

FOSSIL PLANTS FROM THE KAMTHI FORMATION OF MAHARASHTRA AND THEIR BIOSTRATIGRAPHIC SIGNIFICANCE

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ABSTRACT

Megafossils from the Kamthi beds of Kanhargaon, Chandrapur District and Bazargaon, Nagpur District of Maharashtra, have been described. From Kanhargaon 5 genera and 19 species belonging to pteridophytes and Glossopteridales are recorded, of which 2 species of *Glossopteris* are new. From Bazargaon 3 genera with 5 species are described. All the fossils are preserved in the form of impressions. The biostratigraphic importance of Kamthi megafloora has also been discussed by correlating it with the homotaxial floral assemblages of Raniganj and the similar looking lithological formations of Handappa area in Orissa and the Triassic megafloora.

Key-words — Megafossils, Biostratigraphy *Glossopteris*, Kamthi Formation, Upper Permian (India).

सारांश

महाराष्ट्र के कामथी शैल-समूह के पादपाश्र्व तथा इनका जीवस्तरीकीय महत्व - शैला चन्द्रा एवं माजेटी नरसिंह वर प्रसाद

महाराष्ट्र के चन्द्रपुर जनपद में कनहरगाँव एवं नागपुर जनपद में बजरगाँव के कामथी संस्तरों से गुरुपादपाश्र्व वर्णित किये गये हैं। कनहरगाँव से टेरिडोफ़ाइट एवं ग्लॉसॉप्टेरिडेल्स से संबंधित 5 वंश एवं 19 जातियाँ अभिलिखित की गई हैं जिनमें से ग्लॉसॉप्टेरिस की दो जातियाँ नई हैं। बजरगाँव से 3 वंशों की 5 जातियाँ वर्णित की गई हैं। सभी पादपाश्र्व छापों के रूप में परिरक्षित हैं। कामथी गुरुवनस्पतिजात को रानीगंज के एवं उड़ीसा में हंडप्पा क्षेत्र के उसी प्रकार के शैल-समूहों के समकालक्री वनस्पतिजातीय समुच्चयों से तथा ट्रायैसिक गुरुवनस्पतिजात से सहसंबद्ध करते हुए उनका जीवस्तरीकीय महत्व भी विवेचित किया गया है।

INTRODUCTION

THE name 'Kamthi' was first coined by Blanford (in Hughes, 1877), after a military station of 'Kamptee', 12 mile from Nagpur in north-east direction. This formation is exposed extensively in Wardha-Godavari Valley in Maharashtra and Andhra Pradesh. Towards the south-east coast of Andhra Pradesh, near Eluru in West Godavari District, this formation is known as Chintalpudi sandstones (from this place Varma, 1962 described 2 types of Glossopteridalean fructifications) and Dummapet sandstones.

Bunbury (1861) and Feistmantel (1881) described some fossil plants from this formation near Nagpur area, but they were not adequately illustrated. Bunbury (1861) established 3 new species of *Glossopteris*,

viz., *Glossopteris musaeifolia*, *G. stricta* and *G. leptoneura*. The type specimens of these 3 species are kept at the Museum of Geological Survey Society, London.

There is a controversy regarding the age and the stratigraphic position of the Kamthi Formation. From the studies of Bunbury (1861), Oldham (1880) and Feistmantel (1881), the Kamthi Formation appears to be related to the Damuda and of the Lower Gondwana age. King (1881) established the Gondwana system for Pranhita-Godavari Valley as follows:

Upper Gondwana	{ Chikiala sandstones Kota beds Maleri beds
Lower Gondwana	{ Kamthi sandstones Barakar sandstones Talchir beds

Thus he placed the Kamthis at the top in the Lower Gondwana sequence. Das Gupta (1915) also felt that the Kamthi beds are at the top of the Raniganj Series. Cotter (1917) in his revised classification of Gondwana System showed that the Kamthis are equivalent to Raniganj Series on the basis of floral composition. Fox (1931) also placed the Kamthi Formation just above the Raniganj Formation in the general classification of Gondwana Strata of India.

Recently Acharyya, Raha and Singh (in Sastry *et al.*, 1977) stated that the floral assemblage of the Kamthi Formation is similar to that of the Raniganj Formation. Hence, they assigned Upper Permian age to the Kamthi beds. Mangli beds, which have similar lithology like the Kamthis, yielded estherids and vertebrate fauna of Panchet affinity (Lower Triassic). But the typical Triassic fossil plants are not known from this formation. Tasch *et al.* (1975) assigned the Upper Permian age to this formation which has yielded estherids associated with *Glossopteris* Flora. Thus they tentatively assigned the age of the Kamthi rocks in between the Upper Permian and the Lower Triassic. However, Vagyani and Mahabale (1974) are of the opinion that the Kamthi beds are Lower Triassic in age.

MATERIAL AND METHODS

The present material was collected from Kanhargaon Village, Chandrapur District (Map 1) and Bazargaon, Nagpur District (Map 2) of Maharashtra. From Kanhargaon Village megafossil impressions and some petrified gymnospermous woods were collected from a deforested jungle on a hillock. The plant fossils are in the form of impressions on hard, compact ferruginous sandstones which exhibit almost different textures and shades of colour. Bazargaon impressions are found in a metal stone quarry by the side of Nagpur-Amravati road on buff, purple and grey coloured coarse sandstones.

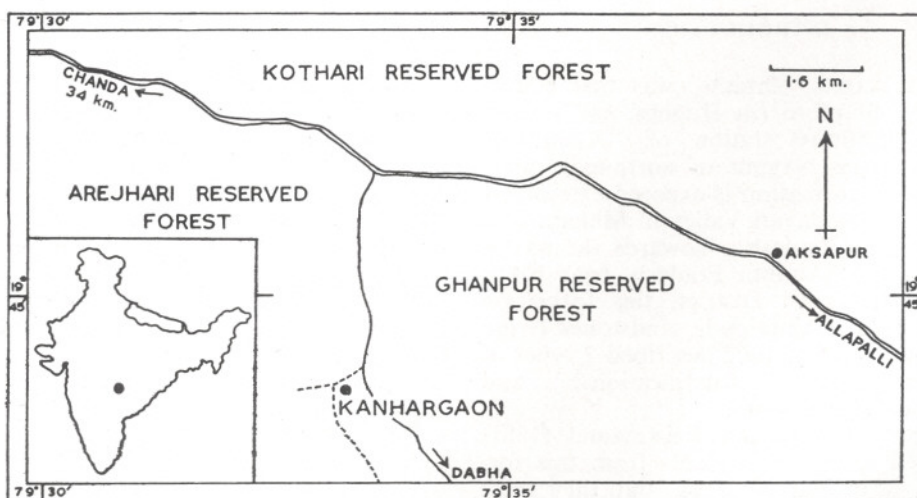
MEGAFLORA FROM KANHARGAON

Genus—*Neomariopteris* Maithy emend. 1975

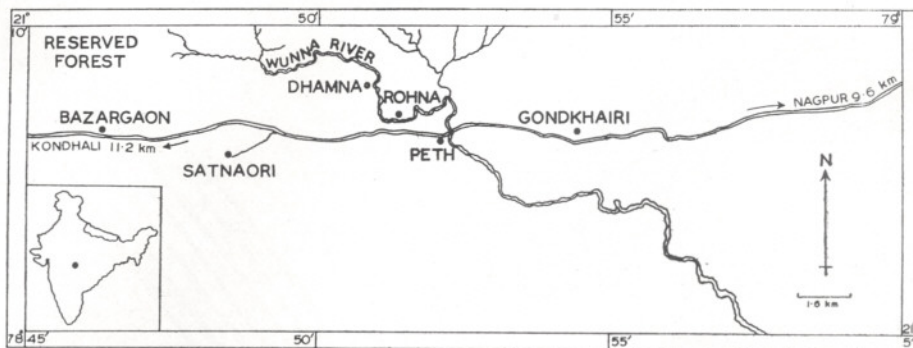
Neomariopteris hughesi (Feistmantel)
Maithy, 1974a

Pl. 1, fig. 1

Description— There are only two fragments in the collection. The figured frond is 8 cm long, compound and bipinnate. Primary rachis is winged and 1 mm broad.



MAP 1



MAP 2

The secondary rachis, arising from the primary rachis alternately at an angle of 40° - 50° , is up to 4 cm long. The rachis ends in a terminal pinnule and so it is imparipinnate compound leaf. The pinnae on the secondary rachis are up to 12 in number, emerging at an angle of 45° . Each pinna has 5-6 pairs of pinnules, \pm lanceolate in shape with decurrent bases, showing typical sphenopteroid venation pattern. Margin of the pinnules is slightly crenulate.

Comparison—The fronds are identical in every respect with the specimens of Feistmantel (1882, pl. 12, fig. 3), Maithy (1974a, pl. 2, fig. 7) and Srivastava (1977, pl. 2, figs 7, 8) and therefore placed under *Neomariopteris hughesi*.

Genus — *Trizygia* Royle, 1839

***Trizygia speciosa* Royle, 1839**

Pl. 3, fig. 23

Description—A single specimen with 7 whorls of attached leaves and a few detached whorls are preserved on the same slab. The stem is slender and articulate, 1-1.5 cm broad with swollen nodes, placed at an interval of 1.2-1.4 cm. Each whorl consists of 6 leaves of which 2 pairs are more or less equal in size, whereas the third pair is smaller in size and compressed towards the axis side. The larger leaves are 1.3-1.8 cm long and 8 mm broad at its broadest region. The leaves are ovate-

cuneate in shape with entire margins. The smaller leaves are 1.1 cm long and 4 mm broad. Each leaf shows 2-3 dichotomously branched veins.

