

PLANT REMAINS OF MESOZOIC AGE FROM LINGSHI BASIN, BHUTAN

*T. M. GANESAN AND M. N. BOSE**

*Kashmir Circle, Geological Survey of India, Srinagar

**Birbal Sahni Institute of Palaeobotany, Lucknow-226 007

ABSTRACT

The upper part of Mo Chu Formation of Lingshi Basin has yielded fossil plant remains. The fossils are rather poorly preserved and amongst them identifiable species are, *Pachypteris* cf. *indica* (Oldham & Morris) Bose & Roy, *Ptilophyllum acutifolium* Morris, *Elatocladus jabalpurensis* (Feismantel) Halle, *Pagiophyllum* sp. A, *Pagiophyllum* sp. B and *Coniferocaulon* cf. *rajmahalense* Gupta. The assemblage somewhat resembles certain plant assemblages known from the Upper Gondwana of India.

INTRODUCTION

The Lingshi Basin is situated in the Tethyan belt of the Higher Himalaya of Bhutan (Text-fig. 1). It forms a WNW-ESE trending synclinorium flanked by the older crystalline rocks in the south and east, while in the north and southwest lie respectively the Tethyan sedimentaries of the Tsang Po Valley and Phari Basin of Tibet.

The plant-bearing rocks forming the part of Lingshi Group unconformably overlies the Shodug Formation and occupies a large tract in the central part of the Lingshi synclinorium. The Lingshi Group consists of a lower 300-350 m thick fresh-water facies comprising laminated quartzite, sandstone and carbonaceous (plant bearing beds) shale and an upper (1,000 m) marine sequence of dark carbonaceous slate and quartzite with thin streaks of plant bearing shale (5-10 cm). The lower fresh-water facies is grouped under Mo Chu Formation and is well developed in the southern and eastern parts of the basin. The upper marine facies of rocks are grouped under Chebesa Formation and is predominantly developed in the central and west central parts.

Mo Chu Formation—The succession starts (Text-fig. 2) with a 150 m thick sequence of dark grey and grey laminated quartzite with thin interbeds of dark slate. The quartzite shows worm trails, while the shale comprises fragmentary plant impressions. This is followed by a thin (5-6 m) bleached slate with ammonite remains which is followed by a 100-150m thick sandstone, greenish feldspathic sandstone having fragmentary plant-remains and thin bivalves. Further up, there is a 25 m thick dark carbonaceous plant-bearing shale, with dark micaceous sandy slate and minor sandstone, which is overlain by a 12 m thick carbonaceous and micaceous slate with plant fossils. The latter two units are exposed at locality F1 (Text-fig. 1). This is followed by a (15 m) grey to white quartzite (often gritty) and pebbles with thin shale bands containing ammonites which has been taken as the upper limit of the Mo Chu Formation.

Chebesa Formation—The succeeding Chebesa Formation is mainly made up of dark carbonaceous slate and minor greenish arenite with remains of bivalves and ammonites. There are a few thin plant-bearing shale streaks (1-10 cm) in the lower part of this formation (localities F2 and F3 in Text-fig. 1).

The field evidences suggest that the Mo Chu Formation is the lateral facies variation of broad Chebesa Formation in the lower part. The lithostratigraphic assemblage

of the Lingshi Group indicates that the overall sedimentation took place in near shore, shallow marine conditions.

