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Palynology of the Siwalik sediments of Kala Amb-Nahan area in Sirmaur District, Himachal Pradesh

R. K. Saxena & A. P. Bhattacharyya

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The palynoflora recovered from the Lower Siwalik (Nahan) and Upper Siwalik sediments exposed along the road sections in Kala Amb-Nahan area in Sirmaur District consists of 18 genera and 25 species. Of these, two species are new. The diagnoses of two palynogenera, viz., *Inaperturopollenites* and *Inapertisporites*, have been emended. One new combination has also been proposed.

The Lower Siwalik (Nahan) palynoflora is represented by 13 genera and 17 species of fungal remains (13%), pteridophytic spores of Cyatheaceae and Polypodiaceae (5%), gymnospermous pollen of Pinaceae (73.5%), and angiospermous pollen of Liliaceae and Myricaceae (8.5%). On the other hand, the Upper Siwalik assemblage is represented by 11 genera and 15 species of fungal remains (14%), gymnospermous pollen of Pinaceae (67%), and angiospermous pollen of Potamogetonaceae, Palmae, Poaceae and Magnoliaceae (19%). A comparison of these Lower and Upper Siwalik assemblages with the known assemblages from the corresponding horizons has been made and it has been observed that the Lower Siwalik assemblage comes closest to that described from the Bhakra-Nangal Section in Himachal Pradesh, whereas the Upper Siwalik assemblage is comparable to the Pinjor assemblage near Chandigarh and Assemblage-1 of Hoshiarpur-Una Road Section assemblage.

Key-words—Palynology, Lower Siwalik, Upper Siwalik, Tertiary (India).

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सारांश

हिमाचल प्रदेश के सिरमौर जनपद में काला अम्ब-नाहन क्षेत्र के शिवालिक अवसादों का परागाणविक अध्ययन

रमेश कुमार सक्सेना एवं अनन्त प्रसाद भट्टाचार्य

सिरमौर जनपद के काला अम्ब-नाहन क्षेत्र में सड़क के संग-संग विगोपित अधरि शिवालिक (नाहन) एवं उपरि शिवालिक अवसादों से उपलब्ध परागाणुवनस्पतिजात में 18 प्रजातियाँ एवं 25 जातियाँ विद्यमान हैं। इनमें से दो जातियाँ नई हैं। दो प्रजातियों अर्थात् इनऍपर्चुरोपोलिनाइटिस एवं इनऍपर्टिस्पोराइटिस का निदान संशोधित किया गया है। एक नव संयोजन भी प्रस्तावित किया गया है।

अधरि शिवालिक (नाहन) परागाणुवनस्पतिजात में कवकीय अवशेषों (13 प्रतिशत) टेरीडोफ़ाइटीयों में स्याथिएसी एवं पोलिपोडिएसी के बीजाणु (5 प्रतिशत), अनावृतबीजीयों में पाइनेसी के परागकण (73.5 प्रतिशत) तथा आवृतबीजीयों में लिलिएसी एवं मिरीकेसी के परागकणों (8.5 प्रतिशत) की 13 प्रजातियाँ एवं 17 जातियाँ मिलती हैं। दूसरी ओर उपरि शिवालिक समुच्चय में कवकीय अवशेषों (14 प्रतिशत), अनावृतबीजीयों में पाइनेसी के परागकण (67 प्रतिशत) तथा आवृतबीजीयों में पोटेमोजीटोनेसी, पाल्मी, पोएसी एवं मैग्नोलिएसी के परागकणों (19 प्रतिशत), की 11 प्रजातियाँ एवं 15 जातियाँ, विद्यमान हैं। इन अधरि एवं उपरि शिवालिक समुच्चयों की तुलना अन्य ज्ञात संस्तरों के समुच्चयों से की गई है तथा यह प्रेक्षित किया गया है कि अधरि शिवालिक समुच्चय हिमाचल प्रदेश में भाखड़ा-नाँगल खंड से वर्णित समुच्चय से घनिष्टता प्रदर्शित करता है, जबकि उपरि शिवालिक समुच्चय चंडीगढ़ के समीप पिंजौर समुच्चय तथा होशियारपुर-ऊना मार्ग खंड समुच्चय की समुच्चय-प्रथम से तुलनीय है।

