Journal of the Palaeontological Society of India
Volume, 53(1), June 2008: 19-30

ISSN 0522-9630

THE GENUS *GLOSSOPTERIS* BRONGNIART FROM THE KAMTHI FORMATION OF CAMP IV AREA, WARDHA VALLEY COALFIELD, WARDHA BASIN, MAHASRASHTRA, INDIA

RAJNI TEWARI

BIRBAL SAHNI INSTITUTE OF PALAEOBOTANY, 53, UNIVERSITY ROAD
LUCKNOW 226 007, INDIA
E-mail: rajni.tewari@gmail.com

ABSTRACT

Twenty one species of the genus *Glossopteris, viz. G. angusta, G. angustifolia, G. barakarensis, G. brongniartii,G. communis, G. indica, G. intermedia, G. hinjridaensis, G. kamthiensis, G. leptoneura, G. longicaulis, G. maheshwarii, G. mohudaensis, G. musaefolia, G. retifera , G. rhabdotaenioides, G . stenoneura, G. subtilis, G. syaldiensis, G. tenuifolia, and G. vulgaris* are systematically described from the Kamthi Formation, Camp IV Area, Chandrapur District, Wardha Basin in the present communication. The species are comparable with those of the Raniganj and Kamthi formations of the Damodar and Handappa, Mahanadi basins, respectively, indicating an Upper Permian age. Besides adding to the knowledge of the flora of the Wardha Basin, systematic analysis of *Glossopteris* leaves from the Camp IV area, Tohegaon Village, Chandrapur District is provided for the first time.

Keywords: *Glossopteris*, Kamthi Formation, Upper Permian, Wardha Valley Coalfields, Wardha Basin

INTRODUCTION

The Wardha Valley Coalfield is a northwestern extension of the Godavari Valley Coalfield across the boundary of Maharashtra state. It is one of the important coalfields of the Wardha Basin, Maharashtra, others being Kamptee, Bandar and Umrer coalfields. Megafossils have been reported from the Barakar and Kamthi formations of the Umrer Coalfield (Sundaram and Nandi, 1984; Agashe *et al.*, 1971) and the Kamthi Formation of Kamptee Coalfield (Bunbury, 1861; Chitnis and Vagyani, 1979; Varadpande 1977a, 1977b; Chandra and Prasad, 1981; Tewari, 2007). Recently, Singh *et al.* (2005) have reported megafossils from the Karharbari Formation of the Nand Coalfield.

Plant megafossil records from the Wardha Valley Coalfield, mainly consist of gymnospermous woods (Agashe and Prasad, 1989; Chandra and Tewari, 1991; Agashe and Shashi Kumar, 1996, 2001). However, megafossils other than woods have also been reported from the Kamthi Formation (Feistmantel, 1881; Chandra and Prasad, 1981; Raja Rao, 1982; Tewari and Rajanikanth, 2001).

The present work deals with the systematic description of twenty one species of the genus *Glossopteris,* viz. *G. angusta, G. angustifolia, G. barakarensis, G. brongniartii, G. communis, G. indica, G. intermedia, G. hinjridaensis , G. kamthiensis, G. leptoneura, G. longicaulis G. maheshwarii, G. mohudaensis, G. musaefolia, G. retifera, G. rhabdotaenioides, G. stenoneura, G. subtilis, G. syaldiensis, G. tenuifolia* and *G. vulgaris* from the Kamthi Formation of the Camp IV area located in Tohegaon Village, about 8 kms south-east of Kanhargaon, Wardha Valley Coalfield, Chandrapur District, Maharashtra (Fig. 1). Besides, a number of samples with impressions of equisetalean axes have also been recorded. This is the first comprehensive report of megafloral elements from this area.

GEOLOGY OF THE AREA

The Wardha Valley Coalfield (Latitudes 19°30'N and 20°27'N and Longitudes 78° 50"E and 79°45'E) mainly lies in the Chandrapur District of Maharashtra with a small portion in the south-west falling in the Yeotmal district. The Gondwana sediments of the Godavari Valley extend uninterrupted towards north-west into the drainage area of Wardha River and its tributaries in Maharashtra. A large part of the Wardha Valley Coalfield does not display the Upper Gondwana Sequence. Major part of the Coalfield exposes the beds of the Kamthi Formation. Usually, the sandstones are dull brownish yellow to brownish red in colour and medium to coarse grained. The Kamthi sandstones are interbedded with variegated shales showing a wide range of colours, *viz.* red, grey, cream or white. The exact thickness of the Kamthi Formation in the Wardha Valley is not known owing to lack of bore hole data. However, based on geological mapping, it has been estimated to be 500m (Raja Rao, 1982). The generalized geological succession of the Wardha Valley Coalfield is shown in Table.1 (after Raja Rao, 1982).

MATERIAL AND METHODS

The plant fossils preserved in the form of impressions on shales were collected from Kamthi Formation of the Camp IV Area (Fig. 1) and show the details of venation pattern and configurations of leaf morphology. The morphotaxonomy of the megafossils was studied with the help of hand lens and low power binoculars. The identification of *Glossopteris* species is based on their external morphological features such as shape, nature of apex, base, midrib, venation pattern and in some, cases size. Nomenclature of shape, apex, base follows Lawrence (1955) and of venation pattern is after Melville (1969). All the specimens are deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow, India.

SYSTEMATIC DESCRIPTION

Equisetales

Equisetalean axes

(Pl. IV, fig.1)

Table 1: Lithostratigraphic succession of the Kamptee Coalfield (after Rajarao, 1982).

Age	Group/Formation	Lithology
Recent	–	Alluvial gravel beds, black cotton soil
?/Eocene	Deccan Trap	Basalts
Cretaceous	Lameta	Limestones, cherts and silicified sandstones
---------- Unconformity ----------		
Upper Triassic	Maleri (only in the southeastern extremity)	Fine to medium- grained sandstone and red shales
Upper Permian-Lower Triassic	Kamthi	Red, brown and variegated sandstones, reddish siltstones and variegated shales
---------- Unconformity ----------		
Lower Permian	Barakar	Light grey to white sandstones, shales and coal seams
(?) Upper Carboniferous to Lower Permian	Talchir	Tillites, turbidites, varves, needle shales and sandstones,
---------- Unconformity ----------		
Precambrian	Sullavai Sandstones	White to light brown quartzitic sandstones, conglomerates
---------- Overlap ----------		
	Pakhal Limestone	Grey, bluish or pinkish limestones and cherts
---------- Unconformity ----------		
Archaean		Quartzites, granite, gneisses, etc.

A number of well preserved unbranched equisetalean axes measuring 4.3-9.8 cm in length and 0.5-2.6 cm in width are present in the collection, most of the specimens show well preserved nodes and internodes, distance between two nodes varies from 3.1cm to 4.0 cm, nodes 0.5 to 1mm wide, ridges and furrows of one internode alternate with those of adjacent internode, ridges 0.5-1mm apart.

Number of specimens: Ten.

Glossopteridales

Genus ***Glossopteris*** Brongniart, 1828

Glossopteris angusta Pant & Gupta, 1971
(Pl. I, fig. 5; Pl. II, fig. 3)

Description: Leaves almost complete, small, shape oblanceolate, apex broken, base narrow, tapering, margin entire, leaves measure 2.9 to 3.0cm in length and 0.8 to 1.0 cm in width, midrib thin flat, striated, persistent, 1 mm wide in basal region, tapering towards apex, veins arise at acute angles from midrib, follow a straight course to meet margin after dichotomizing and anastomosing, meshes arcuate near midrib, elongate, narrow elsewhere, venation not dense.

Comparison: Leaves are comparable in shape, nature of base, midrib and venation pattern with *Glossopteris angusta* (Pant and Gupta, 1971, pl. 21, fig. 33; Chandra and Surange, 1979, pl. 1, fig. 9, pl.6, fig.7, pl. 17, figs. 3,8, pl.43, fig.7).

Number of specimens: Two.

