PALYNOLOGICAL INVESTIGATION OF SIWALIK SEDIMENTS OF BHAKRA-NANGAL AREA, HIMACHAL PRADESH

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ABSTRACT

The palynoflora of the Siwalik Group exposed along Bhakra-Nangal Road section, Bilaspur District, Himachal Pradesh consists of 27 genera and 36 species. Of these, one species is new. A comparison of the present palynomorphs with the living ones indicates the possible representation of Cyatheaceae, Schizaeaceae, Parkeriaceae, Polypodiaceae, Pinaceae, Palmae, Poaceae, Oleaceae, Chenopodiaceae, Sapotaceae, Cruciferae, Meliaceae and Lentibulariaceae. The quantitative analysis reveals the overall representation of fungal remains as 36 per cent, pteridophytic spores 11 per cent, gymnospermous pollen grains 14 per cent and angiospermous pollen grains 39 per cent. In Lower, Middle and Upper Siwaliks respectively, the fungal remains are 33, 47 and 29 per cent, pteridophytic spores are 11, 5 and 19 per cent, gymnospermous pollen grains are 15, 13 and 5 percent and angiospermous pollen grains are 41, 35 and 47 per cent. A comparison of the present palynoflora with already known Siwalik assemblages reveals that the Lower Siwalik assemblage matches with the earlier described Lower Siwalik flora from the same area and also from other areas. The middle and Upper Siwalik assemblages show comparatively lesser representation of gymnospermous pollen than the other assemblages which is probably due to the total absence of inaperturate pollen grains. The environment of deposition of these sediments has been deduced as fluviatile.

INTRODUCTION

The records of palynological studies on the Siwalik Group are meagre. The first paper on this subject was published by BANERJEE (1968) who, on the basis of the recovered palynoflora, commented upon the palaeoclimate and depositional environment during the Lower and Middle Siwalik sedimentation in Bhakra-Nangal area of Himachal Pradesh. Thereafter some more palynological information from Lower Siwalik was provided by VENKATACHALA (1972) and MATHUR (1973), and from Middle Siwalik by LUKOSE (1969), NANDI AND BANDYOPADHYAY (1970), VENKATACHALA (1972) and NANDI (1972). SINGH, KHANNA AND SAH (1973) reported the occurrence of palynoflora in Upper Siwalik (Pinjor Formation) mainly consisting of *Pinus*-type, monosulcate-type and inaperturate (nonsaccate) pollen grains and surmised subtemperate to temperate climate therefor. NANDI (1975) was the first to make an attempt for dividing the Siwalik Sequence of Jawalamakhi area of Himachal Pradesh into 4 informal biozones. She, besides recording many palynotaxa from the Lower and Middle Siwalik, mentioned the occurrence of 7 palynomorph genera from the Upper Siwalik, though without any description thereof. The above mentioned work on the Siwalik palynology has been reviewed by GHOSH (1977), MATHUR AND VENKATACHALA (1979) and SAXENA AND SINGH (1982a). This has been followed by a series of papers on Upper Siwalik palynology by SAXENA AND SINGH (1980, 1981, 1982a, b) and SINGH AND SAXENA (1980, 1981).

The present paper deals with the palynological investigation of the Siwalik sediments exposed along Bhakra-Nangal Road in Bilaspur District, Himachal Pradesh.

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Traversing from Bhakra towards Nangal along Bhakra-Nangal Road, first the Lower Siwaliks are exposed. These are composed of medium to coarse grained, often gritty, grey, pink and rust-coloured sandstones and shaly sandstones alternated by occasional thin bands of ferruginous shale and siltstones. The Lower Siwalik sediments are continuously exposed along the road from Bhakra to 4.5 km. Near 4.5 km the road bifurcates for Olinda Colony and from this point up to about 6 km, Middle Siwaliks are exposed. The Middle Siwaliks are made up of pale brown, greyish, sometimes ferruginous, fine to coarse grained, more or less compact sandstones alternated by a few, generally thin, but occasionally up to 5 m thick, carbonaceous shales. The rocks dip about 40 degrees towards WSW. Thereafter the rocks are densely covered by vegetation and could not be properly observed but at about 7 km well developed exposures of Upper Siwalik were observed. These are made up of greyish-white to white, medium to very coarse grained, friable, massive sandstones and sand rocks, frequently containing highly carbonaceous to lignitic nodules. At place e.g. at 7.4 km, thin carbonaceous streaks were observed in grey, coarse grained sandstone. The Upper Siwalik is steeply dipping up to 80 degrees towards west. Near 8.4 km the sandstone is overlain by the uppermost unit of Upper Siwalik, viz. Boulder Conglomerate, which continues for a short distance and thereafter the road runs over alluvial plain. This abrupt change in the physiography may possibily be attributed to a fault (Fig. 1).

