Floristics, age and stratigraphical position of fossiliferous band in Chitra Mine Area, Saharjuri Outlier, Deogarh Coalfield, Bihar[1]

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The Saharjuri Outlier is one of the three coal-bearing areas in the Deogarh Coalfield. There have been doubts about the age and stratigraphical position of these beds. A recent collection of plant megafossils from Chitra Mine Area in the Saharjuri Outlier shows the presence of *Gangamopteris maheshwarii* sp. nov., *Gangamopteris obovata* Carruthers, *Glossopteris deogarhensis* sp nov., *Glossopteris linearis* Feistmantel, *Glossopteris decipiens* Feistmantel, *Noeggerathiopsis conspicua* Lele & Makada, *Noeggerathiopsis saharjuriensis* sp. nov., *Noeggerathiopsis bihariensis* sp. nov., *Cordaicarpus* sp., *Samaropsis* sp. and *Vertebraria indica* Royle. Overall assemblage is characteristically basal Barakar in composition, having close similarity to some of the known assemblages from the Karharbari "Formation"/"Stage" (*Noeggerathiopsis-Gangamopteris* Assemblage Zone).

Key-words—Stratigraphy, Floristics, Deogarh Coalfield, Basal Barakar (India).

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सारांश

बिहार में देवगढ़ कोयला-क्षेत्र में सहरजुरी पुरान्तःशायी के चित्रा खान क्षेत्र में पादपाश्ममय पट्टी का वनस्पतिजात, इसकी आयु तथा स्तरिकीय स्थिति

ऊषा बाजपेयी

देवगढ़ कोयला-क्षेत्र में सहरजुरी पुरान्तःशायी तीन कोयला-धारक क्षेत्रों में से एक है। इन संस्तरों की आयु एवं स्तरिकीय स्थिति के बारे में संदेह है। इसी पुरान्तःशायी में चित्रा खान क्षेत्र से अभी हाल में गुरुपादपाश्मों के संग्रह में **गंगामॉप्टेरिस माहेश्वराई** नव जाति, **गं० ओबोवेटा केरुथर्स, ग्लॉसॉप्टेरिस देवगढ़ेन्सिस** नव जाति, **ग्लॉ० लाइनियेरिस** फाइस्टमॅन्टेल, **ग्लॉ० डेसीपियन्स** फाइस्टमॅन्टेल, **नैग्रेथिऑप्सिस कॉन्सपिकुआ** लेले व मकाडा, **नै० सहरजुरीयेन्सिस** नव जाति, **नै० बिहारीयेन्सिस** नव जाति, **कोर्डेकार्पस** जाति, **समारोप्सिस** जाति एवं **वर्टीब्रेरिया इंडिका** रॉयर्ल नामक वर्गक विद्यमान हैं। कुल मिलाकर यह समुच्चय लाक्षणिक रूप से आधारी बराकार है तथा करहरबारी "शैल-समूह"/"चरण" (नैग्रेथिऑप्सिस-गंगामॉप्टेरिस समुच्चय मंडल) से कुछ ज्ञात समुच्चयों से घनिष्ठ समानता प्रदर्शित करता है।

THE Deogarh Coalfield comprises three outliers, viz., Jainti, Saharjuri and Kundit Kuraiah, stretching between 86°37′-87°5E′ and 24°5′-24°15′N. In all the outliers sediments of Talchir and Damuda groups are represented; the latter by the Barakar Formation only. The area was first mapped by Hughes (1869). Later Niyogi and Sanyal (1962) and Niyogi (1966) worked on stratigraphy of the Jainti and Saharjuri outliers respectively.

The Talchir Formation lies with a profound unconformity on the Archaeans and covers a major part of the basin. The usual succession of sediments is conglomerate, silt, shale and sandstone. In Jainti area the formation is chiefly represented by silty shales, in Kundit Kuraiah area the conglomerate is more conspicuously exposed with slight preponderance of sandstones over shales and around Saharjuri as many as five conglomerate beds have been reported.

The Barakar Formation has thick beds of carbonaceous shales at places but few coal seams of economic viability. Recent surveys, however, have shown presence of many more seams, particularly in the Chitra area of Saharjuri Outlier.

There has been controversy about the

[1]Contribution to I.G.C.P. Project 237—Floras of the Gondwanic continents.

stratigraphic position and age of the coal-bearing beds of Deogarh Coalfield. This problem was resolved to some extent in Jainti Outlier by Lele and Makada (1974). Palaeobotanical and palynological investigations revealed the presence of elements usually characteristic of the Karharbari "Formation". These elements are *Botrychiopsis valida* Kurtz, *Buriadia sewardii* Sahni, *Noeggerathiopsis spatulata* (Dana) Feistmantel and species of pollen genera *Crucisaccites, Potonieisporites* and *Plicatipollenites* (Puri, 1952; Niyogi & Sanyal, 1962; Lele & Makada, 1972). No palaeobotanical information is so far available from the Saharjuri Outlier.

