PALAEOBOTANICAL EVIDENCE FOR THE PRESENCE OF KARHARBARI STAGE IN THE AURANGA COALFIELD, BIHAR: MEGAFLORA

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ABSTRACT

A good assemblage of Karharbari plant fossils has been recovered for the first time from Lower Gondwana beds of Auranga Coalfield, Bihar. The assemblage is characterised by the presence of *Neomariopteris* (*N. hughesi*), *Gangamopteris* (*G. cyclopteroides, G. clarkeana*), *Glossopteris* (*G. damudica, G. communis*), *Vertebraria* (*V. indica*), *Noeggerathiopsis* (*N. densinervis*), *Euryphyllum* (*E. whittianum*) and *Samaropsis* (*S. ganjrensis*).

The flora compares closely with the known Karharbari assemblages of India.

INTRODUCTION

THE Auranga Coalfield is situated in the Palamau District, Bihar between latitudes 23°42′ to 23°52′ and longitudes 84°17′ (Toposheet nos. 73A/5, 6, 8, 9,10). The other two neighbouring coalfields of this district are the Daltonganj Coalfield in the north-west and the Hutar Coalfield in the south-west. It is the largest of the three coalfields, with an area of about 220 sq km. These three coalfields are collectively referred to as the Koel Valley coalfields as they fall in the valleys of the Son and Koel rivers. More generally, however, they are included as the western continuation of the Damodar Valley Coalfield (Rizvi, 1972, pl. 1).

The area is tectonically highly disturbed being traversed by a number of complex faults and other structural features along its northern and southern boundaries. In the east and west, the Gondwana rock boundaries are almost normal.

In 1880, Ball first reported the plant fossils from this Coalfield from Panchet and Mahadeva Series but not from the Lower Gondwana stages. Later on, Feistmantel (1881a, 1881b, 1882, 1886); Bhattacharyya, B. (1959); Bhattacharyya, A.K. (1963); Maithy (1971); and Srivastava and Anand-Prakash (1973) reported the mega- and miospore assemblages from the Talchir, Barakar and Raniganj stages of the Auranga Coalfield, Bihar. So far, the Karharbari assemblages were unknown from the Lower Gondwana beds of the Auranga Coalfield, Bihar. The present work, for the first time records the Karharbari megafloras from this area.

MATERIAL AND METHODS

The material for the present study was collected from the eastern and western part of the Auranga Coalfield, Palamau District, Bihar, in various excursions made during the years 1970-74.

Megafossils have been collected from the section exposed in north-east bank of Auranga River about 1 km west of Gowa Village where Gowa Nala joins the river and from the rocks exposed in a small Nala, about 0·5 km north-west of Kamandih Village (see Map 1).

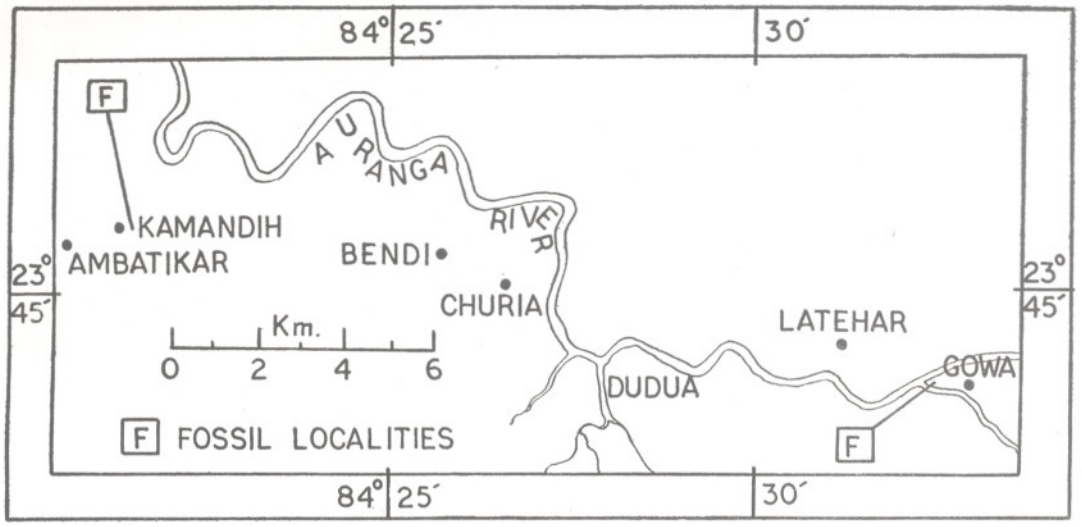
Fossils are found as impressions on the ferruginous sandy and hard fireclay shales.

The plant impressions were studied directly under incident light and also under strong reflected light. Photography was done on Agfa FP-4 or FP-3 plates. In no case filter was needed as there was enough contrast between the fossils and the matrix.

All figured specimens are preserved at the Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

DESCRIPTION

All the available figured records of the plant species, described in the present paper have been examined and their placement have been discussed in detail with reference to holotype or typical examples selected from the original author's material. In addition idealised diagrams have been given to explain the concept of earlier known species.



MAP 1 — Showing the fossil localities.

Genus — *Neomariopteris* Maithy emended, 1975

The fronds described as *Sphenopteris* from the Lower Gondwana of India have recently been transferred under a new genus *Neomariopteris* by Maithy (1974). Although the venation of *Neomariopteris* and *Sphenopteris* is similar but there are other distinct differences between them. In *Sphenopteris* the pinnules are laterally free, i.e. nondecurrent and have a cuneate base. Contrarily in the Lower Gondwana forms of *Sphenopteris* the pinnules are attached to the pinna rachis by their whole broad bases and are decurrent in nature. *Neomariopteris* now includes the following species, *Sphenopteris polymorpha, S. hughesi* and *S. lobifolia*. Among these, *N. hughesi* has been subsequently found in fertile state which has made further emendation of *Neomariopteris* (Maithy, 1975).

Neomariopteris hughesi (Feistmantel) Maithy, 1974

Pl. 2, figs. 7, 8; Text-fig. 1

Lectotype — Specimen no. 5207, Geological Survey of India Museum, Calcutta.

Description — There are six incomplete, fragmentary specimens in the collection. The figured frond is 5·2 cm long, compound and bipinnate in nature. Primary rachis is winged 1 to 2 mm broad. Secondary rachis is 2·5 cm to 4·5 cm long and arises from primary rachis alternately at an angle of 45° to 50°. Pinnae are 7 to 9 in number, emerge alternately from the secondary rachis at an angle of 45°. They are 4 to 6 mm long and 3 to 4 mm broad. Each pinnae possesses 4 to 5 pairs plus one terminal pinnules. Pinnules are lanceolate in shape and show decurrent base and sphenopteroid venation pattern.

Comparison — The present fronds show similarities in their shape and nature with the specimen of Feistmantel (1882, pl. 12, fig. 3) and the frond described by Maithy (1974, pl. 2, fig. 7).