Remarks—The specimen has been identified as *Trizygia speciosa* Royle by its characteristic mode of attachment of leaves to the axis and in having 3 unequal pairs of leaves at each node.

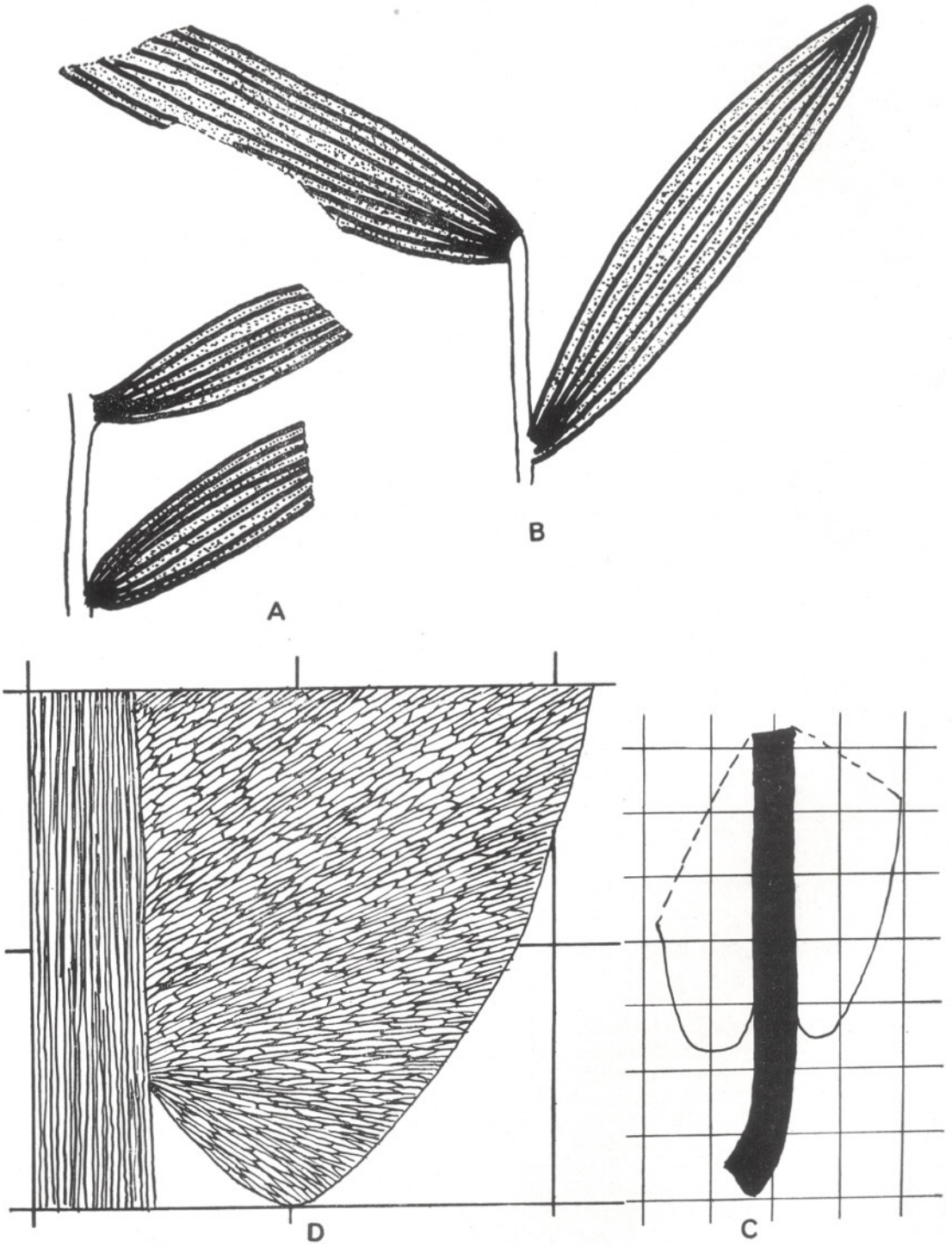
Genus — *Schizoneura* Schimper & Mougeot

***Schizoneura gondwanensis* Feistmantel, 1876**

Text-fig. 1A

Description—The collection includes a few fragmentary leaf sheaths of *Schizoneura*. Only one specimen shows 3 opposite leaf sheaths attached to the axis. Leaf sheath is \pm 1.5 cm wide at its widest part. Eight to nine veins in each leaf sheath, run parallel to each other and converge at the apex. Stem is 3 mm wide, internodes are \pm 2.2 cm in length.

From Bazargaon we collected only one well-preserved specimen of this species. However, several detached leaf sheaths are also noticed. The figured specimen (Pl. 4, fig. 30; Text-fig. 1B) has 3 leaf sheaths attached to an axis and they vary from 7 mm to 3 cm in breadth at its widest part. Seven to nine veins enter the base and run parallel to each other, converging at the apex. Axis 2-3 mm wide, showing ridges and furrows. The internodes are 3.5 cm in length.



TEXT-FIG. 1

Genus — *Vertebraria* Royle*Vertebraria indica* Royle, 1833

Description — The specimen of *Vertebraria* measures 10 cm in length and 1.4 cm in breadth, consisting of rectangular areas, arranged in 21 rows and separated by longitudinal grooves. The rectangular areas are separated by transverse grooves.

Comparison — The specimen is identical to the photograph of *Vertebraria indica* Royle (1833, pl. 2, fig. 1) Feistmantel (1880, pl. 13, fig. 3; pl. 14, figs 1, 2), Arber (1905, pl. 4, figs 2, 3) and Srivastava (1977, pl. 1, fig. 6).

EQUISETALEAN STEM

Description — There are many fragmentary impressions of equisetalean stems in the collection. The stems are devoid of leaves or leaf sheaths and may belong to *Schizoneura* since it is the only member of equisetalean group present in the collection.

Genus — *Glossopteris* Brongniart*Glossopteris musaefolia* Bunbury, 1861

Pl. 2, figs 13, 14; Text-fig. 3N, O

Description — There are 2 incomplete leaf impressions in the collection. The basal part of the described leaf is not preserved. The shape appears to be narrow oblong with obtuse apex. Length is 24 cm (approximately), width 6 cm, and length/width ratio is 4:1. The midrib is strong, distinct, striated, 3-4 mm wide running right up to the apex. Secondary veins slightly arch near the midrib and then run perpendicular to the midrib and the margin. The meshes are very narrow, linear and equal in size throughout the lamina.

Comparison — Our specimen at a glance looks like *G. mohudaensis* Chandra & Surange (1979) and *G. raniganjensis* Chandra & Surange (1979) as they are all big leaves. However, *G. mohudaensis* differs from our specimen in having *taeniopteroid* venation and *G. raniganjensis* in its characteristic shape with dense, *communis* type of venation.

Though superficially *G. musaefolia* and the Australian species, *G. ampla*, look very much alike, their close examination reveals certain differences as mentioned earlier. Keeping in view that the two species come from two different continents and from different geological horizons, it would therefore be safe to recognize them as two different species. The fructifications of the two leaves will no doubt solve this riddle.

We recognized this species from Bazar-gaon locality also. There are two specimens of this species in the collection. The figured leaf (Pl. 4, fig. 34) shows only middle region. It is 5.8 cm wide at its widest region. The midrib is very strong and striated. The secondary veins, after a gentle arch, run perpendicular to the midrib and margin. The meshes formed by the secondary veins are narrow, linear and several times longer than their breadth.

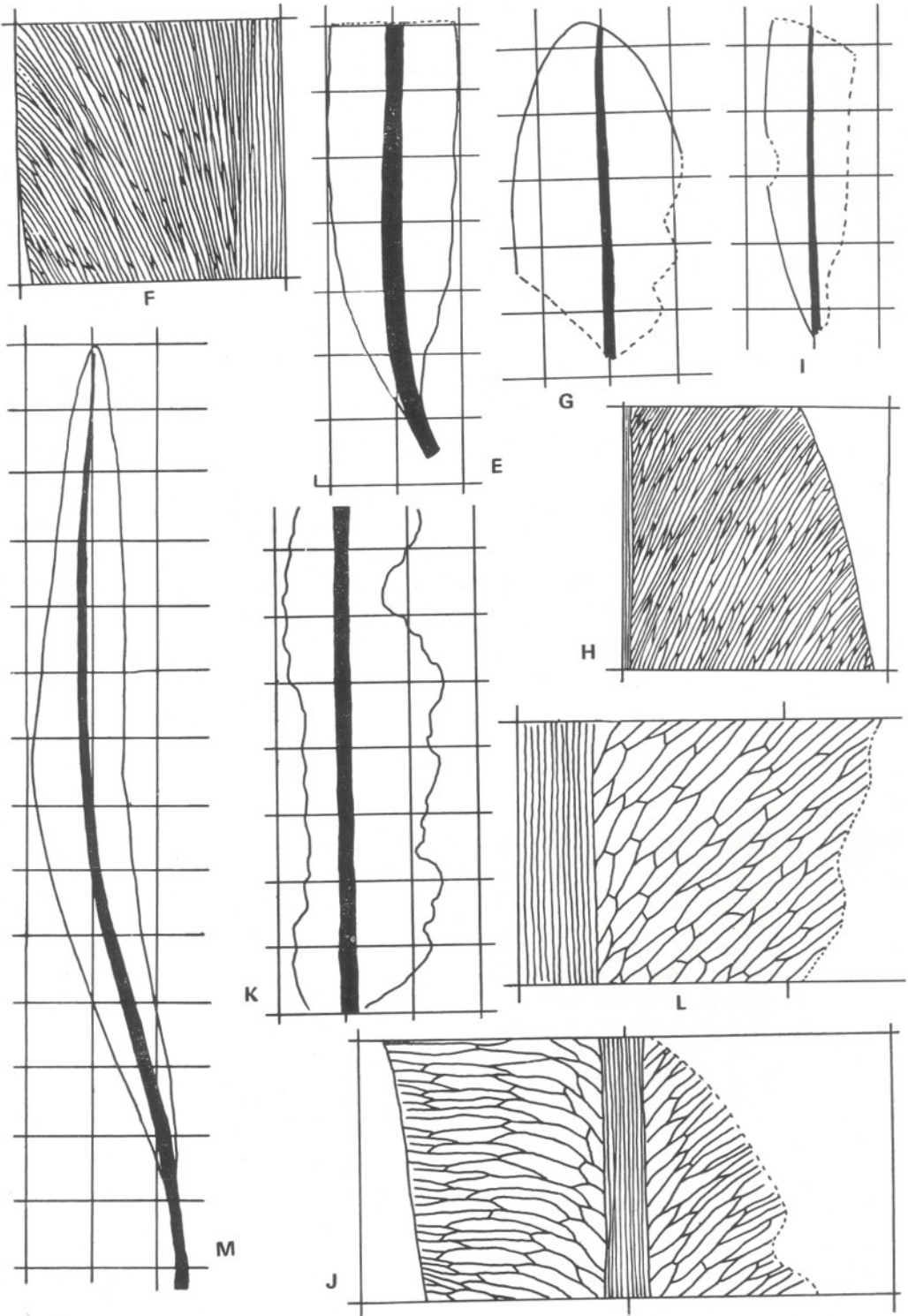
Remarks — Since Bunbury's (1861) type specimen is not available in India, we could not compare our specimens with the type specimen. However, on the basis of Bunbury's description (Bunbury, 1861, pp. 329-330) and outline pencil drawing of the type specimen we have no doubt that our leaves are referable to *G. musaefolia* which incidentally also comes from the same formation.

