

Early Permian Glossopteris flora from the Sharda Open Cast Mine, Sohagpur Coalfield, Shahdol District, Madhya Pradesh

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ABSTRACT

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Well preserved plant fossil assemblage recorded for the first time from the Barakar Formation of Sharda Open Cast Mine, Sohagpur Coalfield, Shahdol District, Madhya Pradesh is documented in this study. The assemblage comprises the orders Equisetales, Glossopteridales and Cordaitales. Equisetales is represented by unidentifiable leafless equisetalean axes bearing nodes and internodes, Glossopteridales comprises one species of *Gangamopteris* (*Gangamopteris intermedia*) and seven species of *Glossopteris* (*Glossopteris communis*, *G. gigas*, *G. giridihensis*, *G. indica*, *G. longicaulis*, *G. spatulata* and *Glossopteris* sp.), and Cordaitales is known by one species of *Noeggerathiopsis* (*Noeggerathiopsis hislopii*). The floral assemblage is broadly comparable with those described previously from the Barakar Formation of Damodar, Mahanadi, Wardha, Godavari, Rajmahal and Satpura Gondwana basins of India. Since the known records of plant mega fossils from the Barakar Formation of Sohagpur Coalfield are meagre, recovery of quantitatively and qualitatively rich plant fossils from the Sharda Open Cast Mine substantiates the geological and geographical distribution of the Glossopteris flora in India in general and that of the Sohagpur Coalfield in particular, and reflects its significance in the formation of coal in the area.

Key-words—Glossopteris flora, Early Permian, Barakar Formation, Sharda Open Cast Mine, Sohagpur Coalfield.

शारदा विवृत खान, सोहागपुर कोयलाक्षेत्र, जिला शहडोल, मध्य प्रदेश से प्रारंभिक पर्मियन ग्लॉसॉप्टेरिस वनस्पति समूह

दीपा अग्निहोत्री, रजनी तिवारी, एस.एस.के. पिल्लै, आंद्रे जास्पर एवं डीटर उल

सारांश

शारदा विवृत खान, सोहागपुर कोयलाक्षेत्र, जिला शहडोल, मध्य प्रदेश के बराकार शैलसमूह से पहली बार प्राप्त सुपरिष्कृत पादप जीवाश्म समुच्चय इस अध्ययन में प्रलेखित किए गए हैं। समुच्चय में इक्वीसिटेल्ज, ग्लॉसॉप्टेरीडेल्ज एवं कॉर्डईटेल्ज कोटि सन्निहित है। इक्वीसिटेल्ज गॉड एवं अंतःगॉड धारी अनभिज्ञेय पर्णरहित इक्वीसिटेलियन तनों से रूपायित है, ग्लॉसॉप्टेरीडेल्ज *गैंगेमाॅप्टेरिस* की एक जाति (*गैंगेमाॅप्टेरिस इंटरमीडिया*) और *ग्लॉसॉप्टेरिस* की सात जातियों (*ग्लॉसॉप्टेरिस कम्युनिस*, *जी. जाइगस*, *जी. गिरिडिहेन्सिस*, *जी. इंडिका*, *जी. लॉगीकॉलिस*, *जी. स्पेचुलेटा* और *ग्लॉसॉप्टेरिस* जाति) से सन्निहित है तथा कॉर्डईटेल्ज *नैगेरेथियोप्सिस* की एक जाति (*नैगेरेथियोप्सिस हिस्लोपाई*) से ज्ञात है। पादप समुच्चय मोटे तौर पर भारत की दामोदर, महानदी, वर्धा, गोदावरी, राजमहल एवं सतपुड़ा गोंडवाना द्रोणियों के बराकार शैलसमूह के पूर्व वर्णित ग्लॉसॉप्टेरिस वनस्पति समूह के तुल्य है। चूंकि सोहागपुर कोयलाक्षेत्र के बराकार शैलसमूह से प्राप्त पादप स्थूल जीवाश्मों के ज्ञात अभिलेख कम हैं, शारदा विवृत खान से मात्रात्मकता व गुणात्मकता प्रचुर पादप जीवाश्मों की प्राप्ति, सामान्यतः भारत में ग्लॉसॉप्टेरिस वनस्पति समूह के भू-वैज्ञानिक व भौगोलिक वितरण तथा विशेषतया सोहागपुर कोयलाक्षेत्र की ओर क्षेत्र में कोयला उत्पत्ति में, इसकी महत्ता को प्रति स्थापित करता है।

सूचक शब्द—ग्लॉसॉप्टेरिस वनस्पति समूह, प्रारंभिक पर्मियन, बराकार शैलसमूह, शारदा विवृत खान, सोहागपुर कोयलाक्षेत्र।

INTRODUCTION

THE Sohagpur Coalfield is the major coal producing area of South Rewa Gondwana Basin and occupies an east-trending rectangular area in the west-central part of the basin. The coal bearing area lies between latitudes $23^{\circ}05' - 23^{\circ}30'$ and longitudes $81^{\circ}13' - 82^{\circ}12'$ (Fig. 1) and is situated in the Shahdol District, Madhya Pradesh (Raja Rao, 1983). The Barakar Formation is the only coal bearing formation in the coalfield. The coal is being exploited by South Eastern Coalfields Limited (SECL—a subsidiary of Coal India Limited). On the basis of occurrence of coal, the coalfield is divided mainly into three sub basins—Jhagrakhand—Bijuri, Kotma and Burhar—Amlai. The present study area—the Sharda Open Cast Mine (OCM)—is a part of the Burhar—Amlai sub basin.

Previous records of the plant megafossils from the Sohagpur Coalfield are sporadic. Hughes (1881, 1884) and Feistmantel (1882) reported the plant fossils from the Talchir and Barakar formations of Sohagpur Coalfield. Later on, Chandra and Srivastava (1982) recorded some *Glossopteris* floral elements from the Talchir Formation and the coal bearing horizon of the Anupur area of this coalfield.