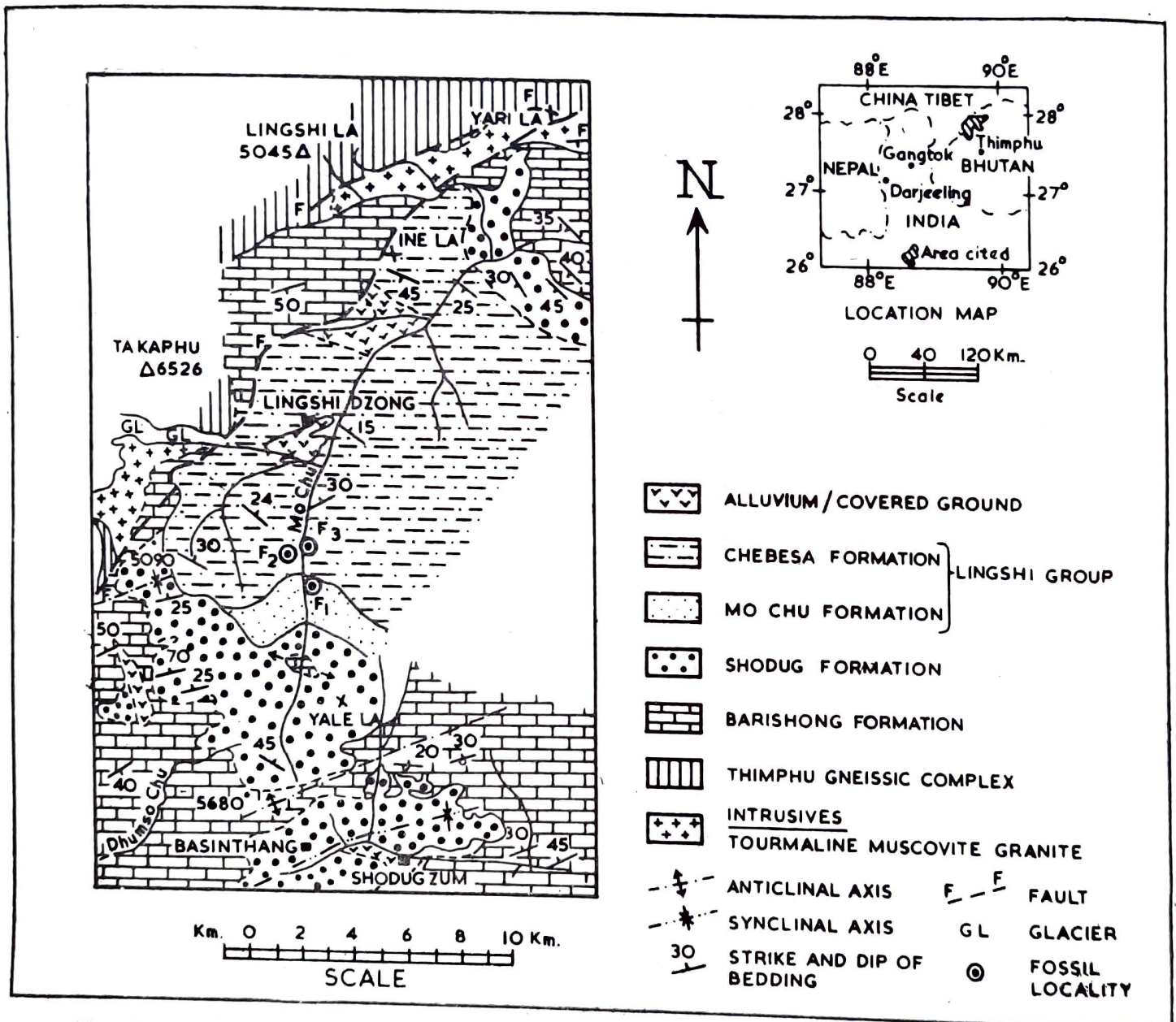
Except two specimens (G.S.I. nos. 19561 and 19562), all the fossils described below were collected by one of us (T.M.G.) and Mr. K. P. Reddy from the upper part of Mo Chu Formation exposed at locality F1 (Text-fig. 1) which lies about 4 km north of Yale La. The other two specimens were collected (by T.M.G. alone) from the basal part of Chebesa Formation exposed at localities F2 and F3 (Text-fig. 1). The plant remains are considered to be of middle to late Jurassic in age. A brief report on these fossils has already been given by GANESAN *et al.* (1980, 1982).