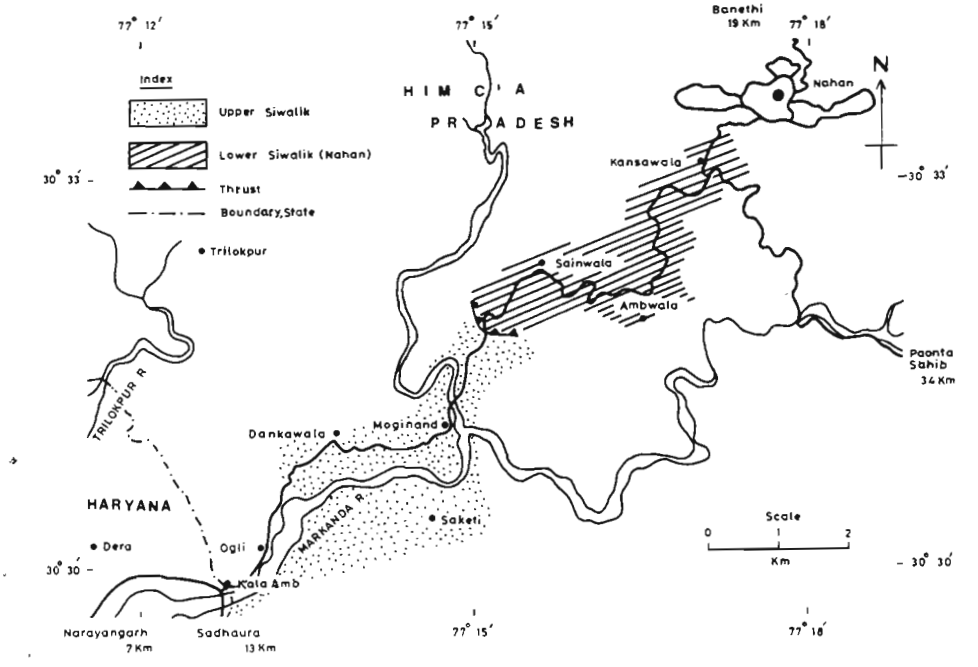
THE palynological studies on the Siwalik Group started in late sixties. Banerjee (1968) published a short paper dealing with the palynoflora, palaeoclimate and environment of deposition of Lower and Middle Siwalik in Bhakra Nangal area of Himachal Pradesh. Thereafter, Lukose (1969), Nandi and Bandyopadhyay (1970), Venkatachala (1972), Nandi (1972), Mathur (1973) and Mathur and Venkatachala (1979) have made significant contributions to Lower and Middle Siwalik palynology. Nandi (1975) and Ghosh (1977) divided the Siwalik sequence of Jawalamukhi area, Himachal Pradesh into four informal zones, viz., Zones 1-4, on the basis of

characteristic palynoassemblages recovered therefrom. Nandi (1980) provided a formal status to these zones as per requirements of the Code of Stratigraphic Nomenclature of India (1971) and tried to extend them in the various traverse sections of the Siwaliks in Uttar Pradesh, Punjab and Himachal Pradesh.

The palynological study of the Upper Siwalik sediments was started a little later. Singh *et al.* (1973) were the first to report the occurrence of *Pinus*-type, monosulcate-type and inaperturate (nonsaccate) pollen grains in the Pinjor Formation (Upper Siwalik) and to surmise subtemperate to temperate climate. Nandi (1975) and Ghosh (1977) reported the occurrence of *Cyathidites, Alsophilidites, Leptolepidites, Pinuspollenites, Podocarpidites, Monoporopollenites, Alnipollenites* and *Tetradomonoporites* in the basalmost part of Upper Siwalik and stated the remaining part of Upper Siwalik to be palynologically completely unfossiliferous. Thereafter, after a gap of few years, palynological studies on the Upper Siwalik were revived by Saxena and Singh (1980, 1981, 1982a, 1982b) and Singh and Saxena (1980, 1981). These assemblages are from the middle and upper parts of the Upper Siwalik, proving these horizons palynologically fossiliferous. Saxena *et al.* (1984) studied Lower, Middle and Upper Siwalik palynofloras of Bhakra-Nangal area, Himachal Pradesh. Saxena and Sarkar (1983) recorded several taxa of reworked Eocene dinoflagellate cysts from the five Siwalik sequences in Himachal Pradesh and Chandigarh, tracing their source in the Subathu Formation and interpreting a fluviatile environment for the deposition of these Siwalik sequences.

MATERIAL AND BRIEF GEOLOGY

The material for the present palynofloral investigation was collected from the Siwalik sequences exposed along the road between Kala Amb and Nahan and Kala Amb and Saketi in Sirmaur District of Himachal Pradesh (Map 1). The section exposes Upper Siwalik between Kala Amb and 6 km from Kala Amb where the uppermost part of Upper Siwalik, viz., Boulder Conglomerate is exposed. The Upper Siwalik consists of buff to rust coloured, fine to coarse grained sandstones with greyish siltstones and purple shales. The uppermost part of the Upper Siwalik is composed of massive boulder conglomerate beds alternated with grey and pinkish siltstones and coarse grained to gritty sandstone beds. The boulder conglomerate beds are composed of pebbles, cobbles and boulders ranging in size from few millimetres to 0.5 metre, embedded in a sandy matrix. 40 samples were collected from the Upper Siwalik (sample nos. 1-34 and 82-87). The Upper Siwaliks are overlain by Nahan (Lower Siwalik) at near 6 km from Kala Amb on Kala Amb-Nahan Road. The contact between the two is thrusted one (Markanda Thrust). The Nahan is composed of buff, compact, fine grained, massive, occasionally micaceous sandstone with subordinate purplish-grey siltstone and ferruginous, reddish to rust coloured shales. Fifteen samples (sample nos. 35-49) were collected from the Nahan sediments. Besides, 32 rock samples (sample nos. 50-81) were collected from the Kala Amb-Saketi Road cutting section exposing the Upper Siwaliks. Altogether, 87 samples from this area were collected, of which eleven samples proved to be palynologically



Map 1—Geological map of Kala Amb-Nahan area, Sirmaur District (Himachal Pradesh) showing the area of present study.

productive. The details of the samples, as to their lithology, location and productivity, are given in Table 1.

