

Palynological investigation of the Lower Siwalik sediments (Middle Miocene) exposed at Koilabas, western Nepal

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ABSTRACT

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A palynofloral assemblage, represented by algal and fungal remains, pteridophytic spores and gymnospermous and angiospermous pollen, is recorded from the Lower Siwalik sediments exposed at Koilabas, western Nepal. Qualitative and quantitative analyses of the assemblage reveal that the gymnospermous pollen are most dominant and are followed by pteridophytic spores, algal and fungal remains and angiospermous pollen. The palynofossils are compared with the modern taxa and from the present day distribution of the represented plant families it is deduced that a warm and humid, tropical-subtropical climate prevailed at the time of Lower Siwalik sedimentation. The palynofossils suggest existence of wet, marshy grassland with open mixed flora. Spores referable to *Zygnema* and *Botryococcus* provide cogent evidence for this inference. The temperate elements, viz. *Abies*, *Picea*, *Pinus* and *Tsuga* appear to be derived from nearby upland area of the rising Himalaya.

Key-words: Palynology, palaeoecology, Lower Siwalik, Middle Miocene, Koilabas, western Nepal.

INTRODUCTION

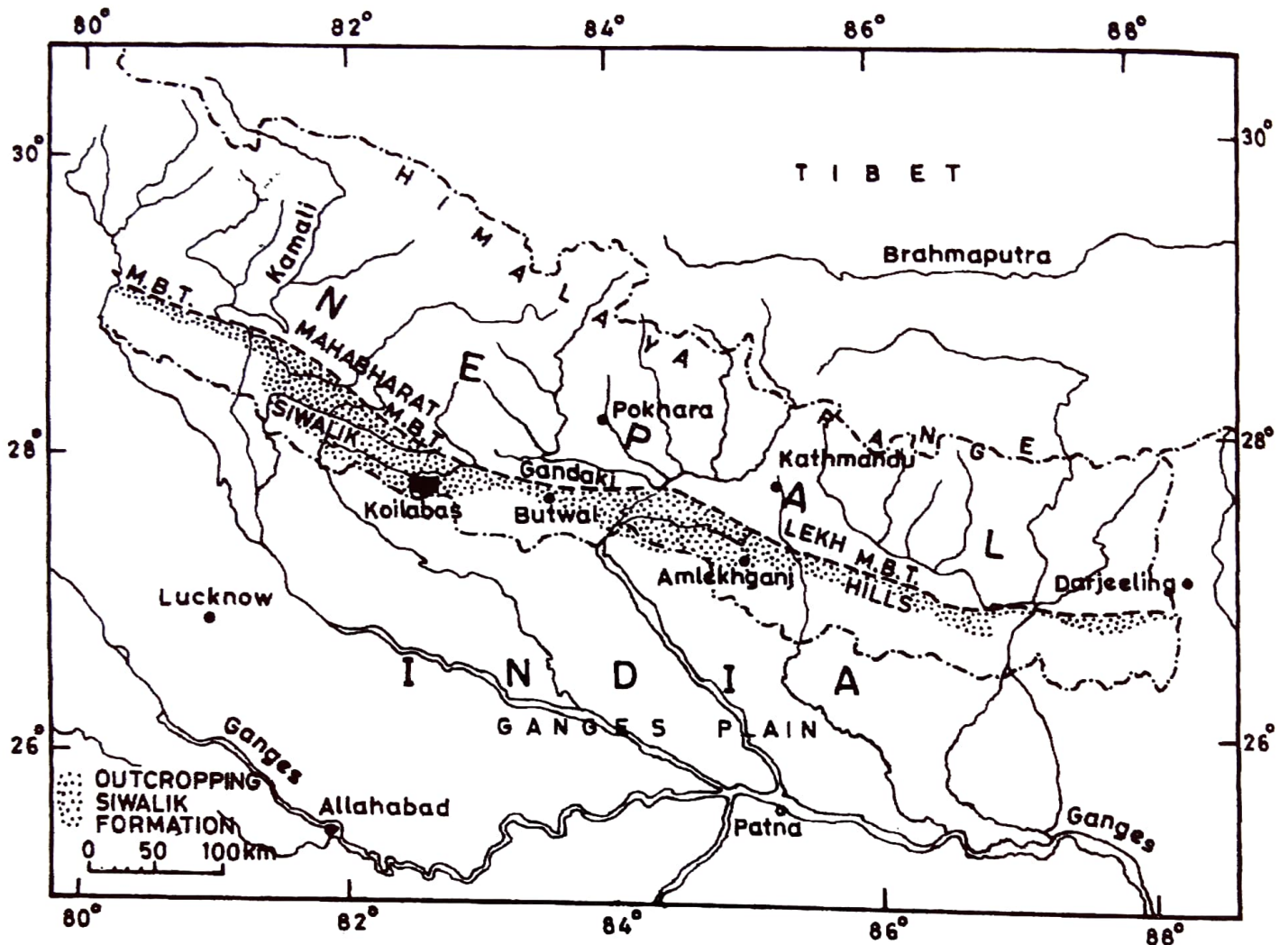
The present fossil locality, Koilabas (Lat. 27°42' N; Long. 82°20' E) lies near Indo-Nepal border, about 5 km north of Jarva in Balrampur District of Uttar Pradesh. Prasad and Prakash (1984), Prasad (1990, 1994) and Prasad et al. (1999) recorded a number of leaf impressions from the Lower Siwalik sediments exposed at about 500 m north-west of Koilabas village (Text-figure 1). A palynological assemblage is being reported here, for the first time, from this area. Sarkar (1990) recorded palynofossils from the Surai Khola of western Nepal. Significant elements of Surai Khola palynoflora are *Botryococcus*, zygospores of *Zygnema* and *Mougeotia*, *Pediastrum*, *Hammenisporis*, *Lycopodiumsporites*, *Monoporopollenites*, *Malvacearumpollis* and *Polyadopollenites*. Except *Pediastrum*, *Malvacearumpollis* and *Polyadopollenites*, all the other genera are recorded also from the present assemblage, hence two assemblages are comparable.