DESCRIPTION

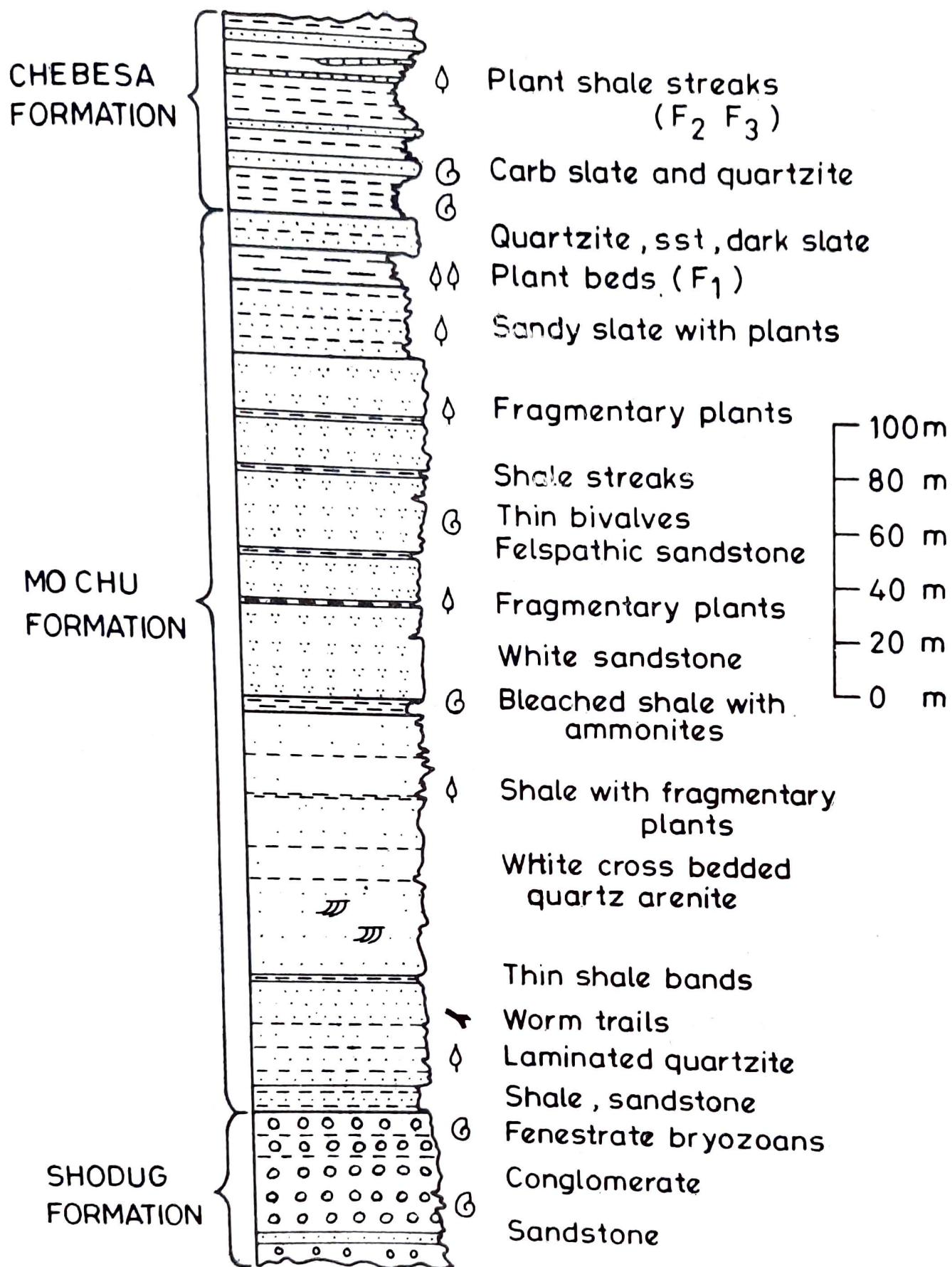
Pachypteris sp. cf. **P. indica** (Oldham & Morris) Bose & Roy

Pl. 1, Figs. 3, 4; Text-fig. 3D

Description—Detached pinnae, shape as a whole lanceolate; largest specimen measur-



Text-fig. 1. Geological map of the fossil locality around Lingshi, Bhutan (after Ganesan, T. M., Chaturvedi, R. K. & Reddy, K. P.).



Text-fig. 2. Columnar section of a part of the Lingshi Group, Lingshi Basin, Bhutan.

ing 10 cm in length and 2.5 cm in width. Rachis 1-2 mm wide, surface smooth. Pinnules alternate, sometimes near apex subopposite, attached by entire base at an angle of about 45°-50°, linear, maximum length 2 cm and breadth 2.5 mm, gradually becoming shorter and narrower towards apex; acroscopic margin contracted or straight, basispic margin slightly decurrent, lateral margins entire; apex acute. Veins obscure.