PALYNOFLORAL ASSEMBLAGE

Check-list of the Palynoflora

Lower Siwalik (Nahan)—*Cyathidites minor* Couper, *Intrapunctisporis, apunctis*, Krutzsch, *Monolites* sp., *Quadrangulosaccites himachalensis* Saxena & Singh, *Laricoidites magnus* (Potonié) Potonié *et al.*, *Inaperturopollenites punctatus* (Saxena) comb. nov., *I. ellipticus* sp. nov., *Inaperturopollenites* sp., *Araucariacites australis* Cookson, *Liliacidites major* Saxena, Monosulcate palynomorph-1, *Myricipites* sp., Polyporate palynomorphs 1 and 2, *Inapertisporites kedvesii* Elsik, *I. udarii* Gupta, *Staphlosporonites siwalikus* sp. nov., *Staphlosporonites* sp., *Polycellaesporonites bellus* Chandra *et al.*, *Spinasphaera robusta* Kar & Saxena.

Upper Siwalik—*Pinuspollenites siwalikus* Singh & Saxena, *Quadrangulosaccites himachalensis* Saxena & Singh, *Laricoidites magnus* (Potonié) Potonié *et al.*, *Inaperturopollenites punctatus* (Saxena) comb. nov., *I ellipticus* sp. nov., *Spinainaperturites* sp., Inaperturate palynomorph, *Palmidites* sp., *Pinjoriapollis magnus* Saxena & Singh, *P. lanceolatus* Saxena & Singh. *Pinjoriapollis* sp., Monosulcate palynomorph-2, *Monoporopollenites* sp., *Inapertisporites kedvesii* Elsik, *I. maximus* Singh & Saxena, *Staphlosporonites siwalikus* sp nov., and *Polycellaesporonites bellus* Chandra *et al.*

DESCRIPTION

Genus—*Monolites* Cookson, 1947 ex Potonié, 1956

Monolites sp.

Pl. 1, fig. 1

Description—Spore subcircular; size 52 × 48 μm; monolete; exine up to 1 μm thick, laevigate.

Genus—*Laricoidites* Potonié *et al.*, 1950 ex Potonié, 1958

Remarks—Since *L. magnus* (Potonié) Potonie *et al.* (1950), the type species of *Laricoidites*, has laevigate exine, it is recommended to retain this genus only for laevigate, inaperturate pollen grains.

Genus—*Inaperturopollenites* Pflug & Thomson in Thomson & Pflug, 1953 emended

Remarks—Pflug and Thomson in Thomson and Pflug (1953, p. 64) proposed this genus to accommodate

Table 1—Details of samples collected with their location, lithology and spore/pollen productivity

*Sample Number**	*Spore/pollen occurrence*	*Lithology*	*Locality*	*Rock Unit*
1-2	Unproductive	Pinkish Clay	Near Kala Amb Bus-stop	
3-4	,,	Purple shale	1 km from Kala Amb near Terpentine factory	
5	Productive	,,	1.1 km from Kala Amb	
6	Unproductive	,,	,,	
7-10	,,	,,	2.1 km from Kala Amb	
11-13	,,	,,	2.5 km from Kala Amb	
14-21	Unproductive	Purple shale in grey sandstone	3 km from Kala Amb	
22	Productive	,,	,,	
23-30	Unproductive	,,	4 km from Kala Amb	
31	Productive	,,	,,	
32-34	Unproductive	,,	5.75 km from Kala Amb	
82-84	,,	Siltstones	6 km from Kala Amb	
85	Productive	,,	,,	
86-87	Unproductive	,,	,,	Upper
50-59	,,	Purple shales	0.4-1.1 km from Kala Amb	Siwalik
60	Productive	,,	,,	
61-78	Unproductive	,,	,,	
79-80	Productive	,,	,,	
81	Unproductive	,,	,,	
		Markanda Thrust		
35	Productive	Reddish-rust coloured shales	1.6 km from Sainwala	
36-37	,,	,,	1.2 km from Sainwala	
38-41	Unproductive	,,	0.2 km from Sainwala	
42-43	,,	,,	9 km from Kala Amb	
44-46	,,	,,	12.6 km from Kala Amb	Lower
47	Productive	,,	,,	Siwalik
48-49	Unproductive	,,	,,	(Nahan)

*Sample nos. 50-81 were collected from Kala Amb-Saketi Road Section and all other samples from Kala Amb-Nahan Road Section. Samples are not arranged in stratigraphic sequence.

