

Plant fossils of Maitur Formation: possibly the ultimate stage of *Glossopteris* flora in Raniganj Coalfield, India

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ABSTRACT

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The present paper deals with the plant megafossil assemblage from the Maitur Formation, the lower part of Panchet Group of rocks, unconformably overlain by coal bearing Raniganj Formation in Raniganj Coalfield, West Bengal. The plant fossils are collected from two localities exposed in Nonia Nala Section near Asansol, Burdwan District, West Bengal. The assemblages are represented by the typical elements of *Glossopteris* flora, viz. *Trizygia speciosa*, *Neomariopteris hughesii*, *N. lobifolia*, *Dichotomopteris lindleyii*, *D. ovata*, *Glossopteris indica*, *G. tenuifolia*, *G. emarginata*, *G. angustifolia*, *G. conspicua*, *G. intermedia*, *G. retifera*, *G. gopadensis*, *G. taeniensis*, *Glossopteris* sp. cf. *G. dhenkanalensis*, one new species *G. burdwanensis* sp. nov., glossopterid scale-leaves and seed-like body.

The age of Maitur Formation has been assigned to Early Triassic but the plant fossil assemblages are comparable with the Late Permian plant fossils of Kamthi, Pachhwara and Bijori formations in having narrow leaf forms of *Glossopteris*. The investigation supports the view that there is no floral break at the Raniganj-Panchet Boundary and flora of Maitur Formation in all probability represents the ultimate stage of *Glossopteris* flora in Raniganj Coalfield before the onset of Early Triassic *Dicroidium* flora in Deoli/Hirapur Formation belonging to upper part of Panchet Sequence in Raniganj Coalfield, West Bengal.

Key-words—Plant fossils, Maitur Formation, *Glossopteris* flora, Raniganj Coalfield.

मैतुर शैलसमूह का पादपाशमः भारत के रानीगंज कोयला क्षेत्र में ग्लॉसोप्टेरिस वनस्पतिजात की संभवतः अंतिम अवस्था

पंकज के. पाल, ए.के. श्रीवास्तव एवं अमित के. घोष

सारांश

यह शोध-पत्र मैतुर शैलसमूह से पादप गुरुजीवाश्म समुच्चय से संबंधित है जो पंचेत समूह चट्टानों का निम्न भाग है और पश्चिम बंगाल के रानीगंज कोयला क्षेत्र में कोयला धारी रानीगंज शैलसमूह द्वारा असमान रूप से उपरीशायी है। इन पादप जीवाश्मों को पश्चिम बंगाल में बर्धवान जिले के आसनसोल के निकट नोनिया नाला खंड में अनावरित दो संस्थितियों से एकत्रित किया गया

है। ये समुच्चय ग्लॉसॉप्टेरिस वनस्पतिजात अर्थात् *ट्राइजिगिया स्पेसियोसा*, *निओमेरीप्टेरिस हुगेसीयाई*, एन. *लोबिफोलिया*, *डाइक्रोटोमोपेरिस लिंडलेयाई*, डी. *ओवेटा*, *ग्लॉसॉप्टेरिस इंडिका*, जी. *टेनुईफोलिया*, जी. *इमर्जीनेटा*, जी. *एंगस्टीफोलिया*, जी. *कोन्सुपीकुआ*, जी. *इन्टरमिडिया*, जी. *रेटिफेरा*, जी. *गोपाडेंसिस*, जी. *टेनिएंसिस*, *ग्लॉसॉप्टेरिस* प्रजाति तुलनात्मक जी. *धेनकानालेंसिस*, एक नयी प्रजाति जी. *बर्धवानेंसिस* नवप्रजाति, *ग्लॉसॉप्टेरिड* शल्क-पत्रियां एवं बीज-रूप शरीर के प्ररूपी तत्वों द्वारा निरूपित होता है।

मैतुर शैलसमूह की आयु प्रारंभिक ट्रायसिक को निर्धारित किया गया है परन्तु पादपाशम समुच्चयों की कामथी, पछवाड़ा एवं बिजौरी शैलसमूहों के अंतिम पर्मियन पादपाशमों से तुलना की गई है जिनमें *ग्लॉसॉप्टेरिस* के संकुचित पर्ण रूप हैं। यह अन्वेषण इस दृष्टि को समर्थन करता है कि रानीगंज-पंचेत सीमा पर कोई वनस्पति रोक नहीं है और सभी संभावनाओं में मैतुर शैलसमूह पश्चिम बंगाल के रानीगंज कोयला क्षेत्र में पंचेत अनुक्रम के ऊपरी भाग से संबंधित देवली/हीरापुर शैलसमूह में प्रारंभिक ट्रायसिक *डिक्रोइडियम* वनस्पतिजात के प्रस्थान से पहले रानीगंज कोयला क्षेत्र में *ग्लॉसॉप्टेरिस* वनस्पतिजात की अंतिम अवस्था को निरूपित करता है।

संकेत-शब्द—पादपाशम, मैतुर शैलसमूह, *ग्लॉसॉप्टेरिस* वनस्पतिजात, रानीगंज कोयला क्षेत्र।

INTRODUCTION

THE non-coaliferous horizon overlying the Raniganj Formation in Raniganj Coalfield known by Panchet Group of rock is characterized by alternating beds of coarse feldspathic, micaceous sandstone, thin beds of khaki-green shales and variegated and red clay beds. The sequence was recognized by Blanford (1861) in the type area Panchet Hill (23°37' N: 86°49' E) situated in Raniganj Coalfield, West Bengal.

Panchet Group is classified into the older Maitur Formation comprises of khaki-green shales, greenish-brown mudstones and khaki-green micaceous sandstones whereas Upper Deoli/Hirapur Formation contains yellow-brown sandstone with alternate red clays and variegated clay beds (Sastri *et al.*, 1977).

