

Plant fossils from Bhareli Formation of Arunachal Pradesh, North-East Himalaya, India

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(Received 01 February 2000; revised version accepted 26 July 2000)

ABSTRACT

Tewari R & Srivastava AK 2000. Plant fossils from Bhareli Formation of Arunachal Pradesh, North-East Himalaya, India. Palaeobotanist 49(2) : 209-217.

Plant fossils collected from Bhareli Formation exposed in Pinjoli Nala section situated on Bhalukpong-Bomdila Road section, West Kameng District, Arunachal Pradesh are described. The assemblage is represented by *Gangamopteris karharbariensis*, *Glossopteris communis*, *G. stenoneura*, *G. longicaulis*, *G. indica*, *G. tenuifolia*, *G. spatulata*, *G. taeniensis*, *G. subtilis*, *Glossopteris* sp. cf. *G. decipiens*, *Glossopteris* sp., *Noeggerathiopsis hislopii*, *Samaropsis ganjrensis*, seed bearing organ, *Vertebraria indica*, scale leaf and equisetalean axes. The flora is comparable with the floristics of Lower Barakar Formation of India.

Key-words—*Glossopteris*, Bhareli Formation, Permian, Arunachal Pradesh.

भारत के उत्तर-पूर्वी हिमालय में स्थित अरुणाचल प्रदेश प्रान्त के भरेली शैलसमूह से प्राप्त
पादपाश्म

रजनी तिवारी एवं अश्विनी कुमार श्रीवास्तव

सारांश

अरुणाचल प्रदेश के पश्चिमी कामेंग जिले के भालुकपोंग-बॉमडिला सड़क परिच्छेद पर अवस्थित पिंजोली नाला परिच्छेद में अनावरित भरेली शैलसमूह के अधोसदस्य से खोजे गए पादपाश्मों का वर्णन प्रस्तुत शोध पत्र में किया गया है। समुच्चय गैंगामॉप्टेरिस करहरबारिएन्सिस, ग्लॉसोप्टेरिस कम्यूनिस, ग्लॉसोप्टेरिस स्टीनोन्यूरा, ग्लॉसोप्टेरिस लांगीकॉलिस, ग्लॉसोप्टेरिस इण्डिका, ग्लॉसोप्टेरिस टेन्यूफोलिया, ग्लॉसोप्टेरिस स्पेट्युलाटा, ग्लॉसोप्टेरिस टीनिफोलिया, ग्लॉसोप्टेरिस सबटिलिस, ग्लॉसोप्टेरिस सबाटिलिस, ग्लॉसोप्टेरिस तुलनीय रूप जी. डेसिपिएन्स, ग्लॉसोप्टेरिस प्रजाति, नॉएगेराथियोप्सिस हिस्लोपाइ, समारोप्सिस गैजरेन्सिस, बीजधारी अंग, वर्टीब्रेरिया इण्डिका एवं इक्वीसीटेलियन अक्ष द्वारा निरूपित है। वनस्पतिजात की तुलना भारत के समुद्रतटीय गोंडवाना क्षेत्र के अधोबराकर शैलसमूह के वनस्पतिजातीय संघटन से की जा सकती है।

संकेत शब्द—ग्लॉसोप्टेरिस, भरेली शैलसमूह, परमियन, अरुणाचल प्रदेश.

INTRODUCTION

THE morphology and taxonomy of plant fossils from Palaeozoic sediments of Arunachal Pradesh have not been studied with proper photographs and descriptions. Jacob & Banerjee (1954) for the first time illustrated and described fragments of two leaves of *Glossopteris* cf. *G. indica* and *Glossopteris* sp. Acharyya *et al.* (1975) reported the occurrence of following plants fossils without illustrations and descriptions: *Glossopteris indica*, *G. communis* var. *stenoneura*, *G. damudica*, *Glossopteris* sp. and *Gangamopteris* cf. *G. cyclopteroides*, *Vertebraria indica*, *Phyllothea* sp. *Schizoneura* and equisetalean axes from Khelong Formation and *Glossopteris indica*, *G. communis* var. *stenoneura*, *G. angustifolia*, *G. longicaulis*, *G. conspicua*, *G. formosa*, *Glossopteris* sp., *Dictyopteridium* sp., *Vertebraria indica*, *Phyllothea* sp. cf. *P. griesbachii*, *Schizoneura gondwanensis* and *Samaropsis* from Bhareli Formation. Bhusan *et al.* (1989, 1991) only provided the names of the fossils while Kumar (1997) illustrated *Gangamopteris cyclopteroides*, *Glossopteris indica*, *G. communis*, *Cordaicarpus* sp. and *Vertebraria indica* without any description. Present assemblage of well preserved specimens belonging to a number of taxa like *Glossopteris*, *Gangamopteris*, *Noeggerathiopsis*, *Samaropsis*, *Vertebraria*, seed bearing organ, scale leaf and equisetalean stem axes suggests the presence of well organized *Glossopteris* flora in Bhareli Formation of Arunachal Pradesh.

