PALYNOLOGY OF THE UPPER SIWALIK SEDIMENTS IN UNA DISTRICT, HIMACHAL PRADESH

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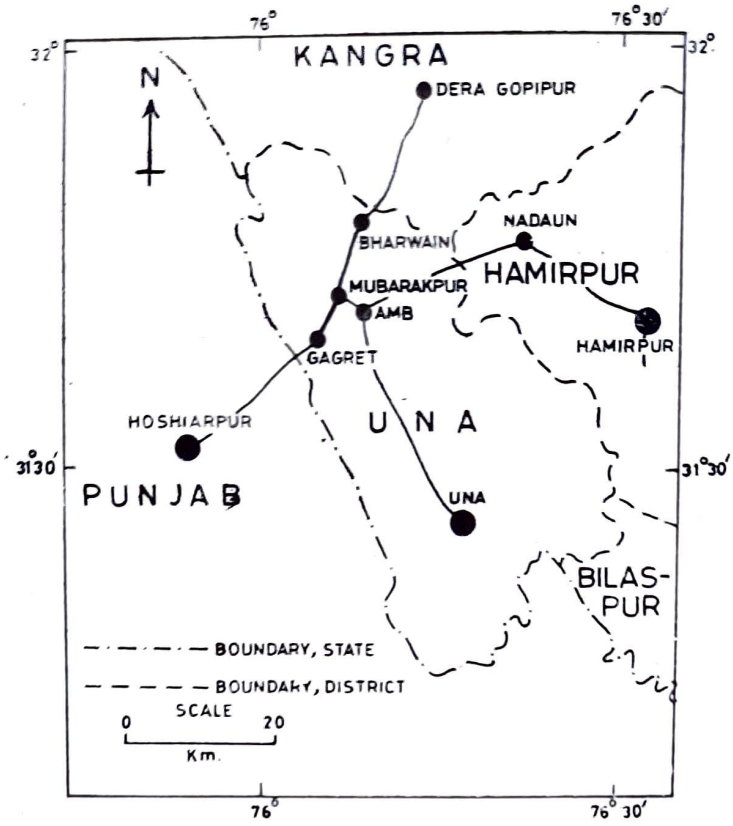
ABSTRACT

The palynofloral investigation of the Upper Siwalik sediments exposed along Gagret-Bharwain Road Section in Una district, Himachal Pradesh reveals a total of 10 genera and 14 species of gymnospermous and angiospermous pollen, fungal spores and conidia and palynomorphs of uncertain affinity. Four species are new. The assemblage is dominated by gymnospermous pollen—both bisaccate and inaperturate ones. Palynofloral comparison shows that the present assemblage resembles that of Pinjor Formation near Chandigarh and, as such, its stratigraphic position has been suggested in the middle part of Upper Siwalik.

INTRODUCTION

The Himalayan foot-hills, spread over a large area from Pakistan in the west to Burma in the east and bordering the northern limit of the Indo-Gangetic plains, constitute an important stratigraphic unit, the Siwalik Group. This group has remained a centre of attraction for geologists and palaeontologists since the last century because of a rich mammalian fauna recovered therefrom. As such, a large number of papers have so far been published on the study of mammalian remains from this group. However, palynological investigation of this group started rather too late. The first paper on the Siwalik palynology was published by BANERJEE (1968) in which he reported palynofloral assemblage and its application in interpreting the palaeoclimate and depositional environment of the Lower and Middle Siwalik sediments exposed in Bhakra-Nangal area of Punjab. Thereafter, LUKOSE (1969), NANDI AND BANDYOPADHYAY (1970), VENKATACHALA (1972), NANDI (1972, 1975), MATHUR (1973), SINGH, KHANNA AND SAH (1973), GHOSH (1977), and SAXENA AND SINGH (1980 ; *in press*) have provided significant information on Siwalik palynology. The above work has been reviewed by SAXENA AND SINGH (*in press*) which indicates that the previous studies have mainly been restricted to the Lower and Middle Siwaliks only while the Upper Siwalik remained comparatively ignored by the palynologists, probably because of absence or poor recovery of palynomorphs. NANDI (1975) and GHOSH (1977), for the first time, recorded an Upper Siwalik palynoflora from the Jawalamukhi area of Himachal Pradesh and established four informal palynozones, viz., Zones 1-4, in the Siwalik sequence exposed in that area. Another fairly good Upper Siwalik (Pinjor Formation) palynoflora from the vicinity of Chandigarh has been recorded by SAXENA AND SINGH (1980; *in press*) which includes 19 genera and 23 species of fungal and pteridophytic spores and gymnospermous and angiospermous pollen grains. The recovery of the above assemblage is, therefore, an attempt towards the beginning of palynological studies on the Upper Siwalik sediments. The present contribution is yet another attempt towards the same objective and deals with the palynoflora and its stratigraphic position from the Upper Siwalik sediments exposed along Gagret-Bharwain Road section, District Una, Himachal Pradesh (Map-1).



