STUDIES IN THE GLOSSOPTERIS FLORA OF INDIA — 42. BARAKAR PLANT MEGAFOSSILS AND MIOSPORES FROM AURANGA COALFIELD, BIHAR

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ABSTRACT

The paper deals with the morphological details of eleven species of *Glossopteris*, viz., *G. indica, G. barakarensis, G. leptoneura, G. fuchsii, G. conspicua, G.* sp. cf. *G. ampla, G. pandurata, G.* sp. cf. *G. intermittens, G. churiensis* sp. nov., *G. communis, G. browniana* and *Vertebraria indica.*

The mioflora (31 genera and 53 species) is dominated by striate disaccate pollen grains and trilete spores. A new non striate disaccate genus *Aurangapollenites* is instituted for the grains having pitcher shaped saccus arrangement.

INTRODUCTION

THE Barakar mega- and miofloral assemblages from the Auranga Coalfield have earlier been reported by Feistmantel (1881a, b, 1882, 1886), Bhattacharyya (1959), Bhattacharyya (1963), Maithy (1971), and Srivastava and Anand-Prakash (1973).

Maithy (1971) has given the following revised list of the megafossils from the Barakar Stage of the Auranga Coalfield:

Trizygia speciosa (Royle) McClelland
Barakaria dichotoma Seward & Sahni
Equisetalean stems
Sphenopteris polymorpha Feistmantel
Vertebraria indica Royle
Glossopteris angustifolia Brongniart
G. linearis Mc Coy
G. communis Feistmantel
G. indica Schimper
G. damudica Feistmantel
G. browniana Brongniart
G. tortuosa Zeiller
G. retifera Feistmantel
Rhabdotaenia danaeoides (Royle) Pant
Scale leaves
Pseudoctenis balli (Feistmantel) Seward

The following miospore genera have earlier been recorded from the Auranga Coalfield, Bihar (Bhattacharyya, 1959; Maithy, 1971; Srivastava & Anand-Prakash, 1973):

Punctatisporites, Microbaculispora, Apiculatisporis, Laevigatisporites, Leiotriletes, Cyclogranisporites, Cristatisporites, Calamospora, Callumispora, Hennellysporites, Verrucosisporites, Lophotriletes, Brevitriletes, Horriditriletes, Lacinitriletes, Indospora, Cyclobaculisporites, Gondisporites, Indotriradites, Latosporites, Thymospora, Parasaccites, Virkkipollenites, Potonieisporites, Striomonosaccites, Densipollenites, Barakarites, Cuneatisporites, Platysaccus, Vestigisporites, Lueckisporites, Schizopollis, Vittatina, Striatites, Lahirites, Striatopodocarpites, Faunipollenites, Direticuloidispora, Vesicaspora, Sulcatisporites, Guttulapollenites, Fusacolpites, Ginkgocycadophytus, Ibisporites, Tiwariasporis, Decussatisporites, Striasulcites Maculatasporites, Balmeella, Quadrisporites, Peltacystia and *Leiosphaeridia.*

The present investigation was carried out to study in detail the morphological and systematic description of the mega— and miofloras of the Barakar Stage of Auranga Coalfield.

For the study of *Glossopteris* species a typical example has been sorted out from the original author's collection. All the figured records have been examined and their placement has been discussed with reference to holotype or typical example. Idealized diagrams have been given to elucidate the morphological concept of the species.

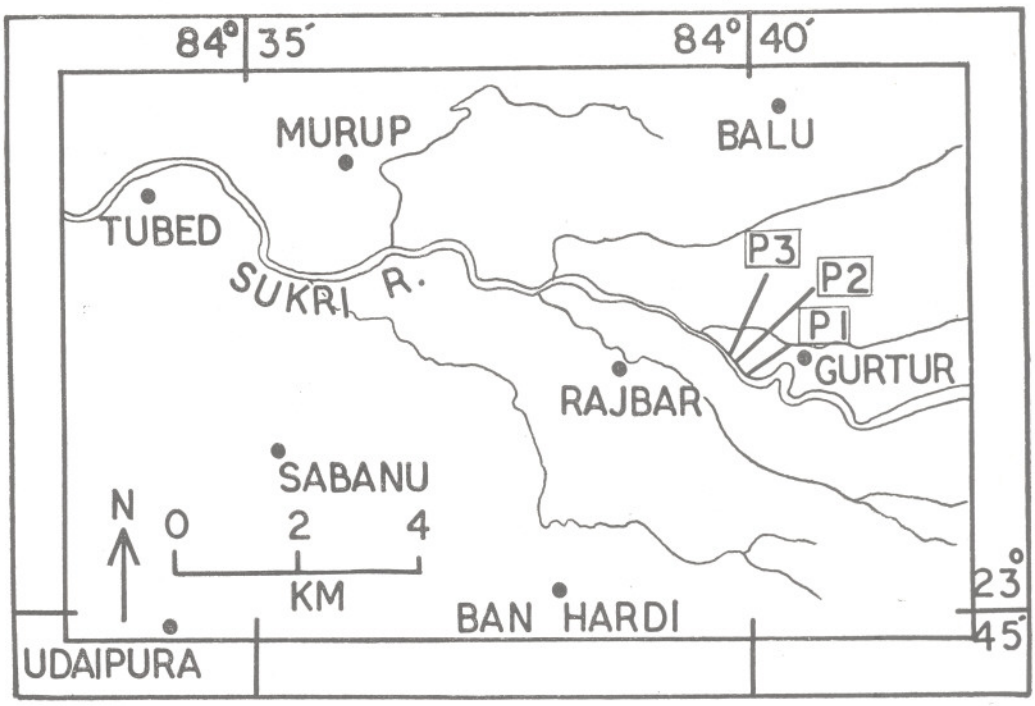
MATERIAL

A. The megafossils have been found as impressions on thinly laminated white to grey fireclay, collected from a section exposed in a quarry about 2 km west-south of west bank of Auranga River which is about 2 km north-west of Churia Village (see in Map; Srivastava, 1977).

B. The palynological assemblages have been recovered from the section exposed in north-east bank of Sukri River (Map-1):

Site-1. About 150 metres west of Gurtur Village. Samples are sandy coaly shale.

Site-2. About 166 metres north of Site 1. Samples are coaly with less sand.



MAP 1 — Showing the palynological sample sites (P1 to P3).

Site-3. About 150 metres further north of Site-2. Samples are grey to dark brown micaceous shale.

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

DESCRIPTION

1. MEGAFOSSILS

Genus — *Glossopteris* (Brongniart) Sternberg, 1825

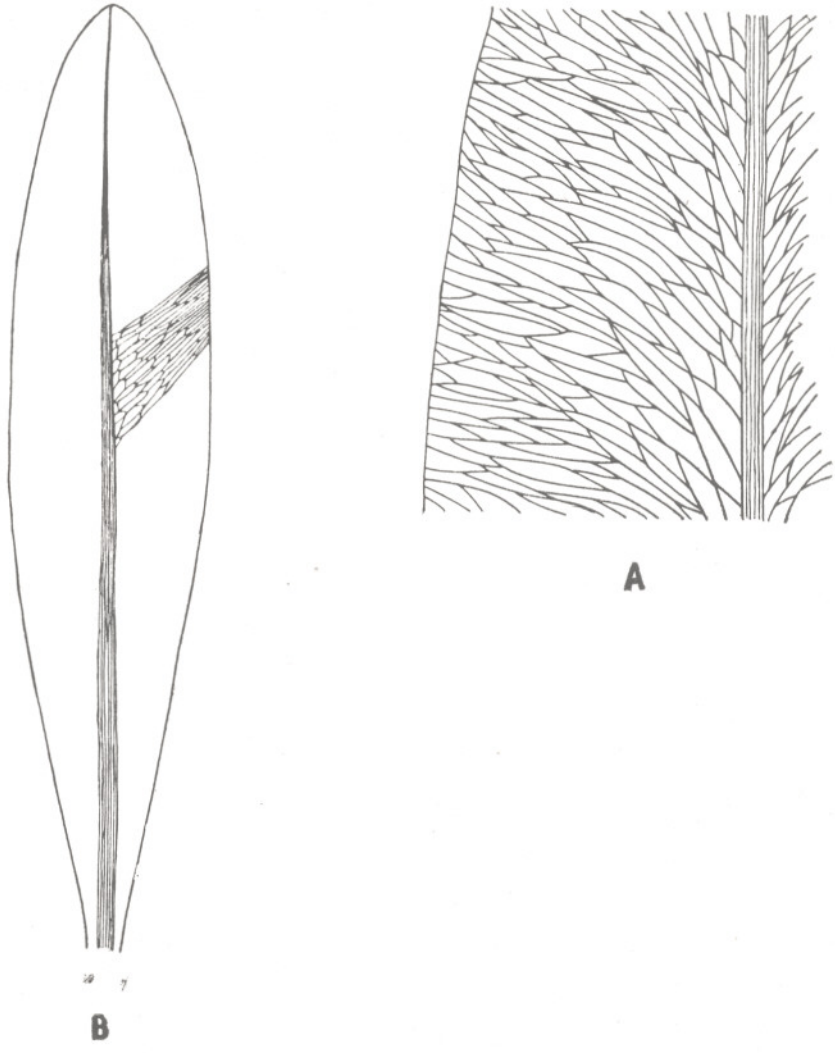
Glossopteris indica Schimper, 1869

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

Typical example from niarBrongt, 1828, pl. 62, fig. 2: Leaf preserved in two pieces; one shows the upper half 7·5 cm long, 4·8 cm broad; other piece shows lower half 9·9 cm long, 4 cm broad; midrib 6 mm broad near the basal portion, 1·5-2·5 mm near apical region; secondary veins arise at 45°; meshes broad, polygonal, few, 1·5-2·5 mm long, 0·8 mm broad, near the midrib, linear, narrow, 2-5 mm long, 0·5-0·7 mm broad in rest of the lamina; veins 12-14 per cm near the midrib and 15-18 per cm near the margin.

