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Additional palaeobotanical information from Madhupur Village, Talchir Coalfield, Orissa, India

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ABSTRACT

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Floristically rich exposures near Handapa Village in Hinjrida Ghati have been explored by various geologists and palaeobotanists ever since they were first located and mapped by Subramanian & Rao (1960). Based on the fossil plants the entire area has been assigned various ages such as Mahadeva (Early Triassic), Raniganj and Kamthi formations (Late Permian) by different workers. A new and rich collection of plant fossils from the Madhupur area revitalise the age of the beds and provides additional information to the fossil flora. *Glossopteris* species dominated the vegetation. Based on the fossil plants Madhupur beds are assigned age equivalent to Lower Kamthi Formation (late Late Permian).

Key-words— *Glossopteris*, Kamthi, Late Permian, Triassic.

भारत के उड़ीसा प्रान्त के मधुपुर ग्राम के तालचेर कोयला क्षेत्र से प्राप्त अतिरिक्त पुरावानस्पतिक सूचनाएँ

कमलजीत सिंह एवं शैला चन्द्रा

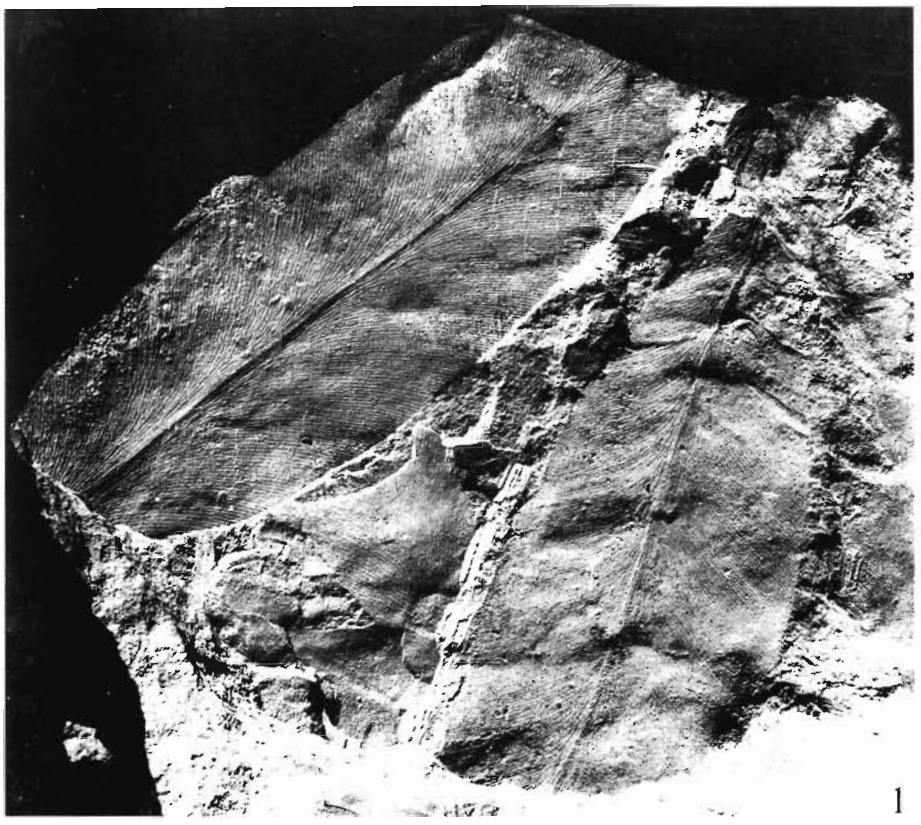
सारांश

सुब्रामणियन एवं राव (1960) द्वारा पहली बार खोजे तथा मानचित्र निर्मित किए जाने के बाद से आज तक हिन्जरीडा घाटी में हण्डपा ग्राम के समीप के वनस्पतिजातीय दृष्टि से समृद्ध क्षेत्र का विभिन्न भूगर्भ वैज्ञानिकों एवं पुरावनस्पतिविदों द्वारा उत्खनन किया जाता रहा है. पादपाश्मों के आधार पर विभिन्न खोजकर्त्ताओं ने समूचे क्षेत्र को विभिन्न आयु वर्गों, जैसे - महादेवा शैलसमूह (प्रारंभिक ट्रायसिक), रानीगंज एवं कामथी शैलसमूह (अन्तिम परमियन) में निर्धारित किया है. मधुपुर क्षेत्र से प्राप्त पादपाश्मों के नवीनतम एवं समृद्ध संग्रह से संस्तरों की आयु का पुनर्निर्धारण किया गया है तथा वनस्पतिजात पादपाश्मों के विषय में अतिरिक्त सूचनाएँ प्राप्त हुई हैं. वनस्पतियों में *ग्लॉसोप्टेरिस* प्रजातियों की प्रचुरता है. पादपाश्मों के आधार पर मधुपुर संस्तरों की आयु अधो कामथी शैलसमूह (अन्तिम-अन्तिम परमियन) के समतुल्य निर्धारित की गयी है.

संकेत शब्द—*ग्लॉसोप्टेरिस*, कामथी, अन्तिम परमियन, ट्रायसिक.

INTRODUCTION

THE Talchir Coalfield covering an area of about 1,800 sq. km. is situated in the Brahmani Valley and falls under Angul and Dhenkanal districts of Orissa. A small portion also lies in the adjoining Sambalpur District. Rocks of both Lower and Upper Gondwana are represented in this coalfield. The stratigraphic sequence met within the coalfield is fresh water sedimentary pile of Talchir, Karharbari, Barakar and post Barakar formations lying unconformably on a Precambrian



