

Palaeobotanical investigation of Permian sediments of Darjeeling area, north-east Himalaya, India

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Permian sediments exposed in Kalijhora, Raktikhola and Bamonpokharia areas of Darjeeling district, West Bengal have yielded a well preserved mio- and megafloral assemblages. The miospores are represented by the species of *Parasaccites*, *Striatopodocarpites*, *Faunipollenites*, *Crescentipollenites*, *Alisporites*, *Densipollenites*, *Cuneatisporites*, *Scheuringipollenites*, *Paravesicaspora*, *Ibisporites*, *Striatites*, *Chordasporites*, *Rhizomaspora*, *Inaperturopollenites*, *Microfoveolatispora* and ? *Botryococcus* colony. The fragmentary leaf specimens of *Glossopteris* spp. and a number of horizontally and vertically preserved *Vertebraria*-axes comprise the megaplant fossils record from Kalijhora stream section. The mioflora is comparable with the assemblage of Raniganj Formation of peninsular Gondwana.

Key-words-Palynology, Megafossils, *In-situ* *Vertebraria*, Permian, Darjeeling.

INTRODUCTION

THE Permian sediments occur in northeastern Himalaya in a narrow belt, north of Tertiary in thrust contact. Coal bearing horizons of Darjeeling have drawn attention of many geologists but palaeobotanical records are rare due to nonavailability of well preserved mega- and microfossils. Ghosh (1973, 1983) described miospores from Tindharia and Rontong areas and discussed their possible correlation and affinity with Gondwana palynoassemblages. Plant megafossils are mainly known from Tindharia section (Acharyya *et al.*, 1975, 1979; Singh & Bajpai 1990). The present paper, for the first time, records the mega- and miospores from Kalijhora stream section and miospores from Raktikhola and Bamonpokharia areas of Darjeeling district, West Bengal.

Geology

The general trend of Permian rocks of Darjeeling is NE-SW. The lithounits in Himalayan foothills close to plain begin with upper Tertiary followed by narrow belt of Permian sequence. The contact between Permian and Tertiary rocks is termed as Main Boundary Fault (MBF). The Permian sequence is characterized by coarse to medium grained sandstone, coarse gritty sandstone, carbonaceous shale and crushed powdery high rank coal seams. The sequence, north of Permian is characterized by metamorphic rocks belonging to Miri/Daling-Darjeeling group of

Precambrian age (Acharyya, 1975, 1976).

Geology of Darjeeling area has recently been carried out by Mukul (2000) around Kalijhora stream where Gondwana group of rocks in the north are thrust over the younger Siwalik (Miocene-Chunabati Formation). The MBT is exposed on the northern and southern banks of Kalijhora stream. Coarse grain Gondwana sandstone is present in the hanging wall of the MBT while bracciated and fractured Gondwana sandstone, shale and coal sequence is partly exposed in fault zone. Gondwana sandstone dips towards the south-east. Similarly in Bamonpokharia and Raktikhola, Gondwana sequence comprises of carbonaceous shale, coal seams and sandstone. The contact of these sections is not clear due to overburden. A diamictite bed has been located in the Bamonpokharia Reserve Forest section. Mukul (2000) has proposed a generalized stratigraphy of Darjeeling Frontal Himalaya (Table 1).

