

On some plant fossils from Gondwana equivalent sediments of Eastern Himalaya

Trilochan Singh* & Usha Bajpai**

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The plant fossils reported here were recovered from Gondwana equivalent continental facies outcropping in Kameng District (Arunachal Pradesh), South Sikkim District (Sikkim) and Darjeeling District (West Bengal). The flora comprising equisetalean axes, *Phyllotheba* sp., *Glossopteris stenoneura* Feistmantel, *G. communis* Feistmantel, *G. sp. cf. G. leptoneura* Bunbury, *G. syaldiensis* Chandra & Surange, *G. formosa* Feistmantel and *Vertebraria indica* Royle resembles that of the Late Permian Raniganj Formation of peninsular India.

Key-words—Glossopteris Flora, Gondwana Supercontinent, Eastern Himalaya, Late Permian.

*Trilochan Singh, Wadia Institute of Himalayan Geology, Dehradun 248 001, India.

**Usha Bajpai, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.

सारांश

पूर्वी हिमालय के गोंडवाना समतुल्य अवसार्णों से कुछ पावप-अवशेष

त्रिलोचन सिंह एवं ऊषा बाजपेयी

दार्जिलिंग जनपद (पश्चिम बंगाल), दक्षिण सिक्किम जनपद (सिक्किम) एवं कामेंग जनपद (अरुणाचल प्रदेश) में गोंडवाना समतुल्य महाद्वीपीय संलक्षणी दृश्यांशों से प्राप्त पादपाश्र्मों का इस शोध-पत्र में वर्णन किया गया है। उपलब्ध वनस्पतिजात में इक्वीसिटेली अक्ष-फिल्लोथेबा जाति, ग्लोसोप्टेरिस स्टीनोन्युरा फाइस्टमन्टेल, ग्लोसो कम्म्युनिस फाइस्टमन्टेल, ग्लोसो जाति सजातीय ग्लोसो लेप्टोन्युरा बनबरी, ग्लोसो स्पालवियेन्सिस चन्द्रा व सुरंगे, ग्लोसो फॉर्मोसा फाइस्टमन्टेल एवं वर्टीब्रेरिया इन्डिका रॉयल नामक पादपाश्र्म सम्मिलित हैं तथा यह प्रायद्वीपीय भारत के अन्ततम रानीगंज शैल-समूह से अनुरूपता प्रदर्शित करता है।

OCCURRENCE of *Glossopteris* leaves in the Permian sediments of Arunachal Himalaya was first reported by Jacob and Banerjee (1954), though plant fossils of Gondwana affinity were recorded much earlier from the Darjeeling—Sikkim Himalaya (Hooker, 1854; Mallet, 1874). Though a number of workers has also subsequently recorded plant fossils, yet no systematic description has been attempted so far.