The coal outcrops in Saharjuri area are located between 86°50′-86°55′E and 24°5′-24°10′N. The topography is rugged and contours vary between 200 to 230 meters. The Talchir Formation is overlain by coal-bearing beds which have usually been referred to Barakar by the field geologists. General sedimentary sequence in the Saharjuri Outlier is as follows (after, Niyogi, 1966):

	Upper arkoses
	Upper (Chitla) coal seams and shales
	Concretionary arkoses
Barakar	Lower (Bhawanipur) coal seams and shales
	Lower arkoses
	Conglomerate
Talchir	Siltstone and silty shales
	Boulder conglomerate
	UNCONFORMITY
Archaeans	

As many as five boulder conglomerate beds have been reported in the Talchir Formation (Niyogi, 1964, p. 268). The Barakar sediments are generally conformable to the under-lying siltstones of Talchir Formation (Niyogi, 1966, p. 963). The sandstone is the dominant rock type. Shales are insignificant except in coal-bearing portions which contain two groups of major seams, viz., Bhawanipur and Chitla; 2 seams in the former and 3 in the latter. Recent reports record the presence of thirteen workable coal seams which form 2 groups, viz., Saharjuri Group and Chitra Group. Following is the general geological succession in the Chitra Mine Area (courtesy Project Office, Chitra Mine):

Formation	*Thickness*	*Lithology*
Recent	0–10 m	Soil and sandy soil, laterite
	UNCONFORMITY	
Barakar	400 m ±	Coarse-grained white to slightly grey sandstone, gritty sandstone, conglomerate, shales, grey shales and coal
Talchir	50 m ±	Coarse-grained sandstone, green shales, fine grained sandstone with felspars
	UNCONFORMITY	
Archaeans		

MATERIAL AND METHODS

Material was collected from two collieries, viz., Girija and Chitra Patrika. Plant remains were found only in the shale dumps of Chitra Patrika abandoned incline whereas the coal seam at Girija was sampled for bulk macerations which yielded only isolated tracheid pieces. For cuticular preparations from megafossils collected from Chitra Patrika a thin film of cellulose acetate was spread on the carbonified crust. After 2-3 hours, the dry peel was taken off and oxidized in concentrated nitric acid for about 24-48 hours. The carbonified pieces turned brown on oxidation. These were thoroughly washed in water and then digested in a dilute solution of potassium hydroxide to clear cuticles. The cuticle pieces were washed in distilled water till the alkali was removed. During the process the upper and lower cuticular layers generally separated. Sometimes the two layers had to be separated with a needle and/or a single hair brush. The cuticle pieces were stained in 10 per cent aqueous safranin 0 and mounted in polyvinyl alcohol and canada balsam. All specimens and slide have been deposited with the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

DESCRIPTION

Noeggerathiopsis Feistmantel 1879 emend. Pant & Verma 1964

1984 *Pantophyllum* Rigby: *Mem. 3rd Congr. Latinoa mer. Paleont. Mexico* : 142.

Type species—*Noeggerathiopsis spatulata* (Dana) Feistmantel 1879.

Remarks—The genus *Noeggerathiopsis* was proposed by Feistmantel (1879) for cordaitean-type leaves from the Talchir-Lower Barakar sediments of peninsular India. He included in it *Noeggerathia?*

(Cyclopteris?) hislopi Bunbury 1861, a fragment of a leaf from the Kamthi Formation, alongwith well-preserved leaves from the Talchir and Lower Barakar formations. It is, however, doubtful if the cordaitean-type of leaf survived up to the Kamthi times. The other leaves have been shown to be indistinguishable from *Noeggerathia spatulata* Dana 1849 which was believed to be a species of the genus *Cordaites* Unger (Rigby, Maheshwari & Schopf, 1980). Rigby (1984), hence assumed that the genus *Noeggerathiopsis* is a junior synonym of *Cordaites*. On this assumption he proposed a new genus *Pantophyllum* to encompass all those cordaitean-type of leaves from the Permian Gondwana for which cuticular information is available and which were earlier ascribed to the genus *Noeggerathiopsis*.

Rigby's argument for creating the new genus is not acceptable because though the leaves of the genus *Noeggerathiopsis* may be morphologically indistinct from those of *Cordaites* yet the former have a uniform epidermal pattern all through Gondwana Supercontinent. There is neither any evidence nor any reason to presume that had the type specimen of *Noeggerathiopsis spatulata* (Dana) Feistmantel possessed a carbonified crust, it would have shown epidermal features different from those of other species which have been transferred under *Pantophyllum*. It is neither plausible nor advisable to create new leaf genera simply on the basis of presence or absence of a cuticle, or one would have to look for new genera for all those specimens which though possess a cuticle, yet are morphographically inseparable from *Gangamopteris, Glossopteris, Palaeovittaria, Rubidgea, Buriadia*, etc.

The name *Pantophyllum* Rigby 1984 is therefore considered to be a junior synonym of *Noeggerathiopsis*. The circumscription and diagnosis of the genus *Noeggerathiopsis* as given by Pant and Verma (1964) are accepted and followed. The genus is easily identifiable on the basis of gross morphography. In species delimitation, the cuticle plays an important role because there is a perceptible variation in epidermal configuration.

Noeggerathiopsis saharjuriensis sp. nov.
Pl. 1, figs 2-4

Diagnosis—Leaves simple, linear-spathulate in shape, margin entire, tapering towards base, apex not known, veins straight, dichotomising but not anastomosing.