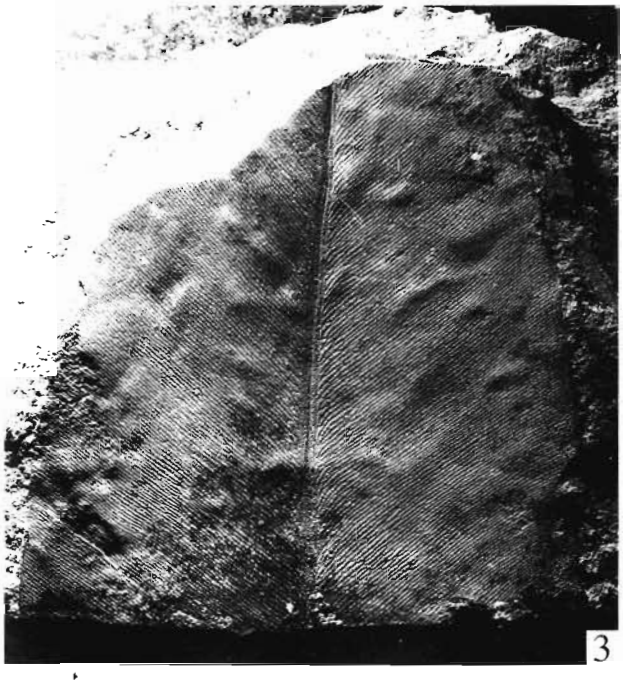


PLATE 1

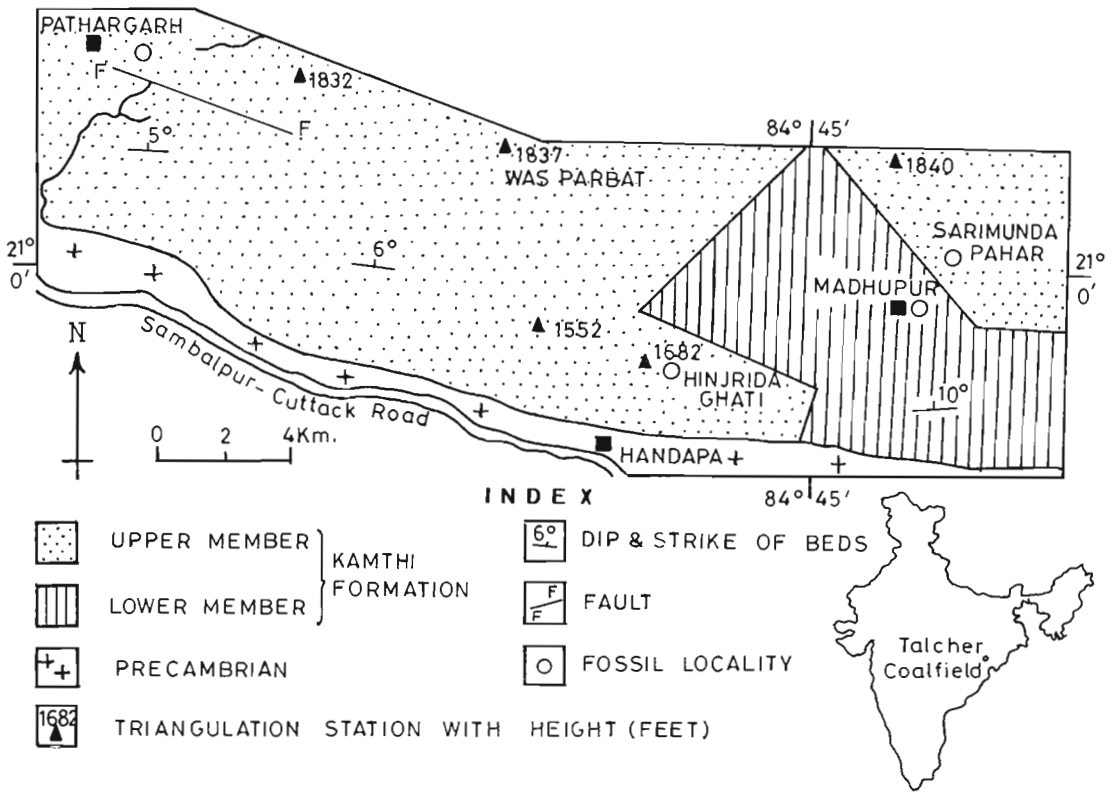


Fig. 1—Geological map of west-central part of Talchir Coalfield, India (after Pal *et al.*, 1991)

metamorphic base. Characteristic and well defined fossil plant assemblages have been recognised and reported mostly by us from Talchir – the Earliest Permian (Chandra & Singh, 1996b), Karharbari – the Early Permian (Chandra & Singh, 1996a) and Barakar – the Late Permian (Singh & Chandra, 1995) formations in this coalfield.

The Barakar Formation is conformably overlain by a sedimentary sequence of fine to medium grained light grey and ferruginous sandstones and shales at the base, and a thick succession of pale greenish sandstones with rare shale and pink clay bands, ferruginous coarse-grained and pebbly sandstone at the top. Several significant palaeobotanical finds and studies in Glossopteris Flora have been reported from the shaly bands of various colour exposed in and around Handapa Village (Surange & Chandra, 1973a, b, c; 1974a, b, c, d; Maithy, 1977; Chandra & Rigby, 1981, 1983; Chandra, 1984; Chandra & Surange, 1979; Surange & Maheshwari, 1970; Chandra & Singh, 1986, 1988, 1989, 1992, 1995, 1996a, b; Singh & Chandra, 1987, 1995). However, all the palaeobotanical finds indicated Late Permian age for these beds sometimes referring them as equivalent to Raniganj or Kamthi Formation.

The post Barakar sequence in the Talchir Coalfield has been variously classified by several geologists on their

PLATE 1

1. *Glossopteris indica* Schimper. Middle portion of two leaves seen preserved. Specimen no. BSIP 38396. x 1
2. *Glossopteris indica* Schimper. Almost a complete leaf without base. Meshes near midrib are short and broad and near the margin they are narrow and short. Specimen no. BSIP 38397. x 1
3. *Glossopteris feistmantelii* Rigby. Middle portion of the leaf showing lateral veins arising at an angle of about 45°and going straight to the margins. Meshes elongate and broad. Cross connections frequent. Specimen no. BSIP 38398. x 1
4. *Glossopteris intermedia* Feistmantel. Very narrow elliptic, medium sized leaf having very broad midrib. Lateral veins arise at an angle of less than 45° and running almost straight to the margins. Specimen no. BSIP 38399. x 2.
5. *Glossopteris spatulata* Pant & Singh. Medium sized oblanceolate leaf having broad midrib which gradually tapers upwards. Lateral veins arise at an angle of less than 45°, then gradually arch out to the margin. The venation is dense with very elongate and narrow meshes. Specimen no. BSIP 38400. x 1