Comparison—The pinnules of *Pachypteris* sp. cf. *P. indica* are like the pinnules of *P. indica* (Oldham & Morris) Bose & Roy (1968) described from Schora, Sher River, Madhya Pradesh. However, the pinnules of the specimens from Schora are slightly smaller than those described here. Recently, a large number of specimens of *P. indica* (yet to be described) have been collected from Ghawad River, Kachchh. Out of these, the pinnules of the larger specimens match exactly the pinnules of the present specimens. The pinnules of *Pachypteris* sp. cf. *P. indica* are somewhat like the larger pinnules of *P. lanceolata* Brongniart described by HARRIS (1964, fig. 55B), but in the latter pinnules have rounded or obtuse apex.

***Ptilophyllum acutifolium* Morris**

Pl. 1, Fig. 6; Text-fig. 3F

1982 *Ptilophyllum* sp. cf. *P. acutifolium*; Ganesan *et al.*, p. 194, fig. 1.

Description—Pinnate frond, 7.7 cm long and 2.8 cm broad at its broadest region. Exposed part of rachis about 3 mm wide, at places obliquely striated, near apical end longitudinally striated. Pinnae attached on upper surface of rachis at an angle of 55°-60°, closely set, sometimes pinnae bases touching each other. Pinnae linear, 1-1.8 cm long and 3-4 cm wide, slightly falcate, margin entire, apex acute, acroscopic margin straight or rarely curving downwards, basispic margin slightly decurrent. Veins mostly obscure, 7-9 in number, forked or unforked, forking at different levels.

Comparison—The specimen resembles most the specimens of *Ptilophyllum acutifolium* figured by BOSE AND KASAT (1972, pl. 1, figs. 1, 6).

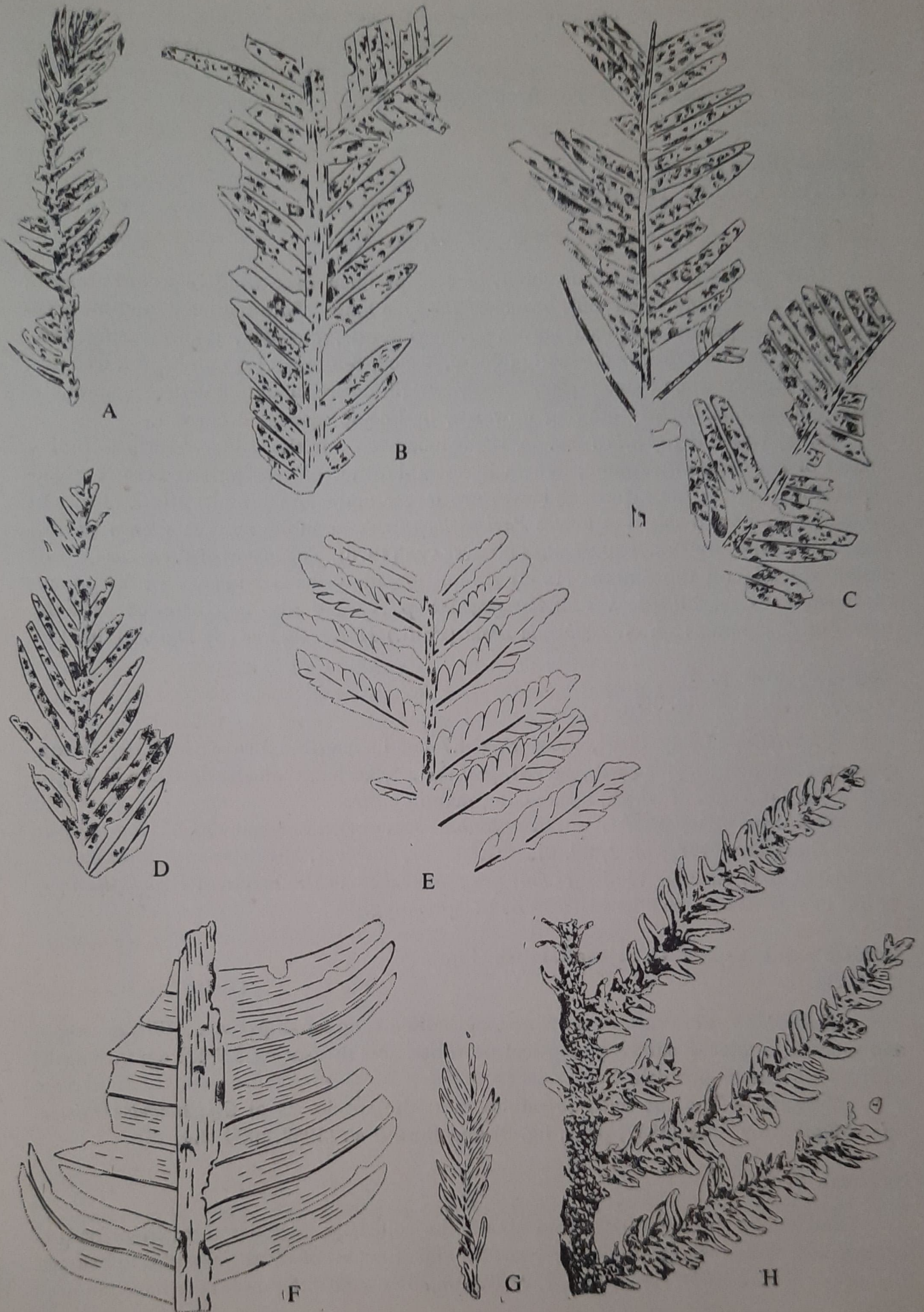
***Elatocladus jabalpurensis* (Feistmantel) Halle**