Cuticles thick, stomata present only on one surface, vein and intervein areas not marked on non-stomatiferous surface, cells rectangular, arranged end-to-end in linear rows, lateral walls straight, surface walls unspecialised.

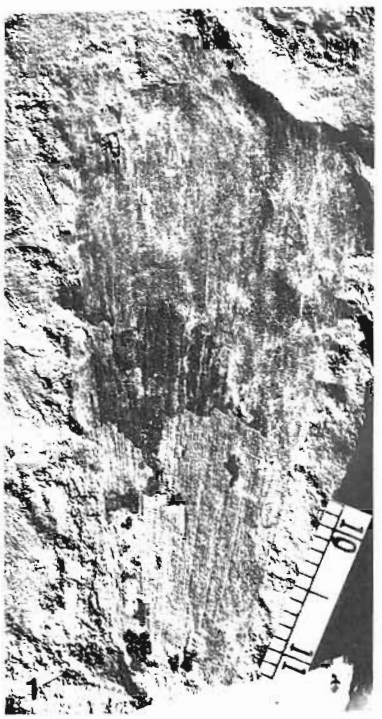
Stomatiferous surface with distinct alternating stomatiferous and nonstomatiferous linear bands; cells of nonstomatiferous band rectangular, arranged end-to-end; those of stomatiferous band polygonal. Stomata anomocytic (haplocheilic), arranged in 2-5 linear rows, stomatal apparatus monocyclic, subsidiary cells 4-8 in number, unspecialised; almost all cells of stomatiferous band having a denser surface wall.

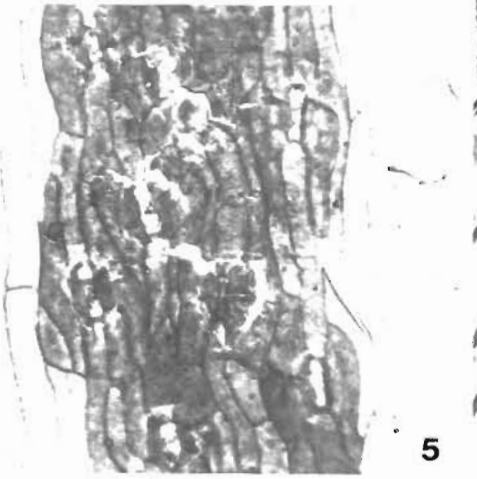
Holotype—Specimen no. BSIP 35933, Chitra Patrika Colliery, Saharjuri Outlier, Deogarh Coalfield, Bihar; Lower Permian, basal part of Barakar ("Karharbari") Formation.

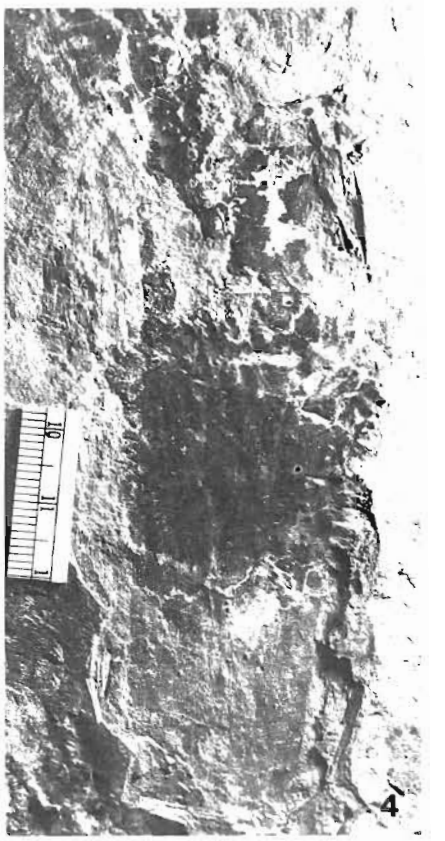
Description—Four specimens can be referred to this species on the basis of general morphography. However, cuticle has been recovered from only one specimen which is designated as the type specimen. All the specimens are incomplete and none shows either the apex or the base. However, it can be presumed that the leaves were simple and linear lanceolate in shape. The leaf margin is entire, broken and the carbonified crust has a shiny surface. As the actual leaf base is not preserved the number of veins entering it is not known. The concentration of veins in the basal region is 14 per cm. The veins dichotomise once or twice and proceed straight to

