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PLANT FOSSILS FROM THE TALCHIR AND COAL-BEARING FORMATIONS OF SOUTH REWA GONDWANA BASIN, INDIA AND THEIR BIOSTRATIGRAPHICAL SIGNIFICANCE

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ABSTRACT

Plant fossils belonging to the Talchir and coal-bearing formations (Lower Permian) of four areas, namely Umaria, Birsinghpur Pali, Anuppur and Chirimiri of the South Rewa Gondwana Basin are described. The Talchir flora is represented by a few species of *Gangamopteris* and *Noeggerathiopsis*, while the megafossils from the coal-bearing formation are represented by various species of *Glossopteris*, *Gangamopteris*, *Noeggerathiopsis* and *Vertebraria*. A new species of *Noeggerathiopsis*, *N. minor*, has been recognised. It has also been observed that the flora of the coal-bearing beds in these areas are characterized by the dominance of *Gangamopteris* and *Noeggerathiopsis*. This suggests that these beds of the South Rewa Gondwana Basin are equivalent to the Karharbari 'Stage' of the Peninsular India.

Key-words — Megafossils, Biostratigraphy, South Rewa Gondwana Basin, Lower Permian (India).

सारांश

दक्षिण रीवा गोंडवाना द्रोणी (भारत) के तालचिर एवं कोयला-धारक शैल-समूहों से प्राप्त पादपाश्म तथा इनका जीवस्तरिकीय महत्व – अनिल चन्द्रा एवं अश्विनी कुमार श्रीवास्तव

दक्षिण रीवा गोंडवाना द्रोणी के तालचिर एवं कोयला-धारक (अधरि परमी) शैल-समूहों से सम्बन्धित चार क्षेत्रों – उमरिया, बीरसिंहपुर पाली, अनूपपुर तथा चिरीमिरी – से प्राप्त पादपाश्मों का वर्णन किया गया है। तालचिर वनस्पतिजात गंगामॉप्टेरिस एवं नैग्रेथिआॅप्सिस की कुछ जातियों से निरूपित है, जबकि कोयला-धारक शैल-समूह के गुरुपादपाश्म ग्लॉसॉप्टेरिस, गंगामॉप्टेरिस, नैग्रेथिआॅप्सिस एवं वर्टीब्रेरिया की विभिन्न जातियों से निरूपित हैं। नैग्रेथिआॅप्सिस की एक नई जाति, नै० माइनर, अभिनिर्धारित की गई है। यह भी प्रेक्षित किया गया है कि इन क्षेत्रों के कोयला-धारक संस्तर गंगामॉप्टेरिस एवं नैग्रेथिआॅप्सिस की बाहुल्यता से अभिलक्षणित हैं। जिससे यह व्यक्त होता है कि ये संस्तर प्रायद्वीपीय भारत के करहरबारी चरण के समतुल्य हैं।

INTRODUCTION

IN 1860, Medlicott collected plant fossils, for the first time, from the South Rewa Gondwana Basin. Hughes made further collection from this basin during 1881-1884. Feistmantel (1879, 1882) described plant fossils in detail (South Rewa) and considered the coal-bearing beds as equivalent to the Karharbari 'Stage' on the basis of floral comparison. Fermor (1914) reported *Glossopteris*, *Vertebraria* and *Schizoneura* from the Barakars of the Kurasia Coalfield. Biswas (1955) studied Fermor's collection and suggested Karharbari correlation of at least a part of the Chirimiri Coal Measures strictly on floral evidence. Surange and Lele (1956) described plant fossils from the Talchir Formation of the Johilla Coalfield (Birsinghpur-Pali). Datta (1957) studied the plant fossils and the miospores from the Barakar and the miospores from the Talchir rocks of the Jhagrakhund area. On the basis of the plant fossils he observed that the Barakar flora in this area is comparable to the lower section of the Lower Gondwana flora. Ganguly (1959) described the plant fossils from the Talchir and the coal-bearing formations of Chirimiri. Lele and Maithy (1964) described two new species of *Noeg-*

gerathiopsis from the Karharbari beds of Ganjra Nala, Birsinghpur-Pali. Pant and Varma (1964) recognized three new species of *Noeggerathiopsis* from the Lower Gondwanas of Manendragarh. Maithy (1966b) considered the coal-bearing beds at Umaria as equivalent to the Karharbari beds of Giridih. Later, he (Maithy, 1968) reported two new fossil plants from the Karharbari beds of Ganjra Nala, Birsinghpur Pali.

South Rewa Gondwana Basin was selected for palaeobotanical (including microfossils) and stratigraphical studies because of the controversy regarding the stratigraphical position of the Karharbari 'Stage'. Another important factor favouring the selection of this basin was the well-developed nature of the Talchir sediments. Detailed systematic study of both plant mega- and micro-fossils was, therefore, planned with the object of finding guide fossils which could be utilized in problems of correlation and dating. The results of the microfossil studies have been partially published (Lele & Chandra, 1967, 1969, 1972, 1973, 1974; Chandra & Lele, 1980; Srivastava & Chandra, 1982).

The present study deals only with the plant fossils collected by one of us (A. C.) during 1966, 1967 and 1968 from the Talchir and coal-bearing formations of four areas, viz., Umaria, Birsinghpur Pali, Anuppur, and Chirimiri of the South Rewa Gondwana Basin, Madhya Pradesh.

GEOLOGY

South Rewa Gondwana Basin forms a small part of the great Central Basin of the Gondwana rocks, occupying a large tpart of Central India. According to Hughes (1884) the geological succession of this basin is as follows:

Surface deposits
Deccan Trap and Lametas
Gondwana System — Supra-Barakars; Barakars with Karharbari; Talchirs
Bijawars
Metamorphics

A brief description of the geology of each area along with the account of the various traverses undertaken in the field is given below.

UMARIA

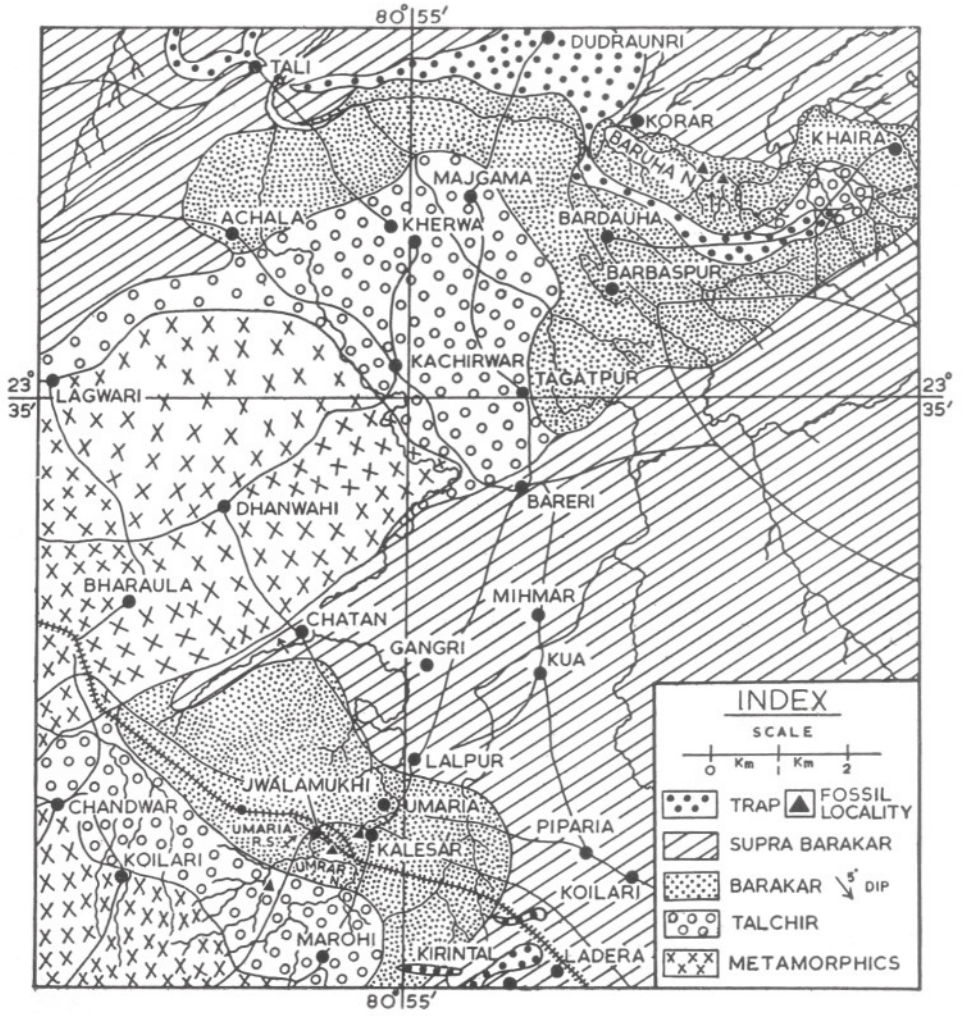
The geological formations (Ahmad, 1957) met with in the area (23° 32': 80° 51', Map 1) are as follows:

Supra Barakar
Barakar Coal Measures
Talchir Series
..... Unconformity .....
Metamorphics

The Archaeans, comprising the metamorphic rocks, are exposed towards west, north and south of Umaria Railway Station. The Talchir sediments occur to the south, south-west and north of Umaria. The Talchirs are generally found to rest over the Metamorphics. A fair idea of the stratigraphic sequence is obtained by taking a downstream traverse along a small stream, between Koilari and Marohi, up to its junction with the Umrar and again along this river near Kalesar, Umaria and Lalpur.

The Barakars generally seem to conformably overlie the Talchir. The lowermost bed of the Barakars is a felspathic, siliceous and slightly ferruginous sandstone which is overlain by a thin band of coaly shale followed by a series of laminated sandstones, argillaceous, blue and carbonaceous shales, and finally a zone of massive sandstones at the top. The Barakar sandstones appear to be deeply eroded near Kalesar. The lower limit of the Barakars is fairly recognisable towards south-west of Umaria. Only the sandstone facies is seen exposed from Kalesar up to the upper boundary of the Barakars which lies between Umaria and Lalpur. These Barakar sandstones are overlain by red and variously coloured clays of the supra-Barakars. A marine fossiliferous zone unconformably overlies the Talchirs and is in turn overlain by the basal members of Barakar Formation. Following traverses are described from this area.

A. *Umaria-Kalesar-Marohi Traverse* — The Barakars are exposed on both the banks of the Umrar River about 1·6 km south-west of Umaria, below the road bridge which connects Umaria with Kalesar. The Barakar sandstone attains a maximum thickness of 12.20 m.



