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UPPER PALAEOZOIC FLORA OF KASHMIR HIMALAYA

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ABSTRACT

The paper deals with plant fossils collected from the Upper Palaeozoic rocks of Kashmir Himalaya ranging in age from Upper Devonian to Permian. The distribution of plants, so far collected in the various formations, is as follows:

Aishmuqam Formation (*Upper Devonian*)—?*Taeniocrada* sp. and ?*Protolepidodendron* sp.

Syringothyris Limestone and Fenestella Shale formations (*Lower Carboniferous*)—*Archaeosigillaria minuta* Lejal, *Lepidosigillaria* cf. *quadrata* Danzé-Corsin, *Lepidodendropsis* cf. *peruviana* (Gothan) Jongmans, *L. fenestrata* Jongmans, *Cyclostigma* cf. *pacifica* (Steinmann) Jongmans, *Rhacopteris ovata* (McCoy) Walkom, *Triphyllopteris lecuriana* (Meek) Jongmans, *Rhodea* cf. *subpetiolata* (Potonié) Gothan and *Palmatopteris* cf. *furcata* Potonié.

Nishatbagh and Mamal formations (Lower Permian)—(a) *Nishatbagh Formation*—*Gangamopteris kashmirensis* Seward, *Glossopteris longicaulis* Feistmantel, *G. nishatbaghensis* sp. nov. and ?*Nummulospermum* sp. (b) *Mamal Formation* — *Parasphenophyllum thonii* var. *minor* (Sterzel) Asama, *Trizygia speciosa* Royle, *Lobatannularia ensifolia* Halle, *Rajahia mamalensis* sp. nov., *Glossopteris intermittens* Feistmantel, *G.* cf. *communis* Feistmantel, *G.* cf. *feistmantelii* Rigby, *G.* cf. *taeniopteroides* Feistmantel, *G. angustifolia* Brongniart, *Glossopteris* sp., ?*Cordaites* sp., *Ginkgophyllum haydenii* (Seward) Maithy, *G. sahnii* (Ganju) Maithy and a cone-like organ.

In the Upper Devonian the plant fossils are extremely rare and very badly preserved. The Lower Carboniferous flora shows a remarkable resemblance with the assemblage described from Peru and is in general agreement with the rest of the Lower Carboniferous floras known from other parts of the world. The Permian flora has two distinct elements, one present in the Nishatbagh Formation and the other in the Mamal Formation. The former is dominated by the presence of *Gangamopteris*, whereas, the latter is dominated by *Glossopteris*. Moreover, at Mamal there are two genera, viz., *Lobatannularia* and *Rajahia* which are typically Cathaysian elements. Some of the species of *Glossopteris*, too, seem to be distinct from all the species of *Glossopteris* reported from the Lower Gondwana of the Peninsular India.

Key-words — Upper Palaeozoic flora, *Glossopteris*, *Gangamopteris*, *Lobatannularia*, *Rajahia*, Permian, Upper Devonian, Kashmir Himalaya, India.

सारांश

काश्मीर हिमालय से उपरि पुराजीवी वनस्पतिजात – गोपाल सिंह, प्रभात कुमार माइती एवं महेन्द्र नाथ बोस

प्रस्तुत शोध-पत्र काश्मीर हिमालय की उपरि डिवोनी से परमी आयु तक की उपरि पुराजीवी चट्टानों के भूवैज्ञानिक एवं पुरावनस्पतिक अध्ययन से सम्बन्धित है। विभिन्न शैल-समूहों से अभी तक एकत्रित पादपाश्मों का वितरण निम्नवत् है :

ऐशमुक़ाम शैल-समूह (उपरि डिवोनी) – ?टीनिओक्रेडा जा० एवं प्रोटोलैपिडोडेन्ड्रॉन जा०।

साइरिंगोथाइरिस चूनाश्म एवं फ़ेनेसटॅला-शैल शैल-समूह (अधरि कार्बनी) – आरकियोसिजिलेरिया माइन्यूटा लेजल, लैपिडोसिजिलेरिया जा० सजातीय क्वाड्रेटा डोन्जें-कोसिन, लैपिडोडेन्ड्रॉप्सिस जा० सजातीय पीरूवियाना (गोथान) योंगमैन्स, लै० फ़ेनेस्ट्रेटा योंगमैन्स, साइक्लोस्टिग्मा जा० सजातीय सा० पैसिफ़िका (स्टाइनमैन) योंगमैन्स, रैकॉप्टेरिस ओवेटा (मैकॉय) वाल्कम्, ट्राइफ़िल्लॉप्टेरिस लैसकुरिआना (मीक) योंगमैन्स, रौडिया जा० सजातीय सबपिटिओलेटा (पोतोनिये) गोथान एवं पाल्मेटॉप्टेरिस जा० सजातीय फ़र्केटा पोतोनिये।

निशातबाग एवं मामल शैल-समूह (अधरि परमी) – (अ) निशातबाग शैल-समूह – गंगामॉप्टेरिस काश्मीरीयेन्सिस सिवर्ड, ग्लॉसॉप्टेरिस लौंगिकॉलिस फ़ाइस्टमॅन्टेॅल, ग्लॉ० निशातबागेन्सिस न० जा० एवं नुमुलोस्पर्मम् जा०। (आ) मामल शैल-समूह – पैरास्फ़ीनोफ़िल्लम् थोनाई उपजाति माइनर (स्टर्जल) असामा, ट्राइज़ाइजिया स्पेॅसिओसा रॉयल, लोबेटऍनुलेरिया ऍन्सिफ़ोलिया हाले, रजाहिआ मामलेन्सिस न० जा०, ग्लॉसॉप्टेॅरिस इन्टरमिटेन्स फ़ाइस्टमॅन्टेॅल, ग्लॉ० जा० सजातीय ग्लॉ० कम्युनिस फ़ाइस्टमॅन्टेॅल, ग्लॉ० जा० सजातीय फ़ाइस्टमॅन्टेॅलाई रिगबी, ग्लॉ० जा० सजातीय टीनिऑप्टेरॉयडिस फ़ाइस्टमॅन्टेॅल, ग्लॉ० ऑगस्टीफ़ोलिया ब्रोंगनिआ, ग्लॉ० जा०, ?कोरडायटिस जा०, गिन्कगोफ़िल्लम् हेडॅनाई (सिवर्ड) माइती, ग्लॉ० साहनाई (गन्जू) माइती तथा एक कोन-सदृश अवयव।

उपरि डिवोनी में पादपाश्म नितान्त दुर्लभ एवं अपूर्णतया परिरक्षित हैं। अधरि कार्बनी वनस्पतिजात पीरू से वर्णित समुच्चय से उल्लेखनीय तथा विश्व के अन्य भागों से विदित शेष अधरि कार्बनी वनस्पतिजातों से सामान्य सजातीयता प्रदर्शित करता है। परमी वनस्पतिजात में दो मुख्य अवयव हैं जिन में से एक निशातबाग शैल-समूह में तथा दूसरा मामल शैल-समूह में विद्यमान है। पहली शैल-समूह गंगामॉप्टेॅरिस से प्रभावी है, जबकि दूसरी में ग्लॉसॉप्टेॅरिस की बाहुल्यता है। इसके अतिरिक्त मामल में दो प्रजातियाँ – लोबेटएनुलेरिया एवं रजाहिआ जो कि सामान्य कैथेसी तत्व हैं – विद्यमान हैं। ग्लॉसॉप्टेॅरिस की कुछ जातियाँ भी प्रायद्वीपीय भारत के अधर गोंडवाना से अभिलिखित ग्लॉसॉप्टेॅरिस की सभी जातियों से भिन्न प्रतीत होती हैं।

INTRODUCTION

IN the Himalaya, Kashmir region exposes one of the best developed Palaeozoic sequences. Palaeobotanically this sequence is well known since long as it contains the Permian plant fossil bearing strata sandwitched between marine fossiliferous sequence. These Permian plant bearing horizons have been variously named as Lower Gondwana Bed, Gangamopteris Bed or Permian Gondwana in the geological literature. Recent discovery by Pal (1978) and Pal and Chaloner (1979) of plant bearing beds from the Lower Carboniferous sequence of Kashmir region has opened a new field of palaeobotanical study involving Carboniferous or Pre-Gondwana flora in Kashmir. The earlier knowledge of Pre-Gondwana flora in Indian subcontinent was negligible and restricted to Spiti in Himachal Pradesh (Gothan & Sahni, 1937; Høeg, Bose & Shukla, 1957; Dhar, Ram & Rao, 1980).

The investigation by Pal (1978) was restricted to a single horizon in the Fenestella Shale Formation (Lower Carboniferous). Since then several new plant bearing horizons in Aishmuqam Formation (Upper Devonian), Syringothyris Limestone Formation (Lower Carboniferous), and the upper part of Fenestella Shale Formation (Lower Carboniferous), have come to light in the Upper Palaeozoic succession of Liddar Valley, Kashmir.

An attempt has been made here to delineate the different plant bearing horizons developed in the Upper Palaeozoic sequence of Kashmir Himalaya. Besides, a systematic account of their floral contents has also been given. In all, six horizons (Table 1) have been recognised at distinct stratigraphic levels, out of which four show the presence of Pre-Gondwana or Devonian-Carboniferous flora and two Permian flora. The latter are somewhat similar to the Lower Gondwana flora of Peninsular India. However, within the Permian the upper horizon has also elements of Northern Hemisphere. The oldest plant bearing horizon, i.e. horizon no. 1, represents B Member of the Aishmuqam Formation (Upper Devonian); horizon no. 2 is developed in the basal part of C Member of Syringothyris Limestone (Tournasian: Lower Carboniferous); horizon no. 3 represents A Member of the Fenestella Shale Formation (Lower Carboniferous); horizon no. 4 represents C Member of the Fenestella Shale Formation (Lower Carboniferous); horizon no. 5 represents the Nishatbagh Formation (Lower Permian); and horizon no. 6 represents the Mamal Formation (Lower Permian).

Within these six horizons, five plant fossil assemblages have been recognized, in which two horizons have similar assemblages. Assemblage 1 is supposed to be of Upper Devonian age, assemblages 2 and 3 from A and C members of Fenestella Shale are

TABLE 1 — UPPER PALAEOZOIC SUCCESSION IN KASHMIR SHOWING PLANT BEARING HORIZONS

Age		Stratigraphic Unit		Main Lithology
		Formation	Member	
PERMIAN	UPPER	ZEWAN	D	Calcareous sandstone with bands of limestone.
			C	Arenaceous and calcareous shale.
			B	Limestone shale intercalation.
			A	Massive limestone with shale partings.
	LOWER	MAMAL		Novaculite, limestone, tuffaceous shale, carbonaceous shale, purple and pinkish shale with arenite.
		PANJAL VOLCANIC		Mainly basic rocks-basalt and andesitic basalt and a few intermediate and acidic rocks.
CARBONIFEROUS		NISHATBAGH		Black shale/slate, siltstone and bands of arenite.
	UPPER	AGGLOMERATIC SLATE	D	Ash colour tuffaceous shale with volcanic bombs lapillae, etc. Clasts rare.
			C	Dominantly quartz-arenite with lenticular conglomerates and clasts.
			B	Dominantly shale and siltstone with abundance of clasts.
			A	Dominantly quartz-arenite with lenticular conglomerate and clasts.
		FENESTELLA SHALE	D	Dominant shale-siltstone with bands of quartz arenite.
			C	Dominant quartz arenite with bands of shale and siltstone.
			B	Dominant shale/siltstone with bands of arenite.
			A	Dominant quartz-arenite with intercalation of shale siltstone.
	LOWER	SYRINGOTHYRIS LIMESTONE	C	Limestone shale/siltstone/arenite intercalations.
			B	Massive and thickly bedded limestone.
			A	Limestone and arenite.
DEVONIAN	UPPER	AISHMUQAM	B	Yellowish-green siltstone-shale with bands of quartz-arenite.
			A	Quartz-arenite with intercalation of blotchy siltstone.
		MUTH-QUARTZITE		Milky white orthoquartzite

////// Indicate plant bearing horizon

similar and are of Lower Carboniferous age. Assemblages 4 and 5 are of Lower Permian age (Text-fig. 1).

STRATIGRAPHY OF THE UPPER PALAEOZOIC ROCKS

The Upper Palaeozoic sequence in Kashmir is represented by several formations, namely Aishmuqam, Syringothyris Limestone, Fenestella Shale, Agglomeratic Slate, Nishatbagh, Panjal Volcanic, Mamal and Zewan in ascending order of succession. The Muth Quartzite Formation, which underlies the Aishmuqam Formation, forms a datum line in the Palaeozoic sequence and represents a distinct lithounit; as such all the post-Muth sequences are included in the Upper Palaeozoic and sequences up to Muth in the Lower Palaeozoic. The details of all the plant bearing horizons developed within the Upper Palaeozoic succession are given in Table 1.

Aishmuqam Formation

Recently a distinct mappable lithounit has been delineated between orthoquartzite sequence of Muth Quartzite Formation and a calcareous-argillaceous-arenaceous sequence of Syringothyris Limestone which has been designated as Aishmuqam Formation by Kumar, Singh and Srivastava (1980). This unit was earlier grouped by Middlemiss (1910) within his Muth Quartzite Unit.

Aishmuqam Formation has been divided here into two members — A and B. A Member is represented by variegated quartz-arenite with blotchy siltstone, whereas, B Member consists of light yellowish and greenish siltstone with thinly to thickly bedded intercalations of quartz-arenite. The light coloured siltstone (B Member) has yielded plant fossils at Kotsu Hill, Diuth Spur and the Spur near Ayun and represents the oldest plant bearing horizon known so far in Kashmir. B Member is widely distributed in Liddar Valley area. No marine fauna has been reported so far from Aishmuqam Formation. The collection of fossil plants has been made mainly from Kotsu Hill and Diuth Spur.

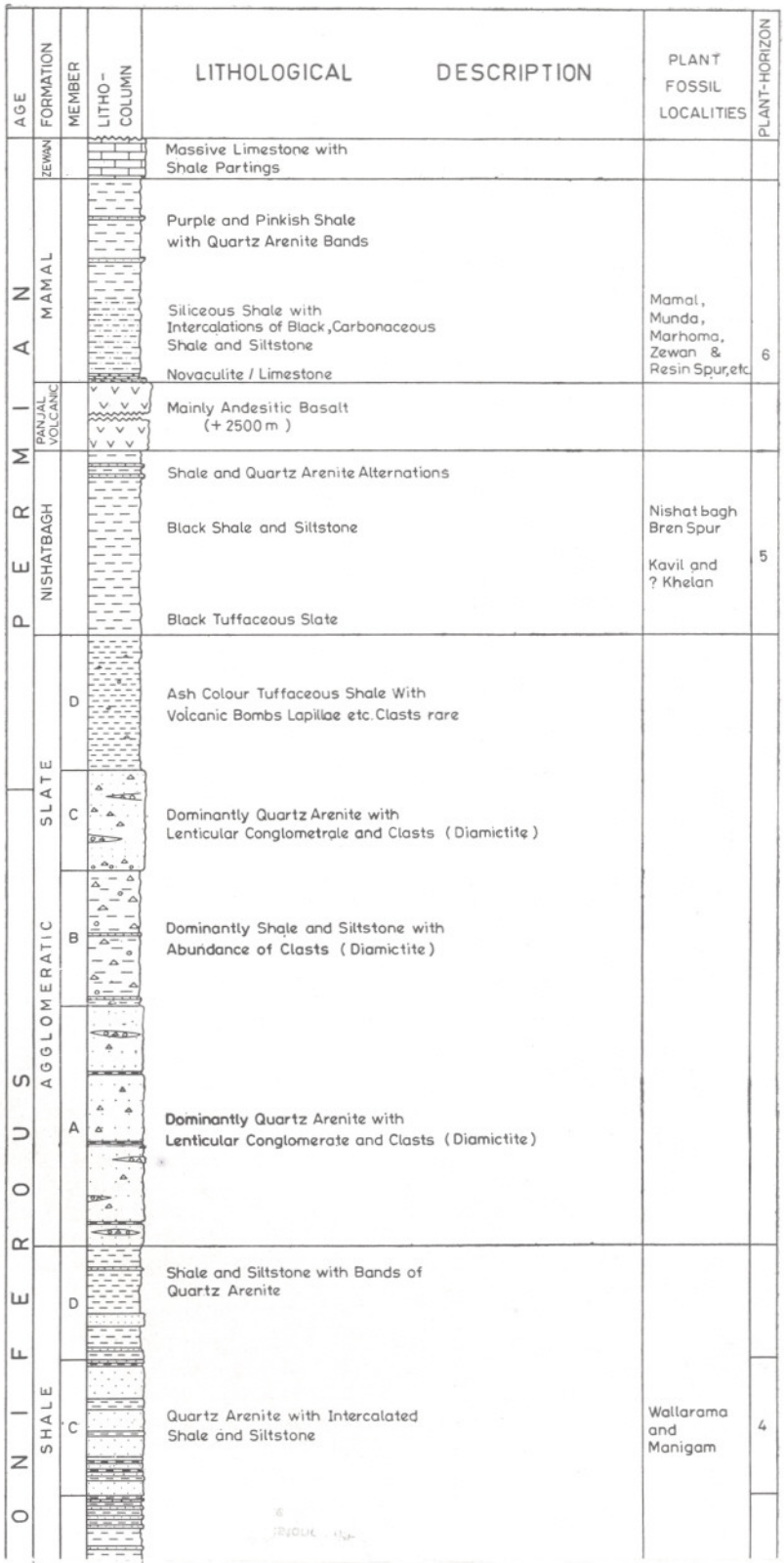
Syringothyris Limestone Formation

On the basis of dominant lithology and sedimentary sequence this formation is divisible into three distinct members — A, B and C.

A Member — It consists mainly of arenaceous limestone which is hard and compact with partings of shale and intercalations of quartz-arenite. Thus this unit essentially shows a mixed facies of arenaceous and calcareous sediments. The marine fossils are occasionally seen in the limestones and comprise brachiopod shells and crinoidal fragments. Amongst the brachiopods, most common genera are *Rhynchonella* and *Chonetes*. Possibly from this unit Savage (1976) and Tewari, Shrivastava and Gupta (1978) have described the conodont of Tournasian age.

B Member — It comprises mainly thickly bedded, hard, compact grey to black limestone. The lower part is massive while the upper part is thickly bedded. The limestone is brown on weathered surfaces and grey on fresh surfaces. This member forms the most distinctive unit of Syringothyris Limestone Formation and has the richest assemblage of marine fossils. The assemblage is dominated by brachiopods amongst which the productids are most common, followed by *Chonetes* and rhynchonellids; and differs from the underlying A Member by its richness in fossils more so because of the abundance of productids.