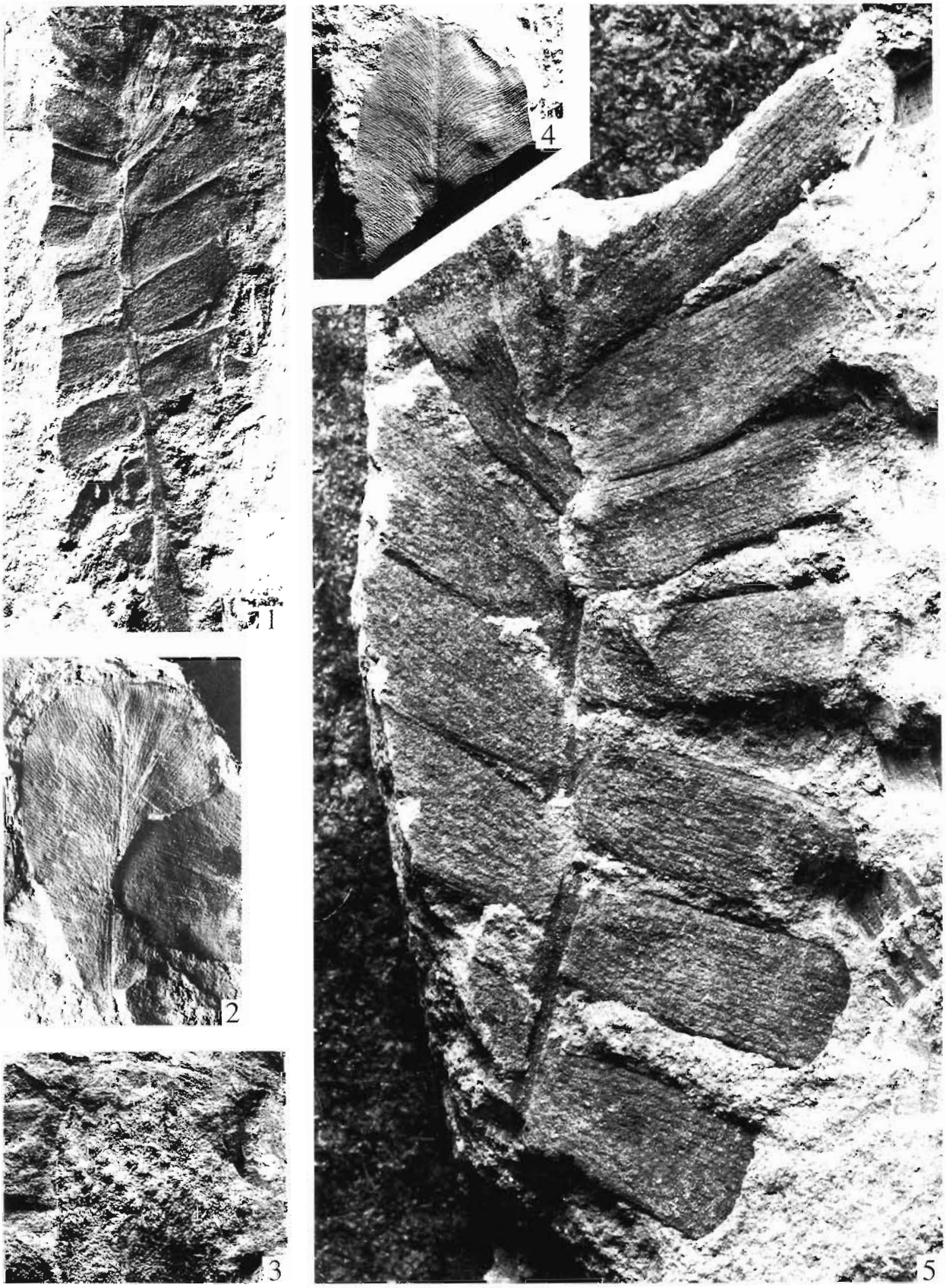


PLATE 2

observations. Subramanian (1962), Chakraborty, *et al.* (1967) divided the sequence into Raniganj, Panchet and Mahadeva formations whereas Raja Rao (1982) considered the entire sequence as a single lithounit of the Kamthi Formation. Chakraborty in an unpublished report of the Geological Survey of India (1989) mapped the west-central part of the Talchir Coalfield and divided the Kamthi sequence into Lower and Upper Member (in Pal *et al.*, 1991). According to him entire Kamthi sequence of 400 m thickness is divisible into Lower Member of 200 m comprising mainly median to coarse-grained pebbly, cross bedded, ferruginous sandstones alternating with clasts of greyish white shales. The Upper Member, also 200 m thick, contains two distinct sets of lithologies. The lower beds of Upper Member are represented by medium-grained buff or white, cross bedded, ferruginous sandstones alternating with thick bands of red and grey shales. The upper beds of Upper Member are characterised by highly ferruginous, hard and quartzitic sandstones, bands of hard, compact, brown to yellow shales, bands of lavender and creamy white shales. These lithological observations of Chakraborty are mentioned in great details in Pal and Ghosh (1997).

Pal *et al.* (1991) and Pal & Ghosh (1997) reported plant fossils from three new localities and tried to demarcate the Permian/Triassic Boundary in the Kamthi Formation of Talchir Coalfield. In recent years, we made a fresh collection of plant fossils from near Madhupur Village in Hinjrida Ghati. A detailed and systematic collection reveals that the flora exposed near Madhupur Village is much more diversified than reported earlier.

Good exposures of whitish grey to pinkish-red, fine-grained shales are exposed at about 1 km south-east of Madhupur Village (Fig. 1). The rocks are exposed on the surface and it is not possible to sample the full lithological variation. This locality is more or less 12 km east of famous Handapa locality and the approach to the fossil location is through thick forest vegetation without proper vehicular road.

PLATE 2

1. *Pseudoctenis balli* (Feistmantel) Seward. Relatively small almost complete oblong to oval simple pinnate leaf with pinnae attached obliquely or at right angles to a slender rachis. Specimen no. BSIP 38401. x 2.
2. *Glossopteris pandurata* Pant & Gupta. A very small pandurate, narrow, obovate leaf having round apex. Midrib tapers upwards very gradually. In the apical region lateral veins are straight. Specimen no. BSIP 38402. x 2.
3. *Cyclodendron leslii* (Seward) Krausel. Stem showing leaf scars Specimen no. BSIP 38403. x 2.
4. *Glossopteris bosei* Chandra & Surange. An incomplete leaf having obtuse-rounded apex. Lateral veins arch out to the margin meeting it at about 80° Meshes very long. Specimen no. BSIP 38404. x 1·5.
5. *Pseudoctenis balli* (Feistmantel) Seward. Counter part of the leaf in figure 1 enlarged to show the details. Apex and base not preserved in this leaf. Pinnae broad and oblong in shape, incised up to rachis and attached on it almost sub-opposite to each other. Pinna margins entire with round to truncate apex and expanded base. Parallel veins forked once or twice but rarely anastomosed. Specimen no. BSIP 38405. x 5.

PLATE 3

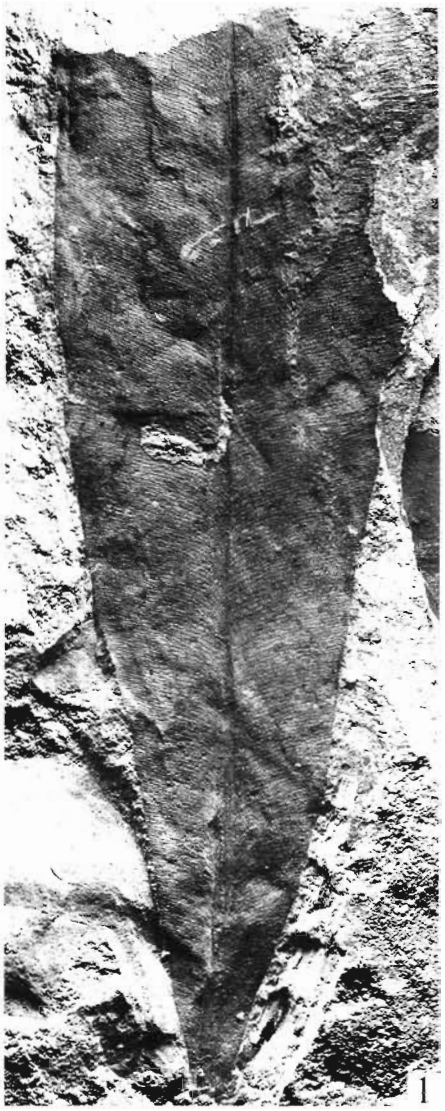
See Page No. 390

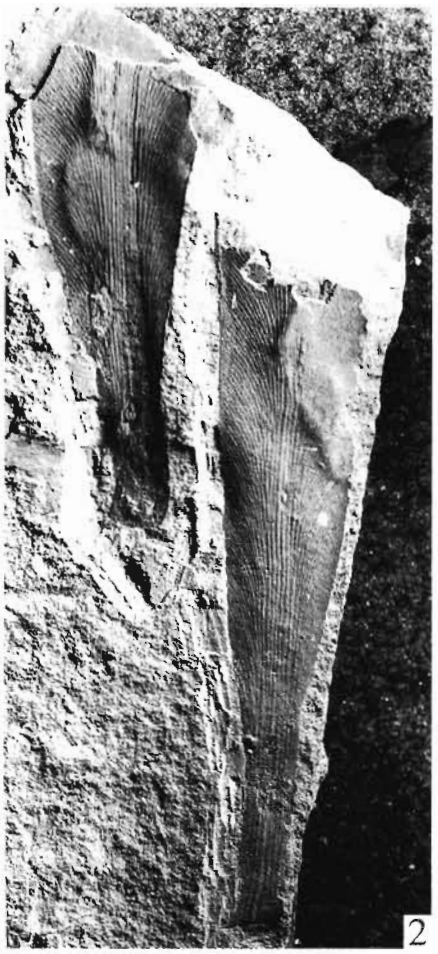
1. *Glossopteris nimishea* Chandra & Surange. An incomplete leaf, seems to be narrow-elliptical in shape. Secondary veins arise at an angle of 75-80° and run straight to the margin. Meshes broad near midrib, narrow and dense near margins. Specimen no. BSIP 38406. x 1.
2. *Glossopteris tenuifolia* Pant & Gupta. Two incomplete leaves with cuneate base. Very fine lateral veins arise at an angle of less than 45° forming dense venation pattern. Specimen no. BSIP 38407. x 1·5.
3. *Glossopteris tenuifolia* Pant & Gupta. A complete leaf with acute apex, persistent midrib and very fine lateral veins. Meshes are very long and narrow. Specimen no. BSIP 38408. x 1
4. *Vertebraria indica* Royle. Two axes joined perpendicular to each other having ridges and furrows. Specimen no. BSIP 38409. x 1·5.
5. *Glossopteris syaldiensis* Chandra & Surange. A medium lanceolate leaf having broad midrib, lateral veins arise at an angle of about 45°, arch backwards and pass straight to the margin meeting it at 80° Meshes short and broad near midrib and elongate and narrow throughout lamina. Specimen no. BSIP 38410. x 1
6. *Glossopteris leptoneura* Bunbury. Lower portion of a narrow leaf, apex and base not preserved. Lateral veins arise at angle of less than 45°. Meshes comparatively narrow and small near the margin. Specimen no. BSIP 38411. x 3.