MATERIAL AND METHOD

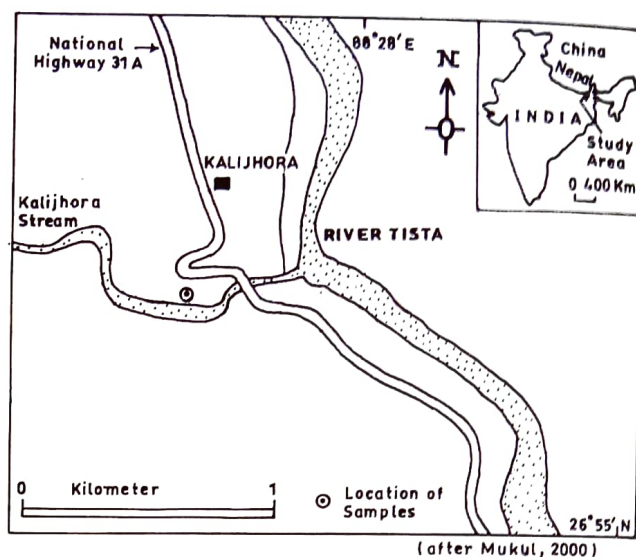
Kalijhora town is situated on NH-31A in Darjeeling district and Kalijhora stream is about 10 km from Siliguri (26° 56' 07' N : 88° 27' 10' E). A small exposure has been observed in road section in Bamonpokharia Reserve Forest. Raktikhola stream is situated, about 2 km north of Bamonpokharia Reserve Forest section. The samples for palaeobotanical

Table 1. Tectonostratigraphic setup in the Frontal Darjeeling and Sikkim Himalayas (after Mukul 2000)

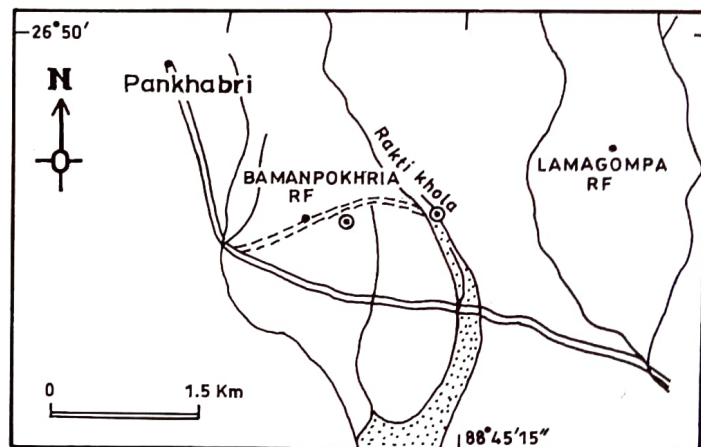
Age	Stratigraphic Unit	Name	
Cenozoic	Micone/ Pliocene	Upper Siwalik (400-500 m)	Murti Boulder bed, Prabu Grit,
		Middle Siwalik (800- 1250 m)	Geabdat Sandstone, Chunabati Formation
	Lower Siwalik (200-500m)	Gondwana Group	Damuda Subgroup, Ranjit Pebble Slate (Talchir?), Buxa Formation
			Reyang Formation, Garubathan Daling Fm.
Palaeozoic	Upper Permian/ Lower Permian		
Precambrian	Daling		

analysis have been collected from different sections of Kalijhora stream, Bamonpokharia and Raktikhola (Maps 1, 2). The lithocolumn of each section is shown in Text-fig.1 indicating the rock sequence and the relative position of productive samples (marked as *). The sample details are documented in Table-2.

Recovery of spores and pollen from Permian sediments of Darjeeling is rare and random due to tectonic activity in the region. Controlled maceration technique has helped in the recovery of spores and pollen. The samples were treated with conc. HNO_3 for 15 days or more and after washing with water, samples were treated 3-4 times with KOH (5%) solution. After repeated washing slides were prepared in polyvenyl alcohol and mounted in canada balsam. The megafossils were collected from Kalijhora stream section (Map 1). The fossils are preserved as impression in carbonaceous shales. All the type slides and figured specimens are preserved in the museum of Birbal Sahni Institute of Palaeobotany, Lucknow.



Map 1. Showing the location of samples of Kalijhora stream



Map 2. Showing the location of samples of Bamonpokharia and Raktikhola.

Palynological composition

The spore and pollen assemblages are not rich in variety and number, however, they are well preserved and stratigraphically significant.

PLATE 1

(Figures are magnified X550.)