Map 1 — Geological map of Umaria, Madhya Pradesh (from the geological map of South Rewa Gondwana Basin, Hughes, 1884).

(i) Following section is exposed just near the bridge on the north bank of Umrar river:

	Lithology	Thickness m	Field Nos.
BARAKARS	Carbonaceous shale (fossiliferous)	0.61	K8F
	Carbonaceous shale intercalated with sandstone	1.52	K7
	Greyish white massive sandstone	12.20	K1

The road running south of Kalesar up to Marohi shows no exposures as all the formations are hidden by the soil. About 3.2 km north of Marohi a 12.20 m thick sandstone member of the Barakar Formation is exposed on either side of the river; current bedding is a common feature.

(ii) Following section is exposed about 9.15 m south of the Railway bridge:

	Lithology	Thickness m	Field Nos.
	Massive sandstone	7.62	M7
	Coal	0.61	M8
BARAKARS	Carbonaceous shale (fossiliferous)	1.22	M9
	Greyish white, coarse-grained sandstone	1.83	M10

B. *Bareri-Tagatpur-Barbaspur (Baruha-Nala) Traverse* — The Supra Barakars are exposed on two hills situated west of the village Bareri which is about 6.4 km north of Umaria. Both the hills were examined. The lithological units are represented by hard pink sandstone (current-bedded), sandstone and red sandstone. The basal members of these hills are well-laminated and block-jointed sandstones and may belong to the Barakars. Weathered garnets, a constituent mineral of these sandstones, are clearly visible to the naked eye. The nala, about 1.6 km north of Bareri, was traversed up to Tagatpur. Barakar rocks are exposed in a stream, locally known as Baruha Nala, about 4.0 km north of Barbaspur. Following two sections were observed along this Nala:

(i) *North bank Section*

	Lithology	Thickness m	Field Nos.
	Shaly sandstone	1.53	BBN 3
	White sandstone	0.61	BBN 2
BARAKARS	Carbonaceous shale (fossiliferous)	1.83	BBN F
	Ash coloured sandstone	0.05	BBN 1

(ii) *Section exposed about* 28 *m east of Section* (i):

	Sandstone and soil (mixed)	0.31	BBN 9
	Carbonaceous shale	0.92	BBN 8
BARAKARS	Sandstone	0.61	BBN 7
	Carbonaceous shale (fossiliferous)	0.92	BBNF 1
	Ash coloured sandstone	6.10	BBN 6

A coal seam measuring 0.20-0.25 m in thickness, was seen exposed at a number of places further east along the nala.

C. *Jwalamukhi*—A few fragmentary fossils of *Noeggerathiopsis hislopi* (JW 6) were collected from the Needle Shale beds of the Talchir Formation, exposed along a nala, about 1.6 km south of Jwalamukhi.

Besides, Umaria R.S.-Kirnital-Umaria and Lalpur-Gangri-Chatan-Umaria traverses were undertaken without encountering any plant fossils.

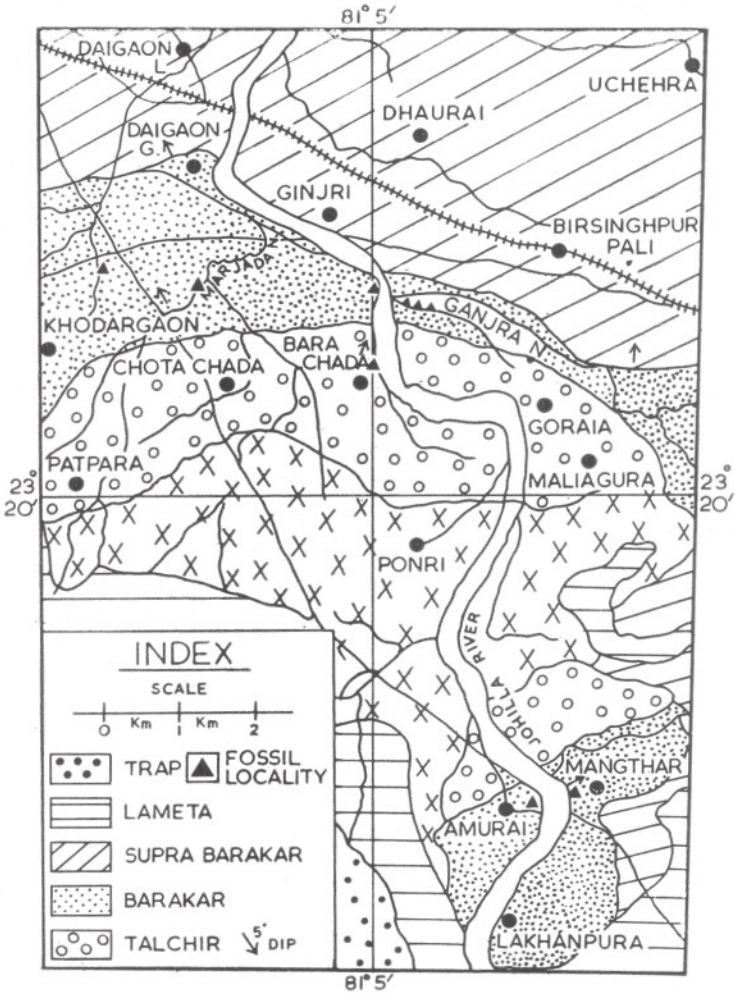
BIRSINGHPUR-PALI

The general succession of the geological formations in this area (Map 2) is as follows (after Hughes, 1884):

Traps
Lametas
Supra Barakars
Barakars
Talchirs
..... Unconformity
Metamorphics

The metamorphic inlier of the Johilla Valley covers an area of about 20.5 sq km. Good metamorphic (gneiss) exposures are seen near Ponri along the banks of Johilla River. Towards north, the metamorphic exposures are generally covered by Talchirs or by alluvium. And towards south-west, the metamorphic rocks appear to be fringed by Lametas while to the south-east and east, they are overlain by Talchirs, Supra-Barakars or alluvium.

The Talchirs occupy a belt about 9.6 km long and 2.4 km wide between Kudri and Kumurdu (Kudri is not shown in the map. It is about 1.6 km north-west of Patpara and about 1.6 km south-west of Khodargaon). Talchirs are also exposed to the north of Mangthar. Good sections of the Talchir Formation are exposed near Barachada, on both the banks of Johilla River. The bottom bed is a compact, greyish, calcareous sandstone. This is succeeded by a thick bed of greyish-green siltstone comprising fragments of quartzites, granites and schists. This siltstone in turn, is overlain by another siltstone member which is yellowish and greenish in colour. This second siltstone bed is overlain by a compact calcareous sandstone bed followed by another silt-



Map 2 — Geological map of Birsinghpur Pali, Madhya Pradesh (from the geological map of South Rewa Gondwana Basin, Hughes, 1884).

stone member at the top. These rocks along the east bank are generally covered by alluvium. On the west bank, however, they can be located at many places in small and large nalas feeding the Johilla River. The Talchirs, examined in all sections, were seen resting on the gneissic rocks of the Metamorphics. The Barakars of the Johilla Valley (Birsinghpur-Pali) are divided into two distinct areas by the Talchirs and gneissic rocks (Metamorphics). Hughes (1884) named them as the North and South areas respectively. These rocks are similar to the Barakars exposed at Umaria and include mostly the yellowish to greyish, felspathic, siliceous sandstone, shaly sandstone, carbonaceous shale and coal. The Supra Barakars of this area seem to overlap on the Talchirs and appear to be faulted against the Ponri gneiss. Only at Ponri they rest over the Metamorphics. In general they rest over the Barakars. The traverses undertaken in this area are described below:

A. *Birsinghpur Pali-Barachada-Goraia-Ponri Traverse* — The Talchirs are well exposed along both the banks of Johilla River, near the village Barachada. A traverse undertaken from Barachada to Ponri via Goraia along the Johilla River shows

that the Metamorphics and the Talchir sediments are exposed near Ponri. The dip is 10° towards north. The following section was studied near Barachada Village.

	Lithology	Thickness m	Field Nos.
TALCHIR	Yellowish silty sandstone	1.83	BC 12
	Yellowish laminated sandstone (fossiliferous)	3.05	BC 11F
	Greenish silty sandstone (fossiliferous)	1.22	BC 10F
	Yellowish laminated sandstone (fossiliferous)	0.31	BC 9F
	Yellowish silty sandstone (fossiliferous)	1.22	BC 8F
	Laminated sandstone (fossiliferous)	0.92	BC 7F
	Laminated yellowish greenish sandstone	9.15	BC 6

B. *Mangthar-Amurai Traverse* — About 1.6 km west of Mangthar Village, the Talchir Boulder bed is exposed in a nala leading to Johilla River. This bad is about 1.22-3.05 m in thickness and reaches up to 9.15 m further west in the nala. The matrix mainly consists of greenish-blackish sandstones and is overlain by 3.05 m thick yellowish-whitish sandstones. The dip is 5° towards east. The Talchir Formation is exposed up to the junction of this nala with the river Johilla. About 0.45 m south of this junction and about 0.28 km west of the river Johilla the carbonaceous shales and sandstones are exposed with gentle dip towards west. The plant fossils were collected from the following two sections:

(i) About 0.40 km west of the village Mangthar and on the east bank of the river Johilla the following section was studied:

	Lithology	Thickness m	Field Nos.
BARAKAR	Yellowish white coarse grained sandstone	1.83	MA 25
	Coal	0.20	MA 24
	Bluish carbonaceous shale (fossiliferous)	1.83	MA 23
	Carbonaceous shale	0.45	MA 22
	Bluish carbonaceous shale (fossiliferous)	1.22	MA 21
	Whitish sandstone	1.53	MA 20

(ii) A few fragmentary fossils were collected from the following section exposed on the right bank (Amurai side) of the Johilla River, 0.18 km north of the road joining Amurai to Lakhanpura:

	Lithology	Thickness m	Field Nos.
BARAKARS	Pinkish sandstone	1.53	LA 9
	White yellowish sandstone	4.58	LA 8
	Carbonaceous shale	0.15	LA 7
	White sandstone	0.92	LA 6
	Carbonaceous shale (Blue)	0.92	LA 5
	Coal	0.31	LA 4
	Carbonaceous shale (fossiliferous)	0.31	LA 3
	Bluish sandstone	0.76	LA 2
	Yellowish sandstone and shale	3.05	LA 1

C. *Khodargaon-Kudri Traverse*—Following section of Supra-Barakar and Barakar members was studied along a nala approximately 1.6 km north-east of Khodargaon Village.