C Member — Intercalations of limestone, arenite and shale-siltstone sequence are characteristics of this member. Boundary between B and C Members is demarcated by the first appearance of dark carbonaceous shale and siltstone. The member is further divisible into four sub-units: (i) — The basal 35 m sequence is characterized by dominant limestone with intercalations of black shale, siltstone and arenite. Here, as compared to B Member the fauna is poorly represented, especially the productids are rare, coral and crinoid are more common alongwith fragmentary plant remains. This is further followed by a sill of basic rock (35 m). (ii) — This sill or basic rock is followed by a 50 m thick sequence of dominant arenite with intercalations of siltstone, shale and limestone. In this unit marine life is absent and plant fossils are abundant at the base and near


AGE
FORMATION
MEMBER
LITHO-COLUMN
LITHOLOGICAL DESCRIPTION
PLANT FOSSIL LOCALITIES
PLANT-HORIZON
PERMIAN
ZEWAN
MAMAL
PANJAL VOLCANIC
NISHATBAGH
SLATE
AGGLOMERATIC
SHALE
ONIFEROUS
D
C
B
A
D
C
Massive Limestone with Shale Partings
Purple and Pinkish Shale with Quartz Arenite Bands
Siliceous Shale with Intercalations of Black, Carbonaceous Shale and Siltstone
Novaculite / Limestone
Mamal, Munda, Marhoma, Zewan & Resin Spur, etc.
6
Mainly Andesitic Basalt (+ 2500 m)
Shale and Quartz Arenite Alternations
Black Shale and Siltstone
Black Tuffaceous Slate
Nishatbagh Bren Spur
Kavil and ? Khelan
5
Ash Colour Tuffaceous Shale With Volcanic Bombs Lapillae etc. Clasts rare
Dominantly Quartz Arenite with Lenticular Conglomerate and Clasts (Diamictite)
Dominantly Shale and Siltstone with Abundance of Clasts (Diamictite)
Dominantly Quartz Arenite with Lenticular Conglomerate and Clasts (Diamictite)
Shale and Siltstone with Bands of Quartz Arenite
Quartz Arenite with Intercalated Shale and Siltstone
Wallarama and Manigam
4

the top and on the whole the entire sequence is plant bearing. This is the second plant bearing horizon which is developed in the entire Liddar Valley area, but the fossils are more common at Kotsu Hill, Gokhan gali and Ichhnar Spur. (iii) — This is represented by a 35 m thick limestone sequence with partings of shale. The limestone contains occasional remains of brachiopods and corals. (iv) — It consists of 25-30 m thick shale dominated sequence with intercalations of limestone and arenite. The limestone bands are fossiliferous in which corals are common with a few brachiopods and crinoids.

Fenestella Shale Formation

This formation conformably overlies the Syringothyris Limestone Formation and has a sequence of quartz-arenite and shale alternations. Recently, Kumar, Singh and Srivastava (1980) have subdivided it into four members namely A, B, C and D which have been dealt below separately. Middlemiss (1910) recognized a Passage Bed between Syringothyris Limestone and Fenestella Shale comprising a sequence of quartzite and shale. However, he grouped this Passage Bed with Fenestella Shale as lithologically it resembled the latter more than the underlying formation. Pal (1978) reported a rich floral assemblage from this Passage Bed at Gund near Banihal and assigned an independent formational status, i.e. the Gund Formation. This formation was instituted because of complete absence of marine fauna and presence of profuse plant fossils. Kumar, Singh and Srivastava (1980) have indicated that similar plant bearing horizon again reappears in the upper part of Fenestella Shale. As such, there are two quartz-arenite dominant sequences, i.e. A and C Members with plant fossils and two argillite dominant sequences, namely B and D with marine fossils, thereby indicating two transgressive and two regressive phases in the sedimentary succession. The Passage Bed of Middlemiss (1910) and Gund Formation of Pal (1978) represent A Member of Kumar, Singh and Srivastava (1980). There are considerable variations in the thickness of these members and as such they are not mappable on a regional scale. However, they can be mapped in the areas where they are well-developed in Liddar Valley and Banihal. The Liddar Valley area is the type area of Fenestella Shale Formation.

A Member — This is dominated by quartz-arenite with intercalations of siltstone and shale and is characterized by the presence of plant fossils and complete absence of marine fossils. The plant fossils are present only in bands of siltstone and shale. Arenites are thickly bedded, often micaceous and light coloured and are devoid of fossils. This Member contains abundant plant fossils at Gund near Banihal while in Liddar Valley they are seen at road-section near Kotsu, Gaos and Manigam, etc.

B Member — This is dominated by shale and siltstone with bands of arenite. The shales are dark grey in colour having profuse pyrite crystals and marine fossils.

C Member — It has dominant sequence of arenite with intercalations of shale and siltstone similar to A Member at Wallarama. Shale and siltstone encompass abundant impressions and casts of stems. Marine fossils are rare or even absent.

D Member — Similar to B Member it is also dominated by argillite with the occurrence of shale, siltstone and bands of thick arenite. In some sections near the top, arenite content increases and a local E Member can be delineated. The shale and siltstone are rich in marine fossils while the plant fossils are rare.

Agglomeratic Slate Formation

So far no plant bearing horizon is known from this formation. Earlier, lithostratigraphically the topmost part of this formation was considered to be plant bearing, but later it was separated as a distinct unit namely Nishatbagh Bed. This classification has been followed in the present work with slight modifications.

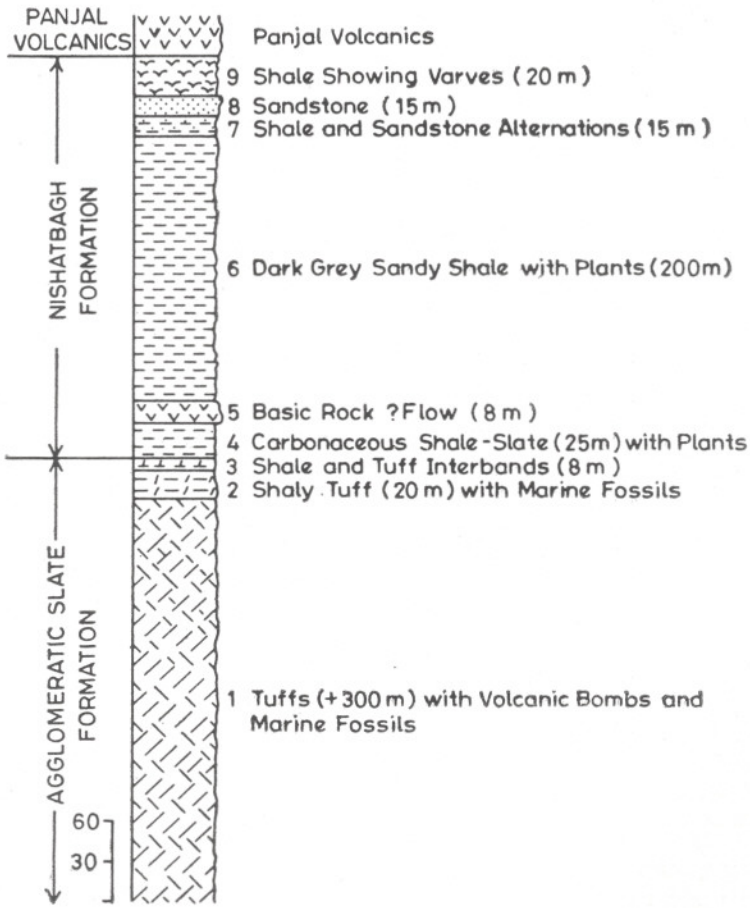
Nishatbagh Formation

Lithostratigraphically this unit was mapped as a part of Agglomeratic Slate by Middlemiss (1910) and Bion and Middlemiss (1926). Then Nakazawa and Kapoor (1975) and Kapoor (1977) recognized it

as a distinct plant bearing unit quite different from the underlying Agglomeratic Slate and named it as Nishatbagh Bed.

The present study in the type area has revealed that the boundary between the Nishatbagh Formation and underlying Agglomeratic Slate lies between bed nos. 3 and 4 of Kapoor (1977) and not above the volcanic flow II which is well within the Nishatbagh Formation. Bed no. 4 consisting of 25 m dark carbonaceous slate, has yielded a rich plant assemblage and is completely devoid of marine elements. Thus the lithological criteria to separate the Nishatbagh Formation from the underlying Agglomeratic Slate Formation should be according to the first appearance of dark carbonaceous slate containing plant fossils only and not as has been suggested by Kapoor (1977). This modified boundary has been shown in Text-fig. 2 and the Nishatbagh Bed has been given the status of a Formation.

The dominant lithology of Nishatbagh Formation consists of dark carbonaceous shale-slate with subordinate sandstone in the upper part. This formation shows a regional development in Kashmir region especially in the areas around Srinagar, Pir Panjal as well as in the Tral and Liddar valleys. Varma and Zutshi (1981) have reported its presence in Pir Panjal area, while Ahmed, Chib and Singh (1978) recorded its presence in Tral Valley near Kavil.



TEXT-FIG 2 — Lithostratigraphic column at Nishatbagh Spur showing Nishatbagh Formation (modified after Kapoor, 1977).

Panjal Volcanic Formation

This Formation is referred as the Panjal Volcanic or Panjal Trap with an estimated maximum thickness of 2,500 m. So far no plant bearing horizon has been reported from this thick succession consisting mainly of basic rocks and a few intermediate and acidic rocks.

Mamal Formation

The horizons with *Glossopteris* and other Gondwana elements overlying the Panjal Volcanic were classified by Kapoor (1977) into four floral beds namely Vihi, Marhoma, Munda and Mamal in ascending stratigraphic order. Lithostratigraphically all these plant bearing beds do not occur together but occupy the same stratigraphic level, i.e. between the underlying Panjal Volcanic and overlying Zewan Formation. Their biostratigraphic distinction as given by Kapoor (1979) is also not very convincing, therefore, here it is proposed to combine the four floral beds into one formational unit. Among the sections wherefrom the plant beds were reported and earlier classified into different floral beds, Munda represents a very condensed and thin section. Marhoma and Mamal show a thick succession and amongst these, the section at Mamal is very rich in plant fossils and as such we consider it as the type section which is here being designated as Mamal Formation.

The above view is more in the lines suggested by Ahmed, Chib and Singh (1978) where they have mentioned " ..Kapoor (1975) and Kapoor and Shah (1979) consider that the bed with Gondwana fossils in the Pahalgam area is the youngest Gondwana plant horizon in the Kashmir Himalaya, but its stratigraphic position above the Panjal Trap and below the well defined *Protoretepora* and *Spirifer raja* horizons of marine Zewan Formation does not seem to warrant the conclusion. Instead it may be an equivalent of Gondwana beds of the Vihi and Marhoma area ".

Lithologically Mamal Formation is represented by black and glassy tuffaceous shales which weather at the surface into light grey or ash colour. This formation is characterized by the presence of siliceous and sandy shale, cherty grey limestone, arenite at times gritty and calcareous, carbonaceous shale, purple or pinkish ash bed and novaculite. The latter generally lies at the base of the formation, though more than one band has been detected in some sections. There is some regional variation in lithology, i.e. all the sequences developed in the Kashmir Valley are characterized by novaculite, limestone and tuffaceous shale at the base of the sequence, whereas, in Pir Panjal area the presence of conglomerate suggests a slightly different depositional environment.

Stratigraphic Position of Nishatbagh and Mamal Formations (Permian) — As stated earlier the plant bearing horizons having Gondwana affinities have been variously named as Gangamopteris Bed, Lower Gondwana Bed and Permian Gondwana by different workers. Earlier the Permian beds in Kashmir Himalaya were treated as a single horizon; though their different stratigraphic positions were recognized by pioneers like Middlemiss (1910), Wadia (1928, 1934), Bion and Middlemiss (1928) and Hazra and Prasad (1957). Till recently they were thought to be restricted to the Intertrappean beds in the Panjal Volcanic, i.e. the Agglomeratic Slate and Panjal Volcanic, and the earlier workers considered them as homotaxial though occurring at different horizons within the Panjal Volcanics. But recently Nakazawa and Kapoor (1975), Kapoor (1977), Ahmad, Chib and Singh (1978) and Kapoor and Shah (1979) have opined that these Gondwana plant beds occur at two distinct stratigraphic levels, i.e. one below and the other above of the Panjal Volcanic. According to Kapoor (1979) the older horizon amongst these two plant bearing beds represents single Gondwana Bed which he designated as Nishatbagh Bed while the plant bearing horizon above the Panjal Volcanic exhibits four distinct floral beds designated as Vihi, Marhoma, Munda and Mamal in ascending order. Ahmed, Chib and Singh (1978), on the contrary, observed that from the stratigraphic position and structural set up the Permian Gondwana plant beds can be considered to occur only at two stratigraphic horizons — one at the base of the Panjal Traps and the other at the top of the Trap. According to them the four floral beds proposed by Kapoor (1979)

are equivalent to each other and represent a single lithounit.

Thus lithostratigraphically the Permian plant bearing horizons below and above the Panjal Volcanic are well established in the regional geology of Kashmir. The one below the Panjal Volcanic is very well developed at Nishatbagh with its characteristic *Gangamopteris* dominated assemblage appropriately designated as Nishatbagh Formation. The one above the Panjal Volcanic, though termed variably by Kapoor (1979) as Vihi, Marhoma, Munda and Mamal beds, in fact lithostratigraphically represent only one formation occupying the same stratigraphic position and having close lithological as well as floral resemblance with each other. As such all these beds have been referred here together as Mamal Formation.

Zewan Formation

Conformably overlying the Mamal Formation is a thick fossiliferous marine sequence of Zewan Formation which consists of limestone, shale and calcareous sandstone of Upper Permian age. No plant bearing horizon is so far known from this formation.

Localities — The plant remains, described here, have been collected from the following localities:

Upper Devonian — (1) Kotsu Hill (Kanjdori) — 0.5 km NE of Kotsu Village (33°51′: 75°15′).
(2) Diuth Spur — 0.5 km North of Diuth Village (33°51′: 75°19′).

Lower Carboniferous — (1) Kotsu Hill (Kanjdori) — 0.5 km NE of Kotsu Village (33°51′: 75°15′).
(2) Wallarama Spur — 1 km NE of Wallarama Village (33°54′: 75°15′).
(3) Manigam Spur — 1 km SE of Manigam Village (33°47′: 75°16′).
(4) Gund — Jammu-Srinagar road section near Gund Village (33°29′: 75°11′).

Lower Permian — (1) Nishatbagh — Spur 1 km East of Nishatbagh Garden, (34°07′: 74°54′).
(2) Marhoma — Spur 2 km NE of Marhoma Village (33°51′: 75°07′).
(3) Mamal — Nala Section 0.5 km West of Mamal Village (33°01′: 75°18′).

DESCRIPTION

Upper Devonian Flora

?Taeniocrada sp.

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

Description — Stems branched or unbranched, 4-13 cm long and 0.2-0.8 cm broad, ribbon-shaped, surface rugose or showing irregular polygonal markings. Each stem having a distinct median ridge or groove perhaps representing vascular strand, ±1 mm wide.

Occurrence — Kotsu Hill (Kanjdari).

Remarks — In general appearance the specimens from Kotsu resemble some of the species of *Taeniocrada* White (1903), such as *T. dubia* Kräusel & Weyland (1930) and *T. langii* Stockmans (1939), etc. However, due to lack of details in the present specimens they have been for the present doubtfully referred to the genus *Taeniocrada.*

?Protolepidodendron sp.

Pl. 1, figs 2, 3; Text-fig. 3B

Description — Stem measuring 7.5 cm in length and 1.2 cm in width; leaf bases spirally arranged, more or less spindle-shaped, 7 mm long and 3 mm wide, apex broadly obtuse, gradually tapering towards base. Leaf scars inconspicuous.

Occurrence — Diuth Spur.

Remarks — The above description is based on a single fragmentary stem with badly preserved leaf bases. Leaf scars are rarely visible and seem to be oval in shape and are placed in vertical direction, occupying almost the central region of leaf bases. Because of ill-preservation the specimen has been provisionally placed under the genus *Protolepidodendron.*

Lower Carboniferous Flora

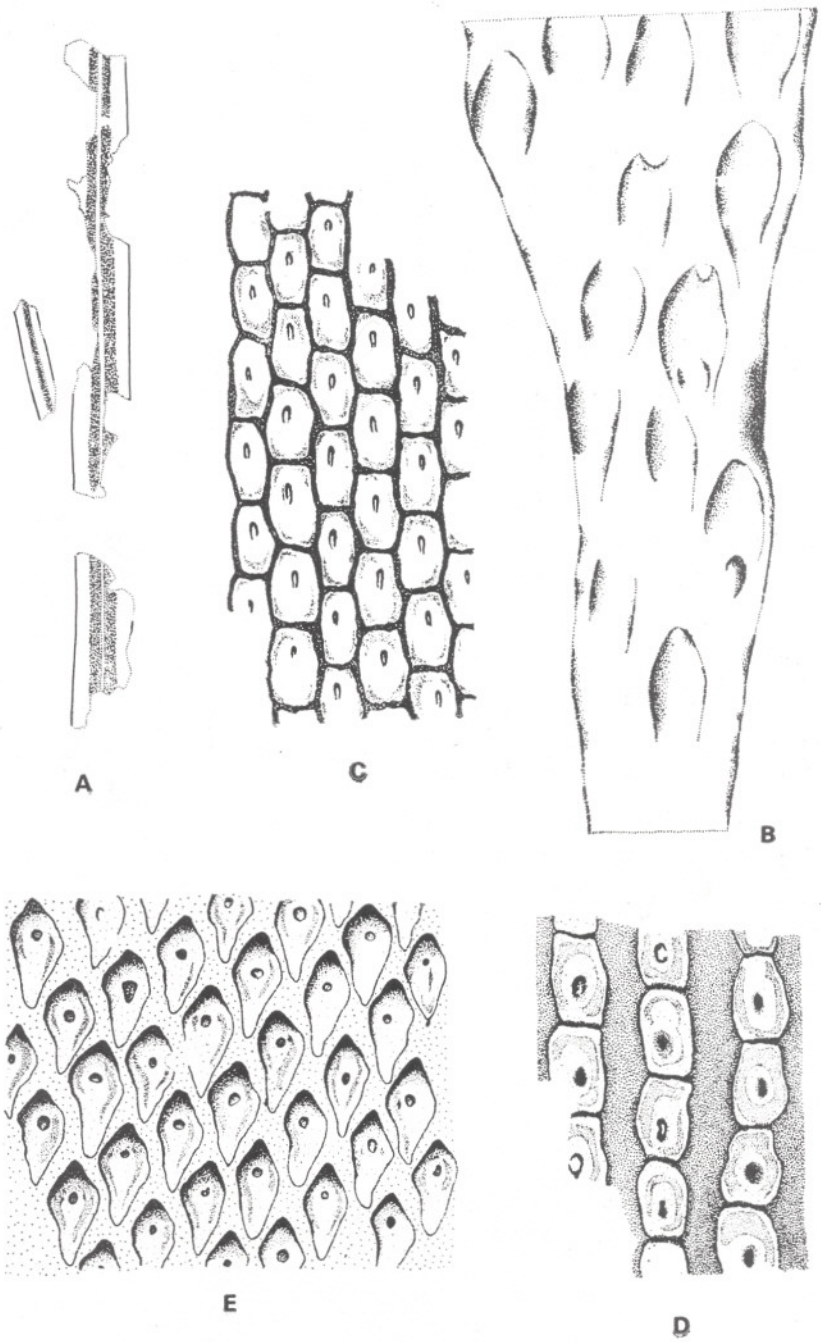
Archaeosigillaria minuta Lejal

Pl. 1, figs 4-6; Text-fig. 3C

Specimens from Kashmir:

1978 *Lepidodendropsis sigillarioides* Jongmans, Gothan & Darrah: Pal, p. 124, pl. 1, figs 2, 3; pl. 3, fig. 12.