Map 1. Showing the location of Gagret-Bharwain Road Section in Una district, Himachal Pradesh.

The material for the present study was collected from the claystone and siltstone bands and lenses within the massive, medium to coarse-grained sandstone of the Upper Siwalik. The material is represented by six samples, numbered 105-110. Of these, five samples yielded palynomorphs. The details of lithological sequence (in ascending order) are given in table 1.

Table 1

Sample No.	Lithology	Thickness
109* & 110	Conglomeratic bed having loose sands and friable sandstone, greyish in colour	15.25 m
108	Grey claystone and siltstone	9.15 m
107	Greenish friable sandstone	1.55 m
105 & 106	Grey friable siltstone	3.10 m

*Unproductive

The slides and unused material have been deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow. Type locality for four new species is Gagret-Bharwain Road section, District Una, Himachal Pradesh.

SYSTEMATIC PALYNOLOGY

Genus—**Pinuspollenites** Raatz, 1937

Pinuspollenites siwalikus sp. nov.

Pl. 1, Figs. 1-2

Holotype—Pl. 1, Fig. 1; Size 71 ×49 μm ; Slide no. 6288/1.

Diagnosis—Pollen grains bisaccate, 71-75 × 49-52 μm, central body circular-longitudinally oval with rimmed margin, bigger than sacci, 44-50 × 42-46 μm, granulose, occasionally ± verrucose. Furrow wide (12-15 μm), ± quadrangular. Sacci kidney-shaped, 38-40 × 26-33 μm, almost equal in size, reticulate.

Comparison—The present species can be differentiated from *P. labdacus* (Potonié) Raatz (1937) in having a granulose central body which is prominently reticulate in the latter. *Pinuspollenites* sp. described by Saxena and Singh (*in press*) from the Pinjor Formation near Chandigarh, and *Disaccites* spp. 1 and 5 described by Lukose (1969) from the Middle Siwalik sediments of Bihar are also different in having distinctly reticulate central body.

Genus—**Aplanosporites** Kar, 1979

Aplanosporites robustus Kar, 1979
Pl. 1, Fig. 3

Description—Palynomorphs oval or irregular in shape due to folding, 63-96 × 60-70 μm (excluding appendage). Germinal mark absent. Exine less than 1 μm thick, laevigate, with few prominent irregular folds. A tail-like appendage without any opening present.

Remarks—The specimens recorded in the present assemblage resemble those described by Kar (1979) from the Maniyara Fort Formation of Kutch. Kar (*loc. cit.*) has included them under microplanktons, although in the generic and specific diagnosis they are described as spores (Kar, 1979, pp. 35-36). These palynomorphs have been compared with fungal spores, microplanktons and gymnospermous pollen, but their affinity still remains uncertain.

Aplanosporites bharwainensis sp. nov.
Pl. 1, Figs. 17-18

Holotype—Pl. 1, Fig. 17; Size 62 × 49 μm (excluding appendage). Slide no. 6290/8.