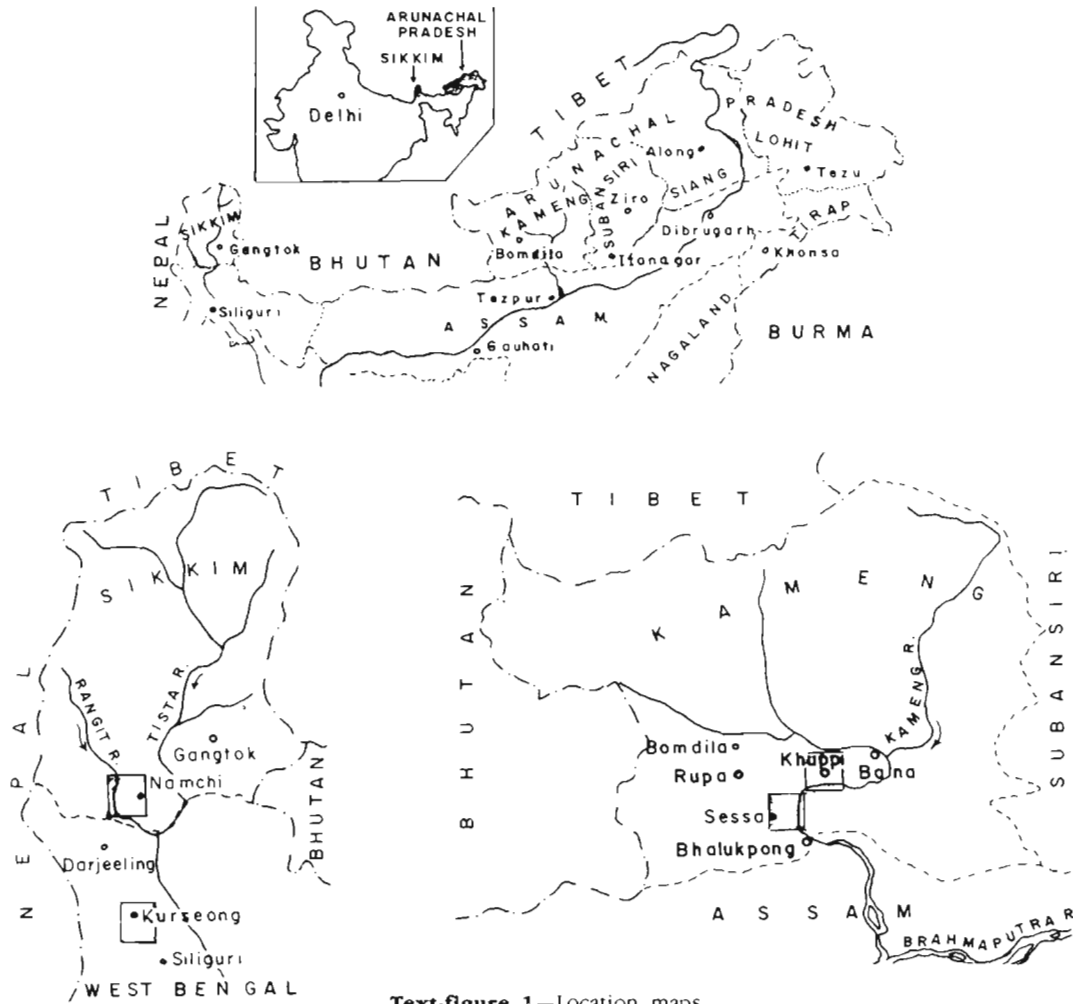
The plant fossils investigated by us were collected from three widely separated localities in the Eastern Himalaya, that is, Kameng District in Arunachal Pradesh, South Sikkim District in Sikkim and Tindharia in Darjeeling District, West Bengal (Text-fig. 1).

The plant-bearing rocks form a part of Gondwana equivalent sediments, which are tectonically disposed in a linear and narrow belt except in the Sikkim Himalaya where these are

exposed in a tectonic window. These rocks occur in the frontal part of the foot-hills, trending east-west on a regional scale, are thrust over the Siwalik Group of sediments, and are in turn thrust over by the sedimentaries of Miri (= Buxa) Group or by the metamorphic rocks of Bomdila (= Daling) Group. The Gondwana equivalent sediments of Eastern Himalaya exhibit continental, marginal marine (coastal), and glacio-marine facies (Singh, MS). However, present interest lies in the sediments of continental facies.

GEOLOGICAL OUTLINE

A brief geological outline of the three areas from where plant fossils have been collected by one of us (TS) is given below:

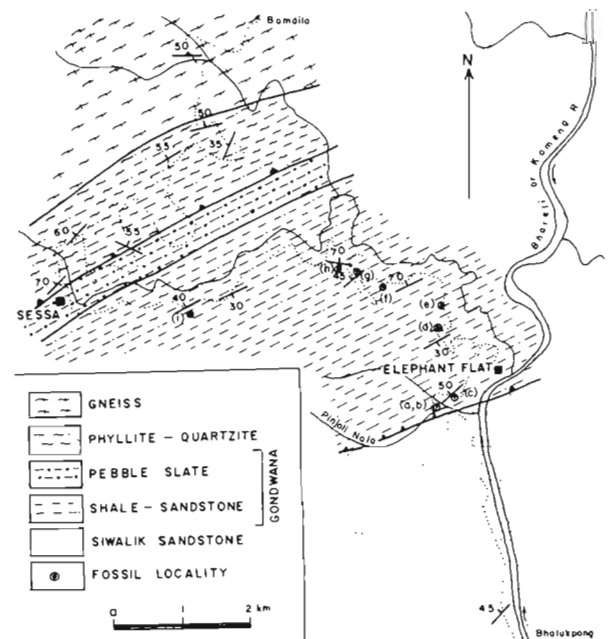


Text-figure 1—Location maps.

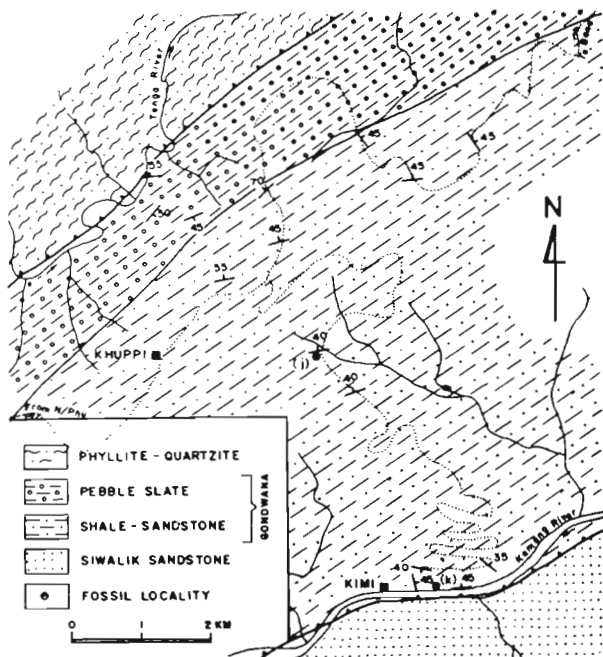
Kameng District (Arunachal Pradesh)

Gondwana equivalent sediments are exposed all along the frontal margin of the foot-hill bounded by the Siwalik sediments towards south by the thrust contact. Towards north, near Sessa in Bhalukpong-Sessa section, and near Khuppi Camp in Khuppi section, these sediments are overlain by the pebble-slate unit, the Rangit Formation. These are overlain by the Phyllite-Quartzite and Gneissic units of the Bomdila Group.

The fresh-water sediments (Bhareli Formation) comprise alternating beds of sandstone and slaty shales, with thin beds of coal in between. The sandstone is light-grey to bluish-grey in colour and is medium-to coarse-grained, sometimes gritty in nature. The sandstone is thinly laminated, often micaceous and contains carbonaceous matter and plant remains. The shales are mostly slaty in character, and sometimes contain pyrite specks. Sandy shales are also common. The carbonaceous shale and coal occur as lenses and/or persistent beds in between the sandstone and slaty shales.



Text-figure 2—Geological map of a part of Bhalukpong-Sessa-Bomdila road section, Kameng District.



Text-figure 3—Geological map of a part of N/Phu-Khuppi-Bana road section, Kameng District.

These rocks have suffered much disturbance and have been somewhat metamorphosed.

Plant fossils are fairly well distributed in the shaly horizons exposed from Pinjoli stream to Sessa on Bhalukpong-Sessa-Jamiri road section (Text-fig. 2); and from Kimi Power House to Khuppi Camp on N/Phu-Khuppi-Bana road section (Text-fig. 3). Collections have been made from a number of localities in this area, viz., (i) At the Pinjoli Stream II : (a) just at the bridge, and (b) about 50 m downstream; (ii) Pinjoli-Sessa road : (a) nearly 100-m before 51 kmst, (b) at about 53.5 kmst, (c) at 54 kmst, (d) about 55.5 kmst and about 100 m before 56 kmst, (e) about 56.5 kmst, (f) about 58 kmst, and (g) about 62.5 kmst; (iii) Khuppi section : (a) nearly 10 km from Khuppi Camp on Khuppi-Kimi Power House road section, after crossing a major stream, and (b) just at the top of the river bed, on way from Kimi Power House towards Kameng River.