Pl. 1, Fig. 7; Pl. 2, Figs. 11, 12; Text-fig. 3 B, C

Description—Repeatedly branched leafy twig, branching at an angle of about 30°-50°. Stem about 1 mm wide. Leaves spirally arranged (in compressed state leaves spreading out in one plane), pointing upwards, attached at an angle of 45°-65°, linear-lanceolate, 0.8-1.1 cm long and 1.5-2 mm broad, margins straight and parallel, base slightly constricted, apex acute. Veins obscure, rarely in some showing a faintly marked midvein.

Comparison—The specimens figured closely here resemble the specimens of *Elatocladus jabalpurensis* figured by FEISTMANTEL (1877, pl. 9, figs. 1-6; pl. 10, fig. 1) and SAHNI (1928, pl. 5, fig. 73). The Lingshi Basin specimens may also be compared with the specimens of *E. jabalpurensis* figured by HALLE (1913, pl. 9, fig. 8). In the mode of attachment of leaves and in gross features *E. pseudotenerrima* Maheshwari & Kumaran

Text-fig. 3. A, *Pagiophyllum* sp. A, G. S. I. No. 19572; ×2. B-C, *Elatocladus jabalpurensis* (Feistmantel) Halle, G. S. I. Nos. 19563 and 19564; ×2. D, *Pachypteris* sp. cf. *P. indica* (Oldham & Morris) Bose & Roy, G. S. I. No. 19560; ×1. E, ?*Cladophlebis* sp., G. S. I. No. 19570; ×2. F, *Ptilophyllum acutifolium* Morris, G. S. I. No. 19561; ×2. G, *Pagiophyllum* sp. B, G. S. I. No. 19573; ×1. H, *Pagiophyllum* sp. A, G. S. I. No. 19571; ×2.



(1976) is similar to the specimens figured here ; however, due to lack of cuticle in the latter specimens further comparison is not possible. In external features *E. jabalpurensis* described here also resembles the twigs of *E. persica* Barnard (1967) reported from Gelli Gach, Iran and *Apterocladus lanceolatus* Archangelsky (1966) described from Bajo Grande, Argentina.

Pagiophyllum sp. A

Pl. 2, Figs. 9, 13, 14; Text-fig. 3A, H

1982 ; *Pagiophyllum* sp. ; Ganesan *et al.*, p. 194, fig. 2.

Description—Branched leafy shoot, largest specimen measuring 13.3 cm in length, branching at an angle of 40°-60°, branches 2.5-3 cm long. Both main axis and branches covered with spirally arranged leaves. Leaves sessile, crowded, laterally spreading, slightly curving upwards or distinctly falcate, keeled, 3-5 mm × 1.4 mm in size, free part of leaves usually twice longer than broad, margin entire, apex pointed or acuminate, acroscopic margin slightly curving upwards, basiscopic margin decurrent.