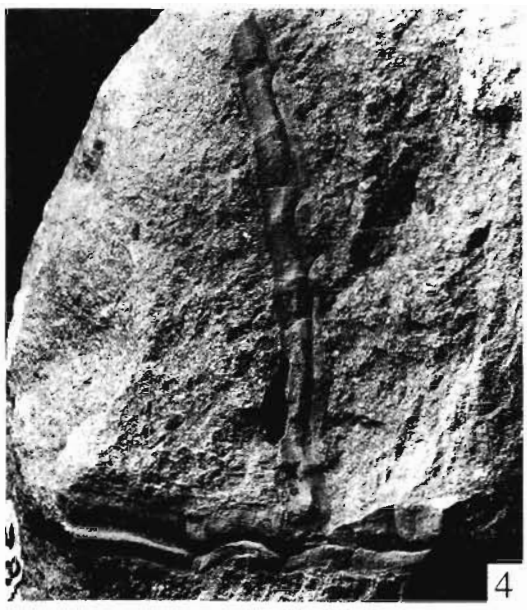
PLATE 4

See Page No. 391

1. *Glossopteris damudica* Feistmantel. A middle portion of the leaf with very thick midrib, secondry veins arise at an angle of about 75-80°and run straight to the margin forming strikingly broad and short meshes. Specimen no. BSIP 38412. x 1
2. *Glossopteris stricta* Bunbury. An ill-preserved, narrow strap-shaped leaf. Apex seems to be acute, midrib broad, lateral veins numerous, arise at an angle of about 70-80° and run straight and horizontally to the margin. Meshes very narrow and long near the margins. Specimen no. BSIP 38413. x 2.
3. *Partha indica* Surange & Chandra. A lanceolate, stalked, fertile scale having four cupules attached to the pedicel on the left side of the stalk. Specimen no. BSIP 38414. x 2.
4. *Glossopteris tenuinervis* Pant & Gupta. An incomplete, narrow, elliptical leaf having retuse apex. Lateral veins arise at an angle of about 70-80° and run almost horizontally to the margin. Meshes are narrow and long. Specimen no. BSIP 38415. x 1·5.







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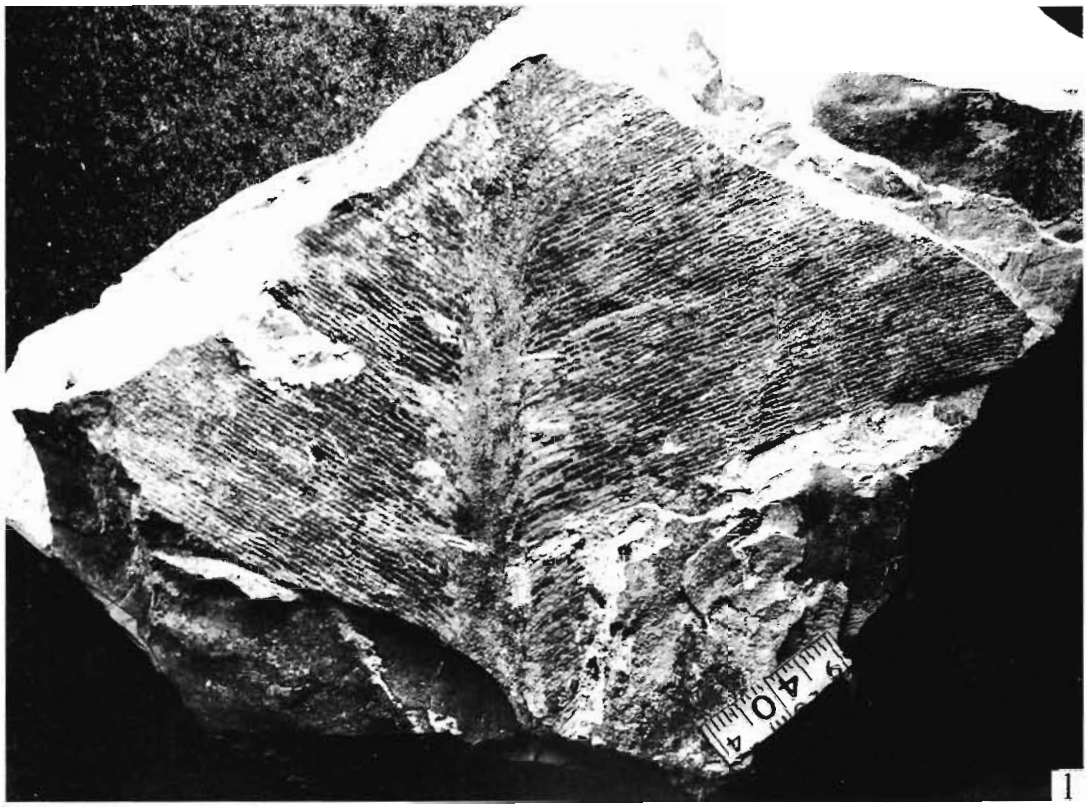

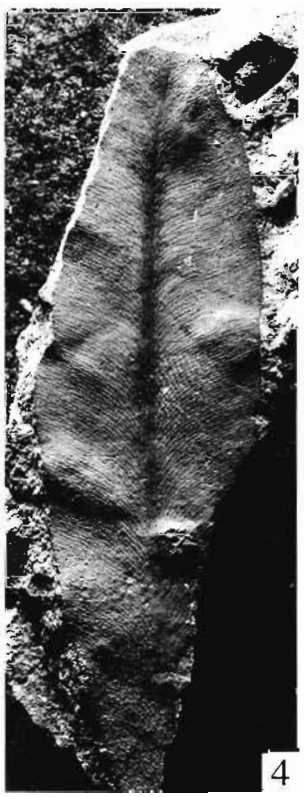

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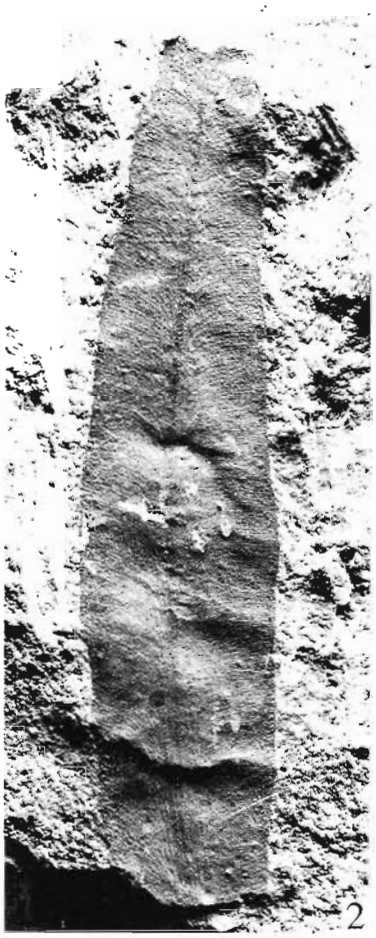