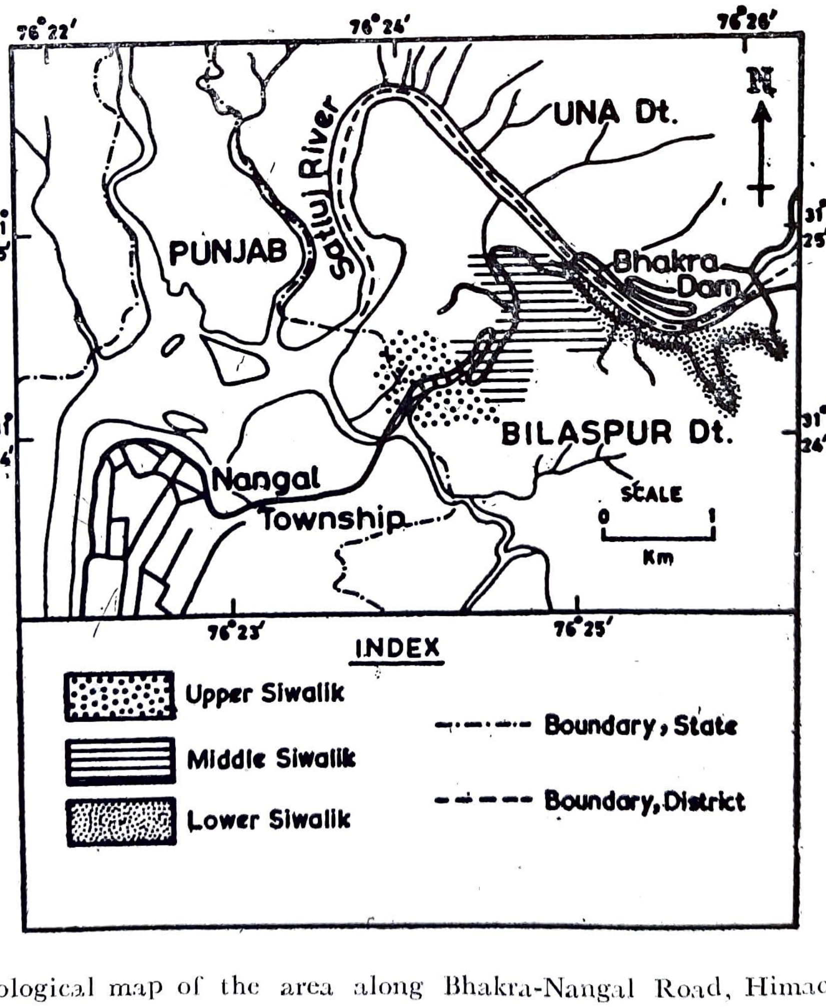


Fig. 1. Geological map of the area along Bhakra-Nangal Road, Himachal Pradesh.

The material for the present study was collected from the above sequence and consists of mainly clay, siltstone, silty shale and carbonaceous shale. Altogether, 193 samples were collected—44 from the Lower Siwalik, 38 from the Middle Siwalik and 111 from the Upper Siwalik. Of these, 16 samples yielded palynofossils. Amongst the productive samples, 8 samples belong to the Lower Siwalik, 5 to the Middle Siwalik and 3 to the Upper Siwalik (Table 1). The slides and negatives of the palynomorphs have been deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Table 1. Section showing lithology and location of the productive samples.