Feistmantel (1881) for the first time described plant fossils from Maitur Formation exposed in Nonia Nala Section near Asansol. The assemblages are known by *Schizoneura gondwanensis* Feistmantel, *Pecopteris concinna* Presl., *Cyclopteris pachyrhachis* Goppert, *Glossopteris indica* Schimper, *G. communis* Feistmantel, *Oleandridium* comp. *stenoneuron* Schenk and *Samaropsis* ?spp. According to Bose (1974) and Banerji and Bose (1977) the specimens of *Pecopteris concinna*, *Cyclopteris pachyrhachis* and *Oleandridium* comp. *stenoneuron* described by Feistmantel (1881) are of doubtful nature. From the same locality Satsangi and Shah (1970) described a

specimen of fertile organ which they assigned to *Schizoneura gondwanensis* Feistmantel. Later, this material has been described as ?cf. *Kendostrobus* sp. by Banerji and Bose (1977). Satsangi (1973) described ?*Dicroidium* and *Podozamites* sp. from the Panchet beds exposed in the north-western branch of Nonia Nala east of the Kumarpur Village. Banerji and Bose (1977) re-examined the collection of Satsangi (1973) and described ?*Dicroidium/Lepidopteris* and *Podozamites* sp. cf. *P. lanceolatus* Lindley & Hutton. They also reported dispersed fragment of ?*Lepidopteris* type cuticle, *Schizoneura gondwanensis* Feistmantel, *Glossopteris browniana* Brongniart, *G. angustifolia* Brongniart, *G. communis* Feistmantel, *G. conspicua* Feistmantel, *G. retifera* Feistmantel, *Glossopteris* sp. cf. *G. intermedia* Feistmantel, *Macrotaeniopteris* sp. and *Cordaicarpus* sp.

Satsangi *et al.* (1968, 1972) reported a striate-bisaccate pollen rich miofloral assemblage from the Panchet beds of Kumarpur. A detailed account of qualitative and quantitative analysis of the miofloras of these beds has been published by Maheshwari and Banerji (1975). Pal *et al.* (1997) reported megaspore assemblage represented by different species of the genera *Banksisporites*, *Virruiriletes*, *Talchirella*, *Pantiella* and *Maiturisporites*.

MATERIAL AND METHODS

Well preserved plant fossils have been collected from two localities (Fig. 1) of Maitur Formation exposed in Nonia Nala (i) North-western branch (northern bank) of Nonia Nala, about 1.6 km east of Kumarpur Village ($23^{\circ}42'15''$ N : $86^{\circ}57'22''$ E) and (ii) Northern branch of Nonia Nala, near “Indigo” factory, Dhakshindhadka ($23^{\circ}43'24''$ N : $86^{\circ}59'25''$ E). Fossils are preserved in fine grained khaki-green shales in the form of brown or

brownish-grey impressions and all the specimens are devoid of carbon crust. Qualitatively and quantitatively plant fossils are rich in Kumarpur area whereas Dhakshindhadka locality has yielded only the specimens of *Glossopteris* including one new species, *G. burdwanensis* sp. nov. Earlier Feistmantel (1881) and Banerji and Bose (1977) have described plant fossils from present areas but present assemblage records additional record of glossopterid and pteridophytic forms which are new to the flora of Maitur Formation.