Description — There are twenty incomplete leaf impressions in the collection. The figured leaf is 8·2 cm long, 3·2 cm broad at its widest part. The shape was probably lanceolate. The tip of apex and base are not preserved, margin is entire. The midrib distinct, 1·5 to 2·5 mm broad near the basal portion and 1 to 1·5 mm near the apical region. 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, linear, hexagonal meshes near the margin. The meshes are 1·5 to 2·5 mm long and 0·8 to 1·0 mm broad near the midrib and 3 to 4 mm long and 0·3 to 0·5 mm broad near the margin. The density of veins is 6 to 18 per cm near the midrib and 15 to 26 per cm near the margin.

Comparison — The present specimens in their venation pattern fairly resemble the



TEXT-FIG. 1 — A. *Glossopteris indica* Schimper, enlarged line drawing of a part of the leaf represented on Pl. 1, fig. 1 × 3. B. Idealised diagram of *Glossopteris indica*.

photograph of the typical specimen described by Brongniart (1828, pl. 62, fig. 2) which is briefly described in the begining and the leaves described by Maheshwari and Prakash (1965, pl. 2, fig. 15) and Kulkarni (1971, pl. 1, fig. 4).

Discussion — Zeiller (1896) and Arber (1905) considered *G. communis* Feistmantel under *G. indica* Schimper. The original photograph and diagram of the specimen, however, show that in *G. indica* there are few, open, hexagonal meshes near the midrib and narrow, elongate meshes in rest of the leaf, whereas in *G. communis* the secondary veins are arched and the meshes are narrow, elongate throughout the lamina. Hence, both the species seem to be distinct. The cuticular evidences also indicate the distinction of two species (Zeiller, 1896; Srivastava, 1956).

Concept of the Species — The species *G. indica* Schimper is distinguished by the following morphological features (Text-fig. 1B).

Leaves broad to linear; apex acute, base contracted; margin entire; midrib broad,

persistent; secondary veins arise at 40°-45°, meshes broad, elongate, polygonal near the midrib and narrow, linear, hexagonal meshes in rest of the leaf.

Following the above concept the more representative specimens of *G. indica* Schimper from the published records are sorted out below:

1828 *G. browniana* var. *indica* Brongniart, pl. 26, fig. 2.
1861 *G. browniana* var. *indica* Bunbury, pl. 8, figs. 1-4.
1881a *G. indica* Feistmantel, pl. 26, fig. 3; pl. 27, fig. 35; pl. 29, fig. 7.
1890a *G. primaeva* Feistmantel, pl. 13, figs. 3, 3a (Arber, 1905)
1897 *G. browniana* var. *indica* Seward, pl. 21, figs. 2,3.
1902 *G. indica* Zeiller, pl. 1, figs. 2, 5.
1911 *G. indica* Halle, pl. 2, figs. 1-5.
1914 *G. indica* Gothan, pl. 1, fig. 1.
1919 *G. indica* Lundquist, pl. 1, figs. 6,7.
1923 G. *indica* cf. var. *wilsonii* Seward & Walton, pl. 21, fig. 13.
1934 *G. indica* Harrington, pl. 1, figs. 1, 2.
1957 *G. indica* Archangelsky, figs. 1,3.
1958 *G. indica* Archangelsky, fig. 39
1960 *G. indica* Hφeg & Bose, pl. 15, fig. 1.
1962 *G. indica* Plumstead, pl. 4, figs. 1-5.
1962 *G. indica* Schopf, pl. 11, figs. 1a, 1b; text-figs. 4a, b, c.
1962 *G. indica* Saksena, pl. 1, figs. 1-4.
1965 *G. indica* Maheshwari & Prakash, pl. 2, fig. 15.
1965d *G. indica* Maithy, pl. 5, fig. 30
1971 *G. indica* Kulkarni, pl. 1, fig. 4.

The following specimens are regarded as doubtful records of *G. indica* Schimper:

1881a *G. indica* Feistmantel, pl. 23, fig. 10; pl. 25, figs. 1, 2; pl. 35, fig. 4; pl. 38, fig. 4.
1928 *G. indica* Walkom, text-figs. 2, 2a.

The following specimens are regarded distinct from *G. indica* Schimper:

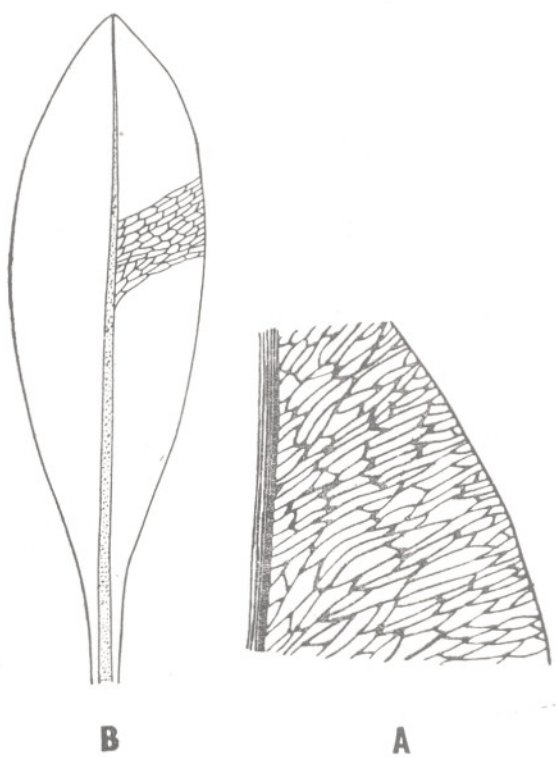
1886 *G. indica* Feistmantel, pl. 12, figs. 2, 6b; pl. 14, fig. 7.
1902 *G. indica* Zeiller pl. 1, fig. 1; pl. 2, figs. 1-4; pl. 3, figs. 1-3.
1903 *G. browniana* var. *indica* Seward, pl. 13, fig. 1 (fragmentary); pl. 10, figs. 3, 4 (venation not clear).
1911 *G. indica* Halle, pl. 2, fig. 6.
1912 *G. indica* Seward, pl. 1, fig. 1; pl. 1, figs. 2,3.
1922 *G. indica* Kurtz, pl. 9, fig. 9; pl. 10, figs. BB1, B2.
1922 *G. indica* Walkom, pl. 2, figs. 10-13a.
1928 *G. indica* Edwards, figs. 1a, 2.
1934 *G. indica* Harrington, pl. 1, fig. 3.
1941 *G. indica* Read, pl. 4, figs. 1, 2, 4; pl. 5, figs. 1, 2, 5.
1948 *G. indica* Dolianiti, pl. 5, fig. 2.
1957 *G. indica* Archangelsky, pl. 7, fig. 2.
1960 *G. indica* Hφeg & Bose, pl. 11, fig. 6; pl. 14, figs. 5, 6.
1962 *G. indica* Saksena, pl. 1, figs. 1-3.
1963 *G. indica* Cridland, pl. 1, figs. 30-32.
1965 *G. indica* Archangelsky & Arrondo, pl. 1, fig. 2.
1966 *G. indica* Rigby, pl. 34, fig. 40 (fragmentary).

Glossopteris barakarensis Kulkarni, 1971

Pl. 2. fig. 11; Text-fig. 2A-B

Holotype — Kulkarni, 1971, specimen no. 34061, B.S.I.P. Museum, Lucknow.

Description — There are four complete to incomplete leaf impressions in the collec-



TEXT-FIG. 2 — A. *Glossopteris barakarensis* Kulkarni, enlarged line drawing of a part of the leaf represented on Pl. 2, fig. 11 × 3. B. Idealised diagram of *Glossopteris barakarensis*.

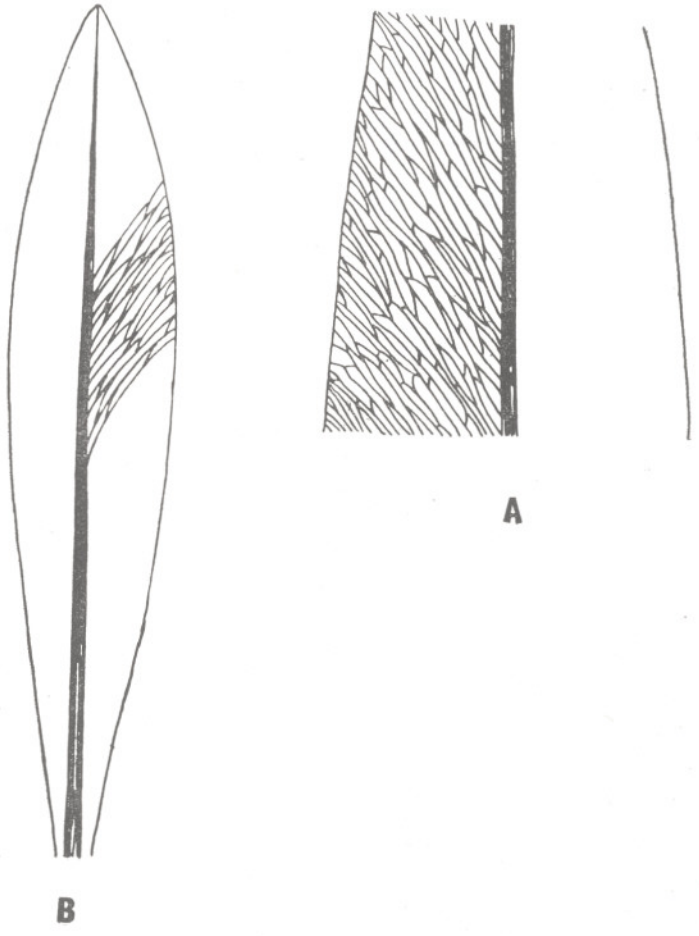
tion. The figured leaf is spathulate to lanceolate in shape. The size is 11·5 cm long and 3·0 cm broad at its widest part. The apex is acute, base contracted and the margin is entire. The midrib is distinct, persistent, 1·5 to 2·0 mm broad near the base and 1·0 mm near the apex. The secondary veins arise at an acute angle. They dichotomize and anastomose to form moderately close, narrow, polygonal meshes throughout the leaf. The meshes are 3·5 mm long and 0·5 mm broad. The density of veins is 18 to 21 per cm near midrib and 22 to 26 per cm near the margin.

Comparison — The specimens fairly resemble with the holotype (Kulkarni, 1971, pl. 2, fig. 13) in their shape and venation pattern. However, the petiolate condition which is clearly seen in the holotype is not evident in the present specimens, though they show the lateral contracting nature of the margin which indicates a petiolate tendency.