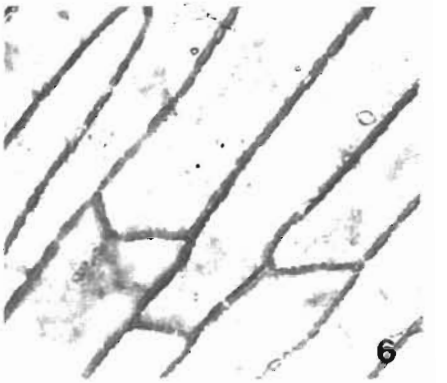
PLATE 1 →

1. *Noeggerathiopsis bihariensis* sp. nov. : Holotype; specimen no. BSIP 35933, × 1.
2. *N. saharjuriensis* sp. nov. : Upper cuticle; Slide no. BSIP 35934-1, × 75.
3. *N. saharjuriensis* sp. nov. : Lower cuticle showing a stomatiferous band with thickened surface walls. Note unspecialised surface walls in some cells; Slide no. BSIP 35934-1, × 400.
4. *N. saharjuriensis* sp. nov. : Holotype; Specimen no. BSIP 35934, × 1.
5. *N. bihariensis* sp. nov. : Lower cuticle showing a stomatiferous band with a number of stomata in rows. On both the sides of stomatiferous rows nonstomatiferous bands are present; Slide no. BSIP 35933-1, × 200.
6. *N. bihariensis* sp. nov. : Lower cuticle showing regular pitting on the lateral walls; Slide no. BSIP 35933-1, × 600.
7. *N. bihariensis* sp. nov. : Lower cuticle showing number of stomatiferous and nonstomatiferous bands. Number of stomata vary in each row; Slide no. BSIP 35933-1, × 75.
8. *N. bihariensis* sp. nov. : Lower cuticle showing stomatiferous band. Subsidiary cells are crescentic in shape; Slide no. BSIP 35933-1, × 200.









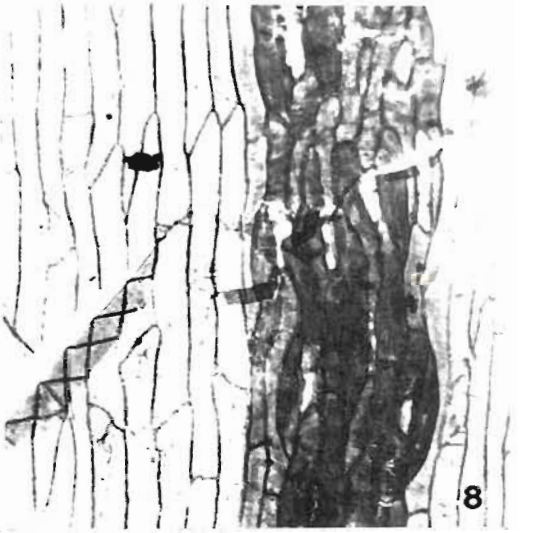


PLATE 1

the apical margin, concentration in the middle region being 26 per cm. The preserved length and maximum width of the leaves vary from 10-12 cm and 4-4.5 cm respectively.

The cuticular layers are well-preserved, both surfaces showing distinct cellular features. Only one surface is stomatiferous. All the cells of the nonstomatiferous surface are similar, being rectangular in shape and arranged end-to-end in linear rows and thus do not mark vein and intervein areas. The cells are 13-19 μm wide and 120-213 μm long. On the other hand, the vein and intervein areas on the stomatiferous surface are marked by nonstomatiferous and stomatiferous linear bands, respectively. The cells of the nonstomatiferous bands are similar to those of nonstomatiferous surface. The cells in the stomatiferous band are polygonal to elongate-polygonal with their surface walls being comparatively dense. However, there are exceptional cells in this band that do not have dense surface walls. The lateral walls show regular pits. The cells are 18-31 × 48 μm in size. The stomata are linearly arranged in 2-5 rows, their orientation being along the course of the veins. Guard cells are rarely seen. Subsidiary cells are 4-8 in number average (6), size being 19-29 × 37-87 μm. Guard cells measure 12-13 μm in length. All the cells of the cuticle are unspecialised, i.e., do not possess papillae.

Comparison—Due to the fragmentary nature of the specimen its exact external morphology is not known. The comparison is therefore mostly based upon the cuticular characters. The concentration of veins in the present specimen closely resembles that of *Noeggerathiopsis bunburyana* Pant & Verma 1964 and *N. papillosa* Pant & Verma 1964 (10-13 per cm in basal region), but the cuticular features of both *N. bunburyana* and *N. papillosa* are different. In *N. papillosa* the subsidiary cells are always papillate while in the present specimen the ordinary epidermal cells and the subsidiary cells are nonpapillate. In *N. bunburyana* the subsidiary cells are nonpapillate but number of stomatiferous rows vary and the cuticle is amphistomatic; in *N. saharjuriensis* the cuticle is hypostomatic. The cuticle of the present specimen shows some interesting characters. The cells of the stomatiferous zone take a comparatively much darker stain in Safranin O. However, some of the cells in this zone behave differently and take a lighter stain similar to that taken by the cells of the nonstomatiferous zone (Pl. 1, fig. 3).

Noeggerathiopsis bihariensis sp. nov.
Pl. 1, figs 1, 5-8

Diagnosis—Leaf simple, small, spathulate in shape, margin entire, slightly tapering towards the base, nature of apex and base not known. Veins thick, fibrous, dichotomising but no anastomoses seen. Leaves hypostomatic.

Upper cuticle thick, vein and intervein areas not marked on nonstomatiferous surface, cells elongated, rectangular, arranged in linear rows, straight-walled, lateral walls pitted, surface walls unspecialised.