Glossopteris angustifolia Brongniart, 1828
(Pl. I, figs.7, 10)

Description: Different parts of leaves preserved separately, shape linear, apex obtuse, base narrow, attenuate, margin entire, leaves measure 3.5 to 6.5cm in length and 0.7 to 1.0 cm in width, midrib thin flat, striated, persistent, 1 to 2mm wide in basal region, thinning towards apex, veins arise at acute angles from midrib, follow a straight course to meet margin after dichotomizing and anastomosing, meshes arcuate near midrib, elongate, trapezoidal elsewhere.

Comparison: Leaves are comparable in shape, nature of apex, base, midrib, venation pattern and length- width ratio with *Glossopteris angustifolia* (Brongniart, 1828, pl.63, figs.1,1a; Chandra and Surange, 1979, pl. 3, fig. 6; pl.13, fig.5, pl. 18, figs.7, 11, pl.42, fig.2).

Number of specimens: Five.

Glossopteris barakarensis Kulkarni, 1971
(Pl. IV, fig. 3)

Description: Single specimen present in the collection, apex obtuse, base narrow, shape oblanceolate, margin entire, leaf small, measures 4.5 x 1.0 cm in size, midrib distinct, persistent, 1 mm wide, secondary veins arise at acute angles from midrib, arch slightly backwards to meet margin after dichotomisation and anastomoses, meshes arcuate near midrib, narrow, trapezoidal elsewhere, smaller and narrower near margin.

Comparison: Leaf compares in shape and venation pattern with *Glossopteris barakarensis* (Kulkarni, 1971, pl. 2, figs.13, 14, 15; Chandra and Surange, 1979, pl.2, fig. 4, pl.19, fig.7, pl.41, fig.3).

Glossopteris brongniartii Pant & Gupta, 1968
(Pl. II, fig.6)

EXPLANATION OF PLATE I

1-3. ***Glossopteris kamthiensis*** Singh and Chandra, 1987, leaves showing acuminate apex. BSIP Specimen Nos. 39163A, 39164B, 39165. x 3.

4. ***Glossopteris maheshwarii*** Singh and Chandra, 1987. BSIP Specimen Nos. 39163B. x 3.

5. ***Glossopteris angusta*** Pant and Gupta, 1971. BSIP Specimen No.39167. x 3.

6. ***Glossopteris hinjridaensis*** Singh and Chandra, 1987,l eaf showing retuse apex. BSIP Specimen No.39168A. x 3.

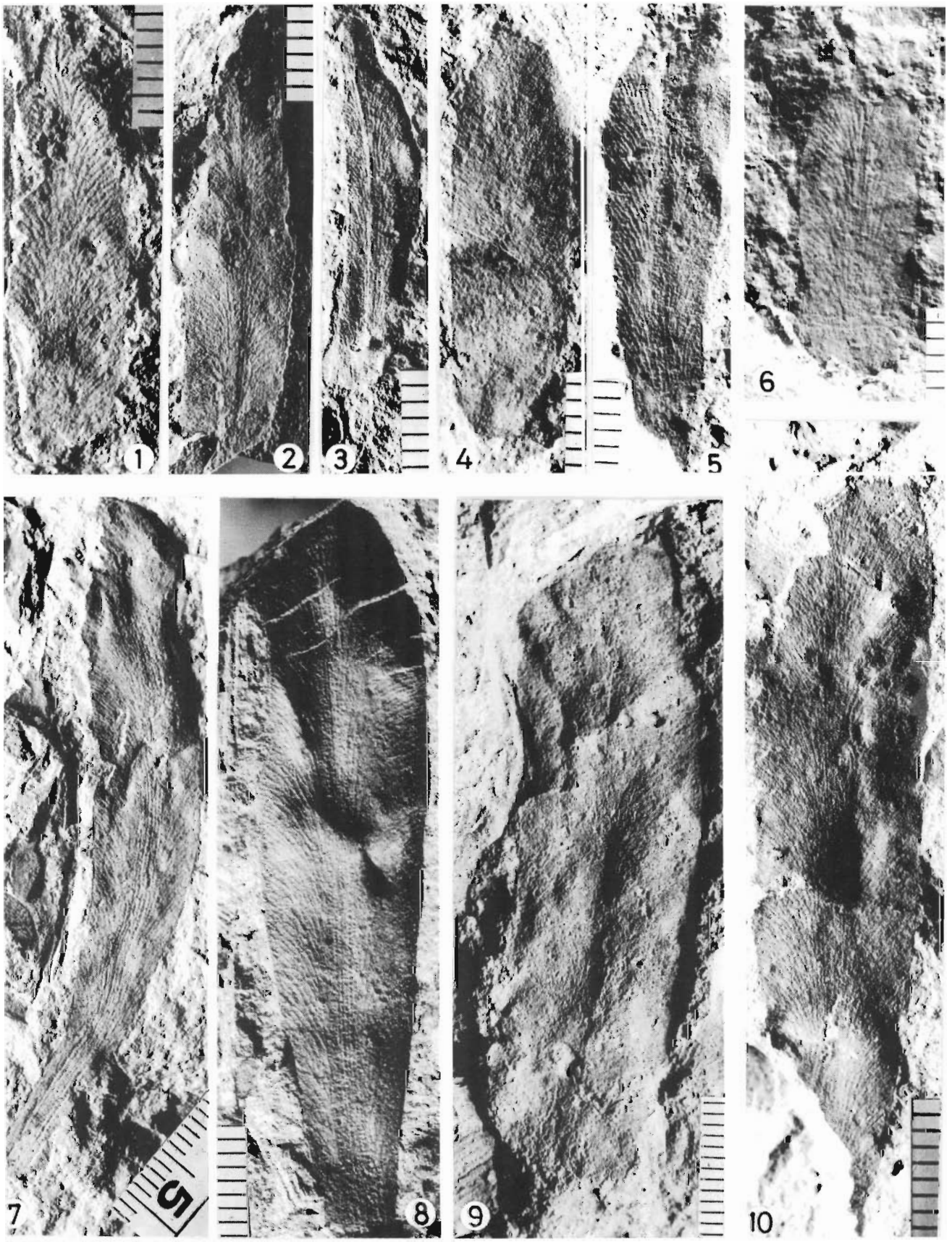
7. ***Glossopteris angustifolia*** Brongniart, 1828. BSIP Specimen No.39164A. x 2.

8. ***Glossopteris intermedia*** Feistmantel, 1880. BSIP Specimen No.39169. x 2.5.

9. ***Glossopteris retifera*** Feistmantel,1880 . BSIP Specimen No.39170. x 2.

10. ***Glossopteris angustifolia*** Brongniart, 1828. BSIP Specimen No.39266. x 3.

Plate I



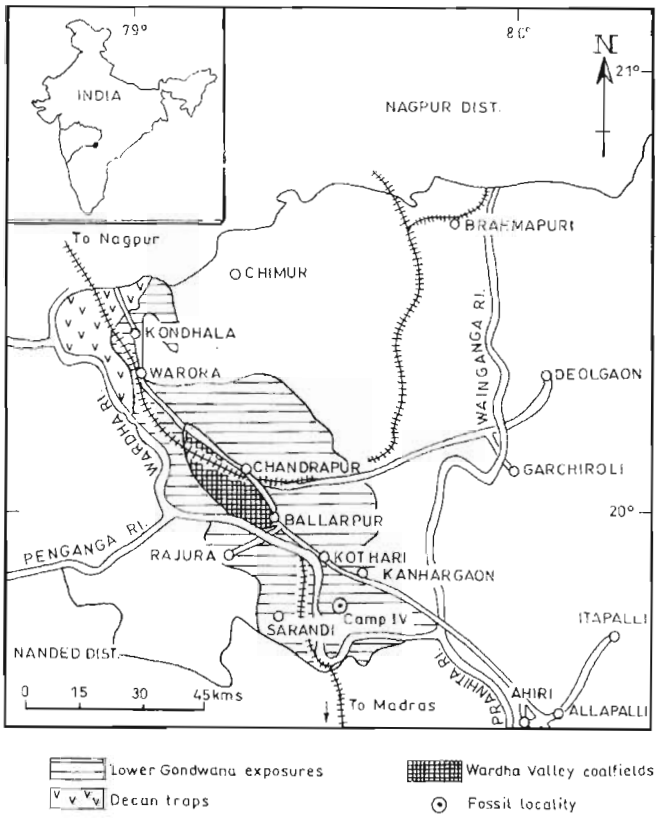


Fig. 1. Map showing the fossil locality.