Rangit Valley (Sikkim)

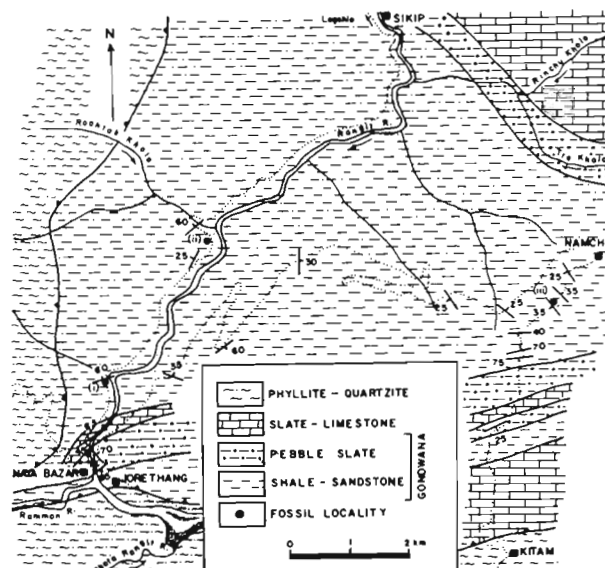
Gondwana equivalent sediments are exposed in a tectonic window, wherein these sediments are

covered by the older rocks, viz., Buxa and Daling Group of rocks (Text-fig. 4). Fresh-water rocks are exposed in Naya Bazar-Legship, Naya Bazar-Namchi and Namchi-Kitam road sections. These comprise sandstones with inter-beds of carbonaceous shales, slaty shales and coal. The sandstones are fine- to coarse-grained to gritty, dark-grey to bluish-grey in colour, hard and well-bedded, occasionally quartzitic in nature. The slaty shales often contain plant impressions. Coal, that grades from semi-anthracitic to graphitic, occurs as thin beds and/or lenses in between shales and sandstone.

Plant fossils have been collected from two localities on Naya Bazar-Legship road section: (i) about 2 km from Naya Bazar bridge just at the road turn towards the Nala, and (ii) just at the road bend to Roaktak Khola. The third locality falls on Namchi-Kitam road section, about 1.75 km from Namchi. However, the preservation is very poor at this locality and is also not rich in fossils.

Darjeeling (West Bengal)

Gondwana equivalent sediments comprising glacio-marine and continental facies have been



Text-figure 4—Geological map of a part of Rangit window, South Sikkim District.

PLATE 1

1. *Glossopteris syaldiensis* Chandra & Surange, specimen no. BSIP 36517, × 1
2. *Glossopteris* sp. cf. *G. leptoneura* Bunbury, specimen no. BSIP 36518, × 1.
3. *Phyllotheba* sp.; a group of linear leaves, specimen no. BSIP 36519, × 1.
4. *G. stenoneura* Feistmantel; details of venation pattern from specimen no. BSIP 36520, × 1.5.