Glossopteris leptoneura Bunbury, 1861

Pl. 2, fig. 10; Text-fig. 3A-B

Typical example from Bunbury, 1861, pl. 9, fig. 2: Leaf complete, 11·8 cm long, 0·8 cm broad; apex acute, base tapering, margin entire; midrib 1·2 mm broad near the base and 0·5 mm near the apex;



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

secondary veins arise at acute angle, meshes linear, narrow, fine, size and other details of meshes not determinable due to unsatisfactory preservations.

Description — There are six incomplete leaf impressions in the collection. The figured leaf is 8·8 cm long and 1·7 cm broad at its widest part. The shape is narrow, linear. The apex is acute, base absent and margin is entire. The midrib is distinct, 1·5 mm broad near the base and 0·5 mm near the apex. One characteristic deep striation is present throughout the length over the surface of midrib. The secondary veins arise at an acute angle from the midrib and run parallel to the midrib for 1 to 2 mm distance, then arch obliquely at an angle of 30° to 35°. They dichotomize and anastomose to form linear, elongate, fine, 2·9 to 5·0 mm long and 1·0 to 1·5 mm broad meshes throughout the lamina. The density of veins is 11 to 15 per cm near the midrib and 12 to 17 per cm near the margin.

Comparison — The present specimens in their size, shape and venation pattern fairly resemble with the figure given by Bunbury (1861; pl. 9, figs. 1,2,4).

Discussion — Arber (1905) considered this species under *G. angustifolia* Brongniart (1828, pl. 68, fig. 1). The original photographs of both the specimens, however, show considerable differences in their venation pattern which Bunbury has also noticed and distinguished it from the leaves of former species and stated "in *G. angustifolia* the veins appear to be coarse and, rather distant and sparingly anastomosing near the midrib only; in our Kampti plant they are very fine and close and anastomose repeatedly throughout their length, even near to the margin. . . . . " He considered its resemblance more with *G. linearis* Mc Coy but the veins are much more oblique than in that species. Therefore, it seems necessary to keep *G. leptoneura* Bunbury, *G. angustifolia* Brongniart and *G. linearis* Mc Coy separate.

Concept of the Species — The morphological features of *G. leptoneura* Bunbury can be outlined as follows (Text-fig. 3B).

Leaves narrow, linear; apex acute, base tapering; midrib narrow, continued to the apex; secondary veins arise at acute angle, oblique, arched; meshes fine elongate, narrow.

In view of the above concept, it may be noted that the following specimens which were described earlier under *G. angustifolia* Brongniart are referable to *G. leptoneura* Bunbury:

1902 *G. angustifolia* Zeiller, pl. 4, figs. 3, 3a, 3b, 4.
1934 *G. angustifolia* Harrington, pl. 2, fig. 3.
1958 *G. angustifolia* Plumstead, figs. 25, 26.
1962 *G. angustifolia* Plumstead, pl. 8, figs. 4-6.
1965d *G. angustifolia* Maithy, pl. 5, fig. 33.
1971 *G. angustifolia* Kulkarni, pl. 1, fig. 10.

The following specimens are considered doubtful records of *G. leptoneura* Bunbury:

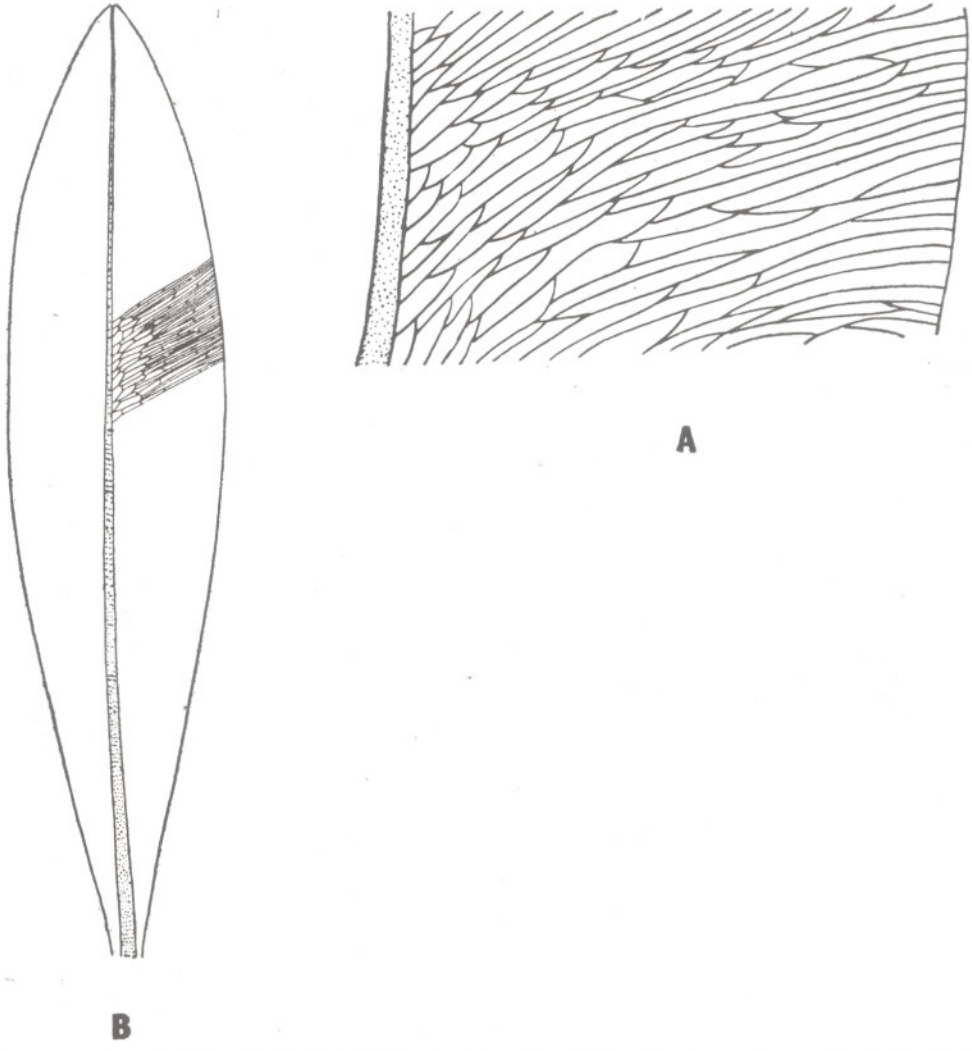
1881a *G. angustifolia* Feistmantel, pl. 39A, figs. 1, 2.
1905 *G. angustifolia* Arber, text-fig. 18B
1965 *G. angustifolia* Maheshwari & Prakash, pl. 2, fig. 12.

Glossopteris fuchsii Plumstead, 1962

Pl. 3, fig. 14; Text-fig. 4A-B

Typical example from Plumstead, 1962, pl. 12, fig. 1: Leaf 16 cm long, 4-5 cm broad; shape linear, lanceolate, apex acute, base tapering, margin entire; midrib 2 mm broad, raised; secondary veins arise at acute angle, bends at 70°, then follow a straight course to the margin, but anastomose seldom; meshes linear, narrow, 1·0 to 1·5 mm long, 0·3 to 0·5 mm broad near the midrib; veins 23 to 30 per cm.

Description — There are three incomplete leaf impressions in the collection. The figured leaf shows lamina only on one side of the midrib which is 12·00 cm long and 3·2 cm broad at its widest part. The apex and base are missing. The margin is entire. The midrib is distinct, 1·0 mm to 1·5 mm broad. The secondary veins emerge at an acute angle, then bend at an angle of 60° and run ± parallel to the margin. They form open, long, linear meshes measuring 5 to 1·0 cm long and 0·6 mm broad near the midrib. Afterwards they follow a straight course to the margin. They dichotomize but never anastomose to form meshes near the margin. The density of veins is 7 to 11 per cm near the midrib and 18 to 25 per cm near the margin.



TEXT-FIG. 4 — A. *Glossopteris fuchsii* Plumstead, enlarged line drawing of a part of the leaf represented on Pl. 3, fig. 14 × 3. B. Idealised diagram of *Glossopteris fuchsii*.

Comparison — The present specimens closely compare in their venation pattern with the specimen described by Plumstead (1962, pl. 12, figs. 1-3; see also observations on a typical specimen given in the beginning). This is the first record of *G. fuchsii* Plumstead from India.

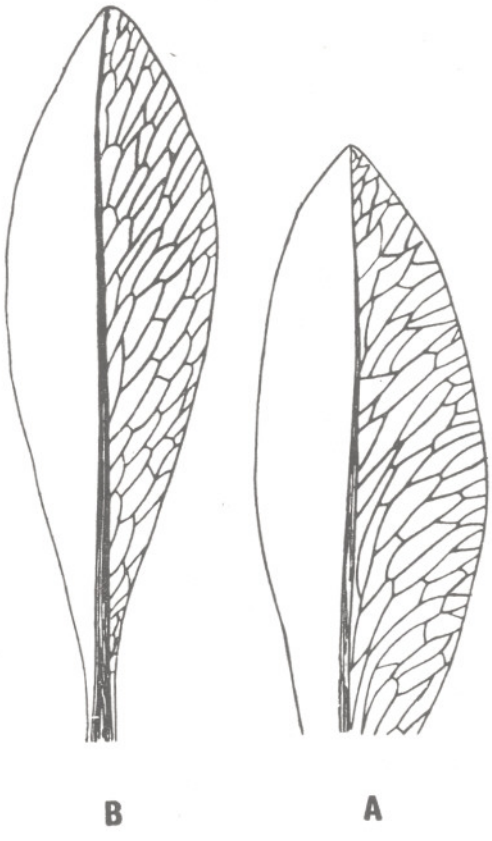
Concept of the Species — In brief the species can be distinguished as follows (Text-fig. 4B).

Leaves linear, lanceolate; apex acute, base tapering; midrib distinct; secondary veins arise at acute angle, bend at 70°; meshes near the midrib linear, narrow, meshes seldom formed near the margin.