Description: Single incomplete leaf present in collection, only apical half of leaf preserved, measures 7.5 x 1.5 cm in size, apex broken, margin entire, midrib thin, flat, striated, 1 mm wide, secondary veins arise at acute angles from midrib, slightly arch backwards, continue at acute angles to meet margin after dichotomisation and anastomoses, meshes arcuate near midrib, elongate, narrow, trapezoidal elsewhere, venation dense.

Comparison: Leaf compares in venation pattern with *Glossopteris brongniartii* (Pant and Gupta, 1968, pl.22, fig. 27; Chandra and Surange, 1979, pl.23, figs. 3, 16).

Glossopteris communis Feistmantel, 1876a
(Pl. II, fig. 7)

Description: Different parts of apical and middle portions present in the collection, complete leaf is not present, apex obtuse, rounded, base not preserved, margin entire, preserved portion of leaves measure 8.0 x 3.5 to 4.0 cm in size, midrib flat, striated, 0.5 to 1mm wide, persistent, gradually thinning upwards, secondary veins arise at acute angles from midrib, arch gracefully backwards to meet margin after dichotomizing and anastomosing, meshes arcuate near midrib, narrow, elongate, trapezoidal elsewhere, venation dense.

Comparison: Leaf is comparable in venation pattern with *G. communis* (Feistmantel, 1876, pl.21, fig.5, 1879, pl. 17, figs.1, 2; Feistmantel, 1882, pl. 21, figs.13, 14; Chandra and Surange, 1979, pl.1, figs. 2,3).

Number of specimens: Four.

Glossopteris hinjridaensis Singh & Chandra, 1987
(Pl. I, fig. 6)

Description: Single incomplete leaf present in collection, leaf small and narrow, widest in apical region, shape narrow oblanceolate, apex emarginate, base narrow, margin entire, measures 1.8 x 0.8cm in size, midrib distinct, persistent, 0.5mm wide, secondary veins thin, arise at acute angles from midrib, arch backwards, dichotomize, anastomose two to three times from midrib to margin, meshes arcuate near midrib, elongate, narrow, polygonal elsewhere.

Comparison: Leaves compare in shape, nature of apex and venation pattern with *Glossopteris hinjridaensis* (Singh and Chandra, 1987, pl.2, figs.2, 4, 5, 8, text-fig. 2A, D).

Glossopteris indica Schimper, 1869
(Pl. IV, fig. 4)

Description: Fragmentary portions of middle parts of leaves present, only half part of lamina on one side of midrib preserved, margin entire, leaves measure 3.5 to 4.3 x 2.2 to 2.5 cm in size, midrib strong, distinct, 2mm wide, secondary veins arising at acute angles from midrib, slightly arching backwards, forming gentle curves to meet margin after dichotomisation and anastomoses, meshes short, broad and arcuate near midrib, long and narrow elsewhere.

Comparison: Leaves are comparable with *Glossopteris indica* (Chandra and Surange, 1979, pl.5, fig.1, pl.10, fig.4, pl.15, fig.11, pl.28, fig.1, pl.29, fig.1; Tewari and Srivastava, 2000, pl.1, fig.4) in shape, nature of midrib and in venation pattern.

Number of specimens: Two.

Glossopteris intermedia Feistmantel, 1880a
(Pl. I, fig. 8)

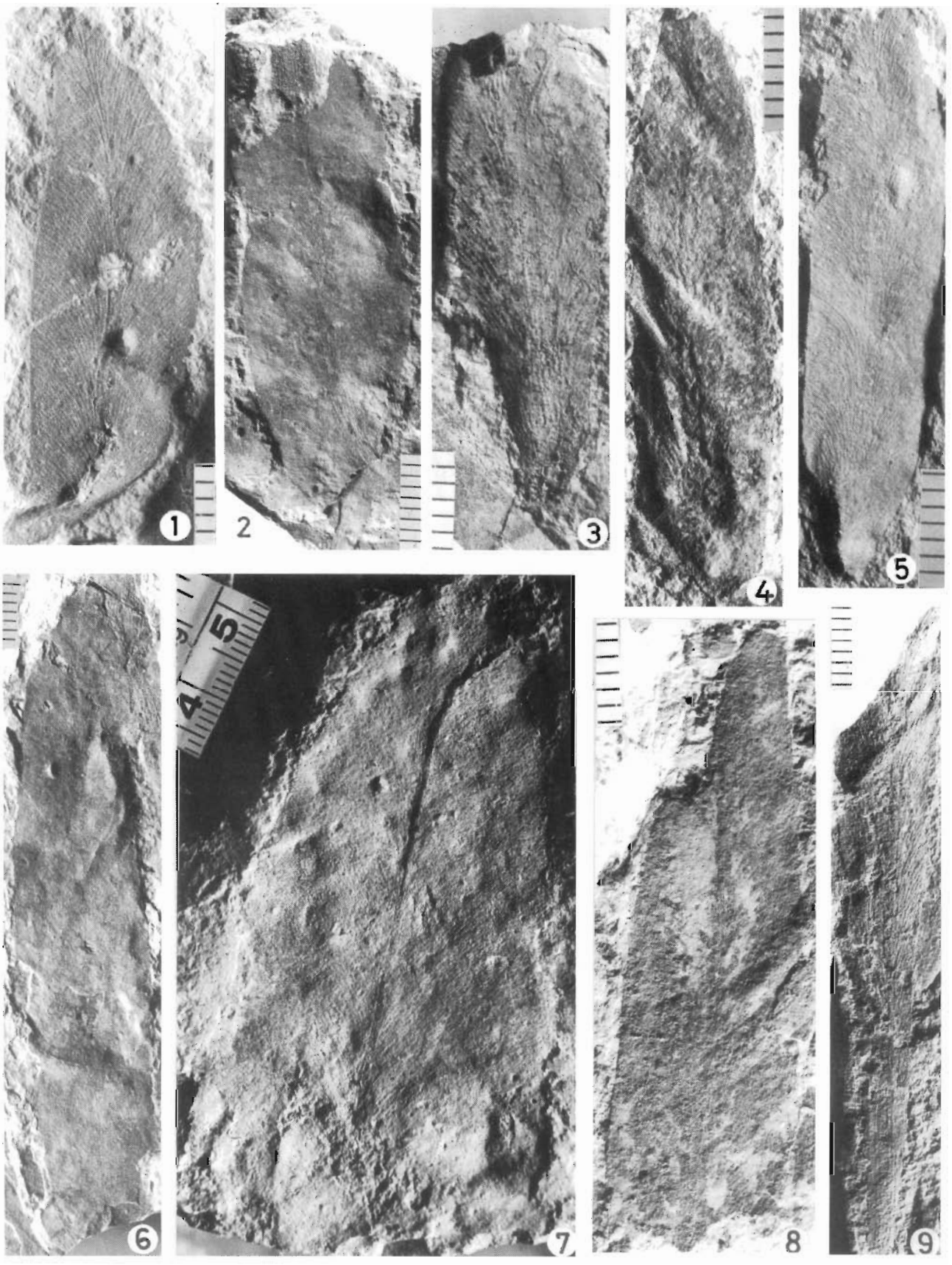
Description: Part and counterpart of a single specimen present in the collection, shape elliptic, apex broken, apparently obtuse, base narrow, margin entire, leaf narrow, small, measures 5.7 x 1.7cm in size, midrib thin, flat striated, persistent, 2 mm wide, broad at base, thinning upwards, secondary veins arise at acute angles from midrib, run straight to meet margin after dichotomisation and anastomoses, meshes arcuate near midrib, broad, uniform in size elsewhere.