Horizon	Sample nos.	Productive sample ncs.	Lithology	Location*
Upper Siwalik	83-193	168	Greyish-black siltstone	8.4 km
		166	Greyish-black siltstone	8.4 km
		165	Carbonaceous shale	8.3 km
Middle Siwalik	45-82	64	Carbonaceous shale	5.4 km
		63	Carbonaceous shale	5.4 km
		62	Carbonaceous shale	5.3 km
		53	Carbonaceous shale	4.6 km
		52	Carbonaceous shale	4.6 km
Lower Siwalik	1-44	43	Grey siltstone	3.2 km
		38	Siltstone	3.2 km
		37	Siltstone	2.6 km
		35	Purple siltstone	2.6 km
		16	Siltstone	1.0 km
		15	Siltstone	1.0 km
		5	Ferruginous shale	0.3 km
		4	Ferruginous shale	0.3 km

*Sample locations are with reference to Bhakhra Dam

SYSTEMATIC PALYNOLOGY

Genus—**Cyathidites** Couper, 1953

Type species—*Cyathidites australis* Couper, 1953

Cyathidites australis Couper, 1953

Pl. 1 Fig. 1

Description—Spore subtriangular with broadly rounded apices and concave inter-apical margins; size 66 ×60 μm. Trilete, rays distinct, straight, extending almost up to the equator. Exine 1.5 μm thick, laevigate.

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

Type species—Lygodiumsporites adriennis (Potonié & Gelletich) Potonié, Thomson & Thiergart, 1950

Lygodiumsporites eocenicus Dutta & Sah, 1970

Pl. 1, Fig. 2

Description—Spore subtriangular with broadly rounded apices and straight to convex inter-apical margins; size 76 ×56 μm. Trilete, rays short, extending up to half radius, Exine 1 μm thick, laevigate.

Genus—**Striatriletes** van der Hammen emend. Kar, 1979

Type species—Striatriletes susannae van der Hammen emend. Kar, 1979

Striatriletes susannae van der Hammen emend. Kar, 1979

Pl. 1, Fig. 3

Description—Spores subtriangular with broadly rounded apices and ± convex inter-apical margins; size range 65-68 μm. Trilete, rays faintly discernible. Exine 2 μm thick, striated, costae running parallel to each other, 6-7 in each inter-radial area, 2 to 3 μm wide, occasionally branched.

Genus—**Polypodiaceaesporites** Thiergart, 1938

Type species—Polypodiaceaesporites haardti (Potonié & Venitz) Thiergart, 1938

Polypodiaceaesporites sp.

Pl. 1, fig. 4

Description—Spore reniform, bilateral ; size 18 × 14 μm. Monolete, ray distinct, about half of the longer axis, uniformly thick, straight. Exine ±1.5 μm thick, laevigate.

Comparison—Polypodiaceaesporites sp. can be differentiated from other known species of the genus by its smaller size and thin, short leasurae.

Genus –**Monolites** Cookson *ex* Potonié, 1956

Type species—Monolites major Cookson *ex* Potonié, 1956

Monolites sp.

Pl 1, Fig. 5

Description—Spore subcircular; size 70 ×60 μm. Monolete, ray distinct, about half of the longer axis. Exine 2 μm thick, finely intrapunctate.

Comparison— Monolites major Cookson (1947) differs from the present species by its smooth exine. *M. minor* Cookson (1947) can be distinguished by its smaller size range and smooth exine. *M. mawkmaensis* Dutta & Sah (1970) can be distinguished by smaller size range and longer laesurae. *M. ovatus* Sah (1967) is distinct by its oval-elongate amb and laevigate exine.

Genus—**Polypodiisporites** Potonié, 1934

Type species—Polypodiisporites favus Potonié, 1934

Polypodiisporites sp.

Pl., Fig. 6

Description—Spores elongated-oval, bilateral, concavo-convex; size 85 × 40 μm. Monolete, ray distinct, extending up to half of the longer axis. Exine 1 μm thick, ornamented with 1 μm high, conical projections, coni more densely distributed along the periphery.

Comparison—The present specimen closely resembles *P. turbinatus* Sah (1967) in shape and exine ornamentation but the latter can be differentiated by its thicker exine and laesurae bordered by slightly raised ridges. *P. miocenicus* Rao & Ramanujam (1978) differs from the present specimen in having thicker exine and sparsely distributed coni all over the exine. *P. impariter* (Potonié & Sah) Rao & Ramanujam (1978) is smaller in size-range and has thick exine beset with coni intermingled locally with verrucae, hence different from the present species.

Genus—**Pinuspollenites** Raatz *ex* Potonié, 1958

Type species—*Pinuspollenites labdacus* (Potonié) Raatz *ex* Potonié, 1958

Pinuspollenites sp.