- Microfoveolatispora* sp. B.S.I.P. Sl. no. 12902 (H 13);
- Striatopodocarpites brevis* B.S.I.P. Sl. no. 12903 (N32/3);
- Alisporites* sp. B.S.I.P. Sl. no. 12904 (X13/2);
- Striatites tectus* B.S.I.P. Sl. no. 12905 (O10);
- Crescentipollenites fuscus* B.S.I.P. Sl. no.12905 (L40/3);
- Paravesicaspora indica* B.S.I.P. Sl. no. 12906 (S20/1);
- Distriatites bilateris* B.S.I.P. Sl. no. 12905 (Q10);
- Striatopodocarpites decorus* B.S.I.P. Sl. no. 12906 (J 27/4);
- Densipollenites invisus* B.S.I.P. Sl. no. 12907 (P23);
- Ibisporites* sp. B.S.I.P. Sl. no. 12905 (X41/2);
- Parasaccites obscurus* B.S.I.P. Sl. no. 12908(O20/4);
- Rhizomaspora indica* B.S.I.P. Sl. no. 12904 (V36/2);
- Botryococcus* colony B.S.I.P. Sl. no. 12905 (Q19);
- Scheuringipollenites barakarensis* B.S.I.P. Sl. no. 12902 (F16/3);
- Rhizomaspora indica* B.S.I.P. Sl. no. 12904 (P23/2);
- Chordasporites* sp. B.S.I.P. Sl. no. 12907 (V36
- Ibisporites* sp. B.S.I.P. Sl. no. 12904 (N16/3).