Diagnosis—Subcircular-oval, 55-66 × 48-52 μm (excluding appendage). Germinal mark absent. Exine up to 0.5 μm thick, laevigate. A long, ± 1.5 μm thick hair-like appendage present being occasionally branched.

Comparison—The present species resembles *A. robustus* Kar (1979) in shape and general organization but can be differentiated by its smaller size-range, thinner exine and long hair-like delicate appendage while latter is bigger in size and has robustly built, shorter appendage and thicker exine. Moreover, the present species lacks irregular exinal folds which occur in *A. robustus*.

Genus—**Laricoidites** Potonié, Thomson & Thiergart emend. Potonié, 1956

Laricoidites magnus (Potonié) Potonié, Thomson & Thiergart, 1950
Pl. 1, Fig. 4

Description—Grains ± circular, 52-79 μm. Germinal mark absent. Exine 0.5 μm thick, laevigate, with few irregular folds.

Laricoidites minutus Singh & Saxena (*in press*)
Pl. 1, Figs. 15-16

Description—Subcircular-oval, 39 × 20 μm. Germinal mark absent. Exine 1.0 μm thick, laevigate, with few prominent but irregular folds.

Genus—**Araucariacites** Cookson ex Couper, 1953

Araucariacites australis Cookson, 1947

Pl. 1, Fig. 5

Description—Grain ±oval, 80×65 μm. Germinal mark absent. Exine about 2.0 μm thick, granulose, grana prominent and closely placed.

Genus—**Verrualetes** Singh & Saxena (*in press*)

Verrualetes assamicus Singh & Saxena (*in press*)

Pl. 1, Fig. 6

Description—Spherical, 45 μm in diameter. Inaperturate. Exine (excluding sculpturing elements) 2.5 μm thick, verrucate/gemmate, verrucae/gemmae 3-4 μm high, robustly built and evenly distributed. Pollen slightly depressed on one side.

Genus—**Graminidites** Cookson, 1947

Graminidites pliocenicus sp. nov.

Pl. 1, Figs. 9-10

Holotype—Pl. 1, Fig. 9; Size 45×39 μm ; Slide no. 6290/4.

Diagnosis—Subcircular, 40-45×36-40 μm. Monoulcate, ulcus circular, 4-5 μm in diameter, surrounded by a well-defined annulus. Exine 1.0 μm thick, laevigate, with 2-3 prominent but irregular folds.

Comparison—The present species can be differentiated from *G. media* and *G. subreticulata* (Cookson, 1947) by its laevigate exine while the latter two have reticulate exine. *G. assamicus* Sah & Dutta (1968) differs from the present species in its oval-elliptical shape and smaller size. *G. chandigarhensis* Saxena & Singh (*in press*) recorded from the Pinjor Formation near Chandigarh differs in being smaller in size and oval in shape.

Fungal Remains

Genus—**Inapertisporites** van der Hammen emend. Sheffy & Dilcher, 1971

Inapertisporites vulgaris Sheffy & Dilcher, 1971

Pl. 1, Fig. 11

Description—Spores spherical, 10-14 μm, inaperturate, unicellate, nonseptate ; wall smooth.

Inapertisporites subcapsularis Sheffy & Dilcher, 1971

Pl. 1, Fig. 7

Description—Spores oval-subcapsular, 19-41×12-31 μm, inaperturate, unicellate, nonseptate ; wall psilate.

Inapertisporites maximus sp. nov.

Pl. 1, Fig. 19

Holotype—Pl. 1, Fig. 19; Size 155×98 μm. Slide no. 6288/9.

Diagnosis—Spores subcircular-elliptical, sometimes attain irregular shape due to folding, 129-155×98-116 μm, inaperturate, unicellate, nonseptate ; wall up to 1 μm thick, psilate, irregularly folded.