Glossopteris conspicua Feistmantel, 1881a

Pl. 1, fig. 5; Text-fig.5A-B

Typical example from Feistmantel, 1881a, pl. 28, fig. 5: Leaf complete, 11·4 cm long, 3·5 cm broad; shape elliptical, apex acute, base tapering, margin entire; midrib 2 mm thick near the base and 0·5 mm near the



TEXT-FIG. 5 — A. *Glossopteris conspicua* Feistmantel, enlarged line drawing of a part of the leaf represented on Pl. 1, fig. 5 × 3. B. Idealised diagram of *Glossopteris conspicua*.

apex; secondary veins arise at an angle of 45°, meshes broad, elongate, polygonal, 0·5-1·5 cm long and 1·5-2·5 mm broad; veins 5-8 per cm.

Description — There are three complete to incomplete leaf impressions in the collection. The figured leaf is elliptical in shape, measuring 4·3 cm long and 1·5 cm broad. The apex is acute, base contracted and margin is entire. The midrib is distinct, persistent, 2 mm broad near the base and 0·5 mm broad near the apical portion. The secondary veins arise directly from the midrib at an angle of 45°. They dichotomize and anastomose to form broad, elongate, hexagonal meshes. The meshes are equal in size throughout the lamina measuring 4 to 6 mm long and 2 mm broad. The density of veins is 4 to 6 per cm.

Comparison — The present specimens agree in their shape, venation pattern with specimen of Feistmantel (1881a, pl. 28, fig. 5) which is typical of the species.

Concept of the Species — Morphologically *G. conspicua* Feistmantel can be distinguished as follows (Text-fig. 5B).

Leaves elliptical to lanceolate in shape; apex acute, base contracted, tapering; midrib persistent; secondary veins arise at 40° to 45°; meshes broad, elongate, polygonal.

In view of the above considerations, some representative specimens of *G. conspicua* Feistmantel are sorted below from the published records.

1881a *G. conspicua* Feistmantel, pl. 28, figs. 1, 5, 6, 8, 9.
1927 *G. conspicua* du Toit, text-fig. 15A.

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

1952 *G. conspicua* Plumstead, pl. 48, figs. 1, 4; pl. 49, fig. 2.
1956 *G. conspicua* Srivastava, pl. 4, figs. 21, 22.

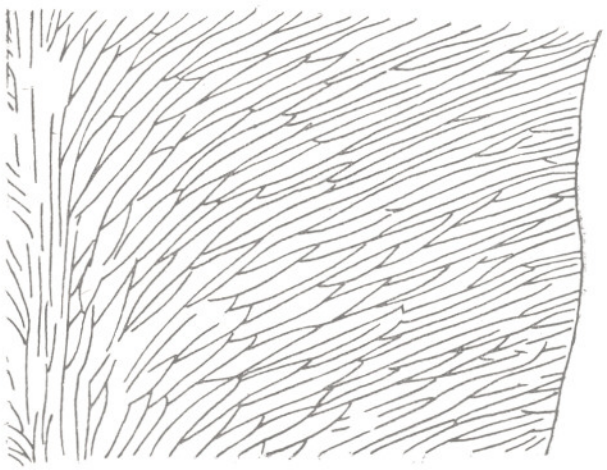
The following specimens are considered distinct from *G. conspicua* Feistmantel:

1905 *G. conspicua* Arber, pl. 3, fig. 3.
1956a *G. conspicua* Plumstead, pl. 8, figs. 1,2.
1958 *G. conspicua* var. *patagonica* Archangelsky, pls. 44, 45.
1962 *G.* cf. *conspicua* Plumstead, pl. 6, figs. 5,6.

Glossopteris sp cf. *G. ampla* Dana, 1849

Pl. 3, fig. 15; Text-fig. 6A-B

Typical example from Dana, 1849, pl. 13, fig. 1b: Leaf shape unknown; only apical portion preserved; 5 cm long, 6·8 cm broad, apex broadly rounded, tip broken, margin entire; midrib distinct, 1-2 mm broad; secondary veins arise at an acute angle, run at an angle of 50°-60°; meshes near midrib broad, open, polygonal, 4-6 mm long and 0·6-0·9 mm broad, meshes near margin few, narrow, elongate, 8-12 mm long and 0·3-0·5 mm broad; veins 15-18 per cm near the midrib and 20-28 per cm near margin.



TEXT-FIG. 6 — A. *Glossopteris* sp. cf. *G. ampla* Dana, enlarged line drawing of a part of the leaf represented on Pl. 3, fig. 15 × 3.

Description — There are five, incomplete fragmentary leaf impressions in the collection. The figured specimen shows only the lower half of the lamina, 9·2 cm long and 15·9 cm broad at its widest part. The apical portion is not preserved, base contracted and margin is entire. The midrib is distinct, 3-7 mm broad throughout the preserved length. The secondary veins emerge from the midrib at an acute angle and immediately arch at an angle of 30° to 40° and run parallel to each other. They dichotomize and anastomose to form broad hexagonal meshes near the midrib and linear, narrow meshes near the margin. The meshes are 4 to 7 mm long and 0·5 to 0·7 mm broad near the margin. The density of veins is 13 to 15 per cm near the midrib and 20 to 25 per cm near the margin.

Comparison — The present specimens compare well with *G. ampla* (Dana, 1849, pl. 13, fig. 1b) in their broad shape and in having broad open, polygonal mesh pattern near the midrib and narrow, elongate meshes near the margin. However, the midrib as shown by Dana (1849, pl. 13, fig. 1a) in his example is much stronger and broad (1·2 cm) than in the present specimens.

Discussion — Dana (1849) has pointed out that the veins rarely anastomose. A clear examination of photographs (*loc. cit.*), however, shows that anastomosis is present but the cross connections are not very evident because the veins are very close near the margin. In contrary to this the veins near the midrib are sparse, open and interconnections are, therefore, distinct. Cuticular characters have so far not been reported.

Concept of the Species — The morphological features of *G. ampla* Dana can be summarised as below (Text-fig. 6B).

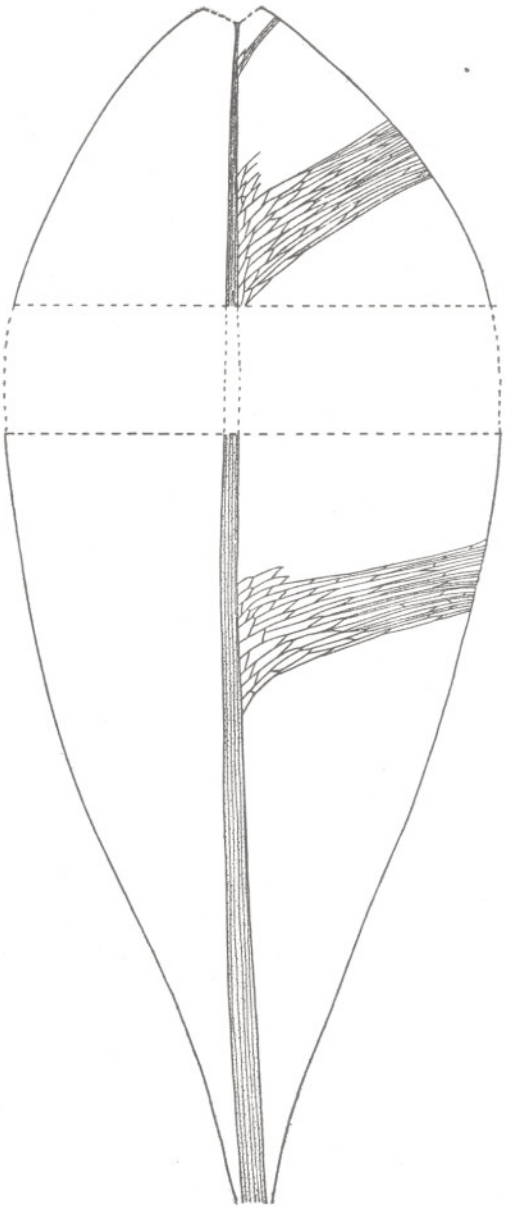
Leaves broad spathulate in shape; apex obtuse, base contracted, margin entire; midrib broad, thick grooved; secondary veins arise at angle of 70° to 80°; meshes open, polygonal, square near the midrib and close, few narrow, linear towards the margin.

The following specimens from the published records have been regarded as typical of *G. ampla* Dana:

1849 *G. ampla* Dana, pl. 13, figs. 1a, 1b.
1890a *G. ampla* Feistmantal, pl. 19, figs. 1, 2.
1908 *G. ampla* White, pl. 6, fig. 9.
1922 *G. ampla* Walkom, figs. 14, 14a, 17, 17a.
1958 *G. ampla* Archangelsky, fig. 35.
1962 *G. ampla* Plumstead, pl. 6, figs. 1, 4.
1963 *G. ampla* Cridland, figs. 7, 8.
1966 *G. ampla* Rigby, pl. 34, fig. 42.

The following specimens are regarded as distinct from *G. ampla* Dana:

1941 *G.* cf. *ampla* Read, pl. 4, figs. 3, 5.
1957 *G. ampla* Archangelsky, pl. 1, fig. 1; text-fig. 1a.



TEXT-FIG. 6 — B. Idealised diagram of *Glossopteris ampla*.

Glossopteris pandurata Pant & Gupta, 1971

Pl. 1, fig. 6; Text-fig. 7A-B

Holotype — Pant and Gupta; specimen no. 1180, Allahabad University, India.

Description — There is a solitary complete leaf impression in the collection. The leaf is pandurate in shape and has a broad, flattened apex, measures 5·5 cm in length and 2·3 cm in breadth at its widest part. The lateral margins show a sudden convergence resulting in a cuneate base. The midrib region is occupied by 5-6 longitudinal parallel running strands which in due course form secondary veins and ultimately 1-2 strands reach the apex. Each strand bifurcates into secondary veins at an acute angle and reaches the margin at the same angle. They dichotomize and anastomose to form narrow elongate meshes of nearly uniform size throughout the lamina. The meshes are 3 to 5 mm long and 0·5 to 1 mm broad. The density of veins is 10 to 13 per cm near the midrib and 15 to 18 per cm near the margin.