The present paper entails a systematic and detailed morphotaxonomic study of macrofloral assemblage of the Barakar Formation recorded from the grey carbonaceous shale associated with Burhar seam IV and Burhar VI bottom seam of the Sharda Open Cast Mine (Fig. 2). The assemblage comprises pteridophytes and gymnosperms. The pteridophytes are represented by a single order Equisetales, and the gymnosperms are represented by the Glossopteridales and Cordaitales.

GEOLOGICAL SETTING

The Sohagpur Coalfield comprises over 1,000 m thick sedimentary strata. The Gondwana sedimentary rocks in the area strike WNW—ESE to E—W and dip up to 5° towards north (Pareek, 1987). The Talchir sediments (early Permian) consist of shale, siltstone and boulder beds and unconformably overlie the basement rocks. The overlying 450 m thick Barakar Formation (early Permian) is composed of sandstones with bands of shale, carbonaceous shale and coal seams. This coal bearing formation is subdivided into three members lower, middle and upper. The lower member conformably overlies the Talchir Formation and includes a greyish-white

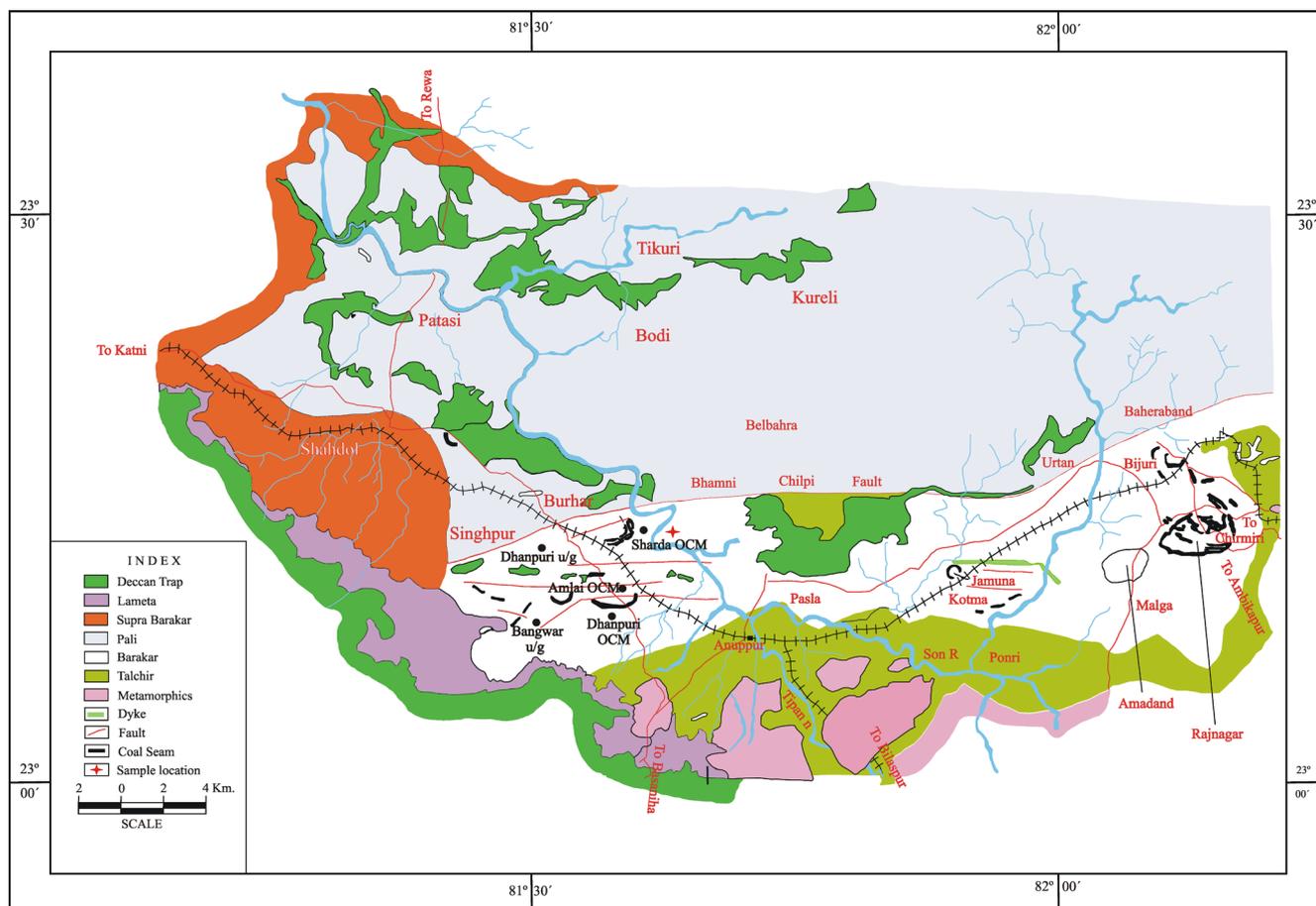


Fig. 1—Geological map of Sohagpur Coalfield showing the fossil locality.

feldspathic garnet sandstone, siltstone and shale, and is devoid of coal seams. The middle member has the maximum thickness and contains cross-bedded feldspathic sandstones with garnet, and thick workable coal seams in the lower portion. The upper member includes ferruginous sandstones, shales, and siltstones. The Pali Formation (late Permian/early Triassic), which overlies the Barakar Formation, is approximately 350 m thick. The Parsora Formation (early Jurassic) is found in the northern part of the basin and includes coarse-grained to pebbly ferruginous sandstones and shales. The overlying Lameta beds (late Cretaceous) contain greenish and reddish, poorly consolidated sandstones and shales with nodular limestone at the top. These beds are separated from the Parsora Formation by a marked unconformity. The coalfield is intruded by dykes and sills (Deccan Trap—late Cretaceous–Eocene). Dolerites are also emplaced along the faults (Dhanam *et al.*, 2013).