	Lithology	Thickness m	Field Nos.
SUPRA BARAKAR	Pinkish yellowish sandstone	1.53	KK 7
	Clay and white sandstone	0.31	KK 6
	Red sandstone	0.31	KK 5
BARAKAR	Weathered sandstone (clayey)	0.31	KK 4
	Coarse grained yellowish sandstone	1.22	KK 3
	Clayey shale (fossiliferous)	0.61	KK 2
	Compact clayey sandstone	0.61	KK 1

D. *Patpara-Marjada Nala Traverse* — In a section about 3.2 km east of Khodargaon Village after crossing the road bridge the succession is as follows:

	Lithology	Thickness m	Field Nos.
BARAKAR	Massive yellowish sandstone	3.05	K 7
	Carbonaceous shaly sandstone	1.22	K 6
	Yellowish sandstone	0.61	K 5
	Carbonaceous shaly sandstone	0.31	K 4
	Carbonaceous shale (fossiliferous)	0.31	K 3
	Coal	1.22	K 2

E. *Ganjra Nala-Johilla River Confluence Traverse* — Fragmentary fossil collection was made from the Ganjra Nala up to its confluence (about 2.4 km south-west of Birsinghpur-Pali Railway Station) with the river Johilla. The sections studied are described below:

(i) Section 0.27 km east of the Ganjra Nala-Johilla Confluence, along the Ganjra Nala:

	Lithology	Thickness m	Field Nos.
BARAKAR	Sandstone (fossiliferous)	—	GN 3
	Carbonaceous shale (fossiliferous)	1.83	GN 2
	Grey micaceous sandstone (fossiliferous)	1.53	GN 1F
	Carbonaceous shale (fossiliferous)	2.14	GN 1
	Coal	—	—

(ii) Section 0.18 km east of Ganjra Nala-Johilla confluence, along the Ganjra Nala:

	Lithology	Thickness m	Field Nos.
BARAKAR	Micaceous sandstone	—	GN 6
	Coaly shale	1.53	GN 6
	Carbonaceous shale (fossiliferous)	1.83	GN 5F
	Coaly shale (fossiliferous)	0.92	GN 4F

(iii) Section 0.09 km west of Ganjra Nala-Johilla confluence:

	Lithology	Thickness m	Field Nos.
BARAKAR	Micaceous sandstone	—	GN 8
	Carbonaceous shale (fossiliferous)	3.05	GN 7

(iv) Section along the other bank of Johilla River, opposite Ganjra-Johilla confluence:

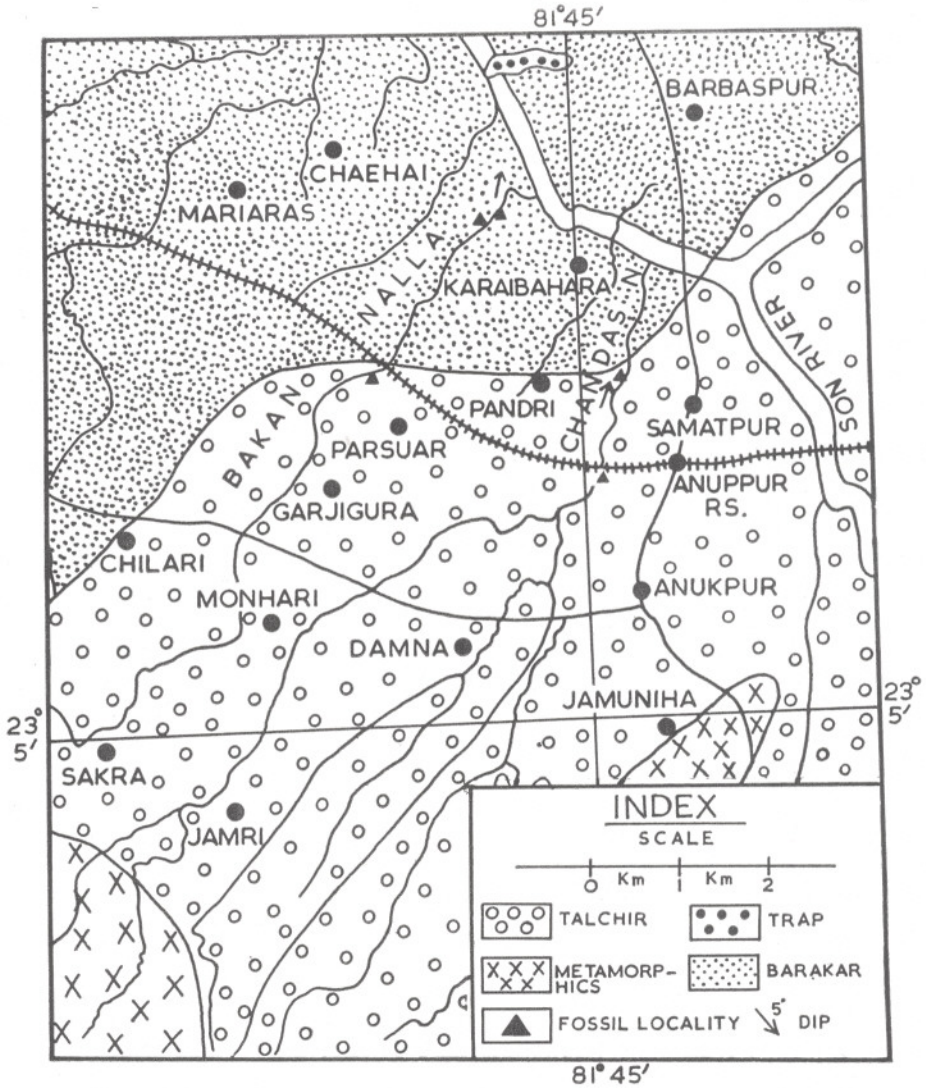
	Lithology	Thickness m	Field Nos.
BARAKAR	Micaceous sandstone (fossiliferous)	—	J1 F
	Carbonaceous shale (fossiliferous)	2.14	J1 F1
	Sandstone	2.44	J1
	Carbonaceous shale	0.92	J2
	Shale and sandstone	—	J3

Anuppur

The geological succession (Chandra & Lele, 1980) of this area (Map 3) is as follows:

Traps
Barakar Coal Measures
Talchir
Metamorphics

The Metamorphics (gneisses, granitic gneisses, schists, etc.) are exposed in the southern extremities of Anuppur. These rocks are overlain by the Lower Gondwana sediments, which are represented by the coal-bearing Barakar and the Talchir formations. Sandstones, shales, carbona-



Map 3 — Geological map of Anuppur, Madhya Pradesh (from the geological map of South Rewa Gondwana Basin, Hughes, 1884).

ceous shales and coal form the general lithology of the coal-bearing formation. The Talchir Formation has the usual lithology of the boulder bed, needle shales, siltstone and sandstones of various shades. The Lower Gondwana formations are well exposed along the Bakan and Chandas nalas. Both these nalas have been surveyed. The areas around the villages, Sakra, Damna, Jamri and Chilari, etc. were visited and the following traverses were undertaken.

A. *Bakan Nala Railway Bridge — Son River Traverse*:

(i) Plant fossils were collected from a carbonaceous shaly bed with sandstone intercalations, exposed about 2.4 km north-east of the Bakan Nala Railway bridge (about 4.8 km north-west of Anuppur R.S.) along Bakan Nala.

This section has the following distinct beds:

	Lithology	Thickness m	Field Nos.
BARAKAR	Coarse grained sandstone	2.75	BN 21
	Carbonaceous shales with sandstone intercalations (fossiliferous)	0.95	BN 20
	Greyish white coarse-grained sandstone	2.44	BN 19

(ii) Well preserved plant megafossils have been collected from a carbonaceous shale bed exposed about 0.8 km south-west of Bakan Nala-Son River confluence along the Bakan Nala. This richly fossiliferous bed contains three species of *Noeggerathiopsis* only. The succession of different beds is as follows:

	Lithology	Thickness m	Field Nos.
BARAKAR	Coarse-grained sandstone	6.10	BN 27
	Carbonaceous shale	0.31	BN 26
	Coal	0.31	BN 25
	Carbonaceous shales (fossiliferous)	0.31	BN 24
	Coal	0.92	BN 23
	Carbonaceous shale	0.31	BN 22
	Whitish-bluish sandstone	1.22	BN 21

B. *Bakan Nala-Monhari Traverse* — In this traverse the rocks belonging to both the Talchir and coal-bearing Barakar formations were met with. In one of the sections, exposed about 0.28 km south-west of the Bakan Nala Railway bridge, some equisetaceous stems have been found. The succession of different beds is as follows:

	Lithology	Thickness m	Field Nos.
TALCHIR	Yellowish-whitish sandstone	3.05	BN 3
	Shaly sandstone (fossiliferous)	1.83	BN 2
	Whitish-yellowish sandstone	3.05	BN 1

C. *Chandas Nala Railway Bridge-Damna Traverse* — The rocks met with belong to the Talchir Formation and include the sandstone, needle shale and boulder bed. The general dip is 8°-10° due north. Equisetaceous stems have been found from the following section exposed about 45 m south of the Railway Bridge (1.6 km west of Anuppur Railway Station).

	Lithology	Thickness m	Field Nos.
TALCHIR	Massive yellowish sandstone	6.71	CN 4
	Shaly sandstone greenish-white (fossiliferous)	0.31	CN 3
	Green sandstone	1.83	CN 2
	Massive yellowish fine-grained sandstone	1.83	CN 1

D. *Chandas Nala Railway Bridge-Son River Traverse* — Both the Talchir and coal-bearing Barakar formations are exposed along the Chandas Nala. Fragmentary megafossils have been collected from a Talchir sequence exposed about 1.6 km north-east of the Chandas Nala Railway Bridge with following distinct beds:

	Lithology	Thickness m	Field Nos.
TALCHIR	Needle shales (fossiliferous)	3.05	CN 28
	Yellowish sandstone	3.05	CN 27
	Talchir Boulder Bed	3.05	CN 26

CHIRIMIRI

According to Biswas (1955) the geological succession of the formations exposed in Chirimiri (23°11′30″: 82°21″; Map 4) area is as follows:

Para-Lavas	Recent or sub-recent
Deccan Traps	Post-Barakar
Lower Barakars	(including Karharbari Stage Lower Barakar)
Talchirs	Upper most Carboniferous or Basal Permian
Archeans	Pre-Cambrian

Small patches of metamorphic rocks are exposed in the south near Akhardand Village and in the north around the village Kothari. The Talchir rocks are exposed in the southern and western extremity of the area. The Talchir Formation includes the Talchir Boulder Bed, Needle shales and sandstones of various shades. The Barakar Formation is exposed in the Kaoria Nala (known as Kararkhoh exposure), Gaemera Nala and around Chirimiri Railway Station. The rock types met within the Barakars include sandstones, shales, carbonaceous shale and coal. A belt of dolerite and basalt overlies both the Talchir and the Barakar formations. In this area the following traverses were undertaken:

A. *Chirimiri-Paradol Railway Cutting Traverse* — A number of good sections of Talchir and Barakar rocks are exposed along the railway line between Chirimiri and Paradol Railway stations. About 0.8 km north-west of the Chirimiri Railway Station, a rich collection of plant fossils was made from the following section. The beds dip 10° due north.