1978 *Lepidodendropsis pranabii* Pal, p. 125, pl. 3, fig. 11.



TEXT-FIG. 3A-E — **A,** ?*Taeniocrada* sp., showing vascular strand, B.S.I.P. no. 36042/2771, from Kotsu, × 1. **B,** ?*Protolepidodendron* sp., showing spindle-shaped scars, B.S.I.P. no. 36044/2543, from Diuth Spur, × 2. **C,** *Archaeosigillaria minuta* Lejal, B.S.I.P. no. 36045/2544, from Wallarama, × 2. **D,** *Lepidosigillaria* cf. *quadrata* Danzé-Corsin, showing a few leaf scars, B.S.I.P. no. 36046/2516, from Wallarama, × 2. **E,** *Lepidodendropsis* cf. *peruviana* (Gothan) Jongmans, only a part of the specimen has been figured, B.S.I.P. No. 36048/2516, from Wallarama, × 2.

Description — Unbranched stem, measuring 3-15.5 cm in length and 1.8-3.5 cm in breadth, surface showing closely set, spirally arranged leaf cushions. Leaf cushions hexagonal in shape, sometimes oval (in ill preserved specimens), 3-8 mm long and 2-3 mm broad; lateral margins either straight or slightly curved. Leaf scars mostly placed closer to apical region of leaf cushion, vertically oval, 1-1.5 mm in length. Rarely near the centre of leaf-scar a small circular depression is visible, perhaps representing the vascular scar.

Occurrence — Manigam Spur, Wallarama Spur and Gund Village.

Remarks — *Archaeosigillaria minuta*, described here, resembles the specimens earlier figured by Lejal (1970) from the Lower Carboniferous of Sahara and the Upper Devonian of Libya by Lejal-Nicol (1975, pl. 2, fig. 10; text-fig. 15).

Lepidosigillaria cf. *quadrata* Danzé-Corsin

Pl. 1, figs 7-9; Text-fig. 3D

Specimens from Kashmir:

1978 *Lepidosigillaria quadrata* Danzé-Corsin: Pal, p. 123, pl. 2, fig. 5; pl. 3, fig. 10.

1978 *Lepidosigillaria* cf. *quadrata* Danzé-Corsin: Pal & Chaloner, p. 296, fig. 1C.

Description — Stems 2.5-12.2 cm long and 2.3-5 cm in diameter, surface covered with spirally arranged leaf cushions. Leaf cushions about 2-4 mm apart in transverse direction, intervening space more or less smooth or somewhat rugose, in vertical direction fairly closely set. Leaf cushions quadrangular in shape, lateral margins slightly convex, measuring 4-6 mm in length and 2-3 mm in breadth. Leaf scar lying closer to apical region of leaf cushions, vertically oval, measuring ± 1 mm in length. Vascular scar and other details not visible.

Occurrence — Manigam Spur, Wallarama Spur and Gund Village.

Remarks — The specimens agree most with the specimens described by Lejal (1968, pl. 2, fig. 4; text-fig. 2) from the Lower Carboniferous of Sahara.

Lepidodendropsis cf. *peruviana* (Gothan) Jongmans

Pl. 2, figs 10, 11; Text-fig. 3E

Description — Stems 2-15 cm long and 2-4 cm wide, unbranched; surface showing leaf cushions arranged in steeply ascending spirals, separated from each other by a margin of about 2 mm in transverse direction, intervening region smooth. Leaf cushions vertically elongated, ± 2 times longer than broad, measuring 4-6 mm in length and 2-3 mm in breadth, broadest region about 1/3 below apical end, apex broadly obtuse, base attenuate. Leaf scar oval, ± 1 mm in diameter, placed closer to apical end of leaf cushion. Vascular scar not visible.

Occurrence — Manigam Spur, Wallarama Spur and Gund Village.

Remarks — The specimens from Kashmir are closest to the specimens described by Jongmans (1954, pl. 20, fig. 15) from the Lower Carboniferous of Peru.

Lepidodendropsis fenestrata Jongmans

Pl. 2, figs 12-15; Text-fig. 4A

Specimens from Kashmir:

1978 *Lepidodendropsis fenestrata* Jongmans & Koopmans: Pal, p. 123, pl. 2, figs 6, 7.

Description — Stems covered with leaf cushions which are arranged in steeply ascending spirals, in broader stems leaf cushions distantly placed, whereas in narrower stems they are closely set, 7-23 cm

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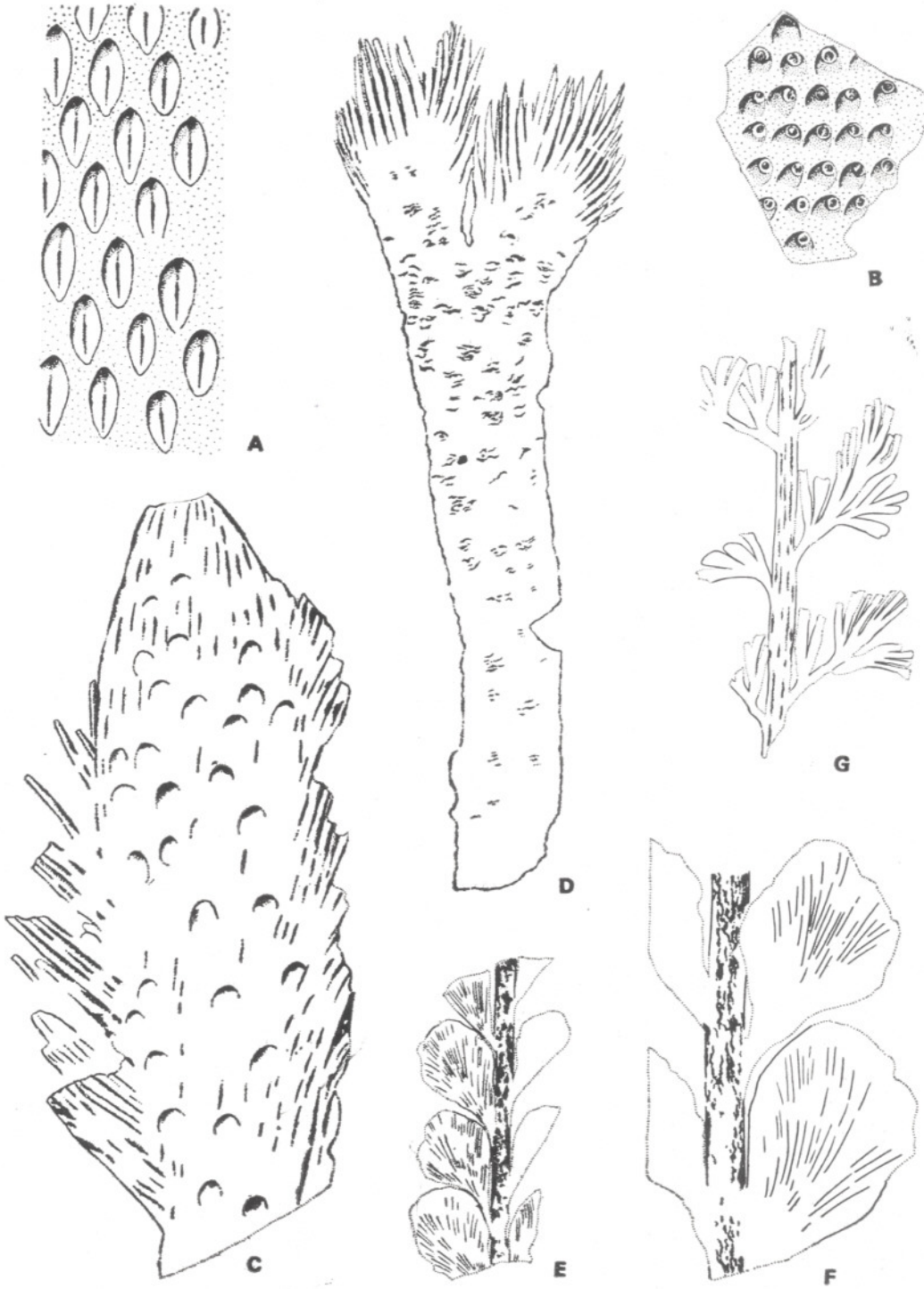
TEXT-FIG. 4A-G — **A**, *Lepidodendropsis fenestrata* Jongmans, showing part of a specimen, B.S.I.P. no. 36051/2544, from Wallarama, × 2. **B**, *Cyclostigma* cf. *pacifica* (Steinmann) Jongmans, B.S.I.P. no. 36052/2515, from Manigam, × 2. **C**, Cone-like structure, B.S.I.P. no. 36054/2515, from Manigam, × 2. **D**, showing a branched stem, B.S.I.P. no. 36055/2519, from Gund, × 1. **E, F**, *Rhacopteris ovata* (McCoy) Walkom, B.S.I.P. nos. 36057/2515 and 36058/2515, from Manigam; E, × 1; F, × 2. **G**, *Triphyllopteris lescuriana* (Meek) Jongmans, showing part of a specimen, B.S.I.P. no. 36091/2516, from Wallarama, × 2.



TEXT-FIG. 4A-G.

long and 2-6 cm broad. Leaf cushions elliptical, ±3 times longer than broad; in narrower stems cushions about 3 mm long and 1 mm wide, whereas, in broader stems 10 mm long and 3 mm wide; apex rounded, base attenuated. Leaf scars oval, elongated in vertical direction, about 3-5 mm long and less than 1 mm in width.

Occurrence — Kotsu Village, Manigam and Wallarama spurs.

Remarks — The specimens from Kashmir agree with most of the specimens figured by Jongmans in Jongmans and Heide (1955, pl. 7, figs 1a, 2a-d; pl. 8, fig, 3a-f. pl. 9, fig. 4a,b) from the Lower Carboniferous of Egypt.

Cyclostigma cf. *pacifica* (Steinmann) Jongmans

Pl. 2, fig. 16; Pl. 3, fig. 17; Text-fig. 4B

Specimens from Kashmir:

1978 *Cyclostigma indica* Pal, p. 128, pl. 4, figs 14, 15.

Description — Stems measuring 4.5-18 cm in length and 1.5-3.5 cm in breadth, surface showing leaf cushions arranged in steeply ascending spirals; intervening space variable. Leaf cushions mammiliform or rhomboidal, 2-6 mm long and 1-4 mm broad; apex broadly oval; base slightly tapering. Leaf scars circular, 1.2 mm in diameter, placed closer to apical end of leaf cushion.

Leaves minute, keeled, triangular in shape, about 3 mm long and 2 mm broad at base, apical end pointing outward or curving upwards; apex aristate.

Occurrence — Manigam Spur, Wallarama Spur and Gund Village.

Remarks — The collection includes about 40 specimens. Out of these, one specimen at places, shows leaves on its lateral sides. The specimens are comparable with some of the specimens described earlier by Jongmans (1954, pl. 17, figs 5-7; pl. 18, figs 8-10; pl. 19, figs 11-13; pl. 20, fig. $14b_2$, b_3) as *C. pacifica*.

Lycophyta-Incertae Sedis

Casts of Stems (*Pl. 4, fig. 23*) — Several specimens preserved in the form of casts have been collected from Wallarama Spur in the position of growth, i.e. in erect condition. Unfortunately, all of them have badly preserved leaf cushions and as such their generic identification is difficult.

Stem casts measuring 10-21 cm in length and 9-10 cm in diameter. Leaf cushions arranged in ascending spirals, mostly their outline is not well-marked, at places seem to be hexagonal or rhomboidal, 1.2-1.5 cm long and 0.8-1.0 cm wide. Leaf scar and other details not available.

Occurrence — Wallarama Spur.

Cone-like structure (*Pl. 3, figs 18, 19*; *Text-fig. 4C*) — Solitary stem terminating in a cone-like structure. Specimen as a whole measuring 5.2 cm in length and 2.2 cm in breadth. Stem surface covered by spirally arranged leaves. Leaves linear, 1-1.5 cm long and 0.2 cm broad; apex acute. (?) Cone ovoid, 2.2 cm long and 1.3 cm broad, ?bracts/sporophylls similar to the leaves covering the main stem.

Occurrence — Manigam Spur.

Remarks — The cone is too ill-preserved to be assigned to a definite genus or species.

Branched Stem (*Text-fig. 4D*) — The description is based on a single specimen preserved as impression. The main stem is about 9 cm in length and 2.1 cm in width at its broadest region. The leaf-bases are imperfectly preserved and their details are not visible. The stem at its apical end is dichotomously branched and each branch is covered with spirally arranged leaves. Leaves are linear, about 2-2.5 cm long and 1-1.5 cm broad.

Occurrence — Gund Village.

Rhacopteris ovata (McCoy) Walkom

Pl. 3, figs 20, 21; Text-fig. 4E, F

Indian specimens:

1937 *Rhacopteris ovata* (McCoy) Walkom-*Rh. inaequilatera* Feistmantel (*non* Goeppert): Gothan & Sahni, p. 196, pl. 16, figs 1, 2.

1937 *Rhacopteris ovata* (McCoy)Walkom: Gothan & Sahni, p. 198, pl. 1,figs 1-4.

1955 *Rhacopteris ovata* (McCoy)Walkom: Hφeg, Bose & Shukla, p. 11, pl. 1, fig. 2.

1955 *Rhacopteris inaequilatera* Goepp. sp.: Hφeg, Bose & Shukla, p. 11, pl. 1, fig. 3.

1955 *Rhacopteris ovata* (McCoy)Walkom: Hφeg, Bose & Shukla, p. 11.
1955 *Rhacopteris* cf. *circularis* Walton: Hφeg, Bose & Shukla, p. 11, pl. 2, figs 13-15.
1955 *Rhacopteris inaequilatera* Goepp. sp.: Hφeg, Bose & Shukla, p. 12, pl. 2, figs 16, 17.
1974 *Rhacopteris* cf. *circularis* Walton: Maithy (review paper), p. 48.
1974 *Rhacopteris ovata* (McCoy)Walkom: Maithy (review paper), p. 48.
1974 *Rhacopteris inaequilatera* Goeppert: Maithy (review paper), p. 48.
1978 *Rhacopteris* cf. *circularis* Walton: Pal, p. 129, pl. 2, fig. 8.
1979 *Rhacopteris* cf. *circularis* Walton: Pal & Chaloner, p. 296, fig. 1d, e.

Description (for description assumed to be bipinnate) — Detached pinnae, measuring 5-10 cm in length and 2-3 cm in breadth; rachis straight, 2-3 mm wide. Pinnules alternate, closely set, sometimes apical part of pinnule (lying below) touching base of pinnule lying immediately above, attached at an angle of about 40°-48°. Pinnule 1.2-2.5 cm long and 0.8-1.4 cm wide, obovate; apex broadly rounded; base tapering below; lateral margins more or less straight, apical margin crenulate. Veins spreading from base, mostly forking once or twice; except a few veins along median region majority slightly curved downwards.

Occurrence — Manigam Spur and Gund Village.

Remarks — The new specimens agree with the earlier specimens figured by Gothan and Sahni (1937) and Hφeg, Bose and Shukla (1955).

Triphyllopteris lescuriana (Meek) Jongmans

Pl. 3, fig. 22; Text-figs 4G, 5A

Indian specimens:

1937 *Sphenopteridium ?furcillatum* Ludwig sp.: Gothan & Sahni, p. 197, pl. 18, figs 1, 2.

Doubtful specimen:

1955 *Sphenopteridium* sp. b: Hφeg, Bose & Shukla, p. 11 (*partim*), pl. 1, fig. 8.

Description — Fronds bipinnate, 7.5-12 cm long and 3·2-6.5 cm broad; main rachis 2-3 mm wide, surface faintly striated in longitudinal direction. Pinnae alternately arranged, attached at an angle of 30°-50°, shape as a whole lanceolate, measuring 3.5-5 cm in length and 0.8-1.5 cm in breadth. Pinnules dissected into lobes, 0.8-1.5 cm long and 0.5-0.8 cm broad, lobes of unequal size and shape, basal part constricted to form a petiole; veins mostly not discernible; 1-3 veins entering from base of each lobe radiating from base, simple or forked.

Occurrence — Manigam and Wallarama spurs.

Remarks — The present specimens match with the specimens earlier figured by Jongmans (1954, p. 26, figs 43-45) from the Lower Carboniferous of Peru.

Rhodea cf. *subpetiolata* (H. Potonié) Gothan

Pl. 5, figs 26, 27; Text-figs. 5D, 6

Indian specimens:

1937 *Sphenopteris* sp. (*Rhodea* sp.): Gothan & Sahni, p. 198, pl. 18, fig. 3.
1955 *Rhodea* sp.: Hφeg, Bose & Shukla, p. 10, pl. 1, fig. 1.
1974 *Rhodea* sp.: Maithy (review paper), p. 49.
1978 *Rhodea tenuis* Gothan: Pal, p. 130, pl. 4, fig. 16.

Description — Fronds fragmentary, overall shape and size not known; main rachis 1-2 mm wide. Pinnules alternately arranged irregularly dissected into linear segments, penultimate segments uni- or bifid; apex broadly obtuse. Each segment showing a median vein.

Occurrence — Manigam and Wallarama spurs.

Remarks — The present specimens are comparable with the specimens described by Gothan (1929, pl. 1, figs 2, 3; pl. 6, fig. 4).

Palmatopteris cf. *furcata* Potonié

Pl. 4, fig. 24; Pl. 5, fig. 25; Text-fig. 5B, C

Description — Fronds tripinnate, exceeding 30 cm in length. Primary rachis 0.8-1.4 cm in breadth, longitudinally striated. Secondary rachis arising at an angle of about 40°-55°, alternate, 0.3-0.6 cm broad, surface finely striated in longitudinal direction. Pinnules alternately arranged, 1.5-2.5 cm long, lamina repeatedly dichotomously

TEXT-FIG. 5A-D.