Discussion — Recently Maithy (1974) has given a detail diagnosis and description of the species. Later on, he recorded the fertile fronds of *N. hughesi* (1975, pl. 2, figs. 5, 6). The present specimens strengthen the idea of *N. hughesi* expressed by Maithy (1974).

Genus — *Gangamopteris* McCoy, 1861

Gangamopteris cyclopteroides Feistmantel, 1876

Pl. 1, figs. 1, 2; Text-fig. 2A-B

Typical example from Feistmantel, 1879, pl. 27, fig. 2: Leaf spathulate; 8.4 cm long

TEXT-FIG. 1 — *Neomariopteris hughesi* (Feistmantel) Maithy, enlarged line drawing of the frond represented on Pl. 2, fig. 7 × 3.

and 5.4 cm broad; apex broadly rounded, tip slightly broken, base contracted, extreme part not preserved; veins arise from the base, meshes narrow, elongate, oblong, 5 to 8 mm long and 0.5 to 1 mm broad; 3 to 4 subparallel veins present in the median region; lateral veins arch at 10° to 12° near the margin; veins 10 to 12 per cm in middle and 18 to 22 per cm near the margin.

Description — There are four incomplete leaf impressions in the collection. In the figured leaf, apex and base are missing, margin is entire and the preserved portion is 5·3 cm long and 2·3 cm broad at its widest part. The veins arise from the base and the median region is occupied by 4 to 5 parallel running strands. The lateral veins arched out at an angle of 7° to 10°. They dichotomize and anastomose to form narrow, oblong, polygonal meshes. The meshes are 4 to 6 mm long and 0·5 to 0·7 mm broad throughout the lamina. The density of veins is 17 to 23 per cm throughout the leaf.

Comparison— The present specimens closely compare with those described by Feistmantel (1879). The venation characters can be matched with Feistmantel's specimen (pl. 27, fig. 2), which is briefly described in the beginning.

Discussion— Feistmantel (1879) instituted this species from the Talchir and Karharbari stages of the Lower Gondwana, but a diagnosis, description and illustration was not given. Later on, in 1879 he gave a detailed diagnosis and description with a number of diagrams showing variation within the species.

Pant and Singh (1968) selected a lectotype for this species from the collection of Feistmantel (Specimen no. 5013) which yielded a well preserved cuticle but the leaf (vide Feistmantel, 1879, pl. 13, fig. 5) is unfortunately incomplete in the apex and base. For morphological comparisons the specimen illustrated in pl. 27, fig. 2 of Feistmantel appears to be more typical.

Feistmantel (1879, 1880, 1881a, 1886, 1890a) proposed many varieties for this species on slight variation such as on the shape of apex and base although they show similar type of venation pattern. Arber (1905) has not recognised these varieties and the same procedure is followed here.

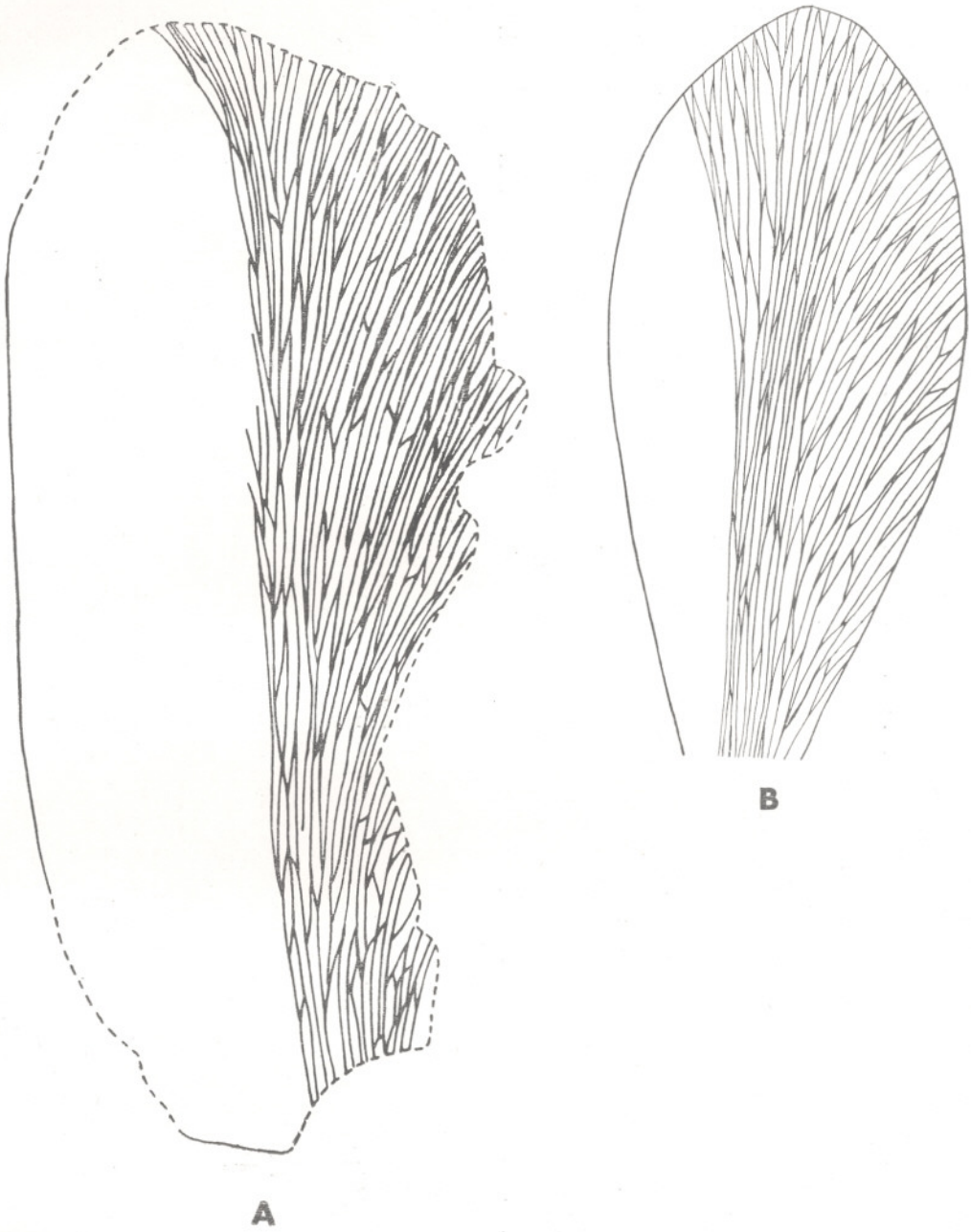
Concept of the Species — From the above observations the salient morphological features of *Gangamopteris cyclopteroides* Feistmantel can be outlined as follows (Text-fig. 2B).

Leaves broadly elongate to ovate; apex obtuse to acuminate, base contracted, narrower, sometimes auriculate; median region occupied by parallel running thin to thick veins; lateral veins arch at 10° to 15°; meshes narrow, oblong, polygonal.