Glossopteris stricta Bunbury, 1861

Pl. 1, figs 2, 3; Text-fig. 2I, J

Description — There are 2 incomplete leaves in our collection. The figured leaf

TEXT-FIG. 1 — A, B. *Schizoneura gondwanensis* Feistmantel showing the leaf sheaths attached to an axis $\times 1$. C. *Glossopteris* sp. 1 showing the basal part of the leaf with auriculate base $\times 1$. D. A portion of the leaf in fig. C enlarged to show the venation pattern and the auriculate base on one side of the midrib $\times 4$.



TEXT-FIG. 2

with its preserved basal portion is 2.5 cm wide. Midrib is narrow. The secondary veins slightly arch near the midrib, otherwise run perpendicular to the margin. The meshes near the midrib are broader, gradually becoming narrow towards the margin.

Remarks — Our specimens resemble the sketch and description of *G. stricta* Bunbury. Furthermore, the described specimen also resembles Feistmantel's *G. stricta* described from the Kamthi sandstones of Wardha-Godavari Valley near Isapur and Silewada. This specimen is the basal portion of a leaf whereas Feistmantel's specimen appears to represent the apical part. We have, therefore, placed our specimens in *G. stricta* on the basis of venation pattern.

Glossopteris leptoneura Bunbury, 1861

Pl. 2, figs 15, 16; Text-figs 2M, 4X

Description — There are 10 incomplete specimens in the collection. The figured leaf is complete with a petiole. Shape is very narrow elliptic, length 13.5 cm, width 1.2 cm and length/width ratio 12:1. The base is acute, cuneate and the apex is attenuate. Midrib is distinct, gradually tapering, persistent up to the apex. The secondary veins arise at an angle of 45° and turn backwards near the margin. The meshes are small, narrow and of equal size throughout the lamina.

Comparison — Our specimen to some extent resembles *G. angustifolia* Brongniart (1828), *G. tenuifolia* Pant & Gupta (1968) and *G. vulgaris* Pant & Gupta (1968). *G. angustifolia* differs in having pointed apex with broader meshes near the midrib and narrower towards the margin. *G. vulgaris* is a lanceolate leaf with acute or obtuse

apex and very fine acute secondary veins, forming elongate meshes. *G. tenuifolia* is a bigger leaf and the meshes are narrow and elongate.

Feistmantel (1881, pp. 19, 36) recorded *G. leptoneura* Bunbury from Kamthi and Silewada but has not given its figures or photographs. The photograph of the type specimen is also not available. However, our specimen agrees with the detailed description and the figure of Bunbury (1881, p. 330). Further, it is also a characteristic species of the Kamthi Formation.

Glossopteris surangei sp. nov.

Pl. 1, figs 4-7; Text-fig. 2E-H

Diagnosis — Leaves elliptic; base acute, cuneate; apex obtuse, rounded; midrib strong, striated, very fine, evanescent in apical region; secondary veins emerge from midrib at an angle of less than 45°, very dense, arch out backwardly near margin, form narrow, very long meshes.

Holotype — B.S.I.P. Museum specimen no. 1874/11 (basal region) 1989/24 (apical region).

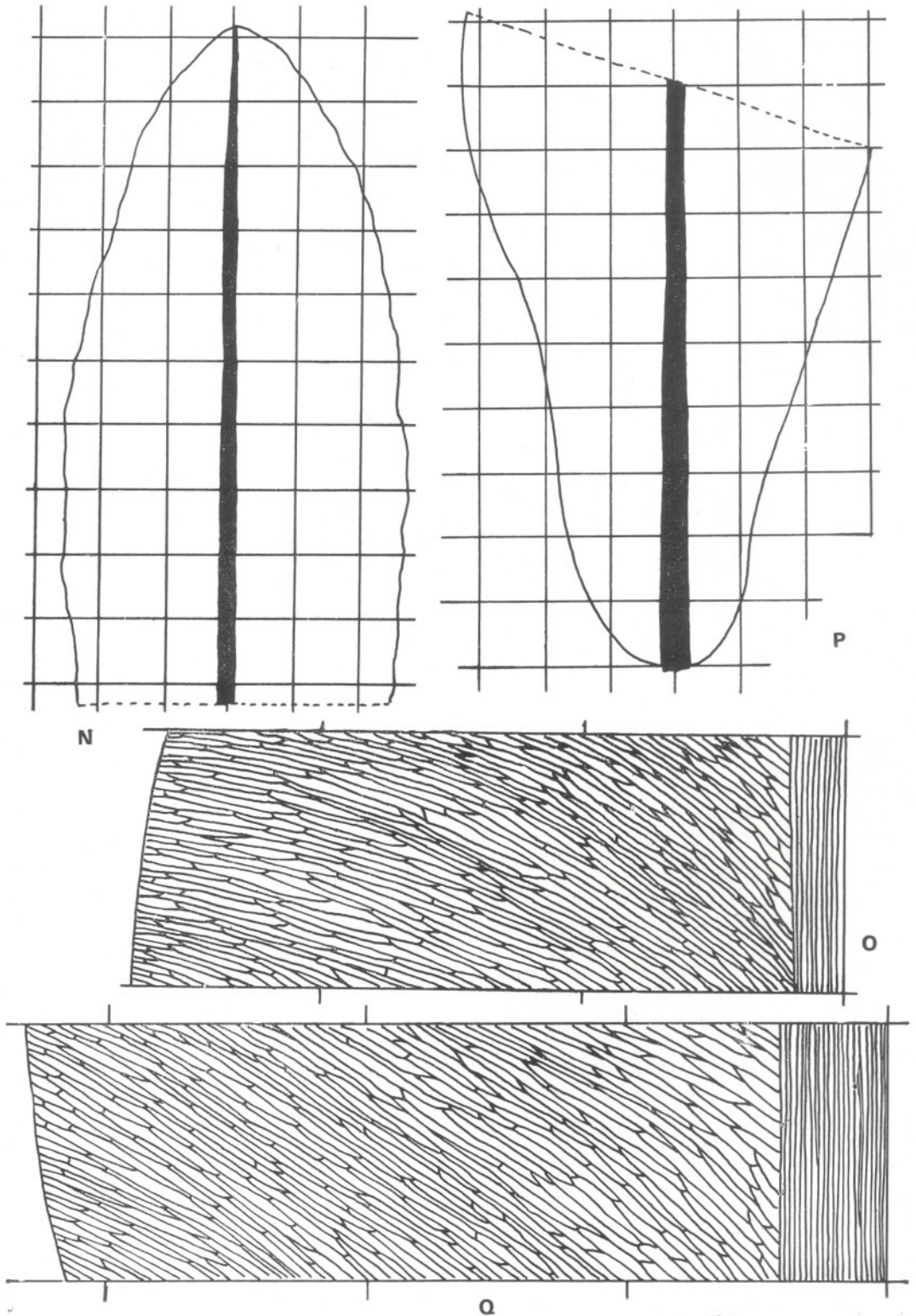
Locality — Kanhargaon Village, Chandrapur District, Maharashtra, India.

Horizon & Age — Kamthi Formation (Lower Gondwana), Upper Permian.

Description — There are 4 fragments in the collection. One represents 2/3 basal portion and the other 1/3 of the apical portion. The approximate length is 10 cm and width 1.8 cm, length/width ratio being 5:1. The shape is narrow elliptic, base acute, cuneate; apex obtuse. The midrib is strong at the base, striated, gradually tapering and becoming very fine in the apical region. The secondary veins arch out from the midrib at an angle of less than 45° and form narrow linear meshes.

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TEXT-FIG. 2 — E. *Glossopteris surangei* sp. nov. showing the basal region of the leaf with petiole × 1. F. A portion of the leaf in fig. E enlarged to show the details of venation pattern × 4. G. *Glossopteris surangei* sp. nov. showing the apical region of the leaf × 1. H. A portion of the leaf in fig. G enlarged to show the details of venation pattern × 4. I. *Glossopteris stricta* Bunbury showing the basal part of the leaf × 1. J. A portion of the leaf in fig. I enlarged to show the details of venation pattern × 4. K. *Glossopteris indica* Schimper showing the middle portion of the leaf × 1. L. A portion of the leaf in fig. K enlarged to show the details of venation pattern × 4. M. *Glossopteris leptoneura* Bunbury showing complete leaf with petiole × 1.