TEXT-FIG. 6 — *Rhodea* cf. *subpetiolata* (H. Potonié) Gothan, B.S.I.P. no. 36061/2544, from Wallarama, × 1.

dissected into fine segments, apices of penultimate segments rounded. At places mid-vein faintly visible.

Occurrence — Kotsu Hill.

Remarks — The specimens from Kotsu Hill resemble most the specimens of *Palma-*

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TEXT-FIG. 5A-D — **A**, *Triphyllopteris lescuriana* (Meek) Jongmans, B.S.I.P. no. 36059/2544, from Wallarama, × 4. **B, C**, *Palmatopteris* cf. *furcata* Potonié, B.S.I.P. nos. 36063/2518 and 36062/2518, from Kotsu; B, × 1; C, × 1/2. **D**, *Rhodea* cf. *subpetiolata* (H. Potonié) Gothan, B.S.I.P. no. 36090/2544, from Wallarama, × 1.

topteris furcata described by Gothan (1931, pl. 26, fig. 2; pl. 27, fig. 1; text-fig. 4) from Westphalian B of Germany. They may also be compared with *Dactylophyllum digitatum* described by Morris (1973, pl. 1, fig. d) from New South Wales, Australia. However, our specimens of *Palmatopteris* cf. *furcata* do not show such variations of pinnules as seen in *D. digitatum*.

LOWER PERMIAN FLORA

NISHATBAGH FORMATION

Gangamopteris kashmirensis Seward

Pl. 5, figs 28-30; Text-fig. 7G

1905 *Gangamopteris kashmirensis* Seward: in Seward & Woodward, p. 3, pl. 8, figs 1-6; pl. 9, figs 1, 2.
1907 *Gangamopteris kashmirensis* Seward, p. 58, pl. 13, figs 1, 2.
1957 *Gangamopteris kashmirensis* Seward: Hazra & Prasad, p. 498, pl. 10, fig. 5.
1963 *Gangamopteris kashmirensis* Seward: Verma, p. 276.
1974 *Gangamopteris kashmirensis* Seward: Chandra (review paper), p. 131.
1977 *Gangamopteris kashmirensis* Seward: Kapoor, pp. 445, 446.

The specimens figured here were collected from Nishatbagh Spur and they exactly match with the specimens of *G. kashmirensis* earlier described by Seward (1905, 1907) from Vihi Valley and Resin Spur.

Occurrence — Banihal Pass, Tata Kuti, Apharwat, Vihi Valley (type locality), Resin and Nishatbagh spurs.

Glossopteris longicaulis Feistmantel

Pl. 5, figs 31, 32; Text-fig. 7F

Description — The collection includes a solitary specimen whose lamina is incomplete on one side of midrib and also its base and apex are missing. In venation pattern the specimen resembles the specimens of *Glossopteris longicaulis* earlier described by Feistmantel (1879-81, pl. 31, figs 1, 3), Maithy (1965, pl. 4, fig. 29), Pant and Gupta (1968, pl. 26, figs 45, 46), Banerjee (1978, pl. 7, fig. 13) and Chandra and Surange (1979, pl. 1, fig. 4; pl. 15, fig. 13).

Occurrence — Nishatbagh Spur.

Glossopteris nishatbaghensis sp. nov.

Pl. 6, figs 34-37; Text-fig. 7E

Diagnosis — Leaf linear, measuring 8-14 cm in length and 0.8-1.2 cm in width at its broadest region, sometimes tortuous, apex sub-acute or obtuse; base attenuate; margins entire. Midrib distinct, persistent up to apex, ± 1 mm wide. Lateral veins arising at an angle of 10°-15°, slightly away from the point of emergence bending upwards and running straight to margin so as to form an angle of 30° with margin, concentration of veins 18-22 per cm, forming short, narrow and polygonal meshes. Meshes near midrib longer than those near margins.

Holotype — No. 36067/2542 of Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — Nishatbagh Spur.

Comparison — In over all shape *Glossopteris nishatbaghensis* resembles most some of the specimens of *G. gondwanensis* Pant & Gupta (1971, pl. 16, fig. 2; also see Chandra & Surange, 1979, pl. 23, fig. 4). In the latter, however, the apex is acute, also the vein meshes are shorter and broader than *G. nishatbaghensis*. In external form *G. wilkinsonii* Feistmantel described by Banerjee (1978, pl. 10, fig. 28) and *G. taenioides* Feistmantel figured by Chandra and Surange (1979, pl. 4, fig. 6) may be compared with *G. nishatbaghensis*. However, in the former two species secondary

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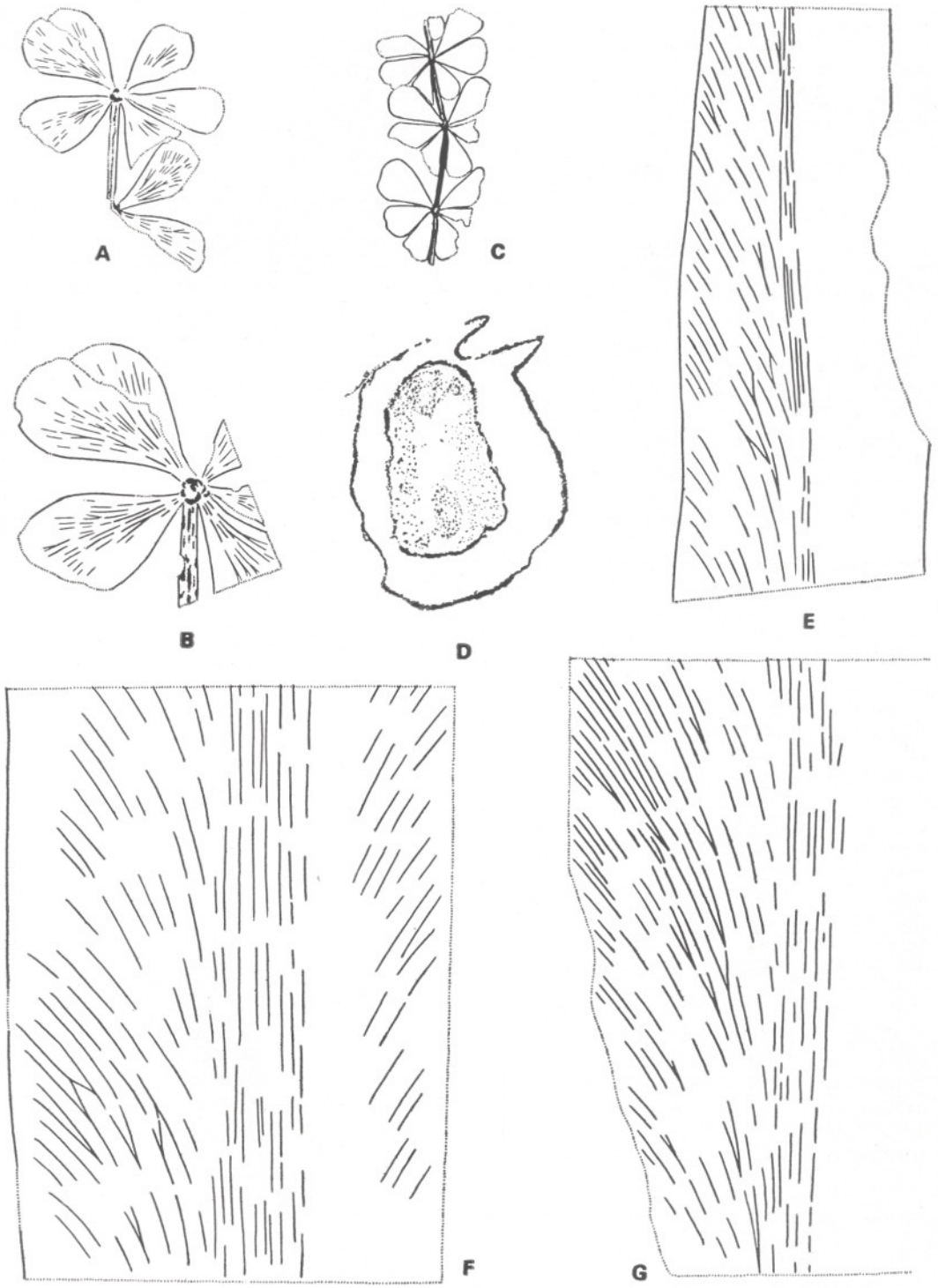
TEXT-FIG. 7A-G — **A, B,** *Parasphenophyllum thonii* var. *minor* (Sterzel) Asama, B.S.I.P. no. 36069/2538, from Mamal; A, × 1; B, details from A, × 2. **C,** *Trizygia speciosa* Royle, B.S.I.P. no. 36071/2538, from Mamal, × 2. **D,** ?*Nummulospermum* sp., B.S.I.P. no. 36068/2542, from Nishatbagh Spur, × 8. **E,** *Glossopteris nishatbaghensis* sp. nov., a portion from the holotype showing veins; B.S.I.P. no. 36066/2542, from Nishatbagh Spur, × 4. **F,** *Glossopteris longicaulis* Feistmantel, part of a specimen showing veins, B.S.I.P. no. 36066/2542, from Nishatbagh Spur, × 4. **G,** *Gangamopteris kashmirensis* Seward, part of a specimen showing veins, B.S.I.P. no. 36064/2542, from Nishatbagh Spur, × 4.



TEXT-FIG. 7A-G.

veins arise at an angle of 70°-90°. *G. senii* Srivastava (1969) is much narrower and smaller in size than *G. nishatbaghensis*. In the former secondary veins arise at an angle of 60°-80°.

?*Nummulospermum* sp.

Pl. 5, fig. 33; Text-fig. 7D

Description — Platyspermic seed, 5×4 mm, broadly oval in shape; central body surrounded by a wing; micropylar end showing a pair of minute beak-like projections.

Occurrence — Nishatbagh Spur.

Remarks — ?*Nummulospermum* sp. resembles *N. bowense*, described by Walkom (1921) and Maithy (1965) in overall shape, however, it differs from the latter species in being much smaller in size.

Mamal Formation

Parasphenophyllum thonii var. *minor* (Sterzel) Asama

Pl. 6, figs 38-40; Text-fig. 7A, B

Description — Specimens incomplete, showing one or two whorls of leaves. Stem articulate, showing a median groove or ridge, ±1 mm wide. Internodes about 1.5 cm long, each whorl having six leaves of almost similar size and shape. Leaves measuring 1-1.5 cm in length and 0.6-1.2 cm in breadth at its broadest region, obovate, apex obtuse, base cuneate, margin entire; 1-3 veins emerging from base, after emergence repeatedly dichotomising, only 2-3 veins running straight along median portion of lamina remaining arching outwards, concentration of veins 18-20 per cm.

Occurrence — Mamal.

Remarks — Unlike *Sphenophyllum* Brongniart (1828), which has straight veins, the present specimens have leaves with arched veins. As such they have been referred to *Parasphenophyllum* Asama (1970). The specimens resemble the earlier described specimens of *P. thonii* var. *minor* (Sterzel) Asama (1970) from the Permian of China, Korea, Maiya and Japan.

Trizygia speciosa Royle

Pl. 6, figs 41, 42; Text-fig. 7C

Description — Fragmentary specimens measuring 2-3.8 cm in length and 0.7-1.2 cm in breadth. Stems less than 1 mm in width, articulate with swollen nodes; internodes 4-7 mm in length, showing a median ridge. Each node consisting of a whorl of six leaves arranged in trizygoid manner, two pairs of lateral leaves (in fossilized condition) larger in size than the remaining two leaves (pointing towards base of specimen). Lateral leaves 4-8 mm long and 3-5 mm broad, the remaining two measuring 3-5 mm in length and 1.5-3 mm in breadth. Over all shape of leaves obovate, margins entire. Leaf apex broadly obtuse, base cuneate; veins obscure, seems to be straight.

Occurrence — Mamal.

Remarks — The Mamal specimens agree with those described from the Lower Gondwana beds of peninsular India by Maheshwari (1968) and Maithy (1978). They also resemble the specimens reported by Asama (1970) from the Permian of China and Korea.

Labatannularia ensifolia Halle

Pl. 7, figs 43-46; Text-fig. 8C, D

Specimens from Kashmir:

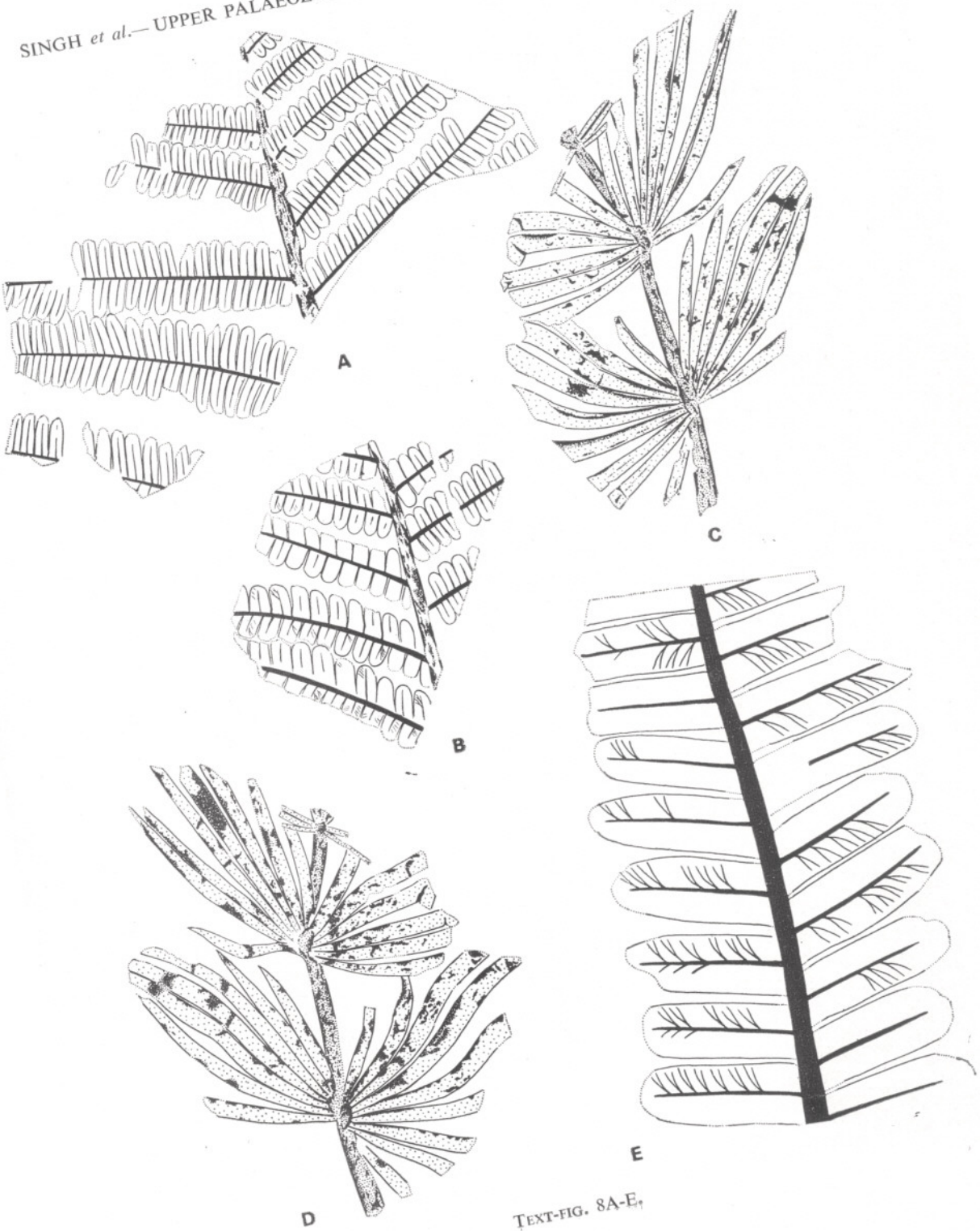
1977 *Kashmiropteris meyenii* Kapoor, p. 446, pl. 169, figs 1, 2.

1977 *Kawizophyllum dunpathriensis* Kapoor, p. 446, pl. 170, fig. 2.

Several specimens have been collected from Mamal. Out of these, except one, the rest are either detached leaves or portions from a leaf whorl. The description is based on the specimen figured in Pl. 7, figs 43, 44.

→

Text-fig. 8A-E — **A, B,** *Rajahia mamalensis* sp. nov., B.S.I.P. nos. 36077/2538 and 36078/2538, from Mamal, × 1. **C, D,** *Lobatannularia ensifolia* Halle, showing part and counterpart, B.S.I.P. nos. 36073/2538 and 36072/2538, from Mamal, × 1. **E,** *Rajahia mamalensis* sp. nov., details from A, × 4.



TEXT-FIG. 8A-E.

Description — The largest specimen, having part and counterpart, measures 6.5 cm in length and 6 cm in breadth. Stem articulate, showing a median ridge, measuring 3 mm in breadth near basal end and 2 mm near apical end; internodes 2-3 cm long, each node with a whorl of leaves, which are divided into two groups on either side of node, each side comprising 6-9 leaves. Leaves linear with acute apex, measuring 1.5-4 cm in length and $\pm$0.2 cm in breadth; each leaf with a median vein; transverse thickenings absent.

Occurrence — Mamal.

Remarks — The present specimens match exactly with the specimens of *Lobatannularia ensifolia* figured by Halle (1927, pl. 11, figs 5, 6) and Boureau (1964, fig. 170).

Raniganjia qubensis Hsü (1976) from the Permian of Southern Xizang is also similar to our specimens of *L. ensifolia* and we think that they should also be referred to *Labatannularia*. In our opinion *Kashmiropteris meyenii* Kapoor (1977) is only an apical portion of *Labatannularia ensifolia* whereas, *Kawizophyllum dunpathriensis* Kapoor (1977) is a detached leaf of the same species.

Rajahia mamalensis sp. nov.

Pl. 7, figs 47-50; Text-fig. 8A, B, E

Diagnosis — Leaves bipinnate, sterile, estimated length and breadth more than 12 cm and 10 cm respectively, substance of lamina thick. Principal rachis straight or slightly curved near apex, 1-3 mm wide, surface showing hexagonal patterns or faint striations in longitudinal direction. Pinnae alternate, attached at an angle of 50°-80°, exceeding 5 cm in length, 0.4-1.5 cm in breadth; surface showing discontinuous, fine longitudinal striations or hexagonal patterns. Pinnules alternate, attached at an angle of 75°-90°, first pinnule arising on basiscopic side (katadromic), closely set, rarely touching each other. Pinnules somewhat oval in shape, 2-7.5 mm long and 1.5-2.5 mm broad (rarely 3 mm); margins entire; apex obtuse; acroscopic margin straight or slightly decurrent. Midrib prominent, towards apex occasionally forking and becoming fainter; lateral veins katadromic, forking once or twice (mostly once), sometimes twice (out of the first two branches only the distal forking once), emerging at an angle of 70°-85°, (rarely 90°), slightly arching.