Pl. 1, Figs. 7-8

Description—Pollen grains bisaccate; size -range 45—55 × 43-54 μm. Central body circular to subcircular, 30-43 μm in size, finely granulose. Sacci equal in size, subequatorially attached, reniform, 43-45 × 18-25 μm in size, infrareticulate, reticulum finer towards the margins.

Comparison—The present species can be distinguished from other known species by its small size and finely granulose central body.

Genus—**Abiespollenites** Thiergart *in* Raatz, 1937

Type species—*Abiespollenites absolutus* Thiergart *in* Raatz, 1937

Abiespollenites sp.

Pl. 1, Fig. 9

Description—Pollen grain bisaccate; size 100 × 70 μm. Central body 90 × 30 μm, oblate in shape, granulose. Sacci smaller than central body, 50 × 30 μm in size, moderately reticulate distally pendent, proximal cap well developed, 3 to 4 μm thick, reticulum finer towards the attachment.

Comparison—The present specimen is superficially similar to *A. maximus* Krutzsch (1959) but differs from the latter by comparatively smaller size and thick proximal cap.

Genus—**Cedripites** Wodehouse, 1933

Type species—*Cedripites eocenicus* Wodehouse, 1933

cf. **Cedripites** sp.

Pl. 1, Fig. 10

Description—Pollen grain bisaccate, overall size 90 × 70 μm. Central body 90 × 30 μm subcircular or oval in equatorial view with undulating margin, granulose. Sacci small, subequatorially attached, subspherical, 50 × 30 μm in size, finely pitted.

Remarks—Since only single specimen of this form has been found, detailed study could not be possible.

Genus—**Palmaepollenites** (Potonié) Potonié, 1951

Type species—*Palmaepollenites tranquillus* (Potonié) Potonié, 1951

Palmaepollenites sp.

Pl. 1, fig. 11

Description—Pollen grain boat-shaped; size 25×14 μm. Monosulcate, sulcus distinct, long, straight, extending from one end to the other, uniformly broad, bordered by thickened lips. Exine 1 μm thick, laevigate.

Comparison—The present specimen can be distinguished from the other known species of the genus by thickened lips bordering the sulcus.

Genus—**Tricolpites** Cookson *ex* Couper emend. Potonié, 1960

Type species Tricolpites reticulatus Cookson, 1947

Tricolpites sp.

Pl. 1, Fig. 12

Description—Pollen grain oval in equatorial view; size 45×25 μm. Tricolpate, colpi long, thin, uniformly broad, straight, length more than 2/3 of the longer axis. Exine thin, ±1 μm thick, finely granulose.

Remarks—The present specimen resembles *Tricolpites* except for having a granulose exine instead of reticulate. Since at present no genus is available to satisfactorily accommodate granulose, tricolpate pollen, it is provisionally assigned to *Tricolpites*. Kemp and Harris (1977 p. 29) have also given similar treatment to the psilate and spinose tricolpate pollen grains recovered from the Tertiary sediments of Nintyeast Ridge of Indian Ocean.

Genus—**Retitrescolpites** Sah, 1967

Type species—*Retitrescolpites typicus* Sah, 1967

Retitrescolpites africanus Sah, 1967

Pl. 1, Fig. 13

Description—Pollen grain spherical in equatorial view, size 65 μm. Tricolpate, colpi long, broad. Exine ± 3 μm thick, sexine thicker than nexine, retipilariate, pila distinct, surface sculpture reticulate, muri of reticulum broad, lumina subcircular to polygonal, ± 5 μm in diameter.

Retitrescolpites minutes sp. nov.

Pl. 1, Figs. 14—15

Holotype—Pl. 1, fig. 15; size 27×25 μm. Slide no. 6848, co-ordinates 3.5×69.8.

Type locality—1 km. from Bhakra along Bhakra-Nangal Road, Bilaspur district Himachal Pradesh, India. Lower Siwalik.

Diagnosis—Pollen grains subcircular in polar view, size range 23-30 μm. Tricolporoidate, colpi small, thin; pore small in size, circular in shape. Exine ± 2.5 μm thick, stratified, sexine thicker than nexine, retipilariate, pila very small, pin-head like, closely placed, imparting a pseudoreticulate appearance.

