crucisaccites monoletus*
7. *Pachysaccus rotates*
8. *Parasaccites talchirensis*
9. *Virkkipollenites latisaccus*
10. *Parasaccites* sp.
11. *Microbaculispora indica*
12. *Callumispora gretensis*
13. *Leiotriletes* sp.
14. *Leiotriletes* sp.
15. *Sahnites gondwanensis*
16. *Tiwariasporis gondwanensis*
17. *Sahnites barrelis*
18. *Striatites* sp.
19. *Crucisaccites latisulcatus*
20. *Sahnites jayantiensis*
21. *Striatopodocarpites* sp.
22. *Rhizomaspora indica*
23. *Crescentipollenites amplus*
24. *Crescentipollenites fuscus*

Remarks—The present leaves resemble with *Gangamopteris cyclopteroides* described by Feistmantel (1879a, pls. 7, 9, 11, figs 2, 34; pl. 10, fig. 3; pl. 12, figs 2, 3; pl. 13, figs 1, 5; pl. 26, figs 1, 3; pl. 27, figs 1, 2, 3,1a, 1b) in absence of midrib, having 4-5 sub-parallel median veins, spathulate shape, narrow contracted base, lateral veins forming narrow, oblong, polygonal meshes. *Gangamopteris cyclopteroides* has additionally been recorded by Chandra and Srivastava (1982; pl. 1, fig. 1; pl. 3, fig. 25) and Chandra *et al.* (1992; pl. 2, fig. 1) from the Talchir Formation of the South Rewa Gondwana Basin, Madhya Pradesh.

Genus—*Glossopteris* Brongniart, 1828

Type species—*Glossopteris browniana,* Brongniart, 1828

Glossopteris gigas Pant & Singh 1971

(Pl. 2.13)

Description—The only incomplete leaf is 6.5 cm long and 3.5 cm wide and has length/width ratio of 1.5-2 : 1. The leaf is wide, elliptic, apex not preserved, base slightly broken, apparently acute-cuneate. The midrib is prominent and 1.5 mm thick. Secondary veins emerge at an angle of 12º-18º, arch out in gentle curves and meet the margin at 55º-65º in the middle part of the leaf. Average concentration of veins is 15-18 per cm near midrib and 18-20 per cm near the margin.

Specimen No.—BSIP Museum Specimen No. 40140.

Horizon—Barakar Formation (Lower).

Remarks—The present leaf resembles with the figures and specimens of *Glossopteris gigas* (Pant & Singh, 1971, pl. 3 figs 10, 14; Chandra & Surange, 1979, pl. 12, fig. 1; pl. 16, fig. 6; pl. 25, fig. 1) in its size, shape and the venation pattern, and other records of *Glossopteris gigas* are described by Goswami (2006, fig. 5a) from the Ib River Coalfield, Mahanadi Basin, Odisha and Tewari (2007, pl. 2, fig. 3; pl. 3, fig. 2) from the Kamptee Coalfield, Wardha Basin, Maharashtra.

Glossopteris indica Schimper 1869

(Pl. 2.3)

Description—There is one incomplete leaf impression in the collection. The apex and base of the leaf not well preserved. Leaf is 12 cm long and 3 cm broad. The shape of leaf is lanceolate and margin is entire. Midrib is distinct, 3 mm broad at basal part and 1.1 mm broad towards apex, 4-5 deep striations are present over the surface of the midrib. The secondary veins arise from the midrib at an angle of 45°. They dichotomize and anastomose to form polygonal, open meshes near the midrib and narrow, elongate meshes towards the margin. Meshes are 3-4 mm long and 0.3-0.4 mm broad near the midrib and 2.5-3.5 mm long and 0.2-0.7 mm wide near the margin. The vein density is 15-20 veins per cm near midrib and 20-28 veins per cm near margin.

Specimen No.—BSIP Museum Specimen No. 40135.

Horizon—Barakar Formation (Lower).