The Sharda Open Cast Mine is located in the eastern part of the Burhar–Amlai sub basin of the Sohagpur Coalfield and was started in the year 1986. The area has gently undulating terrain with elevations ranging from 450 to 480 m above the Mean Sea Level. The mine is situated in 6 km east of the Burhar Town in the Sohagpur area and lies approximately between latitudes 23°12'10"–23°13'45" and longitudes 81°35'12"–81°38'08" (Fig. 1). In the Sharda Open Cast Mine, 0.85 million tons of coal is being exploited per annum by high wall mining technique.

MATERIAL AND METHOD

The present study is based on megafossil samples collected from the Barakar Formation of the Sharda Open Cast Mine, Sohagpur Coalfield, Shahdol District, Madhya Pradesh. Plant fossils have been collected from the carbonaceous grey shales above the seam IV and the carbonaceous shales below the Burhar VI bottom seam of the Sharda Open Cast Mine (Fig. 2). The plant fossils are preserved as impressions on shales with fine details of the venation and gross leaf morphology. Around 45 specimens have been studied. The leaves were studied and identified using a hand lens and a low-power binocular microscope (Olympus SZH). Identifications are made according to the leaf shape, nature of apex, base, midrib and venation pattern. We have adopted the terminology given by Lawrence (1955) for the precise determination of the leaf shape, apex and base. For the venation pattern, terminology provided by Melville (1969) and Chandra and Surange (1979) is followed. All the type and figured specimens are deposited in the Repository of the Birbal Sahni Institute of Palaeobotany (BSIP), Lucknow, India vide BSIP Museum Statement No. 1425.

SYSTEMATICS

Order—EQUISETALES

Equisetalean axes

(Pl. 1.1; 1.2)

Description—Unbranched axes with well-preserved nodes and internodes measuring 90–290 mm long and 24–29 mm wide are available in the collection. The distance between nodes is 48 mm, nodes are 1.5 mm wide, vascular bundles alternating at nodes, vascular bundles are 2 mm apart.

Remarks—Sphenophyte axes with vascular bundles that alternate at the nodes occur in most families of Equisetales (e.g. Calamitaceae, Equisetaceae). Such axes without leaves or fertile structures can thus only be determined up to the order Equisetales.

No. of specimens—Two (40895A, 40895B).

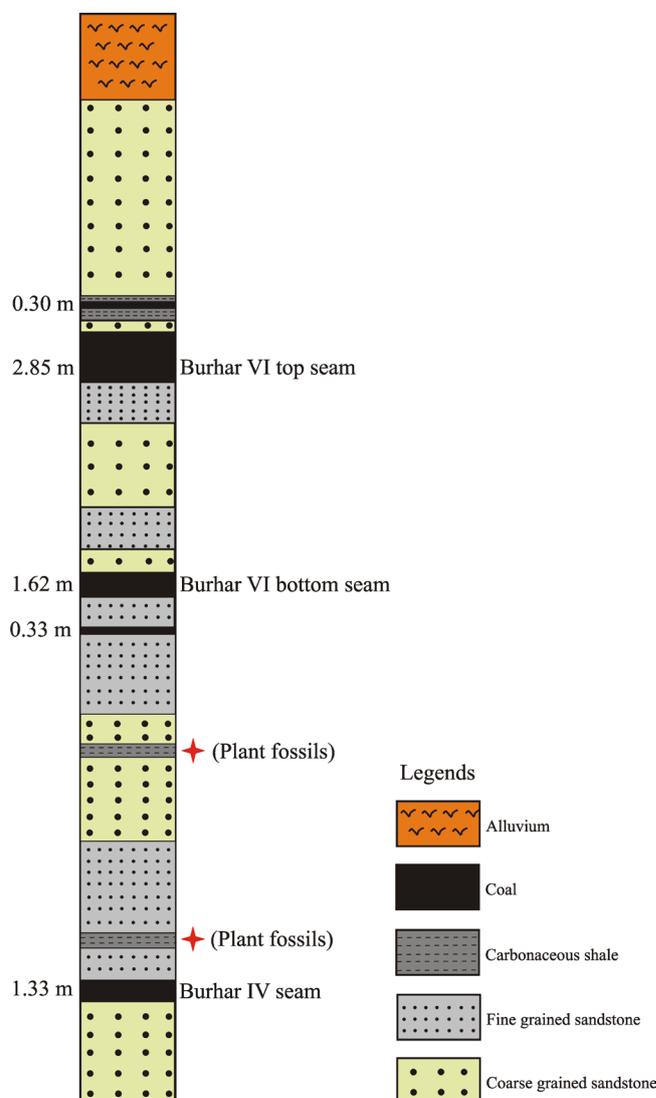


Fig. 2—Litholog of Sharda OCM showing the plant fossil bearing horizons..

Name of taxa	Gondwana basins of India					
	Damodar	Mahanadi	Wardha– Godavari	Satpura	South Rewa	Rajmahal
Equisetalean axes	*	*	*	*	*	*
<i>Gangamopteris intermedia</i>	*			*		
<i>Glossopteris communis</i>	*	*	*	*	*	*
<i>Glossopteris gigas</i>	*	*		*	*	
<i>Glossopteris giridihensis</i>	*	*			*	
<i>Glossopteris indica</i>	*	*	*	*	*	*
<i>Glossopteris longicaulis</i>	*	*	*	*		
<i>Glossopteris spatulata</i>	*	*	*	*	*	
<i>Glossopteris</i> sp.						
<i>Noeggerathiopsis hislopilii</i>	*	*	*	*	*	*

Table 1—Distribution of plant fossil taxa of the Sharda OCM in the Barakar Formation of other Gondwana basins of India.