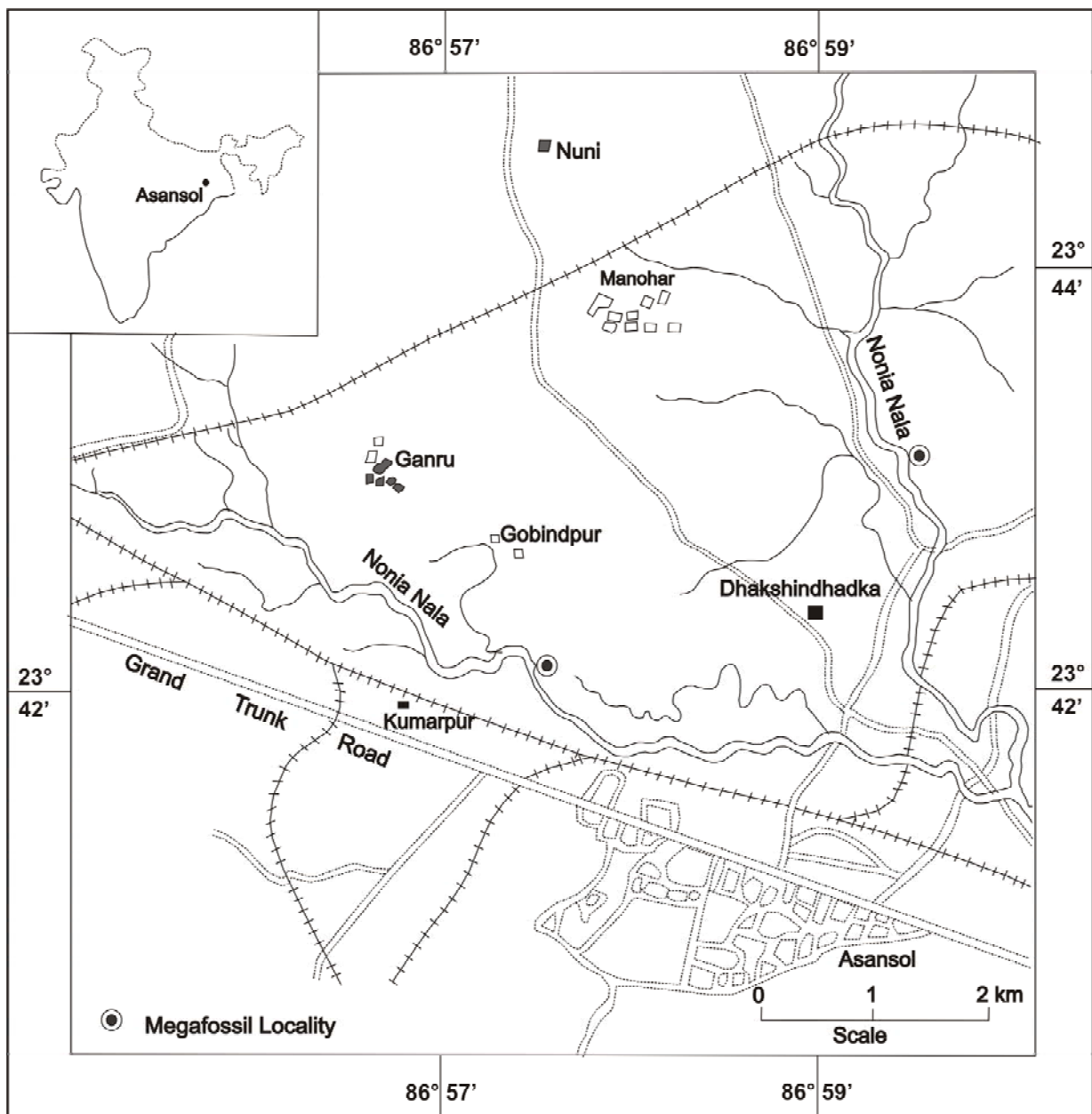


Fig. 1—Map showing the megafossil locality near Asansol, West Bengal.

The fossils were examined under low power binocular and finer details of the samples were studied after soaking the material in xylol or kerosene oil. The comparison of the specimens has normally been made with the known flora of Late Permian and Early Triassic.

LOCALITY 1. PLANT FOSSILS FROM KUMARPUR AREA

Genus—TRIZYGIA ROYLE 1839

Trizygia speciosa Royle 1839

(Pl. 1.1-3; Figs 2A-B)

Remarks—The specimens clearly show the tryzygoid pattern of leaf whorls. *T. speciosa* occurs abundantly in the Raniganj Formation (Upper Permian). Bose and Banerji (1976) have described it from Panchet Formation of Auranga Coalfield.

Genus—NEOMARIOPTERIS MAITHY 1974

Neomariopteris hughesii (Zeiller) Maithy 1974a

(Pl. 1.5-6; Pl. 2.12; Figs 3A-B, 16)

Remarks—Fronds of *N. hughesii* are known by five fragmentary specimens out of which two shows the bipinnate nature and the rest are ultimate pinna-fragments broken at bases. The specimens compare with *Neomariopteris hughesii* (Zeiller) Maithy (1974a) described from the Barakar and Raniganj formations.

Neomariopteris lobifolia (Morris) Maithy 1974a

(Pl. 1.4; Fig. 4)

Remarks—Smooth margin decurrent based pinnules with sphenopteroid venation pattern compare with *N. lobifolia* (Morris) Maithy (1974a) described from the Raniganj Formation (Upper Permian). Bose *et al.* (1977) described a specimen, as *N. sp. cf. N. lobifolia* (Morris) Maithy, from Ramkola-Tatapani Coalfield (Madhya Pradesh).

Genus—DICHOTOMOPTERIS MAITHY

1974

Dichotomopteris lindleyii (Royle) Maithy 1974b

(Pl. 1.7; Fig. 5)

Remarks—The solitary bipinnate frond bearing subopposite pinnules compares with *D. lindleyii* (Royle) Maithy known from the Raniganj Formation (Maithy 1974b, 1975).

Dichotomopteris ovata Maithy 1977

(Pl. 1.8-9; Fig. 6)

Remarks—The ovate shaped pinnules with dichotomizing veins compare with *D. ovata* described by Maithy (1977) from Raniganj Formation of Pachhwara Coalfield, Rajmahal Hills. *D. ovata* is known from Barakar and Raniganj formations.