MATERIAL AND METHOD

Thirty nine samples were collected from the Lower Siwalik sediments exposed at Koilabas, western Nepal. Of these, 11 samples yielded palynofossils. The thickness of the exposed section is about 120 m which is broadly composed of alternate beds of sandstone and clay/mudstone (Text-figure 2). For the recovery of palynofossils, samples were treated with HCl and HF followed by 5% solution of KOH. The slides were prepared in polyvinyl alcohol and mounted in Canada balsam. The material, slides and negatives have been deposited in the museum of the Birbal Sahni Institute of Palaeobotany, Lucknow.

PALYNOFLORA

Algal and fungal remains: Algal type 1, *Botryococcus* sp., zygospores of *Zygnema* and *Spirogyra*, Fungal body type 1, Fungal spore types 1 and 2 and *Palaeomycites robustus* (Kar 1979) Kalgutkar & Jansonius 2000.



Text-figure 1. Locality map showing the area (Koilabas) of investigation.

Pteridophytic spores: *Cyathidites australis* Couper 1953, *Cyathidites* sp., *Hammenisporis susannae* (van der Hammen 1956) Saxena & Trivedi 2009, *Lygodiumsporites lakiensis* Sah & Kar 1969, *Lycopodiumsporites* sp., *Osmundacidites* sp. and *Polypodiaceasporites* sp.

Gymnospermous pollen: *Abiespollenites*

surmaensis Rao 1986, *Abiespollenites* sp., *Cycadopites* sp., *Inaperturopollenites punctatus* (Saxena 1979) Saxena & Bhattacharyya 1987, *Inaperturopollenites* sp., *Piceapollenites* sp., *Pinuspollenites foveolatus* Rao 1986, *Pinuspollenites* sp., *Podocarpidites meghalayaensis* Rao 1986 and *Tsugaepollenites* sp.

Plate 1

(All photomicrographs are magnified ca. x500)

1. *Abiespollenites surmaensis* Rao, Slide No. 13820/20/II/4.
- 2-3. *Piceapollenites* sp., Slide No. 13821/20/II/2 and 20/II/3.
4. *Cycadopites* sp., Slide No. 13822 (12/II/9).
5. *Inaperturopollenites punctatus* (Saxena) Saxena & Bhattacharyya, Slide No. 13823(26/II/2).
6. *Tsugaepollenites* sp., Slide No. 13824(5/IV/2).
7. *Tricolpites* sp., Slide No. 13825(24/IV/2).
8. *Verruletes* sp., Slide No. 13822(12/2/6).
9. Angiosperm pollen type II, Slide No. 13826(14/1/3).
10. *Graminidites* sp., Slide No. 13827(31/ III/1).
11. *Pinuspollenites foveolatus* Rao, Slide No. 13821(20/II/2).
12. Fungal body type 1, Slide No. 13835(24/III).
13. Fungal spore type 2, Slide No. 13822(12/2/10).
14. Angiosperm pollen type 2, Slide No. 13827(31/3).
- 15, 17. *Lycopodiumsporites* sp., Slide No. 13836(26/IV/2); 13828(8/III/1).
16. *Lygodiumsporites lakiensis* Sah & Kar, Slide No. 13829(25/II).

