

# Upper Gondwana plants from the Puna Formation, southern Xizang (Tibet)

Zhou Zhiyan & Wu Yiming

Zhou Z & Wu Y 1994. Upper Gondwana plants from the Puna Formation, southern Xizang (Tibet). *Palaeobotanist* 42(2) : 120-125.

A plant megafossil assemblage comprising *Cladophlebis* sp., *Pachypteris specifica* Feistmantel, a fragmentary leaf, *Ptilophyllum acutifolium* Morris, *Araucarites minutus* Bose & Maheshwari, *Elatocladus tenerrimus* (Feistmantel) Sahnii, *Brachyphyllum* (*Allocladus*?) sp., *Coniferocaulon rajmahalense* Gupta, *Coniferocaulon?* sp. and roots, is reported from the coal-bearing Puna Formation, Tingri District, southern Xizang, Tibet. This assemblage represents the Assemblage Zone 9 (Sukh-Dev, 1988) of India and is considered Early Cretaceous in age. The similarity between the Puna florule and the Indian flora extends further the northern limits of Gondwanaland into southern Tibet.

**Key-words**—Plant megafossils. Phytogeography. Puna Formation, Early Cretaceous, Tibet.

Zhou Zhiyan, Nanjing Institute of Geology and Palaeontology, Academia Sinica, Nanjing 210 008. China.

Wu Yiming, Xizang Institute of Geological Sciences, Geological Bureau. China.

## सारांश

### दक्षिणी जिजौंग (तिब्बत) में पुना शैल-समूह से उपरि गोंडवाना पौधे

झाउ झिआन एवं वु यिमिंग

तिब्बत में दक्षिणी जिजौंग के तिगरी जनपद के कोयला-धारक पुना शैल-समूह से *क्लेडोफ्लेबिस* जा., *पैक्यिप्टेरिस स्पेसिफिका* फ़ाइस्टमैन्टेल, एक विकसित पत्ती, *टिलोफिल्लम एक्यूटिफोलियम* मोरिस, *अंराकाराइटिस माइन्यूटस* बोस व माहेश्वरी, *इलेटोक्लेडस टैनेरिमस* (फ़ाइस्टमैन्टेल) साहनी, *ब्रेक्यिफिल्लम* (*एल्लोक्लेडस*) जाति, *कोनिफ़रोकोलॉन राजमहलेन्से* गुप्ता, *कोनिफ़रोकोलॉन?* जाति एवं कुछ जड़ों से युक्त गुरुपादपाश्म समुच्चय का वर्णन किया गया है। यह समुच्चय भारत के समुच्चय मंडल-9 (सुख-देव, 1988) से सजातीयता व्यक्त करती है तथा क्रीटेशी आयु की प्रस्तावित की गई है। पुना वनस्पतिजात एवं भारतीय वनस्पतिजात की इस पारस्परिक समानता से यह इंगित होता है कि गोंडवानाभूमि की उत्तरी सीमायें दक्षिणी तिब्बत तक विस्तृत थीं।

THE Puna Formation crops out in the Zhaya River, Puna county in the Tingri (Xêgar) District, about 60 km north to Mount Qomolungma (Mt. Everest) (Text-figure 1). Earlier, it was believed to be equivalent to the lower part of the Middle to Late Jurassic Menkadum Formation (Wang, 1987) or the Mengbu Formation (Yu *et al.*, 1983), a Jurassic marine formation in the Mount Qomolungma area. The succession and fossil-bearing horizons of the Puna Formation are as follows : (Text-figure 2)

Overlying beds : Limestones believed to be equivalent to the upper part of the Menkadum Formation in the Mount Qomolungma area

.....Conformity.....