PLATE 1



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| <p>1-3. <i>Trizygia speciosa</i> Royle, from Kumarpur. 1. Specimen No. K/7(c) x 1. 2. Specimen No. K/39 x 1. 3. Specimen No. K/12 x 1.</p> <p>4. <i>Neomariopteris lobifolia</i> (Morris) Maithy, from Kumarpur. Specimen No. K/28 x 1.</p> <p>5-6. <i>Neomariopteris hughesii</i> (Zeiller) Maithy, from Kumarpur. 5. Specimen No. K/45 x 1. 6. Specimen No. K/38 x 1.</p> <p>7. <i>Dichotomopteris lindleyii</i> (Royle) Maithy, from Kumarpur. Specimen No. K/30(b) x 2.</p> | <p>8-9. <i>Dichotomopteris ovata</i> Maithy, from Kumarpur. 8. Specimen No. K/30(a) x 2. 9. Specimen No. K/53 x 2.</p> <p>10-11. <i>Glossopteris angustifolia</i> Brongniart, from Kumarpur. 10. Specimen No. K/186 x 1. 11. Specimen No. K/191 x 1.</p> <p>12. <i>Glossopteris intermedia</i> Brongniart, from Kumarpur. Specimen No. K/7(a) x 1.</p> <p>13. <i>Glossopteris conspicua</i> Feistmantel, from Kumarpur. Specimen No. K/48 x 1.</p> |
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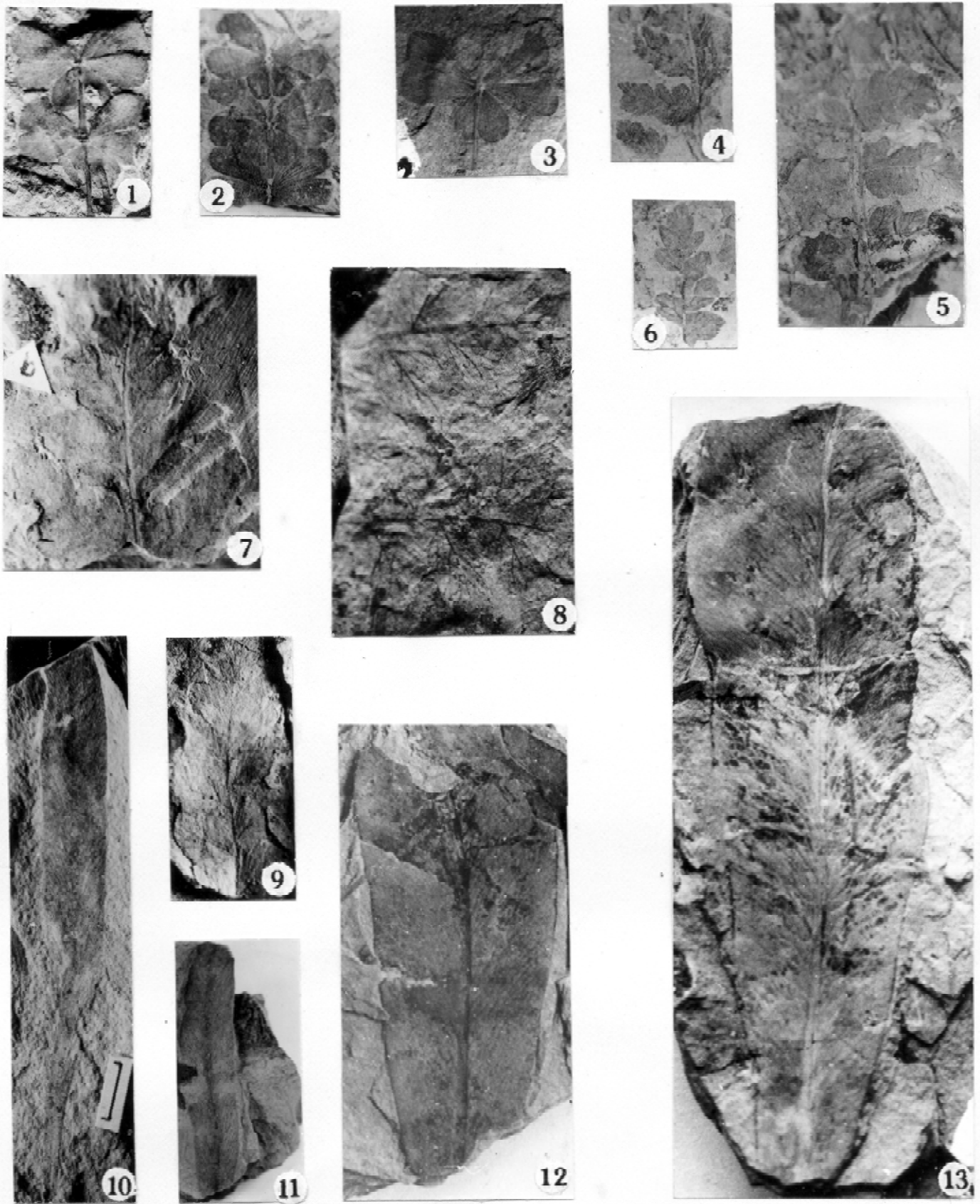


PLATE 1

Genus—GLOSSOPTERIS BRONGNIART
1828

Glossopteris angustifolia Brongniart 1828

(Pl. 1.10-11; Figs 7A-B)

Remarks—This species is represented by twelve fragmentary specimens, largest leaf-measures 7.5 cm in length and 1.5 cm. wide The specimens resemble with *G. angustifolia* described by Brongniart (1828), Bose and Banerji (1976), Banerji and Bose (1977), Banerjee (1978) and Chandra and Surange (1979). *G. angustifolia* has earlier been described from the northern branch of Nonia Nala near the “Indigo” factory bridge by Banerji and Bose, 1977. However, its occurrence in the Kumarpur locality was not known so far.

Glossopteris conspicua Feistmantel 1880

(Pl. 1.13; Fig. 8)

Remarks—This species is represented by a single fragmentary specimen preserved with part and counterpart, 13.2 cm long and it is 4 cm wide comparable with *G. conspicua* described by Feistmantel (1880) and Banerji and Bose (1977) from the northern branch of Nonia Nala near “Indigo” factory (Dhakshindhadka).

Glossopteris intermedia Feistmantel 1880

(Pl. 1.12; Fig. 9)

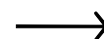
Remarks—This species is represented by three fragmentary specimens and their open elongate mesh compares with *G. intermedia* described by Feistmantel (1880) and Banerji and Bose (1977). This is the first record of the species from Kumarpur locality. The species is characteristic of the flora of Raniganj Formation.

Glossopteris retifera Feistmantel 1881

(Pl. 2.1-3; Figs 10A-C)

Remarks—There are thirty fragmentary leaf impressions in the collection and leaves form open hexagonal mesh pattern closely compare with the leaves of *G. retifera* described by Feistmantel, 1881; Srivastava, 1957; Banerji *et al.*, 1976; Bose *et al.*, 1977; Banerji and Bose, 1977 and Chandra and Surange, 1979. Banerji and Bose (1977) described a fragmentary specimen of *G. retifera* from the northern branch of Nonia Nala, near “Indigo” factory bridge (Dakshindhadha). It is the first record from north-western branch of Nonia Nala, east of Kumarpur. The species is commonly known in the Raniganj and Early Triassic flora of India.