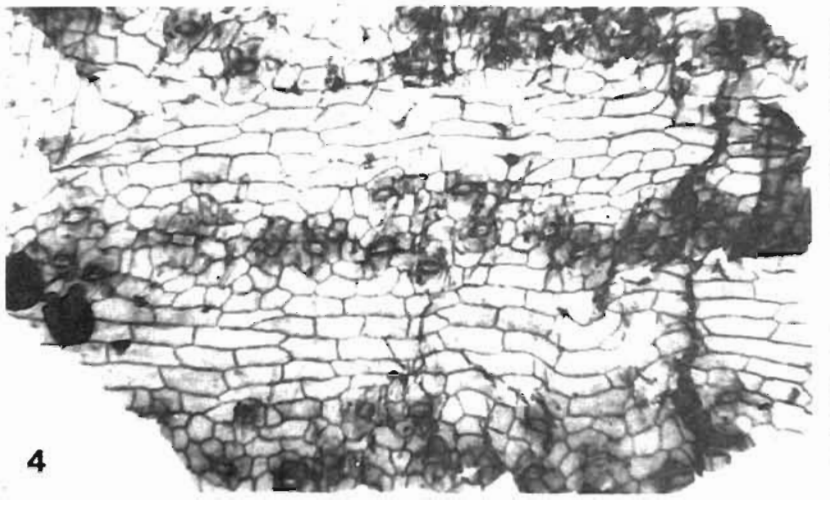
Lower cuticle shows distinct, alternating, stomatiferous and non-stomatiferous linear bands. Cells of non-stomatiferous bands narrow, elongate, arranged end-to-end. Cells of stomatiferous band narrow, elongate, rectangular, often curved, cell walls pitted, somata anomocytic, arranged in 1-5 linear rows, subsidiary cells 4-6, unspecialised.

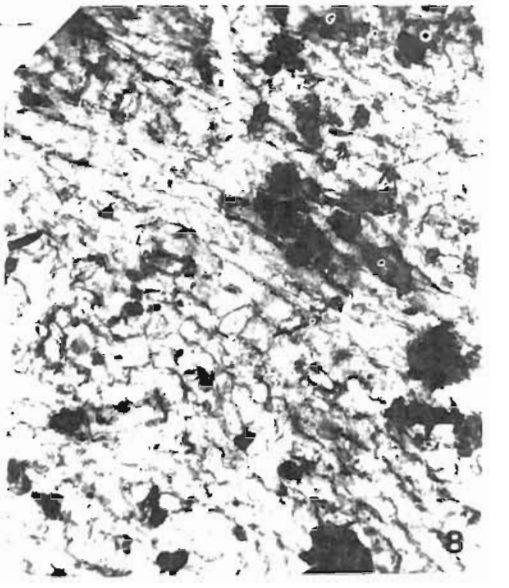
Holotype—Specimen no. BSIP 35934, Chitra Patrika Colliery, Saharjuri Outlier, Deogarh Coalfield, Bihar; Lower Permian, basal part of Barakar ("Karharbari") Formation.

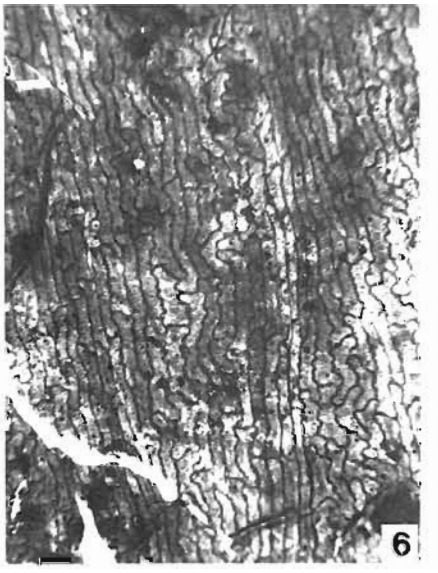
Description—Only one specimen has been referred to this species on the basis of morphological and cuticular characters. The specimen is incomplete, without base and apex. Leaf is simple, small and spathulate in shape. The preserved length of the leaf is 5 cm and the width is 2.5 cm. The leaf margin is entire. The carbonified crust on the leaf gives it a glossy appearance. As the leaf base is not preserved the number of veins entering the leaf is not known. The concentration of veins in the basal region is 10 per cm. Veins are

PLATE 2 →

1. *Gangamopteris maheshwarii* sp. nov.: Holotype; Specimen no. BSIP 35935, × 1
2. *G. maheshwarii* sp. nov. : Lower cuticle showing stomatiferous and nonstomatiferous bands; Slide no. BSIP 35935-1, × 200.
3. *G. maheshwarii* sp. nov. : A stoma with eight subsidiary cells. All the subsidiary cells are of different shape; Slide no. BSIP 35935-1, × 600.
4. *G. maheshwarii* sp. nov. : Lower cuticle showing the distribution and orientation of stomata; Slide no. BSIP 35935-1, × 100.
5. *Glossopteris deogarhensis* sp. nov. : Holotype; Specimen no. BSIP 35936, × 1
6. *G. deogarhensis* sp. nov. : Upper cuticle showing slightly wavy walls of intervein areas; Slide no. BSIP 35936-1, × 100.
7. *G. deogarhensis* sp. nov. : Lower cuticle showing stomata and papillate epidermal cells; Slide no. BSIP 35936-1, × 300.
8. *G. deogarhensis* sp. nov. : Lower cuticle showing distribution and orientation of stomata; Slide no. BSIP 35937-1, × 200.