A survey of the known records shows that the following specimens are typical of *G. cyclopteroides* Feistmantel.

1867 *Cyclopteris jenkisiana*, Tate, pl. 6, fig. 4.

1879 *Gangamopteris cyclopteroides* Feistmantel, pls. 7, 9; pl. 11, figs. 2, 3, 4; pl. 10, fig. 3; pl. 12, figs. 2, 3; pl. 13, figs. 1, 5; pl. 26, figs. 1, 3; pl. 27, fig. 2.



TEXT-FIG. 2 — A. *Gangamop eris cyclopteroides* Feistmantel, enlarged line drawing of a part of the leaf represented on Pl. 1, fig. 1 × 3. B. Idealised diagram of *Gangamopteris cyclopteroides*.

1879 *G. cyclopteroides* var. *subauriculata* Feistmantel, pl. 10, figs. 1, 1a, 1b; pl. 13, fig. 2; pl. 15, figs. 1-3; pl. 16, fig. 3.

1879 *G. cyclopteroides* var. *areolata* Feistmantel, pl. 10, fig. 2; pl. 14, fig. 4.

1879 *G. cyclopteroides* var. *attenuata* Feistmantel, pl. 11, fig. 1; pl. 12, fig. 1;

pl. 13, fig. 3; pl. 14, figs. 1, 2; pl. 16, fig. 5; pl. 27, fig. 1.

1882 *G. cyclopteroides* Feistmantel, pl. 16, figs. 1-3.

1886 *G. cyclopteroides* Feistmantel, pl. 6, figs. 1, 2; pl. 8, fig. 6; pl. 9, fig. 2; pl. 12, fig. 1; pl. 13, fig. 1; pl. 14, figs. 1-4.

1886 *G. cyclopteroides* var. *cordifolia* Feistmantel, pl. 11, figs. 1, 3; pl. 12, figs. 16, 18; pl. 13, fig. 2.

1890a *G. cyclopteroides* Feistmantel, pl. 1, fig. 5; pl. 2, fig. 10; pl. 3, figs. 2, 3; pl. 5, fig. 5.

1894 *G. cyclopteroides* Kurtz, pl. 2, figs. 1-3.

1897 *G. cyclopteroides* Seward, pl. 22, fig. 1.

1903 *G. cyclopteroides* Seward, pl. 13, fig. 5.

1922 *G. cyclopteroides* Kurtz, pl. 1, fig. 7.

1922 *G. cyclopteroides* Walkom, pl. 4, figs. 18-21.

1934 *G. cyclopteroides* Harrington, pl. 3, figs. 1-3.

1934 *G. cyclopteroides* var. *major* Harrington, pl. 4, fig. 1.

1941 *G. cyclopteroides* Darrah, pl. 2, fig. 6.

1957 *G. cyclopteroides* Surange & Lele, pl. 1, fig. 7; pl. 1, fig. 12.

1965d *G. cyclopteroides* Maithy, pl. 1, fig. 1.

1966 *G. cyclopteroides* Maithy, pl. 1, figs. 1, 2.

1968 *G. cyclopteroides* Pant & Singh, pl. 27, fig. 1.

The following specimens are considered as doubtful records of *G. cyclopteroides* Feistmantel:

1955 *G. cyclopteroides* Surange & Lele, pl. 1, fig. 2 (small leaf).

1963 *G. cyclopteroides* Saksena, pl. 1, figs. 11, 12; pl. 2, fig. 13 (small leaf).

1965 *G.* cf. *cyclopteroides* Maheshwari & Prakash, pl. 3, figs. 23, 24.

1965d *G. cyclopteroides* Maithy, pl. 1, fig. 3 (small leaf).

The following specimens are considered distinct from *G. cyclopteroides* Feistmantel:

1881 *G. hughesi* Feistmantel, pl. 43, figs. 6-8 (Arber merged under *G. cyclopteroides*, leaves fragmentary).

1881 *G. anthrophyoides* Feistmantel, pl. 39, figs. 8, 8a (Arber merged under *G. cyclopteroides* but leaves are fragmentary).

1886 *G. cyclopteroides* var. *acuminata* Feistmantel, pl. 7, fig. 5; pl. 8, fig. 5; pl. 11, figs. 4, 7 (Arber merged under *G. cyclopteroides* but leaves are fragmentary).

1886 *G. anthrophyoides* Feistmantel, pl. 5, fig. 4.

1890a *G. clarkeana* Fiestmantel, pl. 20, fig. 3 (Arber merged under *G. cyclopteroides*).

1896 *G. cyclopteroides* var. *attenuata* Zeiller, pl. 10, figs. 1-3.

1942 *G. cyclopteroides* Teichert, pl. 14, figs. 1, 2.

1960 *G. cyclopteroides* Hφeg & Bose, pl. 7, fig. 4; pl. 8, fig. 2; pl. 9, figs. 3, 7, 9; pl. 13, fig. 3.