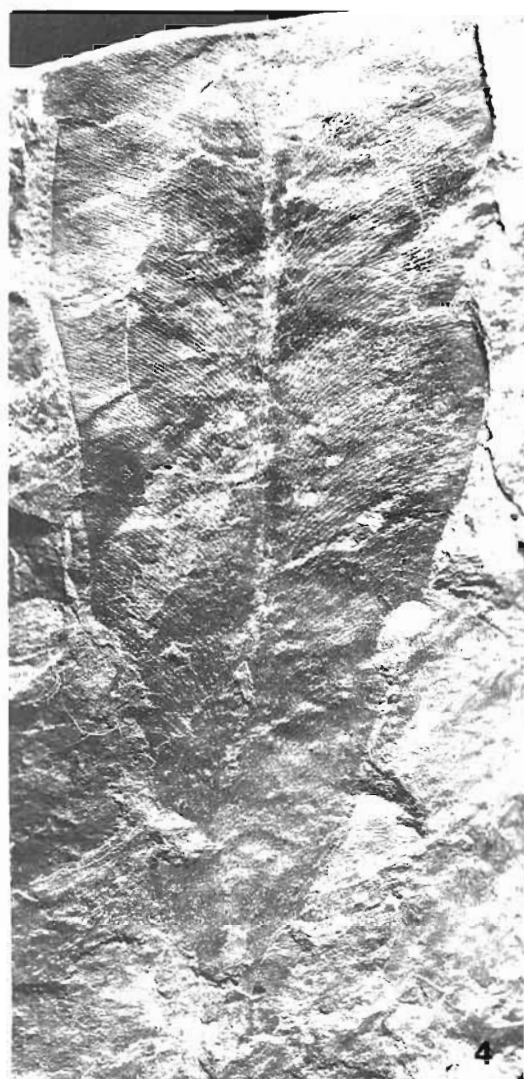
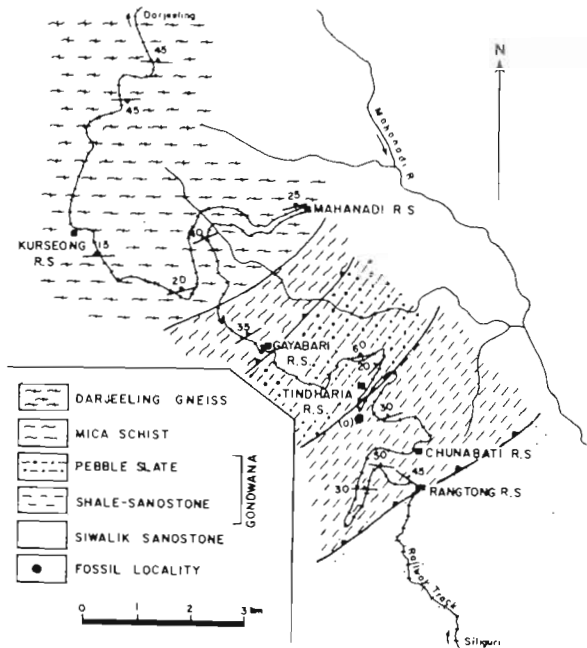


PLATE 1



Text-figure 5—Geological map of a part of Siliguri Tindharia-Darjeeling road section, Darjeeling District.

studied around Tindharia on Siliguri-Darjeeling road (Text-fig. 5).

The sediments are thrust over the Siwalik sediments, which in turn are overlain by the older metasediments, mainly phyllites, schists and quartzites. The sediments of continental facies are represented by sandstones, shales and quartzites with a few limestone bands interbedded. The sandstones and shales are coal-bearing. The sandstones are fine- to medium-grained, micaceous and feldspathic at places, and are bluish-grey and/or brownish in colour. The shale intercalations are splintery and occasionally resemble slate. The shales often yield well-preserved plant fossils. The carbonaceous shales are metamorphosed to graphite schist near the thrust contact. The coal in the Tindharia area is more or less powdery.

Plant fossils have been collected from a locality just at the start of the foot-track to Inspection Bungalow, Tindharia, from the main road opposite Assistant Mechanical Engineer's Bungalow.

DESCRIPTION

Equisetalean axes
Pl. 2, figs 4, 5

Description.—Axes are unbranched, articulate, with 12-14 longitudinal ridges and furrows at each internode. Ridges of adjacent internodes are continuous. The axes are 4-7 cm long and 1-1.4 cm wide. No attached leaf-sheath is seen.

Occurrence.—Specimen no. BSIP 36519 from a locality about 2 km from Naya Bazar bridge on Naya Bazar-Legship road section in South Sikkim District; and specimen no. BSIP 36522 from the locality on Khuppi-Kimi road section in Kameng District.