Comparison—The present species is comparable with *I. kedvesii* Elsik (1968) in having folded spore wall but can easily be distinguished by its exceptionally big size. Other species of *Inapertisporites* are not comparable.

Genus—**Multicellaesporites** van der Hammen emend. Sheffy & Dilcher, 1971

Multicellaesporites sp.

Pl. 1, Fig. 8

Description—Spores elliptical, biconvex, 50 × 12 μm, inaperturate, pentacellate, middle cells squarish and bigger in size while the terminal ones smaller and conical. Septa 4, as thick as spore wall ; wall about 1 μm thick, ± punctate.

Genus—**Monoporisporites** van der Hammen emend. Sheffy & Dilcher, 1971

Monoporisporites minutus van der Hammen, 1954

Pl. 1, Fig. 12

Description—Spores circular, 11-14 μm, unicellate, nonseptate, monoporate, pore small, ca 0.5 μm in diameter, without any thickened margin ; wall psilate.

Genus—**Tetraploa** Berk. & Br.

Tetraploa sp.

Pl. 1, fig. 13

Description—Conidia ± quadrangular, 25 × 14 μm, consisting of 4 columns, each terminating into a nonseptate unicellular appendage ; psilate, pigment light brown. Appendages up to 50 μm long and 5 μm wide (at the base), tapering towards the tips.

Remarks—This specimen is comparable with Type 89 ; *Tetraploa aristata* Berk. & Br., described by VAN GEEL (1978, p. 96 pl. 17, fig. 89). However, latter can be distinguished by its verrucose ornamentation and by having multicellular columns and septate appendages.

DISCUSSION

The palynoflora recorded here from the Upper Siwalik sediments exposed along Gagret-Bharwain Road Section in the district of Una, Himachal Pradesh, consists of 10 genera and 14 species, besides a few reworked phytoplanktons (Pl. 1, Fig. 14). Of this assemblage, three genera and four species belong to gymnospermous pollen, two genera and two species to angiospermous pollen, four genera and six species to fungal spores and conidia and one genus and two species are of unknown affinity.

An analysis of this assemblage shows that it does not contain even a single bryophytic or pteridophytic spore. The gymnospermous pollen form the most dominant element of the assemblage (65%) and are assignable to conifers especially the family Pinaceae. The taxa recorded are : *Pinuspollenites siwalikus*, *Laricoidites magnus*, *L. minutus* and *Araucariacites australis*. Among these, *Pinuspollenites* (33%) is most abundant followed by *Laricoidites* (29%) and *Araucariacites* (3%). The angiospermous pollen (7%) are represented by *Verrualetes assamicus* (2%) and *Graminidites pliocenicus* (5%). The former may be related to Potamogetonaceae and latter to Gramineae. The fungal spores (12%) are represented by three species of *Inapertisporites* (9%) viz., *I. vulgaris*, *I. subcapsularis* and *I. maximus*, *Multicellaesporites* sp. (1%), *Monoporisporites minutus* (2%) and *Tetraploa* sp. Besides, *Aplanosporites robustus* (2%) and *A. bharwainensis* (12%) could not be assigned to any group and their affinity remained uncertain (Table-2, Figs. 1-2).

Palynofloral Comparison—The previous records of the Upper Siwalik palynology are comparatively meagre. The information available is by NANDI (1975), GHOSH (1977) and SAXENA AND SINGH (1980 ; *in press*). NANDI (1975) and GHOSH (1977) reported the occurrence of *Cyathidites*, *Alsophilidites*, *Leptolepidites*, *Pinuspollenites*, *Podocarpidites*, *Monoporopollenites*, *Alnipollenites* and *Tetradomonoporites* from the basal part of Upper Siwalik

Table 2. Showing the distribution palynofossils in Upper Siwalik of Gagret-Bharwain Road Section, Himachal Pradesh.