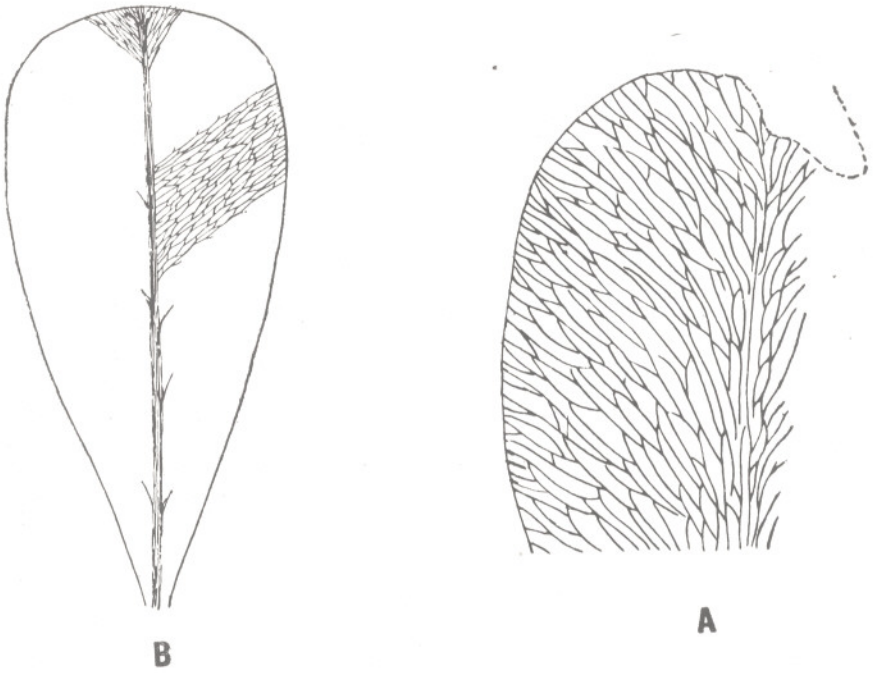
Comparison — The present specimen fairly compares in its shape and venation pattern with the holotype of *G. pandurata*, described by Pant and Gupta (1971, pl. 31, fig. 39). Pant and Gupta (1971) instituted this species on its peculiar pandurate shape. The base of the present leaf is, however, somewhat cuneate in comparison to the gradually contracted base in the holotype. It may be added that the specimen of Pant and Gupta has also a flat midrib, as in the present case, traversed by 5-6 parallel running longitudinal strands which in due course form secondary veins and ultimately 1-2 strands reach the apex. Thus the similarities between the two specimens are close.

Glossopteris sp. cf. *G. intermittens* Feistmantel, 1881a

Pl. 1, figs. 3, 4; Text-fig. 8A-B

Lectotype — Feistmantel, 1881a; specimen no. 5271, G.S.I. Museum, Calcutta.

Description — There are three complete to incomplete leaf impressions in the collection. The figured leaf is spathulate in shape, 6·8 cm long and 2·4 cm broad at its widest part. The apex is broadly rounded, base contracted and margin is entire. The midrib is distinct, striated, 3-4 mm broad near the base and narrower towards the apex. The secondary veins arise from the midrib, they first run parallel to the midrib up to 1-2 mm distance then arch at an angle of 50°. They dichotomize and anastomose to form broad, elongate, square meshes



TEXT-FIG. 7 — A. *Glossopteris pandurata* Pant & Gupta, enlarged line drawing of a part of the leaf represented on Pl. 1, fig. 6 × 3. B. Idealised diagram of *Glossopteris pandurata*.

near the midrib but away from it the veins anastomose rarely to form 1 to 2 close, linear, narrow, hexagonal meshes. The meshes are 2 to 4 mm long and 0·6 mm broad near the midrib and 2·5 to 6 mm long and 0·3 mm broad in rest of the lamina. The density of veins is 9 to 12 per cm near the midrib and 18 to 22 per cm near the margin.

Comparison — The shape and venation pattern of the present specimens stand nearest to the lectotype selected by Pant and Gupta (1968). However, all the specimens described here are in the form of impressions. Cuticular data are not available to confirm and complete the identification of this species. In view of this the specimens are described as *Glossopteris* sp. cf. *G. intermittens* Feistmantel.

Discussion — Arber (1905) considered this species under *G. browniana* Brongniart but an examination of the original photographs of both the species reveals that in *G. browniana* Brongniart (1828, pl. 62, fig. 1) the meshes are broad, hexagonal and frequent throughout the lamina whereas in *G. intermittens* Feistmantel (1881a, pl. 33, fig. 3) meshes are few and broad near the midrib and then they rarely dichotomize to form narrow, linear meshes. Both the species are therefore distinct to each other.

The following specimens do not agree with the lectotype and are considered distinct from *G. intermittens* Feistmantel:

1956 *G. intermittens* Srivastava, pl. 7, fig. 43.
1958a *G. intermittens* Plumstead, pl. 14, figs. 1-3.
1958b *G. intermittens* Plumstead, pl. 29.

Glossopteris churiensis sp. nov.

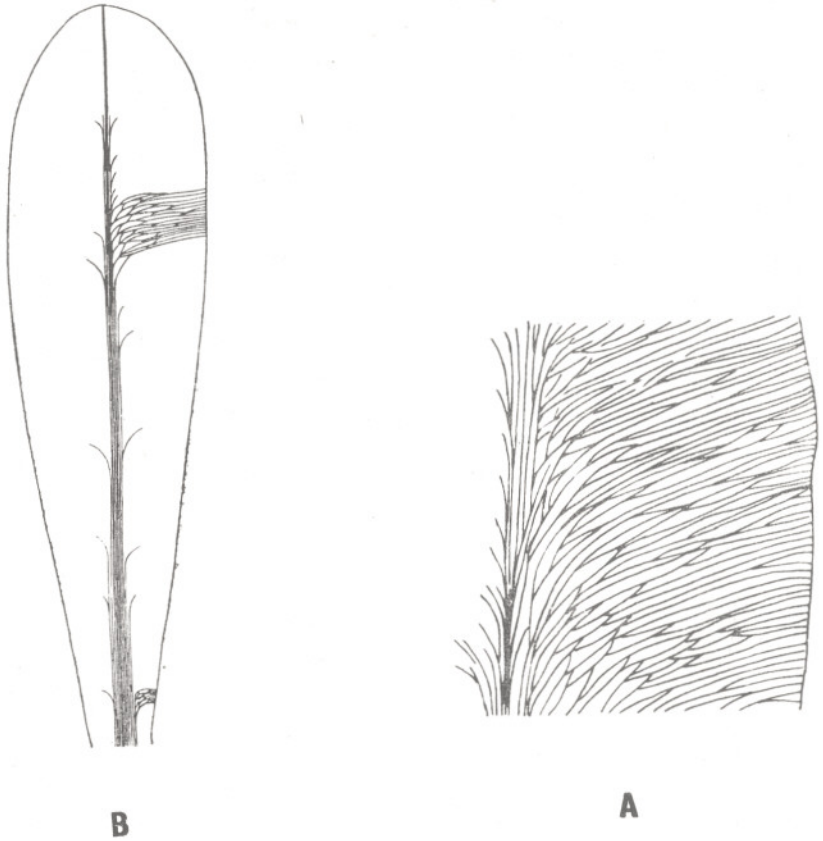
Pl. 2, figs. 8, 9; Text-fig. 9A-B

Holotype — Specimen no. 27/1392, B.S.I.P., Lucknow.

Locality — Churia fire clay pit, Auranga Coalfield, Bihar.

Horizon & Age — Barakar Stage, Lower Permian.

Diagnosis — Leaves spathulate, apex obtuse, base contracted; midrib region

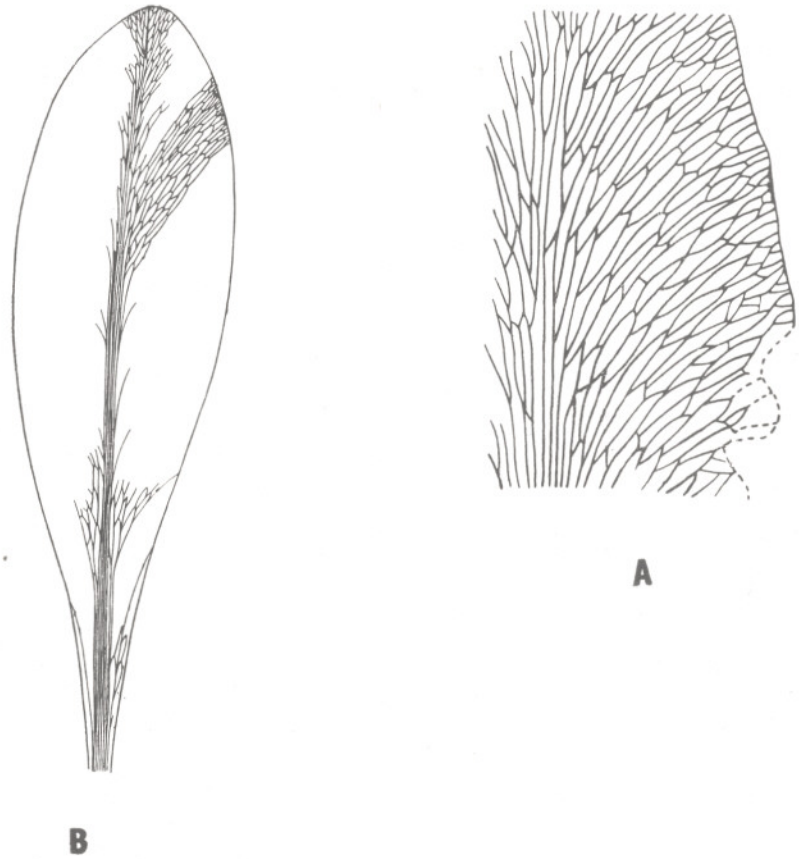


TEXT-FIG. 8 — A. *Glossopteris* sp. cf. *G. intermittens* Feistmantel, enlarged line drawing of a part of the leaf represented on Pl. 1, fig. 3 × 3. B. Idealised diagram of *Glossopteris intermittens*.

occupied by parallel running strands, they dichotomize during upward course, secondary veins bifurcate and anastomose to form open, broad, elongate, polygonal meshes throughout the lamina.