Remarks—The present leaf is lanceolate in shape with broad persistent midrib, polygonal broad meshes near the midrib and narrow, linear meshes near margin and is comparable to *Glossopteris indica* Schimper described by Rigby *et al.* (1980, figs 38-41). The present leaf is similar to *G. indica* described by Srivastava (1977, pl. 1, figs 1, 2, text figs, A-B) from Auranga Coalfield, Srivastava and Tewari (1996; pl. 2, fig. 2) from Barakar Formation, Auranga Coalfield, Tewari and Srivastava (1996, pl. 2, fig. 2) from Jharia Coalfield, Tewari and Srivastava (2000, pl. 2, fig. 2) from Bhareli Formation, Arunachal Pradesh and Singh *et al*. (2006) from the Ib River Coalfield, Odisha.

Glossopteris mohudaensis Chandra & Surange, 1979

(Pl. 2.7)

Description—A single specimen consisting of the middle portion of leaf, measures 8 cm in length and 3.5 cm in width at its widest. The midrib is thick, distinct and 4 mm broad. Secondary veins arise from midrib at an angle of 70°-90°, dichotomize and anastomose to form polygonal, narrow, elongate meshes throughout the lamina. Meshes are 3-4 mm long and 0.3-0.4 mm broad throughout the lamina. The density of veins is 20-22 veins per cm near the midrib and 24-26 veins per cm near the margin.

Specimen No.—BSIP Museum Specimen No. 40139.

PLATE 2

(Scale bar =1 cm, except figs Nos 8 &11 scale bar = 0.5 cm)

1. *Gangamopteris major* BSIP Specimen No. 40133.
2. *Gangamopteris cyclopteroides* BSIP Specimen No. 40134.
3. *Glossopteris indica* BSIP Specimen No. 40135.
4. *Gangamopteris cyclopteroides* BSIP Specimen No. 40136.
5. *Gangamopteris cyclopteroides* BSIP Specimen No. 40137.
6. *Noeggerathiopsis hislopii* BSIP Specimen No. 40138.
7. *Glossopteris mohudaensis* BSIP Specimen No. 40139.
8. *Samaropsis goraiensis* BSIP Specimen No. 40134.
9. *Gangamopteris major* BSIP Specimen No. 40136.
10. *Cordaicarpus zeilleri* BSIP Specimen No. 40136.
11. *Alatocarpus indicus* BSIP Specimen No. 40139.
12. Equisetalean axes BSIP Specimen No. 40141.
13. *Glossopteris gigas* BSIP Specimen No. 40140.