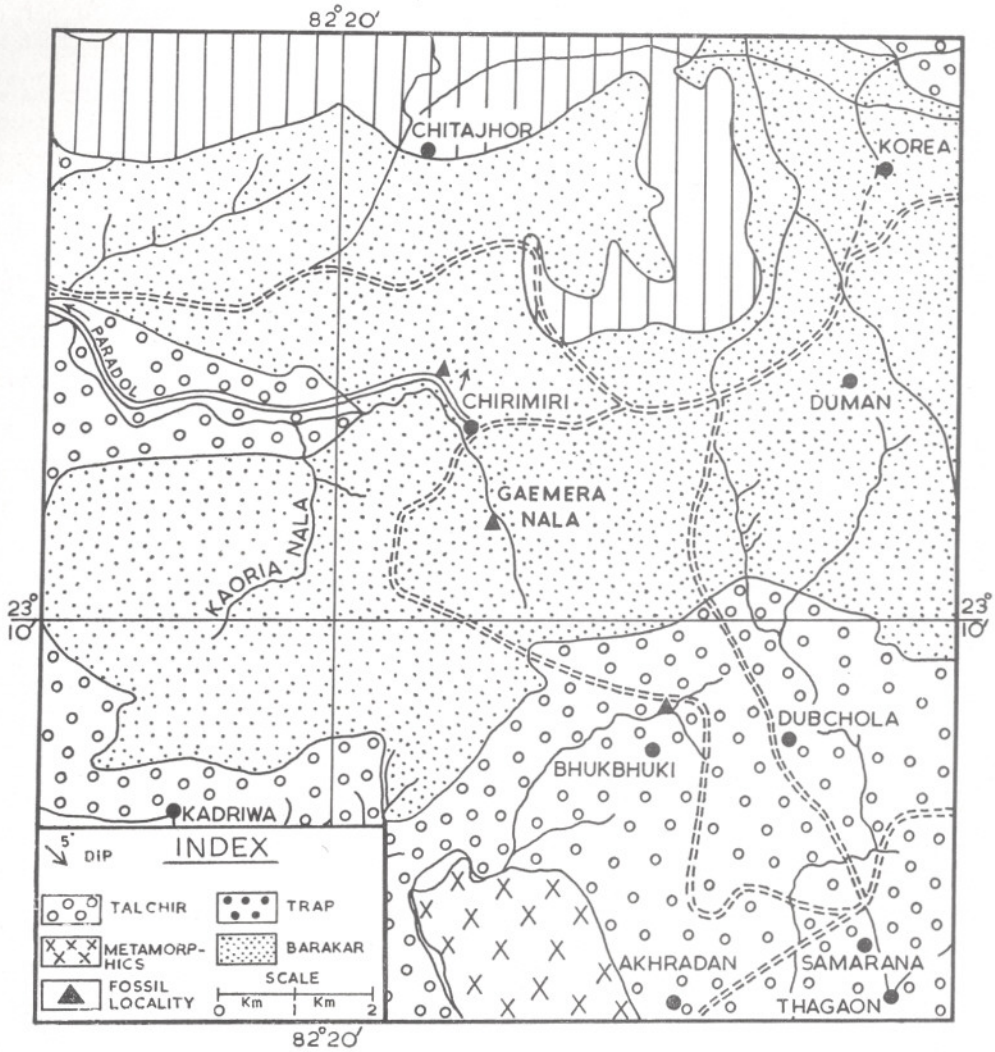
	LITHOLOGY	THICKNESS m	FIELD NOS.
	Yellowish-white coarse-grained sandstone (current bedded)	9.15	CP 6
	Coal	0.15	CP 5
BARAKAR	Carbonaceous shale and sandstone alternating (fossiliferous)	3.65	CP 4
	Carbonaceous shale	0.92	CP 3
	Sandstone	3.05	CP 2
	Carbonaceous shale	0.25	CP 2
	Fine-grained sandstone	9.15	CP 1

B. *Gaemera Nala Traverse* — From the following section, exposed 1.6 km south of Chirimiri Railway Station, a few plant fossils were collected along the bank of the Gaemera Nala:

	LITHOLOGY	THICKNESS m	FIELD NOS.
	Coarse-grained sandstone	6.10	G 1
	Coal and coaly shale	1.53	G 2
BARAKAR	Carbonaceous shale (fossiliferous)	2.44	G 3
	Medium grained, whitish micaceous sandstone	6.10	G 4
	Coal	7.62	G 5

C. *Duman Hill-Korea Coalfield Traverse* — This traverse was undertaken from Duman Hill to Korea Colliery along a private railway line. A rich collection of plant fossils was made from the following section exposed about 0.55 km north of Duman Colliery along the railway line:

	LITHOLOGY	THICKNESS m	FIELD NOS.
	Yellowish sandstone (weathered)	6.10	DK 16
	Shale	0.31	DK 15
BARAKAR	Weathered coal	1.22	DK 14
	Pinkish sandstone	0.92	DK 13
	Carbonaceous shale weathered (fossiliferous)	1.22	DK 12
	Bluish sandstone	0.92	DK 11



Map 4 — Geological map of Chirimiri, Madhya Pradesh (from the geological map of South Rewa Gondwana Basin, Hughes, 1884) with certain modifications.

D. *Chirimiri-Bhukbhuki Traverse* — Both the Talchir and Barakar rocks are seen exposed along this traverse from Chirimiri to Bhukbhuki. A good collection of plant fossils was made from the following section exposed north of the village Bhukbhuki and about 0.46 km west of the road turning.

	Lithology	Thickness m	Field Nos.
	Yellowish sandstone	?	B 5
	Needle shales	3.05	B 4
TALCHIR	Yellowish siltstone (fossiliferous)	1.22	B 3
	Greenish needle shales (fossiliferous)	1.53	B 2

DESCRIPTION OF PLANT FOSSILS

Genus — *Gangamopteris* McCoy, 1861

Gangamopteris cyclopteroides Feistmantel, 1876

Pl. 1, fig. 1; Pl. 3, fig. 25

Description — In all, there are 18 incomplete leaf impressions. The leaves are 9-13 cm long and 3-12.5 cm broad at maximum width. The apex is broadly rounded, base missing, and margin entire. The veins arise from the base and the median region is occupied by 5 to 6, thick, parallel running strands. The lateral veins arch out at angles of 7° to 10°. After anastomosis and dichotomization they form broad, long, polygonal meshes in the middle and linear, narrow meshes near the margin. The meshes are 8 to 12 mm long and 1.0 to 1.5 mm broad in the middle and 10 to 13 mm long and 0.8 to 1 mm broad near the margin. The density of veins is 10 to 12 per cm in the middle and 12 to 15 per cm near the margin.

Comparison — The specimens in their venation pattern and shape resemble the leaves described by Feistmantel (1879, pl. 1, figs 1, 2) and Srivastava (1977a, pl. 1, fig. 1).

Distribution — Talchir Formation — Bhukbhuki, Chirimiri (Traverse D); Coal-bearing Formation — Baruha Nala, Umaria (Traverse B), (i) and (ii), Bakan, Anuppur (Traverse A), (i). Chirimiri-Paradol Section, Chirimiri (Traverse A).

Gangamopteris clarkeana Feistmantel, 1879

Pl. 1, figs 2, 3; Pl. 2, fig. 15

Description — There are four incomplete leaf impressions in the collection. The leaves are 2.5 to 6.8 cm long and 2.5 to 3.7 cm broad at maximum width. The apex is broad obtuse, base missing and the margin is entire. The veins emerge from the base and form 5 to 7 subparallel interconnecting strands in the median region. They are thick, distant and arched. After anastomosis and dichotomization they form open, oblong, polygonal meshes. The meshes are 4 to 10 mm long and 0.5 to 1.5 mm broad in the centre and 5 to 8 mm long and 0.7 to 1 mm broad near the margin. The density of veins is 8 to 10 per cm in the middle and 10 to 20 per cm near the margin.

Comparison — The present specimens are clearly comparable in their venation pattern with *G. clarkeana* Feistmantel (1890, pl. 20, fig. 3), Maithy (1965d, pl. 4, fig. 25) and Srivastava (1977a, pl. 2, fig. 9).

Distribution — Talchir Formation — Bhukbhuki Chirimiri (Traverse D); Coal-bearing Formation — Duman Hill-Korea Section, Chirimiri (Traverse C).

Gangamopteris major Feistmantel, 1879

Pl. 1, fig. 5; Pl. 2, fig. 12

Description — There are six incomplete leaf impressions in the collection. The leaves are 5.6-9.5 cm long and 2.2-3.5 cm broad at maximum width. The leaves are narrow, elongate to spathulate in shape. The apex and base are missing and margin is entire. The median portion of the leaves is occupied by 3 to 7 parallel running strands. The secondary veins are arched and after anastomosis and dichotomization form linear, narrow meshes throughout the lamina. The meshes are 5 to 8 mm long and 0.5 mm broad. The density of veins is 15 to 22 per cm.

Comparison — The specimens resemble *Gangamopteris major* described by Feistmantel (1879, pl. 14, fig. 3) and Maithy (1965d, pl. 2, fig. 7) in its narrow, elongate shape and linear narrow mesh pattern.

Distribution — Talchir Formation — Bhukbhuki, Chirimiri (Traverse D); Coal-bearing Formation — Bakan Nala, Anuppur [Traverse A (i)].

Gangamopteris intermedia Maithy, 1965

Pl. 1, fig. 4

Description—There is only one incomplete leaf impression in the collection. The figured leaf is 6.9 cm long and 4 cm broad at its maximum width and is ovate in shape. The apex and base are missing, margin is entire. The median region of the leaf is occupied by elongate, hexagonal meshes. The secondary veins are arched and after anastomosis and dichotomization form comparatively broad and elongated,

hexagonal meshes in the centre and narrow, hexagonal meshes near the margin of the leaf. The meshes are 8 to 10 mm long and 1.0 mm broad in the centre and 8 to 12 mm long and 0.6 to 1.0 mm broad near the margin. The density of veins is 10 to 12 per cm in the centre and 10 to 16 per cm near the margin.

Comparison — The present leaf is closely comparable with the holotype of *Gangamopteris intermedia* Maithy (1965d, pl. 3, fig. 22) in its shape and venation pattern.

Distribution — Talchir Formation — Bhukbhuki, Chrimiri (Traverse D).