Comparison—*Pagiophyllum* sp. A is distinct from all the so-far-described Indian species of *Pagiophyllum*. Amongst them it resembles most *P. marwarensis* Bose & Sukh-Dev (1972), but in the latter the leaves are larger and more prominently keeled. In branching habit and shape of leaves *Pagiophyllum* sp. A resembles most *P. setosum* (Phill.) Seward described by DOLUDENKO AND ORLOVSKAYA (1976). The leaves of *P. setosum* (Phill.) described by JACOB AND SHUKLA (1955) are less spreading than the leaves in the present specimens. The smaller leaves of *Pagiophyllum* sp. A may also be compared with the leaves of *Pagiophyllum* sp. cf. *Haiburnia setosa* (Phill.) Harris figured by DELLE (1967).

Pagiophyllum sp. B

Pl. 2, Fig. 10; Text-fig. 3G

Description—Leafy shoot, measuring 4.7 cm in length. Leaves helically borne, spreading but pointing forwards, curved, prominently keeled, typically 0.8-1 cm in length and about 1-1.5 mm in width, apex acute, margin entire.

Comparison—*Pagiophyllum* sp. B resembles some of the specimens of *P. rewaensis* Bose & Sukh-Dev (1972, pl. 2, fig. 9). The latter, however, has more spreading leaves. The leaves of *P. veronense* Wesley (1956) are somewhat like the leaves of *Pagiophyllum* sp. B, but in the former the leaves are more spreading.

Conifero-caulon sp. cf. **C. rajmahalense** Gupta

Pl. 1, Fig. 8

Description—Stem surface showing longitudinal ridges and grooves. Within ridges and grooves, at places, showing elliptical protuberances measuring 3.3-4.2 cm in length and 0.3-0.5 cm in breadth.

Comparison—The specimen resembles most the specimens of *Conifero-caulon rajmahalense* figured by BOSE (1957, pl. 1, fig. 9) and BOSE *et al.* (1982, pl. 1, fig. 14).

INCERTAE SEDIS

Besides the specimens described above, the collection includes three more badly preserved specimens whose affinities are not very clear. Out of them two seem to belong to a species of *Cladophlebis* (Pl. 1, Figs. 1, 2; Text-fig. 3E). Both the specimens have minute

pinnules which measure 1-1.5 cm in length and 0.3-0.5 cm in breadth. In none of the pinnules veins are visible.

The third specimen is a fragment of *Ptilophyllum* leaf (Pl. 1, Fig. 5). Here, unlike the specimen of *Ptilophyllum acutifolium* described on preceding page, the rachis is completely concealed by the pinnae. Also the pinnae have obtuse apices like *Ptilophyllum cutchense* Morris figured by BOSE AND KASAT (1972, pl. 1, fig. 7). The specimen, however, differs from *P. cutchense* in having narrower pinnae like *P. tenerrimum* Feistmantel described by BOSE AND KASAT (1972, pl. 2, fig. 18). Further comparison is not possible because in the present specimen veins are missing in all the pinnae.

DISCUSSION

In the Himalaya, the occurrence of Mesozoic plant-bearing beds have been reported from Mo Chu Formation, Lingshi Basin, Bhutan (GANESAN *et al.*, 1980, 1982); Kagbeni-Muktinath, Thakkhola Valley, Nepal (BARALE *et al.*, 1978) and North of Indus Suture Zone, Ladakh (SHARMA *et al.*, 1980). In all these localities the plant assemblages are rather poor in species. In the collection from Lingshi Basin, there are only thirteen specimens which can be referred to six genera. The assemblage consists of? *Cladophlebis* sp., *Pachypteris* sp. cf. *P. indica* (Oldham & Morris) Bose & Roy, *Ptilophyllum acutifolium* Morris, *Ptilophyllum* sp., *Elatocladus jabalpurensis* (Feistmantel) Halle, *Pagiophyllum* sp. A, *Pagiophyllum* sp. B and *Coniferocaulon* sp. cf. *C. rajmahalense* Gupta. This assemblage is distinct from the one described by BARALE *et al.* (1978) from Kagbeni-Muktinath which is dominated by species of *Ptilophyllum* (*P. acutifolium* and *P. sp. cf. P. cutchense* Morris) and a species of *Araucarioxylon* (*A. nepalensis*). According to BARALE *et al.* (1978) Kagbeni-Muktinath assemblage is like the assemblages met within the Upper Gondwana of Peninsular India, especially the assemblage known from the older fossiliferous beds met within the Rajmahal Hills. The Lingshi Basin flora is more like the assemblages met at some of the localities in the Satpura Basin (Sehora and Jatamau) and Kachchh (Kakadbhit, Kurbi and Chawad River). The Lingshi plant-yielding beds seem to be slightly older in age than the fossiliferous bed exposed at Kagbeni-Muktinath and it is perhaps middle to late Jurassic in age.