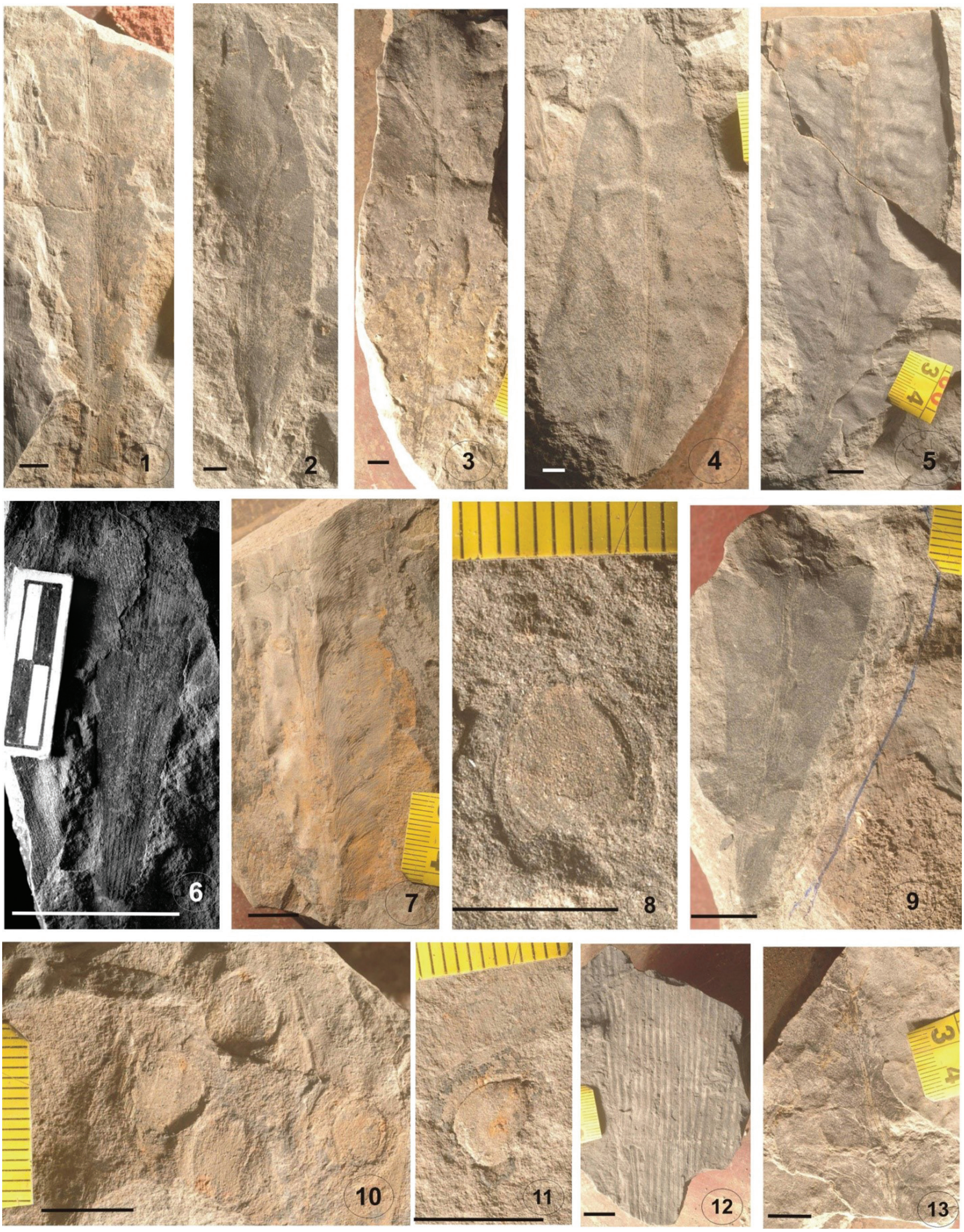

PLATE 2

Remarks—The present specimen having thick midrib and narrow–elongate meshes resembles *Glossopteris mohudaensis* described by Chandra and Surange 1979 (pl. 11, fig. 2; pl. 18, fig. 14; pl. 46, fig. 2).

Order—Cordaitales

Genus—*Noeggerathiopsis* Feistmantel, 1879c

Type species—*Noeggerathiopsis hislopii* (Bunbury) Feistmantel, 1879c

Noeggerathiopsis hislopii (Bunbury) Feistmantel, 1879c

(Pl. 2.6)

Description—The only leaf is lanceolate- spathulate in shape, 6 cm long, 1.4 cm broad at the base and 2.6 cm broad near the apex. The apex is not preserved, margin entire, base tapering and narrow. Several parallel veins arise from the base, run straight and bifurcate frequently along their course. The vein density is 14-20 veins per cm at base and 14-16 veins per cm in the upper part of the leaf.

Specimen No.—BSIP Museum Specimen No. 40138.

Horizon—Barakar Formation (Lower).

Remarks—The spathulate leaf with dichotomizing parallel veins resembles *Noeggerathiopsis hislopii* described by Feistmantel (1879a, pl. 19, fig. 5; pl. 19; figs 1-6; pl. 20, fig. 1) from Karharbari Formation of Karanpura Coalfield, Giridih.

Equisetalean axes

(Pl. 2.12)

Description—There are six specimens of unbranched axes in our collection that measure 6-9.5 cm in length and 2.4 cm in width. Most of them have well preserved nodes and internodes. Alternating ridges and furrows are present on the internodes, ridges are 2 mm apart. No branching is observed.

Specimen No.—BSIP Museum Specimen No. 40141.

Horizon—Barakar Formation (Lower).

Seeds

Genus—CORDAICARPUS Geinitz, 1862

Type species—*Cordaicarpus cordai* Geinitz, 1862

Cordaicarpus zeilleri Maithy, 1965b

(Pl. 2.10)

Description—There are four well-preserved seed impressions in the collection. Seeds platyspermic, pear-shaped with cordate or oval base, pointed apex and 9-10 mm long and 7-8 mm broad. A narrow border of sarcotesta of 0.9-1 mm in size, encircles the sclerotesta uniformly. Several striations are present on the surface of sclerotesta, sometimes faint median ridge is also seen from base to apex. Usually a thin carbonized crust is preserved on the seeds.