"Pollen grains without or with indistinct germinal apparatus, original shape, spherical with a symmetry plane through the equator, sometimes tending to bilateral symmetry or lenticular, exine not cavate (no sacci or similar inflated structure)". Potonié (1958, pp. 77-78) emended the diagnosis as "equator circular, exine thin, infrapunctate, with many secondary folds, smaller, thinner and more strongly punctate exine than in *Laricoidites*".

Since, *Inaperturopollenites dubius* (Potonié & Venitz) Pflug & Thomson in Thomson & Pflug (1953), the type species of the genus, is infrapunctate (Thomson & Pflug, 1953, p. 65), Potonié's (1958), emended diagnosis seems to be more justified. However, much variations in shape and size have been observed by us in the grains of this genus. It is also recommended that this genus should be restricted only for punctate-infrapunctate, inaperturate pollen grains, and laevigate forms not to be included under it. The diagnosis of the genus is therefore emended as follows:

Emended diagnosis—Pollen grains highly variable in shape from circular to subcircular, oval, elliptical and of other irregular shapes. Size variable from small to large, inaperturate. Exine punctate-infrapunctate, irregularly folded.

Comparison—*Inaperturopollenites* closely resembles *Laricoidites* in shape, size and in having no aperture but can be distinguished by its punctate-infrapunctate exine while the latter is laevigate.

Inaperturopollenites punctatus (Saxena, 1979) comb. nov.

Pl. 1, figs 2, 3

Basionym—*Laricoidites punctatus* Saxena, 1979, *Palaeobotanist* **26**(2) : 131, pl. 1, fig. 2

Holotype—*Laricoidites punctatus* Saxena, 1979, pl. 1, fig. 2.

Description—Pollen grains circular-subcircular to oval, size range 68-84 × 54-72 μm, inaperturate. Exine 0.5 to 1.5 μm thick, infrapunctate.

Remarks—Since *Laricoidites* has been retained here only for laevigate-inaperturate grains, *L. punctatus* Saxena (1979) is transferred to *Inaperturopollenites*.

Inaperturopollenites ellipticus sp. nov.

Pl. 1, figs 4, 5

Holotype—Pl. 1, fig. 4, size 110 × 56
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Inaperturopollenites ellipticus sp. nov.

Pl. 1, figs 4, 5

Holotype—Pl. 1, fig. 4, size 110 × 56 μm; B.S.I.P. slide no. 8528, coordinates 7 × 100.

Type Locality—3 kilometre stone, Kala Amb-Nahan Road, Sirmaur District, Himachal Pradesh; Upper Siwalik.

Diagnosis—Pollen grains elliptical in shape, size range 82-135 × 42-76 μm, inaperturate. Exine up to 2 μm thick, infrapunctate, puncta closely and evenly distributed, exine sometimes folded.

PLATE 1

(All the photomicrographs are enlarged ca × 500. The coordinates of the specimens refer to the stage of Olympus Microscope no. 205838)

1. *Monolites* sp.; Slide no. B.S.I.P. 8521, coordinates 8 × 92.4.
2, 3. *Inaperturopollenites punctatus* (Saxena) comb. nov.; Slide no. B.S.I.P. 8526, coordinates 8.3 × 104.6; Slide no. B.S.I.P. 8527, coordinates 6 × 103.4.
4, 5. *Inaperturopollenites ellipticus* sp nov. : Slide no. B.S.I.P. 8528, coordinates 7 × 100 (Holotype), slide no. B.S.I.P. 8528, Coordinates 11 × 93.
6. *Spinainaperturites* sp., Slide no. B.S.I.P. 8530, coordinates 3.7 × 78.3.
7. Monosulcate palynomorph-2; Slide no. B.S.I.P. 8533, coordinates 3.2 × 94 7.
8. *Pinjoriapollis magnus* Saxena & Singh; Slide no. B.S.I.P. 8531, coordinates 10 × 103.5
9. Polyporate palynomorph-1; Slide no. B.S.I.P. 8522, coordinates 7 × 115.5.
10. *Monoporopollenites* sp.; Slide no. B.S.I.P. 8532, coordinates 11.4 × 100.
11. *Palmidites* sp.; Slide no. B.S.I.P. 8528, coordinates 3 × 105.
12, 14. *Staphlosporonites siwalikus* sp. nov.; Slide no. B.S.I.P. 8536, coordinates 13 × 92.6 (Holotype); Slide no. B.S.I.P. 8538, coordinates 9 × 108.
13. Polyporate palynomorph-2; Slide no. B.S.I.P. 8535, coordinates 3.5 × 93.
15. *Inaperturopollenites* sp.; Slide no. B.S.I.P. 8529, coordinates 4 × 83.
16. *Pinjoriapollis* sp.; Slide no. B.S.I.P. 8532, coordinates 15.5 × 106.4.
17. *Myricipites* sp.; Slide no. B.S.I.P. 8534, coordinates 13.3 × 103.
18. *Staphlosporonites* sp.; Slide no. B.S.I.P. 8534, coordinates 9 × 108.
19. Inaperturate palynomorph; Slide no. B.S.I.P. 8528, coordinates 8 × 91.
20. Monosulcate palynomorph-1; Slide no. B.S.I.P. 8522, coordinates 16.3 × 107.8.