Order—GLOSSOPTERIDALES**Genus—GANGAMOPTERIS** McCoy, 1875**Type species—*Gangamopteris angustifolia*** McCoy, 1875***Gangamopteris intermedia*** Maithy, 1965

(Pl. 1.3)

Description—A single leaf is present in the collection. Leaf almost complete, small, 35 mm long and 16 mm broad, shape ovate, apex broad, base narrow. Median region is occupied by 5 parallel veins, cross connections are present. Secondary veins arise at about 18° and meet the margin at about 50°. During the course, veins dichotomize and anastomose to form oblong, broader and longer meshes near median region and narrower and shorter ones near the margin. Meshes are 4–5 mm long and 0.4–0.6 mm broad near the median region, 2–3.5 mm long and 0.2–0.3 mm broad near the margin. Vein density is 12–16 per cm near the median region and 18–23 per cm near the margin.

Remarks—The leaf is identical in shape, size, nature of apex, base and venation pattern to *Gangamopteris intermedia*

Maithy (1965, Pl. 3, fig. 21, Pl. 4, figs 22, 24), Chandra and Srivastava (1982, Pl. 1, fig. 4) and Maithy *et al.* (2006, Pl. 1, fig. 6).

No. of specimens—One (40896).

Genus—GLOSSOPTERIS Brongniart, 1828**Type species—*Glossopteris browniana*** Brongniart, 1828***Glossopteris communis*** Feistmantel, 1876

(Pl. 1.4–1.8)

Description—Leaves incomplete, different parts of apical, middle and basal portions of leaf lamina are preserved. Size of the leaves ranges from 54 to 150 mm in length and from 24 to 56 mm in width. Leaves are elliptic–lanceolate, apex obtuse to slightly acute, base narrow, margin entire. Midrib flat, striate, 2–4 mm wide, secondary veins arise from midrib at about 19°–25° and meet the margin at about 45°–60°. After dichotomizing and anastomosing, the secondary veins form arcuate, narrow, elongate meshes. Meshes are 4–6 mm long and 0.2–0.5 mm wide throughout the lamina. Venation dense, density of veins is 15–21 per cm.

PLATE 1

(Scale bar= 1 cm)



- Equisetalean axis, BSIP Museum Specimen No. 40895A (nodes are indicated by arrows).
- Equisetalean axis, BSIP Museum Specimen No. 40895B.
- Gangamopteris intermedia* Maithy, 1965, BSIP Museum Specimen No. 40896.
- Glossopteris communis* Feistmantel, 1876, BSIP Museum Specimen No. 40897.
- Glossopteris communis* Feistmantel, 1876, BSIP Museum Specimen No. 40898A.
- Glossopteris communis* Feistmantel, 1876, BSIP Museum Specimen No. 40899A.
- Glossopteris communis* Feistmantel, 1876, BSIP Museum Specimen No. 40903A.
- Glossopteris communis* Feistmantel, 1876, BSIP Museum Specimen No. 40901.