Description — There are thirteen complete or incomplete leaf impressions in the collection. The figured leaf measures 6·8 cm long and 2·2 cm broad at its widest part. Leaves are spathulate in shape with an obtuse apex, contracted base and entire margin. The midrib is not solid but represented by 7 to 12 parallel running strands arising from the base which ultimately reduce to 2 or 3 strands near the apex. Each strand runs parallel for 3 to 4 mm distance and then bifurcate at an acute angle to form secondary veins which arch out in the lamina. The secondary veins further dichotomize and anastomose to form open, broad, elongate, oblong, polygonal meshes measuring 3 to 4 mm long and 0·5 to 1·0 mm broad near the midrib but relatively shorter meshes, measuring 1 to 2 mm long and 0·5 mm broad near the margin. The density of veins is 10-12 per cm near the midrib and 20-25 per cm near the margin.

Comparison — *G. churiensis* sp. nov. compares in its shape and venation pattern with *G. browniana* Brongniart but differs in the midrib character. In the former there is no solid midrib, the region being occupied by the parallel running strands which in due course bifurcate to form secondary veins whereas in the latter there is a distinct solid midrib persistent throughout the length with striations. In its midrib character *G. churiensis* sp. nov. resembles *G. fusa* Kulkarni (1971), *G. fibrosa* Pant (1958), *G. hispida* Pant (1958) and *G. colpodes* Pant (1958) but differs in



TEXT-FIG. 9 — A. *Glossopteris churiensis* sp. nov., enlarged line drawing of a part of the leaf represented on Pl. 2, fig. 8 × 3. B. Idealised diagram of *Glossopteris churiensis*.

having fairly open, broad, oblong, polygonal meshes throughout the leaf.

Such types of *Glossopteris* leaves where the midrib region is occupied by parallel running strands may easily be confused with the leaves of *Gangamopteris*. But closer examination indicates that in *Glossopteris* the longitudinal strands never anastomose whereas in the latter the strands in the median portion always anastomose. Pant and Gupta (1968) also support this view on the basis of their own morphological and cuticular evidences.

Glossopteris communis Feistmantel, 1876

Pl. 1, fig. 7

Description — The leaves from the Barakar Stage are incomplete, 5·5 to 8·0 cm long and 4 to 5 cm broad. The apex and base are not preserved; margin entire. The midrib is 1·5 to 2 mm broad, raised and grooved. The secondary veins arise at an acute angle. They are arched and after dichotomy and anastomoses form long, linear, narrow meshes. The meshes are 3 to 5 mm long and 0·3 to 0·5 mm broad. The density of veins is 20 to 25 per cm throughout the lamina.

Remarks — The species will be dealt in detail in the later paper where the described leaves are well preserved and possess detail nature of shape and venation pattern.

Glossopteris browniana Brongniart, 1828

Pl. 2, fig. 12

Description — The leaves of the Barakar Stage are complete, spathulate in shape,

4 to 6·5 cm long and 2·2 to 3·5 cm broad. The apex is obtuse, the base is contracted and the margin is entire. The midrib is distinct, 1 to 2 mm broad. The secondary veins arise at an angle of 45°. They dichotomize and anastomose to form broad, open hexagonal, square shaped meshes. The meshes are 2 to 4 mm long and 0·5 to 1 mm broad. The density of veins is 12 to 15 per cm throughout the leaf.

Remarks — The species will be discussed in subsequent paper where the leaves are more in number and sho v much variation

Genus — *Vertebraria* Royle, 1833

Vertebraria indica Royle, 1833

Pl. 2, fig. 13

Description — The specimens are incomplete, branched, 6 to 8·5 cm long and 1·5 to 2·5 cm broad, consisting nearly square areas in two linear rows which are separated by 1 to 1·5 mm ridge. The areas are transversely separated by 3 to 4 mm broad grooves.

2. Mioflora

The following 53 species and 31 genera have been recorded from the Barakar assemblages of the Auranga Coalfield. Species marked with an asterisk have been described:

1. *Punctatisporites indicus* Tiwari, 1968.
2. *Cyclobaculisporites proprius* Bharadwaj & Salujha, 1965.
3. *Acanthotriletes jhariaensis* Kar, 1968.
4. *Lophotriletes rectus* Bharadwaj & Salujha, 1964.
5. *Granulatisporites* sp. cf. *G. trisinus* Balme & Hennelly, 1965.

*6. *Lacinitriletes conatus* sp. nov.

7. *L. badamensis* Venkatachala & Kar, 1965.
8. *L. minutus* Venkatachala & Kar, 1968.
9. *Brevitriletes unicus* (Tiwari) Bharadwaj & Srivastava, 1969.
10. *B. levis* (Balme & Hennelly) Bharadwaj & Srivastava, 1969.

*11. *Dictyotriletes* sp.

12. *Laevigatosporites punctatus* Venkatachala & Kar, 1968.
13. *Latosporites colliensis* (Balme & Hennelly) Bharadwaj, 1962.
14. *Punctatosporites dulcis* Venkatachala & Kar, 1968.
15. *Kagulubeites verrucosus* Bose & Maheshwari, 1968.
16. *Densipollenites indicus* Bharadwaj, 1962.
17. *D. invisus* Bharadwaj & Salujha, 1964.

*18. *Potonieisporites* sp.

19. *Faunipollenites varius* Bharadwaj, 1962.
20. *F. parvus* Tiwari, 1965.
21. *F. perexiguus* Bharadwaj & Salujha, 1965.
22. *F. goraiensis* (Potonié & Lele) Maithy, 1965.
23. *Striatites alius* Venkatachala & Kar, 1968.
24. *S. karharbarensis* Maithy, 1965.
25. *S. rhombicus* Bharadwaj & Salujha, 1964.
26. *S. varius* Kar, 1968.
27. *S. notus* Bharadwaj & Salujha, 1964.
28. *S. communis* Bharadwaj & Salujha, 1964.
29. *S. subtilis* Bharadwaj & Salujha, 1964.
30. *S. parvus* Tiwari, 1965.
31. *S. barakarensis* Sinha, 1972.
32. *Lahirites parvus* Bharadwaj & Salujha, 1964.
33. *L. rotundus* Bharadwaj & Salujha, 1964.
34. *Verticipollenites gibbosus* Bharadwaj, 1962.
35. *V. finitinus* Bharadwaj & Salujha, 1964.
36. *V. subcircularis* Bharadwaj & Salujha, 1964.
37. *Crescentipollenites fuscus* (Bharadwaj) Bharadwaj, Tiwari & Kar, 1974.
38. *C. brevis* (Bose & Kar) Bharadwaj, Tiwari & Kar, 1974.
39. *Corisaccites vanus* Venkatachala & Kar, 1966.
40. *Distriatites indicus* Sinha, 1972.
41. *D. distinctus* Sinha, 1972.
42. *Mahudapollenites wilsonii* Bandyopadhyay, 1972.
43. *Schizuringipollenites tentulus* (Tiwari) Tiwari, 1973.
44. *Limitisporites plicatus* Bose & Kar, 1966.
45. *L. diversus* Lele & Karim, 1971.
46. *Primuspollenites obscurus* Tiwari, 1965.

*47. *Aurangapollenites gurturiensis* gen. et sp. nov.

48. *Platysaccus densus* Kar, 1968.

*49. *Cuneatisporites* sp.

50. *Striasulcites tectus* Venkatachala & Kar, 1968.
51. *S. ovatus* Venkatachala & Kar, 1968.
52. *Distriamonocolpites circularis* Sinha, 1972.
53. *Kingiacolpites subcircularis* Tiwari & Moiz, 1971.

Anteturma — *Sporites* Potonié, 1893
Turma — *Triletes* (Reinsch) Potonié & Kremp, 1954
Subturma — *Azonotriletes* Luber, 1935
Infraturma — *Apiculati* (Bennie & Kidston) Potonié & Kremp, 1954
Subinfraturma — *Varitrileti* Venkatachala & Kar, 1965

Genus — *Lacinitriletes* Venkatachala & Kar, 1965

Lacinitriletes conatus sp. nov.

Pl. 3, figs. 16-17; Text-fig. 10A-C

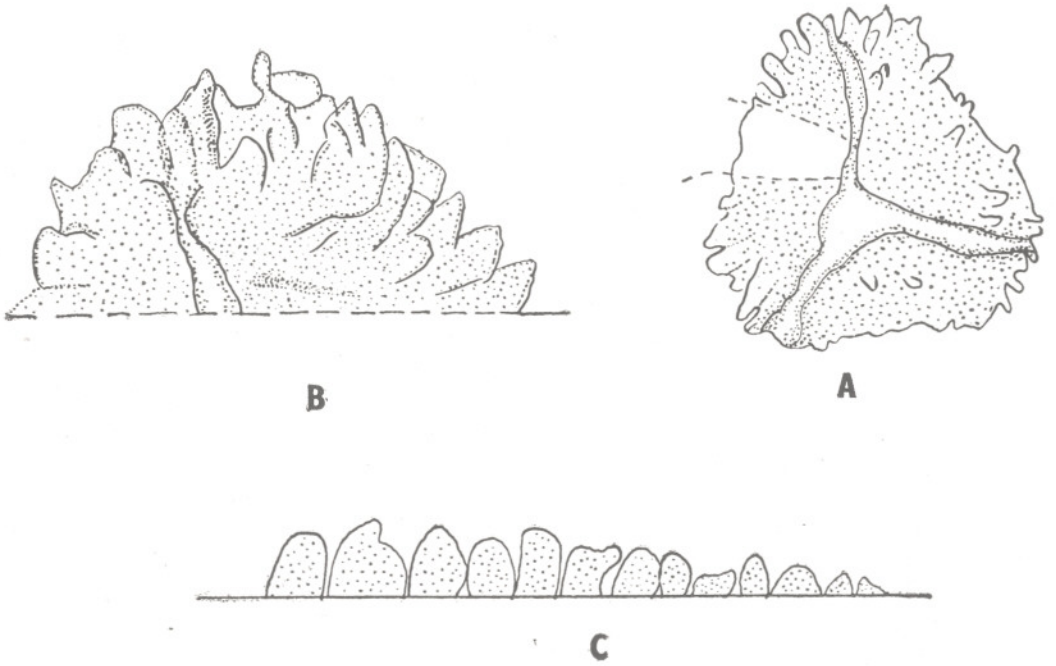
Holotype — Pl. 3, fig. 16; Slide no. 4993.
Type Locality — Sukri River Section, near Gurtur Village, Auranga Coalfield, Bihar.