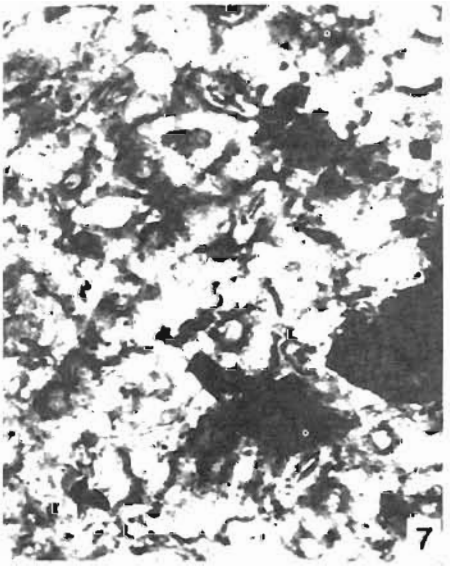


PLATE 2

distinct and thick due to presence of fibers. They dichotomise only once or twice, concentration of veins becoming 22 per cm in the middle region of the leaf.

The cuticle recovered from the specimen is well-preserved, both the surfaces showing distinct cellular outlines. Only one surface is stomatiferous. The cells of upper cuticle are rectangular in shape, arranged end-to-end in linear rows, 12-23 μm wide and 120-213 μm long. Vein and intervein areas are not marked. The lateral walls of the cells exhibit distinct pits.

The lower cuticle shows two distinct bands, non-stomatiferous and stomatiferous, which are also distinguished by differential staining in Safranin O. The non-stomatiferous bands are 12-14 cells wide, cells are narrow, elongate, with straight lateral walls and oblique end walls. The cells of the stomatiferous bands are elongate, rectangular, 12-25 μm wide, 132-213 μm long. The lateral walls are pitted.

The stomata are anomocytic (haplocheilic), distributed in linear rows and orientated parallel to the course of the veins. The guard cells are rarely seen. Subsidiary cells are usually 4 in number, occasionally up to 6, two lateral subsidiary cells surrounding the guard cells are often crescentic in shape.

Comparison—In gross morphography the specimen resembles one species or the other of the genus *Noeggerathiopsis* : for example, the number of veins per cm in the basal region is almost same as in *N. bunburyana* and *N. papillosa* while the concentration of veins in the middle region resembles that of *N. gondwanensis*.

However, the cuticle recovered from the specimen has distinctive features separating it from the known species. In differential stain taken by the non-stomatiferous and stomatiferous bands, the species resembles *N. papillosa* and *N. bunburyana*. The former is distinguished by its papillate cells whereas the latter is an amphistomatic leaf. *N. saharjuriensis* sp. nov. also takes a similar stain but is distinguished by comparatively robust cells. In *N. indica*, the stomatiferous band has comparatively many more rows of stomata.

Gangamopteris McCoy 1847

Gangamopteris mahesbwarii sp. nov.
Pl. 2, figs 1-4

Diagnosis—Specimen incomplete, leaf simple, margin entire, base and apical region not preserved, shape apparently spathulate, a few veins entering the leaf base, dichotomising and anastomosing to form meshes all over, median veins run almost parallel up to the apical part but without forming a solid strand, lateral veins run towards the margin taking a graceful curve.

Leaf hypostomatic, stomata confined to intervein areas, irregularly distributed, orientated more or less parallel to vein course, subsidiary cells 4-8 in number, unspecialised, guard cells showing lateral and polar thickenings.

Holotype—Specimen no. BSIP 35935, Chitra Patrika Colliery, Saharjuri Outlier, Deogarh Coalfield, Bihar; Lower Permian, basal part of Barakar ("Karharbari") Formation.

Description—The species is represented by only one specimen. The preserved length of the leaf is 4.2 cm and width of the leaf is 3.5 cm. Concentration of lateral veins in the basal region is 20 per cm and 25 per cm near the middle region. The lateral veins meet the margin approximately at an angle of 60°-70°

Leaf is hypostomatic. Both the cuticles are almost of the same thickness. All the cells of non-stomatiferous surface are rectangular in shape and arranged end-to-end in linear rows and thus do not mark vein and intervein area. The cells are 19-37 μm wide and 80-139 μm long.

Lower cuticle has stomata only in the mesh areas. The cells of the non-stomatiferous bands, i.e., over the veins, resemble those of upper surface and measure 120-169 μm in length and 18-43 μm in width. The cells of stomatiferous bands, i.e., in the mesh areas, are polygonoid and measure 31-38 μm in width and 49-58 μm in length. The stomata are arranged in 1-3 rows. Stomatal apparatus is monocyclic though the subsidiary cells, which are 4-8 in number, do not form a ring being different in shape and size. Guard cell measures 6.2-12 $\times$ 37-43 μm. Surface of the guard cells shows distinct radiating striations or thickenings similar to the ones seen in certain extant species of the genus *Equisetum*.

Comparison—In external features the leaf apparently has a superficial resemblance with *Gangamopteris obovata* Carruthers, cuticular characters of which are hardly known. The cuticular morphology of the leaf closely resembles that of *G. obtusifolia* Pant & Singh 1968 in the distribution of stomata and the thickening and striations on the guard cells. However, the *G. obtusifolia* leaf is amphistomatic.

All other species of the genus *Gangamopteris* investigated by Pant and Singh (1968), too are amphistomatic, have papillate cells and lack radiating striae on the guard cells.