Comparison: Leaf compares in shape and venation pattern with *Glossopteris intermedia* Feistmantel (Feistmantel,

EXPLANATION OF PLATE II

1. ***Glossopteris maheshwarii*** Singh and Chandra, 1987. BSIP Specimen No. 39171. x 3.
2. ***Glossopteris stenoneura*** Feistmantel, 1877 BSIP Specimen No. 39172. x 2.
3. ***Glossopteris angusta*** Pant and Gupta, 1971. x 3. BSIP Specimen No.39173. x 3.
4. ***Glossopteris leptoneura*** Bunbury, 1861. x 3. BSIP Specimen No.39174C. x 3.
5. ***Glossopteris tenuifolia*** Pant and Gupta, 1968. x 3.Middle portion of a leaf. BSIP Specimen No.39175B. x 3.
6. ***Glossopteris brongniartii*** Pant and Gupta, 1968. x 1.7. BSIP Specimen No.39130A.
7. ***Glossopteris communis*** Feistmantel, 1876a. x 1.5. BSIP Specimen No.39244
8. ***Glossopteris vulgaris*** Pant and Gupta, 1968. x 3 Middle portion of a leaf. BSIP Specimen no. 39245. x 3.
9. ***Glossopteris tenuifolia*** Pant and Gupta, 1968. x 2. Basal portion of a leaf. BSIP Specimen No.39246B. x 2.

Plate II



1881, pl.29A, fig.6; Chandra and Surange, 1979, pl.6, fig.10, pl.18, fig.10, pl.21, fig.3, pl.27, fig.2, pl.43, fig.1).

Glossopteris kamthiensis Singh & Chandra, 1987
(Pl. I, figs.1-3)

Description: Leaves almost complete, extremely narrow, shape lorate, oblong , apex acuminate, base acute-normal, margin entire, measure 2.4 to 3.1 x 0.5 to 0.8 cm in size, midrib distinct, elevated, persistent, 0.5 mm wide, secondary veins thin, arise at acute angles from midrib, arch backwards, meet margin at 45 to 55° after dichotomization, anastomose two to three times from midrib to margin, meshes arcuate near midrib, elongate, narrow, polygonal elsewhere, almost uniform in size, smaller near margin.

Comparison: Leaves compare in shape, nature of apex and venation pattern with *Glossopteris kamthiensis* (Singh and Chandra, 1987, pl.1.figs.7,8, text-fig. 2F).

Number of specimens: Two.

Glossopteris leptoneura Bunbury, 1861
(Pl. II, fig. 4)

Description: Single specimen present in the collection, apical half of leaf preserved, leaf long and narrow, shape apparently linear, apex acute, margin entire, measures 4.5 x 1.1cm in size, midrib faint in apical part, secondary veins arise at acute angles from midrib, slightly curve backwards to meet margin after dichotomisation and anastomoses, meshes arcuate elongate, slightly broad near midrib, smaller and narrower near margin.

Comparison: Leaf compares in nature of apex and venation pattern with *Glossopteris leptoneura* (Bunbury, 1861, pl. 9, figs.1-4; Chandra & Surange, 1979, pl.44, fig.2; Chandra and Singh, 1992, pl.1, fig.2, pl.2, fig.3).

Glossopteris longicaulis Feistmantel, 1880b
(Pl. IV, fig. 8)

Description: Fragmentary incomplete leaf present in collection, only basal half of leaf preserved, measures 13.5 x 3.0 cm in size, petiolate, shape and apex unknown, base obtuse-normal, margin entire, midrib broad, strong, flat, striated, 4 mm wide in basal region, occupying almost the entire width of base and petiole, 2 mm wide further up, secondary veins thin, numerous, arise at acute angles from midrib, arch backwards to meet margin after dichotomisation and anastomoses, meshes arcuate near midrib, elongate, narrow, elsewhere, venation dense.

Comparison: Leaf compares in petiolate base, nature of midrib and in venation pattern with *Glossopteris longicaulis* (Feistmantel, 1880b, pl.31, figs.1, 3; Chandra and Surange, 1979; pl.1, fig. 4, pl.15, fig. 13).

Glossopteris maheshwarii Singh & Chandra, 1987
(Pl. I, fig.4; Pl. II, fig.1; Pl. III, fig.7)

Description: Leaves almost complete, small, extremely narrow, shape narrow elliptic to narrow oblong , apex acute, base acute-normal, margin entire, measure 2.6 to 3.0 x 0.6 to 1.0 cm in size, midrib distinct, striated, persistent, 0.5 mm wide, secondary veins arise at acute angles from midrib, arch backwards, bifurcate and anastomose to form small, narrow, uniform meshes, meshes arcuate near midrib, narrow, polygonal elsewhere.

Comparison: Leaves compare in shape, nature of apex and venation pattern with *Glossopteris maheshwarii* (Singh and Chandra, 1987, pl.1.figs.2, 3, 4, 5, text-fig. 1 A-C).

Number of specimens: Two.

Glossopteris mohudaensis Chandra & Surange, 1979
(Pl. IV, fig. 7)

Description: Single specimen present in the collection, leaf incomplete, only basal part preserved, base narrow, attenuate, margin entire, leaf measures 7.0 x 1.5 cm in size, midrib distinct, 2mm wide, striated, secondary veins arise at acute angles from midrib, curve gently to meet margin after dichotomisation and anastomoses, meshes deltoid to angled near midrib, broad, polygonal elsewhere.

Remarks: Leaf is comparable with *Glossopteris mohudaensis* Chandra & Surange (Chandra and Prasad, 1981, pl.3, fig.24, pl.4, fig.33) in venation pattern. Chandra and Surange (1979) instituted this species and described the secondary veins as taking a straight course and meshes as elongate and narrow. However, Chandra and Prasad (1981) described the meshes of same species as broad elongate. Their photographs also do not show a horizontal course of secondary veins as described earlier. The venation pattern and shape of meshes of present leaf is exactly similar to this leaf as mentioned earlier. It is possible that course of secondary veins in middle portion (Chandra & Surange , 1979, pl.11, fig.2, pl.18, fig.14) is slightly different (horizontal) as compared to that in basal portion as is the case in present leaf.

Glossopteris musaefolia Bunbury, 1861
(Pl. III, fig. 3)

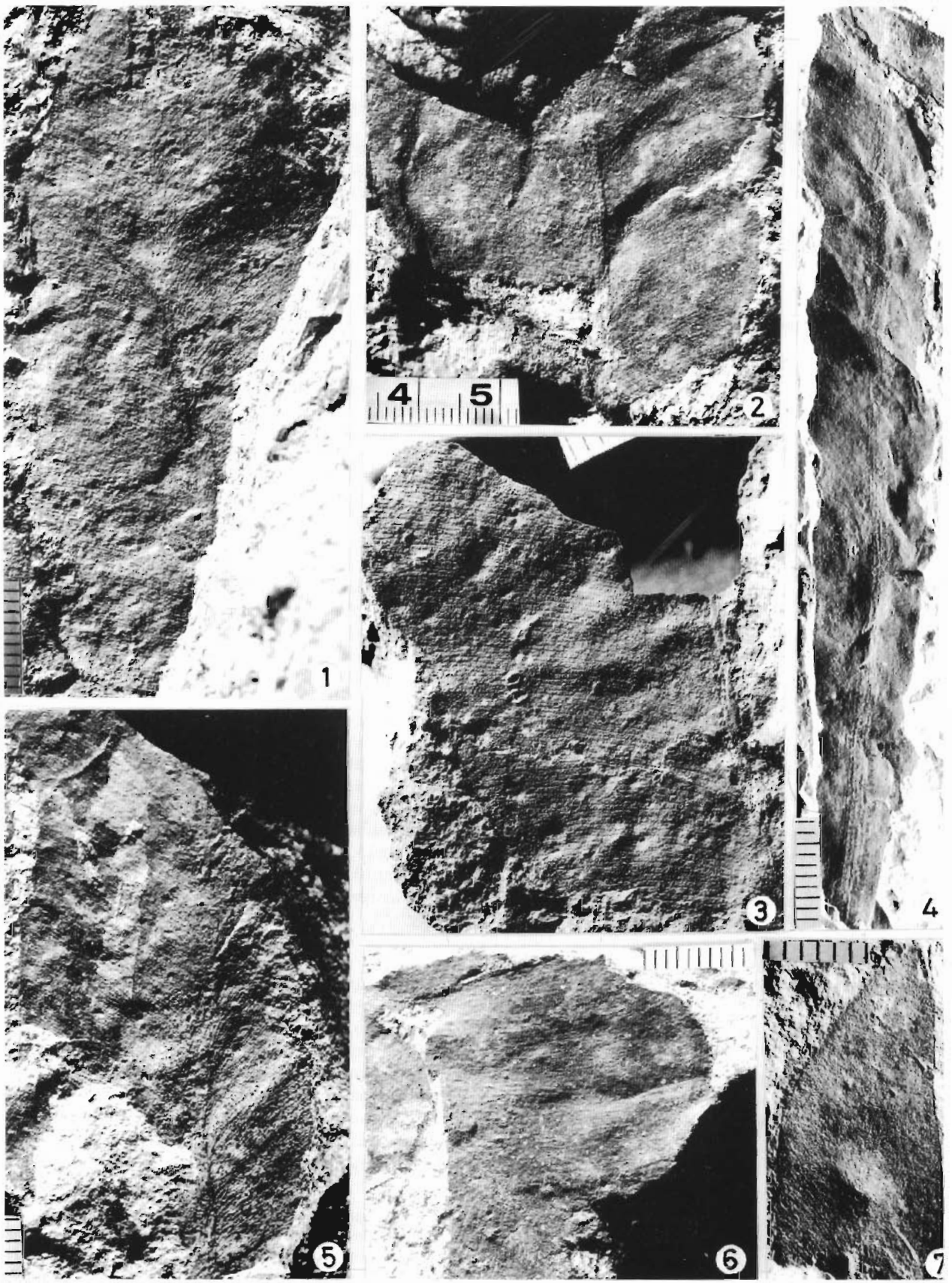
Description: Single specimen present in the collection, only half portion of lamina on one side of midrib of middle part of leaf preserved, margin entire, leaf measures 8.5 x 2.5 cm in size, midrib distinct, strong, striated, 1 mm wide, secondary veins arise at acute angles from midrib, and run straight, almost horizontal to meet margin after dichotomisation and anastomoses, meshes arcuate near midrib, elongate, narrow, almost uniform in size in between midrib and margin, smaller and narrower near margin.