Horizon & Age — Barakar Stage, Lower Permian.

Diagnosis — Spore size range 37-53 × 33-53 μ, amb triangular to subtriangular, sides ± straight, angles rounded, trilete rays distinct, reaching equator, associated with elevated folds. Exine 1 μ thick, proximally smooth, distally bears 1 μ high and 2 μ broad cones with occasionally, verrucae, elements tending to fuse and larger along the radial portion. Folds uncommon.

Description — The mark appears thick due to elevated folds. However, these folds are not consistently devleoped. The distal ornament is dominated by coni with occasional verrucae. The bases of elements often tend to fuse forming small ridges. Also, the ornament is comparatively larger and more prominently developed in radial portions, while the interradial margins have reduced sculpture or are sculptureless.

Comparison — *Lacinitriletes conatus* sp. nov. differs from *L. badamensis* Venkatachala & Kar (1965) and *L. minutus* Venkatachala & Kar (1968a) in the presence of grana/or/and verrucae respectively on distal



TEXT-FIG. 10 — A. *Lacinitriletes conatus* sp. nov., line drawing of the holotype showing trilete mark. and ornamentation × 950. B. Showing the large number of ornamentation on radial portion × 2,500 C. Showing the nature of ornamentation × 2,500.

side. The present species is distinct in having conate elements on distal side.

Infraturma — *Murornati* Potonié & Kremp, 1954

Genus — *Dictyotriletes* (Naumova) Smith & Butterworth, 1967

Dictyotriletes sp.

Pl. 3, fig. 18

Description — Spore size 67×55 μ, amb subtriangular, sides ± straight, angles rounded. Exine 3 μ thick, reticulate with large lamina. Muri 2-2·5 μ, extend 5-6 μ beyond the body, about 17 muri along the equator. Size of lumina is 5×7-10 μ. The high muri cover the entire spore body with the exception of the contact area where are absent (or reduced) in height. Exine of lumina granulose. Trilete rays not distinct.

Comparison — In its shape and structure the specimen compares with *D. muricatus* (Kosanke) Smith & Butterworth (1967) but differs from it in being comparatively smaller in size and the projection of muri beyond the body is less.

Anteturma — *Pollenites* Potonié, 1931
Turma — *Saccites* Erdtman, 1947
Subturma — *Monosaccites* (Chitaley) Potonié & Kremp, 1954
Infraturma — *Monopolsacciti* Hart, 1965 emend. Dibner, 1971
Subinfraturma — *Proximalsaccini* Dibner, 1971

Genus — *Potonieisporites* (Bhardwaj) Bharadwaj, 1964

Potonieisporites sp.

Pl. 3, fig. 19

Description — Size range 80-150×57-170 μ, monosaccate, 40-45×50-55 μ, monolete mark not very distinct, body attachment infold present.

Remarks — The specimens are rare. They compare with *P. novicus* Bhardwaj in the uniform width of the saccus around the body but *P. novicus* is generally larger in size.

Subturma — *Disaccites* Cookson, 1947
Infraturma — *Podocarpoiditi* Potonié, Thomson & Thiergart, 1950

Genus — *Aurangapollenites* gen. nov.

Type Species — *Aurangapollenites gurturiensis* sp. nov.

Generic Diagnosis — Disaccate, bilateral pollen grains, circular to subcircular, sometimes oval in shape; central body proximally intramicropunctate to intramicroreticulate, distally smooth; sacci laterally separated, distally inclined and attached to body. Distal roots of sacci pitcher-shaped with a narrow to broad neck (Text-fig. 11B). Sacci attachment zones straight to convex and chorter than vertical diameter of central body.

Generic Description — The grains are diploxylonoid with a clear central body. The exine is thin, translucent, without any striations, grooves or haptotypic mark. Sacci are nearly subcircular and widely or narrowly separated laterally. Distally the sacci are somewhat constricted near attachment to form a pitcher-shaped neck. The sulcus is narrow and generally shorter than the width of the body. Saccus structure is fine to medium intrareticulate.

Comparison — The present genus differs from all the known nonstriate, disaccate bilateral grains in possessing a characteristic pitcher-shaped saccus. Similar saccus attachment is found in *Verticipollenites* Bharadwaj (1962) and *Hindipollenites* Bharadwaj, (1962) but both the genera possess striations over the body.

Aurangapollenites gen. nov. resembles, *Platysaccus brevizonatus* described by Tiwari (1968, pl. 8, fig. 58) in its pitcher-shaped saccus attachment but differs in its large size (115-130 μ) and in the possession of a narrow equatorial rim around the central body.

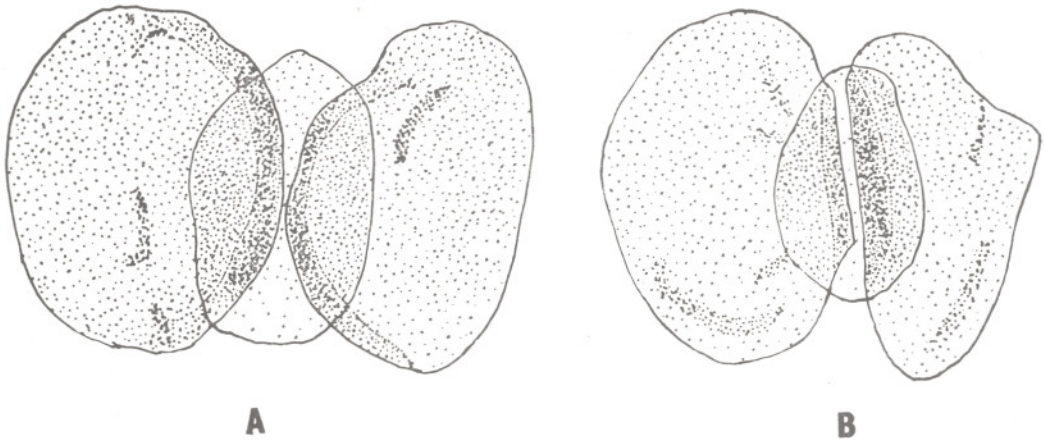
Aurangapollenites gurturiensis sp. nov.

Pl. 3, figs. 21, 22; Text-fig. 11A-B

Holotype — Pl. 3, fig. 21; Slide no. 4993.

Type Locality — Sukri River Section, near Gurtur Village, Auranga Coalfield, Bihar.

Horizon & Age — Barakar Stage; Lower Permian.



TEXT-FIG. 11 — A. *Aurangapollenites gurturiensis* gen. et sp. nov., line drawing of the holotype showing non-striate central body and pitcher shaped saccus attachment × 950. B. Line drawing of the specimen other than holotype × 950.

Diagnosis — Size range 58-98×21-58 μ, central body 25-34×25-30 μ, circular-oval; exine thin, intramicropunctate; sacci pitcher-shaped near the distal roots; sulcus narrow, 2-6 μ wide.

Description — Disaccate, bilateral, diploxylonoid; body sometimes intramicroreticulate; sacci hemispherical, sacci 4 to 7 μ wide, narrowing near distal roots, distally coming very close; sulcus straight sometimes biconcave, narrow; sacci intrareticulation fine to medium.

Genus — *Cuneatisporites* Leschik, 1954

Cuneatisporites sp.

Pl. 3, fig. 20

Description — Size range 130-140×70-75 μ, disaccate, diploxylonoid, body 65-70×65-67 μ, circular to subcircular, exine thin, fine intramicroreticulate, sulcus straight 24-28 μ wide, zones of saccus attachment full, accompanied by thin narrow folds, sacci subspherical, laterally notched, intrareticulation fine.

Comparison — The specimens compare with *Cuneatisporites* sp. B (Tiwari, 1965; pl. 8, figs. 184, 185) but in the latter the distal sulcus is broad (40-50 μ) and distinctly convex. Due to lack of sufficient number of specimens no specific name has been given.

COMPARISON AND DISCUSSION

The megaflora of the Churia fireclay pit is dominated by the narrow mesh species of *Glossopteris*, viz., *G. indica, G. communis, G. leptoneura, G.* sp. cf. *G. intermittens, G. barakarensis, G. fuchsii* and *G. pandurata*. The open mesh species like *G. conspicua, G.* sp. cf. *G. ampla, G. browniana* and *G. churiensis* are less frequent.

Recently Maithy (1974a, b) has shown that the narrow mesh forms of *Glossopteris* are dominant constituent of the Barakar flora, and this criteria can, therefore, be widely used in identifying the Barakar Stage. Maithy's (1971) earlier collections from the Barakar of the Auranga Coalfield also support this contention. The present detailed study of the Barakar flora demonstrates that there are 7 narrow mesh *Glossopteris* as against 4 open mesh ones. Hence, this assemblage can well be considered equivalent to the Barakar flora.

The miospore assemblage is dominated by the striate-disaccates and triletes. The following striate-disaccate genera are quantitatively important (67-80%): *Faunipollenites, Striatites* and *Lahirites*. Amongst triletes (15-12%), *Brevitriletes* and *Lacinitriletes* are important genera.

The following genera are quantitatively few (1-5%): *Verticipollenites, Distriatites, Leiotriletes, Granulatisporites, Lophotriletes,*

Punctatisporites, Latosporites, Crescentipollenites, Limitisporites, Kagulubeites and *Distriamonocolpites.*

The following genera are rare (0·00%): *Laevigatosporites, Punctatosporites, Cyclobaculisporites, Dictyotriletes, Microbaculispora, Densipollenites, Potonieisporites, Hamiapollenites, Limitisporites, Cuneatisporites, Corisaccites, Aurangapollenites, Platysaccus, Mahudapollenites, Scheuringipollenites, Striasulcites* and *Kingiacolpites.*

The present assemblages, dominated by striate-disaccates, viz., *Faunipollenites, Striatites, Lahirites* etc. compare well with the upper Barakar assemblage of the Barakar type area (Tinari, 1973) and of the North Karanpura Basin (Kar, 1973). The significant amount of triletes in Auranga Basin may be due to some local variations in the flora (space varients of Tiwari, 1974).