PLATE 2



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| 1-3. <i>Glossopteris retifera</i> Feistmantel, from Kumarpur. 1. Specimen No. K/182 x 1. 2. Specimen No. K/69 x 1. 3. Specimen No. K/1(a) x 1. | 10. Scale leaf types from Kumarpur. Specimen No. K/185 x 2. |
| 4. <i>Glossopteris. gopadensis</i> Banerji <i>et al.</i> from Kumarpur. Specimen No. K/14(b) x 2. | 11. Cupulate seed like organ, from Kumarpur. Specimen No. K/23 x 2. |
| 5-6. <i>Glossopteris taeniensis</i> Chandra & Surange, from Kumarpur. 5. Specimen No. K/18 x 2. 6. Specimen No. K/192 x 2. | 12. <i>Neomariopteris hughesii</i> (Zeiller) Maithy from Kumarpur. Specimen No. K/21(b) x 1. |
| 7. <i>Glossopteris</i> sp. cf. <i>G. dhenkanalensis</i> Singh & Chandra, from Kumarpur. Specimen No. K/76 x 1. | 13. <i>Glossopteris indica</i> Schimper, from Dhakshindhadka. Specimen No. D/51 x 1. |
| 8. Scale leaf - Type A, from Kumarpur. Specimen No. K/73 x 2. | 14. <i>Glossopteris emarginata</i> Maheshwari & Prakash, from Dhakshindhadka. Specimen No. D/50 x 1. |
| 9. Scale leaf - Type B, from Kumarpur. Specimen No. K/26 x 2. | 15. <i>Glossopteris tenuifolia</i> Pant & Gupta, from Dhakshindhadka. Specimen No. D/31 x 1. |
| | 16. <i>Glossopteris hinjridaensis</i> Singh & Chandra, from Dhakshindhadka. Specimen No. D/14 x 2. |

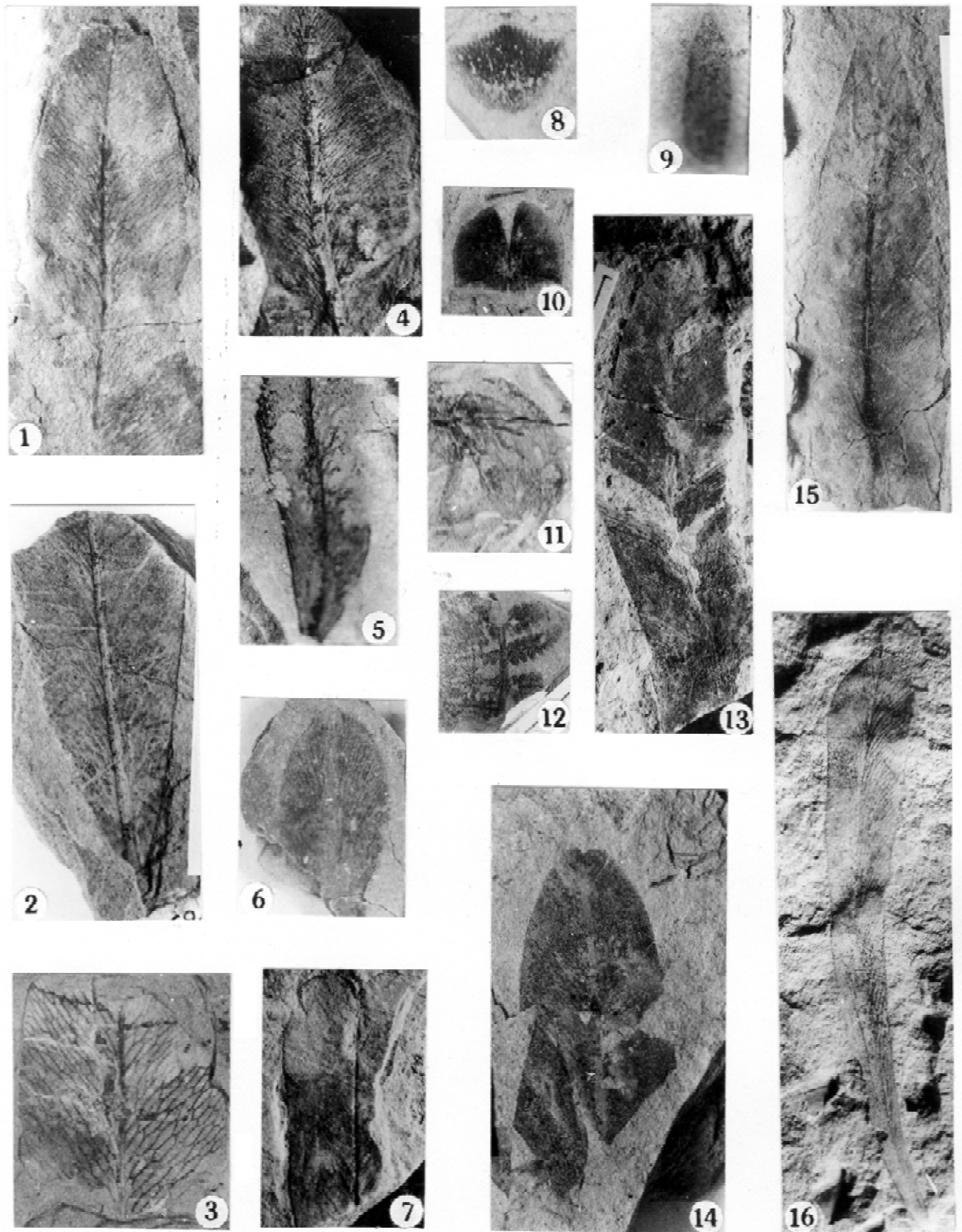


PLATE 2

***Glossopteris gopadensis* Banerji *et al.*, 1976**

(Pl. 2.4; Fig. 11)

Remarks—The solitary specimen, 3.5 cm long and 1.5 cm wide compares with the holotype of *G. gopadensis* described by Banerji *et al.* (1976) from the Triassic beds of Gopad River Section in South Rewa Gondwana Basin.