Holotype — No. 36077/2538 of Birbal Sahni Institute of Palaeobotany, Lucknow.

Occurrence — Mamal.

Remarks — *Pecopteris* sp. figured by Kapoor (1977, pl. 170, fig. 1) resembles our specimens of *Rajahia mamalensis*. From the photograph it is not clear whether the specimen is sterile or fertile. Unfortunately none of the specimens of *Pecopteris* sp. of Kapoor (1977) were available to us, so we have not been able to include Kapoor's specimens under the synonymy of *R. mamalensis*. As our all specimens are sterile so in the diagnosis we have only included the description of sterile specimens.

Comparison — *Rajahia mamalensis* resembles, in gross features, *R. bifurcata* Kośno, *R. linggiuensis* Kośno, *R. pseudohemitelioides* Kośno, *R. rajahii* Kośno and *R. sengensis* Kośno described by Kośno in Kośno, Asama and Rajah, (1970), however, it can be readily distinguished from all of them by its venation pattern. Unlike the Chinese specimens *R. mamalensis* has twice forked veins.

R. mamalensis also resembles *Dizeugotheca qubensis* Hsü (1976, pl. 2, figs 8-12) in general shape of pinnules, however, in the latter species the lateral veins in the pinnules are unforked.

Glossopteris intermittens Feistmantel

Pl. 8, figs 52-54; Text-fig. 9

This is the first record of *Glossopteris intermittens* from Kashmir. All the specimens look similar to the ones earlier described by Feistmantel (1881), Banerjee (1978, pl. 7, fig. 12) and Chandra and Surange (1979, pl. 3, fig. 5; pl. 17, fig. 9).

Occurrence — Mamal.

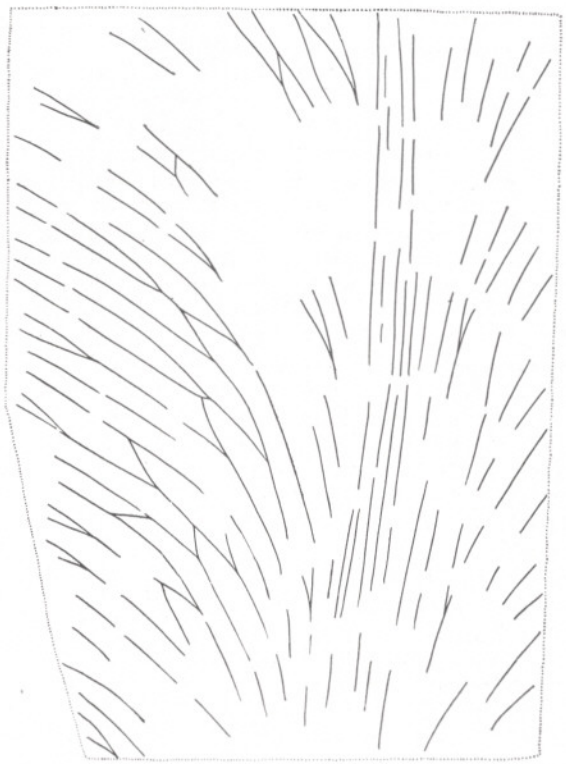
Glossopteris cf. *communis* Feistmantel

Pl. 8, fig. 51; Text-fig. 10

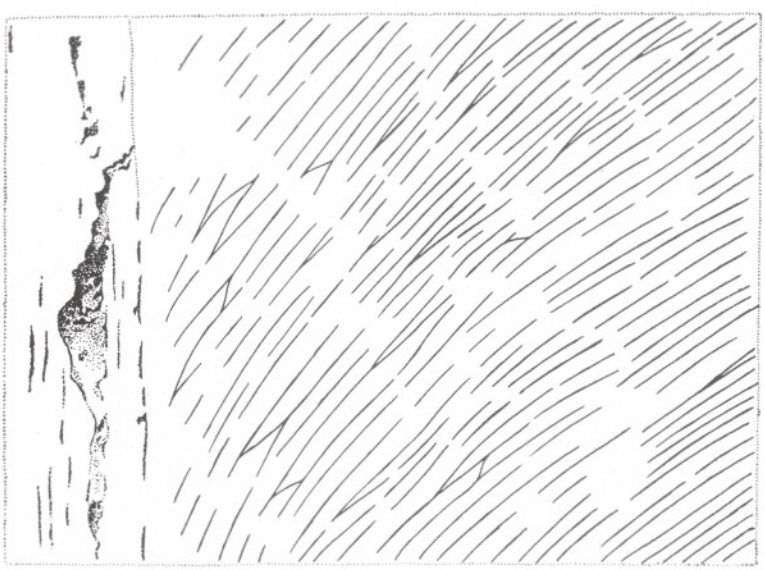
Specimens from Kashmir:

1957 *Glossopteris communis* Feistmantel: Hazra & Prasad, p. 502.

1977 *Glossopteris communis* Feistmantel: Kapoor, p. 446.



TEXT-FIG. 9 — *Glossopteris intermittens* Feistmantel, part of a specimen enlarged to show veins, B.S.I.P. no. 36081/2538, from Mamal, × 4.



TEXT-FIG. 10 — *Glossopteris* cf. *communis* Feistmantel, part of a specimen enlarged, B.S.I.P. no. 36080/2538, from Mamal, × 4.

Description — Leaves incomplete at base and apex, largest specimen 13.5 cm long and 9 cm broad, margin entire. Midrib distinct, 3-5 mm broad, showing a median groove or a ridge; lateral veins arising at an angle of 40°-45°, after emergence running forward for about 1-2 mm distance and then arching upwards, near midrib veins concentration 18 per cm and towards margin 24 per cm. Meshes narrow elongate along major part of lamina, closer to margin much narrower.

Occurrence — Mamal.

Remarks — *Glossopteris communis* Feistmantel (1876) has three lectotypes. The first (G.S.I. No. 5088) was selected by Pant and Gupta (1968) out of the specimens described by Feistmantel (1879-81, pl. 31, fig. 5) from Karharbari. This specimen is preserved in the form of incrustation and its cuticle was studied by Pant and Gupta (1968). The second (G.S.I. No. 5283) was selected by Banerjee (1978) out of Feistmantel's (1881, pl. 36A, fig. 2) specimens from Raniganj Stage. The third (G.S.I. No. 5022) was selected by Chandra and Surange (1979) out of the original collection of Feistmantel (1879-81, pl. 17, fig. 2) from Karharbari. Pant and Gupta (1968) have not mentioned any reason for selecting a lectotype for *G. communis*; nor have Banerjee (1978) and Chandra and Surange (1979) given reasons for rejecting Pant and Gupta's (1968) lectotype of *G. communis* and instituting their own. Also none of these authors have taken into consideration the original figured specimen of Feistmantel (1876, pl. 21, fig. 5).

Without adding to this confusion we have compared our specimens with some of the original specimens of *G. communis* Feistmantel (1879-81, pl. 17, figs 1, 2; pl. 31, fig. 5) and have found them to be somewhat similar. Only difference is that the angle of emergence of lateral veins in Feistmantel's (1879-81) specimen is slightly less than the specimens from Mamal. The present specimens also resemble the specimen of *G. communis* figured by Hsü (1976, pl. 4, fig. 23).

Glossopteris cf. *feistmantelii* Rigby

Pl. 9, fig. 57; Text-fig. 11

Description — Leaf size and shape unknown, largest available leaf measuring 10.5 cm in length and 4 cm in breadth; margin entire. Midrib 2-4 mm wide, showing a distinct median groove or ridge. Lateral veins emerging at an angle of 45°-50° (angle of divergence less towards apex), slightly away from the point of emergence arching upwards and then running straight up to margin, concentration of veins 8-10 per cm near midrib and 12-14 per cm near margin; meshes elongate and broad near midrib; slightly narrower and longer along major part of lamina; smaller and narrower towards margins.

Occurrence — Mamal.

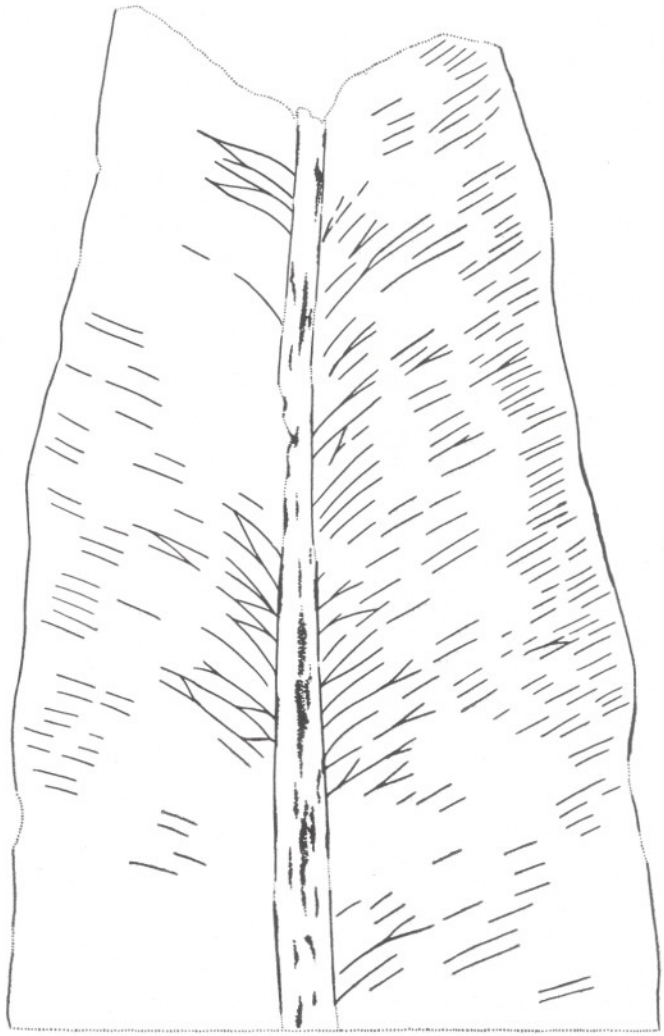
Remarks — Chandra and Surange (1979) while describing *Glossopteris feistmantelii* Rigby, kept the following specimens under its synonomy:

1882 *Glossopteris cordata* Feistmantel, *Mem. geol. Surv. India*, 4, p. 34, pl. XX, fig. 1.
1964 *Glossopteris feistmantelii* Rigby, *Proc. Linn. Soc. N.S.W.*, 89(1), p. 154.
1977 *Glossopteris fuchsii*, Srivastava, A. K., *Palaeobotanist*, 23 (3), pp. 21, 22, pl. 2, fig. 10.

However, they have figured some of these specimens as follows:

Plate 2, fig. 3 — *Glossopteris cordata* Feistmantel (= *Glossopteris fuchsii* of Srivastava, A. K.) specimen no. 37/1992, B.S.I.P.
Plate 5, fig. 3 — *Glossopteris feistmantelii* Rigby, specimen no. 5478, G.S.I.
Plate 10, fig. 3 — *Glossopteris feistmantelii* Rigby (= *Glossopteris browniana* of Feistmantel), specimen no. 5252, G.S.I.
Plate 16, fig. 10 — *Glossopteris feistmantelii* Rigby (= *Glossopteris fuchsii* of *Srivastava*, A. K.), specimen no. 37/1392, B.S.I.P.

Out of the above specimens Chandra and Surange (1979, pl. 38, fig. 2) gave a restoration of *Glossopteris feistmantelii* Rigby based on the specimen figured by Feistmantel (1882, pl. 20, fig. 1). In their restoration of *G. feistmantelii*, they have shown the leaf base as cordate although in the actual specimen the base is missing. In none of our specimens the base is preserved, however, the specimens in gross



TEXT-FIG. 11 — *Glossopteris* cf. *feistmantelii* Rigby, B.S.I.P. no. 36087/2538, from Mamal, × 2.

features and venation pattern resemble most the specimen of *G. cordata* Feistmantel (= *G. fuchsii* of Srivastava, A. K.) figured by Chandra and Surange (1979, pl. 2, fig. 3).

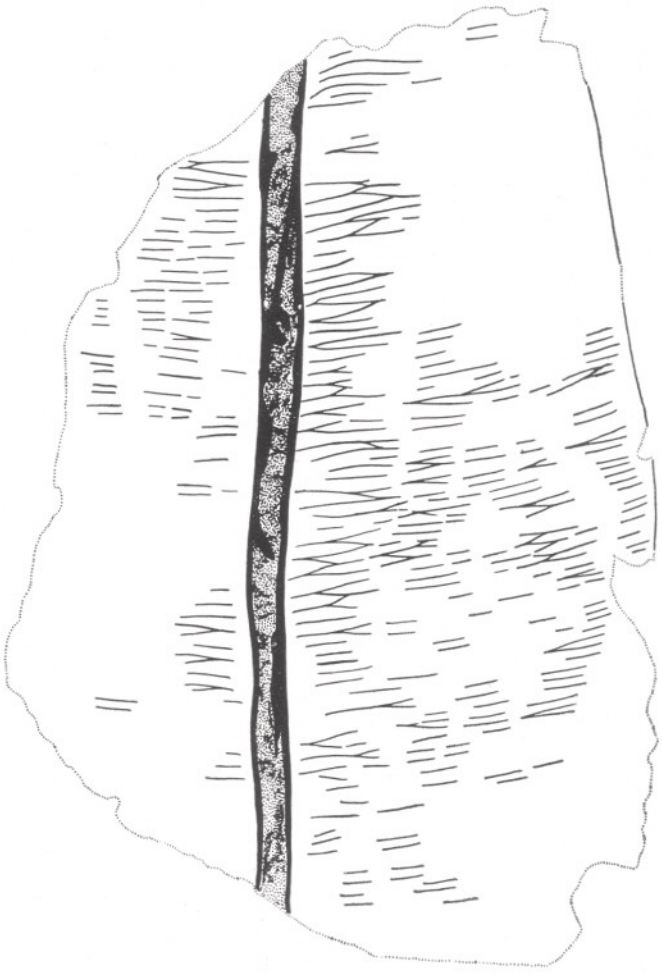
Glossopteris cf. *taeniopteroides* Feistmantel

Pl. 8, fig. 55; Pl. 9, fig. 56; Text-fig. 12

Description — Fragmentary leaves without base and apex, largest specimen measuring 8.5 cm in length and 4.4 cm in breadth; margins entire. Midrib persistent along entire length, 2 mm wide (near apex 1 mm wide); lateral veins arising at an angle of 70°-90° (near apex 60°), running straight up to margin, concentration of veins 14-16 per cm; meshes more or less hexagonal, longer towards midrib, shorter towards margin.

Occurrence — Mamal.

Remarks — The above specimens resemble in venation pattern the leaf of *Glossopteris*



TEXT-FIG. 12 — *Glossopteris* cf. *taeniopteroides* Feistmantel, B.S.I.P. no. 36084/2538, from Mamal, × 2.

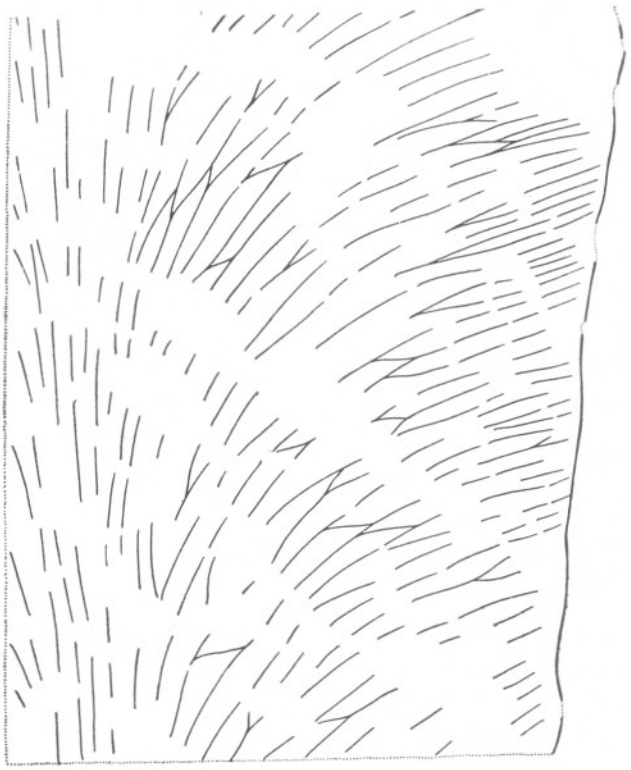
taeniopteroides Feistmantel described by Banerjee (1978, pl. 10, fig. 27). They also resemble the specimen of *G. taeniopteroides* figured by Srivastava (1956, pl. 7, fig. 48) from Raniganj Stage. This letter specimen has now been transferred under *G. srivastavae* Surange & Maheshwari by Chandra and Surange (1979). In our opinion the specimen of *G. taeniopteroides* figured by Srivastava (1956, pl. 7, fig. 48) is quite different from the type specimen of *G. srivastavae* Surange & Maheshwari (1962, pl. 1, fig. 9). In the latter specimen vein meshes are much broader and longer (nearly two times).

Glossopteris angustifolia Brongniart

Pl. 9, figs 58, 59; Text-fig. 13

At Mamal this is the commonest species. All the specimens are incomplete, but in general shape and venation pattern they are in agreement with the various specimens of *G. angustifolia* Brongniart, including the holotype figured by Banerjee (1978, pl. 1, fig. 1) and Rigby *et al.* (1980, figs 15-17). They also resemble the specimens of *G. angustifolia* described by Hsü (1976, pl. 3, figs 16, 17) from southern Xizang, Tibet.

Occurrence — Mamal.



TEXT-FIG. 13 — *Glossopteris angustifolia* Brongniart, a portion of a specimen enlarged showing veins, B.S.I.P. no. 36086/2538, from Mamal, × 4.

Glossopteris sp.

Pl. 9, fig. 62

Description — Leaf incomplete at base and apex, measuring 12.2 cm in length and 3 cm in breadth; midrib prominent throughout the entire length, ±1.5 mm wide; lateral veins emerging at an angle of 80°-90° (towards base almost at 90°), forming broad meshes near midrib, little away from midrib narrower and longer, concentration of veins 18-20 per cm.

Occurrence — Marhoma.

Remarks — *Glossopteris stricta* Bunbury (1861, pl. 9, fig. 5) has two lectotype numbers — the first, no. 10363 of British Museum (Natural History), London is mentioned by Banerjee (1978) and the second no. R 10636 of the Museum of Geological Society, London by Chandra and Surange (1979). Actually Bunbury's (1861, pl. 9, fig. 5) type specimen is now stored in the British Museum (Natural History), London and it bears the number V 19620.