The Ladakh assemblage reported by SHARMA *et al.* (1980) has recently been re-examined (the work is still under progress). It has, beside some of the plants earlier reported by SHARMA *et al.* (1980), also *Klukia*, *Nilssonia*, *Zamites*, etc. ; as such, the assemblage differs markedly from the Jurassic-Cretaceous assemblages known from the Upper Gondwana of India and also the Lingshi Basin assemblage.

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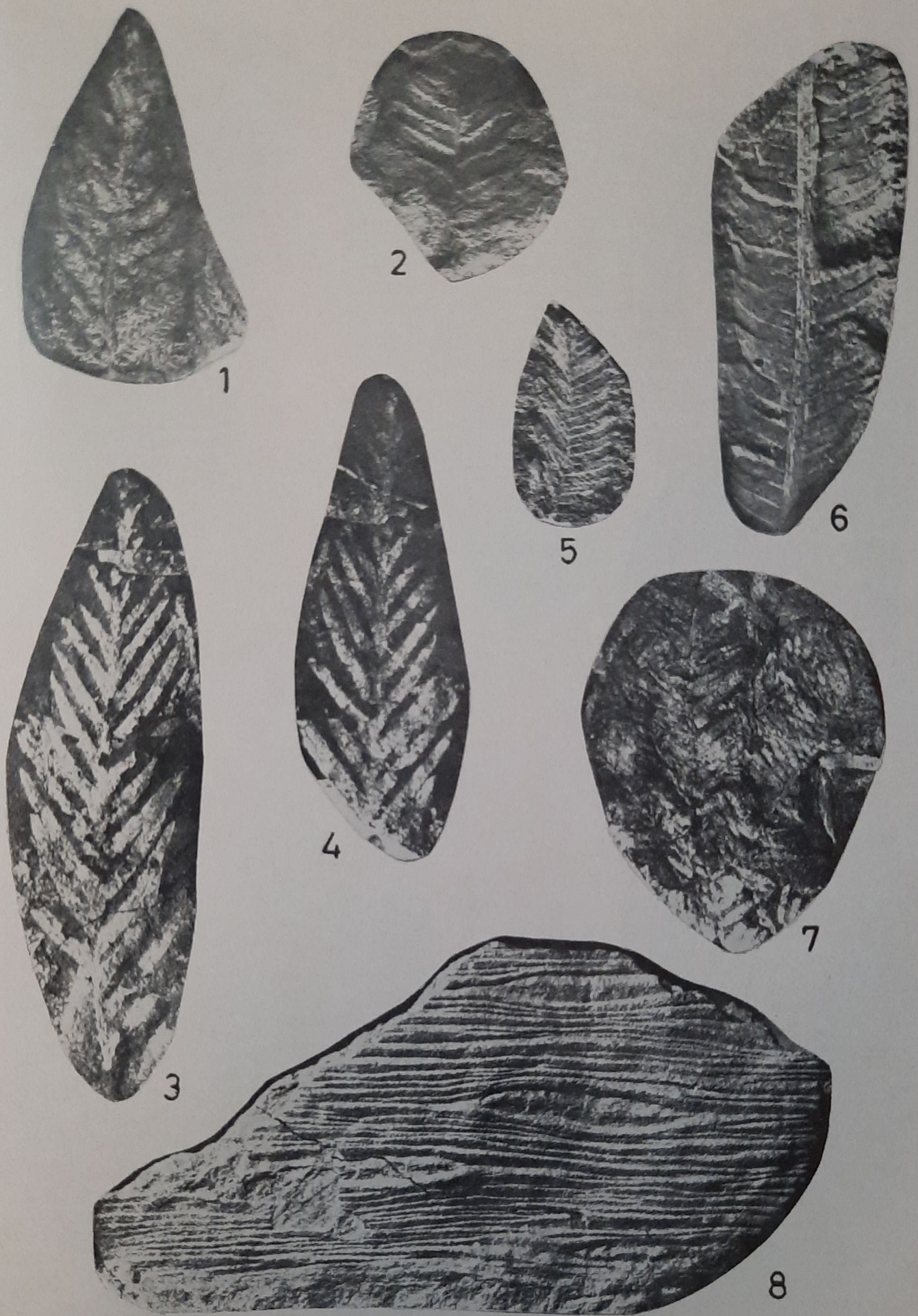
EXPLANATION OF PLATES