***Glossopteris taeniensis* Chandra & Surange 1979**

(Pl. 2.5-6; Figs 12A-B)

Remarks—There are five specimens showing the different portion of the lamina. The leaves in having small in size, open, short polygonal meshes compare with *G. taeniensis* instituted by Chandra and Surange (1979). *G. browniana* described by Banerji *et al.* (1976) from the Triassic beds of Gopad River Section, Madhya Pradesh has also been included under *G. taeniensis* by Chandra and Surange (1979).

***Glossopteris* sp. cf. *G. dhenkanalensis* Singh and Chandra 1987**

(Pl. 2.7; Fig. 13)

Remarks—The solitary specimen broken at the basal region, 4.6 cm long and 2.4 cm broad compares with *G. dhenkanalensis* Singh and Chandra (1987) in having broad emarginated apex however, present leaf is larger in size.

Scale leaf: Type-A

(Pl. 2.8; Fig. 14A)

Remarks—Scale leaves rhomboidal in shape with subacute apex and measuring 0.75-1.6 cm in length and 0.9-1.6 cm in width, veins numerous, dichotomizing and forming elongate meshes. These scale leaves are comparable with the scale leaf of glossopteridean fructification *Eretmonia* du Toit 1932. Similar type of

scale leaves have also been described earlier by Banerji *et al.* (1976) from the Lower Triassic of Gopad River Section, Madhya Pradesh.

Scale leaf: Type-B

(Pl. 2.9; Fig. 14B)

Remarks—Solitary fragmentary specimen preserved with part and counterpart measures 1.3 cm long and 0.3 cm wide, appears to be linear-lanceolate in shape, margin entire and acute apex, veins dichotomize, anastomose to form elongated very fine meshes. The specimen is comparable with the scale leaf of glossopterid fructification, *Gondwanolepis* instituted by Banerjee (1984) from the Raniganj Formation.

Scale leaf: Type-C

(Pl. 2.10; Fig. 15A)

Remarks—Forked scale, semi-circular in shape with a deep apical notch, measuring 0.75-0.8 cm having resemblance with the scale leaf of glossopterid fructification *Mahudaea* instituted by Banerjee (1984) from Mahuda Colliery.