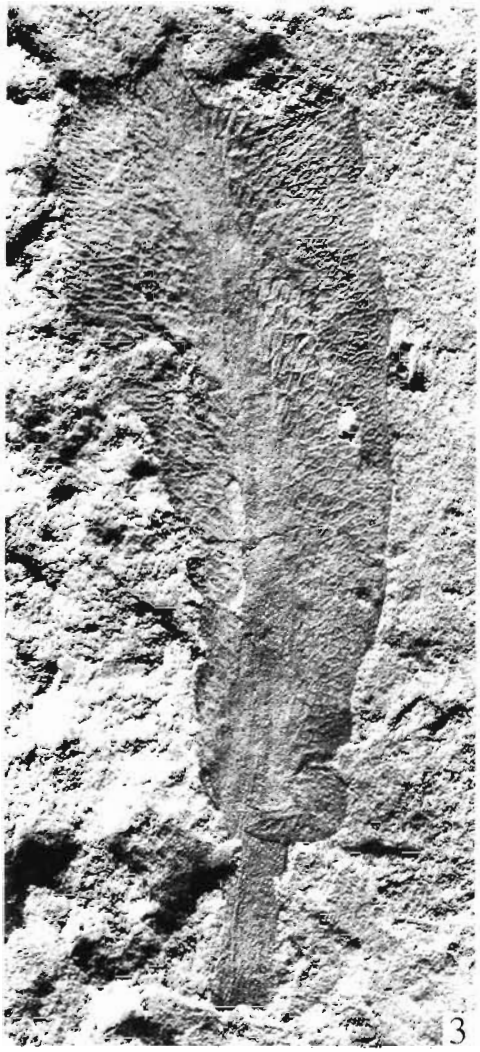

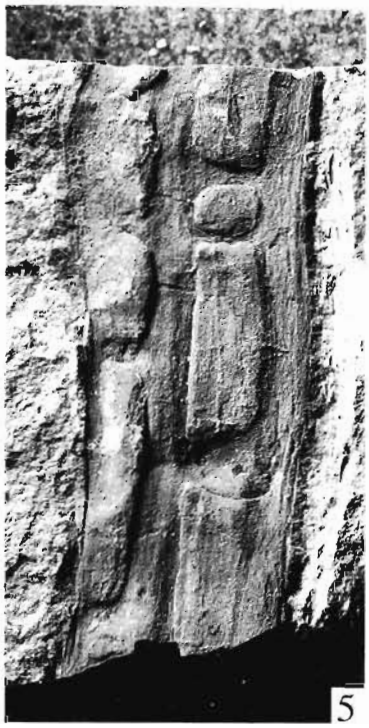

PLATE 5

MEGAFOSSIL ASSEMBLAGE AND DISCUSSION

(Pl. 1·1-5; Pl. 2·1-5; Pl. 3·1-6; Pl. 4·1-4; Pl. 5·1-6; Pl. 6·1-5)

Repository—All the specimens figured in this paper are housed at the Museum of Birbal Sahni Institute of Palaeobotany, Lucknow, vide statement number 1016 and collection numbers range from 38396–38426, numbering thirty one hand specimens.

Pal *et al.* (1991) reported *Trizygia speciosa, Neomariopteris hughesii, Glossopteris communis, G. tenuifolia, G. gigas, Eretmonia* scale leaf, *Pseudoctenis balli*, and *Vertebraria indica* from Madhupur locality, their Assemblage Zone-1 representing Lower Member and accordingly considered to represent an older assemblage than the fossil flora known from Handapa beds. According to them the assemblage is dominated by *Glossopteris* leaves. A fresh collection made by us from the same spot indicates that the fossil flora collected near Madhupur Village contains many more taxa than previously reported. The fossil plant assemblage no doubt is dominated by the genus *Glossopteris* as is reported by earlier authors also but is represented by many more species than mentioned by them. It is represented by at least twenty species of *Glossopteris*, a far greater number than previously recorded and reported by Pal *et al.* (1991). This assemblage has characteristic Late Permian species like *G. leptoneura, G. stricta* and *G. conspicua*. As is apparent from the table (Fig. 2) out of twenty species of *Glossopteris* from Madhupur locality, sixteen are represented in Handapa beds. *Glossopteris intermedia, G. syaldiensis, G. bosei* and *G. feistmantelli* are known only from Madhupur locality and are not recorded so far from Handapa beds.

Nearly twenty six species reported from Handapa beds are not recovered so far from Madhupur locality. There is no doubt that both the assemblages are basically dominated by *Glossopteris* species, but Handapa beds have larger number of species than the Madhupur area. The other common elements of the two floras are *Cyclodendron leslii, Schizoneura gondwanensis, Trizyzia speciosa, Neomariopteris hughesii* and *Pseudoctenis balli*. Percentage wise (Fig. 3) Handapa beds are dominated by *Glossopteris indica* (18·9%) and sub-dominated by *G. angustifolia* (10·17%) whereas in Madhupur area the dominant form of *Glossopteris* is *G. spatulata* (19·2%) and sub-dominant is *G. indica* (16·8%). This can be attributed to a slight ecological variation in the two close by areas. It is not possible to distinguish or separate the two assemblages merely on the basis of plant fossils or lithology as has been mentioned by Pal & Ghosh (1997). The authors also reported same taxa in both the assemblages except *Vertebraria* which has not being reported so far from Handapa beds. The basis on which Handapa beds are assigned younger age than the Madhupur beds is neither clear nor convincing. On the contrary we believe that the Madhupur beds are simply lateral extension of the Handapa beds having more or less the same lithology and plant taxa, and therefore inclined to assign latest Permian age.

Assemblage Zone-III of Pal & Ghosh (1997) contains *Lepidopteris* sp. and ?*Dicroidium* sp. in association with equisetaceous stems, *Neomariopteris hughesii*, and *Glossopteris* sp. According to the authors this assemblage zone in all probability indicates younger age than that of the Raniganj Formation and is comparable with that of the Panchet Formation representing Early Triassic. Identification of *Lepidopteris* and *Dicroidium* has already been doubted by the authors themselves. Except for those two fossils which can as well be small pieces of fern *Neomariopteris* already present in the assemblage identified as a definite common species, rest of the flora represents Late Permian age like that of flora from Handapa or Madhupur localities. Location wise also assemblage zones I, II and III are very close to each other and there is every possibility that they could be just lateral extension of the same beds. A first hand examination of the described specimens is not possible as the authors have not mentioned the repository in their paper.