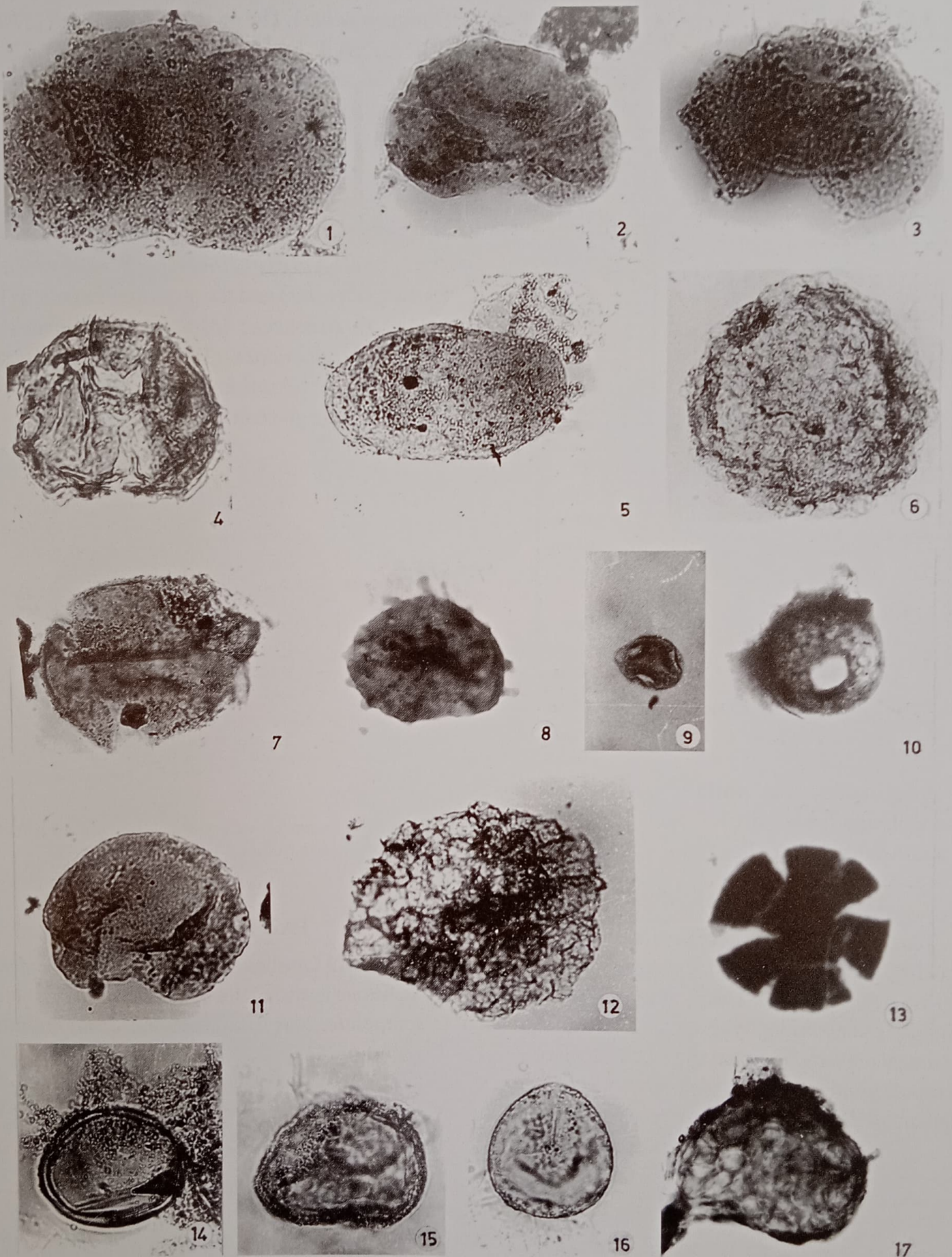
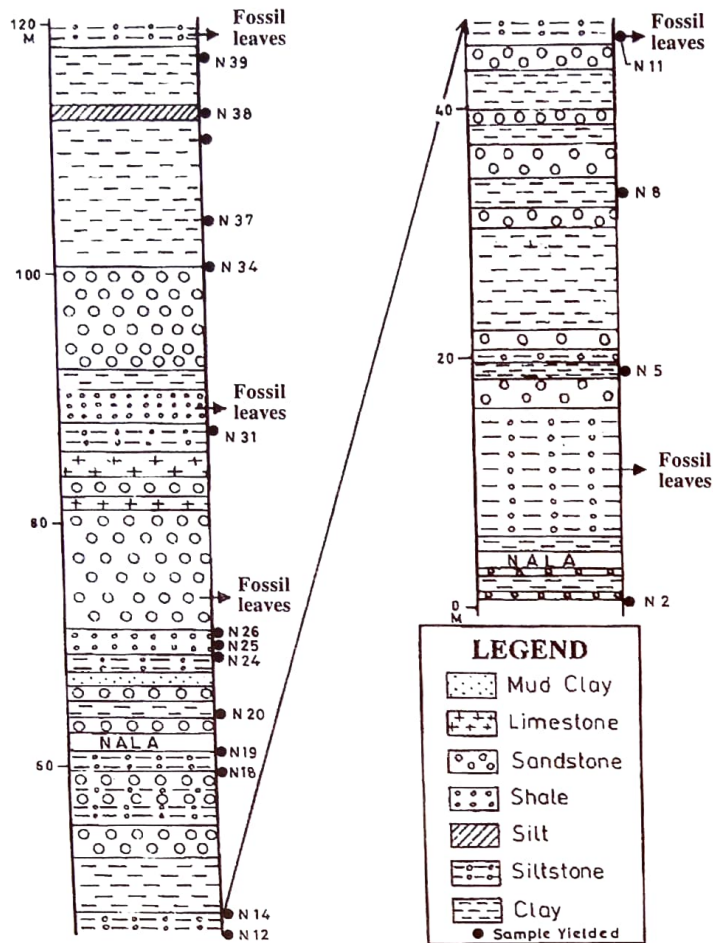