Phyllothea sp.
Pl. 1, fig. 3

Description.—A group of several, 20-35 mm long, linear leaves, each with a mid-vein, is assigned to this genus. No axis or leaf sheath is seen. It is possible that the equisetalean axes described above bore these leaves.

Comparison.—The leaves are reminiscent of those of *Phyllothea griesbachii* Zeiller 1902.

Occurrence.—Specimen no. BSIP 36519 from a locality about 2 km from Naya Bazar bridge on Naya Bazar-Legship road section in South Sikkim District.

Glossopteris stenoneura Feistmantel 1881
Pl. 1, fig. 4; Pl. 2, fig. 1

Description.—The specimen is incomplete; only the basal part is preserved. It is presumed that the leaf was simple, spatulate in shape, broadest near the middle region and gradually narrowing towards the base. The preserved length and maximum width of the leaf are 8 cm and 4 cm, respectively. The midrib is distinct, 2 mm wide and is present throughout the preserved length. At places the midrib shows a few strands paralleling its course. The veins leave the midrib at narrow angles, which become 20°-25° within a millimeter distance, gradually arch out to dichotomise once or twice. The concentration of veins near the midrib is 35 per cm and 40 per cm near the margin. The veins show rather scarce anastomosing and form very long and narrow meshes of uniform size. No cuticle could be recovered.

Comparison.—The leaf resembles those of *Glossopteris communis* Feistmantel, *G. raniganjensis* Chandra & Surange, *G. syaldiensis* Chandra & Surange and *G. stenoneura* Feistmantel in having a distinct midrib, similar angle of emergence of veins and elongate narrow meshes. However, *G. communis*, *G. raniganjensis* and *G. syaldiensis* differ in leaf shape; only *G. stenoneura* shows a definite resemblance (Feistmantel, 1881, p. 99, pl. 32, fig. 3; pl. 33, fig. 1, pl. 38, fig. 5, Banerji, Maheshwari & Bose, 1976, pl. 2, fig. 1; pl. 2, figs 16-18; text-fig. 3 A-D)

Occurrence.—Specimen no. BSIP 36520 from a locality near Kimi Power House in Kameng District.