Under the synonymy of *G. stricta*, Chandra and Surange (1979) have referred a specimen of *G. stricta* figured by Feistmantel (1881, pl. 38A, fig. 3). They have also figured this specimen (Chandra & Surange, 1979, pl. 5, fig. 4). We, however, consider this specimen to be quite distinct from the original specimen of *G. stricta* figured by Bunbury (1861, pl. 9, fig. 5). Bunbury's specimen shows about 1-2 mm wide infra-marginal portion which is thinner than the rest of the lamina. This infra-marginal region has much smaller and polygonal meshes as compared to the meshes over the major part of the lamina. Such infra-marginal region is not present in the specimen figured by Chandra and Surange (1979, pl. 5, fig. 4) and it is quite likely that it is different from the original specimen of Bunbury (1861, pl. 9, fig. 5). Our speci-

men resembles the specimens of *G. stricta* figured by Chandra and Surange (1979, pl. 5, fig. 4) in gross features as well as in venation pattern. It, however, differs from *G. stricta* of Bunbury (1861, pl. 9, fig. 5) in lacking the infra-marginal region.

?*Cordaites* sp.

Pl. 9, figs 60, 61; Text-fig. 14

Description — Fragmentary leaf devoid of base and apex, measuring 5.2 cm in length and 2 cm in breadth; veins parallel, unforked, concentration of veins 12-14 per cm; interveining spaces occupied by fibre-like structure.

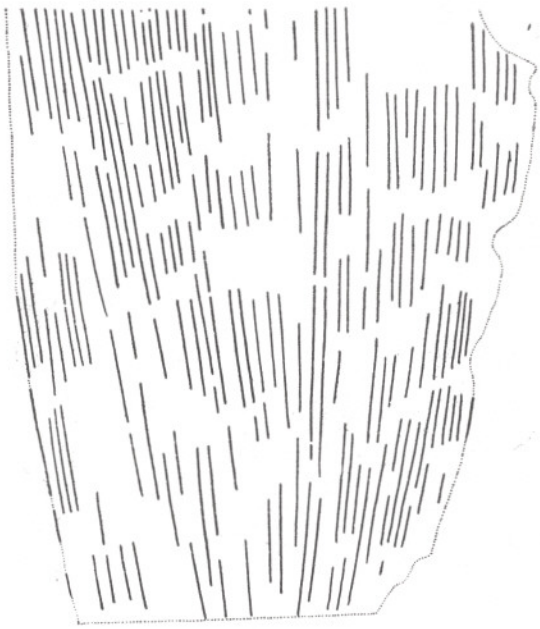
Occurrence — Mamal.

Remarks — The specimen is too incomplete; it has been doubtfully referred to ?*Cordaites* sp. because of the presence of fibre-like structure in between veins.

Ginkgophyllum haydenii (Seward) Maithy

Text-figs 15, 16

1905 *Psygmophyllum* sp.: Seward in Seward & Woodward, p. 6, pl. 9, fig. 3.



TEXT-FIG. 14 — ?*Cordaites* sp., part of a specimen showing veins, B.S.I.P. no. 36088/2538, from Mamal, × 4.

1912 *Psygmophyllum haydeni* Seward, p. 6, pl. 3, figs 8-11.

1943 *Psygmophyllum haydeni* Seward: Sitholey, p. 184, pl. 10, fig. 1; pl. 11, figs 2-8; text-figs 1-3.

1957 *Psygmophyllum haydeni* Seward: Hazra & Prasad, p. 502, pl. 10, figs 6, 7.

1960 *Ginkgophyton haydeni* (Seward) Høeg & Bose, p. 42.

1974 *Ginkgophyllum haydenii* (Seward) Maithy, p. 303.

Emended Diagnosis — Leaves flabellate, measuring up to 13 cm in length and 12 cm in width; base narrow, forming a petiole, 4-5 mm broad; apical end deeply dissected into six or more obcuneate segments, angle of division small; veins diverging from base, repeatedly dichotomising, running straight, subparallel, concentration of veins near base 10 per cm, towards apex 20-22 per cm.

Lectotype — Pl. 3, fig. 10 in Seward (1912).

Comparison — In gross features *Ginkgophyllum haydenii* somewhat resembles *G. kidstonii* Maithy (1974), but the latter differs in having a single median fissure. *G. hollandii* (Seward) Maithy (1974) differs from *G. haydenii* in having only two distinct segments in each leaf.

Ginkgophyllum sahnii (Ganju) Maithy

Text-fig. 17

1943 *Psygmophyllum sahnii* Ganju, p. 205, pl. 14, fig. 1; text-figs 1-3

1974 *Ginkgophyllum sahnii* (Ganju) Maithy, p. 303.

1982 *Psygmophyllum sahnii* Ganju: Pant, p. 67, fig. 4F.

Emended Diagnosis — Stem measuring 21.5 cm in length and 0.8-1.2 cm in width, longitudinally striated. Leaves spirally arranged, obcuneate, base drawn into petiole-like structure, measuring 5.5-7.5 cm in length and 5-6.5 cm in width, leaf bilobed, each lobe further divided into two incomplete lobes; median fissure extending nearly 1/2 to 3/4 length of leaf, lateral fissures extending nearly up to 1/4 length of leaf. Veins emerging from base, after emergence repeatedly dichotomising, concentration of veins 10-12 per cm.

Lectotype — No. R/5 of the Department of Botany, Lucknow University, Lucknow.

TEXT-FIG. 15 — *Ginkgophyllum haydenii* (Seward) Maithy, redrawn from Sitholey (1943, text-fig. 1), ×1/2;

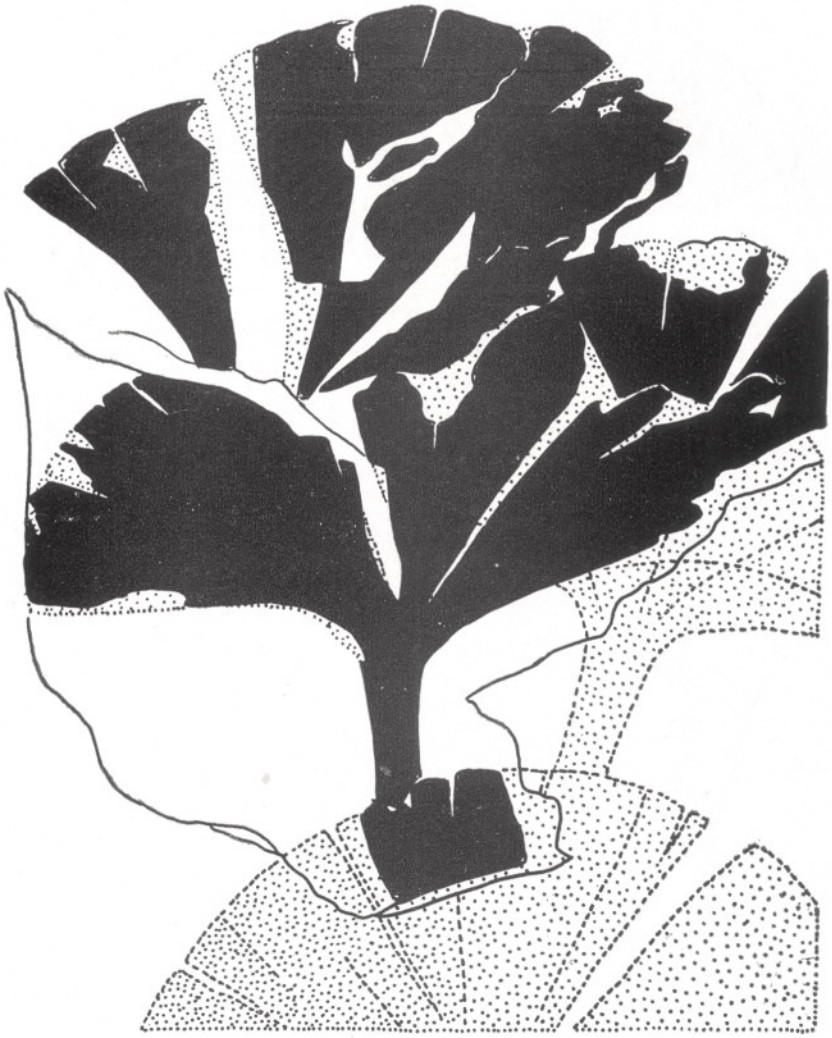
Comparison — *Ginkgophyllum hollandii* (Seward) Maithy (1974) differs from *G. sahnii* in having a single median fissure. Moreover, the veins in *G. hollandii* are running more or less straight, whereas, in *G. sahnii* the veins are curved. *G. kidstonii* (Seward) Maithy (1974), too, has a single median fissure. *G. haydenii* (Seward) Maithy has six or more segments.

INCERTAE SEDIS

Observations on *Lepidostrobus kashmirensis* Srivastava & Kapoor

Text-fig. 18

Srivastava and Kapoor (1967, pl. 5, figs 1-3; text-fig. 1) described *Lepidostrobus kashmirensis* from the tuffaceous shales



TEXT-FIG. 16 — *Ginkgophyllum haydenii* (Seward) Maithy, redrawn from Sitholey (1943, text-fig. 2), ×1.

of Mamal. We have also collected a few fragmentary pieces of similar cones. The description of the most complete specimen is as follows:

Cone cylindrical, uniformly broad from base to apex, measuring 18.7 cm in length and 2.4 cm in width. Exposed part of stalk about 0.5 cm long and 0.4 cm wide. Cone scales spirally arranged, rhomboidal in shape, mostly keeled.

Occurrence — Mamal.

Remarks — The figured specimen (Text-fig. 18), which is available in part and counterpart, do not show any resemblance with any of the known species of *Lepidostrobus*. It is most unlikely that it belongs to the genus *Lepidostrobus*. This has already been doubted by Surange (1971). It is quite likely that these cones may belong to one of the genera present in the Mamal assemblage.

DISCUSSION

The occurrence of various genera and species, at different localities, within the

TEXT-FIG. 17 — *Ginkgophyllum sahnii* (Ganju) Maithy, redrawn from Ganju (1943, text-fig. 1), × 1/2.

Upper Palaeozoic sequence of Kashmir Himalaya has been shown in Table 2. Within this sequence the oldest assemblage, occurring at Kotsu and Diuth spurs, has only two genera with doubtful affinities. Both *Taeniocrada* and *Protolepidodendron* are Devonian forms and their occurrence in Kashmir is important, because so far we do not have any other record of Devonian plants anywhere in Kashmir. May be further search will yield a better Devonian flora in B Member of the Aishmuqam Formation, which is overlain by a sequence having mega- and microfauna of Tournasian age.

The Lower Carboniferous flora has two distinct assemblages. Out of these, the older assemblage belongs to the basal part of C Member of the Syringothyris Limestone Formation which overlies the marine fauna of Tournasian age. Here the fossiliferous beds, exposed at Kotsu, are full of *Lepidodendropsis fenestrata* Jongmans and *Palmatopteris* cf. *furcata* Potonié. The floral assemblage and the associated marine fauna suggest a Visean age for the C Member of Syringothyris Limestone Formation. The younger assemblage, consisting of *Archaeosigillaria minuta* Lejal, *Lepidosigillaria* cf. *quadrata* Danzé-Corsin, *Lepidodendropsis* cf. *peruviana* (Gothan) Jongmans, *L. fenestrata* Jongmans, *Cyclostigma* cf. *pacifica* (Steinmann) Jongmans, *Rhacopteris ovata*, (McCoy) Walkom, *Triphyllopteris lescuriana* (Meek) Jongmans and *Rhodea* cf. *subpetiolata* (H. Potonié) Gothan, comes from A and C Members of Fenestella Shale Formation which on the faunal evidence has been dated as Middle Visean to Bashkirian in age. The overall assemblage is more like the Lower Carboniferous assemblage earlier described by Høeg, Bose and Shukla (1955) rom the Po Series of Spiti. In Spiti, Høeg, Bose and Shukla (1955) had failed to find any lycopsid remain. Their presence in Spiti has now been recorded by Dhar, Ram and Rao (1980). In its overall floral composition the Fenestella Shale assemblage resembles most the assemblage described by Jongmans (1954) from the Lower Carboniferous of Peru.

←

TEXT-FIG. 18 — Cone-like organ, redrawn from Srivastava and Kapoor (1969, text-fig. 1), × *ca* 1.

TABLE 2 — SHOWING DISTRIBUTION OF VARIOUS GENERA AND SPECIES DESCRIBED IN THIS PAPER

Fossil Plants	Upper Devonian		Lower Carboniferous				Lower Permian							
	Diuth	Kotsu	Kotsu	Gund	Manigam	Wallarama	Nishatbagh	Mamal	Marhoma	Golabgarh	Dandlutar	Munda	Risin	Gunyul
?*Taeniocrada* sp.	–	+	–	–	–	–	–	–	–	–	–	–	–	–
?*Protolepidodendron* sp.	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Archaeosigillaria minuta Lejal	–	–	–	+	+	+	–	–	–	–	–	–	–	–
Lepidosigillaria cf. *quadrata* Danzé-Corsin	–	–	–	+	+	+	–	–	–	–	–	–	–	–
Lepidodendropsis cf. *peruviana* (Gothan) Jongmans	–	–	–	+	+	+	–	–	–	–	–	–	–	–
Lepidodendropsis fenestrata Jongmans	–	–	+	–	+	+	–	–	–	–	–	–	–	–
Cyclostigma cf. *pacifica* (Steinmann) Jongmans	–	–	–	+	+	+	–	–	–	–	–	–	–	–
Parasphenophyllum thonii var. *minor* (Sterzel) Asama	–	–	–	–	–	–	–	+	–	–	–	–	–	–
Trizygia speciosa Royle	–	–	–	–	–	–	–	+	–	–	–	–	–	–
Lobatannularia ensifolia Halle	–	–	–	–	–	–	–	+	–	–	–	–	–	–
Rhacopteris ovata (McCoy) Walkom	–	–	–	+	+	–	–	–	–	–	–	–	–	–
Triphyllopteris lescuriana (Meek) Jongmans	–	–	–	–	+	+	–	–	–	–	–	–	–	–
Rhodea cf. *subpetiolata* (H. Potonié) Gothan	–	–	–	–	+	+	–	–	–	–	–	–	–	–
Palmatopteris cf. *furcata* Potonié	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Rajahia mamalensis sp. nov.	–	–	–	–	–	–	–	+	–	–	–	–	–	–
Gangamopteris kashmirensis Seward	–	–	–	–	–	–	+	–	–	+	–	+	+	–
Glossopteris longicaulis Feistmantel	–	–	–	–	–	–	+	–	–	–	–	–	–	–
Glossopteris nishatbaghensis sp. nov.	–	–	–	–	–	–	+	–	–	–	–	–	–	–
Glossopteris intermittens Feistmantel	–	–	–	–	–	–	–	+	–	–	–	–	–	–
Glossopteris cf. *communis* Feistmantel	–	–	–	–	–	–	–	+	–	–	–	+	–	–
Glossopteris cf. *feistmantelii* Rigby	–	–	–	–	–	–	–	+	–	–	–	–	–	–
Glossopteris cf. *taeniopteroides* Feistmantel	–	–	–	–	–	–	–	+	–	–	–	–	–	–
Glossopteris angustifolia Brongniart	–	–	–	–	–	–	–	+	–	–	–	–	–	–
Glossopteris sp.	–	–	–	–	–	–	–	–	+	–	–	–	–	–
?*Cordaites* sp.	–	–	–	–	–	–	–	+	–	–	–	–	–	–
Ginkgophyllum haydenii (Seward) Maithy	–	–	–	–	–	–	–	–	–	+	+	+	–	–
Ginkgophyllum sahnii (Ganju) Maithy	–	–	–	–	–	–	–	–	+	–	–	–	+	+
?*Nummulospermum* sp.	–	–	–	–	–	–	+	–	–	–	–	–	–	–
Cone-like organ	–	–	–	–	–	–	–	+	–	–	–	–	–	–

However, the Fenestella Shale assemblage may also be compared with most of the Lower Carboniferous floral assemblages described from Ghana (Menash & Chaloner, 1971), Shara (Lejal, 1968), Morocco (Danzé-Corsin, 1965), Libya (Lejal-Nicol, 1975), Egypt (Jongmans & Heide, 1955), Australia (Rigby, 1973; Morris, 1975), China (Szé, 1936; Chang, 1956; Asama, 1973), Western Europe (Lutz, 1933; Lacey, 1962; Wagner, 1978) and U.S.A. (Jongmans, Gothan & Darrah, 1935; Chaloner & Meyen, 1973). Thus it seems that the Lower Carboniferous flora of India was similar to those known from the other parts of the world.

Like Lower Carboniferous, the Lower Permian, too, has two distinct assemblages. The older one, i.e. the assemblage from the Nishatbagh Formation, is dominated by *Gangamopteris* and the younger assemblage from Mamal is dominated by *Glossopteris*. The Nishatbagh Formation consists of *Gangamopteris kashmirensis* Seward, *Glossopteris longicaulis* Feistmantel, *G. nishatbaghensis* sp. nov. and ?*Nummulospermum* sp. The Mamal Formation has *Parasphenophyllum thonii* var. *minor* (Sterzel) Asama, *Trizygia speciosa* Royle, *Lobatannularia ensifolia* Halle, *Rajahia mamalensis* sp. nov., *Glossopteris intermittens* Feistmantel, *G.* cf. *communis* Feistmantel, *G.* cf. *feistmantelii* Rigby, *G.* cf. *taeniopteroides* Feistmantel, *G. angustifolia* Brongniart, *Glossopteris* sp., ?*Cordaites* sp., *Ginkgophyllum haydenii* (Seward) Maithy, *G. sahnii* (Ganju) Maithy and a cone-like organ.

The fossil flora from the Nishatbagh Formation has been compared by earlier workers with the Talchir flora of Peninsular India. Recently, Kapoor (1977) opined that Nishatbagh and Vihi beds are homotaxial to the Talchir Formation rather than Karharbari Formation. In the common occurrence of *Gangamopteris* the Nishatbagh assemblage is more like the one known from the Rikba Bed of Peninsular India. However, at Nishatbagh *Glossopteris nishatbaghensis* is dominant, unlike Rikba where *Gangamopteris cyclopteroides* is dominant. The Karharbari Formation has both *Gangamopteris* as well as *Noeggerathiopsis*. At Nishatbagh so far, we have failed to collect any specimen of *Noeggerathiopsis*.

The Mamal assemblage is characterized by the dominance of several species of *Glossopteris* and by the presence of two characteristic Cathaysian genera, viz., *Lobatannularia ensifolia* Halle and *Rajahia mamalensis* sp. nov. and shows close similarity with the assemblages described by Hsü (1973, 1976) from Mt. Jolmo Lungma region and southern Xizang in Tibet. The Tibetian assemblage from southern Xizang has specimens resembling *Lobatannularia* and *Rajahia* alongwith the species of *Glossopteris* (*G. communis*, *G. angustifolia* and *G. indica*). It has also *Sphenophyllum speciosum*.