Comparison—*Retitrescolpites minutes* sp. nov. can be distinguished from *R. africanus* Sah (1967) by its very small size-range and short pila. *R. typicus* Sah (1967) differs in having bigger size-range and distinctly reticulate ornamentation. *R. splendens* Sah (1967) possesses bigger size-range and very few lumina of varying shapes and sizes, hence distinctly different from the present species. *R. kivuensis* Sah (1967) can be differentiated by its baculate exine.

Genus—**Granustephanocolpites** Saxena, 1979

Type species—*Granustephanocolpites granulatus* (Venkatachala & Kar) Saxena, 1979

Granustephanocolpites sp.

Pl. 1, Figs. 16-17

Description—Pollen grains subcircular and septalobate; size 42×38 μm. Polycolpate, colpi 7 in number, narrow, 5 to 7 μm in length, mesocolpial margin highly convex. Exine ± 4 μm thick, granulose, grana small, closely placed, sexine thicker than nexine.

Comparison—*G. cooksonii* (Sah & Dutta) Saxena (1982) can be differentiated from the present species in having 5 to 6 colpi. *G. vimalii* (Sah & Dutta) Saxena (1982) possesses 8 longer colpi and much thicker exine, hence quite different.

Genus—**Sapotaceoidaepollenites** Potonié, Thomson & Thiergart, 1950

Type species—*Sapotaceoidaepollenites manifestus* (Potonié) Potonié, 1960

Sapotaceoidaepollenites parvus Sah, 1967

Pl. 1, Fig. 18

Description—Pollen grain oval; size 19×12 μm Tricolporate, colpi long, narrow; pore small, circular, lalongate, Exine thin, laevigate.

Genus—**Tetracolporites** Couper, 1953

Type species—*Tetracolporites oamaruensis* Couper, 1953

Tetracolporites sp.

Pl. 1, Fig. 19

Description—Pollen grain spheroidal, size 38×36 μm. Tetracolporate, colpi small, narrow; pore small, circular or elliptical in shape, pore margin thickened. Exine ± 2 μm thick, sexine thicker than nexine, laevigate.

Comparison—*Tetracolporites* sp. can be distinguished from other known species by its laevigate exine and presence of thickening around the pore. Only a single specimen has been recorded.

Genus—**Graminidites** Cookson, 1947

Type species—*Graminidites media* Cookson, 1947

Graminidites media Cookson, 1947

Pl. 1, Fig. 20

Description—Pollen grains subcircular, size-range 45—50 μm. Monoulcate, ulcus small, circular, surrounded by $\pm$ 2 μm thick annulus. Exine 1 μm thick, finely granulose.

Remarks—Most of the pollen grains have highly folded exine.

Genus—**Polyporina** Naumova *ex* Potonié, 1960
Type species—*Polyporina multistigmosa* (Potonié) Potonié, 1960

Polyporina globosa Sah, 1967
Pl. 1, Fig. 21

Description—Pollen grains circular to subcircular, size-range 25-28 μm. Polyporate, pores numerous, circular to slightly oval, $\pm$ 2 μm in diameter, scattered all over the exine. Exine $\pm$ 2.5 μm thick, pilate, tegillate.

FUNGAL REMAINS

Genus—**Inapertisporites** van der Hammen emend. Sheffy & Dilcher, 1971
Type species—*Inapertisporites pseudoreticulatus* Rouse, 1959

Inapertisporites minutus van der Hammen, 1954
Pl 2, Fig. 22

Description—Spores spherical, dark brown in colour, size-range 10-12 μm. Inaperturate, unicellate. Spore wall thin, up to 1 μm thick, scabrate.

Inapertisporites vulgaris Sheffy & Dilcher, 1971
Pl. 2, Figs. 23-24

Description—Spores subcircular, dark brown in colour, siz-range 6-7 μm. Inaperturate, unicellate. Wall smooth, less than 1 μm thick.

Remarks—In the present assemblage, *Inapertisporites vulgaris* has been recorded in an ascocarp-like structure, which is pear-shaped with reticulate surface ornamentation.

Inapertisporites circularis Sheffy & Dilcher, 1971
Pl. 2, Fig. 25

Description—Spores circular, size-range 12-14 μm. Spore wall $\pm$ 1 μm thick, smooth, pigment medium to light brown.