Gangamopteris clarkeana Feistmantel, 1878

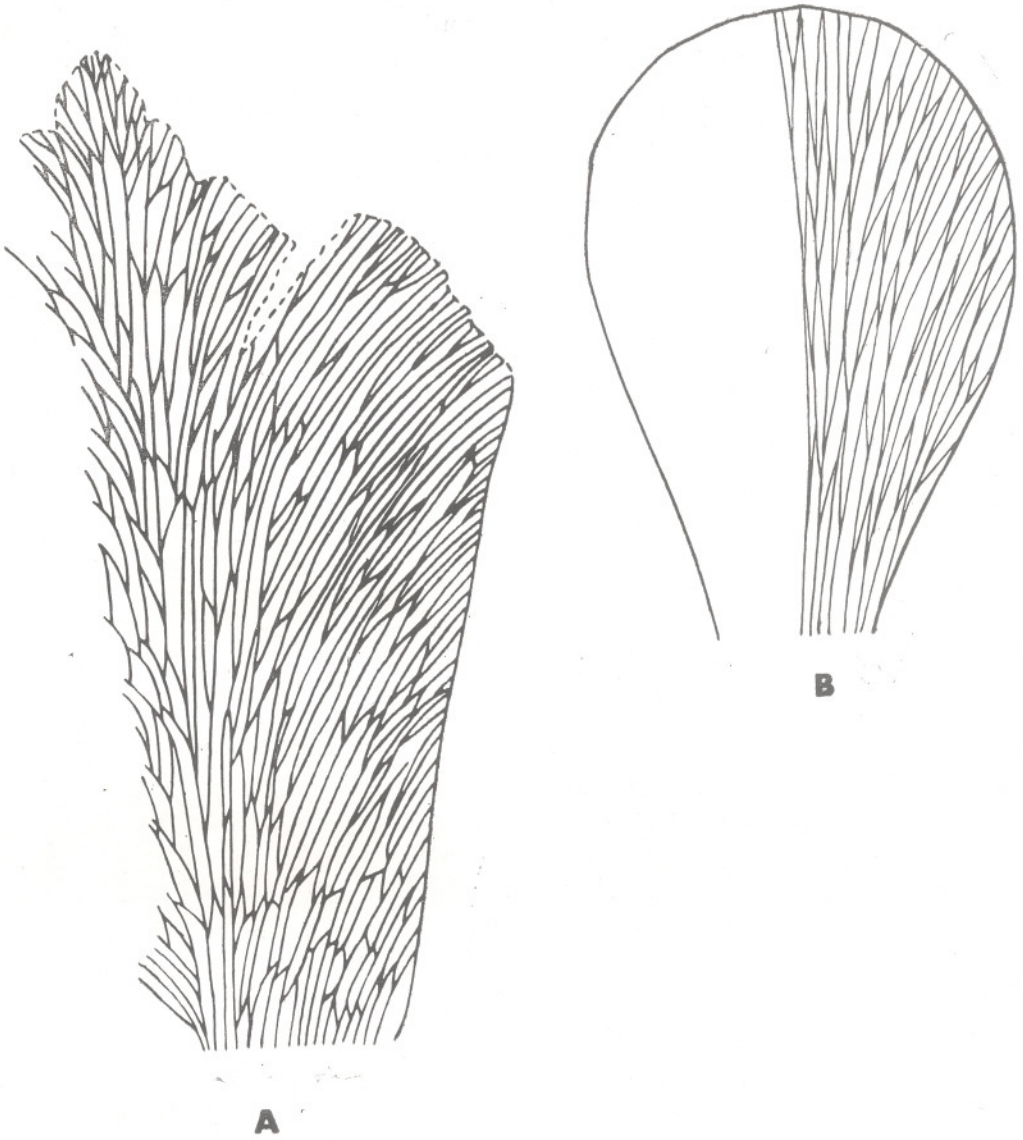
Pl. 2, fig. 9; Text-fig. 3A-B

Typical example from Feistmantel, 1890a, pl. 20, fig. 3: Leaf spathulate, 6·9 cm long, 4·2 cm broad; apex broadly rounded, base contracted; veins arise from the base, straight in the middle and arched near the margin; meshes oblong, polygonal, open, 14-22 mm long, 0·6 to 1·0 mm broad; veins 14-17 per cm.

Description — There are three incomplete leaf impressions in the collection. The figured leaf is 5·3 cm long and 3·3 cm broad at its widest parts. The apex and base are missing and the margin is entire. The veins emerge from the base and form a number of subparallel interconnecting strands in the median region. They are thick, distant and after anastomoses and dichotomization form open, oblong, polygonal meshes. The meshes are 1·0 to 1·6 mm long and 0·5 mm borad. The density of veins is 16 to 19 per cm throughout the leaf.

Comparison — The specimens are closely identical in their shape and venation pattern with typical example of leaf described by Feistmantel (1890a; pl. 20, fig. 3) which is briefly described earlier. The leaf described by Maithy (1965d; pl. 4, fig. 25) is also similar in shape and venation pattern.

Discussion— Feistmantel (1878) instituted this species and some typical examples were subsequently described by him (Feistmantel, 1890a; pl. 20, fig. 3). Arber (1905) has merged this species under *G. cyclopteroides* Feistmantel. Later, on re-examination



TEXT-FIG. 3 — A. *Gangamopteris clarkeana* Feistmantel, enlarged line drawing of a part of the leaf represented on Pl. 2, fig. 9 × 3. B. Idealised diagram of *Gangamopteris clarkeana*.

Maithy (1965d) has found reasons to distinguish this species and retained it. The present study also supports that the species is distinct from *Gangamopteris cyclopteroides* Feistmantel.

Concept of the Species — The external morphology of *Gangamopteris clarkeana* Feistmantel can be outlined as follows (Text-fig. 3B):

Leaves spathulately rounded, coriaceous; apex rounded, base tapering; veins thick, distant, straight in middle, arched near the margin; meshes open, oblong.

The following specimens have been regarded as a typical of *G. clarkeana* Feistmantel:

1886 *G. cyclopteroides* Feistmantel, pl. 12, fig. 17.
1890a *G. clarkeana* Feistmantel, pl. 20, fig. 3.
1922 *G. cyclopteroides* Walkom, pl. 4, fig. 20.
1965d *G. clarkeana* Maithy, pl. 4, fig. 25.

The following specimens are regarded as doubtful records of *G. clarkeana* Feistmantel:

1954b *G. obovata* var. *major* Dolianiti, pl. 2, fig. 1.

1963 *G.* cf. *clarkeana* Plumstead, pl. 1, figs. 1-3; pl. 3, figs. 11, 12.