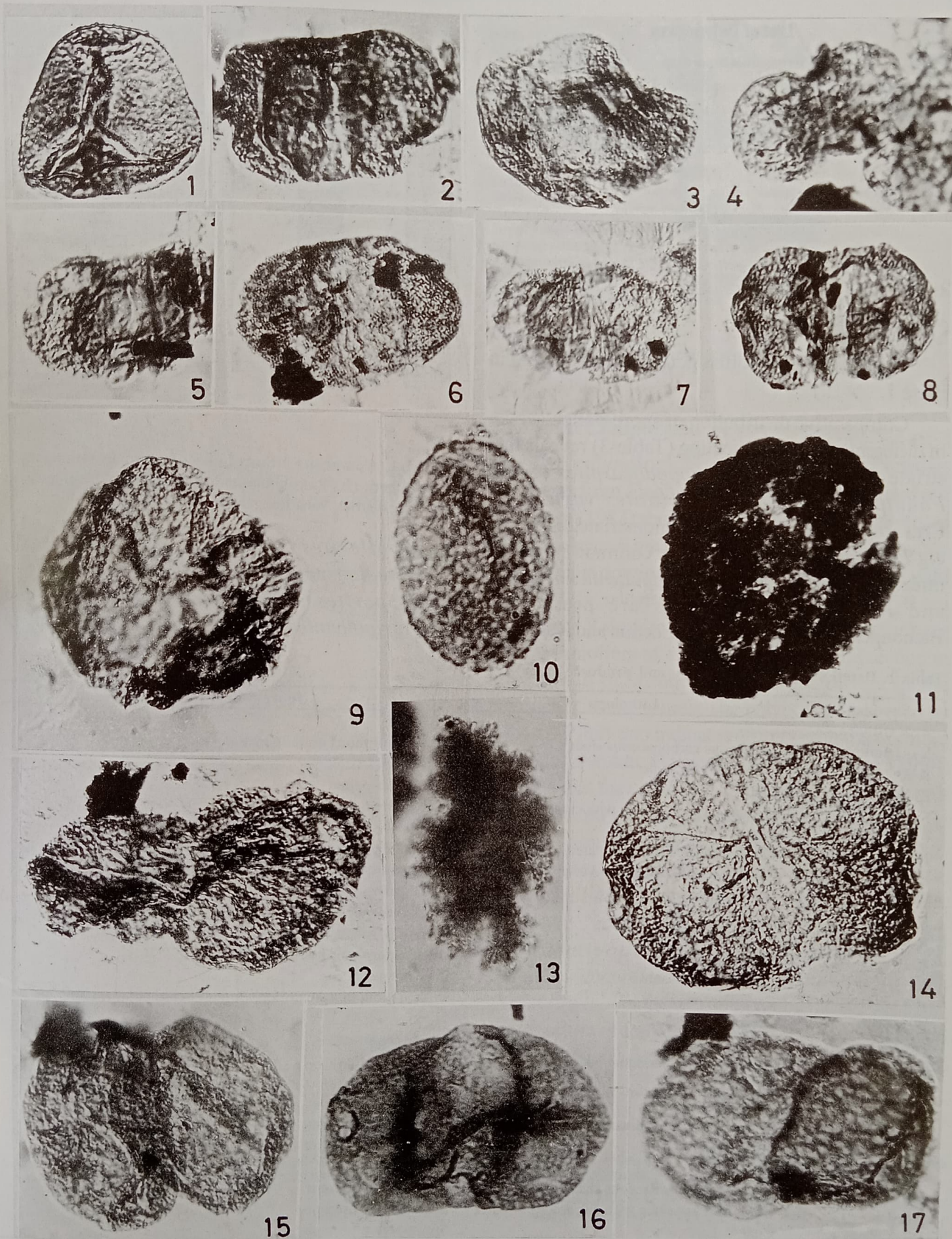


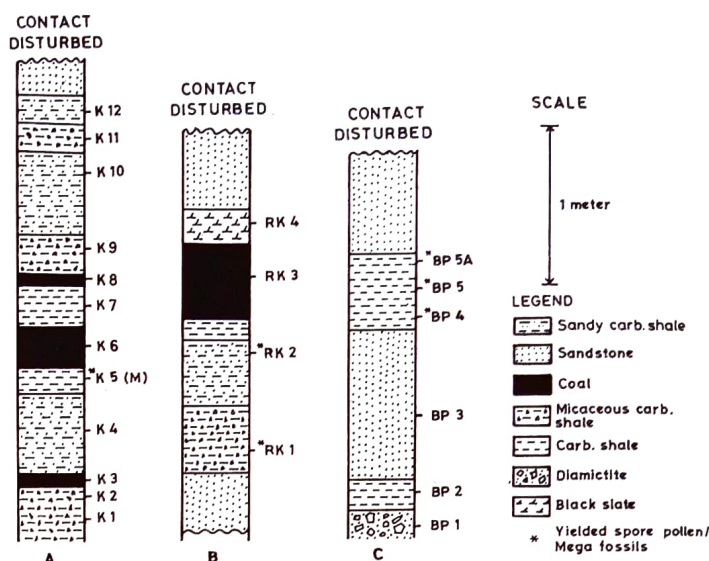
PLATE 1

List of Palynotaxa

Trilete	<i>Microfoveolatispora</i> sp.
Monosaccate	<i>Parasaccites obscurus</i> , <i>Densipollenites invisus</i>
Non-striate disaccate	<i>Scheuringipollenites maximus</i> , <i>S. barakarensis</i> , <i>Ibisporites</i> sp., <i>Alisporites</i> sp., <i>Cuneatisporites</i> sp., <i>Paravesicaspora indica</i> , <i>Rhizomaspora indica</i>
Striate disaccate	<i>Striatites varius</i> , <i>S. tectus</i> , <i>Crescentipollenites fuscus</i> , <i>Faunipollenites varius</i> , <i>Striatopodocarpites brevis</i> , <i>S. decorus</i> , <i>Distriatites bilateris</i> , <i>Inaperturopollenites</i> sp., <i>Chordasporites</i> sp.
Algal colony	<i>Botryococcus</i> colony
Acritarch	<i>Peroletes</i> sp.

Important spore-pollen genera are illustrated in Plate 1.

Comparative distribution of spore-pollen genera in different areas of Darjeeling (Table-3) reveals that striate disaccate e.g. *Striatopodocarpites brevis*, *Faunipollenites varius*, *Striatites varius* and *Crescentipollenites fuscus*, and nonstriate disaccate, e.g. *Paravesicaspora indica* are common in all the three sections whereas *Scheuringipollenites maximus* and *Parasaccites obscurus* are present in Bamonpokharia Reserve Forest Section and Kalijhora.