Puna Formation :

17. Greyish black carbonaceous sandstones and mudstones with a coal seam.....1.29 m
16. Dark grey siltstone, yielding? *Macrocephalites* cf. *etheridgei* (Spath) (84 PVI) (identified by Wang Yigang) in the upper part.....17.74 m
15. Grey fine-grained sandstones.....22.74 m

14. Grey fine-grained sandstones with coal seams.....4.55 m
13. Grey siltstone .....4.7 m
12. Black carbonaceous mudstones with a thin coal seam .....0.53 m
11. Greyish white, medium-grained sandstones with thin coal seams .....14.48 m
10. Greyish white, medium-grained quartzitic sandstones .....3.03 m
9. Grey shale with thin-bedded sandstones .....1.55 m
8. Coal seam .....0.66 m
7. Alternations of greyish white medium-grained sandstones and greyish black carbonaceous siltstone with fossil plants in the upper part : *Pachypteris?* sp., *Ptilophyllum acutifolium* Morris, *Araucarites minutus* Bose & Maheshwari, *Brachyphyllum* (?*Allocladus*) sp., *Coniferocaulon?* sp. and roots (84 PIV), and indeterminable plants in the lower part (84 PIV) .....1.9 m
6. Black carbonaceous mudstones and a thin coal seam .....0.25 m
5. Greyish white, medium-grained sandstones, with a layer of grey siltstone 0.2 m thick at the top, yielding *Pachypteris specifica* Feistmantel, *Ptilophyllum* sp., *Araucarites minutus* Bose & Maheshwari, *Elatocladus tenerrimus* (Feistmantel)



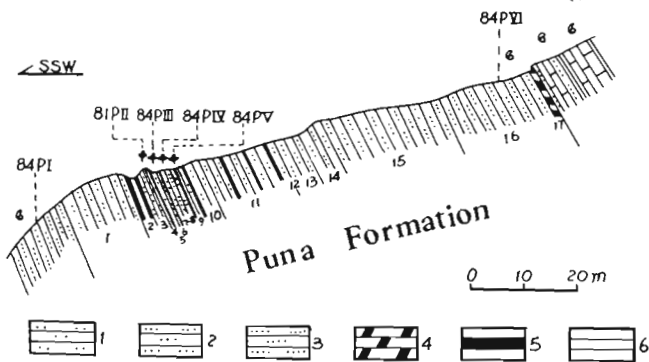
**Text-figure 1**—Map showing the localities of the Lower Cretaceous Puna florule and other Mesozoic localities in the Himalayas : Kagbeni (Barale *et al.*, 1978); Lingshi (Ganesan & Bose, 1982); Tansen (Kimura *et al.*, 1985).

- Sahni, *Brachyphyllum (Allocladus?)* sp., *Coniferocaulon rajmabalense* Gupta and roots (84 PIII) ..... 1.08 m
4. Black carbonaceous mudstones with a thin coal seam ..... 0.36 m
3. Greyish white, medium-grained, quartzitic sandstones, with a grey siltstone 0.3 m thick at the top, yielding *Cladophlebis* sp., *Elatocladus tenerrimus* (Feistmantel) Sahni, *Brachyphyllum (Allocladus?)* sp., and roots (84 PII) ..... 2.21 m
2. Coal seam ..... 1.81 m
1. Greyish white, medium-grained, quartzitic sandstones with thin-bedded siltstone in the upper part containing fragments of plants ..... 13.2 m
- ..... Conformity .....

Underlying beds : Grey, thick-bedded siltstone yielding indeterminable ammonites, and bivalves *Palaeoneilo* cf. *asabarbitensis* Cox and *Thracia?* sp. (84 PI), identified by Wen Shixuan, believed to be equivalent to the Middle Jurassic Niehnieh Hsiungla Formation.

On the basis of the doubtful macrocephalid ammonites the coal-bearing Puna Formation was referred to Lower Callovian (Wu & Hong, 1987, 1989). In the Lower part of the Menkadum Formation, ammonites are well-preserved and much more abundant (Wang & Zhang, 1974; Zhao, 1979) than in the Puna Formation.

The bivalves, found in the underlying siltstone, appear to indicate a Bathonian or Callovian age. All



**Text-figure 2**—Stratigraphical section of the Puna Formation in Puna County, Tingri, showing the fossil-bearing horizons.

the fossil plants of the Puna Formation have suffered from metamorphism and usually have a shining surface. Though coaly substance is commonly present on the specimens, no useful cuticles have been obtained by maceration. All the specimens described in the present paper were deposited in NIGPAS under the registration number : PB14735-14766.