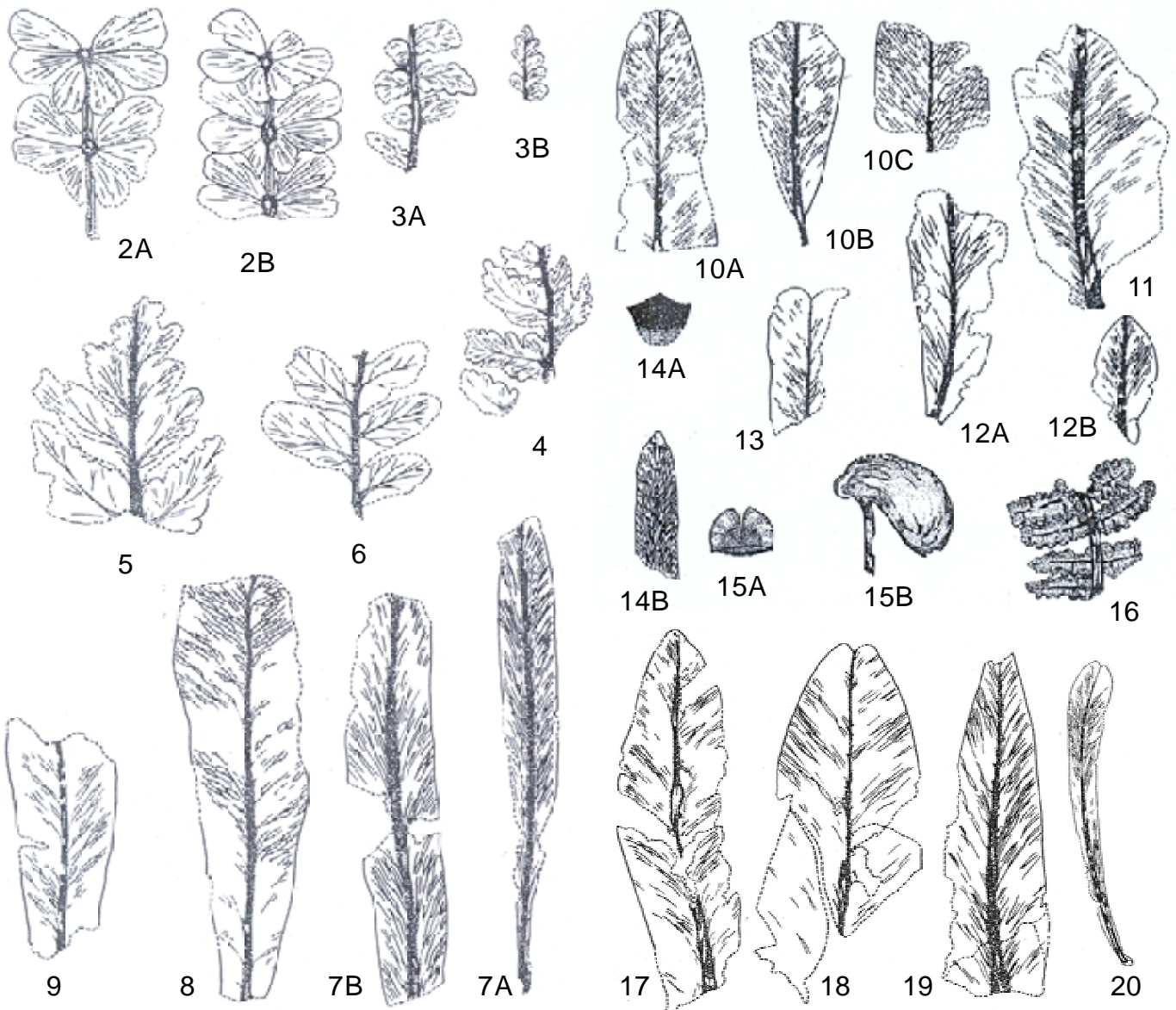
Seed-like organ

(Pl. 2.11; Fig. 15B)

Remarks—The specimen is an impression of a single seed, 1.4 cm long and 0.9 cm wide with slender stalk and it is comparable with the single seed of seed bearing organ of glossopterid fructification *Rusangea* instituted by Lacey *et al.* (1975).

**LOCALITY 2. PLANT FOSSILS FROM
DHAKSHINDHADKA AREA****Genus—GLOSSOPTERIS BRONGNIART**

1828



Figs. 2-20—2A-B. *Trizygia speciosa* Royle 1839 x 1; 3A-B, 16. *Neomariopteris hughesii* (Zeiller) Maithy 1974a 3 x 0.5, 16 x 0.85; 4. *Neomariopteris lobifolia* (Morris) Maithy 1974a x 1; 5. *Dichotomopteris lindleyii* (Royle) Maithy 1974b x 1.4; 6. *Dichotomopteris ovata* Maithy 1977 x 1.5; 7A-B. *Glossopteris angustifolia* Brongniart 1828 7A x 0.7, 7B x 1.5; 8. *Glossopteris conspicua* Feistmantel 1880 x 0.45; 9. *Glossopteris intermedia* Feistmantel 1880 x 0.4; 10A-C. *Glossopteris retifera* Feistmantel 1880 10A x 0.47, 10B-C x 0.5; 11. *Glossopteris gopadensis* Banerji *et al.*, 1976 x 1.4; 12A-B. *Glossopteris taeniensis* Chandra & Surange 1979 12A x 1.4, 12B x 1; 13. *Glossopteris* sp. cf. *G. dhenkanalensis* Singh & Chandra 1987 x 0.5; 14A. Scale leaf: Type-A x 1; 14B. Scale leaf: Type-B x 1.2; 15A. Scale leaf Type-C x 1; 15B. Seed-like organ x 1.5; 17. *Glossopteris indica* Schimper 1869 x 0.65; 18. *Glossopteris emarginata* Maheshwari & Prakash 1965 x 0.8; 19. *Glossopteris tenuifolia* Pant & Gupta 1968 x 0.6; 20. *Glossopteris burdwanensis* sp. nov. x 0.9.

***Glossopteris indica* Schimper 1869**

(Pl. 2.13; Fig. 17)

Remarks—There are eleven fragmentary leaf

impressions which compare with *G. indica* Schimper in having shorter meshes near the midrib and narrow-elongate meshes towards the margin as described by Feistmantel (1880-81); Kulkarni (1971); Bose and Banerji (1976); Bose *et al.* (1977); Srivastava (1977)

and Singh *et al.* (2005).

***Glossopteris emarginata* Maheshwari & Prakash
1965**

(Pl. 2.14; Fig. 18)

Remarks—Solitary specimen in having distinct emarginated apex compare with *G. emarginata* Maheshwari and Prakash (1965) described from Rajmahal Hills, Bihar.

***Glossopteris tenuifolia* Pant & Gupta 1968**

(Pl. 2.15; Fig. 19)

Remarks—Leaf shows striated midrib, secondary veins arise at an acute and arch out towards margin to form narrow meshes near the midrib and comparatively shorter meshes near the margin of leaf angle. The specimen is comparable with *G. tenuifolia*, instituted by Pant and Gupta (1968) mainly on cuticular features. But later identified by Chandra and Surange (1979) on the morphological features.

***Glossopteris burdwanensis* sp. nov.**

(Pl. 2.16; Fig. 20)

Diagnosis—Leaf small, narrowly oblanceolate, broadest near the apical portion of leaf, leaf base long narrowly acute, margin entire, apex emarginate; midrib distinct persistent, secondary veins emerge from midrib at acute angle (10-15° near base and 35-40° near the widest region of the lamina), arching very little towards margin; secondary veins dichotomize and anastomose to form narrow, elongate polygonal meshes; throughout the lamina, density of veins 12-15/cm near midrib and 13-20/cm near the margin of leaf.

Holotype—Specimen No. D/14, Palaeobotany and Palynology Section, Department of Botany, University of Burdwan.

Type Locality—Northern Branch of Nonia Nala, near Indigo factory (Dhakshindhadka), Asansol, Burdwan District, West Bengal, India.

Horizon—Maitur Member, Panchet Formation, Raniganj Coalfield.

Repository—Palaeobotany and Palynology Laboratory, Department of Botany, University of Burdwan, West Bengal, India.

Etymology—The species is instituted after the name of Burdwan District.