Text-fig. 1. Composite lithocolumn of Permian sediments in (A) Kalijhora (B) Raktikhola and (C) Bamonpokharia areas of Darjeeling district, West Bengal.

Densipollenites invisus, *Alisporites* sp., *Ticrofoveolatispora* sp., *Chordaspora* sp., *Peroletes* sp., *Ibisporites* sp., *Rhizomaspora indica* and *Schuringipollenites barakarensis* are present only in

Table 2. Detail of samples, lithology and productivity

Samples No.	Lithology	Spore-pollen content
A. Kalijhora		
K-1 (Bottom)	Micaceous carbonaceous shale	Black amorphous organic matter, rare <i>Botryococcus</i>
K-2	Carbonaceous shale	<i>Botryococcus</i> colony
K-3	Coal	Rare spore-pollen
K-4	Micaceous sandy shale with carbonaceous streak	Black carbonaceous matter
K-5.	Carbonaceous shale associated with coal	Spore-pollen present
K-6	Carbonaceous shale in coal seam	Black amorphous matter
K-7	Carbonaceous shale	Black amorphous matter
K-8	Coal	Black amorphous matter
K-9	Carbonaceous shale	Black amorphous matter
K-10	Shaly sandstone	Black amorphous matter
K-11	Carbonaceous shale	Rare <i>Botryococcus</i>
K-12 (Top)	Carbonaceous shale	Broken monosaccate pollen, <i>Botryococcus</i> colonies rare
B. Bamonpokharia Reserve Forest		
BP-1 (Bottom)	Quartz/Diamictite	No spore-pollen
BP-2	Just above the diamictite bed	No spore-pollen
BP-3	Sandstone	No spore-pollen
BP-4	Carbonaceous shale	Spore-pollen present
BP-5	Micaceous carbonaceous shale	Spore-pollen present
BP-5a (Top)	Carbonaceous shale	Spore-pollen present
C. Raktikhola		
RK-1 (Bottom)	Micaceous carbonaceous shale	Spore-pollen present
RK-2	Carbonaceous shale with calcareous nodules	Spore-pollen present
RK-3 (Top)	Coal	Spore-pollen present

Table 3. Comparative distribution of spore-pollen.

Name of spore-pollen	Bamonpokharia Reserve Forest	Raktikhola	Kalijhora Section
<i>Striatopodocarpites brevis</i>	+	+	+
<i>Faunipollenites varius</i>	+	+	+
<i>Cuneatisporites</i> sp.	+		
<i>Paravesicaspora indica</i>	+	+	+
<i>Striatites varius</i>	+	+	+
<i>Crescentipollenites fuscus</i>	+	+	+
<i>Ibisporites</i> sp.			+
<i>Alisporites</i> sp.			+
<i>Microfoveolatisporites</i> sp.			+
<i>Striatites tectus</i>	+		
<i>Scheuringipollenites maximus</i>		+	+
<i>S. barakarensis</i>			+
<i>Densipollenites invisus</i>			+
<i>Chordasporites</i> sp.			+
<i>Rhizomaspora indica</i>			+
<i>Peroletes</i> sp.			+
<i>Parasaccites obscurus</i>		+	+
<i>Inaperturopollenites</i> sp.			+
<i>Botryococcus</i> colony		+	+
<i>Distriatites bilateris</i>	+		

Kalijhora. Trilete spores are absent in Raktikhola and Bamonpokharia Reserve Forest sections while *Microfoveolatispora* sp. is present in Kalijhora section.

The assemblages recovered from Darjeeling district indicate dominance of *Faunipollenites* (16%) and *Striatopodocarpites* (15%). Non-striate genera are subdominant, *Scheuringipollenites* (6%) and *Crescentipollenitis* (10%) (Histogram-1). *Rhizomaspora*, *Chordasporites* and *Ibisporites* are frequently recorded in the assemblages. Other palynotaxa are rarely represented Algal colony *Botryococcus* is present in Bamonpokharia and Kalijhora sections.