→

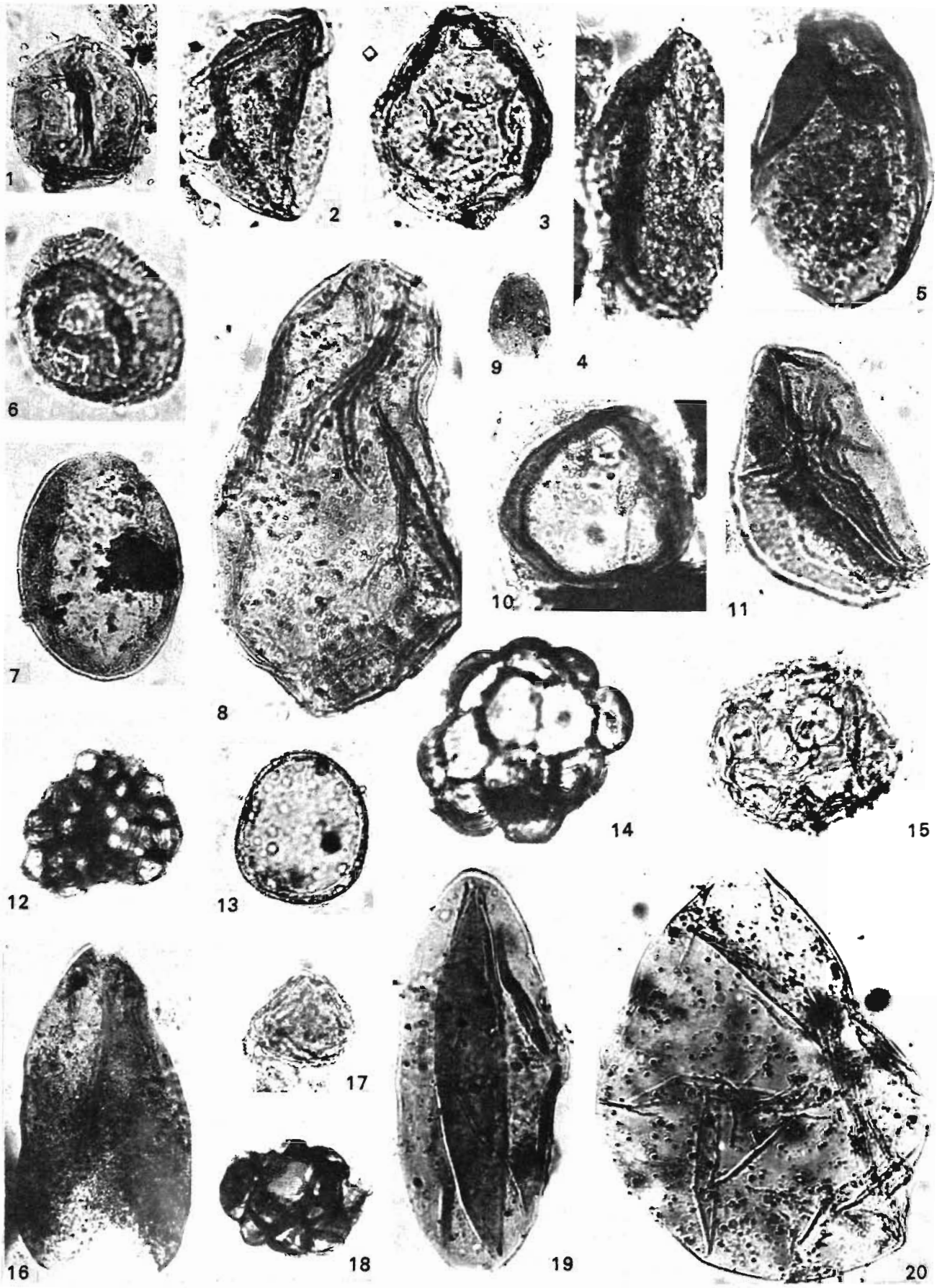

PLATE 1

Comparison—The present species can easily be distinguished from *I. dubius* by its bigger size and elliptical shape. *I. ruptus* Potonié & Sah (1960) differs from the present species in being smaller in size. *I. punctatus* (Saxena, 1979) comb. nov. is circular-oval in shape.

Inaperturopollenites sp.