Formation		Upper Siwalik				
Taxa / Sample No.		105	106	107	108	110
Inapertisporites subcapsularis		—				
Monoporisporites minutus		—				
Aplanosporites robustus		—	—			
Graminidites pliocenicus		—	—			
Inapertisporites vulgaris		—	—			—
Araucariacites australis		—		—		—
Laricoidites magnus		—	—	—		—
Pinuspollenites siwalikus		—	—		—	—
Laricoidites minutus		—	—	—	—	—
Aplanosporites bharwainensis			—	—		—
Multicellaesporites sp.				—		
Tetraploa sp.				—		
Verrualetes assamicus					—	
Inapertisporites maximus						—

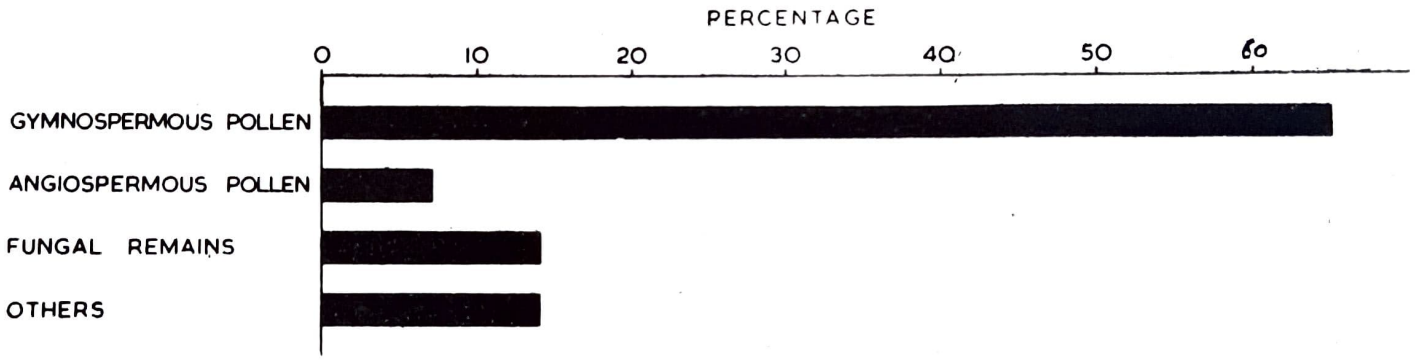


Fig. 1. Showing the group-wise percentage of palynomorphs.

exposed in Jawalamukhi area of Himachal Pradesh. This assemblage is comparable to the present assemblage in the common occurrence of only *Pinuspollenites* and *Monoporopollenites* (=*Graminidites*). The pteridophytic spores (*Cyathidites*, *Alsophilidites* and *Leptolepidites*), *Podocarpidites*, *Alnipollenites* and *Tetradomonoporites* are altogether unrepresented in the present assemblage while *Aplanosporites* (14%), *Laricoidites* (29%), *Araucariacites* (3%), *Verrualetes* (2%) and a few species of fungal spores (12%) recorded in the present assemblage are completely absent from the Jawalamukhi assemblage. Such difference in the palynofloral composition makes the two assemblages conspicuously different from each other and may be attributed to the disparity in their stratigraphic positions.

Another Upper Siwalik palynoflora has been worked out by Saxena and Singh (1980; *in press*), who described a fairly good palyno-assemblage comprising 19 genera and 23 species from the Pinjor Formation exposed near Chandigarh. This assemblage is closely comparable with the present assemblage in having common elements viz. *Pinuspollenites*, *Laricoidites*, *Araucariacites*, *Graminidites*, *Inapertisporites* and *Monoporisporites*. However, *Aplanosporites* is absent from that of Pinjor Formation while reverse is the case