**DESCRIPTION**

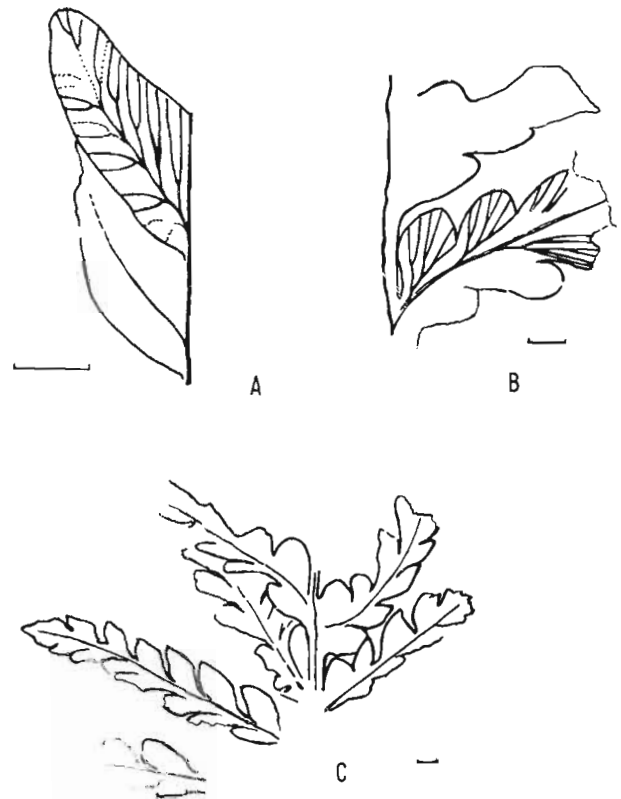
Genus—*Cladophlebis* Brongniart

*Cladophlebis* sp.

Pl. 1, fig. 1; Text-fig. 3A

**Description**—Fragmentary pinna, rachis less than 1 mm wide. Pinnules alternate, deltoid, slightly falcate, 2-3.5 mm long and less than 2.5 mm wide at base. Margin entire. Apex obtusely pointed. Midrib giving off lateral veins at about 45°-60°; veins mostly forked once.

**Remarks**—Only a fragmentary apical part of a pinna is found with mostly once forked lateral veins.



**Text-figure 3**—A, *Cladophlebis* sp., PB14737, showing the shape of pinnules and venation; B,C, *Pachypteris specifica* Feistmantel, PB14740, 14747, showing the shape of pinnae and venation; scale = 1 mm.

**Genus—*Pachypteris* Brongniart***Pachypteris specifica* Feistmantel 1876

Pl. 1, figs 3, 4; Text-fig. 3B, C

*Remarks*—Two fragmentary bipinnate fronds have been recovered, which resemble *Pachypteris specifica* Feistmantel described by Bose and Banerji (1984) from Kachchh, India in gross features.

**A fragmentary leaf**

Pl. 1, fig. 2

*Description*—Fragmentary leaf 10 mm long and 11 mm wide. Midrib about 1 mm wide at the lower part, becoming evanescent upwards. Lateral veins make a narrow angle, bifurcate at least twice.

**Genus—*Ptilophyllum* Morris***Ptilophyllum acutifolium* Morris 1840

Pl. 1, fig. 5

*Remarks*—A couple of specimens, resembling *P acutifolium* Morris described by Bose and Banerji (1984), can be compared with some other species of *Ptilophyllum* in shape and size, but their cuticular features are not known.