Description—The leaf is 4.9 cm long and it is widest near the apical portion of leaf, 7 mm broad and shows oblanceolate in shape. Leaf base is narrow-elongate somewhat pulvinus and laminar base is acute cuneate. The apex of leaf is distinctly emarginated and margin is entire. Midrib is present up to the apex, about 0.8 mm wide near base and very gradually attenuating upwards apex. Secondary veins emerge from midrib at acute angle (10-15° near base; 35-40° near the middle region of lamina) and arch out towards the margin of leaf. They dichotomize and anastomose to form narrow elongate polygonal meshes (typically 3.5 x 0.5 mm). Number of meshes vary from 2-3 during the course of lateral veins from midrib to margin. Density of veins is 12-15/cm near the midrib and 18-26/cm near the margin of leaf.

Comparison—*Glossopteris burdwanensis* sp. nov. compares with *G. emarginata* Maheshwari & Prakash (1965) and *G. hinjridaensis* Singh & Chandra (1987) in having emarginate apex. However, *G. emarginata* differs in having comparatively broad (2.8 cm wide) and oblong shaped leaf. *G. hinjridaensis* is based on fragmentary specimen and its basal portion is not preserved whereas *G. burdwanensis* sp. nov. is a complete leaf where basal portion is characteristically narrow-elongate and contracted which is distinct from all the known species of *Glossopteris*.

DISCUSSION

Maitur Formation representing the lower part of Panchet has generally been assigned to Early Triassic (Blanford, 1861; Cotter, 1917; Tripathi, 1961), however, discovery of reptilian remains and *Amblypterus* fish in the area supports the Late Permian

age (Das-Gupta, 1928; Gee, 1932; Mukherjee & Ghosh, 1973).

The floristic analysis across the Permian/Triassic boundary shows similarity of Maitur plant fossils with the flora of Raniganj Formation (Maheshwari, 1974) indicating the continuation of Upper Permian flora in Maitur Formation. While examining the palynomorphs from Maitur Formation Maheshwari and Banerji (1975) clearly states that “if the boundary between the Permian and Triassic in India is considered on floral contents alone, it should be extended into the Maitur Formation.” They further elaborated that “The strong Late Permian affinities of the Maitur Formation flora are indicated by the occurrence in it of *Glossopteris conspicua* and *G. retifera*, the absence of true *Dicroidium* and the preponderance of bisaccate pollen (particularly the striate ones).” The present assemblage is also comparable with the flora of Late Permian in having the species of *Glossopteris*, e.g. *Glossopteris angustifolia*, *G. conspicua*, *G. intermittens*, *G. retifera*, *G. gopadensis*, *G. taeniensis*, *G. burdwanensis*, *G. indica*, *G. tenuifolia*, *G. emarginata* along with *Neomariopteris hughesii*, *N. lobifolia*, *Dichotomopteris lindleyii*, *D. ovata* and absence of *Dicroidium*.

Banerji and Bose (1977) described the plant fossils from Maitur Formation and re-examined the fossils earlier described from the Maitur Formation by Feistmantel (1881), Satsangi and Shah (1970) and Satsangi (1971, 1973). The flora compiled by them contains the elements of Permian flora, e.g. *Schizoneura gondwanensis*, *Trizygia speciosa*, *Glossopteris browniana*, *G. angustifolia*, *G. communis*, *G. conspicua*, *G. retifera*, *G. sp. cf. G. intermedia*, *Macrotaeniopteris sp.*, *Cordaicarpus sp.* and *Kendostrobus*. They have observed that the specimens having Triassic affinity viz., *Pecopteris concinna*, *Cyclopteris pachyrhachis*, *Taeniopteris sp. cf. T. stenoneuron*, *?Dicroidium/Lepidopteris*, *Podozamites sp. cf. P. lanceolatus* and dispersed cuticle of *Lepidopteris*-type are ill preserved, fragmentary and their taxonomic assignment is uncertain.

The Maitur Formation characterized by khaki-green silty shales and greenish brown mudstones overlying the coal bearing Raniganj Formation is floristically comparable with the non-coaliferous horizons of Kamthi beds of Wardha, Mahanadi Basin of Orissa and Maharashtra, Pachhwara Formation of Rajmahal Basin, Jharkhand and Bijori Formation of Satpura Gondwana Basin, Madhya Pradesh in having the common occurrence of *Glossopteris angustifolia*, *G. browniana*, *G. conspicua*, *G. intermittens*, *G. retifera*, *G. tenuifolia*, *G. indica*, *G. taeniensis*, *Neomariopteris hughesii*, *Trizygia speciosa* and *Schizoneura gondwanensis*. Srivastava and Agnihotri (2010) have discussed the floristic composition of Kamthi, Pachhwara and Bijori formations and observed that the flora of non coaliferous horizons beyond the limit of coal bearing Raniganj Formation contains small-narrow leaf forms of *Glossopteris*, viz. *G. surangei*, *G. kamthiensis*, *G. gopadensis*, *G. utkalensis*, *G. bosei*, *G. mohudaensis*, *G. dhenkanalensis*, *G. zeilleri*, *G. intermittens*, *G. tenuifolia* along with *G. retifera* and *G. conspicua* with fewer records of pteridophytes. The flora shows clear deviation from the flora of Raniganj Formation which contains large sized *Glossopteris* leaves and number of equisetals, sphenophyllales, ferns and fern-like pinnules. As discussed by Maheshwari and Banerji (1975) the age of Maitur Formation is debatable, though it has been assigned to Early Triassic but palaeobotanical investigation indicates its affiliation with the Late Permian flora and as observed in the floras of non coaliferous horizons of Kamthi, Pachhwara and Bijori formations beyond the limit of Raniganj Formation (Srivastava & Agnihotri, 2010), Maitur Formation in all likeness represents the ultimate stage of *Glossopteris* flora in Raniganj Coalfield before the incoming of typical *Dicroidium* flora of Early Triassic. The turn over of flora has been attributed to change in the climatic condition from warm-humid to warm and dry condition (Lele, 1976; Chandra & Chandra, 1987).

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