Gangamopteris angustifolia McCoy, 1861

Pl. 2, fig. 14

Description — There are only 2 incomplete leaf impressions in our collection. The figured leaf is 6.8 cm long and 2.0 cm broad. The leaf is linear, narrow in shape. The apex is acute, base missing, margin entire. The median region is occupied by 5 to 6 subparallel running veins which give rise to secondary veins which form linear, elongate, hexagonal meshes throughout the lamina. The meshes are 6 to 8 mm long and 0.25 mm broad. The density of veins is 22 to 28 per cm near the margin.

Comparison — The present specimens resemble *G. angustifolia* described by Feistmantel (1879, pl. 9, fig. 5) and Maithy (1965d, pl. 2, figs 9, 10).

Distribution — Coal-bearing Formation — Mangthar, Birsinghpur Pali [Traverse B(i)] Baruha Nala, Umaria [Traverse B(i) and (ii)].

Gangamopteris karharbariensis Maithy, 1965

Pl. 2, fig. 13

Description — There are only two incomplete leaf specimens in the collection. The figured leaf is 10.2 cm long and 3.0 cm broad at its maximum width. Only upper part of the leaf is present. The leaf is linear to lanceolate in shape, apex pointed, base missing, margin entire. The median region of leaf is occupied by 6-7 weak subparallel veins which give rise to arched secondary veins at an acute angle. The secondary veins form narrow, elongate meshes of equal size throughout the lamina.

Comparison — The venation pattern and general shape of the specimen closely resemble *Gangamopteris karharbariensis* described by Maithy (1965d, pl. 2, figs 11-13).

Distribution — Coal-bearing Formation — Patpara-Marjada Nala Section, Birsinghpur Pali, (Traverse D).

Gangamopteris cyclopteroides var. *attenuata* Feistmantel, 1879

Pl. 2, fig. 11

Description — There are four incomplete fragmentary leaf specimens in the collection. The figured leaf is more or less complete, measuring 10.1 cm long and 3.5 cm broad at its maximum width. The apex is obtuse, base contracted and margin entire. The median region of leaf is occupied by 4 to 5 parallel running veins which form secondary veins which are thicker in the lower part. After anastomosis and dichotomization secondary veins form linear oblong, narrow meshes throughout lamina. The meshes are 4-7 mm long and 0.5 mm broad. The density of veins is 15-20 per cm near the margin of the leaf.

Comparison — The present specimens in their contracted base, i.e. attenuate base, general shape and venation pattern compare with *G. cyclopteroides* var. *attenuata* described by Feistmantel (1879, pl. 11, fig. 1; pl. 14, figs 1, 2).

Distribution — Coal-bearing Formation — Baruha Nala, Umaria (Traverse B).

Genus — *Glossopteris* Brongniart, 1882

Glossopteris sp.

Pl. 4, fig. 27

Description — Leaf is large, broad, spathulate in shape measuring 14.5 cm in length and 7.6 cm in width. The apex and base are missing, only one side of lamina is preserved. The midrib is thick, 2-3 mm broad, persistent, grooved and striated. Secondary veins arise at an acute angle, arched, after anastomosis and dichotomization form open, elongate

hexagonal meshes near the midrib and linear elongate, fine meshes towards the margin. The meshes are 7 to 10 mm long and 0.75 to 1 mm broad near the midrib and 10 to 18 mm long and 0.5 mm broad near the margin. The density of veins is 9 to 10 per cm near the midrib and 20 to 22 per cm near the margin.

Comparison — The venation pattern of the present leaf is comparable with that of *G. communis* Feistmantel. However, our specimen is considerably large in size. Due to the absence of apex, base and margin of the leaf, it is difficult to assign this specimen to any known species of *Glossopteris*.

Distribution — Coal-bearing Formation — Baruha Nala, Umaria (Traverse B).

Glossopteris decipiens Feistmantel, 1879

Pl. 4, fig. 28

Description — There are seven incomplete leaf impressions in our collection. The figured leaf is 6.9 cm long and 2.8 cm broad at its maximum width. The apex is acuminate, base absent and margin is entire. The midrib is distinct, up to 3.5 cm from the basal region and then diffuses into fine secondary veins near the apex. The secondary veins arise from the midrib at an acute angle and after dichotomization and anastomosis form narrow, oblong meshes throughout the lamina. The meshes are 3 to 5 mm long and 0.25 to 0.5 mm broad. The density of veins is 10 to 12 per cm in the middle and 15-18 per cm near the margin.

Comparison — The present leaf resembles *G. decipiens* (Feistmantel, 1879, pl. 18, fig. 4).

Distribution — Coal-bearing Formation — Mangthar, Birsinghpur Pali) [Traverse B (i)].

Glossopteris communis Feistmantel, 1876

Pl. 4, fig. 29

Description — There are 10 incomplete leaves in the collection. The figured leaf is 8.1 cm long and 3.5 cm broad. The apex and base are missing, margin is entire. The midrib is 1.5 to 2.0 mm broad and striated. The secondary veins arise at an angle of 45°. They are slightly arched and after dichotomy and anastomosis form long, linear, narrow hexagonal meshes throughout the leaf. The meshes are 5 to 8 mm long and 0.15 mm broad. The density of the veins is 10 to 16 per cm near the midrib and 18 to 25 per cm near the margin.

Comparison — The present specimen closely agrees in its general shape and venation pattern with *G. communis* described by Feistmantel (1881a, pl. 36, fig. 2; pl. 32, fig. 2; 1886, pl. 2, figs 1, 2) and Maheshwari and Gyan Prakash (1965, pl. 2, fig. 14).

Distribution — Coal-bearing Formation — Baruha Nala, Umaria (Traverse B), Mangthar-Amurai Section, Traverse B(i) and (ii), Khodargaon-Kudri Section (Traverse C), Patpara-Marjada Nala Section (Traverse D), Ganjra Nala — Johilla confluence Section, Traverse E; Birsinghpur Pali. Bakan Nala, Anuppur [Traverse A(i)]. Chirimiri-Paradol Railway Cutting Section (Traverse A), Duman Hill-Korea Section (Traverse C), Chirimiri.

Glossopteris karharbariensis Chandra & Surange, 1979

Pl. 2, fig. 16

Description—There are six incomplete leaf impressions in the collection. The figured leaf is 5.2 cm long, 1.8 cm broad at its maximum width. The leaf is linear, narrow in shape. Apex is acute, base missing and margin entire. Midrib distinct, striated, 1.0 to 1.5 mm broad. The secondary veins arise at an acute angle from the midrib and after 1 mm they arch and reach the margin of the leaf. They dichotomize and anastomose to form narrow, linear, polygonal meshes throughout lamina. Meshes are 3 to 4 mm long and 0.5 mm broad. The density of veins is 20 to 22 per cm throughout the lamina.

Comparison— Chandra and Surange (1979, pl. 47, fig. 3; text-figs 26A, 1a, a_2, 46N) erected a new species, *Glossopteris karharbariensis* for the leaf described earlier under *Glossopteris angustifolia* by Kulkarni (1971, pl. 1, fig. 10). The present leaves are comparable to the holotype of *G. karharbariensis* (specimen no. 33072, B.S.I.P. (Museum) in their shape and venation pattern.

Distribution — Coal-bearing Formation — Baruha Nala, Umaria (Traverse B).

Glossopteris angusta Pant & Gupta, 1971

Pl. 3, fig. 22

Description — There are two incomplete leaves in the collection. The figured leaf is narrow, spathulate in shape, 9.1 cm long and 2.2 cm broad at its maximum width, only one side of the lamina is well-preserved. The apex and base is missing, margin entire. The midrib region is occupied by 5-6 parallel running strands which in due course form secondary nerves and ultimately one strand reaches the apex. The secondary veins form long narrow rectangular meshes of equal size throughout the lamina. The meshes are 2 to 4 mm long and 0.3 mm broad. The density of veins is 15 to 20 per cm near the midrib and 20 to 25 per cm near the margin.

Comparison — The specimens closely compare with the holotype of *G. angusta* Pant & Gupta (1971, pl. 21, figs 33, 34), in their shape and venation pattern.

Distribution — Coal-bearing Formation — Baruha Nala, Umaria (Traverse B).

Glossopteris indica Schimper, 1869

Pl. 3, fig. 23

Description — The specimens are fragmentary. The figured leaf is 4.6 cm long and 2.0 cm broad at its maximum width. The apex, base and margin of the leaf are not preserved. Midrib is distinct, 2·5 mm broad and persistent throughout the preserved length. The secondary veins arise at an angle of 45°. They dichotomize and anastomose to form few broad, elongate, polygonal meshes near the midrib and narrow, elongate, hexagonal meshes near the margin. The meshes are 2 to 2.5 mm and 0.75 to 1 mm broad near the midrib and 3 to 4 mm long and 0.25 to 0.5 mm broad near the margin.

Comparison — The specimens fairly resemble the basal part of *G. indica* (Schimper, 1869) which has been rephotographed by Rigby, Maheshwari and Schopf (1980), Kulkarni (1971, pl. 1, fig. 15) and Srivastava (1977b, pl. 1, fig. 1).

Distribution — Coal-bearing Formation — Duman Hill-Korea Section, Chirimiri (Traverse C), Mangthar-Amurai Section, Birsinghpur-Pali [Traverse B (i)], Khodargaon-Kudri Section, Birsinghpur-Pali (Traverse C).

Glossopteris zeilleri Pant & Gupta, 1968

Pl. 3, fig. 24

Description — Leaf fragmentary, figured leaf 4.8 cm long and 2.4 cm broad, narrow, elongate, base absent, apex acute, margin entire, midrib distinct, striated, 1·5 mm broad. Secondary veins arise at an acute angle, slightly arched, after anastomosis and dichotomization form narrow elongate, hexagonal meshes throughout lamina. Density of veins is 15-20 per cm near the midrib and 20-25 per cm near the margin.

Comparison — The present leaf compares well with the holotype of *G. zeilleri* Pant & Gupta (1968, pl. 21, fig. 20) in its shape and venation pattern.

Distribution — Coal-bearing Formation — Duman Hill-Korea Section, Chirimiri (Traverse C).

Genus—*Noeggerathiopsis* (Feistmantel) Maithy,1965

Remarks — Rigby, Maheshwari and Schopf (1980) have not recognized the separate existence of the genus *Noeggerathiopsis* and considered it to be the Synonym of the genus *Cordaites*.

Noeggerathiopsis hislopi (Bunbury) Feistmantel, 1879

Pl. 1, figs 6-8; Pl. 2, fig. 17

Description — There are 16 specimens in the collection. The specimens from Talchir Formation are fragmentary but well preserved. The leaves are 4-10 cm long and 1.5-2.7 cm broad at maximum width. The apex is missing, base contracted but extreme base is not preserved, margin entire. The shape of leaf is probably linear-lanceolate. The veins arise from the base, dichotomize frequently during upward course. The angle of divergence between two veins is 2° and 4°. The density of veins is 16-20 per cm.