Specimen No.—BSIP Museum Specimen No. 40136.

Horizon—Barakar Formation (Lower).

Remarks—The present seeds closely resemble with *Cordaicarpus zeilleri* described by Maithy 1965b (pl. 1, figs 1, 2, 3; text-figs 1, 2) from Karharbari Formation of Giridih Coalfield, in being platyspermic, possessing narrow border of sarcotesta, cordate base, acute or roundly acute apex and absence of median ridge. Our specimens also resemble *Cordaicarpus zeilleri* described by Maithy (1966, pl. 1, fig. 5) from Karharbari Formation of Umaria Coalfield, Lele and Makada (1974, pl. 1, fig. 3) from Jayanti Coalfield, Maithy (1969) from Daltonganj Coalfield, Bajpai (1990) from Deogarh Coalfield and Srivastava (1992) from Raniganj Coalfield. Recently *C. zeilleri* was reported from Barakar Formation of Umrer Coalfield, Wardha Basin (Tewari *et al*., 2012).

Genus—ALATOCARPUS Lele, 1969

Type species—*Alatocarpus indicus* Lele, 1969

Alatocarpus indicus Lele, 1969

(Pl. 2.11)

*Description—*This specimen is represented by a single well preserved seed in the collection. Seed is oval to sub-circular in outline, measuring 1 cm long and 1.2 cm broad. Seed is compressed, platyspermic, sarcotesta well spread equally on either side of the sclerotesta in the transverse direction. A shallow to deep depression or sinus is present in sarcotesta at two ends, seed surface shows fine striations. Sarcotesta distinct, about 3 mm wide.

The sclerotesta is 0.8 cm long and 0.6 cm wide, pear-shaped projected on one end (distal) into two beak- like structures (micropyle) with a narrow cleft in between with a sharp tip. Beak contains distal sinus, sarcotesta connected laterally with sclerotesta. A strong median longitudinal groove or ridge runs from apex to base across the whole length of sclerotesta.

Specimen No.—BSIP Museum Specimen No. 40139.

Horizon—Barakar Formation (Lower).

Remarks—The present seed resembles *Alatocarpus indicus* described by Lele 1969 (pl. 1, figs 1-4, text-figs 1, 2) from Karharbari Formation of Singrauli Coalfield in being large and broad with wings and having median longitudinal groove. *Alatocarpus indicus* shows same kind of general organization as *A. johillensis*. It does not possess a distal inclination like that of *A. johillensis,* it is about 60º from transverse axis. Secondly, the median longitudinal ridge in *A. indicus* is more obvious and runs the entire length, whereas it is short and rather inconspicuous in *A. johillensis*.

Genus—SAMAROPSIS Göeppert, 1864

Type species—*Samaropsis ulmiformis* Göeppert, 1864

Samaropsis goraiensis Surange & Lele, 1957

(Pl. 2.8)

Description—There is one specimen in our collection. Seed pear-shaped, 12 mm long and 10 mm broad. Sclerotesta is 9 mm long and 7 mm wide. Sarcotesta thick and encircles the sclerotesta expect at apex and base. It has median sinus at apex and broad V-shaped notch at the base. Base of sarcotesta is 1.2 mm wide, which narrows in middle (1 mm) and is 0.2 mm wide towards the apex.

Specimen No.—BSIP Museum Specimen No. 40134.

Horizon—Barakar Formation (Lower).

Remarks—In being platyspermic, having thick sarcotesta around sclerotesta, median sinus at apex, V-shaped notch at base and cordate sarcotesta the present seed closely resembles *Samaropsis goraiensis* described by Surange and Lele (1957, pl. 1, figs 3, 4, 14, text-fig. 3) from Talchir Formation of South Rewa Gondwana Basin, M.P. The seed described here resembles with the specimens described by Maithy (1965b, pl. 1, figs 9, 10, text-fig. 6) from the Karharbari Formation of Giridih Coalfield, Lele and Makada (1974, Pl. 1, fig. 2) from the Karharbari Formation of Jayanti Coalfield and by Rigby *et al*. (1980, figs 51, 52) from Australia.