***Glossopteris* Brongniart 1828**

Glossopteris deogarhensis sp. nov.
Pl. 2, figs 5-8

Diagnosis—Leaves simple, spathulate in shape, margin entire, tapering towards base. Midrib faintly marked, flat, veins fine, closely placed, arising at an acute angle from midrib, dichotomising and anastomosing to form narrow elongate meshes.

Leaves hypostomatic. Vein and intervein areas demarcated on both surfaces. Cells of non-stomatiferous surface (upper) rectanguloid, lateral walls sinuous, surface walls unspecialised, stomata confined to intervein (mesh) areas on lower surface. Cells over veins rectanguloid, relatively straight-walled. Cells of stomatiferous bands polygonoid, walls sinuous. Stomata haplocheilic, irregular in distribution and orientation, subsidiary cells 4-6 (mostly 4), not forming a ring and similar to ordinary epidermal cells.

Holotype—Specimen no. BSIP 35936, Chitra Patrika Colliery, Saharjuri Outlier, Deogarh Coalfield, Bihar; Lower Permian, basal part of Barakar ("Karharbari") Formation.

Description—Four specimens have been referred to this species on the basis of external morphology, of these three specimens also yielded cuticles.

All the specimens are incomplete and do not show the apex and the base. However, it can be presumed that the leaves were simple, broader in the middle region and gradually narrowed towards the base. The leaves were probably spathulate in shape.

The preserved length and maximum width of the leaves are 6.2-8.5 and 3.4-6 cm, respectively. Midrib is not very distinct, at places shows a number of longitudinal parallel running strands. Veins leave midrib at acute angles, 10°-15°, and form long, elongate and narrow meshes of more or less uniform size. Leaves are hypostomatic, upper and lower cuticles are almost of the same thickness. The cells of the upper cuticle are rectanguloid in shape, sinuous in outline, measure 29-43 × 101-181 μm, are arranged end-to-end in linear rows over the veins, walls of cells in intervein areas are comparatively more sinuous.

The cell outlines over veins and in intervein areas on the stomatiferous surface differ in shape. The cells over the veins are rectanguloid and arranged end-to-end. Their walls are slightly wavy. The cells in the intervein areas are polygonoid in shape with sinuous to wavy walls. The stomata are haplocheilic and do not exhibit any regularity in distribution and orientation. The subsidiary cells do not differ from ordinary epidermal cells, their number and placement varies a lot. At places the subsidiary cells give a "winged" look. The guard cells are usually not well-preserved, sometimes a thickening is noticed towards the pole.

Comparison—In leaf morphography and cuticular features *Glossopteris deogarhensis* resembles most *G. harrisii* Pant & Gupta 1968. In both, the lateral veins leave the midrib at acute angles and dichotomise and anastomose to form narrow elongate meshes. The cell walls are sinuous on both the surfaces and the stomatal frequency is almost the same. However, *G. harrisii* differs due to the presence of a short median papilla on the surface wall of each cell. Further, the subsidiary cells in the Saharjuri specimen do not form a ring, whereas in *G. harrisii* a monocyclic or partly "amphicyclic" condition is reported.

DISCUSSION AND REMARKS

As stated earlier, the stratigraphical relationship of beds containing a glossopterid flora in Deogarh group of coalfields has been a matter of controversy, that is, whether the lower most beds of the Permian coal measures are lithologically a part of the Barakar Formation or they comprise an independent formation, i.e., the Karharbari Formation.

The shale associated with the coal seam in Chitra Patrika abandoned shaft has yielded following identifiable species :

Glossopteris deogarhensis sp. nov.
G. linearis Feistmantel
G. decipiens Feistmantel
Gangamopteris maheshwarii sp. nov.
Noeggerathiopsis conspicua Lele & Makada
N. saharjuriensis sp. nov.
N. bihariensis sp. nov.
Cordaicarpus sp.
Samaropsis sp. and
Vertebraria indica Royle, etc.

The genera *Noeggerathiopsis* and *Glossopteris* are almost equally represented. The genus *Gangamopteris* is rather scarce. The overall assemblage is characteristic of a Lower Barakar megaflora as known from many localities under the Karharbari "Stage" Two important elements that mark the Karharbari "Stage" are, however, missing. These are *Botrychiopsis valida* Kürtz and *Buriadia sewardii* Sahni. A survey of literature shows that though these two taxa are reported from many areas, their illustrations are few. In fact, it seems that some of the specimens placed under *Buriadia sewardii* may be tufts of rootlets of *Vertebraria*. The report of

Botrychiopsis from Jainti Outlier (Lele & Makada, 1974) is also not very convincing. It would thus seem that *Botrychiopsis valida* and *Buriadia sewardii* are associated in a very localised flora, presently known from the Giridih Coalfield. The main question is whether the Chitra Patrika megafloral assemblage is to be referred to the Karharbari "Stage" or to the Lower Barakar "Stage" Here it may be mentioned that chronostratigraphy of peninsular Permian deposits has not yet been worked out and hence the unit "Stage" can not be convincingly used at present.