Comparison — The present specimens are comparable with *N. hislopi* described by Feistmantel (1879, pl. 20, fig. 1; pl. 29, figs 1, 2) and Maithy (1965b, pl. 1, figs 1, 2).

Distribution — Talchir Formation — Chandas Nala, Anuppur (Traverse D), Jwala-

mukhi, Umaria; Coal-bearing Formation — Mangthar Birsinghpur-Pali [Traverse B(i)], Bakan Nala, Anuppur [Traverse A(i)], Chrimiri-Paradol Section (Traverse A), Gaemera Nala (Traverse B), Duman Hill-Korea Section (Traverse C), Chirimiri.

Noeggerathiopsis spathulata (Dana) Maithy, Maithy, 1965

Pl. 2, fig. 18

Description — There are three specimens present in the collection. The figured leaf is 6.8 cm long and 2.8 cm broad at its maximum width. The leaf is broad, spathulate. The apex is missing, base tapering; margin is entire. The veins arise from the base, they are divergent and dichotomise frequently during upward course. The angle of divergence between two veins is 6° and 9°. Veins are not very close, the density is 14-18 per cm.

Comparison — Although the apical portion of the leaves is not preserved in the present collection but in the nature of divergent veins, the specimens are comparable with *N. spathulata* described by Maithy (1965b, pl. 1, figs 4, 5).

Distribution — Coal-bearing Formation — Bakan Nala, Anuppur [Traverse A(ii)], Mangthar-Amurai Section, Birsinghpur-Pali [Traverse B(i)], Chirimiri-Paradol Section, Chirimiri (Traverse A), Gaemera Nala, Chirimiri (Traverse B), Duman Hill-Korea Section, Chirimiri (Traverse C).

Noeggerathiopsis minor sp. nov.

Pl. 2, figs 19-21

1879 *Noeggerathiopsis hislopi* Feistmantel, pl. 19, figs 3, 4, 5.

Diagnosis — Leaf simple, symmetrical, small; spathulate in shape; apex broad, rounded, base narrow, contracted, margin entire; veins arise from base, thick, erect, dichotomize twice or thrice, open, angle of divergene 2°-4°, density of veins 11-14 per cm.

Holotype — Pl. 2, fig. 19, B.S.I.P. specimen no. 35989.

Type Locality — Bakan Nala, Anuppur [Traverse A(ii)].

Horizon—Coal-bearing Formation (Lower Permian).

Description — Six complete to incomplete leaf impressions are present in the collection. The leaves are small in size, varying from 3.5 to 6.0 cm in length and 1 to 1.5 cm in width and are spathulate in shape. The apex is always broadly rounded, base contracted, sometimes tapering, margin is entire. Veins are comparatively thick, fairly open, dichotomize only twice or thrice during upward course. The angle of divergence between two veins is 2° to 4°. The density of veins is 11 to 14 per cm.

Comparison — The present species has been instituted to accommodate the smaller leaves having open veins with distinct rounded apex. Such small leaves have earlier been described under *N. hislopi*. But it has been found that such leaves are morphologically distinct and characteristic, therefore, they have been assigned to a new species, *Noeggerathiopsis minor*.

Distribution — Coal-bearing Formation — Duman Hill-Korea Section, Chirimiri (Traverse C).

Noeggerathiopsis sp.

Pl. 1, fig. 9

Description — There are many fragmentary impressions of incomplete leaves in the collection. The apex and base are absent; margin is entire. The lamina of the leaves is occupied by erect, parallel running veins emerging from the base of the leaves. The angle of divergence of veins is 3°-7°. The density of veins is 12-15 per cm.

Comparison — The specimens are very fragmentary and it is difficult to compare them with any well known species of *Noeggerathiopsis*.

Distribution — Talchir Formation — Chandas Nala Railway bridge-Son River Section, Chandas Nala, Anuppur (Traverse D).

EQUISETACEOUS STEM

Pl. 1, fig. 10; Pl. 3, fig. 26

The collection includes a large number of well-preserved equisetaceous stems with continuous ridges and grooves.

Distribution — Talchir Formation — Barachada, Birsinghpur Pali (Traverse A); Coal-bearing Formation — Patpara-Marjada Nala Section (Traverse D), Mangthar-

Amurai Section [Traverse B(i)], Khodargaon-Kudri Section (Traverse C), Birsinghpur Pali. Baruha Nala, Umaria [Traverse B(i)], Bakan Nala, Anuppur [Traverse A(ii)], Chirimiri-Paradol Section, Chirimiri (Traverse A), Duman Hill-Korea Section, Chirimiri (Traverse C).

Vertebraria indica Royle, 1833

Well-preserved impressions of this species have been recorded from the Coal-bearing Formation of Birsinghpur-Pali.

COMPARISON AND DISCUSSION

Megafossils from the Talchir Formation — The Talchir plant fossils are poorly known from India. Feistmantel (1879) reported plant fossils referable to Talchir Formation from Deogarh, Karanpura, Auranga and Hutar coalfields and South Rewa Gondwana Basin. Surange and Lele (1956, 1957) reported Talchir plant fossils from the Johilla and Giridih coalfields. Lele (1966) observed a few species of *Gangamopteris* and *Samaropsis* from the Singrauli Coalfield. All the megafossil records from the Talchir Formation were synthesized by Lele (1966, table 2) and pointed that the oldest Talchir horizon is devoid of any plant fossil whereas *Gangamopteris* associated with *Noeggerathiopsis* is the common element in the younger horizons. *Glossopteris* is found in the youngest Talchirs (Rikba bed) or its presence is indicative of the overlying Karharbari flora.

The Talchir assemblage from Anuppur is represented by *Noeggerathiopsis hislopi*, *Noeggerathiopsis* sp. and equisetaceous stems. On the other hand, Chirimiri assemblage is composed of four species of *Gangamopteris*. The Chirimiri assemblage is comparable to the Singrauli flora which comprises 3 species of *Gangamopteris* and one species of *Samaropsis* (Lele, 1966). We have not found other plant fossils in Chirimiri as reported by Biswas (1955). The Anuppur flora is typical in having only *Noeggerathiopsis* and is not comparable to any known Talchir flora. It is interesting to note that the Talchir assemblage in Chirimiri is represented by *Gangamopteris* while the one from Anuppur shows only *Noeggerathiopsis*.

Megafossils from the Coal-bearing Formation — The Umaria assemblage is represented by 3 species of *Gangamopteris*, four species of *Glossopteris* and equisetaceous stems, the Birsinghpur Pali assemblage by two species of *Gangamopteris*, four species of *Glossopteris*, *Vertebraria indica*, *Arberia surangei* (Chandra & Srivastava, 1981), two species of *Noeggerathiopsis* and equisetaceous stems, the Anuppur flora by two species of *Gangamopteris*, three species of *Noeggerathiopsis*, one species of *Glossopteris* and equisetaceous stems, and the Chirimiri flora by two species of *Gangamopteris*, three species of *Noeggerathiopsis*, three species of *Glossopteris* and equisetaceous stems (Table 1).

The Karharbari plant fossils have earlier been reported from various Lower Gondwana localities such as Giridih Coalfield (Feistmantel, 1879; Maithy, 1965a-d, 1966b), Ganjra Nala bed, Birsinghpur Pali (Saksena, 1955, 1963; Maithy, 1968; Lele & Maithy, 1969), Chirimiri Coalfield (Biswas, 1955; Ganguly, 1969), South Karanpura Coalfield (Kulkarni, 1970), Jayanti Coalfield (Lele & Maithy, 1966; Lele & Makada, 1974), Auranga Coalfield (Srivastava, 1977a), etc. Recently Chandra and Surange (1979) have recognised distinct *Glossopteris* species in the different Lower Gondwana formations of India. According to them nine species of *Glossopteris* namely *G. taenoides*, *G. angusta*, *G. recurva*, *G. pandurata*, *G. giridihensis*, *G. karharbariensis*, *G. zeilleri*, *G. communis*, *G. decipiens* and *G. taeniensis* are typical of the Karharbari Stage.

The floral assemblage from the coal-bearing formations of Umaria, Birsinghpur Pali, Anuppur and Chirimiri, in general, is dominated by *Noeggerathiopsis* and *Gangamopteris*. *Glossopteris* in this assemblage is represented by seven species, of which five species namely *G. kaharbariensis*, *G. communis*, *G. angusta*, *G. decipiens* and *G. zeilleri* are common to those typical of the Karharbari Stage as listed by Chandra and Surange (1979). We have not been able to find even a single species of either *Botrychiopsis* or *Buriadia*. These palaeobotanical observations suggest that the Coal-bearing Formation in these parts of the South Rewa Gondwana Basin are equivalent to the Karharbari 'Stage' of the Peninsular India.

TABLE 1-DISTRIBUTION OF PLANT FOSSILS IN THE AREAS OF INVESTIGATION

		UMARIA	PALI	ANUPPUR	CHIRIMIRI
COAL BEARING FORMATION	GANGAMOPTERIS				
	G. cyclopteroides				
	G. cyclopteroides var attenuata				
	G. major				
	G. angustifolia				
	G. karharbariensis				
	G. clarkeana				
	GLOSSOPTERIS				
	G. karharbariensis				
	G. communis				
	G. angusta				
	G. deciplens				
	G. indica				
	G. zeilleri				
	G. sp.				
	NOEGGERATHIOPSIS				
	N. hislopi				
	N. spathulata				
	N. minor sp. nov				
	VERTEBRARIA				
	V. indica				
	EQUISETACEOUS STEM				
	ARBERIA				
	A. surangei				
TALCHIR FORMATION	GANGAMOPTERIS				
	G. cyclopteroides				
	G. intermedia				
	G. clarkeana				
	G. major				
	NOEGGERATHIOPSIS				
	N. hislopi				
	Noeggerathiopsis sp.				
	EQUISETACEOUS STEM				

STRATIGRAPHICAL STATUS

Blanford (1976) for the first time recognised the Karharbari 'Stage' in the Giridih Coalfield. This stage was characterized by the presence of *Botrychiopsis validum* and *Buriadia sewardi* and by the dominance of *Gangamopteris* and *Noeggerathiopsis* to distinguish it both from the underlying Talchir and the overlying Damuda. Because of the dominance of *Noeggerathiopsis* and *Gangamopteris*, the Karharbari was accepted as the upper part of the Talchir Formation (Feistmantel, 1879; Oldham, 1893; Wadia, 1957). On the other hand, the discovery of a marine fossiliferous bed (Sinor, 1923) below the Coal-measures and unconformably overlying the Talchirs at Umaria was taken as an evidence to place the Karharbaris at the base of Damuda Group (Fox, 1931; Pascoe, 1959; Krishnan, 1960).