TEXT-FIG. 3

Comparison — Our specimens show some resemblance with *G. zeilleri* Pant & Gupta (1968) but differs from it in many respects. *G. zeilleri* is characterized by its spatulate shape. In *G. surangei* the midrib is gradually tapering and becoming evanescent in the apical part. Although the venation pattern is similar in both the species; fibrous strands are present in the mesh areas of *G. zeilleri* whereas they are absent in *G. surangei*.

Glossopteris venustus sp. nov.

Pl. 2, figs 17, 18; Text-fig. 4V, W

Diagnosis — Leaves narrow, obovate with rounded apex, base acute, cuneate, midrib strong, tapering towards apex; secondary veins emerge from midrib at an angle of 45°, longer meshes towards midrib, gradually narrowing towards margin.

Holotype — B.S.I.P. Museum Specimen No. 1874/30 (with counterpart).

Locality — Kanhargaon Village, Chandrapur District, Maharashtra, India.

Horizon & Age — Kamthi Formation (Lower Gondwana), Upper Permian.

Description — There is only one complete specimen in the collection. It is narrow, obovate in shape, 5.8 cm in length, 3 cm in width and length/width ratio is 2:1. The leaf base is acute cuneate and apex rounded. The midrib is distinct and gradually tapering towards apex. Secondary veins arise at an angle of 45°, form longer meshes near midrib, and gradually becoming narrow towards the margin.

Comparison — *G. venustus* superficially resembles *G. pandurata* Pant & Gupta (1971) and *G. retusa* Maheshwari (1965a). In these three species the venation is more or less similar but they have different shapes and sizes. *G. pandurata* is different from *G. venustus* in its characteristic pandurate shape with broad apical region. *G. retusa* differs in having two deep notches on either side of the apex.

Glossopteris raniganjensis Chandra & Surange, 1979

Pl. 3, figs 21, 22; Text-fig. 3P, Q

Description — The figured leaf is 6 cm broad at its widest part. There are 3 incomplete specimens in the collection. Apical portion of the leaf is not preserved. On reconstruction, the approximate length may be 15 cm and width 6 cm, length/width ratio 2.5:1. Thus the shape appears to be obovate, oblanceolate and the base acute, normal. The midrib is 5 mm broad, strong striated and persists up to the apex. The secondary veins arise from the midrib at an angle of 45°, dichotomise and anastomose to form narrow, elongate meshes of almost equal size throughout the lamina.

Comparison — Chandra and Surange (1979) resolved the species *G. communis* and the name *G. communis* has been retained to the leaves of the Karharbari Formation which are narrow elliptic and usually smaller in size. Furthermore, the leaves from the Raniganj Formation with *communis*-type of venation, having much bigger size, and wide midrib are kept under a separate species, *G. raniganjensis*.

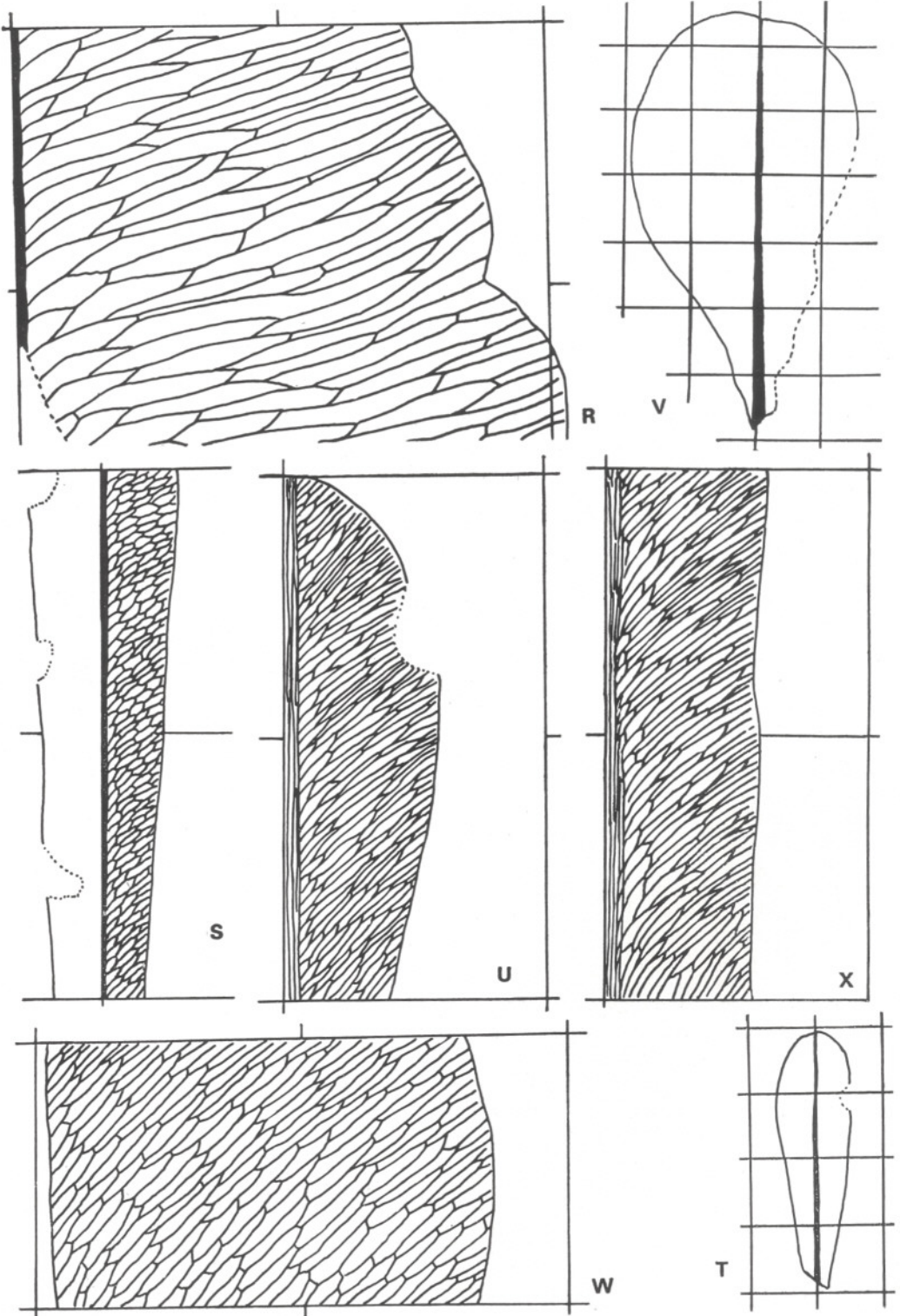
The above described specimen shows broader, striated midrib, larger leaf with dense *communis*-type of nervation and therefore has been identified as *G. raniganjensis* Chandra & Surange (1979).

Glossopteris mohudaensis Chandra & Surange, 1979

Pl. 3, fig. 24

Description — There are 3 fragmentary specimens in the collection. The described specimen shows the middle portion of the leaf which is 4.8 cm wide. Midrib is distinct and solid. The secondary veins arise from the midrib at an angle of more than 45° and less than 90°, dichotomizing and anastomosing is rare, forming broad meshes which are several times longer than broad.

TEXT-FIG. 3 — N. *Glossopteris musaefolia* Bunbury showing the apical portion of the leaf $\times 1$. O. A portion of the leaf in fig. N enlarged to show the details of venation pattern $\times 4$. P. *Glossopteris raniganjensis* Chandra & Surange showing the basal region of the leaf $\times 1$. Q. A portion of the leaf in fig. P enlarged to show the details of venation pattern $\times 4$.



TEXT-FIG. 4

Comparison — Our specimens closely resemble the fertile leaf of *Glossopteris* described by Banerjee (1969) from the Raniganj Formation of Murulidih Colliery, Jharia Coalfield to which the fructification *Senotheca murulidihensis* is attached and *G. taeniopteroides* described by Maheshwari (1965) from the Raniganj Formation of Raniganj Coalfield; Maheshwari's leaf also shows *Senotheca*-type of fructification lying across the midrib. *G. taeniopteroides* has been described from Australia by Feistmantel (1890). To such type of Indian leaves showing *taeniopteroid* type of venation, Chandra and Surange (1979) gave a new specific name *G. mohudaensis* which is distinct from the Australian species, *G. taeniopteroides*, in shape and venation pattern. Since the described leaf shows *taeniopteroid* venation it has been assigned to *G. mohudaensis* Chandra & Surange (1979). From Bazargaon also we recovered one specimen of this species (Pl. 4, fig. 33). In the described specimen the base and apex are not preserved. It is 6.5 cm wide at its widest region. The midrib is strong and solid. The secondary veins arise at an angle of more than 45° and less than 90°. Dichotomization of the secondary veins is frequent and anastomosing is rare. Thus the secondary veins run almost parallel to each other. The meshes are broader and several times longer than their width.

Glossopteris indica Schimper, 1869

Pl. 2, fig. 11; Pl. 3, fig. 12; Text-fig. 2K, L

Description — There are 9 incomplete specimens in the collection. The described specimen shows the middle region of the leaf but the margins are not preserved. The midrib is strong and striated. The secondary veins arch out at an angle of 45°. The meshes are hexagonal in shape and are

broad near the midrib, they gradually become narrow towards the margin.