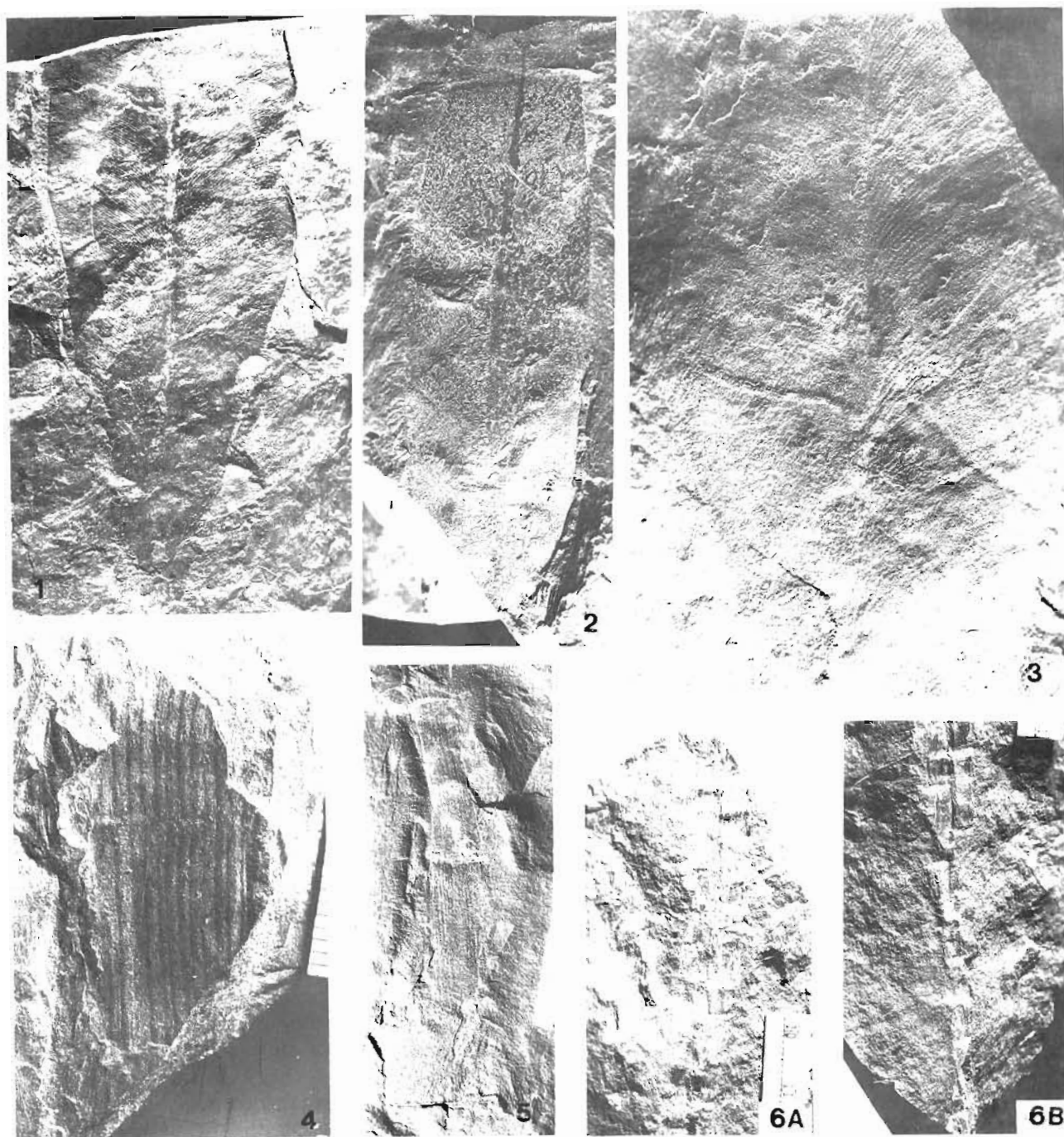


PLATE 2

1. *Glossopteris stenoneura* Feistmantel, specimen no. BSIP 36520, $\times 1$
2. *Glossopteris formosa* Feistmantel, specimen no. BSIP 36521, $\times 1$.
3. *Glossopteris communis* Feistmantel, specimen no. BSIP 36520, $\times 2$
4. Equisetalean axis showing one clear node, specimen no. BSIP 36522, $\times 2.5$
5. An equisetalean axis, specimen no. BSIP 36519, $\times 1$
6. *Vertebraria indica* Royle, specimen no. BSIP 36523, $\times 1$, illustrated in two parts A and B

Glossopteris communis Feistmantel 1876
Pl. 2, fig. 3

Description—The preserved length and maximum width of the leaves are 9-11 cm and 6-6.5 cm, respectively. The midrib is distinct and is 5 mm wide in the lower and 3 mm wide in the upper regions. At places it shows a number of strands running parallel to it. The veins leave the midrib at acute angles (15°-20°) and after dichotomising and anastomosing 2-3 times form long, elongate and narrow meshes of more or less uniform size. The number of dichotomies is more near the midrib than away from it.

Comparison—In shape and venation the leaves compare with those of *Glossopteris communis* (Feistmantel, 1881, pl. 26, figs 1, 4, pl. 27, fig. 1; pl. 36, figs 1, 2).

Occurrence—Specimen no. BSIP 36520 from the locality near Kimi Power House in Kameng District, 10 km from Khuppi on Khuppi-Kimi road section after crossing a stream, in Kameng District.