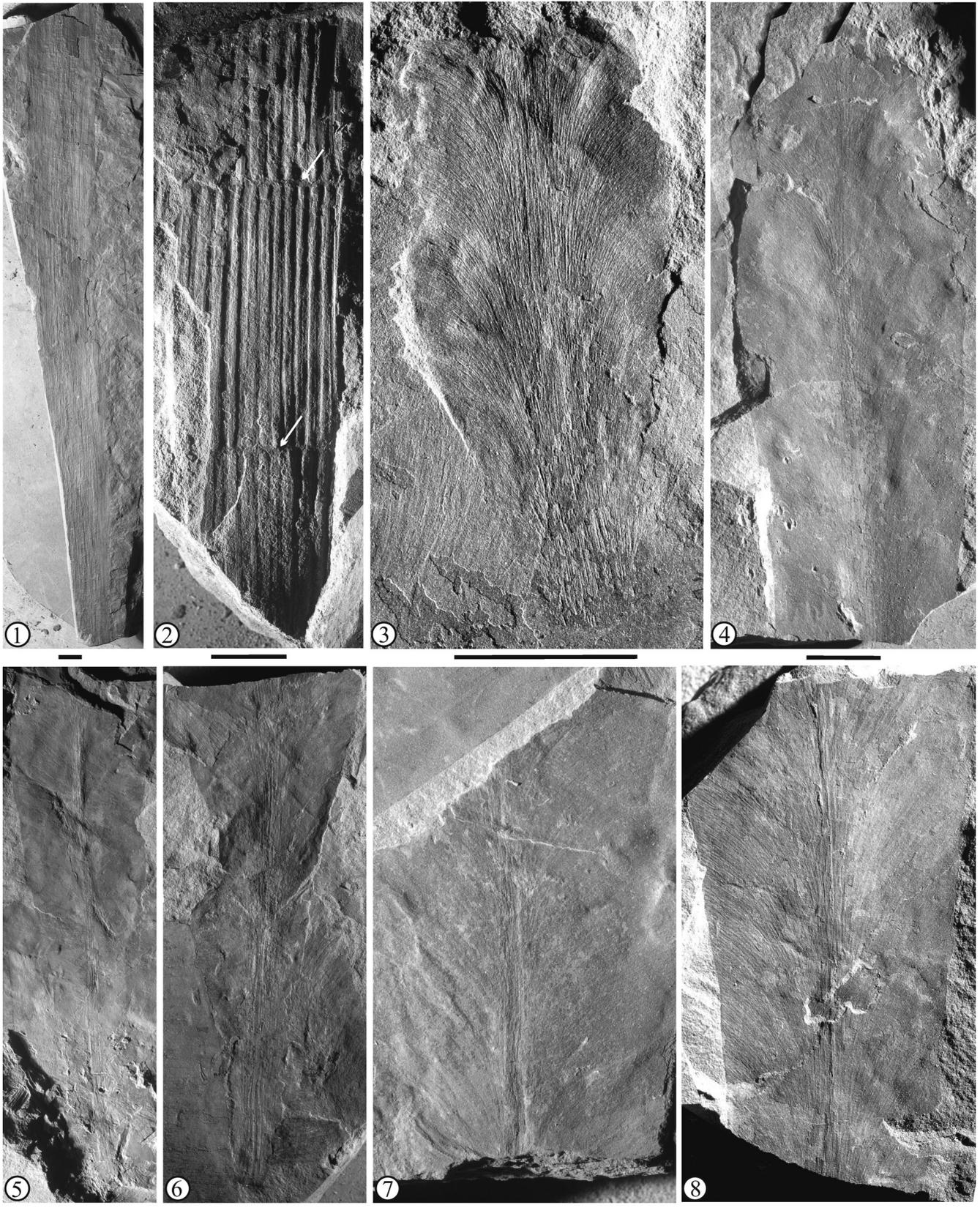


PLATE 1

Remarks—This is the most common species of the genus *Glossopteris* and is recorded from all the lower Gondwana basins of India. The leaves are identical in venation pattern to *G. communis* recorded by Feistmantel (1879, Pl. 17, figs 1, 2), Feistmantel (1882, Pl. 21, figs 13, 14), Feistmantel (1890, Pl. 17, figs 2, 6), Chandra and Surange (1979, Pl. 1, figs 2, 3), Pant and Gupta (1968, Pl. 26, figs 44–49, text-fig. 14), Chandra and Srivastava (1982, Pl. 4, fig. 29), Maheshwari and Tewari (1992, Pl. 1, fig. 2), Singh *et al.* (2006a, Pl. 4, fig. 3), Tewari (2008, Pl. 2, fig. 7) and Tewari *et al.* (2012, figs 5K, L).

No. of specimens—Twelve (40897, 40898A, 40899A, 40900A, 40900B, 40901, 40902, 40903A, 40903B, 40904, 40905, 40906).

***Glossopteris gigas* Pant & Singh, 1971**

(Pl. 2.1–2.3)

Description—Five incomplete leaves are present in the collection. Leaves measure 129–220 mm in length and 26–126 mm in width. Shape apparently ovate, apex broad rounded, base broken, margin entire. Midrib is distinct, flat, striate, persistent, 6 mm wide at base, thinning towards apex, 2 mm wide in apical region. Secondary veins arise at about 40°–45° from the midrib and arch slightly to meet the margin at about 75°–80°. After dichotomizing and anastomosing, they form narrow, elongate meshes throughout the lamina. Meshes are 6–9 mm long and 0.3–0.7 mm broad. The density of veins is 11–20 veins per cm.

Remarks—Leaves resemble the specimens of *Glossopteris gigas* described by Pant and Singh (1971, Pl. 3, figs 10, 14) and Chandra and Surange (1979, Pl. 12, fig. 1, Pl. 25, fig. 1), respectively, in shape, large size, nature of the midrib and venation pattern. The present leaves are also identical to *G. gigas* figured by Chandra and Singh (1992, Pl. 3, fig. 3, Pl. 6, fig. 1), Tewari (2007, Pl. 2, fig. 3, Pl. 3, fig. 2) and Singh *et al.* (2011, Pl. 6, figs 2, 4).

No. of specimens—Five (40907, 40908, 40909, 40910, 40911).

***Glossopteris giridihensis* Pant & Singh, 1971**

(Pl. 2.4)

Description—A single specimen is present in the collection. Leaf incomplete, only middle part is preserved. Size of the leaf fragment is 49 mm in length and 10 mm in width. Shape narrow, oblong, apex and base are absent. Midrib is striate, 3 mm broad in lower region and 2 mm in upper region. Secondary veins arise from midrib at about 19°, slightly arch and meet the margin at about 74°. During their course, the veins dichotomize and anastomose to form narrow, elongate meshes. Meshes are 3–5 mm long and 0.2–0.5 mm broad. Density of veins is 11–17 veins per cm.

Remarks—The leaf is consistent with *Glossopteris giridihensis* described by Pant and Singh (1971, Pl. 20, fig. 29) in small size, shape and venation pattern. The present leaf also resembles *Glossopteris giridihensis* figured by Chandra and Surange (1979, Pl. 47, fig. 4) and Singh and Saxena (2015, Pl. 6, fig. 2) in having similar venation pattern. However, Singh and Saxena (2015) reported the species from the late Permian sediments.

No. of specimens—One (40912A).

***Glossopteris indica* Schimper, 1869**

(Pl. 2.5–2.7)

Description—Eight incomplete leaves are present in the collection. Shape is oblanceolate, elliptic, apex absent, base long, narrow, attenuate, margin entire. Size of leaves ranges from 70–212 mm in length and 29–87 mm in width, midrib distinct, striate, elevated, persistent, 3–6 mm wide at basal region, thinning towards the apex. Secondary veins arise at about 23°–35° from the midrib, slightly arch and meet the margin at about 51°–68°. Veins dichotomize and anastomose to form meshes. Meshes are short, broad, arcuate, 2–4 mm long and 0.6–0.9 mm broad near the midrib, and long, narrow, 6–8 mm long and 0.2–0.4 mm wide elsewhere. The density of veins is 9–16 per cm near the midrib and 22–30 near the margin.