PLATE-1

- 1-2. ?*Cladophlebis* sp., G. S. I. Nos. 19569 and 19570. $\times 1$.
- 3-4. *Pachypteris* sp. cf. *P. indica* (Oldham & Morris) Bose & Roy, G. S. I. Nos. 19559 and 19560. $\times 1$.
5. *Ptilophyllum* sp., G.S.I. No. 19562. $\times 1$.
6. *Ptilophyllum acutifolium* Morris, G.S.I. No. 19561. $\times 2$.
7. *Elatocladus jabalpurensis* (Feistmantel) Halle, G. S. I. 19564. $\times 1$.
8. *Coniferocaulon* sp. cf. *C. rajmahalense* Gupta, G. S. I. No. 19575. $\times 1$.

PLATE-2

9. *Pagiophyllum* sp. A., G. S. I. No. 19572. $\times 1$.
10. *Pagiophyllum* sp. B, G. S. I. No. 19573. $\times 1$.
11. *Elatocladus jabalpurensis* (Feistmantel) Halle, G. S. I. No. 19563. $\times 1$.
12. A part of the above magnified. $\times 2$.
13. *Pagiophyllum* sp. A, G. S. I. No. 19571. $\times 1$.
14. A part of the above magnified. $\times 2$.





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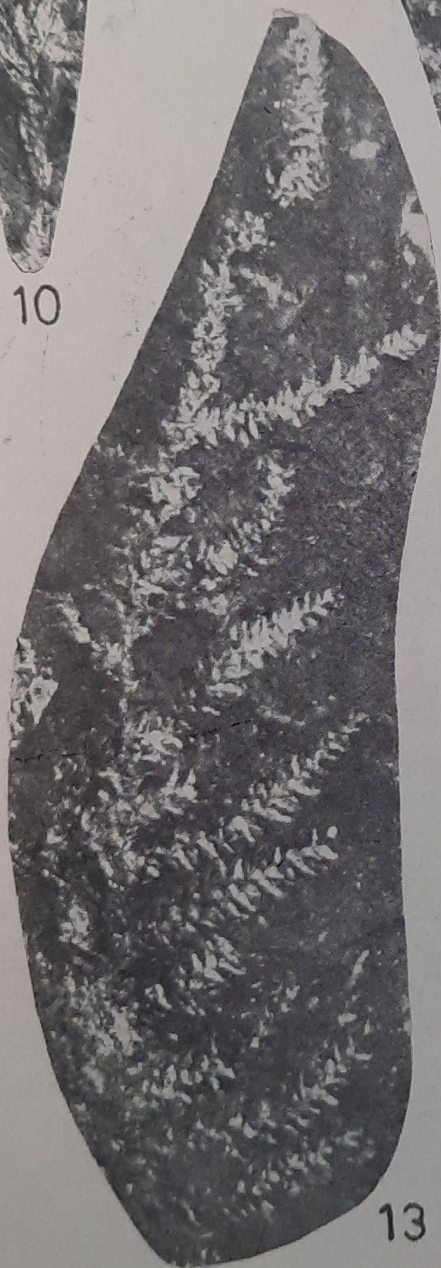
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