Comparison: Leaf compares in venation pattern with *Glossopteris musaefolia* (Bunbury, 1861, pl.8, fig.6, Chandra and Surange, 1979, pl.18, fig. 13; Chandra and Prasad, 1981, pl.2, fig.14, pl.4, fig.34, text-fig. 3 N, O).

EXPLANATION OF PLATE III

1. ***Glossopteris syaldiensis*** Chandra and Surange, 1979, apical half of a leaf. BSIP Specimen No.39247. x 2.
2. ***Glossopteris subtilis*** Pant and Gupta, 1971, fragmentary specimen showing venation pattern. BSIP Specimen No.39174A. x 3.
3. ***Glossopteris musaefolia*** Bunbury, 1861, fragmentary specimen showing venation pattern. BSIP Specimen No.39165B. x 3.
4. ***Glossopteris tenuifolia*** Pant and Gupta, 1968, an incomplete leaf. BSIP Specimen No.39175A. x 2.
5. ***Glossopteris syaldiensis*** Chandra and Surange, 1979, middle portion of a leaf. BSIP Specimen No. 39174B. x 2.
6. ***Glossopteris rhabdotaenioides*** Pant and Singh, 1971, fragmentary specimen showing venation pattern. BSIP Specimen No.39249. x 2.
7. ***Glossopteris maheshwarii*** Singh and Chandra, 1987, leaf showing acute apex. BSIP Specimen No. 39250. x 3.

Plate III



Glossopteris retifera Feistmantel, 1880a
(Pl. I, fig. 9)

Description: Leaves incomplete, only middle part preserved, margin broken, entire wherever preserved, leaves measure 3.7 to 5.8 x 1.7 to 1.9 cm in size, midrib distinct, 1 mm wide, secondary veins arise at acute angles from midrib, curve gently to meet margin after dichotomisation and anastomoses, meshes short and broad deltoid to angled near midrib, pentagonal to hexagonal in between midrib and margin, shorter and narrower near margin.

Comparison: Leaves are comparable with *Glossopteris retifera* (Feistmantel, 1881, pl.28A, figs. 2,7,10, pl.41A, fig.9) in venation pattern.

Number of specimens: Two.

Glossopteris rhabdotaenioides Pant & Singh, 1971
(Pl. III, fig. 6)

Description: Single specimen present in the collection, only half portion of lamina on one side of midrib of middle part of leaf preserved, margin entire, leaf measures 3.5 x 2.5 cm in size, midrib broken, secondary veins arise at acute angles from midrib, apparently perpendicular to midrib and run straight to meet margin after dichotomisation and anastomoses, meshes deltoid, angled near midrib, elongate, broad, polygonal between midrib and margin, narrower near margin.

Comparison: Leaf compares in venation pattern with *Glossopteris rhabdotaenioides* (Pant and Singh, 1971, pl.7, figs. 41, 45; Chandra and Surange, 1979, pl.9 fig. 5, pl.13, fig.1, pl.18, fig.6, pl.20, fig.3, pl.33, fig.1).

Glossopteris stenoneura Feistmantel, 1877
(Pl. II, fig. 2; Pl. IV, fig. 6)

Description: Complete leaf not preserved, middle parts measuring 4.2 to 4.5 x 1.5 cm in size present in collection, margin entire, midrib, flat, thin, evanescent, 1mm wide, secondary veins arise at acute angles from midrib, curve backwards to meet margin after dichotomisation and anastomoses, meshes arcuate near midrib, narrow, elongate, trapezoidal elsewhere, venation dense.

Comparison: Leaf compares in venation pattern with *Glossopteris stenoneura* (Chandra & Surange 1979, pl.1, fig.7, 8, pl.15, fig.8, pl.17, figs.1, 4, Srivastava & Tewari 2001, pl.2, fig.2; Tewari and Srivastava 2000a, pl.1, fig.3, 2000b, pl.1, fig.2).

Number of specimens: Two.

Glossopteris subtilis Pant & Gupta, 1971
(Pl. III, fig. 2, Pl. IV, fig. 2)

Description: Middle portions of leaves present in the collection, margin entire, leaves measures 5.0 to 6.8 x 2.4 to 4.8 cm in size, midrib distinct, flat, striated, 1 to 1.5 mm wide, secondary veins arise at acute angles from midrib, arch backwards, continue straight to meet margin after dichotomisation and anastomoses, meshes angled and deltoid near midrib, elongate, oblong, polygonal in shape elsewhere, apparently uniform in size.

Comparison: Leaf compares in venation pattern and in having oblong, polygonal meshes with *G. subtilis* Pant and Gupta (Pant & Gupta, 1971, text-fig.2 B, C, Chandra and Surange, 1979, pl.3, fig.7, pl.14, fig.3, pl.21, fig.2, pl.22, figs.3, 12; Singh and Chandra, 1996, pl.1, fig.1 pl.3, fig.3).

Number of specimens: Two.

Glossopteris syaldiensis Chandra & Surange, 1979
(Pl. III, figs. 1, 5)

Description: Single specimen present in the collection, middle part of leaf preserved, margin entire, leaf measures 5.0 x 2.5 cm in size, midrib thin, flat, striated, 1mm wide, secondary veins arise at acute angles from midrib, arch slightly backwards to meet margin after dichotomisation and anastomoses, meshes arcuate, short and broad near midrib, elongate, narrow elsewhere.

Comparison: Leaf compares in venation pattern with *Glossopteris syaldiensis* (Chandra & Surange, 1979, pl.2, fig. 1, pl.15, fig.5, pl.43, fig.4).

Glossopteris tenuifolia Pant & Gupta, 1968
(Pl. II, figs. 5, 9; Pl. III, fig. 4; Pl. IV, fig. 5)

Description: Leaves incomplete, different parts preserved separately, shape linear, lorate, apex acute, base attenuate, margin entire, leaves measure 5.5 to 8.3 cm x 1.0 to1.5 cm in size, midrib thin, flat, striated, 2 mm wide at base, gradually tapering upwards where 1 to 2 mm wide, secondary veins arise at acute angles from midrib, arch backwards to meet margin after dichotomisation and anastomoses, meshes arcuate near midrib, long, narrow, trapezoidal elsewhere.