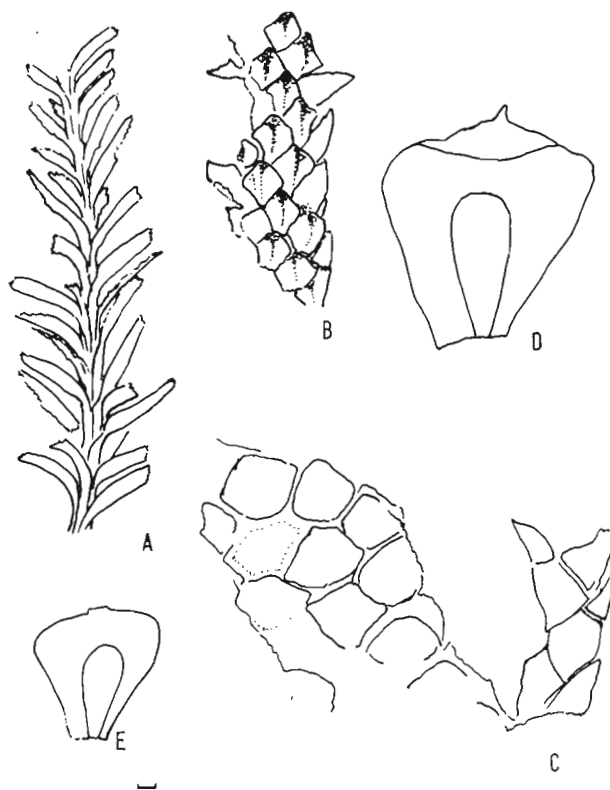
**Genus—*Araucarites* Presl***Araucarites minutus* Bose & Maheshwari 1973

Pl. 1, figs 6-7; Text-fig. 4D, E

*Remarks*—These cone scales look similar to *Araucarites minutus* described by Bose and Maheshwari (1973) from the Jabalpur Formation, India. Two of the present specimens (PB14764, and 14765, unfigured) are slightly larger in size.

**Genus—*Elatocladus* Halle***Elatocladus tenerrimus* (Feistmantel) Sahnii 1928

Pl. 1, figs 8, 8a. Text-fig. 4A



**Text-figure 4**—A. *Elatocladus tenerrimus* (Feistmantel) Sahnii, PB14742 (left); B.C. *Brachyphyllum* (*Allocladus*?) sp., PB14753, 14736; D.E. *Araucarites minutus* Bose & Maheshwari, PB14764, 14765; scale = 1 mm.

*Remarks*—The presence of narrow and usually straight leaves having obtuse apices and strongly decurrent bases, giving off at wide angles, shows that the present specimens belong to *E. tenerrimus*.

**Genus—*Brachyphyllum* Brongniart***Brachyphyllum* (*Allocladus*?) sp.

Pl. 1, figs 9-11; Text-fig. 4B, C

*Description*—Fragmentary branched-leafy shoots, bearing  $\pm$  rhomboidal leaves. Leaves small, close to sparsely arranged and appressed to the stem. Upper leaf short, triangular; lower leaf bulging out into a small knob; some leaves keeled. Apex acute. Leaf-base cushion  $\pm$  rhomboidal.

**PLATE 1**

- |  |   |
|--|---|
| 1. <i>Cladophlebis</i> sp., PB14737, $\times 3$ .                                    | 8,8a. <i>Elatocladus tenerrimus</i> (Feistmantel) Sahnii, PB14744, $8 \times 1$ , 8a $\times ca. 2.5$ . |
| 2. A fragmentary leaf, PB14750, $\times 3$ .   | 9-11. <i>Brachyphyllum</i> ( <i>Allocladus</i> ?) sp., PB14753, 14741, 14736, all $\times 2$ .          |
| 3,4. <i>Pachypteris specifica</i> Feistmantel, PB14746, 14747 both $\times 2$ .      | 12-13. <i>Coniferocaulon rajmabalense</i> Gupta, PB14766, 14763. $\times 1$ .                           |
| 5. <i>Ptilophyllum acutifolium</i> Morris, PB14756. $\times 1$ .                     | 14. <i>Coniferocaulon</i> ? sp., PB14751, $\times 3$ .  |
| 6,7. <i>Araucarites minutus</i> Bose & Maheshwari, PB14740, 14748, both $\times 2$ . | 15-18. Roots, PB14752, 14735, 14762, 14755; 15, 17, 18 $\times 1$ , 16 $\times 2$ .                     |