Comparison — Our specimens resemble closely the specimens of Feistmantel (1886) identified as *G. indica* from the Kamthi Formation of Nagpur area. Also the described specimen matches with the description and venation drawings of Zeiller (1896) who described Schimper's (1869) type specimen of *G. indica* in detail.

Glossopteris angustifolia Brongniart, 1828

Pl. 3, fig. 29

Description — There are 6 specimens in the collection. The specimen is almost a complete leaf without base and apex, 4 cm long and 6 mm broad, length/width ratio is 7:1. The shape is lorate. The midrib is 2 mm wide, with distinct parallel running secondary veins. The secondary veins emerge from the midrib at an angle of 45° and form narrow, long meshes of almost equal size throughout the lamina.

Comparison — The described specimens closely resemble the specimens of *G. angustifolia* Brongniart (Feistmantel, 1881, pl. XXVIIA, figs 11, 13) described from the Raniganj Coalfield.

Glossopteris tenuifolia Pant & Gupta, 1968

Pl. 3, figs 27, 28

Description — There are 2 incomplete specimens in the collection. Only the apical 2/3 portion of the leaf is preserved in the figured specimen which is 3 cm (after reconstruction) long and 1.5 cm broad. The shape is very narrow elliptic, apex acute and length/width ratio 8:1. The midrib is very fine, tapering upwards near the apex. The secondary veins arch out at an angle of 45° and form elongate meshes.

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TEXT-FIG. 4—R. *Glossopteris* sp. 2 enlarged to show the details of venation pattern × 4. S. *Glossopteris* sp. 3 enlarged to show the details of venation pattern × 4. T. *Glossopteris bosei* Chandra & Surange showing almost a complete leaf × 1. U. A portion of the leaf in fig. T enlarged to show the details of venation pattern × 4. V. *Glossopteris venustus* sp. nov. showing almost a complete leaf × 1. W. A portion of the leaf in fig. V enlarged to show the details of venation pattern × 4. X. *Glossopteris leptoneura* Bunbury, a portion of the leaf in Text-fig. 2, fig. M enlarged to show the details of venation pattern × 4.

Comparison — The venation pattern in our specimens resembles *G. tenuifolia* Pant & Gupta (1968).

Glossopteris lanceolatus Pant & Singh, 1971

Pl. 3, figs 25, 26

Description — There are 4 incomplete specimens in the collection. The described specimen shows only the basal part of the leaf on one side of the midrib and measures 4 cm in width after reconstruction. The midrib is thin and persists up to the apex. The secondary veins arch out from the midrib at an angle of more than 45° and less than 90° and form short meshes near the midrib, gradually forming long and narrow meshes near the margin.

Comparison — Our specimens closely resemble the specimens of *G. lanceolatus* instituted by Pant and Singh (1971, pl. 5, fig. 25; text-fig. 4B).

Glossopteris bosei Chandra & Surange, 1979

Pl. 2, fig. 19; Text-fig. 4T, U

Description — There is only one complete specimen in the collection, 4.5 cm long and 1 cm broad. The shape is oblanceolate, length/width ratio 4:1, cuneate base and rounded apex. The midrib is 1.5 cm wide, distinct and striated. The secondary veins arise at an angle of 45° and arch backward near the margin. The meshes are short and narrow throughout the lamina.

Remarks — The present described specimen resembles *G. bosei* Chandra & Surange (1979) though there is a slight variation in size; otherwise the shape, midrib and the venation pattern are very much similar to *G. bosei*.

Glossopteris sp. 1

Pl. 1, figs 8, 9; Text-fig. 1C, D

Description — There is only one specimen in the collection of which only the basal portion is preserved. The base is auriculate. Midrib is very strong and striated. In the basal lobes the secondary veins emerge at an angle of more than 90°. Above the basal region they arch out at

an angle of more than 45°. The meshes are narrow and linear.

Comparison — Our specimen is comparable to *G. cordiformis* Pant & Singh (1971), *G. transversalis* Pant & Singh (1971), *G. divergens* Feistmantel (1881) and *Belemnopteris elongata* Lacey *et al.* (1974). It, however, differs from them in having narrow linear meshes, whereas the other listed forms have broad meshes. *Belemnopteris elongata* also differs from our specimen in having two distinct additional midveins in the basal lobes.

Glossopteris sp. 2

Pl. 2, fig. 20; Text-fig. 4R

Description — There is only one fragmentary specimen in the collection. Only the lamina on one side of the midrib is preserved. The base and apex are not preserved. Midrib is thin, 1.5-2 mm wide, solid and tapers gradually. The broadest region is 3.6 cm wide. The secondary veins arise at an angle of 90°, form broad, elongate meshes, gradually becoming narrow towards the margin.

Comparison — Our specimen resembles to some extent with *G. damudica*. Nevertheless, it differs from our described specimen in having a strong midrib, and the secondary veins forming broad, polygonal meshes near the midrib and narrow long meshes towards the margin. Further, *G. damudica* is a bigger leaf.

Glossopteris sp. 3

Pl. 1, fig. 10; Text-fig. 4S

Description — There is only one specimen in the collection, without base and apex. The leaf is strap-shaped and very small in size, measuring 3 cm in length and 5 mm in breadth. The midrib is very fine and narrow. The secondary veins arise at an angle of 45° and form short, polygonal meshes of uniform size throughout the lamina.

Comparison — Our leaf resembles *G. gopadensis* Banerji *et al.* (1975) and *G. senii* Srivastava (1969). *G. gopadensis* is different from the described specimen in having distinct midrib and sinuous secondary veins, emerging at acute angles and form-

ing elongate polygonal meshes with wavy sides. *G. senii* also differs in having distinct midrib. The secondary veins arise at an angle of 60°-80° forming polygonal meshes near the midrib and somewhat narrow and long meshes towards the margin.

Glossopteris arberi Srivastava, 1951

Pl. 4, fig. 32

Description — There is only one fragmentary specimen in the Bazargaon collection. The base and apex are not preserved. The approximate width of the leaf is 5.6 cm. The midrib is very strong, 7 mm wide and striated. The secondary veins arise at an angle of 45°, run parallel, form linear meshes which are longer than their breadth. The shape of meshes vary from hexagonal to polygonal. There is not much difference in the mesh size near midrib and the margin.

Comparison — The described specimen closely resembles *G. arberi* Srivastava (1957, pl. 9, figs 57, 58). *G. arberi* is identified on the basis of morphography and epidermal structures. The presently described specimen is devoid of carbon. However, its venation pattern is similar in all respects to *G. arberi*.

Genus — *Dictyopteridium* Feistmantel

Dictyopteridium sporiferum Feistmantel, 1881

Pl. 4, fig. 31

Description — There is a single specimen in the Bazargaon collection which is sessile and preserved as an impression. The lanceolate fertile structure measures 4.8 cm in length and 1.2 cm in breadth at the broadest part. The surface is covered with oval-circular elevations of seed cushions, arranged apparently in spiral manner. The seed cushions are 0.5 cm broad and 0.3 mm long with a small circular scar on which the seeds might have been lodged.

Comparison — The specimen described here closely resembles *Dictyopteridium sporiferum* described by Surange and Chandra (1973a, pl. 1, figs 2, 3) from Hinjrida Ghati in Dhenkanal District, Orissa, India. It also resembles *Dictyopteridium sporiferum*

of Feistmantel (1881, pl. XXIII, fig. 4; pl. XXIII A, fig. 5).

All the specimens of *Dictyopteridium* described by various authors so far belong to the Raniganj Formation whereas our specimen is the first record from Kamthi Formation.

DISCUSSION AND CONCLUSION

Earlier the flora of the Kamthi Formation was studied by Bunbury (1861), Oldham (1880) and Feistmantel (1881). Hislop had collected some plant fossils and vertebrate animal fossil remains from the Kamthi Formation of Wardha-Godavari Valley. The plant fossils of the same collection were described by Feistmantel (1880).

Bunbury (1861) described the following plants from the Kamthi Formation of Nagpur area — *Glossopteris browniana* var. *indica*., *G. browniana* var. *australiasica*, *G. musaeifolia*, *G. leptoneura*, *G. stricta*, *Pecopteris cladophlebis*, *Taeniopteris danaeoides*, *Filicites* and *Noeggerathiopsis hislopii*. Also he described some plants of doubtful affinities, viz., *Phyllothea indica*, *Vertebraria*, *Knorria*, *Yuccites*, rhizome of a fern and some stems with ridges and furrows.

Feistmantel (1880) identified the following plant fossils from Isapur, 4 miles south-east of Chanda — *Glossopteris indica*, *G. browniana* var. *indica*, *G. cf. G. musaeifolia*. From Chawart *Actinopteris* sp. is recorded. Here the seeds are also abundant and Hughes prefers to call them as *Cycadinocarpus* Schimper. From Kawarsa *Phyllothea indica*, *Schizoneura*, *Glossopteris indica*, *G. browniana* were recorded. From Anur, 2 miles south-east of Antargaon, *Phyllothea indica*, *Schizoneura* sp., a fragment of common Raniganj form, *Schizoneura* sp., a leaf resembling that of Morris' *Zeugophyllites elongatus* from New South Wales, *Glossopteris browniana* and *G. leptoneura* Bunbury were recorded.

In 1880, Oldham described the plant fossils from Kamthis, viz., *Phyllothea indica*, *Vertebraria indica*, *Glossopteris communis*, *G. indica*, *G. browniana*, *G. damudica*, *G. stricta*, *G. musaeifolia*, *G. leptoneura*, *Gangamopteris hughesi*, *Angiopteridium* cf. *A. maclellandi*, *Macrotaeniopteris danaeoides*, *M. feddeni* and *Noeggerathiopsis hislopii*.