DISCUSSION

There is difference of opinion regarding the age of the sediments of Johilla-Ganjra Nala confluence. On the basis of mega- and palynofossils, Early Permian age (Karharbari affinity) was assigned by Saksena (1952, 1971). Based on the

Name of Taxa / Name of Basins/Coalfields	Rajmahal Basin	Mahanadi Basin		Damodar Basin						South Rewa Gondwana Basin			Wardha-Godavari Basin	
		Ib River	Talchir	Raniganj	Jharia	Karanpura	Giridih	Bokaro	Auranga	Singrauli	Korba	Johilla	Godavari	Wardha
Gangamopteris cyclopteroides Feistmantel, 1876	-	+	-	+	-	-	+	-	+	-	+	+	-	+
Gangamopteris major Feistmantel, 1879	-	+	+	+	-	+	+	-	+	+	-	+	-	-
Glossopteris gigas Pant & Singh, 1971	-	+	+	+	-	-	-	-	-	-	+	+	-	+
Glossopteris indica Schimper, 1869	+	+	-	+	+	+	-	-	+	-	+	+	+	-
Glossopteris mohudaensis Chandra & Surange, 1979	-	+	-	-	-	-	-	-	-	-	-	+	+	-
Noeggerathiopsis hislopii Feistmantel, 1879	-	+	-	+	-	+	+	-	+	-	+	+	-	-
Alatocarpus indicus Lele, 1969	-	-	-	-	-	-	-	-	-	+	-	+	-	-
Cordaicarpus zeilleri Maithy, 1965	+	-	-	+	-	-	+	-	-	-	-	-	-	-
Samaropsis goraiensis Surange & Lele, 1957	-	-	-	-	-	-	+	-	-	-	-	+	-	-

Table 2—Comparative distribution of plant fossils recorded from Johilla –Ganjra Nala confluence with other Lower Gondwana Basins of India.

physical and chemical analysis of the sediments of Ganjra Nala and adjoining areas, Basu (1964) suggested Karharbari age to these sediments. Lele and Maithy (1969) recorded the dominance of monosaccates- *Parasaccites, Plicatipollenites, Potonieisporites, Crucisaccites, Rugasaccites* and *Stellapollenites* along with *Faunipollenites, Lunatisporites* and *Gondisporites* indicating an Early Permian age showing affinity with the Karharbari Formation of the Damodar Basin to the Ganjra Nala bed. Similar age was also assigned by Chandra and Srivastava (1982) on the basis of palynological study. Anand-Prakash and Srivastava (1984) studied the sediments of Ganjra Nala-Johilla confluence and recorded Upper Karharbari to Upper Barakar palynoassemblages. Tiwari and Ram Awatar (1989) observed that the palynoflora of the Johilla Coalfield is peculiar than the other basins of Indian Gondwana. In the other basins the monosaccates decline in the Barakar Formation, while in Johilla Coalfield, monosaccate pollen grains are recorded in high percentage in the Barakar Formation. This may be due to the latitudinal difference because South Rewa Basin occupies low lying area and is closer to the South Pole as compared to the Damodar Basin (Tiwari & Ram-Awatar 1989).

Quantitative and qualitative analyses of the plant fossil assemblage shows the occurrence of *Gangamopteris, Glossopteris, Noeggerathiopsis,* equisetalean axes and a variety of seeds. The flora is comparable with the known plant fossil assemblages of the Karharbari Formation of Lower Gondwana sequence (Feistmantel, 1879a, b; Kulkarni, 1971; Srivastava, 1977; Singh *et al.,* 2006) reported from Damodar, Satpura and Mahanadi basins of Indian Gondwana.

A comparative distribution of plant megafossils collected from Johilla- Ganjara Nala confluence known to that of other basins of Lower Gondwana in India is given in Table 2.

CONCLUSIONS

Prior to the present study, no mega/palynofloral assemblages were reported from the studied area, though, Lele and Maithy (1964, 1969) and Saksena (1963, 1971) recorded mega- and palynofloral assemblages from the Ganjra Nala Section, adjacent to the present study area showing Karharbari affiliation. The mega- and palynofloral data suggests an Early Permian age corresponding to the Upper Karharbari / Lower Barakar formations.