Assemblage Zone IV from Pathargarh locality comprises *Dicroidium* rich mega flora with three distinct species. The other associated elements are *Lepidopteris, Elatocladus, Yabiella* and *Desmiophyllum* representing typical Triassic forms. As mentioned by the authors *Glossopteris* and other

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PLATE 5

1. *Glossopteris angusta* Pant & Gupta. A complete oblanceolate leaf broad in the retuse apical part and tapering towards acute-normal base. Lateral veins arise at very acute angles forming elongate, narrow meshes. Specimen no. BSIP 38416. x 2.
2. *Glossopteris leptoneura* Bunbury. An incomplete narrow, linear leaf having medium-sized midrib. Lateral veins dense, arise at an angle of less than 45° and arch out to the margin forming elongate, narrow meshes. Specimen no. BSIP 38417. x 2.
3. *Glossopteris tortuosa* Zeiller. Almost a complete, oblanceolate, petiolate leaf having obtuse apex and comparatively broad midrib. Lateral veins follow an undulating course from midrib to margin forming trapezoidal meshes. Specimen no. BSIP 38418. x 3.
4. Scale leaf A. An elliptic, oblanceolate sterile scale leaf having acute apex and faint dichotomising secondary veins. Specimen no. BSIP 38419. x 1·5.
5. *Vertebraria indica* Royle. Axis showing horizontally preserved specimen with typical rectangular areas interveined by two longitudinal furrows or ridges. Specimen no. BSIP 38420. x 1·5.
6. *Glossopteris conspicua* Feistmantel. A very small incomplete, obovate leaf having thick midrib, lateral veins arise at an angle of less than 45° forming comparatively broad and long meshes. Specimen no. BSIP 38421. x 3.

Fig. 2—Gondwana plant taxa in and around Handapa and Madhupur localities in Talchir Coalfield.

Plant Taxa / Number	Permian		Triassic	
	HANDAPA	MADHUPUR	? SARI-MUNDA HILL	PATHARGARH
Lycophyta - 1				
Cyclodendron leslii (Seward) Kräusel	+	+		
Arthrophyta (Equisetales & Sphenophyllales) -10				
Equisetaceous stems			+	
Schizoneura gondwanensis Feistmantel	+	+		
Phyllotheca indica Bunbury	+			
Lelstotheca robusta (Feistmantel) Maheshwari	+			
Raniganjia bengalensis (Rigby) Pant & Nautiyal	+			
R.etheridgei (Arber) Pant & Nautiyal	+			
Sphenophyllum churulianum Srivastava & Rigby	+			
S. utkalensis Pant, Srivastava & Das	+			
S. crenulatum (Maithy) Srivastava & Rigby	+			
Trizygia speciosa Royle	+	+		
Filicophyta - 8				
Neomariopteris polymorpha (Feistmantel) Maithy	+			
N. hughesii (Zeiller) Maithy	+	+	+	
N. khanii Maithy	+			
N. lobifolia (Morris) Maithy	+			
Damudopteris bengalensis Chandra & Rigby	+			
Dizeugotheca phegopteroides (Feistmantel) Maithy	+			
Pantopteris gracilis (Lele) Chandra & Rigby	+			
Asansolia cf. *phegopteroides* (Feistmantel) Pant & Mishra	+			
Cycadales - 2				
Senia reticulata Khan	+			
Pseudoctenis balli (Feistmantel) Seward	+	+		
Ginkgoales - 1				
Handapaphyllum indicum Chandra & Singh	+			
Peltaspermales - 2				
Lepidopteris sp. cf. *L. stormbergensis* (Seward) Townrow				+
Lepidopteris sp. Pal, Chakraborty, Ghosh & Ghosh			+	
Coristospermales - 4				
Dicroidium zuberi (Szajnocha) Archangelsky				+
D. giarensis Pal				+
D. superbum (Shriby) Townrow				+
Dicroidium sp. Pal, Chakraborty, Ghosh & Ghosh			+	
Coniferales -1				
Elatocladus sp. Pal, Chakraborty, Ghosh & Ghosh				+
Insertae sedis -2				
Desmiophyllum sp. Pal, Chakraborty, Ghosh & Ghosh				+
Yabiella sp. Pal, Chakraborty, Ghosh & Ghosh				+
Glossopteridales (leaf forms) - 51				
Glossopteris indica Schimper	+	+		
G. communis Feistmantel	+	+		
G. intermedia Feistmantel		+		
G. damudica Feistmantel	+	+		
G. angustifolia Brongniart	+	+		
G. kamthiensis Singh & Chandra	+			
G. maheshwarii Singh & Chandra	+			
G. acuminata Singh & Chandra	+			
G. utkalensis Singh & Chandra	+			
G. hinjridaensis Singh & Chandra	+			
G. inaequalis Singh & Chandra	+			
G. dhenkanalensis Singh & Chandra	+			
G. stricta Bunbury	+	+		
G. leptoneura Bunbury	+	+		
G. retifera Feistmantel	+			

G. conspicua Feistmantel	+	+	
Glossopteris sp.cf. *G. divergens* Feistmantel	+		
G. stenoneura Feistmantel	+	+	
G. tortuosa Zeiller	+	+	
G. arberi Srivastava	+		
G. vulgaris Pant & Gupta	+		
G. tenuifolia Pant & Gupta	+	+	
G. varia Pant & Gupta	+		
G. zeilleri Pant & Gupta	+		
G. subtilis Pant & Gupta	+		
G. spatulata Pant & Singh	+	+	
G. lanceolatus Pant & Singh	+		
G. gondwanensis Pant & Gupta	+		
G. gigas Pant & Singh	+	+	
G. radiata Pant & Singh	+		
G. barakarensis Kulkarni	+		
G. pandurata Pant & Gupta	+	+	
G. angusta Pant & Gupta	+	+	
G. tenuinervis Pant & Gupta	+	+	
G. nautiyalii Pant & Singh	+		
G. obscura Pant & Singh	+		
G. sastrii Pant & Singh	+		
G. oldhamii Pant & Singh	+		
G. gopadensis Banerji, Maheshwari & Bose	+		
G. taeniensis Chandra & Surange	+		
G. nimishea Chandra & Surange	+	+	
G. mohudaensis Chandra & Surange	+		
G. browniana Brongniart	+		
G. syaldiensis Chandra & Surange		+	
G. bosei Chandra & Surange		+	
G. feistmantelii Rigby		+	
Scale leaf A		+	
Scale leaf B		+	
Glossopteris fragments			+
Surangephyllum elongatum Chandra & Singh	+		
Vertebraria indica Royle	+	+	
Glossopteridales (fertile forms) - 24			
Dictyopteridium sporiferum Feistmantel	+		
Glossotheca utkalensis Surange & Maheshwari	+	+	
G. immanis Chandra & Surange	+		
G. orissiana Surange & Chandra	+		
Eretmonia utkalensis Surange & Maheshwari	+		
E. hinjridaensis Surange & Maheshwari	+	+	
E.ovata Surange & Chandra	+		
E. karanpurensis Surange & Maheshwari		+	
Lidgettonia indica Surange & Maheshwari	+		
L. mucronata Surange & Chandra	+		
Lidgettonia. sp.		+	
Denkania indica Surange & Chandra	+		
Partha indica (Surange & Maheshwari) Surange & Chandra	+	+	
P. spathulata Surange & Chandra	+	+	
Scutum sahnii Surange & Chandra	+		
S. elongatum Surange & Chandra	+		
S. indicum Surange & Chandra	+		
Scutum sp. Surange & Chandra	+		
Cistella ovata Surange & Chandra	+		
Cistella sp. Surange & Chandra	+		
Indocarpus elongatus Surange & Chandra	+		
Utkalia dichotoma Chandra	+		
Nesowalesia indica Chandra & Singh	+		
Khania dhenkanalensis Chandra & Singh	+		