From the foregoing account it seems that the Permian flora of Kashmir is different from the Permian assemblages known from Peninsular India. The assemblage from Nishatbagh Formation differs from Talchir and Karharbari formations in having *Gangamopteris kashmirensis* and *Glossopteris nishatbaghensis*. As the fossiliferous beds belonging to Nishatbagh Formation overlie the Lower Permian beds having *Eurydesma*, the age of the Nishatbagh Formation may safely be considered as early Artinskian.

The younger assemblage from Mamal Formation is also quite distinct from all the Permian assemblages known from Peninsular India. The various species of *Glossopteris* described above resemble more the Barakar species of *Glossopteris* in gross features. However, when their cuticular structure will be known they may prove to be different. Moreover, the presence of *Lobatannularia ensifolia* Halle and *Rajahia mamalensis* sp. nov. make the assemblage different from that of the Barakar assemblage. The fossiliferous beds belonging to Mamal Formation are overlain by the Zewan Formation. The basal A Member has been dated as Abadehian because of the presence of characteristic foraminifers like *Abadehella* and *Colaniella*. As such the age of the Mamal Formation is considered as early Kungurian.

In the Himalaya, like the Mamal assemblage, recently a mixed assemblage comprising Lower Gondwana elements and northern hemisphere species like *Annularia* sp. cf. *A. stellata*(Schlothiem) has been reported by Tiwari and Singh (1981) from the Kumaun Himalaya. From Solan area, along Kalka-Simla Road, Kulshreshtha *et al.* (1982) have reported *Gangamopteris fibrosa* Maithy. These records along with the records of mixed floras occurring at Mamal and southern Xizang suggest that during Lower Permian

the Himalayan region had floral assemblages which were quite distinct from the assemblages known from the Lower Gondwana of Peninsular India and the northern Cathaysian flora. This naturally raises the question whether there was a separate land mass between the Cathaysia on the north and the Gondwana Land on the south.

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EXPLANATION OF PLATES

PLATE 1

1. ? *Taeniocrada* sp. from Kotsu; B.S.I.P. no. 36043/2771.× 1.
2. ?*Protolepidodendron* sp. from Diuth Spur; B.S.I.P. no. 36044/2543.× 1.
3. Details of part of the above specimen.× 2.
4. *Archaeosigillaria minuta* Lejal from Wallarama; B.S.I.P. no. 36045/2544.× 1.
5. A portion from the above specimen enlarged.× 2.
6. *Archaeosigillaria minuta* Lejal from Gund; B.S.I.P. no. 36093/2519.× 1.
7. *Lepidosigillaria* cf. *quadrata* Danzé-Corsin from Wallarama; B.S.I.P. no. 36046/2516.× 1.
8. *L.* cf. *quadrata* Danzé-Corsin from Wallarama; B.S.I.P. no. 36047/2515.× 1.
9. Part of fig. 7, showing leaf bases and scars.× 2.

PLATE 2

10. *Lepidodendropsis* cf. *peruviana* (Gothan) Jongmans from Wallarama; B.S.I.P. no. 36048/2516.× 1.
11. Details of part of the above specimen.× 2.
12, 13. *Lepidodendropsis fenestrata* Jongmans from Wallarama; B.S.I.P. nos. 36051/2544 and 36050/2544.× 1.
14. *L. fenestrata* Jongmans from Wallarama, showing oval leaf bases; B.S.I.P. no. 36092/2544.× 1.
15. *L. fenestrata* Jongmans from Wallarama, showing a young stem; B.S.I.P. no. 36049/2544.× 1.
16. *Cyclostigma* cf. *pacifica* (Steinmann) Jongmans from Manigam, showing only a part of the specimen; B.S.I.P. no. 36052/2515.× 2.

PLATE 3

17. *Cyclostigma* cf. *pacifica* (Steinmann) Jongmans from Wallarama; B.S.I.P. no. 36053/2544.× 1.
18. Cone-like structure from Manigam; B.S.I.P. no. 36054/2515.× 1.
19. The above enlarged.× 2.
20, 21. *Rhacopteris ovata* (McCoy) Walkom from Manigam; B.S.I.P. nos. 36057/2515 and 36058/2515.× 1.
22. *Triphyllopteris lescuriana* (Meek) Jongmans from Wallarama; B.S.I.P. no. 36059/2544.× 1.

PLATE 4

23. Lycopsid stem cast from Wallarama; B.S.I.P. no. 36056/2544.× 1.
24. *Palmatopteris* cf. *furcata* Potonié from Kotsu; B.S.I.P. no. 36062/2518. *ca.* × 1/2.

PLATE 5

25. *Palmatopteris* cf. *furcata* Potonié from Kotsu; B.S.I.P. no. 36063/2518.× 1.
26, 27. *Rhodea* cf. *subpetiolata* (H. Potonié) Gothan from Wallarama; B.S.I.P. nos. 36060/2544 and 36061/2544.× 1.
28. *Gangamopteris kashmirensis* Seward from Nishatbagh Spur, showing apical part of a leaf; B.S.I.P. no. 36065/2542.× 1.
29. *G. kashmirensis* Seward from Nishatbagh Spur; B.S.I.P. no. 36064/2542.× 1.
30. A portion from the above specimen enlarged, showing veins.× 4.
31. *Glossopteris longicaulis* Feistmantel from Nishatbagh Spur; B.S.I.P. no. 36066/2542.× 1.
32. Details of veins from the above specimen.× 4.
33. ? *Nummulospermum* sp. from Nishatbagh Spur; B.S.I.P. no. 36079/2542.× 8.

PLATE 6

34-36. *Glossopteris nishatbaghensis* sp. nov. from Nishatbagh Spur; B.S.I.P. nos. 36066/2542 (holotype), 36068/2542 and 36067/2542.× 1.
37. Part of fig. 34 enlarged to show details of veins. × 4.
38, 39. *Parasphenophyllum thonii* var. *minor* (Sterzel) Asama from Mamal; B.S.I.P. nos. 36069/2538 and 36070/2538.× 1.
40. Fig. 39 enlarged to show veins.× 2.
41. *Trizygia speciosa* Royle from Mamal; B.S.I.P. no. 36071/2538.× 1.
42. The above magnified.× 2.

PLATE 7

43,44. *Lobatannularia ensifolia* (Halle) from Mamal, part and counterpart; B.S.I.P. nos. 36072/2538 and 36073/2538.× 1.
45. *L. ensifolia* Halle from Mamal, a detached leaf showing median vein; B.S.I.P. no. 36075/2538. × 2.
46. *L. ensifolia* Halle from Mamal, showing a few leaves; B.S.I.P. no. 36074/2538.× 1.
47-49. *Rajahia mamalensis* sp. nov. from Mamal; B.S.I.P. nos. 36077/2538 (holotype), 36078/2538 and 36076/2538.× 1.
50. Part of fig. 47 enlarged to show veins.× 4.

PLATE 8

51. *Glossopteris* cf. *communis* Feistmantel from Mamal; B.S.I.P. no. 36080/2538.× 1.
52, 53. *G. intermittens* Feistmantel from Mamal; B.S.I.P. nos. 36081/2538 and 36082/2538.× 1.
54. A portion of fig. 52 enlarged to show veins.× 4.
55. *Glossopteris* cf. *taeniopteroides* Feistmantel from Mamal; B.S.I.P. no. 36083/2538.× 1.

PLATE 9

56. *Glossopteris* cf. *taeniopteroides* Feistmantel from Mamal; B.S.I.P. no. 36084/2538.× 1.
57. *Glossopteris* cf. *feistmantelii* Rigby from Mamal; B.S.I.P. no. 36087/2538.× 1.
58, 59. *G. angustifolia* Brongniart from Mamal; B.S.I.P. nos. 36086/2538 and 36085/2538.× 1.
60. ? *Cordaites* sp. from Mamal; B.S.I.P. no. 36088/2538.× 1.
61. A portion from the above specimen enlarged to show details of venation pattern.× 4.
62. *Glossopteris* sp. from Marhoma; B.S.I.P. no. 36089/2540.× 1.

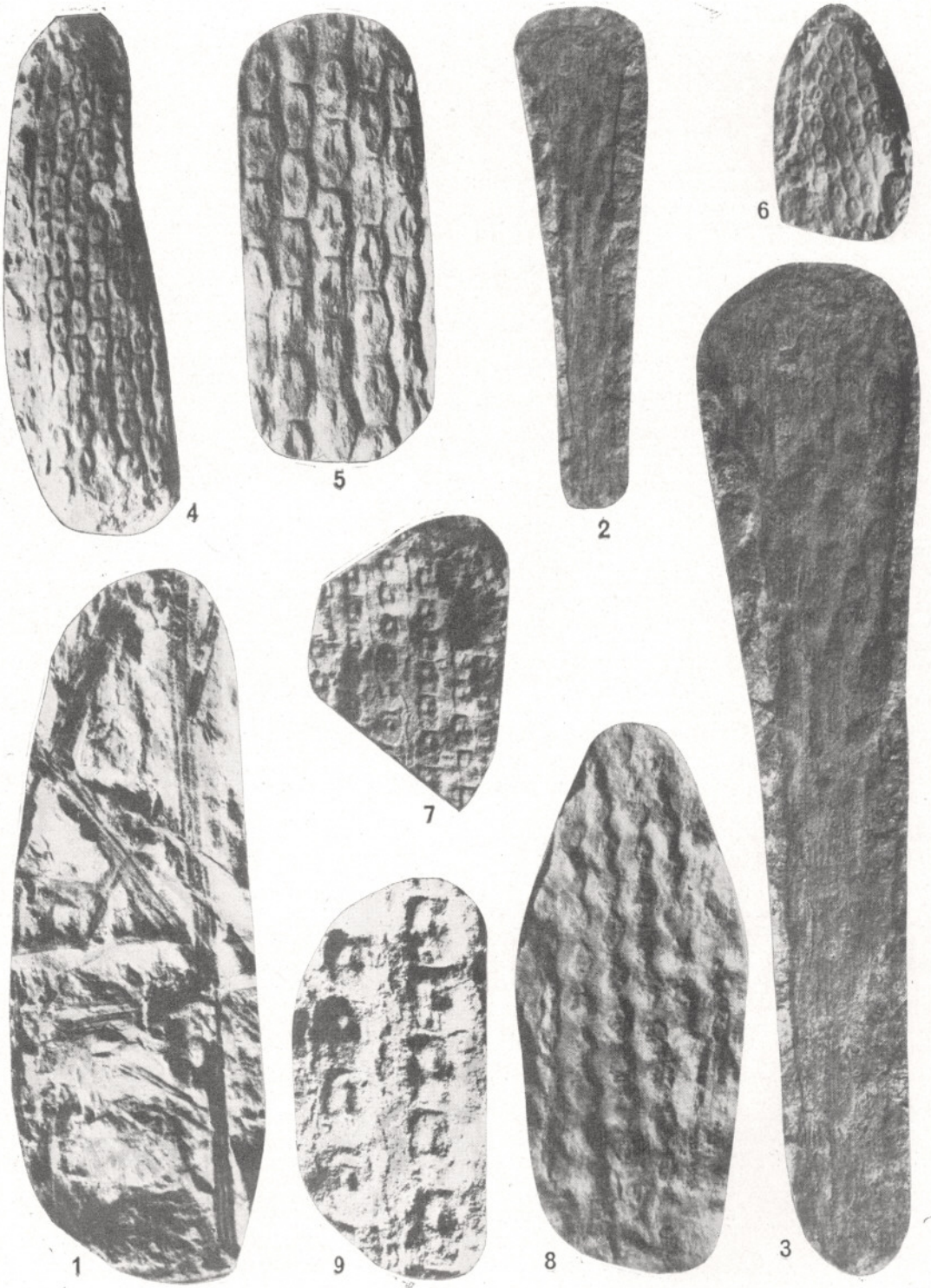
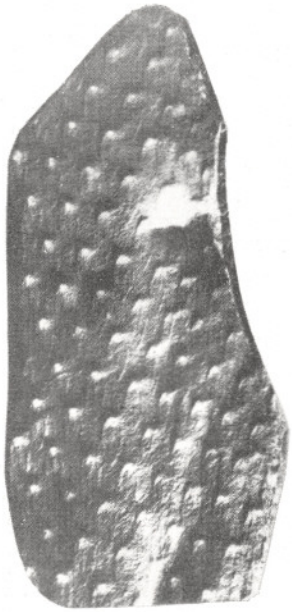


PLATE 1



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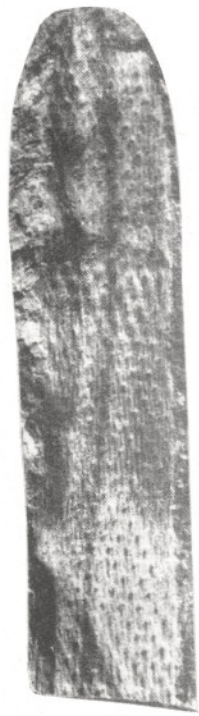

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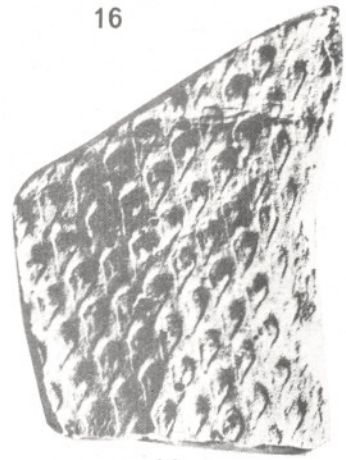

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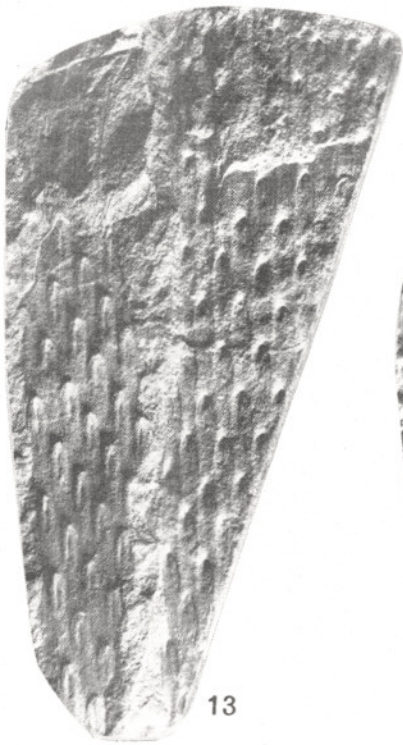