The lithological types constituting the Coal Measures in the South Rewa Gondwana Basin are shales, carbonaceous shales, coal and sandstones. It has been found very difficult to distinguish the Karharbari and Barakar formations on the basis of lithology. Recently Ghosh *et al.* (1964) have suggested the presence of a Boulder and/or a conglomeratic bed below the Barakars as a means of recognising the Karharbaris. The presence of a Boulder and/or conglomeratic bed below the Barakar is very uncommon feature and it is not generally possible to utilize this character in recognising the Karharbaris. A pebbly sandstone bed has been observed in a few sections in the areas of investigation. The beds overlying this zone were naturally thought to belong to the Barakar Stage. These beds overlying the pebbly zone are normally represented by thick massive sandstone or sometime carbonaceous shale. We have, however, failed to find any megafossil above this pebbly zone.

It is still disputed whether Karharbari should be recognized as a distinct formation geologically, floristically at least the plant bearing Coal-Measures (so-called Barakars) of these areas of the South Rewa Gondwana Basin are equivalent to the Karharbari Formation of the Peninsular India. These biostratigraphical studies support the views expressed earlier by Biswas (1955), Ganguly (1959), Maithy (1966, 1967, 1968, 1969) and others. The Karharbari flora is quite distinct from the typical Barakar flora and is closer to the known Talchir flora. On the other hand, the lithology of the beds having Karharbari flora is similar to that of the Barakar Formation and is distinct from that of the Talchir Formation. These facts make it apparently clear that the plant similarities between two geological horizons do not necessarily mean the lithological similarities as well and vice-versa.

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EXPLANATION OF PLATES

(All type and figured specimens are preserved at the B.S.I.P. Museum, Lucknow. Specimens shown in Plate 1 are from Talchir while those in Plates 2, 3 and 4 belong to the Coal-bearing Formation)

PLATE 1

1. *Gangamopteris cyclopteroides* Feistmantel, specimen no. 35352.× Nat. size; Bhukbhuki, Chirimiri.
2, 3. *Gangamopteris clarkeana* Feistmantel, specimen nos. 35354 and 35353.× Nat. Size; Bhukbhuki, Chirimiri.
4. *Gangamopteris intermedia* Maithy, specimen no. 35355.× Nat. size; Bhukbhuki, Chirimiri.
5. *Gangamopteris major* Feistmantel, specimen no. 35356.× Nat. size; Bhukbhuki, Chirimiri.
6-8. *Noeggerathiopsis hislopi* (Bunbury) Feistmantel, specimen nos. 35999. × 1.5; Chandas Nala, Anuppur; 36000. × 1.5; Chandas Nala, Anuppur; and 36001. × Nat. size; Jwalamukhi, Umaria.
9. *Noeggerathiopsis* sp., specimen no. 36002.× 1.5; Chandas Nala, Anuppur.
10. Equisetaceous stem, specimen no. 35357.× Nat. size; Barachada, Birsinghpur Pali.

PLATE 2

11. *Gangamopteris cyclopteroides* var. *attenuata* Feistmantel, specimen no. 35981.× Nat. size; Baruha Nala, Barbaspur, Umaria.
12. *Gangamopteris major* Feistmantel, specimen no. 35982.× Nat. size; Bakan Nala, Anuppur.
13. *Gangamopteris karharbariensis* Maithy, specimen no. 35983.× Nat. size; Patpara-Marjada Nala Traverse, Birsinghpur Pali.
14. *Gangamopteris angustifolia* McCoy, specimen no. 35984.× Nat. size; near Mangthar, Birsinghpur Pali.
15. *Gangamopteris clarkeana* Feistmantel, specimen no. 35985.× Nat. size; Duman Hill-Korea Traverse, Chirimiri.
16. *Glossopteris karharbariensis* Chandra & Surange, specimen no. 35986. × Nat. size; Baruha Nala, Barbaspur, Umaria.
17. *Noeggerathiopsis hislopi* (Bunbury) Feistmantel, specimen no. 35987.× Nat. size; near Mangthar, Birsinghpur Pali.
18. *Noeggerathiopsis spathulata* (Dana) Maithy, specimen no. 35988.× Nat. size; Bakan Nala, Anuppur.
19. *Noeggerathiopsis minor* sp. nov., specimen no. 35989.× Nat. size (Holotype); Bakan Nala, Anuppur.
20. *Noeggerathiopsis minor* sp. nov., specimen no. 35989.× 2 (enlargement of fig. 19); Bakan Nala, Anuppur.
21. *Noeggerathiopsis minor* sp. nov., specimen no. 35990.× Nat. size; Duman Hill-Korea Traverse, Chirimiri.

PLATE 3

22. *Glossopteris angusta* Pant & Gupta, specimen no. 35991.× Nat. size; Baruha Nala, Barbaspur, Umaria.
23. *Glossopteris indica* Schimper, specimen no. 35992. × Nat. size; Khodargaon-Kudri Traverse, Birsinghpur Pali.
24. *Glossopteris zeilleri* Pant & Gupta, specimen no. 35990.× Nat. size; Duman Hill — Korea Traverse, Chirimiri.
25. *Gangamopteris cyclopteroides* Feistmantel, specimen no. 35994.× Nat. size; Baruha Nala, Barbaspur, Umaria.
26. Equisetaceous stem — specimen no. 35983.× Nat. size; Patpara — Marjada Nala Traverse, Birsinghpur Pali.

PLATE 4

27. *Glossopteris* sp., specimen no. 35996.× 3/4; Baruha Nala, Barbaspur, Umaria.
28. *Glossopteris decipiens*, Feistmantel, specimen no. 35997.× Nat. size; near Mangthar, Birsinghpur Pali.
29. *Glossopteris communis* Feistmantel, specimen no. 35998.× Nat. size; near Mangthar, Birsinghpur Pali.