GEOLOGY OF THE AREA

Palaeozoic sequence of Bhalukpong-Bomdila Road section rests unconformably over the Bomdila Group and is in tectonic contact with the Main Boundary Fault with the Siwalik Supergroup. Lithologically, it was subdivided into different lithostratigraphic units by earlier authors. Anon (1974) subdivided it into Bichom Group containing marine fauna and continental beds with the remains of plant fossils as Gondwana Group. Jain *et al.* (1974) considered the entire sequence as the Gondwana Formation of Permocarboniferous age. Acharyya *et al.* (1975) compared the beds with Damuda Group of Peninsular India and divided the sequence into Rangit Pebble slate, Khelong, Bhareli and Rilu formations. The plant bearing Khelong and Bhareli formations were equated with Barakar and Raniganj formations of Damodar Basin. Recent field investigations (Bhusan *et al.*, 1991) and compilation of the data suggest the following lithostratigraphic succession as shown in Fig. 1.

Bhareli Formation marked by a thick sequence of grey feldspathic sandstones and grey to black carbonaceous shales with lenticular coal beds represents the continental deposits and contains plant fossils. Bhusan *et al.* (1889, 1991) subdivided it into Lower and Upper members. Lower Member is characterized by arkosic silicified sandstones, siltstones and black to carbonaceous shales with thin, impersistent lenticular coal and is exposed between Elephant Camp and Sessa. Upper

Age	Group	Formation	Member/Unit
Quaternary		Hapoli	
----- Frontal Thrust -----			
Middle Miocene to Lower Pleistocene	Siwalik Group	Kemin Formation Subansiri Formation Dafla Formation	
----- Main Boundary Fault (MBF) -----			
Lower Eocene to Cretaceous to Eocene		Dalbhuig Formation Yinkiang Formation	
----- Unconformity -----			
Lower to Upper Permian	Monpa Group	Bhareli Formation Bichom Formation Miri Formation	Upper Member Lower Member Upper Member Lower Member
----- Tectonic/Unconformity -----			
Middle to Upper Proterozoic	Bomdila Group	Intrusives Dirang Formation Dedza Formation Tenga Formation	Upper Member Lower Member Upper Member Lower Member
----- Main Central Thrust (MCT) -----			
Lower Proterozoic	Sela Group		

Fig. 1—Lithostratigraphic succession.

Member is composed of feldspathic sandstones, black carbonaceous shales with thin impersistent lenticular coal and is distributed between Elephant Camp and Main Boundary Fault. Geology of Arunachal Pradesh has been discussed in detail by Kumar (1997).

Sample location—Carbonaceous shale samples (2-3 m thick) belonging to Bhareli Formation exposed in Pinjoli Nala section situated about 14 km North of Bhalukpong Town in West Kameng District (Fig. 2) have a variety of plant fossils. The fossils are preserved as impressions with shining texture. Most of them, though, fragmentary in nature, show the details of venation pattern and configurations of leaf morphology. The identification of different types of leaves are based on their external morphological features.

All the type and figured specimens are deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

SYSTEMATICS

Genus—GANGAMOPTERIS Mc Coy 1847

GANGAMOPTERIS KARHARBARIENSIS Maithy

1965a

(Pl. 2·3)

Leaf incomplete, measures 5·7 cm in length and 1·5 cm in width; apex and base not preserved; median region occupied by 4-5 sub-parallel veins which give rise to arched secondary veins at an acute angle to form narrow, elongate, hexagonal meshes of equal size throughout lamina.