Remarks—Leaves are identical to *G. indica* Schimper described by Chandra and Surange (1979, Pl. 5, fig. 1, Pl. 10, fig. 4, Pl. 15, fig. 11, Pl. 28, fig. 1, Pl. 29, fig. 1), Tewari and Srivastava (2000a, Pl. 1, fig. 4), Tewari (2007, Pl. 1, fig. 4, Pl. 3, fig. 1, Pl. 4, fig. 2, Pl. 6, figs 5, 7), Tewari (2008, Pl. 4, fig. 4), Singh *et al.* (2011, Pl. 7, figs 2, 4), and Tewari *et al.* (2012, figs 6E–H) in shape, nature of the midrib and venation pattern.

PLATE 2
(Scale bar= 1 cm)



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| <ol style="list-style-type: none"> 1. <i>Glossopteris gigas</i> Pant & Singh, 1971, BSIP Museum Specimen No. 40907. 2. <i>Glossopteris gigas</i> Pant & Singh, 1971, BSIP Museum Specimen No. 40910. 3. <i>Glossopteris gigas</i> Pant & Singh, 1971, BSIP Museum Specimen No. 40911. 4. <i>Glossopteris giridihensis</i> Pant & Singh, 1971, BSIP Museum Specimen | <ol style="list-style-type: none"> No. 40912A. 5. <i>Glossopteris indica</i> Schimper, 1869, BSIP Museum Specimen No. 40918. 6. <i>Glossopteris indica</i> Schimper, 1869, BSIP Museum Specimen No. 40912B. 7. <i>Glossopteris indica</i> Schimper, 1869, BSIP Museum Specimen No. 40915. |
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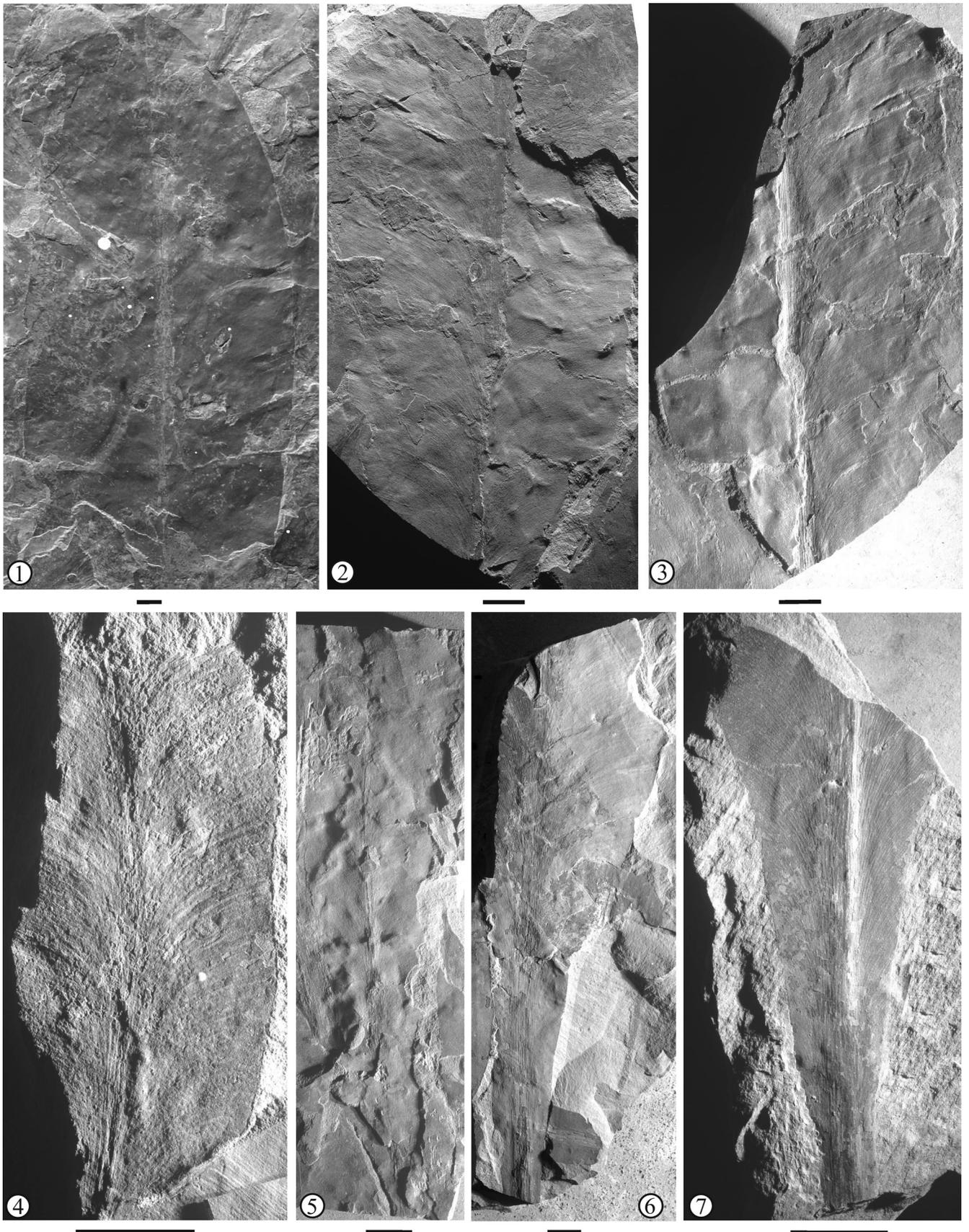


PLATE 2

No. of specimens—Eight (40912B, 40913, 40914, 40915, 40916, 40917, 40918, 40919).