Pl. 1, fig. 15

Description—Pollen grain subcircular, size 66 × 63 μm, inaperturate. Exine 1.5 μm thick, faintly infrapunctate, many irregularly developed ridges present over the surface forming a coarse reticulum, some ridges prominent while others thin and incomplete.

Comparison—The present species differs from the other species by its irregularly developed ridges forming coarse reticulum.

Genus—*Spinainaperturites* Pierce, 1961

Spinainaperturites sp.

Pl. 1, fig. 6

Description—Pollen grain oval, size 68 × 53 μm, inaperturate. Exine up to 1 μm thick, ornamented with sparsely placed and irregularly distributed conate spinules.

Comparison—The present species differs from *S. magnificus* Ramanujam (1966) and *S. scabratus* Mathur (1966) in having sparsely placed and irregularly distributed conate spinules.

Inaperturate palynomorph

Pl. 1, fig. 19

Description—Elliptical palynomorphs, size 152 × 62 μm. No aperture visible, but a strong fold throughout the length of the longer axis present, suggesting the presence of a sulcus. Exine laevigate.

Genus—*Palmidites* Couper, 1953

Palmidites sp.

Pl. 1, fig. 11

Description—Pollen grain oval-elliptical in shape, size 88 × 53 μm. Monosulcate, sulcus not clearly discernible. Exine up to 1 μm thick, laevigate.

Genus—*Pinjoriapollis* Saxena & Singh, 1981

Pinjoriapollis sp.

Pl. 1, fig. 16

Description—Pollen grain elliptical, size 124 × 63 μm. Monosulcate. Exine 1 μm thick, infrapunctate.

Comparison—the present specimen differs from *P. magnus* and *P. lanceolatus* both described by Saxena and Singh (1981) in having infrapunctate exine.

Monosulcate palynomorph 1

Pl. 1, fig. 20

Description—Irregularly oval palynomorph, size 156 × 115 μm. Monosulcate, sulcus ± triangular in shape. Exine hyaline, laevigate.

Monosulcate palynomorph 2

Pl. 1, fig. 7

Description—Circular-oval palynomorphs, size range 62-77 × 52-62 μm. Monosulcate, sulcus wide, oval, conforming to the pollen margin. Exine up to 1.5 μm, psilate to weakly infrapunctate.

Genus—*Monoporopollenites* Meyer, 1956 emend. Potonié, 1960

Monoporopollenites sp.

Pl. 1, fig. 10

Description—Pollen grains circular to elliptical in shape, size range 66-140 × 60-62 μm. Monoporate, pore circular to oval, 11-28 × 9-11 μm. Exine laevigate.

Genus—*Myricipites* Wodehouse, 1933

Myricipites sp.

Pl. 1, fig. 17

Description—Pollen grain triangular, size 35 × 32 μm. Triorate, angulaperturate, interoral margin straight to ± convex. Exine 1.0 μm thick, granulose, grana closely placed and evenly distributed.

Comparison—The present specimen resembles *M. vulgaris* Dutta & Sah (1970) in having similar shape, size and exine ornamentation but in the latter ora are crassimarginate. *M. globatus* Kar & Saxena (1981) differs in having bigger size range (64-78 × 56-70 μm) and subcircular shape.

Polyporate palynomorph 1

Pl. 1, fig. 9

Description—Oval palynomorph, size 35 × 23 μm. Polyporate, pores 4 (or 5), equatorially placed. Exine 0.5 μm thick, laevigate.

Polyporate palynomorph 2

Pl. 1, fig. 13

Description—Subcircular palynomorph, size 54 × 47 μm. Polyporate, pores numerous, sparsely placed, periporate. Exine up to 1 μm thick, infrapunctate.

Remarks—The present specimen resembles the pollen grains of Chenopodiaceae/Amaranthaceae.

Genus—*Inapertisporites* van der Hammen, 1954 ex Rouse, 1959 emended

Remarks—Van der Hammen (1954) proposed this genus for reference to various inaperturate spores found

in the Cretaceous and Tertiary sediments of Colombia without providing the generic diagnosis or type species. As such this genus remained invalid. Rouse (1959, p. 312) conserved this genus for inaperturate algal, fungal and possibly bryophytic spores and validated it by providing a generic diagnosis and nominating *I. pseudoreticulatus* Rouse (1959, pl. 2, figs 16-17) as its type species. Elsik (1968, p. 268) emended the generic diagnosis and restricted this genus only for inaperturate, psilate, unicellate and variable shaped fungal spores. Sheffy and Dilcher (1971, p. 27) again emended the diagnosis to include both algal and fungal spores of varied ornamentation. Sheffy and Dilcher (1971) stated the shape as 'globular or subglobular' and size range as 5-11 μm, which is not correct for most of the species of this genus. In the present emended diagnosis size and shape are therefore given as 'variable'.