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PLATE 2

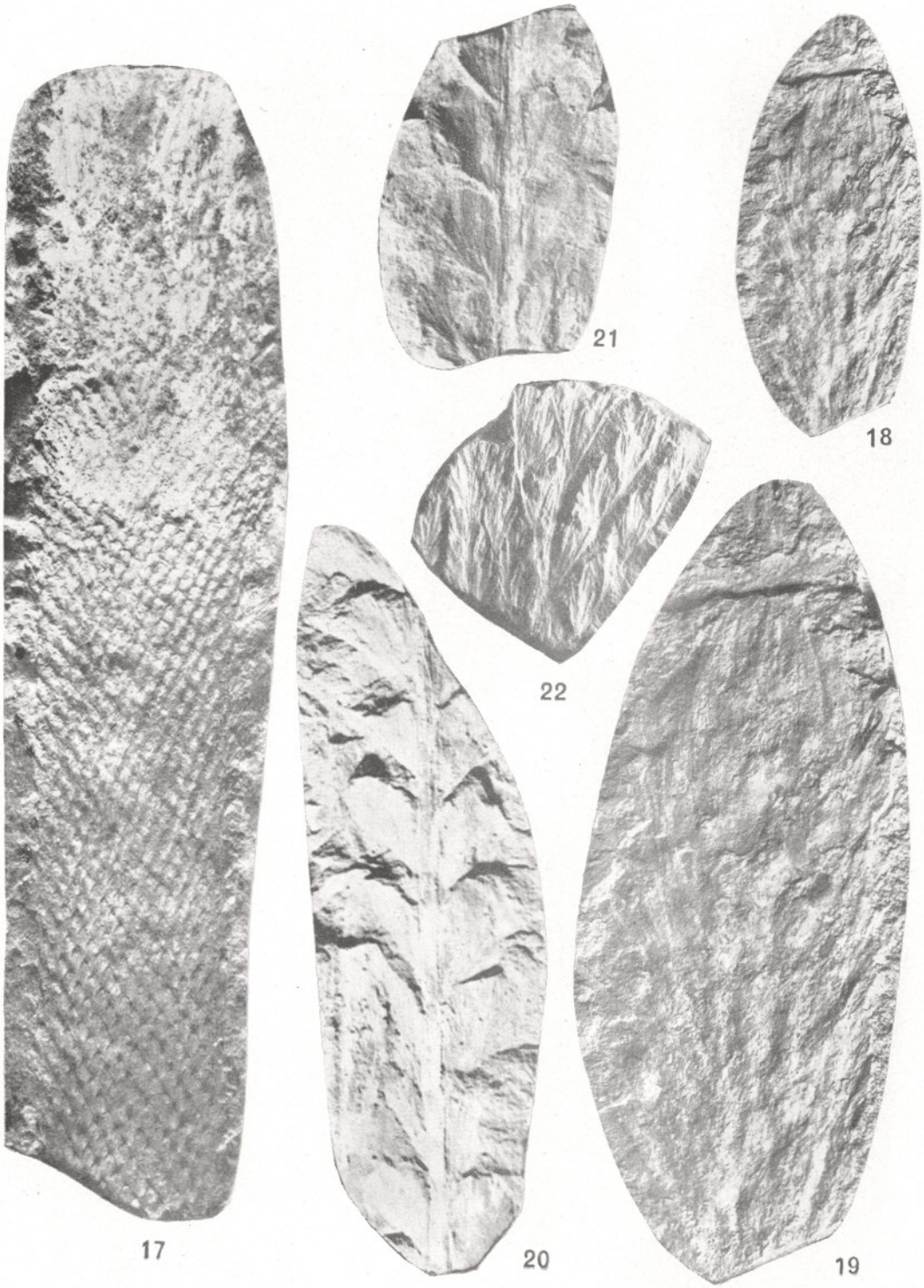

PLATE 3

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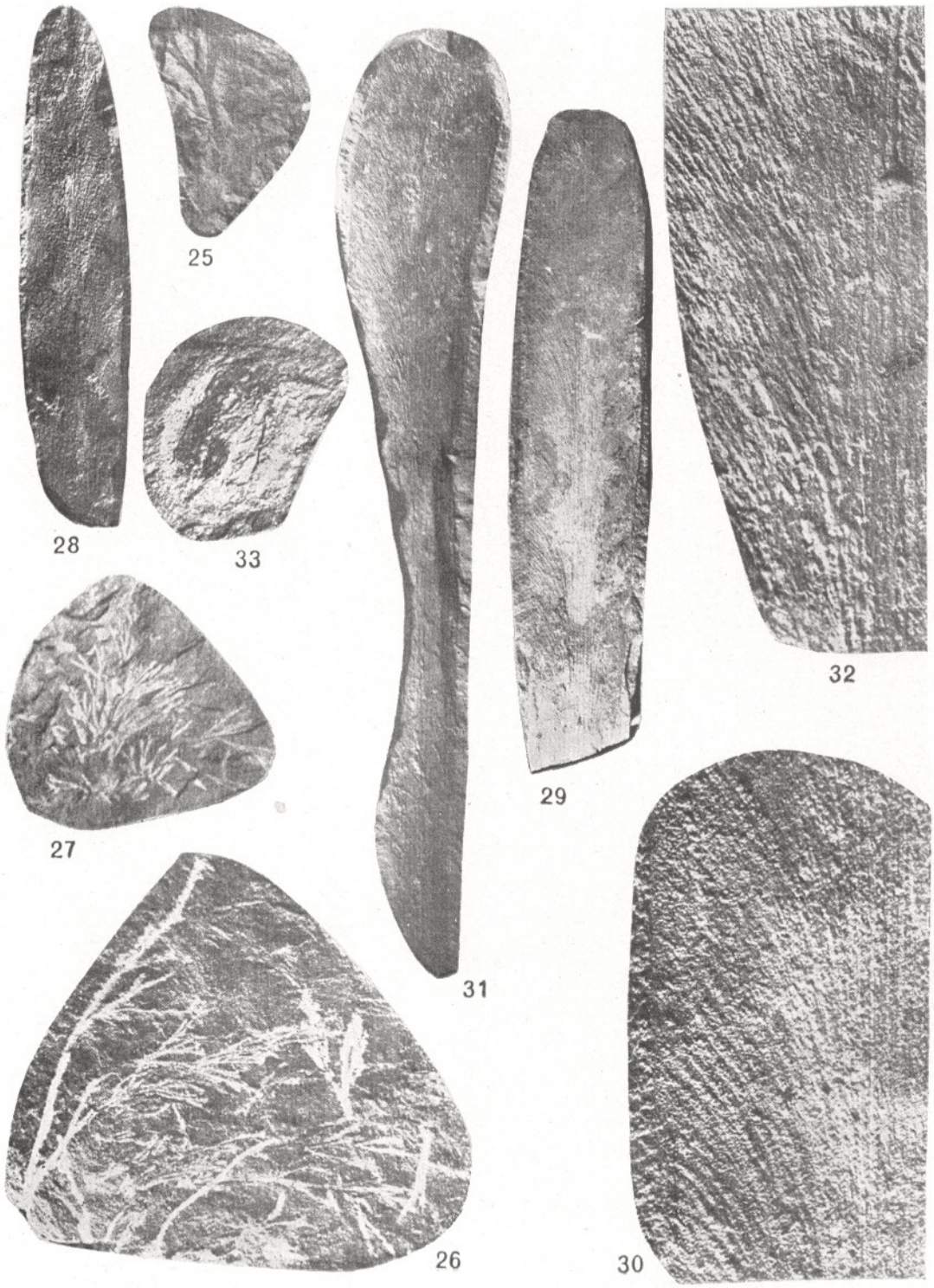
PLATE 4



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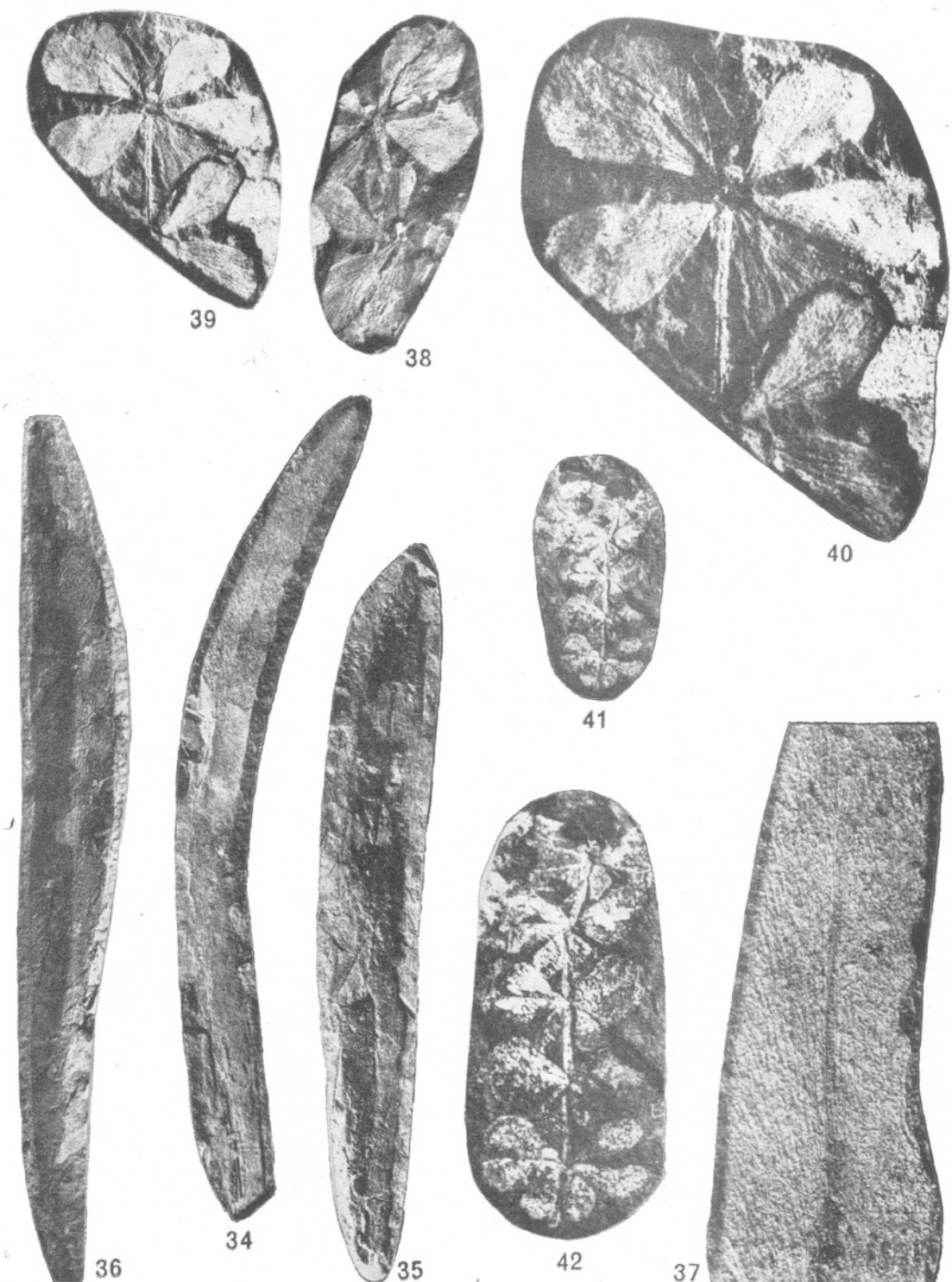

PLATE 6

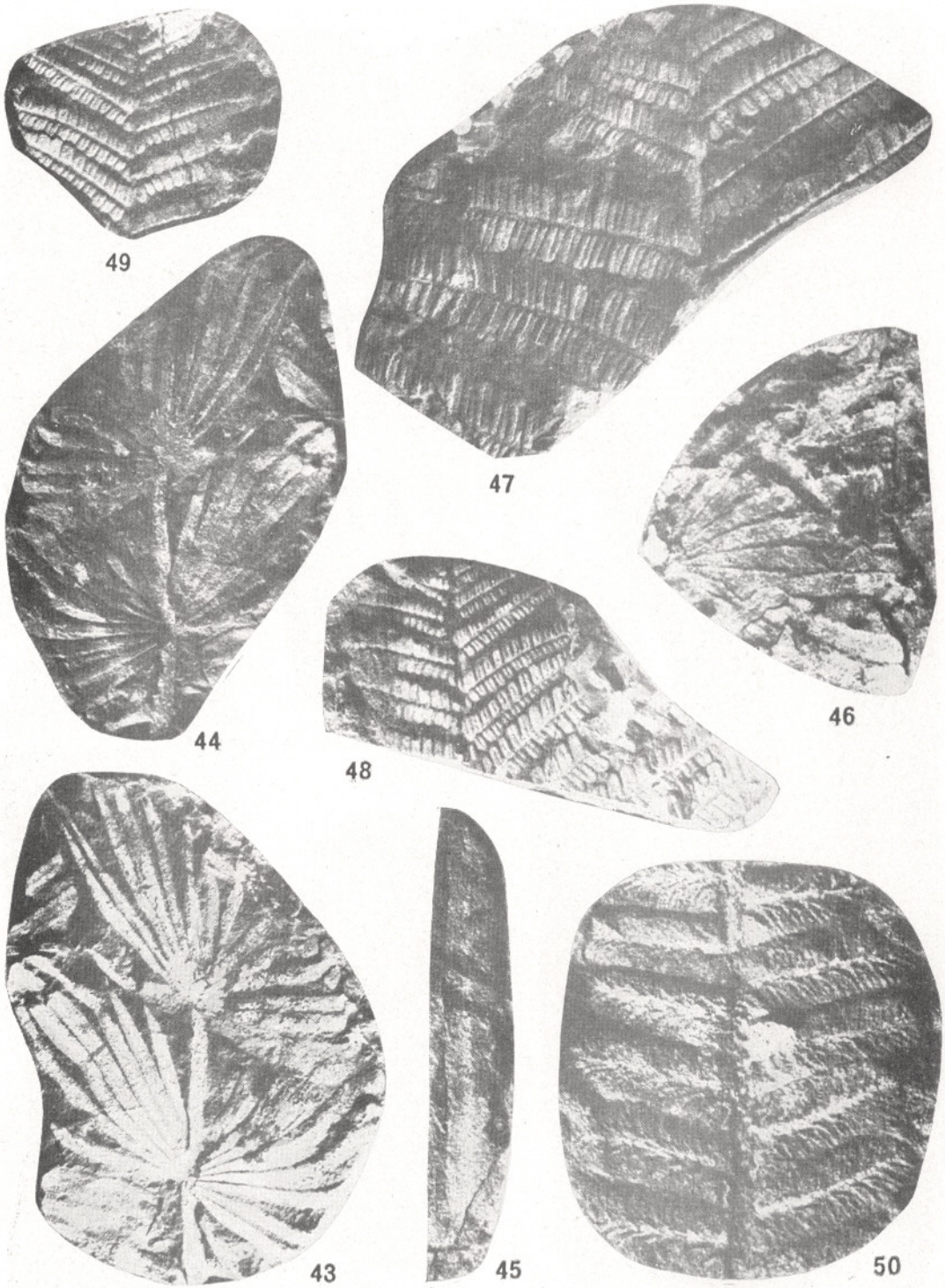

PLATE 7

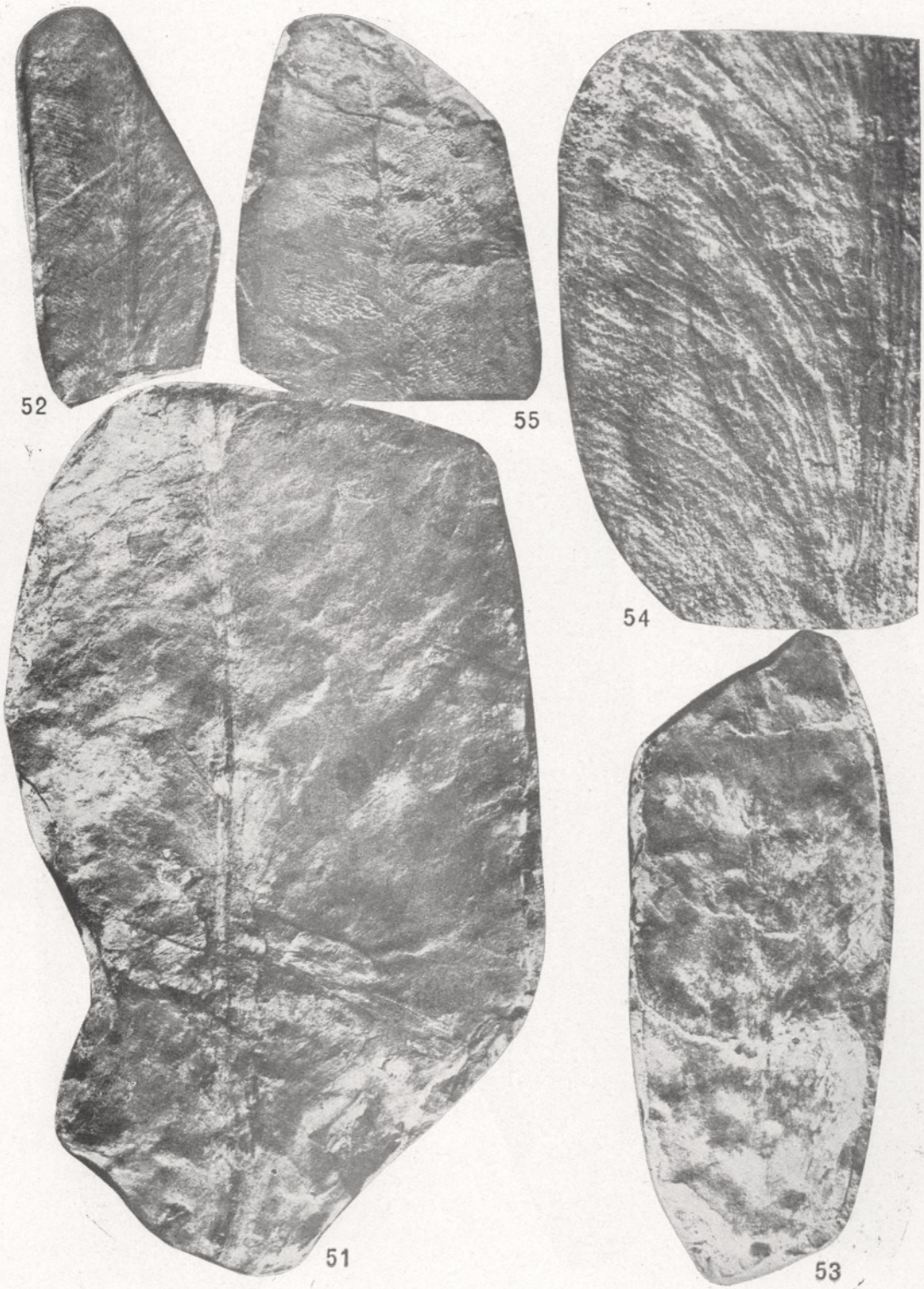

PLATE 8

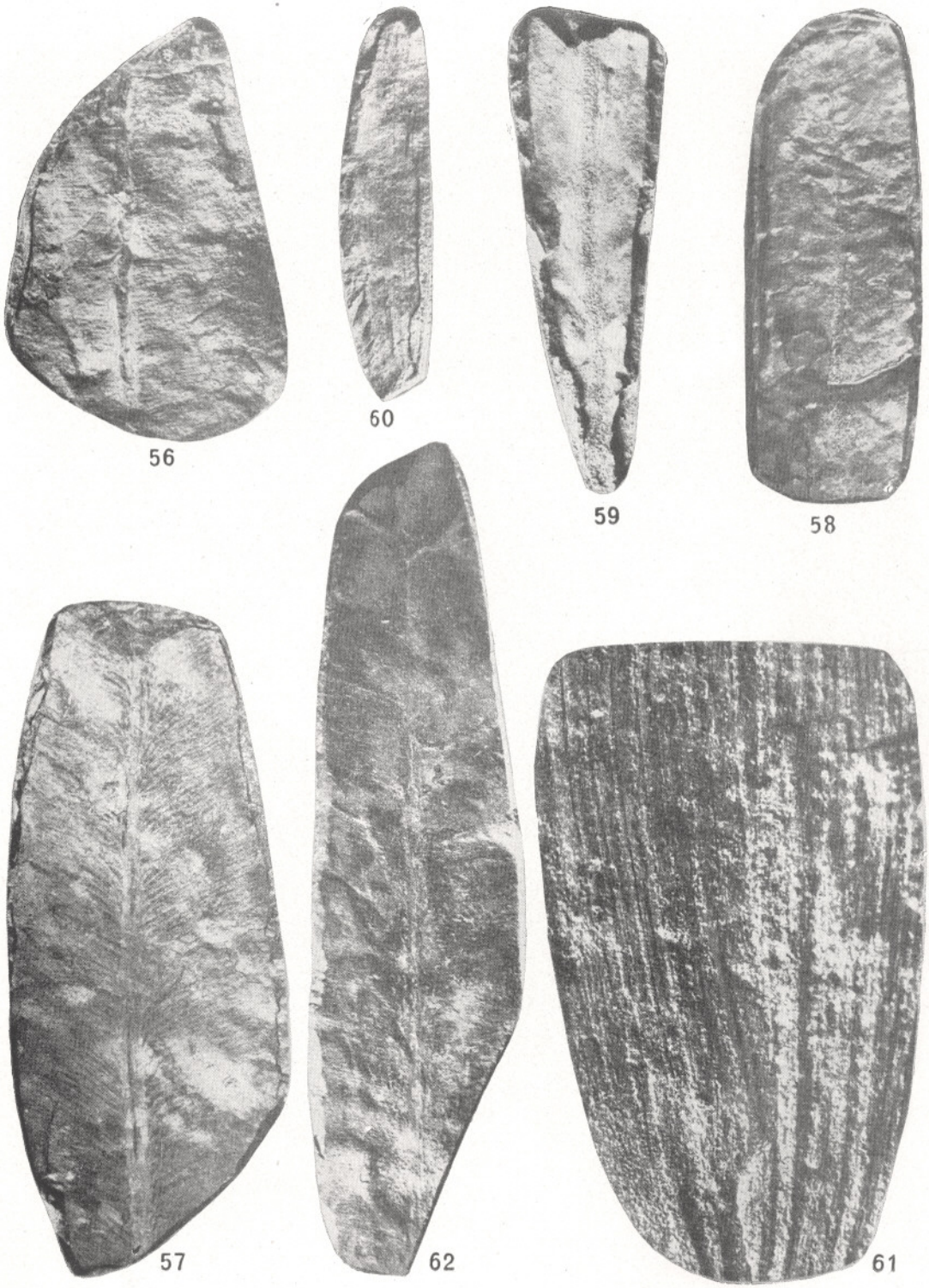

PLATE 9