Srivastava and Anand-Prakash (1984) reported the Lower and Upper Barakar palynofloras from Johilla Coal Mine and Ganjra Nala confluence, from the same locality. In the former assemblages non-striate bisaccate pollen *Scheuringipollenites* has been reported which is a characteristic palynomorph of the Barakar Formation, however, in the present assemblage *Scheuringipollenites* has not been recorded, therefore, it is possible that their collection probably belonged to the younger horizon of the Johilla Coal Mine showing Lower and Upper Barakar palynofloral affinities.

Acknowledgements—We are thankful to Prof. Sunil Bajpai, Director, Birbal Sahni Institute of Palaeobotany, Lucknow for granting permission to publish the paper. One of the authors (SG) is thankful to the authorities of UGC for granting the financial support (RGNF) to carry out the Ph.D. work at the Institute. Thanks are due to Dr. Nilay Govind for modifying the table and plates.

REFERENCES

Anand-Prakash & Srivastava SC 1984. Miofloral studies of the Lower Gondwana sediments in Johilla Coalfield, Madhya Pradesh, India. Palaeobotanist 32: 243-252.

Bajpai U 1990. Floristic, age and stratigraphical position of fossiliferous band in Chitra Mine area, Saharjuri Outlier, Deogarh Coalfield, Bihar. Palaeobotanist 37: 306-315.

Basu TN 1964. On the inter-correlation of Gondwana coalfields, Bihar, India. Mines Metals Review, November: 1-31.

Bharadwaj DC 1974. Palaeobotany of Talchir and Karharbari formations and Lower Gondwana glaciations. *In*: Surange KR, Lakhanpal RN & Bharadwaj DC (Editors)—Aspects and Appraisal of Indian Palaeobotany: 369-385. Birbal Sahni Institute of Palaeobotany, Lucknow.

Biswas B 1955. Geology of the Kurasia Coalfield around Chirimiri area, South Rewa Gondwana Basin, Madhya Pradesh. Quaterly Journal of the Geological, Mining and Metallurgical Society of India 27: 39-65.

Brongniart A 1828. Histoire Des Vegetaux Fossiles, Vol. 1. W Junk Berlin W Sachsische Str. 68.

Chandra A & Srivastava AK 1981. A new species of *Arberia* from the Lower Gondwana of the South Rewa, Gondwana Basin, India. Palaeobotanist 28-29: 40-45.

Chandra A & Srivastava AK 1982. Plant fossils from Talchir and coal-bearing formations of South Rewa Gondwana Basin, India and their biostratigraphical significance. Palaeobotanist 30: 143-167.

Chandra A & Srivastava AK 1986. Palynological studies of coal measures in South Rewa Gondwana Basin and their biostratigraphical significance. Palaeobotanist 35: 85-92.

Chandra S, Srivastava AK & Singh KJ 1992. Lower Permian plant fossils from India and early developmental history of the *Glossopteris* flora. Acta Palaeobotanica 32: 5-19.

Chandra S & Surange KR 1979. Revision of the Indian species of *Glossopteris*. Monograph No. 2. Birbal Sahni Institute of Palaeobotany. Lucknow, India.

Deshmukh GP 1971. Johilla Coalfield. Memoirs of the Geological Survey of India 88: 283-287.

Feistmantel O 1879a. The fossil flora of Lower Gondwana System. The flora of the Talchir-Karharbari beds. Memoirs of the Geological Survey of India, Palaeontologia Indica 12: 1- 48.

Feistmantel O 1879b. Palaeobotanical Notes from Satpura Coal Basin. Records of the Geological Survey of India 12: 74-83.

Feistmantel O 1879c. Notes on the fossil genera *Noeggerathia*, Stbg., *Noeggerathiopsis*, Fstm., *Rhiptozamites*, Schmlh.in Palaeozoic and secondary rocks of Europe, Asia and Australia. Records of the Geological Survey of India 13: 61-64.

Feistmantel O 1882. Fossil flora of Gondwana System in India-1. The fossil flora of the South Rewa Gondwana Basin. Memoirs of the Geological Survey of India, Palaeontologia Indica Series 12: 1-52.

Fermor LL 1914. Geology and coal resources of Korea State. Memoirs of the Geological Survey of India 41: 148-245.