Genus—*Glossopteris* (Brongniart) Sternberg, 1825

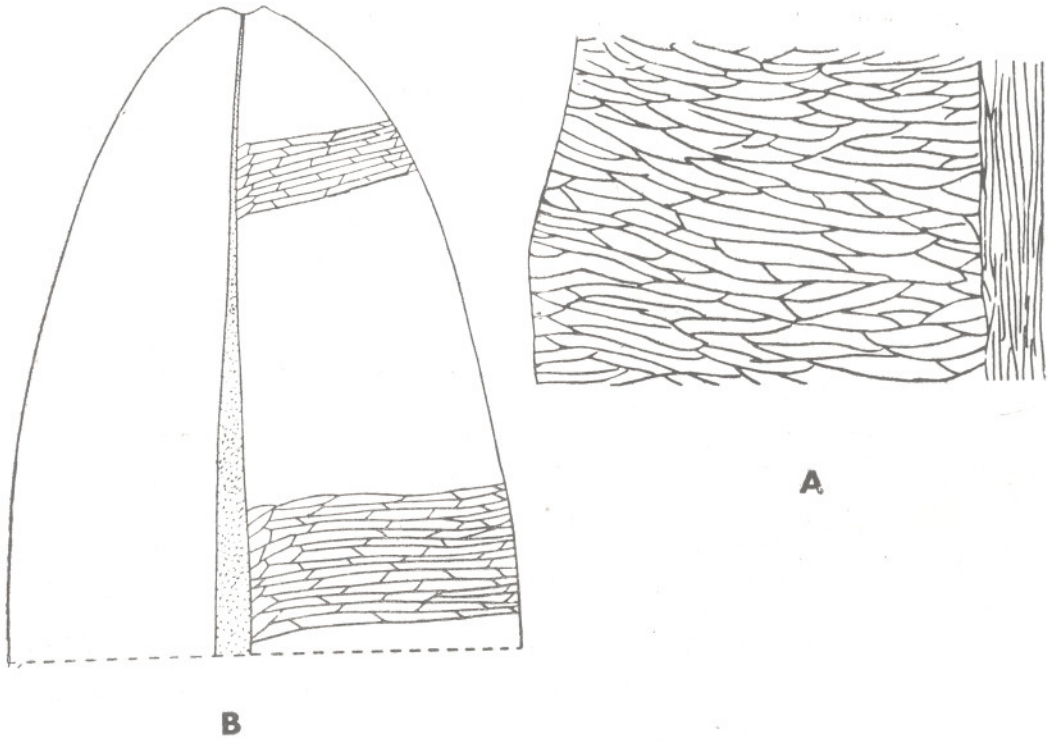
Glossopteris damudica Feistmantel, 1879

Pl. 2, figs. 11, 12; Text-fig. 4A-B

Typical example from Feistmantel, 1881a, pl. 30, fig. 1: Leaf incomplete, 16·5 cm long, 12·3 cm broad; spathulate, apex broad, emarginate, base absent, margin entire; midrib distinct, grooved, 5 mm broad in the lower portion and 0·5 mm broad near the apex; secondary veins arise at an angle of 80° to 85°, run ± parallel, meshes near the midrib 2 to 3 short, broad, trigonal to polygonal, 5-10 mm long, 1-2 mm broad linear, elongate, trapezoidal, 10-15 mm long, 0·5-0·7 mm broad, in rest of the lamina; veins 8-10 per cm near the midrib and 15-18 per cm near the margin.

Description — There are three incomplete leaf impressions in the collection. The figured leaf is 8 cm long and 4 cm broad showing lamina only on one side of the midrib. The shape is unknown. The apex and base are not preserved; margin is entire. The midrib is 4 mm broad, present throughout the preserved length, showing longitudinal striations over the surface. The secondary veins arise from the midrib at an angle of 90°. They dichotomize and anastomose to form 2-3 broad trigonal to polygonal meshes in rest of the lamina. The meshes are 7 to 9 mm long and 1·0 to 1·5 mm broad near the midrib and 9 to 15 mm long and 0·7 to 1 mm broad near the margin. The density of veins is 10 to 12 per cm near the midrib and 12 to 15 per cm near the margin.

Comparison — The present specimens possess venation characters similar to the typical example of *G. damudica* (Feistmantel,



TEXT-FIG. 4 — A. *Glossopteris damudica* Feistmantel, enlarged line drawing of a part of the leaf represented on Pl. 2, fig. 10 × 3. B. Idealised diagram of *Glossopteris damudica.*

1881a, pl. 30, fig. 1) which is briefly described in the beginning. The specimen described by Maheshwari and Prakash (1965, pl. 2, fig. 16) is also similar with the present specimens in its venation pattern.

Discussion — Feistmantel (1879) proposed this name for the leaves recovered from Passerabhia, Karharbari beds in the Karharbari Coalfield. Later, in 1881 he gave a diagnosis, detailed description and illustrations showing variation within the species.

Arber (1905) accommodated *G. musaefolia* Bunbury, 1861 and *G. damudica* Feistmantel, 1881a under *G. ampla* Dana, 1849. But examination of original figures of all the three species reveals considerable differences amongst them.

In *G. ampla* Dana the secondary veins arise at an acute angle and arch at an angle of 70°-80° to form 2-3 open, elongate meshes near the midrib and few linear, narrow meshes near the margin. Dana (1849) has described it as " venation close, narrow, reticulate; near the margin for nearly an inch, veins very much subdivided; more closely crowded, and scarcely reticulate. Spaces average 4/10 of an inch in length and 16 to 18 of them in breadth occupy half an inch. Near the margin there are 24 or more to a half an inch ". The apex seems to be broken to appear as emarginate.

In *G. musaefolia* Bunbury secondary veins arise directly from the midrib at an angle of 90° and run straight, perpendicular. Bunbury (1861) pointed out as " the direction of the veins, which (unless very near their base) are straight and almost perpendicular both to the midrib and to the margin, cause the plant to be taken for *Taeniopteris*; but these veins are in fact dichotomous and anastomose repeatedly near the midrib. They are extremely numerous, very fine and close and for the greater part of their length quite parallel ".

In contrast to the above two species the secondary veins in *G. damudica* Feistmantel arise at right angle to the midrib and form 2-3 trigonal to polygonal meshes near the midrib and narrow, linear, elongate, trapezoidal meshes in rest of the lamina. In view of these differences, the three species *G. ampla* Dana, *G. musaefolia* Bunbury and *G. damudica* Feistmantel are considered as distinct.

Concept of the Species — Following the diagnosis of Feistmantel (1881a) the external morphology of *G. damudica* Feistmantel can be outlined as follows (Text-fig. 4B):

Leaves, large, broad, spathulate; apex broad, obtuse, base unknown; midrib stout, broad; secondary veins arise at 70° to 80°, run almost parallel; meshes broad, short, trigonal to polygonal near the midrib and elongate, trapezoidal, open in rest of the lamina.

The following records are considered as typical of *G. damudica* Feistmantel.

1881a *G. damudica* Feistmantel, pl. 30, figs. 1, 2; pl. 31, figs. 1-3; pl. 32, fig. 1; pl. 40, fig. 6.
1886 *G. damudica* Feistmantel, pl. 1A, fig. 3; pl. 4A, fig. 1; pl. 16A, fig. 6.
1890b *G. damudica* Feistmantel, pl. 2, figs. 5, 8.
1941 *G.* cf. *ampla* Read, pl. 4, figs. 3, 5.
1965 *G. damudica* Maheshwari & Prakash, pl. 2, fig. 16.

The following specimens are considered reliable records of *G. damudica* Feistmantel:

1889 *G. damudica* var. *stenoneura* Feistmantel, pl. 4, figs. 7, 7A.
1962 *G. damudica* Plumstead, pl. 5, figs. 1, 7.
1971 *G. damudica* Kulkarni, text-fig. 5.

The following specimens are considered distinct from *G. damudica* Feistmantel:

1849 *G. ampla* Dana, pl. 13, figs. 1a, 1b.
1849 *G.* (?) *cordata* Dana, pl. 8, fig. 5 (Arber merged this species).
1861 *G. musaefolia* Bunbury, pl. 7, fig. 6.
1902 *G. damudica* Zeiller, pl. 4, figs. 5-7.
1905 *G. ampla* Arber, text-fig. 20.
1956 *G. damudica* Srivastava, pl. 6, figs. 3, 7.
1957 *G. damudica* Archangelsky, text-figs. 1b, b.
1958 *G. damudica* Archangelsky, pl. 34.
1958a *G. damudica* Plumstead, pl. 11.

G. communis Feistmantel, 1876

Pl. 2, fig. 12

Description — The Karharbari forms are incomplete. The figured leaf is 3·3 cm long and 2·9 cm broad. The apex and base are not preserved. The margin is entire. Midrib 1 mm broad. The secondary veins arise at an angle of 45°, arch out and anastomose to form 2 to 4 mm long and 0·3 mm broad, linear elongate meshes.

The veins are 18 to 20 per cm throughout the leaf.