Comparison—The leaf is comparable with *G. karharbariensis* Maithy (1965a, Pl. 2·11-13) in venation pattern.

No. of specimens—Two.

Genus—GLOSSOPTERIS Brongniart 1828

GLOSSOPTERIS STENONEURA Feistmantel 1877

(Pl. 1·2)

The collection includes middle portions of leaves, measuring 3-10·1 cm in length and 2·2 - 3·7 cm in width, midrib 1·5 to 2 mm wide, striated; secondary veins arise from midrib at 45°, curve slightly backwards and after dichotomising and anastomosing form narrow elongate meshes throughout lamina.

Comparison—Leaves are comparable with *G. stenoneura* Feistmantel (1881; pl. 32·3; pl. 33·5).

No. of specimens—Ten.

GLOSSOPTERIS COMMUNIS Feistmantel 1876

(Pl. 1·4)

Different portions of leaves measuring 6·8-10·5 cm in length and 3·0-7·0 cm in width present in collection; apex not

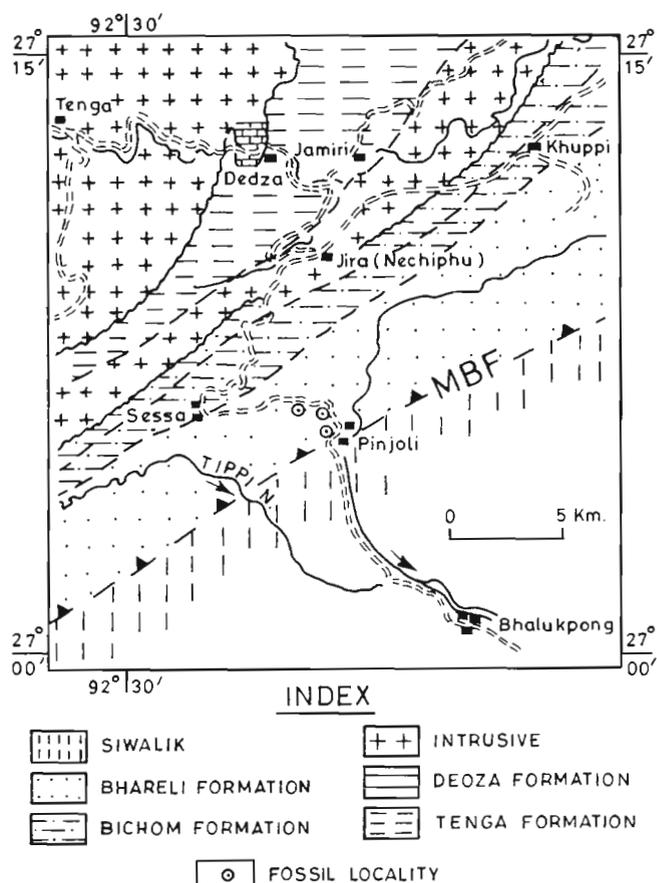


Fig. 2—Geological Map of the area showing fossil locality (after Bhusan *et al.*, 1991).

preserved, base narrow, attenuate; midrib 4-5 mm wide, striated, with pits, evanescent; secondary veins arise from midrib at 45°, arch backwards to form linear, elongate, meshes after dichotomization and anastomoses.

Comparison—Venation pattern of leaves is similar to *G. communis* Feistmantel (1879, pl. 21·5; pl. 17·1-2).

No. of specimens—Five.

GLOSSOPTERIS LONGICAULIS Feistmantel 1880

(Pl. 1·3)

Leaf incomplete, preserved part measures 11 cm in length and 3 cm in width; apex absent, base attenuate, distinctly petiolate; midrib 4 mm wide, covering base of leaf; secondary veins arise from midrib at acute angles, form narrow meshes which become shorter near margin.

Comparison—Leaf compares with *G. longicaulis* Feistmantel (1880, pl. 31·1, 3) in venation pattern and in having a petiolate base.

No. of specimen—One.