Fox CS 1932. Gondwana System and related formations. Memoirs of the Geological Survey of India 58: 1-241.

Fox CS 1934. The Lower Gondwana coalfields of India. Memoirs of the Geological Survey of India 59: 1-386.

Geinitz HB 1862. Dyas oderdie zechstein Formation und das Rothliegende H.Z. Die pfanzen-der Dyas und Geologishes: 131-342. Wilhelm Engelmann. Leipzig.

Göeppert HR 1864. Die fossile flora der Permischen Formation. Palaeontographica 12: 1-136.

Goswami S 2006. Records of Lower Gondwana megafloral assemblage from Lower Kamthi Formation of Ib River Coalfield, Orissa, India. Journal of Biosciences 31: 115-128.

Hughes TWH 1881. Notes on the South Rewa Gondwana Basin. Records of the Geological Survey of India 14: 126-138.

Hughes TWH 1884. The Southern coalfields of Rewa Gondwana Basin. Umaria, Johilla, Sohagpur, Kurasia, Koreagarh, Jhilimili. Memoirs of the Geological Survey of India 21: 1-68

Jha N & Aggarwal N 2010. Early and Late Permian palynoflora from Lower Gondwana sediments of Gundala area, Godavari Graben, Andhra Pradesh, India. Palaeobotanist 59: 71-80.

Jha N & Sarate OS 2001. Palynological analysis of Lower Gondwana coals from Ramagundam area, Godavari Valley Coalfield, Andhra Pradesh, India. Minetech 22: 25-31.

Kulkarni S 1971. *Glossopteris* and *Gangamopteris* species from South Karanpura Coalfield. Palaeobotanist 18: 297-304.

Lele KM 1969. Studies in the Middle Gondwana Flora-3. Platyspermic seeds and megaspore impressions from the South Rewa Gondwana Basin. Palaeobotanist 11: 13-18.

Lele KM & Maithy PK 1964. Studies in the *Glossopteris* flora of India-15. Revision of epidermal structure of *Noeggerathiopsis*. Palaeobotanist 12: 7-17.

Lele KM & Maithy PK 1969. Miospore assemblage of the Ganjra Nala beds, South Rewa Gondwana Basin, with some remarks on the age of the beds. Palaeobotanist 17: 298-309.

Lele KM & Makada R 1974. Palaeobotanical evidences on the age of the coal-bearing Lower Gondwana Formation in the Jayanti Coalfield, Bihar. Palaeobotanist 21: 81-106.

Maithy PK 1965a. Studies in the Glossopteris flora of India 26. Glossopteridales from Karharbari beds, Giridih Coalfield, India. Palaeobotanist 13: 248-263.

Maithy PK 1965b. Studies in the Glossopteris flora of India 18. Gymnospermic seeds and seed bearing organs from the Karharbari beds of the Giridih Coalfield, Bihar. Palaeobotanist 13: 45-56.

Maithy PK 1966. Studies in the Glossopteris flora of India 33. Fossil plants and miospores from the coal-bearing beds of the Umaria Coalfield with some remarks on the age of the beds. Palaeobotanist 14: 52-60.

Maithy PK 1968. Studies in the Glossopteris flora of India 35. On the new fossil plants from the Ganjra Nala beds, South Rewa Gondwana Basin. Palaeobotanist 16: 219-221.

Maithy PK 1969. Palaeobotany and stratigraphy of the coal-bearing beds of the Daltonganj Coalfield, Bihar. Palaeobotanist 17: 265-274.

McCoy F 1847. On the fossil Botany and Zoology of rocks associated with the coal of Australia. Annual Magazine of Natural History Museum 20: 145, 226, 298.

Medlicott JG 1860. On the geological structure of the central portion of the Narbudda District. Memoirs of the Geological Survey of India 2: 183-267.

Mehta KR 1945. Microfossils from a carbonaceous shale from the Pali beds of South Rewa Gondwana Basin. Proceeding of the National Academy of Sciences, India 14: 125-141.

Mitra ND 1993. Stratigraphy of Pali- Parsora- Tiki formations of South Rewa Gondwana Basin and Permo-Triassic boundary problem. *In:* Dutta KK & Sen S (Editors)—Gondwana Geological Magazine 1993; Birbal Sahni Centenary National Symposium Special Volume: 41-48.