Opinions differ as to the problem whether the Karharbari Formation can be identified on lithological grounds. According to Pascoe (1959, p. 940) "The Karharbari group which was regarded as an upper member of the Talchir series, is but an early phase of the Barakar and scarcely merits separation there from" A perusal of available data shows that initially the Karharbari unit was identified on the basis of contained megaflora (Feistmantel, 1879). Later lithological differences were sought to separate it from the Barakar sediments (Ghosh, Deekshitulu & Murthy, 1964) though earlier geologists accepted that there was hardly any lithological separation between the Karharbari and the Barakar sediments (Blanford, 1878). According to Pareek (1966, p. 76) the Karharbari sandstones contain angular to subangular pieces and fragments of quartz and usually kaolinised felspar whereas in the Barakar sandstones the quartz and felspar pieces are partially well rounded. He also noticed a pebble bed, 0.15-3.5 metre thick, marking the boundary between the Karharbari and Barakar sediments in the Ray-Bachra area of North Karanpura Coalfield, Bihar. Ghosh (1958) recorded a conglomeratic band between the Karharbari and the Talchir sediments near Ray in the same coalfield. There, however, does seem to be an identifiable biostratigraphic unit at the base of Coal Measures that roughly corresponds with Karharbari "Stage/Formation" This biostratigraphic unit was named as *Gondwanidium-Buriadia* Assemblage Subzone by Shah, Singh and Sastry (1971). This assemblage subzone is virtually similar to the lower *Noeggerathiopsis-Paranocladus* Assemblage Subzone found in the Talchir Formation except for occasional and irregular finds of the genera *Botrychiopsis* and *Buriadia* (Feistmantel, 1879; Puri, 1952; Ganguli, 1959) which are also not found in the undisputed Barakar sediments.

The available palaeobotanical data from Saharjuri Outlier favours a close comparison with the basal Barakar flora. Following identifiable spore/pollen taxa that have been found attached on the plant cuticles also support this contention : *Callumispora, Didecitriletes, Brevitriletes, Horriditriletes, Plicatipollenites, Cannanoropollis, Parasaccites, Potonieisporites, Crucisaccites, Gondwanipollenites*, etc. The palynoflora of the basal Barakar beds has usually been referred as the palynoflora of Karharbari 'Stage' (see Bharadwaj, 1974).

It is therefore concluded that though the flora of the shales associated with coal in Chitra Mine area of Saharjuri Outlier belongs to an identifiable floral assemblage zone, i.e., *Noeggerathiopsis Gangamopteris* Assemblage Zone the evidence in itself is not corroborative of a formation rank to basal Barakar sediments which have a prevalence of reworked material from Talchir Formation. In age it seems to be homotaxial with Middle Ecca flora of Bubye Coalfield, Zimbawbe from where Sutton and Bond (1962, in Bond, 1967) have reported *Glossopteris* associated with *Gangamopteris* and *Noeggerathiopsis hislopi* [= *Noeggerathiopsis spathulata* (Dana) Feistmantel] A more or less similar association-*Schizoneura gondwanensis, Glossopteris indica, Ottokaria* sp., *Noeggerathiopsis* sp. cf. *N. hislopii, Gangamopteris obovata* and *Cordaicarpus zeilleri* is known from the couches a charbons de la Sakoa (Singh & Shah, 1967).

According to Bond (1967, p. 189), the association of *Glossopteris* spp. with *Gangamopteris* spp. probably implies a cold sub-arctic climate: Bharadwaj (1974) also identifies a cold climate (1st Interglacial) for the Damuda sediments (his basal Karharbari) in the adjacent Jainti Outlier. It may be recalled here that all the glossopterid species recorded in this paper are small in size and have closely placed veins and high stomatal frequency.

Leaf development is remarkably consistent and majority of higher plants can be recognised by the leaf shape. On the other hand, leaf size, vein density, trichome density and stomatal frequency are sensitive to environment; the last three increase with increased xeromorphy. This would apparently indicate a xeric environment for the Chitra Patrika fossils.

However, leaf development and growth are complex processes. Leaf size is reduced not only due to water deficit but even high irradiance or higher insertion level may cause small leaf size. Deficient nutrient level may also dramatically decrease leaf elongation rates. The final size of a leaf is the product of the rate and duration of expansion, but it is the extension of cells that must contribute to increase in leaf size. Therefore, small leaf size need not always indicate a xeric or water deficit environment.

The dense venation and high stomatal frequency

in the Chitra Patrika leaves also indicate a xeric environment. It is known that within the same species leaf extension growth between lateral veins is much greater in shade than in sun leaves resulting in a higher stomatal frequency in the latter. It is therefore, probable that only sun leaves are represented in the present collection. Trichomes have also so far not been found on any of the Chitra Patrika leaves though the surface walls of intervein cells on stomatiferous surface of *Noeggerathiopsis* leaves are characteristically thickened. Xeromorphy is also reported to be accompanied by amphistomaty, a character not observed so far in this material. Rather all the leaves are hypostomatic. Therefore, a xeric condition may be ruled out.

At present dominance of complete hypostomaty is observed only in temperate deciduous trees. The presence and preponderance of stomata only on the lower surface may also be a reflection of heavy precipitation, simply being an adaptation for preventing clogging of stomatal pores by rain drops. This data read together with occurrence of workable coalseams indicates a temperate climate with increased rainfall.

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