Emended Generic Diagnosis—Inaperturate algal or fungal spores, unicellate, nonseptate. Shape and size variable, outline smooth or often uneven because of wrinkles or folds. Spore well ornamentation variable.

Genus—*Staphlosporonites* Sheffy & Dilcher, 1971

Staphlosporonites siwalikus sp. nov.

Pl. 1, figs 12, 14

Holotype—Pl. 1, fig. 12, size 61 × 52 μm; B.S.I.P. slide no. 8536, coordinates 13 × 92.6.

Type Locality—0.6 km from Kala Amb, Kala Amb-Saketi Road, Sirmaur District, Himachal Pradesh; Upper Siwalik.

Diagnosis—Fungal spores subcircular in shape, size range 61-77 × 52-70 μm. Multicellate, septa very thick, thicker than spore wall, individual cells circular-polygonal, small in size. Spore wall psilate.

Staphlosporonites sp.

Pl. 1, fig. 18

Description—Fungal spore subcircular to irregular in shape. Size 45-77 × 35-70 μm. Multicellate, cells irregularly arranged and vary in size, inaperturate. Spore wall dark brown in colour, psilate.

DISCUSSION

The palynofloral assemblage described here from the Lower Siwalik (Nahan) and Upper Siwalik sediments of Kala Amb-Nahan area in Sirmaur District, Himachal Pradesh, consists of 18 genera and 25 species of palynomorphs. These include fungal remains, pteridophytic spores, gymnospermous and angiospermous pollen grains and palynomorphs of uncertain affinity. Two new species and one new combination have been proposed. The number of palynomorphs per sample being very low, both in case of Lower and Upper Siwaliks, the quantitative analysis has been made on the basis of composite assemblages recovered from all the samples of Lower and Upper Siwaliks respectively. An analysis of the palynoflora is discussed ahead.

Lower Siwalik (Nahan) Assemblage

From the Lower Siwalik (Nahan) sediments a total of 15 samples were collected, of which only four samples yielded palynofossils. The assemblage consists of 13 genera and 17 species. Of these, three genera and five species are of fungal spores, three genera and three species of pteridophytic spores, four genera and six species of gymnospermous pollen, two genera and two species of angiospermous pollen and one genus and one species of uncertain affinity. The fungal spores constitute about 13 per cent of the assemblage, being represented by *Staphlosporonites, Inapertisporites* and *Polycellaesporonites*. The pteridophytic spores are comparatively poorly represented (5%) and may be related to Cyatheaceae and Polypodiaceae. The gymnospermous pollen grains showing affinity with the family Pinaceae constitute the bulk of the assemblage (73.5%). Amongst the gymnospermous pollen alone, inaperturate pollen share 96% (*Laricoidites* 46%; *Inaperturopollenites* 46% and *Araucariacites* 4%). The rest of the gymnospermous pollen are represented by bisaccate pollen grains. The angiospermous pollen grains are also insignificantly represented (8.5%) and have been assigned to Liliaceae and Myricaceae.

Upper Siwalik Assemblage

For the palynofloral investigation of the Upper Siwalik of this area, a total of 71 samples were collected, but only seven of them proved to be productive. The assemblage recorded from these samples consists of 11 genera and 15 species. The assemblage is represented by three genera and four species of fungal spores, four genera and five species of gymnospermous pollen grains and four genera and six species of angiospermous pollen grains. The fungal spores of this assemblage are qualitatively similar to those of the Lower Siwalik and constitute 14 per cent of the assemblage, being represented by *Inapertisporites, Staphlosporonites* and *Polycellaesporonites*. The assemblage is devoid of any positive evidence of bryophytic or pteridophytic spores. The gymnospermous pollen grains are comparatively less represented (67%) than those in the Lower Siwalik assemblage. The gymnospermous pollen are represented mainly by the inaperturate pollen grains (*Laricoidites* 28% and *Inaperturopollenites* 68%) while bisaccate pollen of *Quadrangulosaccites* share only 4%. All the gymnospermous pollen show affinity with Pinaceae. The angiospermous pollen are referable to Potamogetonaceae, Palmae, Poaceae and Magnoliaceae and share about 19 per cent of the assemblage.