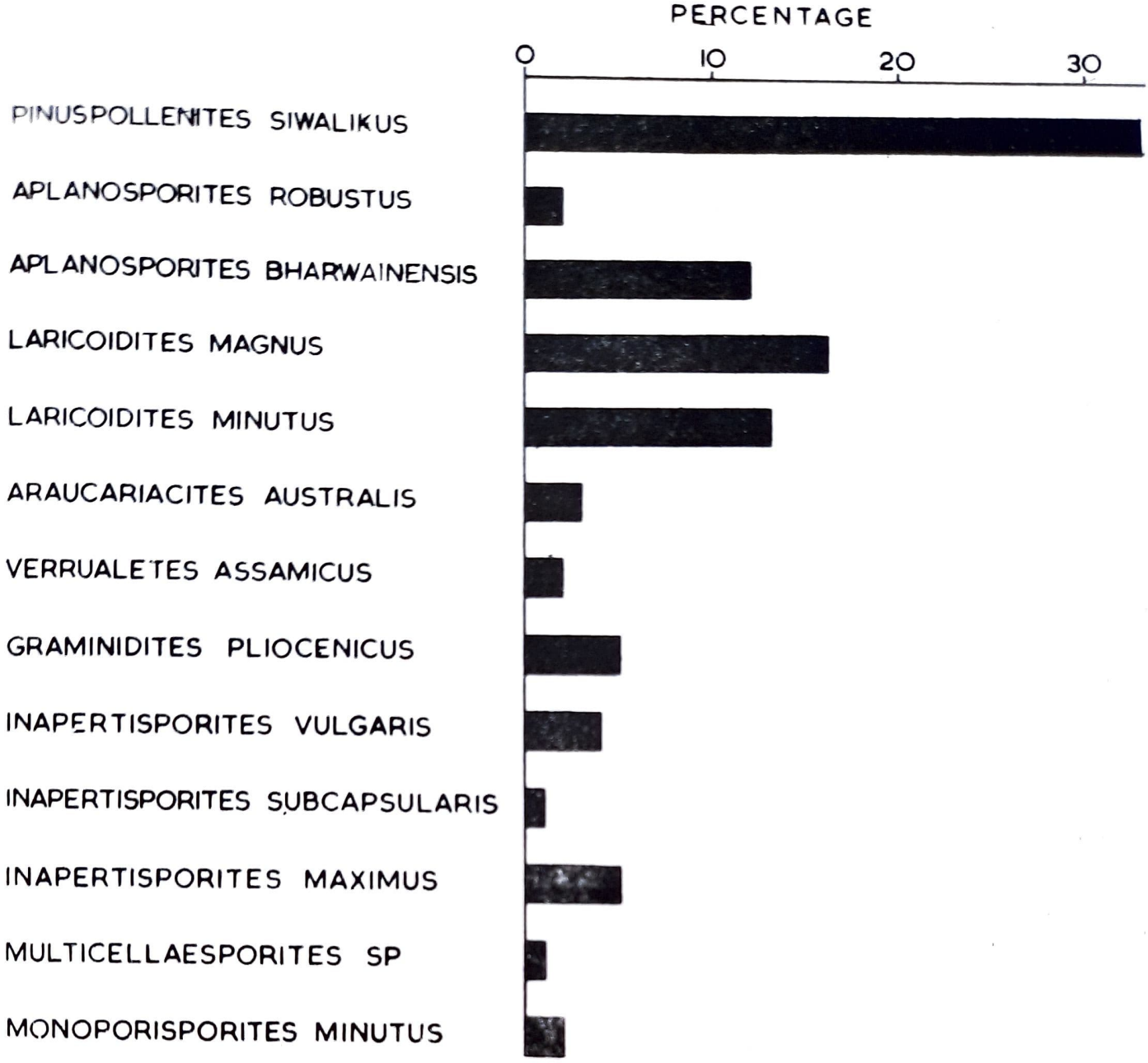


Fig. 2. Showing the frequency of various palynomorph species.

with *Pinjoriapollis* and *Psilamonocolpites*. Other taxa of both the assemblages are insignificantly represented, hence of restricted value in palynofloral comparison. A group-wise comparison of the present assemblage with that from Pinjor Formation of Chandigarh brings the two even closer (Table-3).