Name of Genera
Microfoveolatispora sp.
Densipollenites invisus
Parasaccites obscurus
Alisporites sp.
Cuneatisporites sp.
Scheuringipollenites maximus
Paravesicaspora indica
Ibisporites sp.
Striatites varius
Striatites tectus
Faunipollenites varius
Striatopodocarpites brevis
Chordasporites sp.
Rhizomaspora indica sp.
Inaperturopollenites sp.
 ?*Botryococcus*



Histogram 1: Showing percentage distribution of miospores

Miofloral Comparison

The palynological investigation of Permian sediments from Tindharia and adjacent area carried out by Ghosh (1983) shows two palynozones. Non-striate disaccate genera are dominant in lower member while upper unit is dominated by striate disaccate along with rich trilete spores. Palynofloras recorded from Kalijhora, Raktikhola and Bamonpokharia compare with the mioflora of upper unit of Tindharia section in dominance of striate disaccate but differs in the absence of trilete spores. The palynoflora recorded by Ghosh (1983) also indicates affinity with the mioflora of upper Barakar. However, Srivastava *et al.* (1998) suggest that the upper unit assemblage compares with the mioflora of Raniganj Formation of Peninsular Gondwana in having striate disaccate e.g. *Striatopodocarpites*, *Lahirites*, *Indospora*, *Verticypollenites* and *Gnetaceaepollenites*. The present assemblages are dominated by *Crescentipollenites*, *Faunipollenites*, *Striatopodocarpites*. *Crescentipollenites* along with *Scheuringipollenites* are comparable to the Raniganj palynoflora of Palynozone IX of Tiwari and Tripathi (1992). The mioflora of Skkip Member of Sikkim

PLATE-2

- Vertically preserved *Vertebraria*-axis showing main axis with spreading branches in horizontal plane B.S.I.P. Museum no. 39066.
- Small piece of vertically preserved *Vertebraria*-axis. B.S.I.P. Museum no. 39066.

- Relatively large sized specimen showing preservation across the bedding plane. B.S.I.P. Museum nos. 39067, 39068.
- Horizontally lying *Vertebraria*-axis over the surface of rock. B.S.I.P. Museum no. 39069.