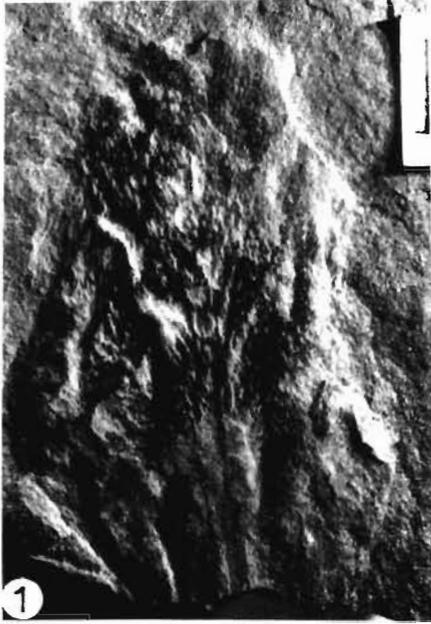


PLATE 1

GLOSSOPTERIS TENUIFOLIA Pant & Gupta 1968

(Pl. 1·5)

Preserved portion of leaf represents lower part of lamina measuring 7·3 cm in length and 1·8 cm in width; shape linear lorate; apex not preserved; base narrow; midrib 2 mm wide, flat, striated; secondary veins arise from midrib at 45°, arch backwards to form long, narrow meshes near midrib and broad polygonal meshes towards margin.

Comparison—Venation pattern and shape of *G. tenuifolia* Pant and Gupta (1968, pl. 21·15) is comparable with the present leaf.

No. of specimen—One.

GLOSSOPTERIS SPATULATA Pant & Singh 1971

(Pl. 1·6)

Apical portion of leaf measures 5·5 cm in length and 4·3 cm in width; apex acute-rounded; midrib 1·5 mm wide, distinct, solid; secondary veins arise from midrib at 45°, gradually arch out to meet margin, form narrow-elongate, hexagonal meshes.

Comparison—Leaf compares with *G. spatulata* Pant and Singh (1971, Pl. 10.60).

No. of specimen—One.

GLOSSOPTERIS TAENIENSIS Chandra & Surange

1979

(Pl. 2·1)

Leaf small, obovate in shape, measures 2·8 cm in length and 1·2 cm in width; apex obtuse, base acute-cuneate, broken on one side; midrib 1 mm wide, slender; secondary veins arise at 45° from midrib and form broad, hexagonal meshes.

Comparison—Shape and venation pattern of leaf is comparable with *G. taeniensis* Chandra & Surange (1979, Pl. 23.7, 9)

No. of specimen—One.

GLOSSOPTERIS SUBTILIS Pant & Gupta 1971

(Pl. 2·2)

Leaf incomplete, measures 5·2 cm in length and 3·3 cm in width; apex not preserved, base obtuse, petiolate; midrib thin, 1 mm wide, slightly elevated; secondary veins arise from midrib at acute angles and after dichotomising and

anastomosing meet margin without arching, meshes narrow, pentagonal, elongate, deltoid, angled, slightly broader near midrib, short and narrow near margin and narrow, elongate, in between midrib and margin.

Comparison—Venation pattern of leaf compares well with *G. subtilis* Pant & Gupta (1971, Text-fig. 2B, C)

No. of specimen—One.

GLOSSOPTERIS INDICA Schimper 1869

(Pl. 2·12)

Preserved specimens represent middle and basal portions of leaves measuring 6·7-10·5 cm in length and 2·5-5 cm in width; base tapering; midrib distinct; striated, 5 mm wide; secondary veins arise from midrib at 45°, form short, broad meshes near midrib and narrow, elongate, linear, hexagonal meshes near margin.

Comparison—The leaves compare in venation pattern with *G. indica* Schimper Feistmantel (1881, Pl. 26·3).

No. of specimens—Three.

GLOSSOPTERIS sp. cf. **G. DECIPIENS** Feistmantel,

1879

(Pl. 1·1)

Leaf incomplete, measures 6·2 cm in length and 4·0 cm in width; apex and base not present; midrib 2 mm wide, striated, evanescent, present only in lower portion of leaf; secondary veins arise at acute angles from midrib to form narrow, oblong meshes, throughout lamina.