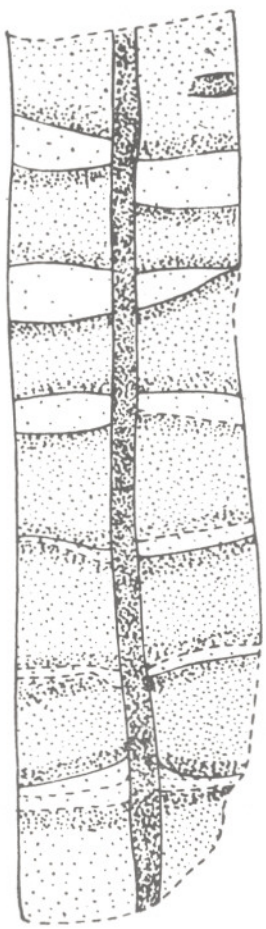
Genus — *Vertebraria* Royle, 1833

Vertebraria indica Royle, 1833

Pl. 1, fig. 6; Text-fig. 5

Description — There are two incomplete specimens, measure 4·0 to 5·5 cm long and 1·0 to 1·5 cm broad, consisting of almost square areas in two linear rows which are separated by a median longitudinal ridge. The areas are transversely separated by 2 to 3 mm wide grooves.

Comparison— The present specimens closely resemble with *Vertebraria indica* described by Royle (1833, pl. 2, fig. 1), Feistmantel (1880, pl. 13, fig. 3; pl. 14, figs. 1, 2) and Arber (1905, pl. 4, figs. 2, 3). The present specimens did not possess any anatomical details for comparison (Pant & Singh, 1968).



TEXT-FIG. 5 — *Vertebraria indica* Royle, enlarged line drawing of the specimen represented on Pl. 1, fig. 6 × 3.

Genus — *Noeggerathiopsis* (Feistmantel) Maithy, 1965b

Noeggerathiopsis densinervis Maithy, 1965b

Pl. 1, fig. 3; Text-fig. 6A-B

Holotype — Specimen no. 20391, Birbal Sahni Institute of Palaeobotany Museum, Lucknow.

Description — There are five incomplete, fragmentary leaf impressions in the collection. The figured leaf is 4·8 cm long and 2·7 cm broad at its widest part. The apex and base are missing and margin is entire. The veins arise from the base, thin, close and dichotomize frequently during their forward course. The angle of divergence between the two veins is less than 5°. The density of veins is 20 to 25 per cm.

Comparison — The present specimens are incomplete and somewhat larger but in their close and thin veins they fairly resemble with *N. densinervis* Maithy (1965b, pl. 1, fig. 6).

Discussion — Maithy (1965b) instituted this species for the leaves having lanceolate shape and acute apex with thin and close veins.

Genus — *Euryphyllum* Feistmantel, 1879

Euryphyllum whittianum Feistmantel, 1879

Pl. 1, fig. 4; Text-fig. 7A-B

Typical example from Feistmantel, 1879, pl. 21, fig. 1: Leaf 15·7 cm long, 5·3 cm broad, spathulate in shape; apex obtuse, base contracted, margin entire; veins arise from the base, dichotomize but never anastomose, straight in the middle, arch at an angle of 5° near the margin, 16 to 20 per cm in the middle.

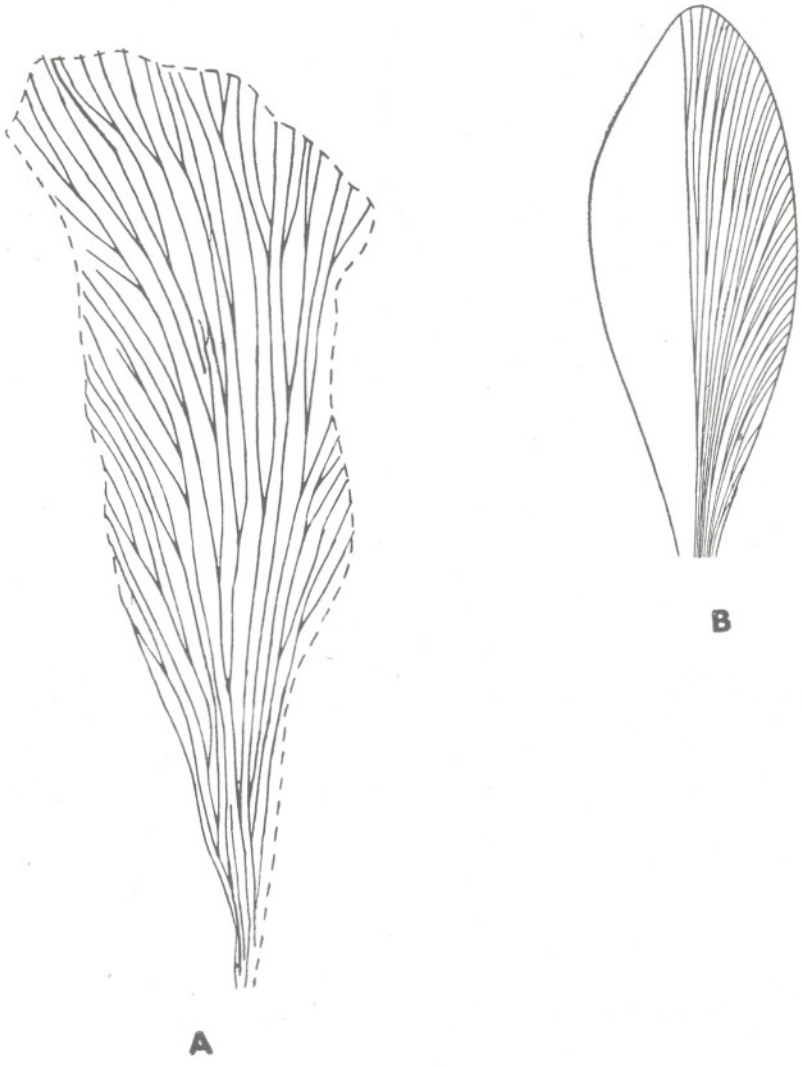
Description — There are three incomplete fragmentary leaf impressions in the collection. The figured leaf is 4·7 cm long and 1·6 cm broad at its widest part. The shape is unknown. The apex is missing, base contracted, margin entire. The veins

TEXT-FIG. 6 — A. *Noeggerathiopsis densinervis* Maithy, enlarged line drawing of a part of the leaf represented on Pl. 1, fig. 3 × 3. B. Idealised diagram of *Noeggerathiopsis densinervis*.

arise from the base. They are straight, dichotomous subparallel in the median region and arched towards the margin. The density of veins is 8 to 10 per cm.

Comparison — The present leaves in their venation pattern are similar with the typical specimen of Feistmantel (1879, pl. 21, fig. 1) and closely resemble with the leaves described by Maithy (1965b, pl. 1, figs. 9, 10).

Discussion— Feistmantel (1879) instituted this species from the Karharbari Coalfield of the Karharbari Stage. Arber (1905) has merged this genus under *Noeggerathiopsis* and instituted *N. whittiana* to accommodate this species. But later Seward and Sahni (1920) and Maithy (1965b) maintained the generic status of *Euryphyllum* on the grounds that the veins are straight and subparallel in the middle but they are arched laterally towards the margin. The present study also confirms this view. Maithy (1965b) has given a detailed description of this species and the same concept is followed here.