Glossopteris longicaulis Feistmantel, 1879

(Pl. 3.1)

Description—Two incomplete specimens are present in the collection. Size of leaves ranges from 162 to 220 mm in length and 43 mm in width. Leaves are distinctly petiolate, oblong–lanceolate in shape, apex not preserved, base narrow–tapering, margin entire. Midrib is distinct, striate, 4 mm broad, petiole 20 mm long, striate and 6 mm wide. Secondary veins arise at about 18°–20° from the midrib and arch to meet the margin at 45° after dichotomizing and anastomosing. Meshes are arcuate, 5–8 mm long and 0.5–0.9 mm broad near the midrib and 2–4 mm long and 0.2–0.3 mm broad near the margin. The density of veins is 11–14 per cm near the midrib and 19–24 per cm near the margin.

Remarks—The leaves are consistent with *Glossopteris longicaulis* Feistmantel (1879) as illustrated by Chandra and Surange (1979, Pl. 1, fig. 4, Pl. 15, fig. 13) in having similar nature of midrib, petiole and venation pattern. They also match *G. longicaulis* described by Singh *et al.* (1982, Pl. 5, figs 31, 32, text–fig. 7f), Tewari (2008, Pl. 4, fig. 8) and Tewari *et al.* (2012, figs 6K, L).

No. of specimens—Two (40898B, 40932).

Glossopteris spatulata Pant & Singh, 1971

(Pl. 3.2–3.4)

Description—Four leaves are present in the collection of which one is preserved as part and counterpart. Leaves are 130–165 mm long and 55–88 mm broad, shape spatulate, apex rounded, base narrow, midrib persistent, striate, 2 mm broad in the lower part and 1 mm broad in the upper part, margin entire. Secondary veins arise at about 40°–45° and meet the margin at about 60°–65° after dichotomization and anastomosis. Meshes are long, narrow, arcuate, 6–8 mm long and 0.5–0.8 mm broad near the midrib and narrow, shorter, trapezoid, 1.5–4 mm long and 0.2–0.5 mm broad near the

margin. Venation dense, density of veins is 16–25 per cm near the midrib and 24–31 per cm near the margin.

Remarks—The leaves are similar to *G. spatulata* as illustrated by Pant and Singh (1971, Pl. 10, fig. 60), Chandra and Surange (1979, Pl. 8, fig. 1, Pl. 12, fig. 5, Pl. 17, fig. 7, Pl. 18, fig. 1, Pl. 27, fig. 1), Tewari and Srivastava (2000b, Pl. 1, fig. 6) and Singh and Chandra (2000, Pl. 1, fig. 5), in shape, nature of midrib and venation pattern. Leaves also match with *G. spatulata* described by Tewari (2007, Pl. 1, fig. 7, Pl. 2, fig. 2, Pl. 5, fig. 1, Pl. 7, fig. 6) and Singh *et al.* (2011, Pl. 7, figs 1, 3).

No. of specimens—Four (40920, 40921, 40922A, 40923).

***Glossopteris* sp.**

(Pl. 3.5)

Description—Single leaf is present in the collection. Leaf small, incomplete, only one side of the lamina is preserved, 36 mm long and 10 mm broad, shape oblong, apex and base are absent, midrib broad, striate, margin entire. Secondary veins arise at 45° from the midrib and meet the margin at about 60°. Veins dichotomize and anastomose to form broad, polygonal meshes of uniform size. Meshes are 2–4 mm long and 0.5–0.6 mm broad. Density of veins is 11–16 veins per cm in preserved part of the lamina.

Remarks—The small size of the leaf with its broad median region makes it significantly different from other known species of *Glossopteris*. Since the specimen is fragmentary, it is not possible to constitute a new species.

No. of specimens—One (40922B).

Order—CORDAITALES

Genus—NOEGGERATHIOPSIS Feistmantel, 1879

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

Noeggerathiopsis hislopii (Bunbury) Feistmantel, 1879

(Pl. 3.6–3.8)

PLATE 3

(Scale bar= 1 cm)



- Glossopteris longicaulis* Feistmantel, 1879, BSIP Museum Specimen No. 40898B (arrow indicates the petiole).
- Glossopteris spatulata* Pant & Singh, 1971, BSIP Museum Specimen No. 40920.
- Glossopteris spatulata* Pant & Singh, 1971, BSIP Museum Specimen No. 40921.
- Glossopteris spatulata* Pant & Singh, 1971, BSIP Museum Specimen No. 40923.
- Glossopteris* sp., BSIP Museum Specimen No. 40922B.
- Noeggerathiopsis hislopii* (Bunbury) Feistmantel, 1879, BSIP Museum Specimen No. 40924.
- Noeggerathiopsis hislopii* (Bunbury) Feistmantel, 1879, BSIP Museum Specimen No. 40925.
- Noeggerathiopsis hislopii* (Bunbury) Feistmantel, 1879, BSIP Museum Specimen No. 40927.