It may be concluded that the megaflora from the Churia fireclay pit locality as well as the mioflora from the Sukri River section (near Gurtur locality) are assignable to a Barakar age. The results are in conformity with the geological work of Rizvi (1972).

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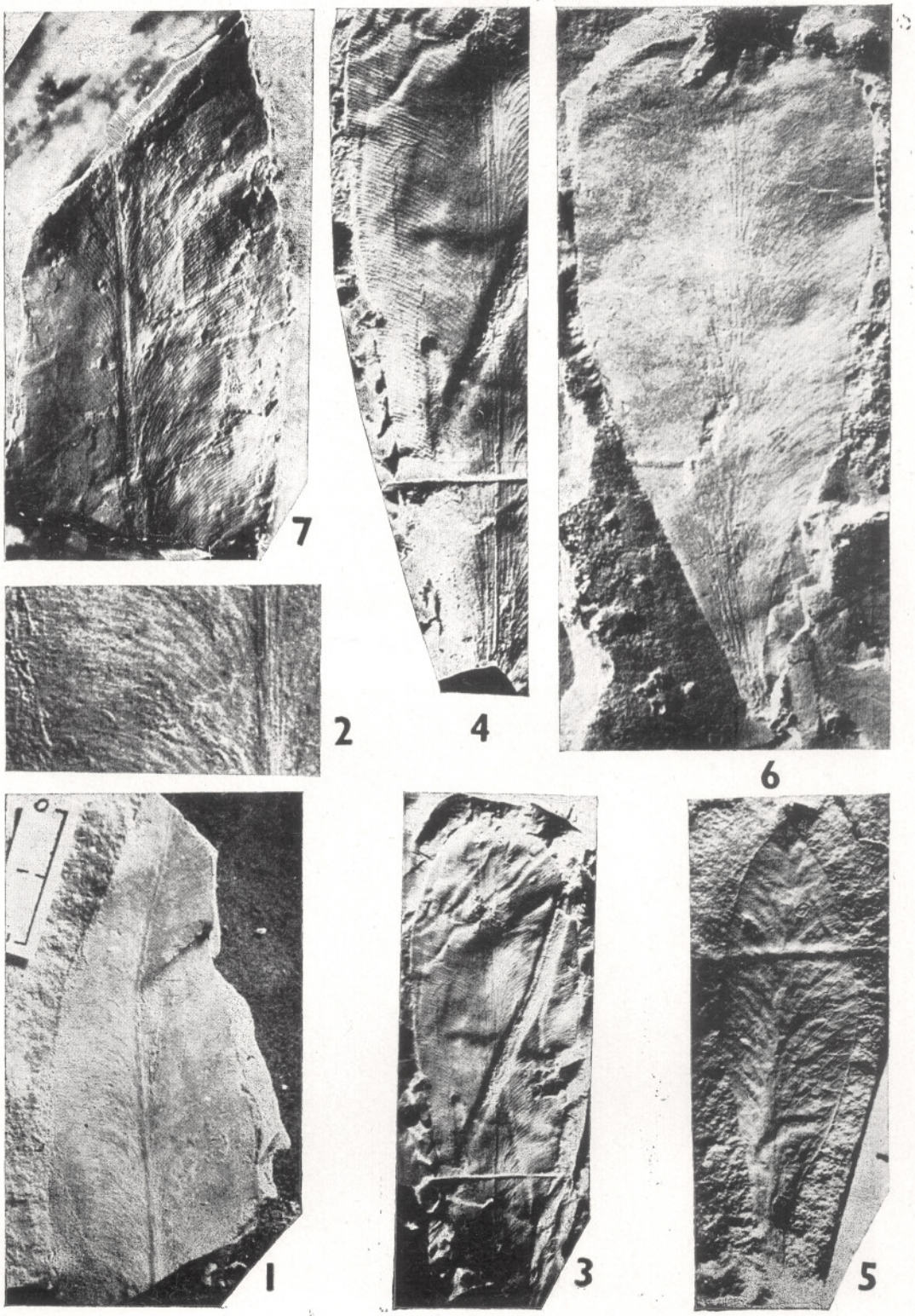
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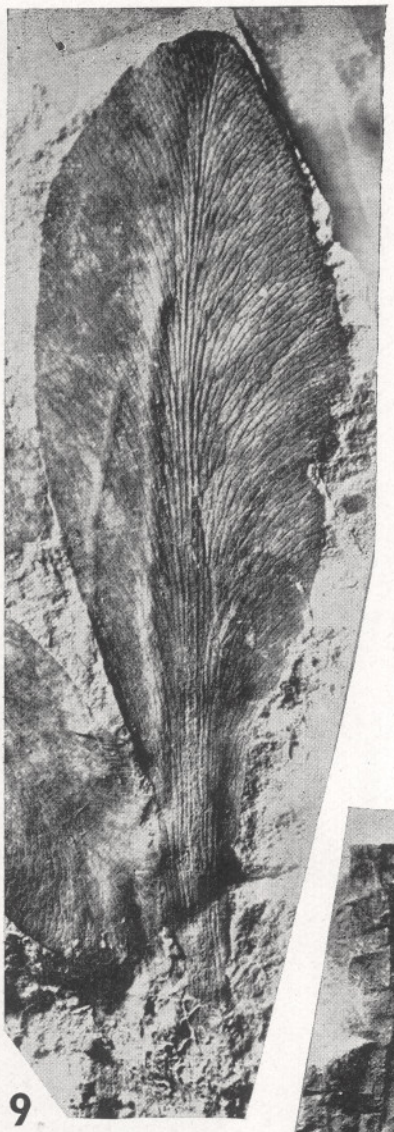

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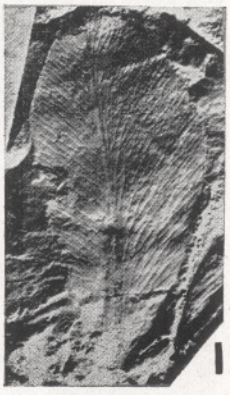

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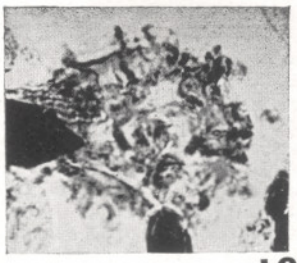

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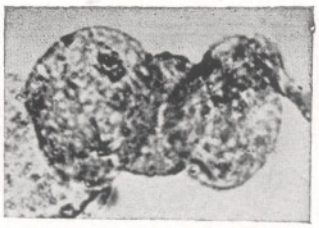

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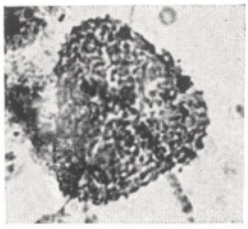

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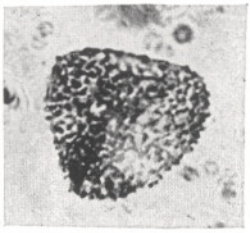

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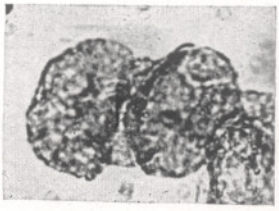

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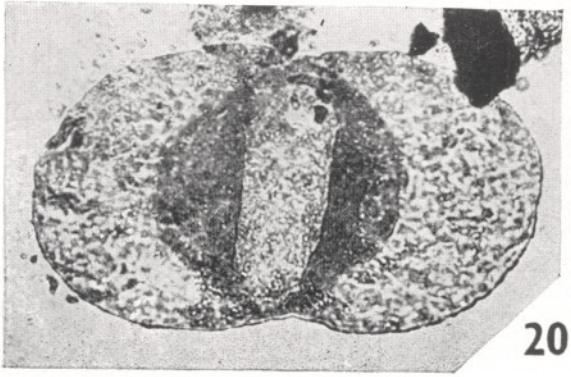

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EXPLANATION OF PLATES

Plate 1

1. *Glossopteris indica* Schimper showing middle portion of a leaf. Specimen no. 93/1311. × Nat. Size.

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

3. *Glossopteris* sp. cf. *G. intermittens* Feistmantel showing striated midrib. Specimen no. 41/1391. × Nat. Size.

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

5. *Glossopteris conspicua* Feistmantel showing a complete leaf. Specimen no. 6/1311. × 2.

6. *Glossopteris pandurata* Pant & Gupta showing a leaf with pandurate apex. Specimen no. 12/1598. × 2.

7. *Glossopteris communis* Feistmantel showing median portion of a leaf. Specimen no. 32/1392. × Nat. Size.

Plate 2

8. *Glossopteris churiensis* sp. nov. Holotype showing two complete leaves with obtuse apex and contracted base. Specimen no. 27/1392 × Nat. Size.

9. A leaf in fig. 8 enlarged to show the venation details. × .2.

10. *Glossopteris leptoneura* Bunbury showing upper part of a leaf with acute apex. Specimen no. 3/1392. × Nat. Size.

11. *Glossopteris barakarensis* Kulkarni showing acute apex and contracted base. Specimen no. 51/1392. × Nat. Size.

12. *Glossopteris browniana* Brongniart a small leaf with obtuse apex and distinct midrib. Specimen no. 54/1392. × 2.

13. *Vertebraria indica* Royle. Specimen no. 1/1398. × Nat. Size.

Plate 3

14. *Glossopteris fuchsii* Plumstead showing one half of lamina with a distinct midrib. Specimen no. 37/1392. × Nat. Size.

15. *Glossopteris* sp. cf. *G. ampla* Dana showing a lower part of a leaf. Specimen no. 39/1392. × Nat. Size.

16. *Lacinitriletes conatus* sp. nov. holotype. Slide no. 4993. × 500.

17. *L. conatus* sp. nov. Slide no. 4993. × 500.

18. *Dictyotriletes* sp. Slide no. 4993. × 500.

19. *Potonieisporites* sp. Slide no. 4996. × 500.

20. *Cuneatisporites* sp. Slide no. 5000. × 500.

21. *Aurangapollenites gurturiensis* gen. et sp. nov. holotype. Slide no. 4993. × 500.

22-23. *A. gurturiensis* gen. et sp. nov. Slide no. 4993. × 500.