In 1881, Feistmantel described the plant fossils from the Kamthi group of Wardha-

TABLE 1

	RANIGANJ FLORA	KAMTHI FLORA	TRIASSIC FLORA
Floristic comparison	R	K	T
LYCOPODS			
<i>Lycopodites sahani</i>	—	—	+
ARTICULATES			
<i>Trizygia speciosa</i>	+	+	+
<i>Phyllothea griesbachii</i>	+	—	—
<i>P. indica</i>	+	?	—
<i>P. australis</i>	+	—	?
<i>Raniganjia bengalensis</i>	+	—	—
<i>Schizoneura gondwanensis</i>	+	+	+
<i>Neocalamites foxi</i>	—	—	+
FERNS			
<i>Neomariopteris hughesi</i>	+	+	—
<i>N. lobifolia</i>	+	—	?
<i>N. polymorpha</i>	+	—	—
<i>N. khanii</i>	—	+	—
<i>Dichotomopteris major</i>	+	—	—
<i>D. lindleyii</i>	+	—	—
<i>D. ovata</i>	+	—	—
<i>D. falcata</i>	+	—	—
<i>Santhalia bansloiensis</i>	?	—	—
<i>Dizeugotheca phegopteroides</i>	+	—	—
<i>Belemnopteris woodmasoni</i>	+	—	—
<i>Cladophlebis</i>	—	—	+
<i>Angiopteridium</i>	—	?	—
<i>Cyclopteris pachyrachis</i>	—	—	+
<i>Danaeopsis gracilis</i>	—	—	+
<i>Parsorophyllum indicum</i>	—	—	+
<i>Marattlopsis</i>	—	—	+
GLOSSOPTERIDAE			
<i>G. tortuosa</i>	+	—	—
<i>G. lanceolatus</i>	+	—	—
<i>G. sastrii</i>	+	—	—
<i>G. maculata</i>	+	—	—
<i>G. euryneura</i>	+	—	—
<i>G. rhabdotaenioides</i>	+	—	—
<i>G. srivastavae</i>	+	—	—
<i>G. sahani</i>	+	—	—
<i>G. nautiyalii</i>	+	—	—
<i>G. gondwanensis</i>	+	—	—
<i>G. formosa</i>	+	—	—
<i>G. conspicua</i>	+	—	—
<i>G. retifera</i>	+	—	—
<i>G. intermedia</i>	+	—	—
<i>G. subtilis</i>	+	—	—
<i>G. oldhamii</i>	+	—	—
<i>G. cordiformis</i>	+	—	—
<i>G. rewaensis</i>	+	—	—
<i>G. orbicularis</i>	+	—	—
<i>G. feistmanteli</i>	+	—	—
<i>G. vulgaris</i>	+	—	—
<i>G. bosei</i>	+	—	—
<i>G. searsolensis</i>	+	—	—
<i>G. spathulata</i>	+	—	—
<i>G. retusa</i>	+	—	—
<i>G. pantii</i>	+	—	—
<i>G. gigas</i>	+	—	—

Contd

TABLE 1 — *Contd*

	RANIGANJ FLORA	KAMTHI FLORA	TRIASSIC FLORA
<i>G. major</i>	+	—	—
<i>G. tenuinervis</i>	+	—	—
<i>G. brongniarti</i>	+	—	—
<i>G. varia</i>	+	—	—
<i>G. radiata</i>	+	—	—
<i>G. arberi</i>	+	+	—
<i>G. mohudaensis</i>	+	+	—
<i>G. tenuifolia</i>	+	+	—
<i>G. angustifolia</i>	+	+	—
<i>G. musaeifolia</i>	+	+	—
<i>G. leptoneura</i>	+	+	—
<i>G. stricta</i>	+	+	—
<i>G. raniganjensis</i>	+	+	—
<i>G. surangei</i> sp. nov.	—	+	—
<i>G. venustus</i> sp. nov.	—	+	—
<i>G. bosei</i>	+	+	—
<i>G. sp. 1</i>	—	+	—
<i>G. sp. 2</i>	—	+	—
<i>G. sp. 3</i>	—	+	+
<i>G. indica</i>	+	+	+
<i>G. papillosa</i>	—	—	+
<i>G. senii</i>	—	—	+
<i>G. gopadensis</i>	—	—	+
<i>Vertebraria</i>	+	+	+
<i>Palaeovittaria kurzi</i>	+	—	—
<i>P. raniganjensis</i>	+	—	—
<i>Rhabdotaenia danaeoides</i>	+	—	—
<i>R. feddenii</i>	+	—	—
<i>R. fibrosa</i>	+	—	—
<i>Rhabdotaenia</i> sp.	—	—	+
<i>Noeggerathiopsis</i>	—	?	?
<i>Macrotaeniopteroides</i>	—	—	?
PTERIDOSPERMS			
<i>Dicroidium</i>	—	—	+
<i>Lepidopteris</i>	—	—	+
PTERIDOSPERM FRUCTIFICATIONS			
<i>Bosea</i>	—	—	+
<i>Indotheca</i>	—	—	+
<i>Pteruchus</i>	—	—	+
<i>Nidistrobos</i>	—	—	+
<i>Satsangia</i>	—	—	+
<i>Nidia</i>	—	—	+
CYCADS			
<i>Pseudoctenis balli</i>	+	—	+
<i>Pterophyllum burdwanensis</i>	+	—	—
<i>P. karkatiensis</i>	—	—	+
<i>P. sahnii</i>	—	—	+
<i>Pteronilssonsonia gopalli</i>	+	—	—
<i>Taeniopteris spatulata</i>	—	—	+
<i>T. glandulata</i>	—	—	+
<i>T. cf. T. feddeni</i>	—	—	+
CONIFERALES			
<i>Desmiophyllum</i>	—	—	+
<i>Podozamites</i>	—	—	?
<i>Elatocladus</i>	—	—	?
<i>Araucarites</i>	—	—	+
<i>Conites</i>	—	—	+
<i>Pagiophyllum</i>	—	—	+
<i>Voltzia</i>	—	—	?

Contd

TABLE 1 — *Contd*

	RANIGANJ FLORA	KAMTHI FLORA	TRIASSIC FLORA
GINKGOALES			
<i>Rhipidopsis</i> (= <i>Platyphyllum</i>)	+		+
<i>Baiera indica</i>	—		+
INSERTAE-SEDIS			
<i>Filicites</i>	—	+	—
<i>Yuccites</i>	—	+	—
<i>Knorria</i>	—	+	—
<i>Senia reticulata</i>	—	+	—
<i>Glottolepis rugosa</i>	—	—	+
<i>G. glabrosa</i>	—	—	+
<i>G. sidhiensis</i>	—	—	+
<i>G. ovata</i>	—	—	+
<i>Gopadia papillata</i>	—	—	+
<i>G. coriacea</i>	—	—	+
<i>Chakrea papillosa</i>	—	—	+

Index: +, Present; —, Absent; ?, Doubtful occurrence.

Godavari Valley, viz., ?*Alethopteris* sp., *Macrotaeniopteris danaeoides*, *M. feddeni*, *Angiopteridium* cf. *A. maclellandi*, *Glossopteris communis*, *G. stricta*, *G. musaeifolia*, *G. indica*, *G. damudica*, *G. angustifolia*, *G. leptoneura*, *Gangamopteris hughesi*, *Noeggerathiopsis hislopi*, *Anthrophyopsis* and *Rhipidopsis densinervis*.

In the present investigation the following plant fossils (impressions) have been identified from Kanhargaon — *Neomariopteris hughesi*, *Trizygia speciosa*, *Schizoneura gondwanensis* (identified from Bazargaon also), equisetalean stems, *Glossopteris musaeifolia* (present in Bazargaon collection also), *G. stricta*, *G. leptoneura*, *G. mohudaensis* (identified from Bazargaon also), *G. indica*, *G. raniganjensis*, *G. angustifolia*, *G. lanceolatus*, *G. tenuifolia*, *G. bosei*, *G. densinervis* sp. nov., *G. venustus* sp. nov., *G. sp. 1*, *G. sp. 2*, *G. sp. 3* and *Vertebraria indica*.

From Bazargaon we recorded *Glossopteris arberi* and *Dictyopteridium sporiferum*, in addition to *G. musaeifolia*, *G. mohudaensis* and *Schizoneura gondwanensis*, which are also present in Kanhargaon collection.

From the Kamthi Formation of Kanhargaon Chandra and Prasad (1979a, b) Prasad and Chandra (1978a, b; 1979a, b, c, d) described the petrified gymnospermous woods, viz., *Dadoxylon chandrapuraensis* sp. nov., *D. maharashtraensis* sp. nov., *D. parenchymosum* Surange & Maithy, *Tri-*

gonomyelon kamthiensis sp. nov., *Kaokoxyylon pseudotrime-dullaris* sp. nov., *Taxopitys indica* sp. nov., *T. surangei* sp. nov., *Australoxyylon kanhargaoense* sp. nov., *A. longicellularis* sp. nov., *Zalesskioxylon lepekhinae* sp. nov., *Z. simplexum* sp. nov., *Prototaxoxylon uniseriale* sp. nov., *P. maithyi* and *Baieroxylon multiseriale* sp. nov.

The fossil flora of Raniganj, Kamthi and Triassic are compared with each other as shown in Table 1. It is clear that the Kamthi flora has many more plants of Raniganj Formation along with its own distinct species than those of Triassic age. Although the lithology of Kamthi and Raniganj formations differ a great deal and the Raniganj flora is richer, there is a striking resemblance between the flora of the two formations. All the three marker species of *Glossopteris* Bunbury (1861) described from Kamthi Formation, viz., *Glossopteris musaeifolia*, *G. leptoneura*, *G. stricta* have been found at Kanhargaon and Bazargaon. Besides, the new species, viz., *Glossopteris surangei* sp. nov., *G. venustus* sp. nov., *G. sp. 1*, *G. sp. 2*, *G. sp. 3* have also been added to the Kamthi flora. The later three *Glossopteris* spp. are typical of Kamthi Formation and are not known from the Raniganj Formation.