Table 3

Assemblage / Group	Pinjor Formation (Upper Siwalik) near Chandigarh	Upper Siwalik of Gagret Bharwain Road Section, Himachal Pradesh
Pteridophytic spores	3	0
Gymnospermous pollen	65	65
Angiospermous pollen	23	7
Fungal remains	9	14
Reworked microplanktons	+	+
Palynomorphs of unknown affinity	0	14

+Present

Stratigraphic Position—The monotony of lithology in Siwalik Group of Himachal Pradesh and absence of suitable lithological markers therein make the lithostratigraphic correlation of these sediments extremely difficult. The vertebrate fauna, which occurs abundantly throughout the Siwalik Group, has successfully been utilized for demarcating the various horizons. But this fauna is found only in restricted zones and to know the stratigraphic position of apparently unfossiliferous horizons remained a problem for stratigraphers. In such cases palynology may play a vital role. Limited efforts have so far been made to study Upper Siwalik palynology and more data are still required to establish suitable palynomorph controls for the demarcation of various levels therein. Such study requires systematic sampling from the measured sections and investigation of the palynological succession obtained from them. These sections may later serve as standard reference sections for the correlation of equivalent beds in other areas. Unfortunately, such a detailed study on Upper Siwalik has so far not been carried out, probably because of absence or poor recovery of palynomorphs. However, an attempt is made here to comment upon the stratigraphic position of the sediments under present study with the help of whatever data are available.

The analysis of the present assemblage and its comparison with the earlier recorded Upper Siwalik assemblages show that it is best comparable with the one described by SAXENA AND SINGH (1980 ; *in press*). The frequencies of the main and dominating element—the gymnospermous pollen, of both the assemblages correspond with each other. The presence of pteridophytic spores in the Chandigarh assemblage and some difference in the frequency of fungal spores seem to be an influence of local vegetation hence not significant. However, the present assemblage shows some difference in the frequency of the angiospermous pollen which is obviously due to the absence of magnoliaceous and palmaceous pollen and 14 per cent representation of *Aplanosporites* (a palynomorph of uncertain affinity). The occurrence of reworked phytoplanktons of Eocene age is a common factor with both the assemblages and indicates towards their similarity.

It may, therefore, be concluded that, in spite of some minor difference, the present assemblage appears to be homotaxial to that described by SAXENA AND SINGH (1980; *in press*) from the Pinjor Formation exposed near Chandigarh.

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EXPLANATION OF PLATE 1

(All photomicrographs are enlarge. ca × 500)

1-2 *Pinuspollenites siwalikus* sp. nov., Slide no. 6288/1 (Holotype), 6288/4.
3. *Aplanosporites robustus* Kar, Slide no. 6289/3.
4. *Laricoidites magnus* (Potonié) Potonié, Thomson & Thiergart. Slide no. 6290/5.
5. *Araucariacites australis* Cookson, Slide no. 6291/2.
6. *Verrualetes assamicus* Singh & Saxena, Slide no. 6292/7.
7. *Inapertisporites subcapsularis* Sheffy & Dilcher, Slide no. 6289/10.
8. *Multicellaesporites* sp., Slide no. 6291/3.
9-10. *Graminidites pliocenicus* sp. nov., Slide nos. 6290/4 (Holotype), 6288/3.
11. *Inapertisporites vulgaris* Sheffy & Dilcher, Slide no. 6289/5.
12. *Monoporisporites minutus* van der Hammen, Slide no. 6289/4.
13. *Tetraploa* sp., Slide no. 6291/1.
14. Reworked phytoplankton, Slide no. 6289/11.
15-16. *Laricoidites minutus* Singh & Saxena, Slide no. 6290/1, 6290/1.
17-18. *Aplanosporites bharwainensis* sp. nov., Slide no. 6290/8 (Holotype), 6290/8.
19. *Inapertisporites maximus* sp. nov., Slide no. 6288/9 (Holotype).