Plate 1



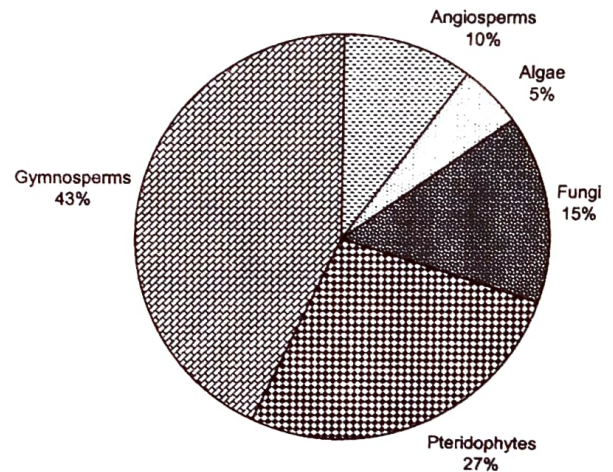
Text-figure 2. Lithology of the exposed section in Koilabas area.

Angiospermous pollen: *Graminidites* sp., *Monocolpopollenites* sp., *Tricolpites* sp., *Verrualetes* sp. and Angiosperm pollen types 1, 2 and 3.

PALYNOFLORAL ANALYSIS

The palynoflora consists of algal and fungal remains, pteridophytic spores and gymnospermous and angiospermous pollen. The gymnospermous pollen dominate over pteridophytic spores followed by algal and fungal remains. The algal and fungal remains (20%) are represented by Botryococcaceae (*Botryococcus*), Zygnemataceae (*Zygnema*, *Spirogyra*) and VAM fungi

(*Palaeomycites*). The pteridophytic spores (27%) are represented by Cyatheaceae (*Cyathidites*), Schizaeaceae (*Lygodiumsporites*), Lycopodiaceae (*Lycopodiumsporites*), Osmundaceae (*Osmundacidites*), Ceratopteridaceae (*Hammenisporis*) and Polypodiaceae (*Polypodiaceasporites*); gymnospermous pollen are represented by Cycadaceae (*Cycadopites*), Podocarpaceae (*Podocarpidites*) and Pinaceae (*Abiespollenites*, *Pinuspollenites*, *Piceapollenites*) and the angiosperm pollen (10%) belong to Arecaceae (*Monocolpopollenites*) and Poaceae (*Graminidites*) (Text-figure 3). The possible affinities of palynofossils and their present day distribution are given in Table 1.



Text-figure 3. Quantitative analysis of Lower Siwalik palynoflora of Koilabas, western Nepal.