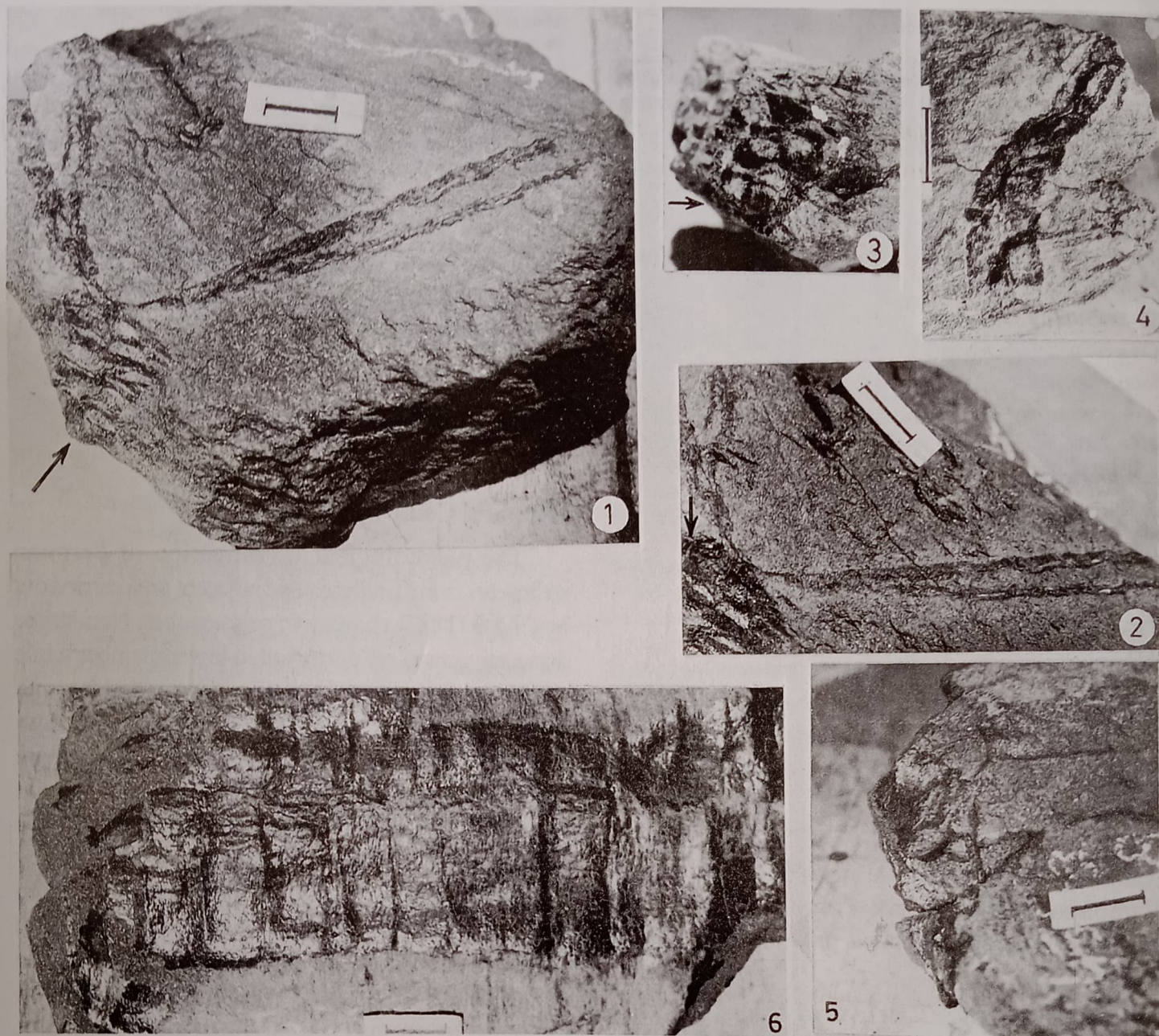


PLATE 2

compares, but differs in having *Lunatisporites*, *Ephedripites*, *Weylandites* and *Gnetaceaepollenites* (Srivastava & Bhattacharyya 1992). The Permian palynoassemblage described from Dewathang area in Bhutan (Banerjee & Dasgupta 1983) dominated by *Scheuringipollenites* and *Primuspollenites* is also distinct from present assemblage.

Megafloral Composition

The megafossils have been recovered only from Kalijhora stream section (Map 1). Fragmentary but well preserved specimens of *Glossopteris communis*, *G. indica*, *G. angustifolia*, *G. varia* and *G.*

stenoneura constitute the megafloral assemblage. It is interesting to note that this section has yielded well preserved specimens of vertically preserved *Vertebraria*-axes along with horizontally lying specimens (Pl. 2, fig. 6). Such specimens are 4-6 cm in length and 1-2.2 cm in diameter and show almost uniform thickness all through their preservation. The specimens have been found embedded in the rocks across the bedding plane and it is possible to expose the axes after splitting the rock. Fine branches of axes spreading horizontally in different directions have also been noticed (Pl. 2, figs. 1-5). The nature and preservation of vertically preserved *Vertebraria* axes

have been discussed by Srivastava (1995) and Srivastava and Bhattacharyya (1998). The study suggests the possibility of autochthonous or *in situ* deposition of plant material. Horizontally lying specimens are common in the Gondwana flora in southern hemisphere. In India, they are known right from the Talchir up to the Panchet formations. The axes of *Vertebraria* have been interpreted as stem, rhizome or root. However, petrified material from Trans-Antarctic confirms the root nature of *Vertebraria* (Neish *et al.* 1997).

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