Pant DD & Singh KB 1971. Cuticular structure of some Indian Lower Gondwana species of *Glossopteris* Brongniart Part III. Palaeontographica 135: 1-40.

Raja Rao CS 1983. Coalfields of India Vol. III: Coal resources of Madhya Pradesh, Jammu & Kashmir. Bulletin of the Geological Survey of India, Series A 45: 119-129.

Rigby JF, Maheshwari HK & Schopf JM 1980. Revision of plants collected by J.D. Dana during 1839-1840 in Australia. Geological Survey of Queensland: 1-21.

Saksena SD 1952. Correlation of Gondwana based upon the evidence of fossil plants. Agra University Journal (Science) Research 1: 1-13.

Saksena SD 1963. On fossil flora of Ganjra Nala beds, South Rewa: Part 1. Macrofossils. Palaeobotanist 11: 23-36.

Saksena SD 1971. On fossil flora of Ganjra Nala beds: Part II- Microflora-(A). Dispersed spores and pollen grains. Palaeobotanist 18: 237-257.

Schimper WP 1869. Triate de Paleontologie vegetale. 1 JB Bailliere et Fils, Paris.

Singh KJ, Goswami S & Chandra S 2006. Megafloral assemblage similar to Karharbari biozone from Talchir Coalfield of Mahanadi Basin, Orissa. Journal of the Geological Society of India 68: 277-287.

Srivastava AK 1977. Palaeobotanical evidences for the presence of Karharbari Stage in the Auranga Coalfield: Megaflora. Palaeobotanist 23: 206-219.

Srivastava AK 1992. Plant fossil assemblages from the Barakar Formation of Raniganj Coalfield, India. Palaeobotanist 39: 281-302.

Srivastava AK & Tewari R 1996. Plant fossils from the Barakar Formation, Auranga Coalfield, Bihar. Geophytology 26: 83-88.

Srivastava SC 1973. Palynostratigraphy of the Giridih Coalfield. Geophytology 3: 184-194.

Srivastava SC & Anand-Prakash 1984. Palynological succession of the Lower Gondwana sediments in Umaria Coalfield, Madhya Pradesh. Palaeobotanist 32: 26-34.

Srivastava SC & Jha N 1995. Palynostratigraphy and correlations of Permian-Triassic sediments in Budharam area, Godavari Graben, India. Journal of the Geological Society of India 46: 647-653.

Srivastava SC & Sarate OS 1989. Palynostratigraphy of the Lower Gondwana sediments from Shobhapur Block, Pathakhera Coalfield, Madhya Pradesh. Palaeobotanist 37: 125-133.

Surange KR & Lele KM 1956. Studies in the Glossopteris flora of India 3. Plant fossils from Talchir needle shales from Giridih Coalfield. Palaeobotanist 4: 153-157.

Surange KR & Lele KM 1957. Studies in the Glossopteris flora of India 6. Plant fossils from Talchir beds of South Rewa Gondwana Basin. Palaeobotanist 5: 82-90.

Tewari R 2007. The Glossopteris flora from Kamptee Coalfield, Wardha Basin, Maharashtra, India. Palaeontographica 277**:** 43-64.

Tewari R, Mehrotra NC, Pillai SSK, Pandita SK & Agnihotri D 2012. Gymnospermous seeds from the Barakar Formation of Umrer Coalfield, Wardha Basin, Maharashtra. Palaeobotanist 61: 123-130.

Tewari R & Srivastava AK 1996. Plant fossil assemblage from the Barakar Formation of Jharia Coalfield, Bihar. Geophytology 25: 35-39.

Tewari R & Srivastava AK 2000. Plant fossils from the Bhareli Formation of Arunachal Pradesh North-East Himalaya, India. Palaeobotanist 49: 209-217.

Tiwari RS & Ram-Awatar 1989. *Sporae-dispersae* and correlation of Gondwana sediments in Johilla Coalfield, Son Valley Graben, Madhya Pradesh. Palaeobotanist 37: 94-114.

Virkki C 1946. Spores from the Lower Gondwana of India and Australia. Proceeding of the National Academy of Sciences, India 15: 93-176.