PALAEOCLIMATE

Of the 13 families represented in the assemblage, 6 families are restricted to tropical-subtropical, 2 families to temperate, and 5 families are cosmopolitan in distribution (Table-1). The pteridophytic spores generally favour moist and shady habitat. *Ceratopteris* (represented by *Hammenisporis*) is a water fern

Plate 2

- Osmundacidites* sp., Slide No. 13830(24/II/1).
13. *Hammenisporis susannae* (van der Hammen) Saxena & Trivedi, Slide No. 13831(5/III/1); 13827 (8/III).
- Botryococcus* sp., Slide No.13828 (8/III/2).
- Cyathidites* sp., Slide No.13832 (25/III/1 5131A/31).
- Angiosperm pollen type 3, Slide No.13827 (31/III).
- Fungal spore-type 1, Slide No.13835 (24/III/1).
- 7-9. Algal type 1, Slide No. 13833(5/II/1), (26/III).
10. *Zygnema* sp., Slide No. 13834(5/II/1).
11. *Palaeomycites robustus* (Kar) Kalgutkar & Jansonius, Slide No. 13827 (31/III/2).
12. *Lycopodiumsporites* sp., Slide No.13829 (8/III/1).

Table 1. Possible affinities of palynofossils and their present day distribution.

Botanical affinity	Name of fossil/ modern taxa	Geographical distribution
Zygnemataceae	<i>Zygnema</i> , <i>Spirogyra</i>	Cosmopolitan
Botryococcaceae	<i>Botryococcus</i>	Cosmopolitan
Cyatheaceae	<i>Cyathidites australis</i> , <i>Cyathidites</i> sp.	Tropical-subtropical
Lycopodiaceae	<i>Lycopodiumsporites</i> sp.	Tropical-subtropical
Osmundaceae	<i>Osmundacidites</i> sp.	Tropical-temperate
Ceratopteridaceae	<i>Hammenisporis susannae</i>	Tropical-subtropical
Schizaeaceae	<i>Lygodiumsporites lakiensis</i>	Tropical-subtropical
Polypodiaceae	<i>Polypodiaceasporites</i> sp.	Tropical
Cycadaceae	<i>Cycadopites</i> sp.	Tropical-subtropical
Podocarpaceae	<i>Podocarpidites meghalayaensis</i>	Temperate
Pinaceae	<i>Pinuspollenites</i> spp. <i>Piceapollenites</i> sp. <i>Abiespollenites</i> spp.	Widely distributed, temperate
Arecaceae	<i>Monocolpopollenites</i> sp.	Tropical-subtropical
Poaceae	<i>Graminidites</i> sp.	Widely distributed throughout the world

growing in tropical region. The presence of fungal spores is indicative of warm and humid condition. The overall vegetation pattern indicates a tropical-subtropical humid climate during the sedimentation of the Lower Siwalik. The plant megafossils recorded from the Koilabas area also supports this contention. The temperate flora, belonging to Pinaceae, appears to be transported from the upland areas in the north.

ENVIRONMENT OF DEPOSITION

The ecologically significant taxa were categorized into montane, low-land and fresh water swamp and water edge. An analysis of the palynoflora reveals that montane and fresh water elements are dominant over the other groups.

Montane: *Cycadopites*, *Inaperturopollenites*, *Podocarpidites*, *Pinuspollenites*, *Abiespollenites* and *Piceapollenites*.

Low-land: *Graminidites*.

Fresh water swamp and water edge: *Zygnema*, *Spirogyra*, *Lygodiumsporites*, *Cyathidites*, *Lycopodiumsporites*, *Osmundacidites* and *Hammenisporis*.

The presence of zygnemataceous zygospores indicates stagnant shallow and more or less mesotrophic

fresh water habitat (van Geel 1976, van Geel & van der Hammen 1978). Presence of *Lygodiumsporites* and *Hammenisporis* is indicative of freshwater swamps and ponds near the site of deposition. High incidence of algal and fungal remains and fern spores (*Lycopodium*, *Ceratopteris*) and grass pollen indicates existence of wet and marshy grassland with open mixed flora. The records of leaf impressions belonging to *Isoptera*, *Dipterocarpus*, *Hopea*, *Shorea*, *Euphorea*, *Swintonia*, *Bouea*, *Tapiria*, *Mangifera*, *Pongamia*, *Albizia*, *Cassia*, *Dalbergia*, *Millettia*, *Anogeissus*, *Terminalia*, *Combretum*, *Diospyros*, *Ficus* and *Phyllanthus* (Prasad et al. 1999) from the same area also supports an open mixed flora.

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