TEXT-FIG. 7 — A. *Euryphyllum whittianum* Feistmantel, enlarged line drawing of a part of the leaf represented on Pl. **1**, fig. 4 × 3. B. Idealised diagram of *Euryphyllum whittianum*.

The following specimens are regarded as typical *E. whittianum* Feistmantel:

1879 *E. whittianum* Feistmantel, pl. 21, figs. 1, 1a.

1965b *E. whittianum* Maithy, pl. 1, figs. 9, 10.

The following specimens are regarded as reliable records of *E. whittianum* Feistmantel.

1894 *Noeggerathiopsis hislopi* var. *euryphylloides* Kurtz, pl. 4, fig. 3.

1922 *N. hislopi* var. *typica* Kurtz, pl. 3, figs. 30, 32, 34, 37.

1922 *N. hislopi* var. *subcuneformis* Kurtz, pl. 4, figs. 37, 38.

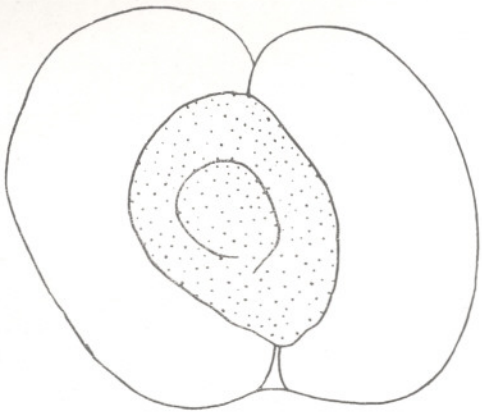
1922 *N. hislopi* var. *cuneformis* Kurtz, pl. 4, figs. 42, 42a.

Genus — *Samaropsis* Göppert, 1865

Samaropsis ganjrensis Saksena, 1955

Pl. 1, fig. 5; Text-fig. 8

Holotype — Specimen no. R.S. 1/29, Birbal Sahni Institute of Palaeobotany Museum, Lucknow.



TEXT-FIG. 8 — *Samaropsis ganjrensis* Saksena, enlarged line drawing of a seed represented on Pl. 1, fig. 5 × 6.

Description — There are four complete platyspermic seed impressions in the collection. The shape is subcircular. The figured specimen is 4×3·7 mm in diameter. The apex is slightly pointed and base rounded. The sarcotesta is thin, surrounds the sclerotesta except at the apical end. The sclerotesta is rounded 2·3×1·5 mm in diameter, wider at the apical end and narrower at the base.

Comparison— The present specimens closely resemble in their shape with the holotype and the specimens described by Maithy (1965a, pl. 1, figs. 7, 8).

Discussion — Saksena (1955) instituted this species from India and has given a detailed diagnosis and description. Maithy (1965a) has described this species from the Karharbari Stage of the Giridih Coalfield.

The following specimens have been regarded as typical of *S. ganjrensis* Saksena:

1955 *S. ganjrensis* Saksena, text-figs. 5-11.
1965a *S. ganjrensis* Maithy, pl. 1, figs. 7, 8; text-fig. 5.

COMPARISON AND DISCUSSION

Megafloristically the present assemblage is dominated by *Gangamopteris* and *Noeggerathiopsis*. However, *Glossopteris*, *Euryphyllum*, *Neomariopteris* and gymnospermic seeds are also common.

The megaflora of the type area Giridih Coalfield shows the dominance of *Gangamopteris*, *Noeggerathiopsis* with the frequent occurrence of characteristic elements *Buriadia* and *Gondwanidium* (Feistmantel, 1879; Maithy, 1965a-d, 1966). Similarly the Karharbari megaflora of the Ganjra Nala beds (Lele & Maithy, 1969; Maithy, 1968; Saksena, 1955, 1963), the South Karanpura Coalfield (Kulkarni, 1971) and the Jayanti Coalfield (Lele & Maithy, 1966; Lele & Makada, 1974) are dominated with *Gangamopteris* and *Noeggerathiopsis* alongwith *Gondwanidium*, *Buriadia* and gymnospermic seeds as common representatives. But *Glossopteris*, *Euryphyllum* and *Palmatophyllites* are also present in some of the areas.

On the whole, the Karharbari megaflora is predominated by *Gangamopteris* and *Noeggerathiopsis* together with the characteristic presence of *Gondwanidium* and *Buriadia*. *Glossopteris* and gymnospermic seeds are also common.

Thus, it seems most appropriate to place this assemblage under the Karharbari flora. The peculiar Karharbari forms *Buriadia* and *Gondwanidium* are still not recorded from the Auranga Coalfield. However, their apparent absence does not alter the strong Karharbari aspect of the flora.