The flora from the Raniganj Formation is much better known. A number of both

male and female Glossopteridalean fructifications such as *Kendostrobus cylindricus*, *Dictyopteridium feistmantelii*, *D. sporiferum*, *Senotheca murulidihensis*, *Scutum stowanum*, *Plumsteadios-trobus ellipticus*, *Venustostrobus indicus*, *V. diademus*, *Jambadostrobus pretiosus* have been described (Chandra & Surange, 1976, 1977a, b, c; Surange & Chandra, 1974c; Banerjee, 1968, 1969, 1973; Maheshwari, 1965b). However, only one detached female Glossopteridalean fructification *Dictyopteridium sporiferum* is recorded from Bazargaon.

The Kamthi flora also resembles the flora of Handappa area (Orissa). Also the lithology of both these formations is similar. The Handappa flora, however, closely resembles the Raniganj flora in having male and female fructifications, viz., *Cistella*,

Scutum, *Partha*, *Lidgettonia*, *Denkania*, *Dictyopteridium*, *Glossotheca*, and *Eretmonia* (Surange & Maheshwari, 1970; Surange & Chandra, 1973a, b, c; 1974a, b, c) and in the presence of impressions of Glossopteridalean and pteridophytic remains (Khan, 1969; Maithy, 1977; Subramanian & Rao, 1960).

Thus the Kamthi flora does not have any typical Triassic floral elements (Table 1) but it does show close relationship with the Raniganj flora and Handappa flora of Orissa.

We feel that the Kamthi flora may be almost contemporaneous with the Raniganj flora although the Kamthi may indicate a different facies. Therefore an Upper Permian age has been confirmed to this formation on the basis of megafloristics.

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EXPLANATION OF PLATES

PLATE 1

1. *Neomariopteris hughesii* (Feistmantel) Maithy showing an incomplete frond. × 4. Specimen no. 1989/1.
2. *Glossopteris stricta* Bunbury showing the basal part of the leaf. × 1. Specimen no. 1989/32.
3. A portion of the leaf in fig. 2 showing the details of venation. × 4.
4. *Glossopteris surangei* sp. nov. Holotype showing the basal part of the leaf. × 1. Specimen no. 1874/11.
5. A portion of the leaf in fig. 4 showing the details of venation. × 4.
6. *Glossopteris surangei* sp. nov. Holotype showing the apical part of the leaf. × 1. Specimen no. 1989/24.
7. A portion of the leaf in fig. 6 showing the details of venation. × 4.
8. *Glossopteris* sp. 1 showing the basal part of the leaf with auriculate leaf base and prominent midrib. × 1. Specimen no. 1989/1.
9. A portion of the leaf in fig. 8 showing the details of venation. × 4.
10. *Glossopteris* sp. 3 showing the details of venation. × 4. Specimen no. 1989/3.
11. A portion of the leaf in Pl. 1, fig. 12, showing the details of the venation. × 4.

PLATE 2

12. *Glossopteris indica* Schimper showing the middle portion of the leaf. × 1. Specimen no. 1989/26.
13. *Glossopteris musaefolia* Bunbury showing the apical region of the leaf. × 1. Specimen no. 1874/4.
14. A portion of the leaf in fig. 13 showing the details of venation. × 2.
15. *Glossopteris leptoneura* Bunbury showing a complete leaf with petiole. × 1. Specimen no. 1989/10.
16. A portion of the leaf in fig. 15 showing the details of venation. × 4.
17. *Glossopteris venustus* sp. nov. Holotype showing a complete leaf. × 1. Specimen no. 1874/30.
18. A portion of the leaf in fig. 17 showing the details of venation. × 2.
19. *Glossopteris bosei* Chandra & Surange showing almost a complete leaf. × 3. Specimen no. 1989/28.

20. *Glossopteris* sp. 2 showing the details of venation on one side of the midrib. × 2. Specimen no. 1989/19.

PLATE 3

21. *Glossopteris raniganjensis* Chandra & Surange showing the basal region of the leaf. × 1. Specimen no. 1989/6.
22. A portion of the leaf in fig. 21 showing the details of venation and broad striated midrib. × 2.
23. *Trizygia speciosa* Royle showing the articulate stem with five whorls of leaves. × 1. Specimen no. 1874/1.
24. *Glossopteris mohudaensis* Chandra & Surange showing the details of venation in the middle region of the leaf. × 2. Specimen no. 1874/12.
25. *Glossopteris lanceolatus* Pant & Singh showing the basal part on one side of the midrib. × 1. Specimen no. 1989/21.
26. A portion of the leaf in fig. 25 showing the details of venation. × 2.
27. *Glossopteris tenuifolia* Pant & Gupta showing apical portion of the leaf. × 1. Specimen no. 1989/25.
28. A portion of the leaf in fig. 27 showing the details of venation and very fine midrib. × 4.
29. *Glossopteris angustifolia* Brongniart. showing the details of venation. × 2. Specimen no. 1874/3.

PLATE 4

30. *Schizoneura gondwanensis* Feistmantel showing the leaf sheaths. × 1. Specimen no. 1994/1.
31. *Dictyopteridium sporiferum* Feistmantel almost a complete specimen showing the seed cushions. Specimen no. 1875/4.
32. *Glossopteris arberi* Srivastava showing the details of venation and broad solid midrib. × 2. Specimen no. 1875/1.
33. *Glossopteris mohudaensis* Chandra & Surange showing the details of venation. × 2. Specimen no. 1875/2.
34. *Glossopteris musaefolia* Bunbury showing the details of venation. × 2. Specimen no. 1875/3.