Comparison—Leaf is similar to *G. decipiens* Feistmantel (1879, Pl. 18·3-5) in presence of evanescent midrib.

No. of specimen—One.

GLOSSOPTERIS sp.

(Pl. 2·11)

Leaves linear; apex and base not preserved; middle part of leaves measure 3·5-5·2 cm in length and 0·6-0·7 cm in width; midrib faint, indistinct; secondary veins indistinct, arching backwards, meshes arcuate, narrow, trapezoidal near midrib, elsewhere not clear.

Remarks—Due to indistinct and faint nature of veins, it is difficult to identify the species of leaf.

No. of specimens—Two.

**PLATE 1**

1. *Glossopteris* sp. cf. *G. decipiens* Feistmantel. Leaf showing evanescent midrib. Specimen no. BSIP 38377. x 1·3.
2. *Glossopteris stenoneura* Feistmantel. Specimen no. BSIP 38377. x 1.
3. *Glossopteris longicaulis* Feistmantel. An incomplete leaf showing long, narrow petiolate base. Specimen no. BSIP 38379. x 1.
4. *Glossopteris communis* Feistmantel. Specimen no. BSIP 38380. x 1
5. *Glossopteris tenuifolia* Pant & Gupta. Specimen no. BSIP 38381. x 1.
6. *Glossopteris spatulata* Pant & Singh. Specimen no. BSIP 38382. x 1·5.