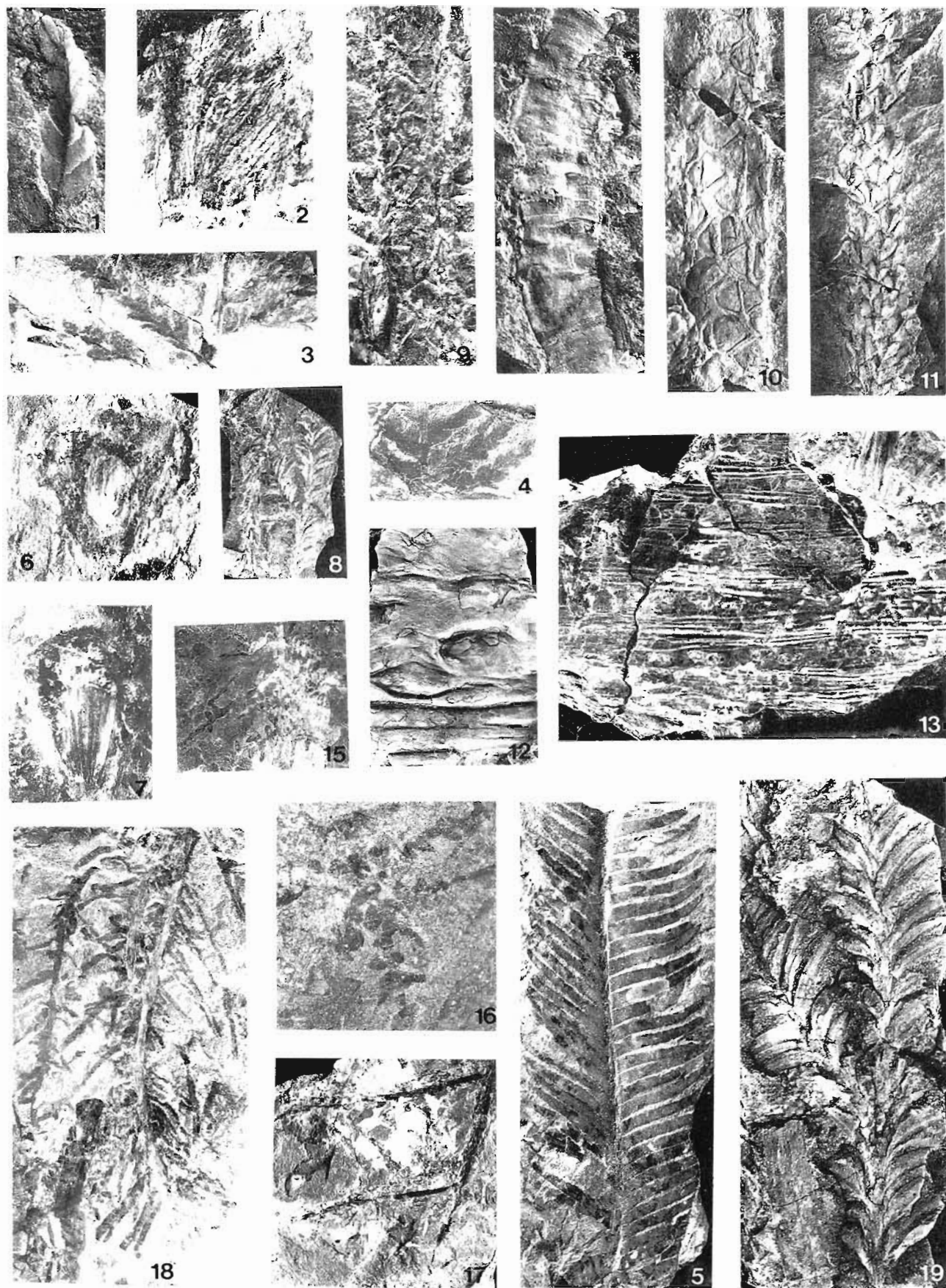


PLATE 1

*Remarks*—Three fragmentary leafy shoots bearing  $\pm$  rhomboidal leaves appressed to the stem are found. These leaves show variation in the degree of their closeness and presence of knob and keel on the convex lower surface. Provisionally they are described as *Brachyphyllum (Allocladus?)* sp. The present form is somewhat comparable to *Brachyphyllum regulare* Borkar & Chiplonkar 1973, *B. eikaiostomum* Sukh-Dev & Bose 1977 and *Allocladus bansaensis* Sukh-Dev & Zeba-Bano 1979 in external morphology, but are not identical.