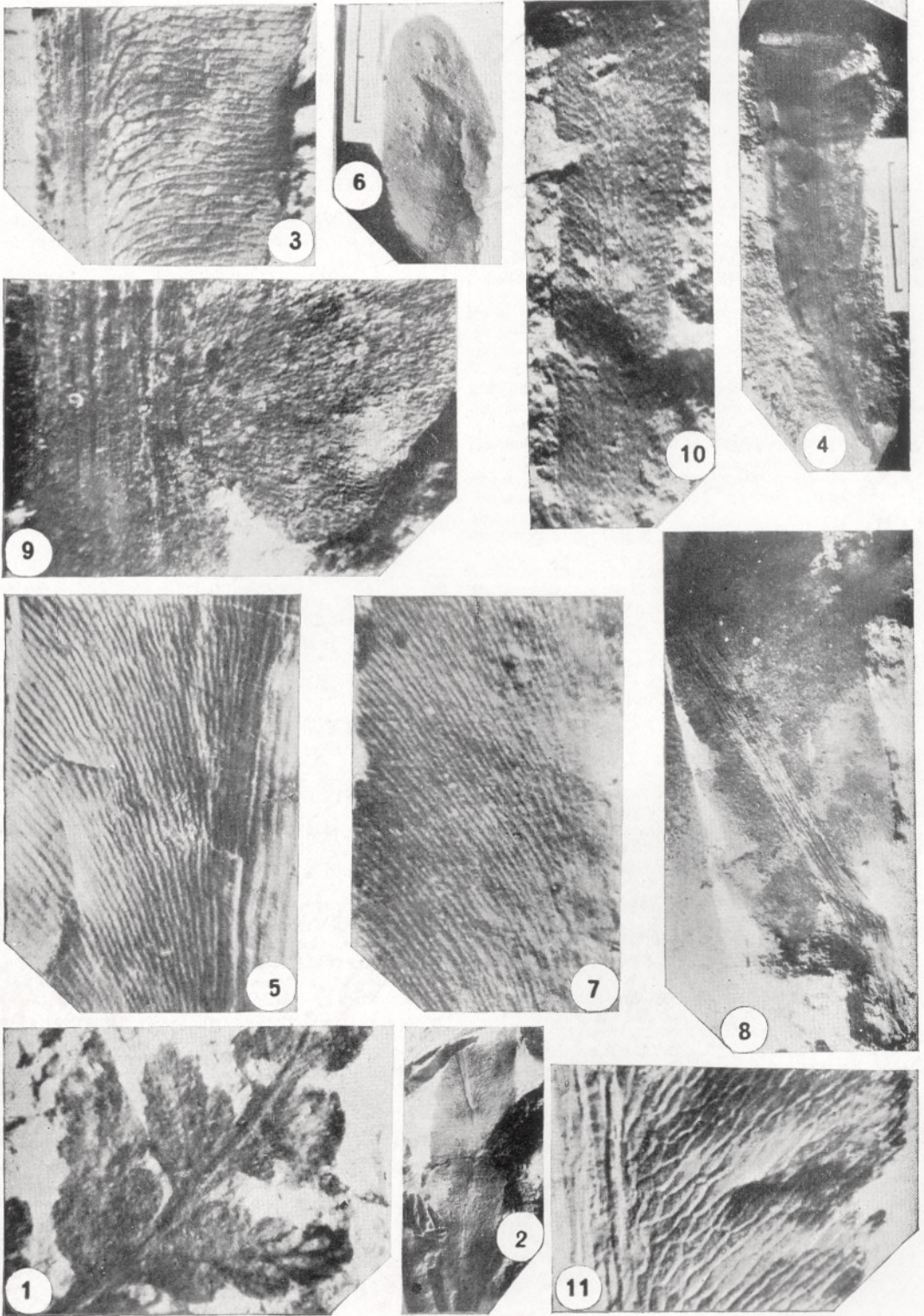


PLATE I

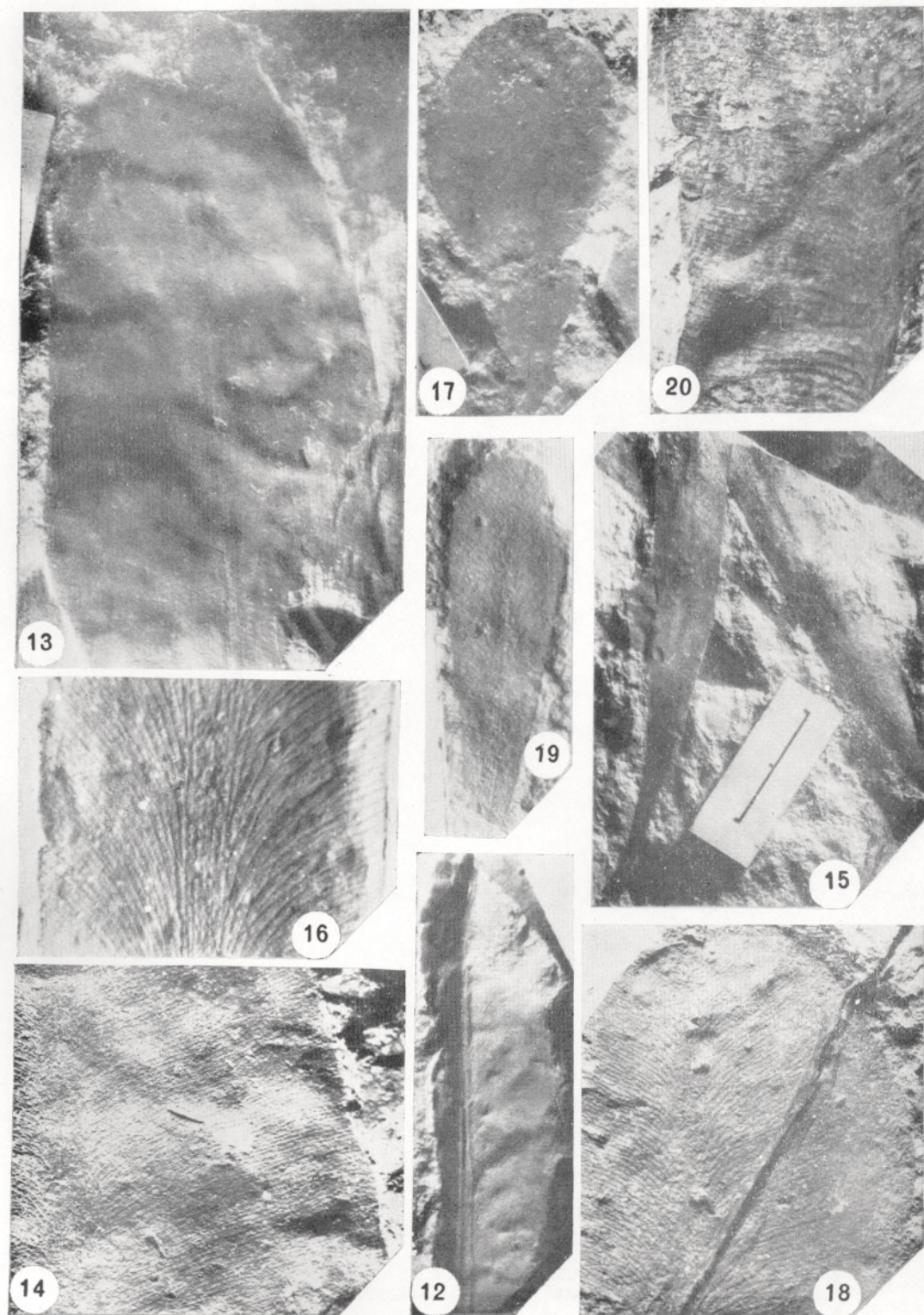


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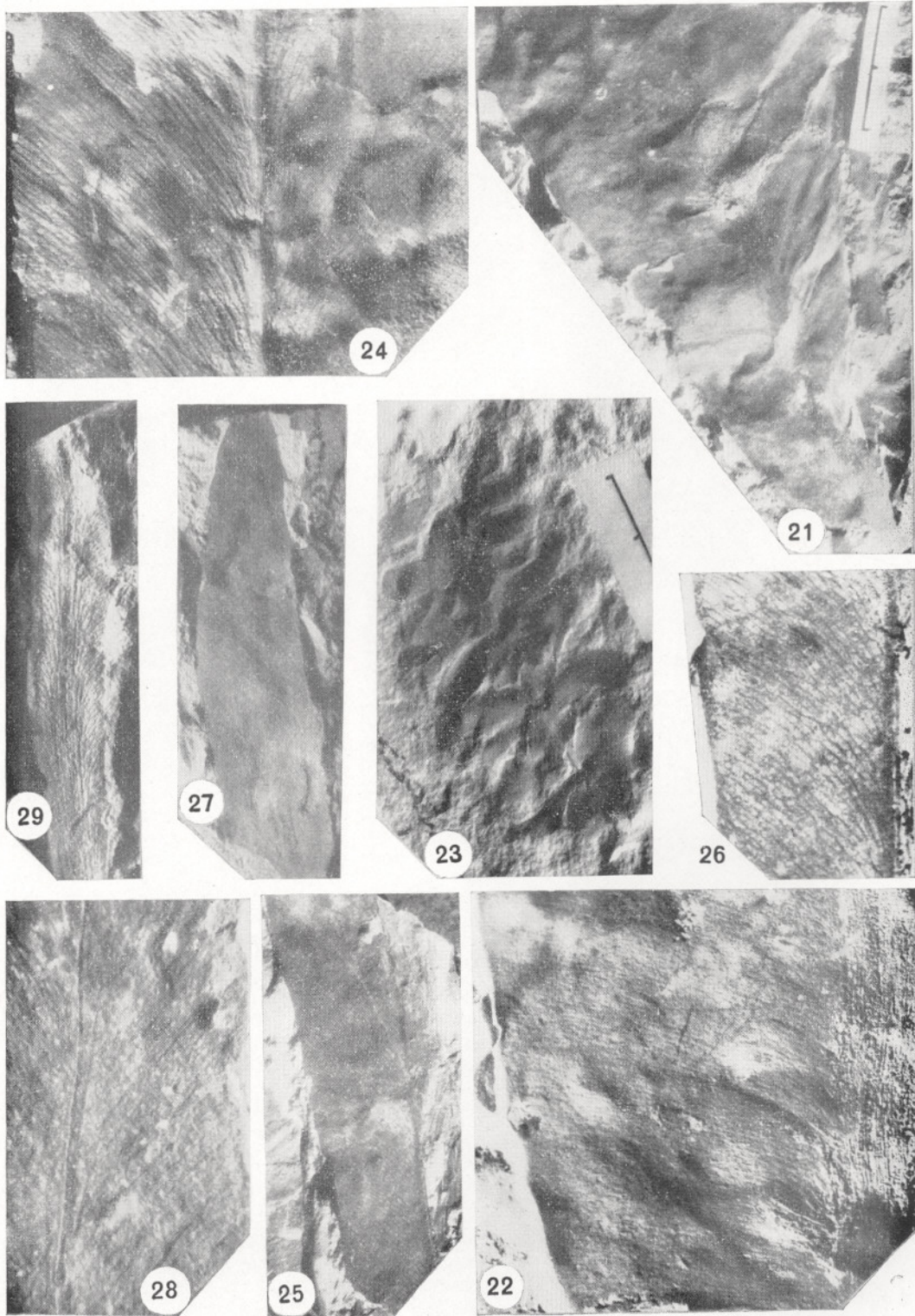
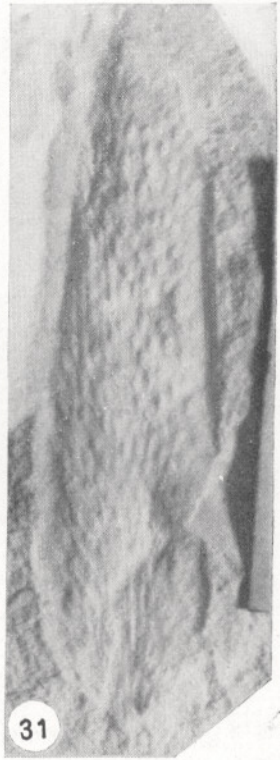


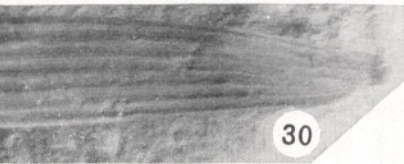
PLATE 3



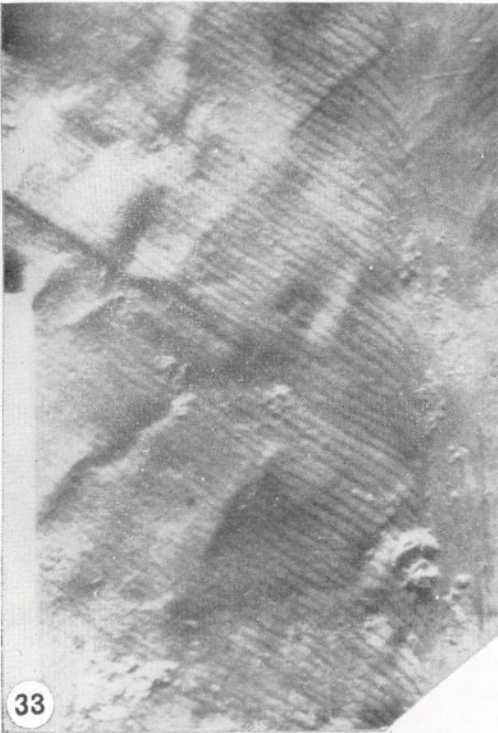
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