Comparison: Leaves are comparable in shape, apex, base and venation pattern with *G. tenuifolia*.(Pant and Gupta, 1968, pl.21, fig.15, Chandra and Surange, 1979, pl.6, fig.1, pl.15, fig.10, pl.17, fig.10, pl. 42, figs.1, 6).

Number of specimens: Four.

Glossopteris vulgaris Pant & Gupta, 1968
(Pl. II, fig. 8)

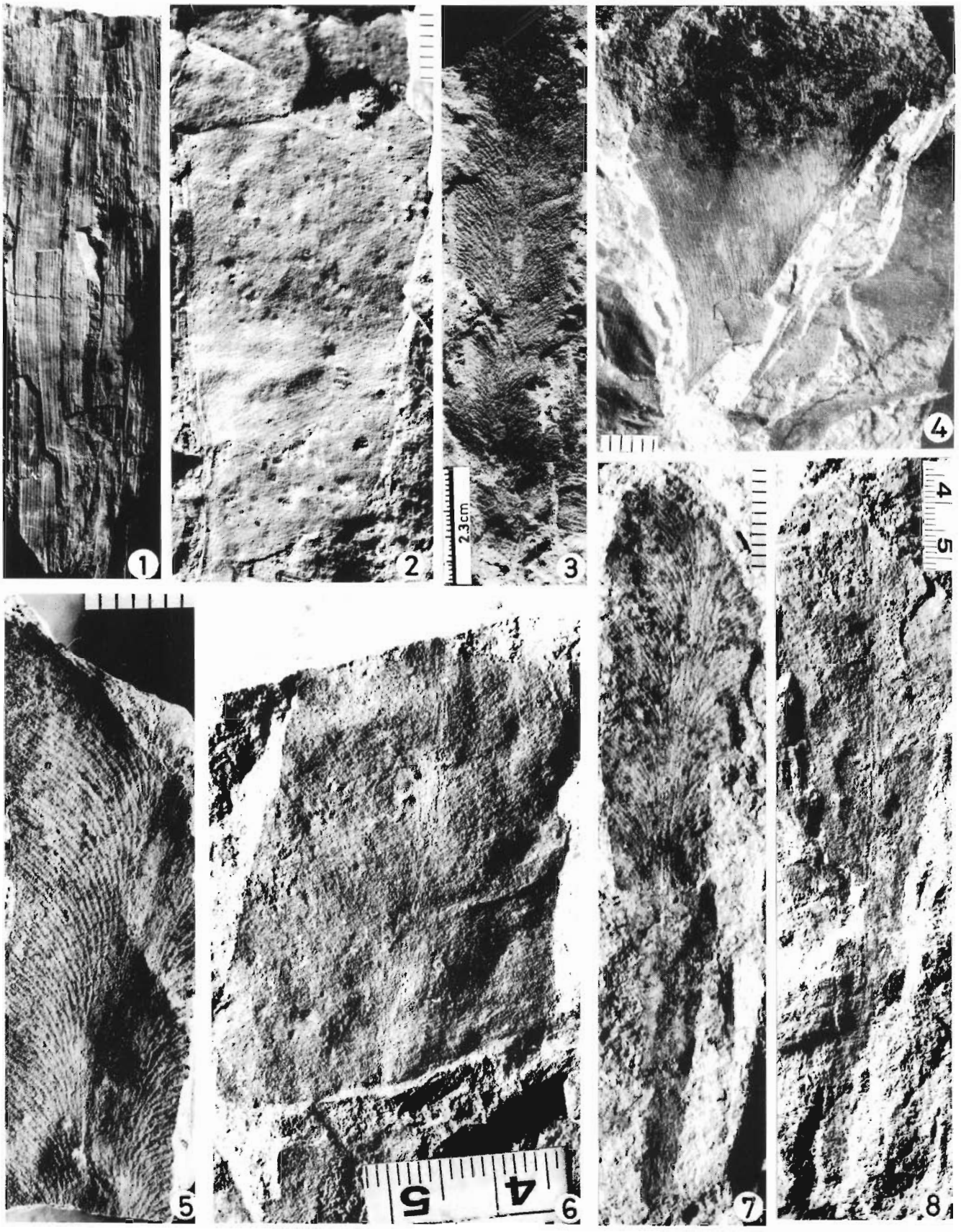
Description: Leaf incomplete, middle part of leaf preserved, margin entire, leaf narrow, small, measure 3.8 x 1.0 cm in size, midrib thin, flat 1 mm wide, secondary veins arise at acute angles from midrib, slightly curve backwards, run straight to meet margin after dichotomisation and anastomoses, meshes arcuate near midrib, elongate, slightly broad elsewhere.

Comparison: Leaf compares with *Glossopteris vulgaris*

EXPLANATION OF PLATE IV

1. **Equisetalean axis**, an unbranched axis showing nodes and internodes with alternating ridges and furrows. BSIP Specimen No. 39251. x 1.
2. ***Glossopteris subtilis*** Pant and Gupta, 1971, fragmentary specimen showing venation pattern. BSIP Specimen No. 39252. x 3.
3. ***Glossopteris barakarensis*** Kulkarni, 1971, leaf. showing venation pattern. BSIP Specimen No. 39176B. x 2.3.
4. ***Glossopteris indica*** Schimper, 1869 Fragmentary specimen showing venation pattern. BSIP Specimen No. 39253. x 2.
5. ***Glossopteris tenuifolia*** Pant and Gupta, 1968, middle portion of a leaf showing venation pattern. BSIP Specimen No. 39254. x 2.
6. ***Glossopteris stenoneura*** Feistmantel, 1877, middle portion of a leaf. showing venation pattern. BSIP Specimen No. 39246A. x 2.
7. ***Glossopteris mohudaensis*** Chandra and Surange, 1979, basal portion of a leaf showing venation pattern. BSIP Specimen No. 39255. x 2.
8. ***Glossopteris longicaulis*** Feistmantel, 1880, basal portion of a leaf. showing petiole. BSIP Specimen No. 39256. x 2.

Plate IV



TEWARI

Table 2: Distribution of plant fossils from the Kamthi Formation of the Wardha Basin in Godavari and Mahanadi basins.