PALYNOFLORAL COMPARISON

Lower Siwalik (Nahan)—The Lower Siwalik palynoassemblages have been described by Banerjee (1968), Venkatachala (1972), Mathur (1973), Nandi (1975), Ghosh (1977) and Saxena *et al.* (1984). Banerjee (1968) recovered pteridophytic spores belonging to Gleicheniaceae and Polypodiaceae, gymnospermous pollen of *Pinus* spp., *Disaccites* sp. and inaperturate types and angiospermous pollen of Compositae, Gramineae, Palmae, tricolpate, tetracolpate and polycolpate types from the Lower Siwalik sediments of Bhakra-Nangal area. This palynoflora compares with the present assemblage in common occurrence of monolete spores and inaperturate and bisaccate pollen grains. However, the present palynoflora is conspicuous in having poorly represented pteridophytic spores and bisaccate pollen grains, poor and less diversified angiospermous pollen grains and very high representation of inaperturate pollen and fungal spores. Venkatachala (1972) mentioned the occurrence of Palmae and Gramineae pollen and *Quercoidites, Haloragacidites, Cupuliferoipollenites, Sapotaceoidaepollenites* and *Araceoipollenites*. None of these taxa has been recorded in the present palynoflora. Mathur (1973) described a rich palynoflora consisting of 13 genera and 17 species from the Lower Siwalik sediments of Tharukhola-Chepang, northeast of Nepalgunge, Nepal. It has been observed that none of the species of this palynoflora is common to the present assemblage. In the Tharukhola-Chepang assemblage, angiospermous pollen grains are dominant followed by pteridophytic spores and gymnospermous pollen grains whereas the present assemblage is dominated by gymnospermous pollen grains and fungal spores with sporadic representation of pteridophytic spores and angiospermous pollen grains. Nandi (1975) and Ghosh (1977) mentioned the occurrence of 27 palynogenera in the Lower Siwalik of Jawalamukhi area of Himachal Pradesh. Of these, only *Cyathidites, Polypodiaceaesporites* (± = *Monolites*) and *Pinuspollenites* (± = *Quadrangulosaccites*) are common to the present assemblage. The Jawalamukhi assemblage is rich in pteridophytic spores and angiospermous pollen grains whereas the present assemblage is rich in fungal spores and gymnospermous pollen with subordinate representation of pteridophytic spores and angiospermous pollen grains. Saxena *et al.* (1984) recorded 23 genera and 28 species of palynomorphs from the Lower Siwalik of Bhakra-Nangal area of Himachal Pradesh. Of these, only five genera are common to the present Lower Siwalik assemblage. Quantitatively the two assemblages are comparable in the frequency of fungal remains and pteridophytic spores whereas inaperturate gymnospermous pollen dominate in the present assemblage in contrast to the angiospermous pollen in the Bhakra-Nangal assemblage.

Upper Siwalik—The Upper Siwalik palynofossils have so far been recorded by Singh *et al.* (1973), Nandi (1975), Ghosh (1977), Singh and Saxena (1980, 1981), Saxena and Singh (1980, 1982a, 1982b) and Saxena *et al.* (1984). Singh *et al* (1973) reported the occurrence of *Pinus* type, monosulcate type and inaperturate (nonsaccate) pollen grain. All these types have also been recorded from the present Upper Siwalik assemblage. Nandi (1975) and Ghosh (1977) recorded *Cyathidites, Alsophilidites, Leptolepidites, Pinuspollenites, Podocarpidites, Monoporopollenites, Alnipollenites* and *Tetradomonoporites* from the Upper Siwalik sediments of Jawalamukhi area of Himachal Pradesh. Of these, only *Pinuspollenites* and *Monoporopollenites* are common to both the assemblages. The present assemblage differs from Jawalamukhi assemblage in total absence of pteridophytic spores and rich representation of inaperturate pollen and fungal remains. Singh and Saxena (1980, 1981) recorded Upper Siwalik assemblage from Gagret-Bharwain Section in Una district of Himachal Pradesh. This assemblage largely compares with the present assemblage in common occurrence of *Pinuspollenites, Laricoidites, Monoporopollenites* (± = *Graminidites*) and *Inapertisporites*. A group-wise comparison of the two assemblages is given in Table 2.

Table 2—Group-wise comparison of the present Upper Siwalik assemblage with the Gagret-Bharwain Section assemblage of Una District, Himachal Pradesh

Group / Assemblage	*Upper Siwalik of Gagret-Bharwain Road Section, Himachal Pradesh (Singh & Saxena, 1981)*	*Upper Siwalik of Kala Amb-Nahan Road Section, Himachal Pradesh*
Fungal remains	28	14
Gymnospermous pollen	65	67
Angiospermous pollen	7	19
Reworked palynomorphs	Present	Absent

Saxena and Singh (1982a) reported Pinjor (Upper Siwalik) palynoflora from near Chandigarh. The present assemblage very much resembles this assemblage in common representation of *Pinuspollenites, Laricoidites-Inaperturopollenites, Palmidites, Pinjoriapollis, Monoporopollenites* (± = *Graminidites*) and *Inapertisporites*. Saxena and Singh (1982b) recorded Upper Siwalik palynoflora from the Hoshiarpur-Una Road Section in Punjab and Himachal Pradesh and established two informal zones. The present assemblage compares with the Assemblage-1 of the above section in the high frequency of inaperturate pollen grains and fungal remains. Saxena *et al.* (1984) recorded seven genera and nine species of palynomorphs from the Upper Siwalik of

Bhakra-Nangal Section in Himachal Pradesh. Of these, *Inapertisporites, Pinuspollenites* and *Graminidites* (± = *Monoporopollenites*) are also found in the present assemblage.

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