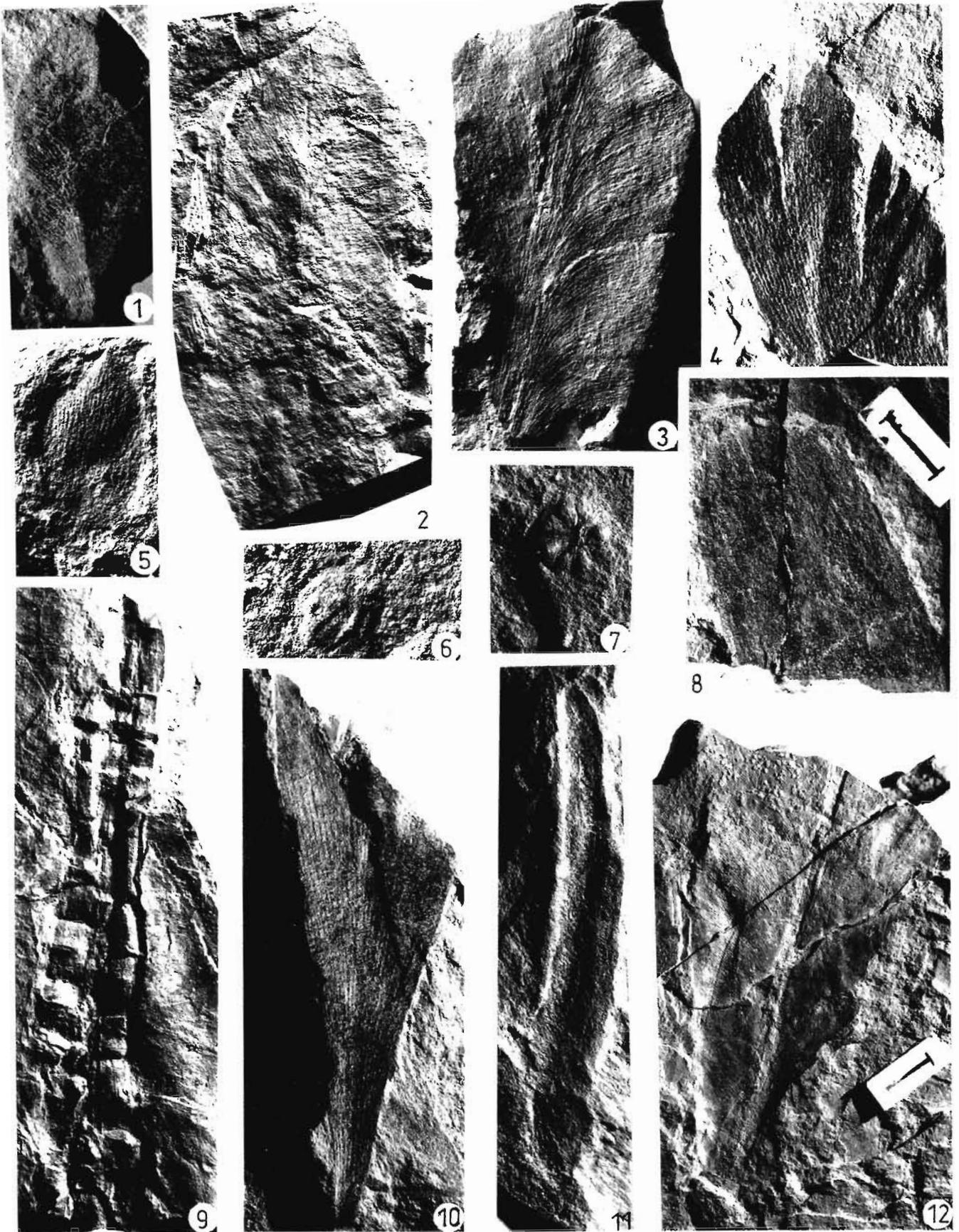


PLATE 2

Genus—NOEGGERATHIOPSIS Feistmantel 1879

NOEGGERATHIOPSIS HISLOPII Feistmantel 1879

(Pl. 2·4, 8, 10)

Different portions of leaves measure 4·2-5·0 cm in length and 1·2-1·8 cm in width, shape spatulate, apex obtuse, base narrow, elongate, tapering, number of parallel veins arise from base, bifurcate frequently during upward course, side veins show slight arching near margin.

Comparison—The leaves are comparable to *Noeggerathiopsis hislopii* Feistmantel (1879, Pl. 19·2-6) in shape and venation pattern.

No. of specimens—Five.

SCALE LEAF

(Pl. 2·5)

Leaf small, ovate, 1·1 cm long and 0·8 cm wide, apex acute, base narrow, rounded; a number of veins arise from base, dichotomise, anastomose to form narrow, elongate meshes.

No. of specimen—One.

Genus—SAMAROPSIS Göeppert 1864

SAMAROPSIS GANJRENSIS Saksena 1956

(Pl. 2·6)

Seed platyspermic, pear shaped, measures 5 mm in length and 4 mm in width, apex acute, notched, base rounded; sclerotesta 2 mm wide, surrounds sarcotesta except at apex where it forms a 'V' shaped sinus; faint striations present on the surface. A distinct ridge runs from base to apex in the centre of sarcotesta.

Comparison—Seed is comparable to *Samaropsis ganjrensis* Maithy (1965b; Pl. 1·7, 8). However, in Maithy's specimen, median ridge is not present.

No. of specimen—One.

SEED BEARING ORGAN

(Pl. 2·7)

Part and counter part of detached, round seed bearing organ, 7 mm in diameter with eight lobes present in collection,

each lobe probably contains a single seed; associated bract or scale leaf absent.

Remarks—The nature and organisation of seed bearing organ is comparable to peltate disc of *Partha Srivastava* (1992, Pl. 7·1-3). However, present specimen is distinct in having eight chambers.

No. of specimen—One.

Genus—VERTEBRARIA Royle 1839

VERTEBRARIA INDICA Royle 1839

(Pl. 2·9)

A number of specimens ranging in size from 2·5-11·3 cm in length and 0·4-1·7 cm in width, show two rows of rectangular blocks separated by 1-1·5 mm ridge.

No. of specimens—Eleven.

EQUISETALEAN-AXES

Branched and unbranched axes measuring 3·5-12·1 cm in length and 0·4-2·7 cm in width present in collection, show nodes and internodes, ridges and furrows present in internodal areas.

No. of specimens—Fourteen.

DISCUSSION

Plant bearing Palaeozoic sequence of Arunachal Pradesh is considered a continental deposit and is divided by many workers under different nomenclatures e.g., Gondwana, Damuda Group, Permo-Carboniferous, Khelong and Bhareli formations (Jain *et al.*, 1974; Acharyya *et al.*, 1975; Tripathi & Chowdhary, 1983). Recent classification divides the plant bearing Bhareli Formation into Lower and Upper members (Bhusan *et al.*, 1989, 1991; Kumar, 1997). It has been observed by earlier workers that the Lower Member contains the species of *Gangamopteris* and *Glossopteris* and the Upper Member shows the presence of equisetalean taxa, e.g., *Phyllothea* and *Schizoneura* alongwith the leaves of *Glossopteris*, *Gangamopteris* is not recorded in this assemblage.