#### Genus—*Conifero-caulon* Fliche

*Conifero-caulon rajmahalense* Gupta 1954

Pl. 1, figs 12-13

*Remarks*—The specimens from the Puna Formation match with *C. rajmahalense* Gupta 1954 reported from Rajmahal Hills, Bihar, Madhya Pradesh (Bose, 1959), Rajasthan (Bose *et al.*, 1982) and Lingshi Basin, Bhutan (Ganesan & Bose, 1982).

*Conifero-caulon?* sp.

Pl. 1, fig. 14

*Description*—Stem 10 cm long, 1.7 cm wide at the widest portion and incomplete. Stem surface showing lenticular leaf-scars arranged spirally, 0.6-1.5 mm high and 2-5 mm wide.

*Remarks*—The markings of grooves and ridges on the stem surface in the present form are quite different from *Conifero-caulon rajmahalense*.

#### Roots

Pl. 1, figs 15-18

*Description*—Two different types of roots are found. One of them (Pl. 1, fig. 17) consists of a main axis, more than 8 cm long and 3 mm wide, and lateral appendages up to 4 cm long and about 1 mm wide, given off at angles of about 30°-60° from the axis. The other type has a main axis about 2 mm thick and more than 10.5 cm long, bearing lateral appendages of two orders. Appendages of the first order long and linear; ultimate appendages irregular in shape and size.

#### DISCUSSION

The present plant assemblage recovered from the Puna Formation, Tingri District, southern Xizang (Tibet) comprises *Cladophlebis* sp., *Pachypteris specifica* Feistmantel, a fragmentary leaf, *Ptilophyllum acutifolium* Morris, *Araucarites minutus* Bose & Maheshwari,

*Elatocladus tenerrimus* (Feistmantel) Sahni, *Brachyphyllum (Allocladus?)* sp., *Conifero-caulon rajmahalense* Gupta, *Conifero-caulon?* sp. and roots. In this assemblage, ferns are rare and the pteridosperms are represented by a single species *Pachypteris specifica*, while cycadophytes and conifers are fairly well-represented. In general composition the Tibetan plant assemblage is closely comparable with that of Lingshi Group in Bhutan (Ganesan & Bose, 1982). As such it represents Assemblage Zone 9 established by Sukh-Dev (1988) in the Mesozoic floras of the Indian subcontinent, and is thus of Early Cretaceous and not of Callovian or Jurassic as formerly believed. This close identity of the Puna fossil florule with the Indian flora further extends the northern limits of Gondwanaland into Tingri District, southern Xizang (Tibet) in Mesozoic times. The discovery of *Glossopteris* in Tingri District has demonstrated that an association of southern Xizang Block and the Indian Plate existed early in the Permian (Hsü, 1976). According to the palaeomagnetic evidence (Zhu & Tang, 1984), Indian Plate rifting took place by the Middle Triassic and while small blocks started drifting northwards in the Late Triassic. It appears from the present study that at least in the Early Cretaceous the southern Xizang Block was attached to the Indian Plate.