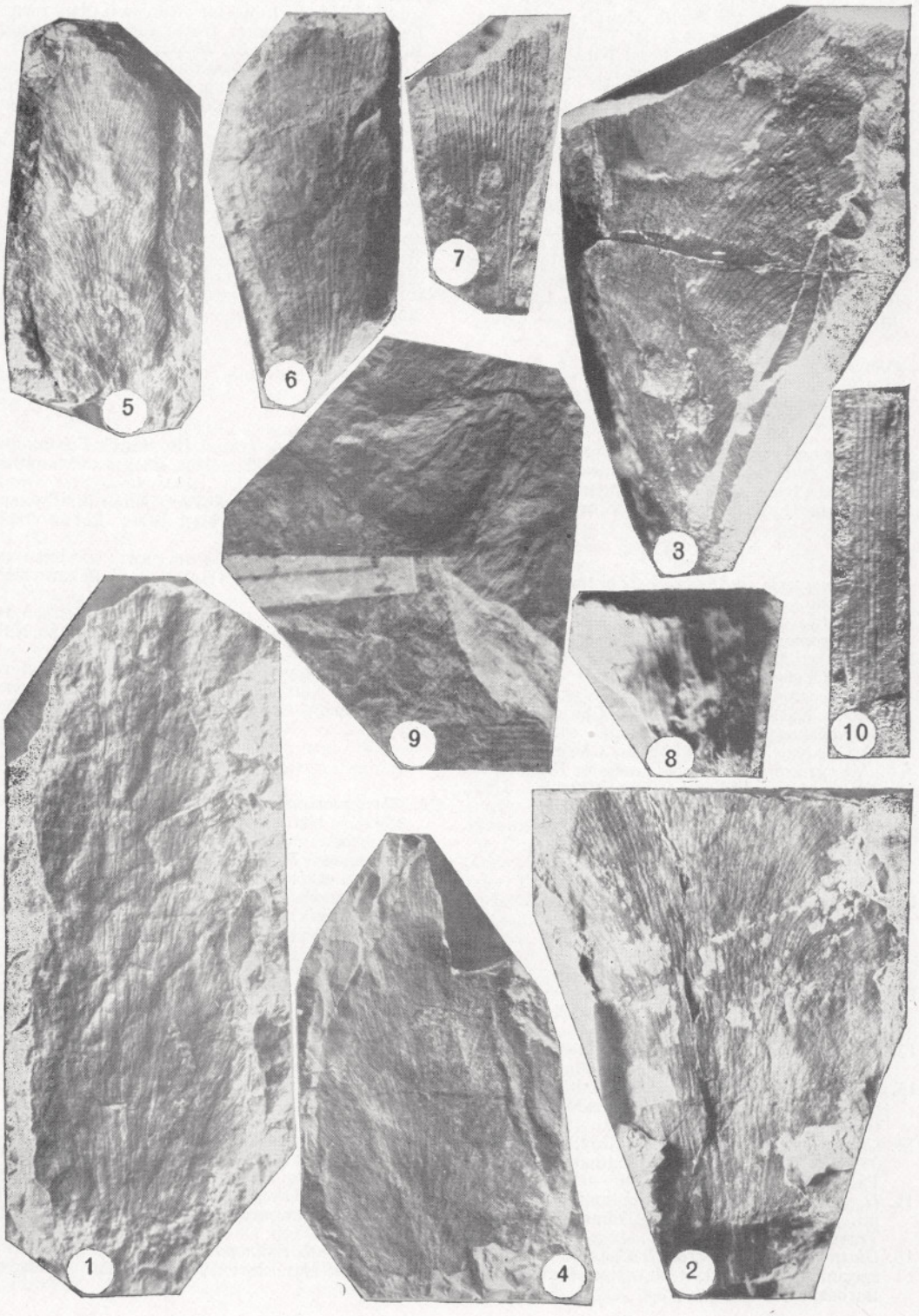

PLATE 1

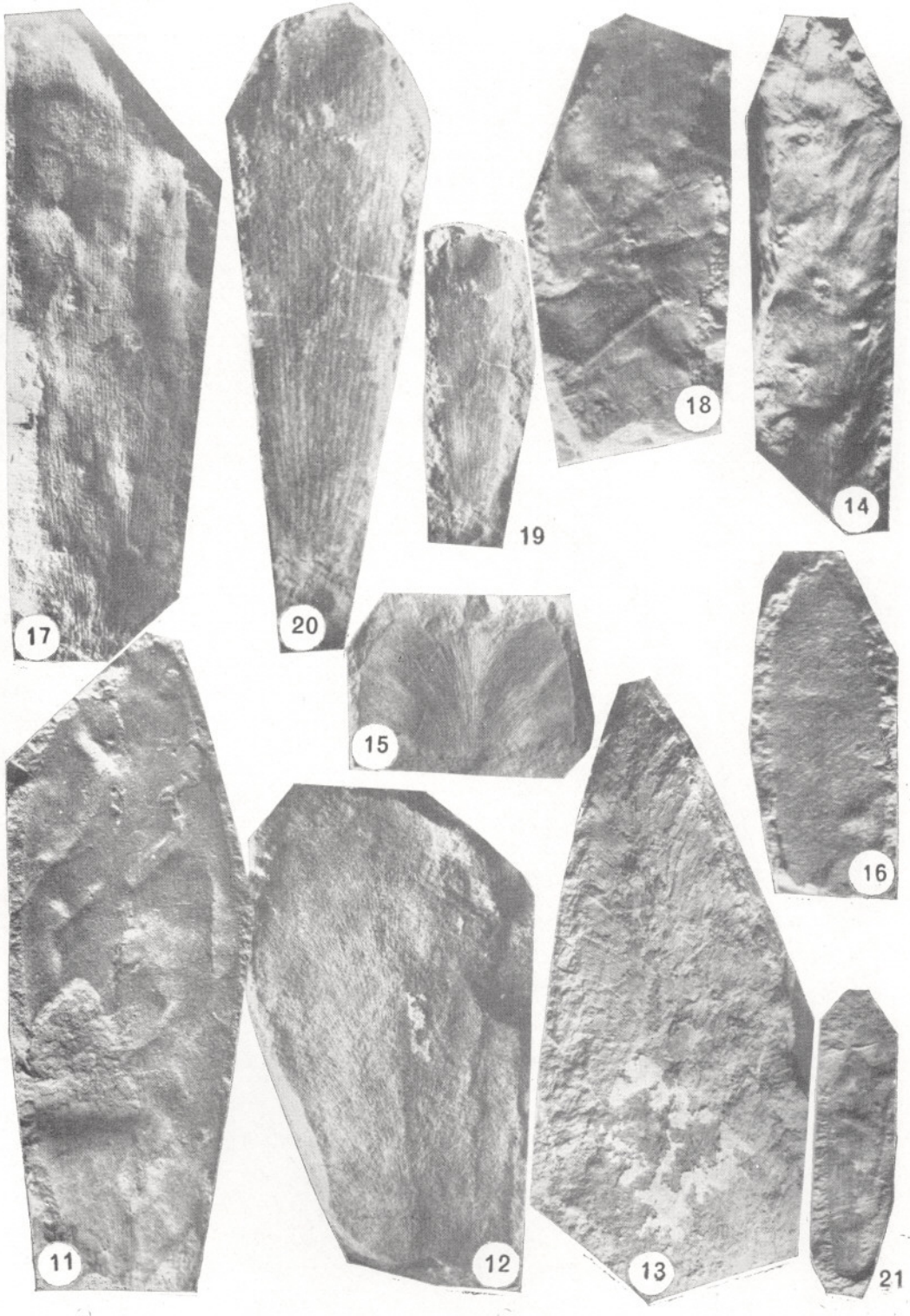

PLATE 2

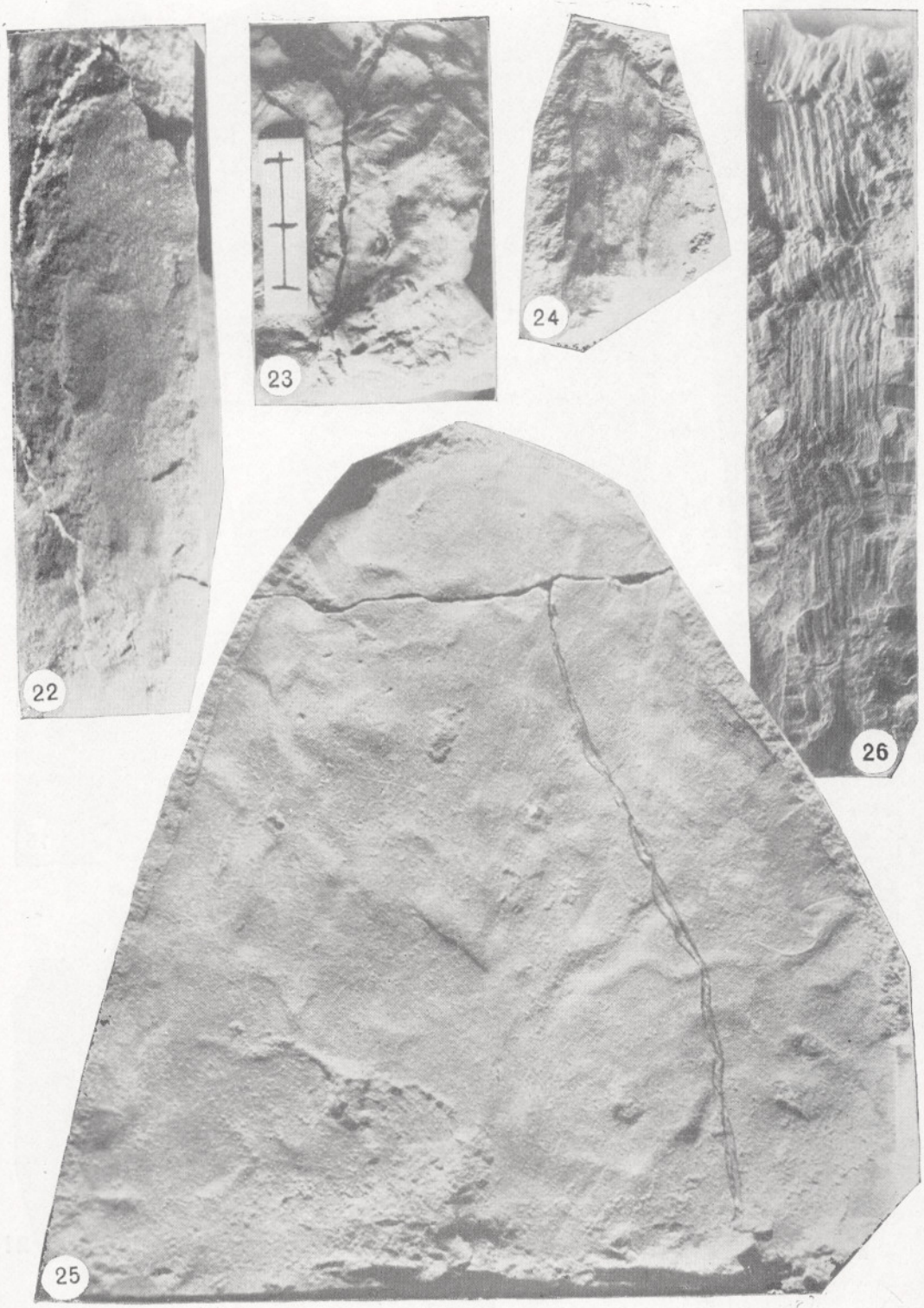

PLATE 3

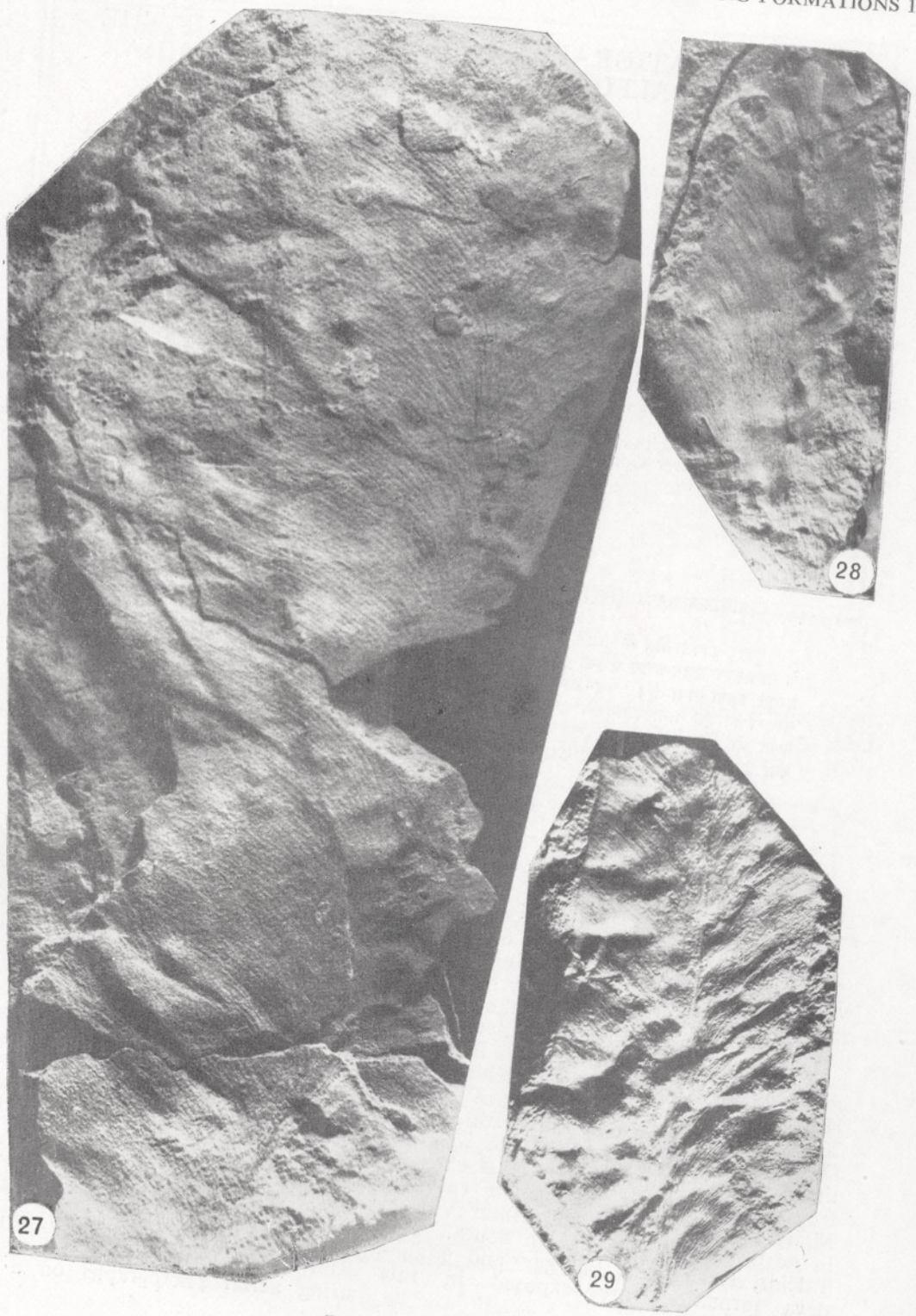

PLATE 4