The plant fossils of Pinjoli Nala section belonging to Bhareli Formation of Arunachal Pradesh are represented by the species of *Gangamopteris*, *Noeggerathiopsis*, *Glossopteris*, *Samaropsis*, *Vertebraria*, seed bearing organ,



PLATE 2

1. *Glossopteris taeniensis* Chandra & Surange. Small, obovate leaf showing venation pattern. Specimen no. BSIP 38383. x 2.
2. *Glossopteris subtilis* Pant & Gupta. Specimen no. BSIP 38384B. x 1·3.
3. *Gangamopteris karharbariensis* Maithy. Specimen no. BSIP 38385. x 2.
- 4,8,10. *Noeggerathiopsis hislopii* Feistmantel. Specimen nos. BSIP 38391B. x 1·5, 38386A. x 1·3 and 38387. x 2, respectively.
5. Scale leaf. Specimen no. BSIP 38388. x 2·6.
6. *Samaropsis ganjrensis* Saksena. Platyspermic oval seed. Specimen no. BSIP 38386B. x 4.
7. Seed bearing organ. Specimen no. BSIP 38389. x 2·5.
9. *Vertebraria indica* Royle. Specimen no. BSIP 38384A. x 1
11. *Glossopteris* sp. Linear leaf with faint secondary veins, Specimen no. BSIP 38390. x 2.
12. *Glossopteris indica* Schimper. Specimen no. BSIP 38391A.

scale leaf and equisetalean axes. In Gondwana Sequence of Peninsular India, *Gangamopteris* and *Noeggerathiopsis* leaves are common in the Lower Permian horizons of Karharbari and Barakar formations (Surange, 1975; Srivastava, 1997). However, Karharbari flora is distinct in having typical elements of its own i.e., *Buriadia* and *Botrychiopsis* whereas *Gangamopteris* and *Noeggerathiopsis* continue in the Lower Barakar, alongwith *Glossopteris* (Maithy, 1969; Lele, 1976; Srivastava, 1997). The present assemblage in having known species of *Gangamopteris* and *Noeggerathiopsis* and a number of species of *Glossopteris* which are common in Lower Barakar viz., *G. cf. G. decipiens*, *G. communis*, *G. stenoneura*, *G. indica*, *G. taeniensis*, *G. spatulata*, *G. tenuifolia* and *G. subtilis* compares closely with the Lower Barakar flora of Raniganj and Auranga coalfields (Srivastava, 1992; Srivastava & Tewari, 1996).

Present assemblage is distinct in having many species of *Glossopteris* which have not been recorded earlier from the Khelong and Bhareli formations (Acharyya *et al.*, 1975) and Lower and Upper members of Bhareli Formation (Bhusan *et al.*, 1991). The age of these formations and members has been assigned to Late and Early Permian, respectively. Kumar (1997) has noticed that lithologically it is difficult to distinguish the Lower and Upper members of Bhareli Formation and the sequence is inverted in field. The sample site has been attributed to the Upper Member of Bhareli Formation by him mainly due to absence of *Gangamopteris* and presence of equisetales and *Glossopteris* leaves (Bhusan *et al.*, 1991). However, recovery of *Gangamopteris* alongwith *Noeggerathiopsis* and seeds indicates that affinity of the flora is with Lower Permian. The palynodating of Gondwana equivalent beds in West Kameng District by Dutta *et al.*, (1988) also favours the Early Permian age. In order to resolve the stratigraphic position of the Bhareli Formation it is imperative to examine the flora *vis-à-vis* lithounits of Gondwana equivalent sediments of Arunachal Pradesh.

Acknowledgements—We are thankful to Prof Anshu K. Sinha, Director, Birbal Sahnii Institute of Palaeobotany, Lucknow for his kind permission to publish the paper (vide BSIP/RCPC/Publ/2000-12). Thanks are also due to Suresh C. Srivastava for his help in collection of samples.

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