#### REFERENCES

- Barale G, Bassouillet JP & Bose MN 1978. On a collection of Mesozoic plants from Kagbeni-Mukhtinath, Thakkhola Valley, Nepal. *Palaeobotanist* **25** : 32-38.
- Borkar VD & Chiplonkar GW 1973. New plant fossils from the Umia of Saurashtra. *Palaeobotanist* **20** : 269-279.
- Bose MN 1959. Some fragmentary plant fossils from Narsinghpur District, Madhya Pradesh, India. *Palaeobotanist* **6** : 49-50.
- Bose MN & Banerji J 1984. The fossil floras of Kachchh—Part 1. Mesozoic megafossils. *Palaeobotanist* **33** : 1-189.
- Bose MN, Kumaran KPN & Banerji J 1982. *Pachypteris baburensis* n. sp. and other plant fossils from the Pariwar Formation. *Palaeobotanist* **30**(1) : 1-11.
- Bose MN & Maheshwari HK 1973. Some detached seed-scales belonging to Araucariaceae from the Mesozoic rocks of India. *Geophytology* **3**(2) : 205-214.
- Feistmantel O 1876. Jurassic (Oolitic) flora of Kach. In: Fossil flora of the Gondwana System. *Mem. geol. Surv. India Palaeont. Indica*, ser. 11, **2**(1) : 1-80.
- Ganesan TM & Bose MN 1982. Plant remains of Mesozoic age from Lingshi Basin, Bhutan. *Geophytology* **12**(2) : 279-286.
- Gupta KM 1954. Notes on some Jurassic plants from the Rajmahal Hills, Bihar, India. *Palaeobotanist* **3**(1) : 18-25.
- Hsü J 1976. On the discovery of a *Glossopteris* flora in southern Xizang and its significance in geology and palaeogeography. *Sci. Geol. Sin.* (4) : 330-335. (in Chinese with English Summary).
- Kimura T, Bose MN & Sakai H 1985. Fossil plant remains from Taltung Formation, Palpa District, Nepal lesser Himalaya. *Bull. Natn. Sci. Mus.* **11**(4) : 141-153.
- Sahni B 1928. Revisions of Indian fossil plants : Part-1. Coniferales (A. Impressions and incrustations). *Mem. geol. Surv. India Palaeont. Indica*, n.s. **11** : 1-49.
- Sukh-Dev 1988. Floristic zones in the Mesozoic formations and their relative age. *Palaeobotanist* **36** : 161-167.

- Sukh-Dev & Bose MN 1974. On some conifer remains from Bansa, South Rewa Gondwana Basin. *Palaeobotanist* **21**(1) : 59-69.
- Sukh-Dev & Zeba-Bano 1979. Observations on the genus *Allocladus* and its representatives in the Jabalpur Formation. *Palaeontographica* **B169** : 116-121.
- Wang Yigang 1987. Reclassification of the Jurassic of the Mount Qomolungma area. *J. Stratigr. (Beijing)* **11** : 287-298 (in Chinese).
- Wang Yigang & Zhang Mingliang 1974. The Jurassic System. In *Reports for scientific expedition to the Mt. Qomolungma area—Geology* : 127-147. Science Press, Beijing (in Chinese).
- Wu Yiming & Hong Yurong 1987. Discovery of Middle Jurassic Callovian plant fossils of Gondwana aspect in Tingri, Xizang (Tibet). *Kuexue Tongbao* **32**(24) : 1881-1883 (in Chinese).
- Wu Yiming & Hong Yurong 1989. Discovery of Gondwana facies fossil plants of Callovian stage in Tingri, Xizang. *Chin. Sci. Bull.* **34**(1) : 61-62.
- Yu Guangming, Zhang Qihua, Gou Zhonghai, Lan Bolong, Wang Chengshan, Xu Yalin, Wang Guorong, Li Xiaochi, Wang Xiaoqiao & Huang Yaping 1983. Subdivision and correlation of Jurassic System in the Nyalam area, Xizang (Tibet). In *Contribution to the Geology of the Qinghai-Xizang (Tibet) Plateau* **11** : 165-177. Geol. Publ. House, Beijing (in Chinese).
- Zhao Jinke 1979. Jurassic and Cretaceous ammonites in the Mount Qomolungma area. In : *Reports for scientific expedition to the Mt. Qomolungma area—Palaeobotanist* **3** : 503-545. Science Press, Beijing (in Chinese).
- Zhu Zhiwen & Tang Jiwen 1984. The palaeomagnetic evidence for small blocks of the Indian Plate drifting towards the north and colliding with Eurasian Plate after the Gondwana disintegrated. In : Li Guangcen & Merqier JL (Editors)—*Sino-French Cooperative investigation in Himalaya* : 17-23 (in Chinese with English Summary).