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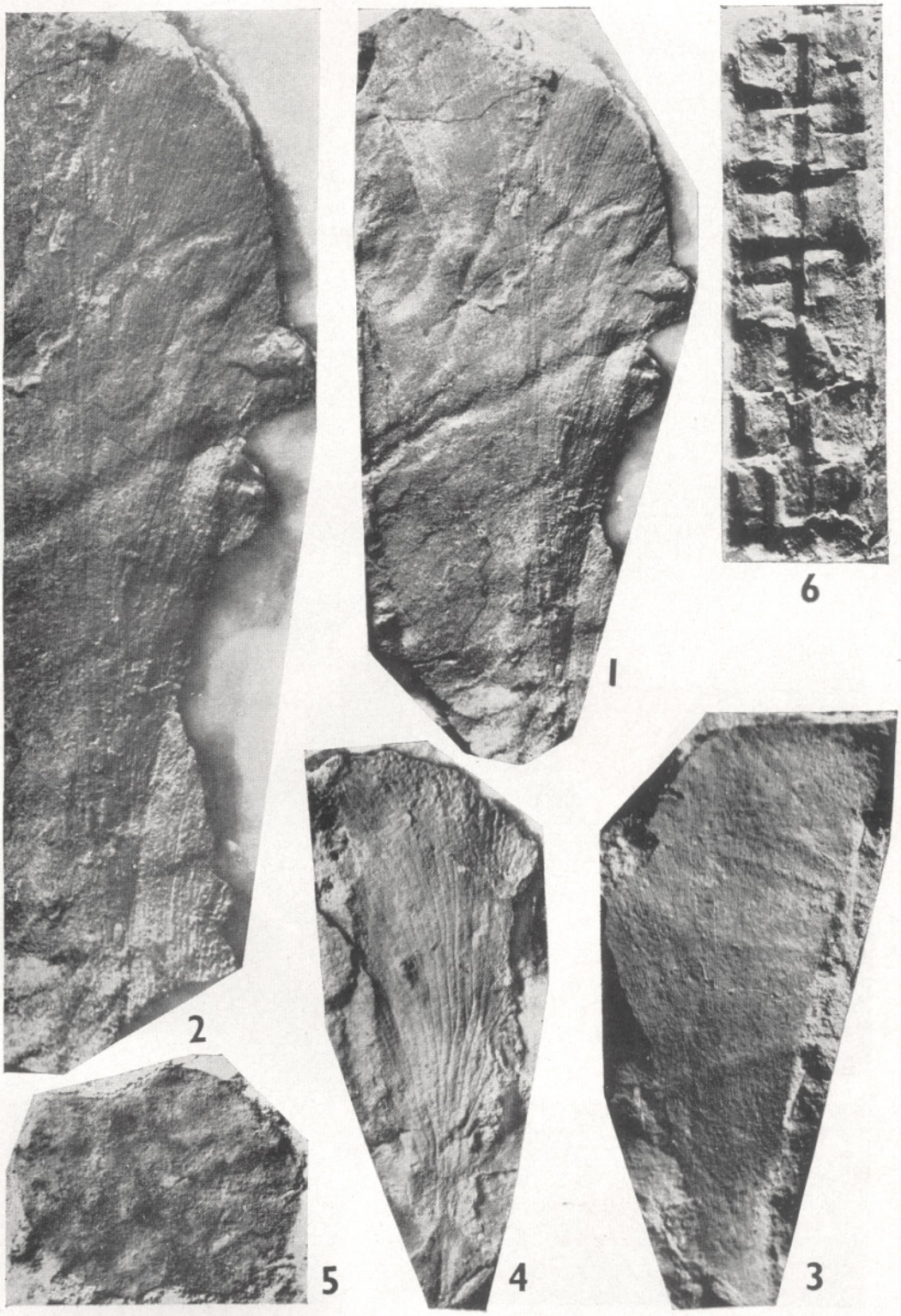
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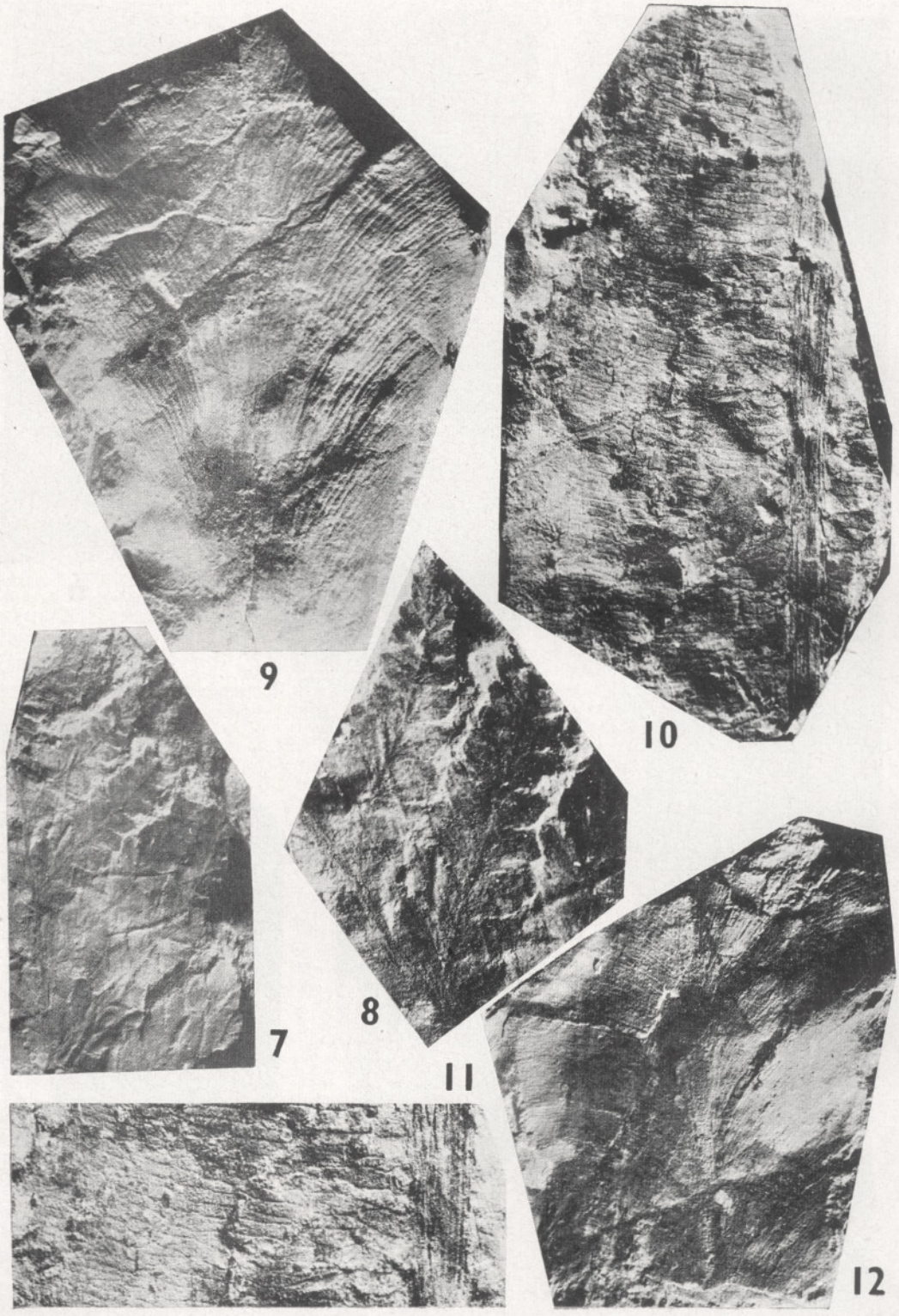
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EXPLANATION OF PLATES

PLATE 1

1. *Gangamopteris cyclopteroides* Feistmantel showing middle part of the leaf. Specimen no. 14/1393 × 2.

2. A portion of the leaf in fig. 1 enlarged to show the details of venation. × 3.

3. *Noeggerathiopsis densinervis* Maithy showing middle portion of leaf with a contracted base. Specimen no. 12/1393 × 2.

4. *Euryphyllum whittianum* showing an incomplete leaf. Specimen no. 13/1393 × 2.

5. *Samaropsis ganjrensis* Saksena. Specimen no. 8/1393 × 5.

6. *Vertebraria indica* Royle. Specimen no. 3/1393 × 2.

PLATE 2

7. *Neomariopteris hughesi* (Feistmantel) Maithy showing an incomplete frond. Specimen no. 13/1551 × Nat. size.

8. A portion of pinnae enlarged to show the pinnules with decurrent base. × 2.

9. *Gangamopteris clarkeana* Feistmantel showing middle portion of leaf. Specimen no. 11/1393 × 2.

10. *Glossopteris damudica* Feistmantel showing one half of lamina. Specimen no. 33/1393 × 2.

11. A portion of the leaf in fig. 10 enlarged to show the details of venation. × 3.

12. *Glossopteris communis* Feistmantel showing incomplete leaf with distinct midrib. Specimen no. 19/1393 × 2.