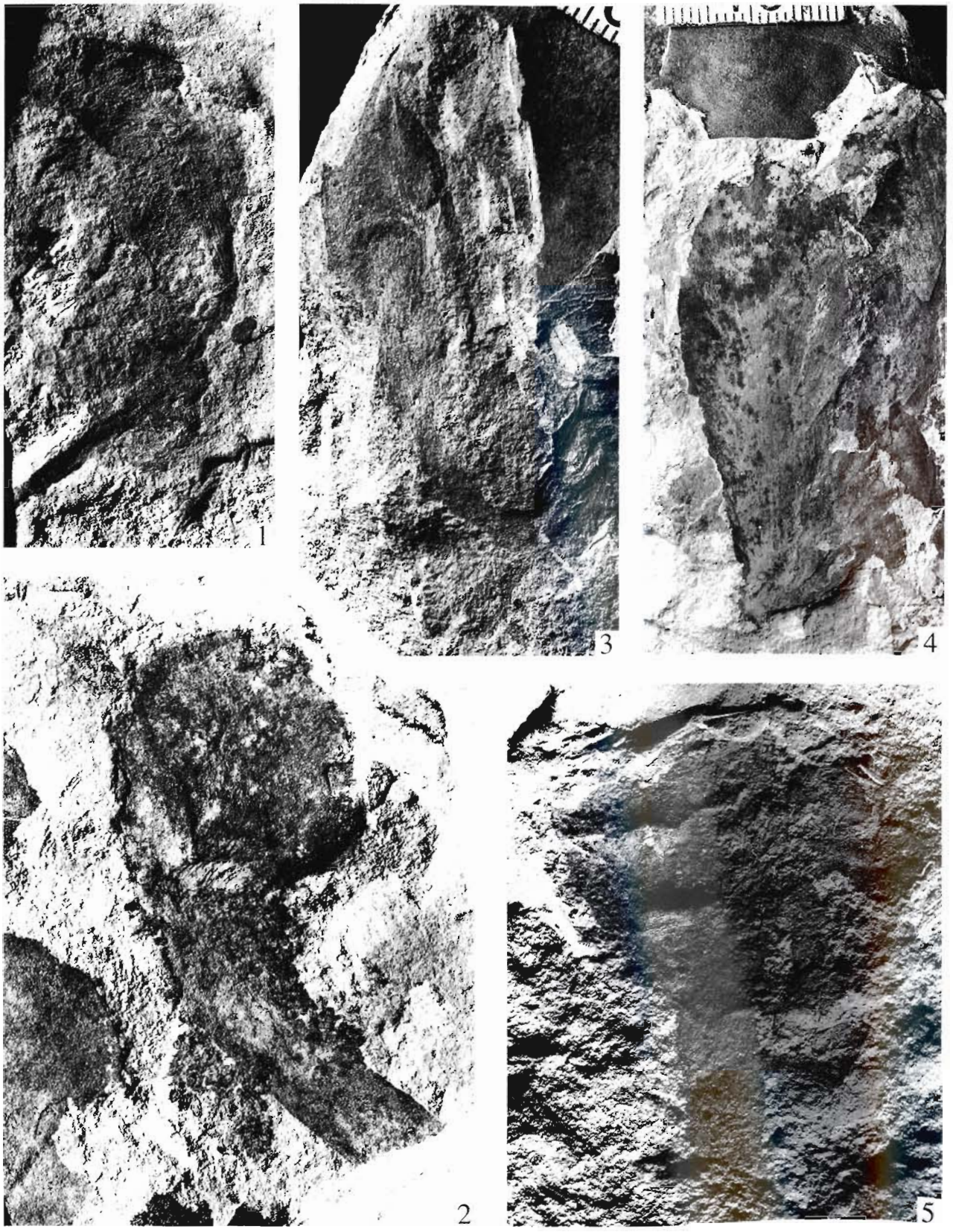

PLATE 6

Plant Taxa	Handapa	Madhupur
Glossopteris indica	18·9	16·8
G. communis	5·23	2·4
G. intermedia		1·2
G. damudica	0·29	6·02
G. angustifolia	10·17	1·2
G. kamthiensis	0·29	
G. maheshwarii	0·58	
G. acuminata	0·29	
G. utkalensis	0·87	
G. hinjridaensis	1·45	
G. inaequalis	2·62	
G. dhenkanalensis	0·29	
G. stricta	0·87	2·4
G. leptoneura	1·16	2·4
G. retifera	3·78	
G. conspicua	5·81	1·2
Glossopteris sp. cf. *G. divergens*	0·29	
G. stenoneura	1·74	1·2
G. tortuosa	2·03	2·4
G. arberi	0·87	
G. vulgaris	0·29	
G. tenuifolia	7·85	4·8
G. varia	0·87	
G. zeilleri	0·87	
G. subtilis	5·23	
G. spatulata	2·62	19·2
G. lanceolatus	4·36	
G. gondwanensis	3·49	
G. gigas	4·94	1·2
G. radiata	0·29	
G. barakarensis	0·87	
G. pandurata	0·87	1·2
G. angusta	1·16	3·6
G. tenuinervis	2.32	1·2
G. nautiyalii	1·16	
G. obscura	2·32	
G. sastrii	0·87	
G. oldhamii	0·58	
G. gopadensis	1·16	
G. taeniensis	1·16	
G. nimishea	4·36	2·4
G. mohudaensis	1·16	
G. syaldiensis		1·2
G. bosei		1·2
G. feistmantelii		2·4

Permian forms are missing from the Assemblage Zone-IV and have equated these upper beds of Upper Member with Tiki Formation of South Rewa Gondwana Basin which is considered to represent Upper Triassic age based on dominance of *Dicroidium*.

So far all attempts to demarcate the Permian-Triassic Boundary in outcrop sections are through palynological studies (Maheshwari, 1974, 1997; Maheshwari & Banerji, 1975; Bharadwaj *et al.*, 1979; Kumar, 1996; Srivastava *et al.*, 1997; Srivastava & Jha, 1995) and it has been very difficult to demarcate the boundaries based on megafossil studies especially on few, fragmentary and unidentifiable plant fossils.

Generally age assignment of beds is based on percentage frequency of taxa be it palynological or megafossil. Pal *et al.* (1997) have not tried to give any percentage frequency of taxa in any of their assemblage zones especially in Assemblage Zones I, II and IV which would have been very useful in drawing such important conclusions. Palynological studies are not possible in this area which would have been very helpful in age determination as all attempts to recover spore and pollen proved futile. The best course would be to make a detailed survey of the area and thorough and further systematic collection of plant fossils for age determination and confirmation of the Permian/Triassic Boundary. A detailed drilling in the area exposing all the rock sequences would be helpful in this direction.

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REFERENCES

Bharadwaj DC, Tiwari RS & Anand-Prakash 1979. Permo-Triassic palynostratigraphy and lithological characteristic in Damodar Basin, India. Biological Memoirs 4 : 49-82.

Chakraborty SN, Das SN & Banerjee SP 1967. Final report on investigation by drilling in the central part of Talcher Coalfield, Orissa. Unpublished Report, Geological Survey of India.

Chakraborty U 1989. Unpublished report of Geological Survey of India.

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Fig. 3—Percentage representation of *Glossopteris* species in Handapa and Madhupur localities.

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PLATE 6

1 *Eretmonia hinjridaensis* Surange & Maheshwari. A spathulate, stalked leafy bract having obtuse-round apex. Sporangia forming two clusters, one each on either side of the stalk. Specimen no. BSIP 38422. x 2.