Name of Taxa	Wardha Basin	Godavari Basin	Mahanadi Basin
Angiopteridium cf. A.maclellandi (Morris) Schimper 1869 (in Feistmantel 1881)	*		
Dizeugotheca phegopteroides (Feistmantel) Maithy 1975	*		*
Neomariopteris hughesii (Zeiller) Maithy1974	*		*
Neomariopteris polymorpha (Feistmantel) Maithy1974	*		*
•Equisetalean axes	*		*
Schizoneura gondwanensis Feistmantel 1879a	*		*
Phyllotheca indica Bunbury 1861	*		*
Raniganjia bengalensis (Rigby) Pant & Nautiyal 1968	*		*
Tryzygia speciosa Royle 1839	*		*
Gangamopteris hughesii Feistmantel 1876b	*		
•*Glossopteris angusta* Pant & Gupta 1971			
• *Glossopteris angustifolia* Brongniart 1828	*	*	*
Glossopteris arberi Srivastava 1957	*		*
•*Glossopteris barakarensis* Kulkarni 1971			
Glossopteris bosei Chandra & Surange 1979	*		*
•*Glossopteris brongniartii* Pant and Gupta1968	*		
Glossopteris browniana Brongniart. Royle 1839	*	*	*
•*Glossopteris communis* Feistmantel 1876a	*	*	*
Glossopteris conspicua Feistmantel 1880a	*		*
Glossopteris damudica Feistmantel 1879b	*		*
Glossopteris danae Maheshwari & Tewari 1992	*		
Glossopteris decipiens Feistmantel 1879a	*		
Glossopteris emarginata Maheshwari & Prakash 1965	*		
Glossopteris feistmantelii Rigby 1964	*		*
Glossopteris gigas Pant & Singh 1971	*		*
•*Glossopteris hinjridaensis* Singh and Chandra 1987	*		*
•*Glossopteris indica* Schimper 1869	*	*	*
•*Glossopteris intermedia* Feistmantel 1880a	*		
Glossopteris intermittens Feistmantel 1881	*		
•*Glossopteris kamthiensis* Singh and Chandra 1987	*		*
Glossopteris lanceolatus Pant & Singh 1971	*		*
•*Glossopteris leptoneura* Bunbury 1861	*		*
•*Glossopteris longicaulis* Feistmantel 1880b	*		
•*Glossopteris maheshwarii* Singh and Chandra 1987	*		*
•*Glossopteris mohudaensis* Chandra & Surange 1979	*		*
•*Glossopteris musaefolia* Bunbury 1861	*		
•*Glossopteris retifera* Feistmantel 1880a	*		*
• *Glossopteris rhabdotaenioides* Pant & Singh 1971	*		
Glossopteris spathulata Pant & Singh 1971	*		*
• *Glossopteris stenoneura* Feistmantel 1877	*		*
Glossopteris stricta Bunbury 1861	*		*
•*Glossopteris subtilis* Pant & Gupta1971	*		*
Glossopteris surangei Chandra & Prasad 1981	*		
•*Glossopteris syaldiensis* Chandra & Surange 1979	*		*
Glossopteris taeniensis Chandra & Surange 1979	*		*
•*Glossopteris tenuifolia* Pant & Gupta 1968	*		*
Glossopteris venustus Chandra & Prasad 1981	*		
•*Glossopteris vulgaris* Pant and Gupta 1968	*		*
Glossopteris sp.	*		
Filicites (in Bunbury 1861)	*		*
Dictyopteridium sporiferum Feistmantel *1880a*	*		*
Rhabdotaenia danaeoides (Royle) Pant 1958	*		
Cycadinocarpus (in Hughes 1877)	*		
Samaropsis ganjrensis Saksena 1956	*		
Vertebraria indica Royle 1839	*		*
Noeggerathiopsis hislopii Feistmantel 1879a	*		
Noeggerathiopsis sp.	*		
Macrotaeniopteris feddenii Feistmantel 1881	*		
Rhipidopsis densinervis Feistmantel 1881	*		
Rhipidopsis gondwanensis Chitnis & Vagyani 1979	*		

• *Glossopteris* species recorded in the present study

Note: The table does not include fossil woods.

(Pant and Gupta, 1968, pl.24, fig. 34; Chandra and Surange, 1979, pl.6, fig.9, pl.15, fig.9, pl.42, fig.5) in venation pattern.

Number of specimens: Two.

FLORAL COMPARISON

In addition to the Kamptee (Bunbury, 1861; Chitnis and Vagyani, 1979; Chandra and Prasad, 1981) and Wardha Valley coalfields of the Wardha Basin, Kamthi Formation has been identified in the Godavari and Mahanadi basins (Table 2). Though megafloral records from the Mahanadi Basin are rich (Chandra and Singh, 1992; Singh and Chandra, 1987, 2000; Pal *et al.*,1991; Pal and Ghosh, 1997), those from Godavari are sporadic (Brongniart, 1828; Royle, 1839; Schimper, 1869; Feistmantel, 1876b). A comparative analysis of the floral constituents of the Kamthi Formation from Wardha, Godavari and Mahanadi basins exhibits similarity in their floras, thereby indicating the same age, i.e. Upper Permian.

DISCUSSION

The present study and the review of earlier work reveal that a rich flora belonging to different plant groups existed in the Wardha Valley Coalfield during deposition of the Kamthi sediments. The flora consisting of filicales, equisetales, glossopteridales, cordaitales and ginkgoales is similar to that of the Raniganj Formation of the Damodar Basin (Lele, 1976) that has been assigned an Upper Permian age. It is also comparable with the Kamthi flora of Handappa, Mahanadi Basin (Singh and Chandra, 1987; Chandra and Singh, 1992). Besides the present report, the species *G. kamthiensis*, *G. hinjridaensis*, *G. maheshwarii* are reported only from the Mahanadi Basin. The Presence of these species along with *G. angusta, G. angustifolia, G. barakarensis, G. brongniartii, G. communis, G. indica, G. intermedia, G. leptoneura, G. longicaulis, G. mohudaensis, G. musaefolia, G. retifera, G. rhabdotaenioides, G. stenoneura, G. subtilis, G. syaldiensis, G. tenuifolia* and *G. vulgaris* in the Kamthi Formation of Wardha Basin indicates similarity with the Kamthi flora of the Mahanadi Basin that has also been assigned an Upper Permian age (Chandra and Singh, 1992). Additionally, the present assemblage also shows a variety of only typical Upper Permian species of the genus *Glossopteris*. Jha and Srivastava (1996) and Srivastava and Jha (1997) assigned a Lower Triassic age to the Kamthi Formation on the basis of palynological records. According to them, occurrence of the elements of *Glossopteris* flora in the Triassic reflects continuation of Permian elements. Endeavour for search of typical *Dicroidium* floral constituents in the Kamthi Formation is required for assignment of Triassic age to this Formation with precision..

ACKNOWLEDGEMENTS

The author is thankful to Dr. N. C. Mehrotra, Director, Birbal Sahni Institute of Palaeobotany, Lucknow, for providing necessary facilities to carry out this work.

REFERENCES

Agashe, S. N. and Chitnis S.R. 1971.Studies on the fossil gymnosperms, Part III. *Prototaxoxylon andrewsii* a new species of taxinean wood from the Lower Gondwana strata. *Palaeontographica*, **113B**: 52-60.

Agashe, S. N. and Prasad K.R. 1989. Studies on fossil gymnospermous woods- Part VII: Six new species of Lower Gondwana (Permian) gymnospermous woods from Chandrapur District of Maharashtra state, India. *Palaeontographica*, **212B**: 71-102.

Agashe, S. N. and Shashi Kumar, M.S. 1996. Studies in fossil gymnospermous woods- Part VIII: A new species of *Araucarioxylon* i.e. *A. wejgaoense* from Lower Gondwana Strata of Chandrapur District of Maharashtra, India. *Palaeobotanist*, **45**: 15-19.

Agashe, S. N. and Shashi Kumar, M.S. 2001. Studies in fossil gymnospermous woods- Part X; Three new species of *Araucarioxylon* from Lower Gondwana Strata of Chandrapur District of Maharashtra, India. *Palaeobotanist*, **50**: 381-393.

Brongniart. A. 1828. Histoire des vegetaux fossils ou recherches botaniques et geologiques sur les vegetaux renfermes dans les diverse couches du globe. *Prodomus d'une histoire des vegetaux fossils*, **1**: 1-488.

Bunbury, C.J.F. 1861. Notes on a collection of fossil plants from Nagpur, central India. *Quarterly Journal of Geological Society London*, **17**: 325-346.

Chandra, S. and Prasad, M.N.V. 1981. Fossil plants from the Kamthi Formation of Maharashtra and their biostatigraphic significance. *Palaeobotanist*, **28-29**: 99-121.

Chandra, S. and Singh, K. J. 1992. The genus *Glossopteris* from the Late Permian beds of Handapa, Orissa, India. *Review of Palaeobotany and Palynololgy*, **75**: 183-218.

Chandra, S. and Surange, K. R. 1979. *Revision of the Indian species of Glossopteris. Monograph 2*. Birbal Sahni Institute of Palacobotany, Lucknow.

Chandra, S. and Tewari, R. 1991. A catalogue of fossil plants from India. Part 2. Palaeozoic and Mesozoic megafossils. Birbal Sahni Institute of Palacobotany, pp.1-81, Lucknow.

Chitnis, S.R. and Vagyani, B. A. 1979. Additions to the Glossopteris Flora from the Kamthi beds near Satnavri, District Nagpur, (M.S.). *Geophytology*, **9**: 62-64.

Feistmantel, O. 1876a. On some fossil plants from the Damuda series in the Raniganj Coalfield, collected by Mr. J. Woodmason. *Journal of the Asiatic Society Bengal*, **45**: 329-380.

Feistmantel, O. 1876b. Notes on the age of some fossil floras in India-VII. Flora of the Jabalpur Group in South Rewah, near Jabalpur and in the Satpura Basin. *Records of Geological Survey of India*, **9(4)**: 125-129.