Inapertisporites ovalis Sheffy & Dilcher, 1971
Pl. 2, Fig. 26

Description—Spores oval, dark brown in colour, size $10\text{-}20 \times 5\text{-}10$ μm. Wall $\pm$ 1 μm thick, psilate.

Remarks—Size of the present specimen is comparatively bigger than those described by SHEFFY AND DILCHER (1971).

Genus—**Dicellaesporites** Elsik emend. Sheffy & Dilcher, 1971
Type species—*Dicellaesporites popovii* Elsik, 1968

Dicellaesporites fusiformis Sheffy & Dilcher, 1971

Pl. 2, Fig. 29

Description—Spore fusiform in shape; size 20×10 μm. Dicellate, one cell bigger than the other. single septum present. Spore wall smooth, 1 μm thick.

Genus—**Multicellaesporites** Elsik emend. Sheffy & Dilcher, 1971

Type species—*Multicellaesporites nortonii* Elsik, 1968

Multicellaesporites sp. A

Pl. 2, Fig. 32

Description—Fungal spore cone-shaped, dark brown in colour; a long hyphae attached at one end; size 30×22 μm. Tricellate, middle cell larger in size, uppermost cell triangular, basal cell subcircular, septa thin. Spore wall ± 1 μm thick, psilate. Stalk 30 μm in length and 4 μm in width, cylindrical, nonseptate, golden yellow in colour.

Comparison—The present specimen differs from other known species by its cone-shaped appearance and presence of long stalk. *Multicellaesporites simplicissimus* Sheffy & Dilcher (1971) possesses oval shape, smaller size-range and no stalk, hence quite different from the former. *M. capsularis* Sheffy & Dilcher (1971) can be distinguished by the presence of thick, non-parallel septa.

Multicellaesporites sp. B

Pl. 2, Fig. 30

Description—Fungal spore elongated-oblong in shape; size 50×10 μm. Septacellate, middle cells comparatively larger and rectangular in shape, terminal cells taper; septa 6, thin, few longitudinal septa present in the middle cells. Spore wall 5 μm thick, faintly granulose.

Comparison—The present specimen can be distinguished from other known species by its longitudinal septa and faintly granulose spore wall. *M. elongatus* Sheffy & Dilcher (1971) resembles the present specimen in septacellate condition but differs in having psilate spore wall and tapered terminal cell forming flat basal attachment.

Multicellaesporites sp. C

Pl. 2, Fig. 31

Description—Fungal spore elongated-elliptical in shape; size 26×10 μm. Inaperturate, tetracellate, terminal cells taper, middle cells bigger in size than the terminal ones, septa weakly developed. Wall less than 1 μm thick, dark brown in colour, ± 0.5 μm thick, granulose, grana small.

Comparison—*Multicellaesporites ellipticus* Sheffy & Dilcher (1971) resembles the present specimen in tetracellate condition but differs in having slight constriction between two middle cells. *M. allomorphus* Sheffy & Dilcher (1971) compares favourably with this specimen in tetracellate condition and granulose spore wall but differs in having central constriction in second cell and blunt opposite end.

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

Type Species—*Pluricellaesporites typicus* van der Hammen, 1954

Pluricellaesporites sp.

Pl. 2, Fig. 33

Description—Fungal spore light brown in colour; size 77×15 μm. Pentacellate, basal cells flattened, apex round with a single pore, one end of the cell highly constricted to form a cap-like structure, central cells bigger in size, septa disc like, thin, few longitudinal folds observed. Spore wall psilate, ± 1 μm thick.

Comparison—The present specimen can be differentiated from other known species by its bigger size-range and constricted neck-like cell. *P. suboblongatus* Sheffy & Dilcher (1971) differs from the present specimen by its smaller size and thick septa.

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

Type Species—*Monoporisporites minutus* van der Hammen, 1954

Monoporisporites sp.

Pl. 2, fig. 27

Description—Fungal spore circular to subcircular in shape, dark brown in colour; size 15 μm, Monoporate, pore circular in shape bordered by a thick margin, wall double layered, ± 1 μm thick, psilate to scabrate.

Comparison—*Monoporisporites* sp. closely resembles *M. annulatus* van der Hammen (1954) in overall appearance but latter can be distinguished by its asymmetrical pore with raised annulus. *M. ovates* Sheffy & Dilcher (1971) differs from this in its oval shape and apical pore.