2. *Eretmonia karanpurensis* Surange & Maheshwari. A stalked fertile leaf having more or less orbicular and expanded lamina. Two sporangial clusters, one on either side of the fertile leaf stalk are seen. Specimen no BSIP 38423. x 2·5.

3. *Glossotheca utkalensis* Surange & Maheshwari. A small, linear, stalked fertile leaf having *Glossopteris* type venation. Three pairs of sporangial clusters are seen on either side of the leaf stalk. Specimen no. BSIP 38424. x 2.

4. *Partha spathulata* Surange & Chandra. A fertile scale leaf having spathulate lamina but the stalk is not preserved. Dichotomous veins are present on the leaf. Only one pedicel can be seen having four oval cupules. Specimen no. BSIP 38425. x 1·5.

5. *Lidgettonia* sp. Thomas. An ill-preserved, stalked fertile scale. Three cupulate discs in a row can be seen on the right side of it. The discs on the other side are not distinguishable from the matrix. Specimen no. BSIP 38426. x 2.

Chandra S 1984. *Utkalia dichotoma* gen. *et* sp. nov. a fossil fructification from the Kamthi Formation of Orissa, India. Palaeobotanist 31 : 208-212.

Chandra S & Rigby JF 1981. Lycopsid, sphenopsid and cycadaceous remains from the Lower Gondwana of Handapa, Orissa. Geophytology 11 : 214-219.

Chandra S & Rigby JF 1983. The filicales from the Lower Gondwanas of Handapa, Orissa. Palaeobotanist 31 : 143-147.

Chandra S & Singh KJ 1986. *Surangephyllum* gen. nov. from the Kamthi Formation of Handapa, Orissa. Indian Society of Geoscientists Bulletin 1 : 15-18.

Chandra S & Singh KJ 1988. A new seed bearing plant organ from the Kamthi Formation of Orissa, India. Current Science 57 : 996-998.

Chandra S & Singh KJ 1989. *Handapaphyllum* - a new leaf type from the Upper Permian of Orissa, India. Palaeobotanist 37 : 143-146.

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

Chandra S & Singh KJ 1995. First report of Late Permian sporangiate fructification *Nesowalesia* Pant from India. Current Science 69 : 400-401.

Chandra S & Singh KJ 1996a. On *Euryphyllum* Feistmantel and its epidermal features. Palaeobotanist 45 : 7-14.

Chandra S & Singh KJ 1996b. Plant fossils from the type locality of Talchir Formation and evidence of earliest Plant/Animal activity in Gondwana of India. Ninth International Gondwana Symposium, Hyderabad 1994, 1 : 397-414.

Chandra S & Surange KR 1979. Revision of the Indian species of *Glossopteris*. Birbal Sahni Institute of Palaeobotany, Monograph 2 : 1-301.

Feistmantel O 1880. The fossil flora of the Gondwana system. The flora of the Damuda and Panchet divisions. Memoirs of geological Survey of India, Palaeontologia Indica Series 12, 3 : 1-77.

Feistmantel O 1881. The fossil flora of the Gondwana System. The flora of the Damuda and Panchet divisions. Memoirs. of Geological Survey of India. Palaeontologia Indica Series 12, 3 : 1-154.

Khan AM 1969. *Senia reticulata*, a new plant fossil from the Raniganj rocks of the Talchir Coalfield, Orissa, India. *In :* Santapau H *et al.* (Editors)—J. Sen Memorial Volume . 335-338. Botanical Society of Bengal, Calcutta.

Kumar P 1996. Permo-Triassic palynofossils and depositional environment in Satpura Basin, Madhya Pradesh. Geophytology 25 : 47-54.

Maheshwari HK 1974. Raniganj-Panchet Boundary. *In:* Surange KR *et al.* (Editors)—Aspects and appraisal of Indian Palaeobotany : 408-420. Birbal Sahni Institute of Palaeobotany, Lucknow.

Maheshwari HK 1997. Permian-Triassic Boundary . a tyro's view. Palaeobotanist 46 : 63-74.

Maheshwari HK & Banerji J 1975. Lower Triassic palynomorphs from the Maitur Formation, West Bengal, India. Palaeontographica B 152 : 149-190.

Maithy PK 1977. Three, new fern fronds from the *Glossopteris* flora of India. Palaeobotanist 24 : 96-101.

Pal PK, Chakraborty U, Ghosh AK & Ghosh A 1991. Triassic plant megafossils from the Kamthi Formation of Talchir Coalfield, India -a new report. Indian Journal of Geology 63 : 119-125.

Pal PK & Ghosh AK 1997. Megafloral zonation of Permian-Triassic sequence in the Kamthi Formation, Talchir Coalfield, Orissa. Palaeobotanist 46 : 81-87.

Pant DD, Srivastava PC & Das PK 1985. Some new pteridophytic remains from the Lower Gondwana rocks of Hinjrida Ghati, Orissa. Current Science 54 90-92.

RajaRao CS 1982. Coalfields of India. Bulletin of Geological Survey of India Series. A No. 45 : 1-103.

Singh KJ & Chandra S 1987. Some new species of *Glossopteris* from the Kamthi Formation of Handapa, Orissa. Geophytology. 17 39-55.

Singh KJ & Chandra S 1995. Plant fossils from the exposure near Gopal Prasad Village, Talchir Coalfield, Orissa with remarks on the age of the bed. Geophytology 26 : 69-75.

Srivastava AK & Rigby JF 1983. *Sphenophyllum, Trizygia* and *Gondwanophyton* from Barakar Formation of Raniganj Coalfield, with a revision of Lower Gondwana Sphenophyllales. Geophytology 13 : 55-62.

Srivastava SC, Anand-Prakash & Kar R 1997 Palynology of Permian-Triassic sequence in Iria Nala, Tatapani-Ramkola Coalfield, MP, India. Palaeobotanist 46 75-80.

Srivastava SC & Jha N 1995. Palynostratigraphy and correlation of Permian-Triassic sediments in Budhram area, Godavari Graben, India. Journal of Geological Society of India 46 647-653.

Subramanian KS 1962. Progress report on the geological mapping of the Talcher Coalfield, Orissa. Unpublished Report of Geological Survey of India.

Subramanian KS & Rao CN 1960. *Glossopteris* from the Mahadevas of Hinjrida Ghati, Talcher Coalfield, Orissa. Proceeding Indian Science Congress Association. 47th session, Part 3 278.

Surange KR & Chandra S 1973a. *Dictyopteridium sporiferum* Feistmantel - female cone from the Lower Gondwana of India. Palaeobotanist 20 127-136.

Surange KR & Chandra S 1973b. *Denkania indica* gen. *et* sp. nov. a glossopteridean fructification from the Lower Gondwana of India. Palaeobotanist 20 : 264-268.

Surange KR & Chandra S 1973c. *Partha* - A new type of female fructification from the Lower Gondwana of India. Palaeobotanist 20 : 356-360.

Surange KR & Chandra S 1974a. Fructifications of Glossopteridae from India. Palaeobotanist 21 : 1-17.

Surange KR & Chandra S 1974b. *Lidgettonia mucronata* sp. nov a female fructification from the Lower Gondwana of India. Palaeobotanist 21 : 121-126.

Surange KR & Chandra S 1974c. Further observations on *Glossotheca* Surange and Maheshwari : a male fructification of glossopteridales. Palaeobotanist 21 : 248-254.

Surange KR & Chandra S 1974d. Some male fructifications of glossopteridales. Palaeobotanist 21 : 255-266.

Surange KR & Maheshwari HK 1970. Some male and female fructifications of glossopteridales from India. Palaeontographica B 129 : 178-192.