Feistmantel, O. 1877. Notes on fossil floras in India-XI. Note on plant fossils from Barakar District (Barakar Group). *Records of the Geological Survey of India*, **10**: 73-74.

Feistmantel, O. 1879a. The fossil flora of the Lower Gondwanas- 1. The flora of the Talchir-Karharbari beds. *Memoirs of the Geological Survey of India, Palaeontologia indica series, 12*, **3 (1)**: 1-48.

Feistmantel, O. 1879b. Palaeontological notes from the Satpura Coal Basin. *Records of Geological Survey of India*, **12(1)**: 74-83.

Feistmantel, O. 1880a. The fossil flora of the Lower Gondwanas- 2. The flora of the Damuda and Panchet divisions. *Memoirs of the Geological Survey of India, Palaeontologia indica series, 12*, **3 (2)**: 1-77.

Feistmantel, O. 1880b. The fossil flora of the Lower Gondwanas- 1 (Suppl.) The flora of the Talchir-Karharbari beds. *Memoirs of the Geological Survey of India, Palaeontologia indica series, 12*, **3 (1)**: 49-64.

Feistmantel, O. 1881. Fossil flora of the Gondwana System. 3. (Lower Gondwanas) 3.The flora of the Damuda and Panchet divisions. *Memoirs of the Geological Survey of India, Palaeontologia indica series, 12*, **3 (3)**: 78-149.

Feistmantel, O. 1882. The fossil flora of the Gondwana System.in India-1. The fossil flora of the South rewah Gondwana Basin. *Memoirs of the Geological Survey of India, Palaeontologia indica series, 12*, **3 (4)**: 1-52.

Jha, N. and Srivastava, S. C. 1996. Kamthi formation-Palynofloral diversity, 355-368. In: *Gondwana nine* (Eds. Guha, P. K. *et al.*), 1 (of 2), New Delhi.

Kulkarni, S. 1971. *Glossopteris* and *Gangamopteris* species from South Karanpura Coalfield. *Palaeobotanist*, **18**: 297-304.

Lawrence, G. H. M. 1955. *An introduction to plant taxonomy*. The Macmillan Company, New York.

Lele, K. M. 1976. Late Palaeozoic and Triassic floras of India and their relation to the floras of northern and southern hemispheres. *Palaeobotanist*, **23**: 89-115.

Maheshwari, H.K. & Pradash, G. 1965. Studies in the Glossopteris flora of India-21. Plant mega fossils from the Lower Gondwana exposwes along Bansloi River in Rajmahal Hills, Bihar. *Palaeobotanist*, **13(2)**: 115-128.

Maithy, P.K. 1974. A revision of the Lower Gondwana *Sphenopteris* from India. *Palaeobotanist*, 21(1): 70-80.

Maithy, P.K. 1975. Some contribution to the knowledge of Indian Lower Gondwana ferns. *Palaeobotanist.* **22(1)**: 29-38.

Melville, R. 1969. Leaf venation patterns and origin of angiosperms. *Nature*, **224**: 121-125.

Pal, P. K. and Ghosh, A.K. 1997. Megafloral zonation of Permian-Triassic sequence in the Kamthi Formation, Talcher Coalfield, Orissa. *Palaeobotanist*, **46**: 81-87.

Pal, P. K., Chakraborty, U. and Ghosh, A.K. 1991. Triassic plant megafossils from the Kamthi Formation of Talcher Coalfield, India-A new report. *Indian Journal of Geology*, **63:** 119-125.

Pant, D.D. 1958. The structure of some leaves and fructifications of the Glossopteris flora of Tanganjika. *Bulletin of the British Museum Natural History* (Geology) London, **3**: 125-175.

Pant, D. D. and Gupta, K. L. 1968. Cuticular structure of some Indian Lower Gondwana species of *Glossopteris* Brongniart- Part I. *Palaeontographica*, **124B**: 45-81.

Pant, D. D. and Gupta, K. L. 1971. Cuticular structure of some Indian Lower Gondwana species of *Glossopteris* Brongniart- Part 2. *Palaeontographica*, **132B**: 130-152.

Pant, D.D. & Nantiyal, D.D. 1968. On the structure of *Raniganjia bengalensis* (Feistmantel) Rigby with a discussion of its affinities. *Palaeontographica*, **121B(1-3)**: 52-64.

Pant, D. D. and Singh, K. B. 1971. Cuticular structure of some Indian Lower Gondwana species of *Glossopteris* Brongniart- Part –III. *Palaeontographiča*, **135B**: 1-40.

Raja Rao, C. S. 1982. Coalfields of India-2.Coal resources of Tamil Nadu, Andhra Pradesh, Orissa and Maharashtra. *Geolological Survey of India Bulletin Series A*, **45**: 9-40.

Rigby, J.F. 1964. Contributions on Palacozoic floras-1. On the identification of *Glossopteris Cordata* Dana. proceedings of Linnacan Society of New South Wales. **89(1)**: 152-154.

Royle, J. F. 1939. Illustrations of the botany and other branches of the natural history of the Himalayan Mountains and of the flora of Cashmere. London.

Schimper, W. P. 1869. *Traité de Paléontologie végétale*. 1. J. b. Bailliere et Fils, Paris.

Singh, K. J. and Chandra, S. 1987. Some new species of *Glossopteris* from the Kamthi Formation of Handapa, Orissa. *Geophytology*, **17:** 39-55.

Singh, K. J. and Chandra, S. 1996. Plant fossils from the exposure near Gopal Prasad Village, Talchir Coalfield, with remarks on the age of bed. *Geophytology*, **26:** 69-75.

Singh, K. J. and Chandra, S. 2000. Additional palacobotanical information from Madhupur Village, Talchir Coalfield, Orissa , India. *Palaeobotanist*, **49:** 385-398.

Singh, K. J., Sarate, Omprakash S., Bhattacharya, A. P. and Goswami, Shreerup 2005. Record of Megafloral Assemblage from the Nand Coalfield, Wardha Basin, Nagpur District, Maharashtra. *Journal of the Geological Society of India*, **66 (3)**: 293-302.

Srivastava, A. K. and Tewari, R. 2001. Lower Gondwana plant fossils from Barren Measures of Jharia Coalfield, Bihar, India, p.127-134. In: *Proceedings of National Seminar on Recent Advances in Geology of Coal and Lignite Basins of India, Calcutta*, 1997 (Eds. Dutta, K. B. *et al.*), **54,** Geological Survey of India Special Publication.

Srivastava, P.N. 1957 Studies in the Glossopteris flora of India-4. *Glossopteris Gangamopteris and Palaeovittaria* from the Ranizanj Coabfield. *Palaeobotanist*, **5(1)**: 1-45.

Srivastava, S. C. and Jha, N. 1997. Status of Kamthi Formation: lithological and palacobotanical evidences. *Palaeobotanist*, **45**: 88-96.

Sundaram, D. and Nandi, A. 1984. Palacobotanical study of Umrer Coalfield, Nagpur, Maharashtra, with special reference to biostratigraphy, p. 315-321. In: *Symposium Evolutionary Botany & Biostratigraphy, Calcutta 1979* (Eds. Sharma A. K. *et al.*), Today & Tomorrow's Printers & Publishers, New Delhi.

Tewari, R. 2007. The *Glossopteris* flora from Kamptee Coalfield, Wardha Basin, Maharashtra, India. *Palaeontographica* **277B:** 43-65.

Tewari, R. and Rajanikanth, A. 2001. Occurrence of Glossopteris Flora, Pisdura Nand-Dongargaon Sub-Basin. *Palaeobotanist*, **50:** 411-414.

Tewari, R. and Srivastava, A. K. 2000. Plant fossil assemblage from the Talchir Formation, Auranga Coalfield, Bihar, India. *Palaeobotanist*, **49**: 23-30.

Varadpande, D.G. 1977a. *Dadoxylon satnauriense,* A new species of Petrified Gymnosperm wood from the Lower Gondwanas of India. *Journal of the University of Poona, Science and Technology,* **50**: 157-162.

Varadpande, D.G. 1977b. Fossil Plants from Kamthi Beds of Lower Gondwanas of India. *Journal of the University of Poona, Science and Technology,* **50**: 227-234.

Manuscript Accepted January 2008