Glossopteris sp. cf. *G. leptoneura* Bunbury, 1861
Pl. 1, fig. 2

Description—Five leaves have been referred to this species on the basis of external morphology. All the specimens are incomplete. The leaves are simple, linear-lanceolate with acute apices and a gradually tapering base. The petiole is not seen. The preserved length and maximum width of the leaves are 8.5-18 × 1.5-3.5 cm, respectively. The midrib is distinct, persists right up to the apex and measures 1-2 mm in width. The secondary veins are not well-preserved and are faintly seen, that, too only at few places. The veins emerge at narrow angles and after dichotomising a few times meet the margins at oblique angles. The meshes are narrow, polygonoid. The concentration of veins could not be ascertained.

Comparison—In overall shape and venation pattern the leaves compare with *Glossopteris leptoneura* Bunbury (1861, pp. 330-331, pl. 9, figs 1-4).

Occurrence—Specimen no. BSIP 36518 from a locality about 2 km from Naya Bazar bridge on Naya Bazar-Legship road section in South Sikkim District.

Glossopteris syaldiensis Chandra & Surange 1979
Pl. 1, fig. 1

Description—The species is represented by one specimen, both in part and counterpart. The leaf is more or less complete but is without any carbonified crust. The leaf is simple and lanceolate/spatulate in shape, with an acute apex and basal portion

gradually tapering into a broad base. The leaf is 17.5 cm long and 4 cm at the widest part which is about 2/3 length from the base. The midrib is broad but flat and persistent up to the apex. The secondary venation is indistinct, but comprises long, narrow meshes.

Comparison—The venation of the leaf is of *Glossopteris communis* type. However, in overall shape it resembles *G. syaldiensis* (Chandra & Surange, 1979, pl. 2, fig. 1; pl. 15, fig. 5; pl. 43, fig. 4).

Occurrence—Specimen no. BSIP 36517 from a locality about 2 km from Naya Bazar bridge on Naya Bazar-Legship road section in South Sikkim District.

Glossopteris formosa Feistmantel 1881
Pl. 2, fig. 2

Description—Incomplete specimen measuring 8 cm in length and 3 cm in width, linear in shape. Venation open, meshes longish—polygonal, of almost equal size throughout.

Occurrence—Specimen no. BSIP 36521 from Tindharia in Darjeeling District.

Vertebraria indica Royle 1839
Pl. 2, fig. 6a, b

Description—The axis is 12.7 cm long and 8 mm broad, and shows rectangular blocks, arranged one on the other in longitudinal direction.

Occurrence—Specimen no. BSIP 36523 from a locality about 2 km from Naya Bazar bridge on Naya Bazar-Legship road section in South Sikkim District.

DISCUSSION

The plant megafossil assemblage reported herein is meagre for a meaningful age determination. *Glossopteris leptoneura* and *G. syaldiensis* have so far not been reported from sediments older than the Raniganj Formation. The presence of a species comparable with *Phyllothea griesbachii* also points to a Raniganj equivalent age. More material needs to be investigated for arriving at the age or stratigraphical position of these beds. However, evidence supporting a Raniganj equivalent age is also provided by Misra *et al.* (1987) on the basis of vitrinite/inertinite (V/I) ratio pattern of the coal together with typical dominance of vitrinite maceral over inertinite and the rarity or absence of fusinized resins. Our contention is also corroborated by the palynofossil assemblages from the underlying Permian sediments from which assemblages resembling those of the Talchir and Barakar

formations of peninsular India have been recorded (Srivastava *et al.*, 1987).

The association of glaciogenic diamictites with sediments bearing Early Permian marine fauna, and elements of the *Glossopteris* Flora is significant for correlating these sediments with the sequences of peninsular India and the Tibetan Autonomous Region.

The Permian sediments of Eastern Himalaya have a depositional history different from that of peninsular India (Srivastava *et al.*, 1987). Even the coals associated with Permian sediments of Kameng District have petrographical and chemical properties different from peninsular Permian coal (Misra *et al.*, 1987). On the other hand, the Permian sequences of Eastern Himalaya show resemblance to those of Tibetan Block.

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