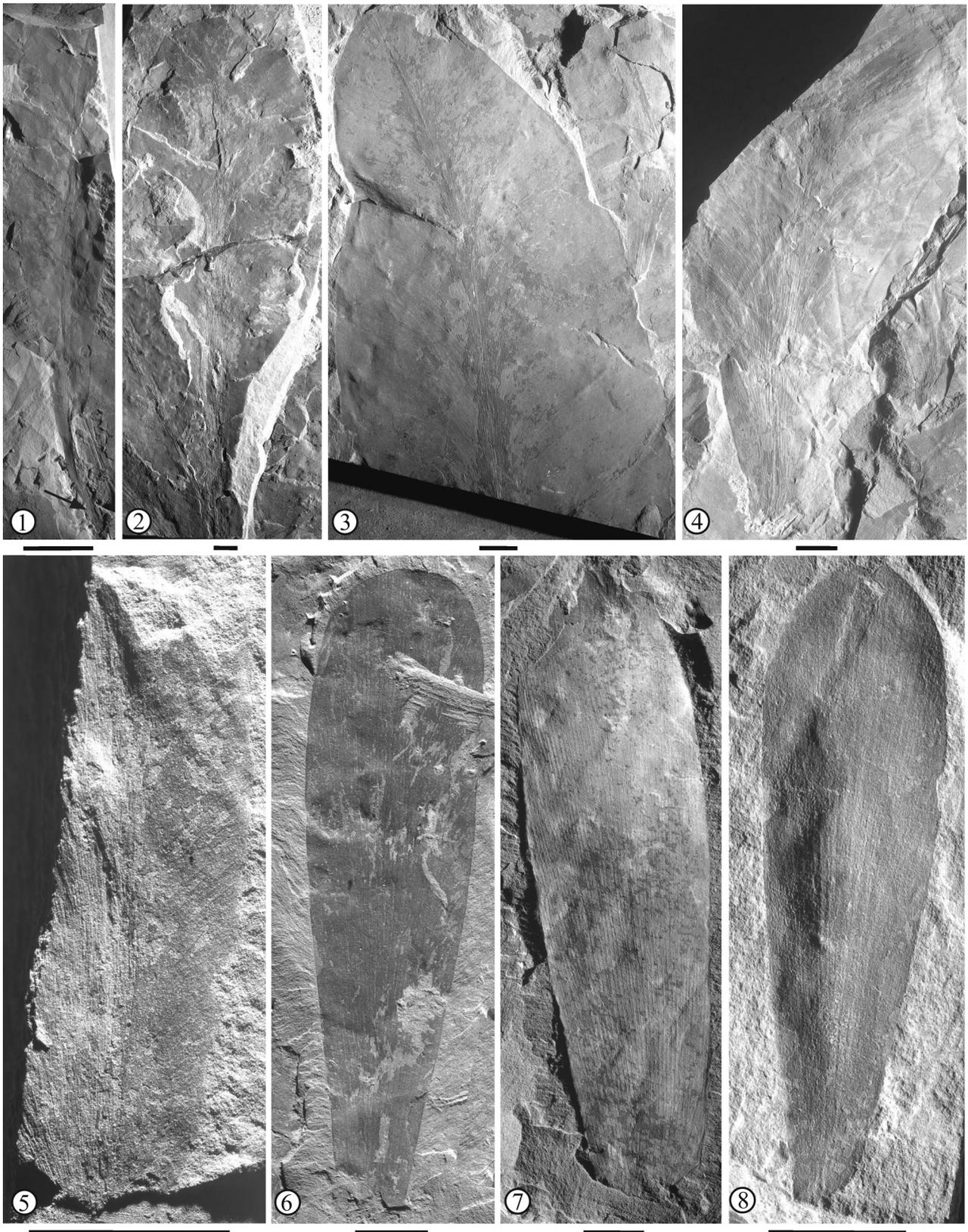


PLATE 3

Description—Nine specimens both—complete and fragmentary are present in the collection. The leaves are lanceolate—spatulate, 43–106 mm long and 19–29 mm wide, apex obtuse, base tapering, narrow, margin entire. Several parallel veins arise from the base, run straight and dichotomize frequently along their course. Vein density is 12–14 veins per cm in lower part and 17–20 veins per cm in upper part of the leaf.

Remarks—The leaves are identical to *Noeggerathiopsis hislopii* figured by Feistmantel (1879, Pl. 12, fig. 5, Pl. 19, figs 1–6, Pl. 20, fig. 1) in shape and venation pattern.

No. of specimens—Nine (40924, 40925, 40926, 40927, 40928A, 40928B, 40929, 40930, 40931).

CONCLUDING REMARKS

The Glossopteris flora is well known from almost all the major Gondwana basins of India. However, plant fossil records from the Sohagpur Coalfield of South Rewa Basin are so far sporadic. The floral assemblage from the Barakar Formation of Sharda Open Cast Mine, Sohagpur Coalfield, Shahdol District, Madhya Pradesh comprises the order Equisetales of pteridophytes and, the orders Glossopteridales and Cordaitales of gymnosperms. Equisetales includes equisetalean axes and Cordaitales is represented by *Noeggerathiopsis hislopii*. Glossopteridales dominates the assemblage and is represented by one species of *Gangamopteris*, *G. intermedia*, and seven species of *Glossopteris*, namely *G. communis*, *G. gigas*, *G. giridihensis*, *G. indica*, *G. longicaulis*, *G. spatulata* and *Glossopteris* sp. The present floral assemblage is the first record from the area and is broadly comparable with those of the Barakar Formation of the Damodar (Srivastava, 1992; Srivastava & Tewari, 1996; Tewari & Srivastava, 1996), Mahanadi (Singh & Chandra, 1996; Singh *et al.*, 2006a, b, 2007), Wardha (Tewari, 2008), Godavari (Tewari & Jha, 2006), Rajmahal (Maheshwari & Prakash, 1965) and Satpura (Srivastava & Agnihotri, 2009; Srivastava *et al.*, 2012) basins of India (Table 1). The presence of *Gangamopteris* and *Noeggerathiopsis* leaves in the assemblage is very characteristic and normally such association is correlated with the underlying flora of the Karharbari Formation. However, further studies from the lower part of the Barakar Formation of South Karanpura (Kulkarni, 1971), Raniganj (Srivastava, 1992) and Umrer (Tewari *et al.*, 2012) coalfields indicate their continued presence in the onward flora. The presence of the above mentioned plant groups in the Barakar sediments of the Sharda Open Cast Mine suggests their importance in the formation of coal in the area. Further, the occurrence of large leaves like those of *Glossopteris communis*, *G. gigas*, *G. indica* and *G. spatulata* in these sediments supports the existence of conducive warm, temperate and humid climatic condition during the coal formation (Lele, 1976; Chandra & Chandra, 1987; Chandra, 1992).

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