Genus—**Diporisporites** van der Hammen, emend. Elsik, 1968

Type species—*Diporisporites elongatus* van der Hammen, 1954

Diporisporites hammenii Elsik, 1968

Pl. 2, Fig. 28

Description—Fungal spore oval with both ends rounded, size 23×16 μm. Unicellate, diporate, pores small, one pore at each end. Wall stratified, ± 1 μm thick, psilate.

Remarks—The size of the present specimen is comparatively bigger than the specimens originally described by Elsik (1968).

Genus—**Phragmothyrites** Edwards emend. Kar & Saxena, 1976

Type species—*Phragmothyrites eocaenica* Edwards emend. Kar & Saxena, 1976

Phragmothyrites eocaenica Edwards emend. Kar & Saxena, 1976

Pl. 2, Fig. 34

Description—Ascostromata subcircular, size range 44-65 μm. Nonostiolate. Hyphae radially arranged and interconnected with each other to form pseudoparenchymatous cells, free hyphae absent. Cells of the central region slightly bigger than peripheral ones, polygonal to hexagonal in shape, marginal cells ± squarish to subcircular in shape.

Phragmothyrites assamicus (Kar, Singh & Sah) comb. nov.

Pl. 2, Fig. 35

Basionym—*Callimothallus assamicus* Kar, Singh & Sah, 1972 *Palaeobotanist* 19(2): 151, pl. 2, figs. 19-20

Holotype—*Callimothallus assamicus* Kar, Singh & Sah, 1972, pl. 2, fig. 19.

Description—Ascostromata subcircular; size range 140 × 100 μm, Nonostiolate, margin wavy, central cells more or less circular in shape, marginal cells bigger in size and rectangular in shape, a small circular pore present in each cell of the central region, margin of the individual cell thickened.

Remarks—Kar and Saxena (1976) merged *Callimothallus* into *Phragmothyrites* Edwards emend. Kar & Saxena (1976), hence this species is recombined with the latter.

Phragmothyrites sp.

Pl. 2, Fig. 36

Description—Ascostromata circular to subcircular in shape with irregular margin, size 120 × 100 μm. Nonostiolate. Hyphae radially arranged, interconnected with each other to form a thick pseudoparenchymatous disc-shaped structure, free hyphae absent. Cells small, elongated, arranged in a centrifugal manner. Size of the cells almost same throughout the ascostromata.

Comparison—The present specimen can be distinguished from the other known species by its small, uniformly distributed cells and irregular margin.

Genus—**Notothyrites** Cookson, 1947

Type species—*Notothyrites setiferus* Cookson, 1947

Notothyrites setiferus Cookson, 1947

Pl. 2, Fig. 37

Description—Ascostromata subcircular; size 100 μm. Hyphae radially arranged, interconnected with each other to form small, rectangular cells forming pseudoparenchymatous structure. Ostiolate, ostiole 20 μm in diameter, surrounded by a dark brown, rim-like structure, few setae present, margin of the ascostromata thickened.

Notothyrites amorphus Kar & Saxena, 1976

Pl. 2, Fig. 39

Description—Ascostromata subcircular, dark brown in colour, size 80 μm in diameter, radiating hyphae forms a pseudoparenchymatous structure, structure of the individual cells is not clearly discernible. Ostiolate, ostiole 9 μm in diameter, ostiole margin thickened.

Genus—**Aplanosporites** Kar, 1979

Type species—*Aplanosporites robustus* Kar, 1979

Aplanosporites robustus Kar, 1979

Pl. 2, Fig. 40

Description—Palynomorph irregular in shape, highly folded, size 80 × 45 μm.

Wall ± 2 μm thick, laevigate. A tail-like appendage present, $\pm$ 60 μm in length and 4 to 5 μm in width.

Genus—**Frasnacritetrus** Taugourdeau emend. Saxena & Sarkar, in press

Type species—Frasnacritetrus josettae Taugourdeau, 1968

Frasnacritetrus sp.

Pl. 2, Fig. 38

Description—Fungal conidia quadriseriate. Body rectangular in shape; size 60 $\times$ 40 μm, laterally slightly bulging out, quadrangular. Surface verrucose in ornamentation verrucae very small, closely placed, setae straight uniformly broad, 60-65 μm long and 2-3 μm wide, septate.

DISCUSSION

The palynoflora recorded here from the Lower, Middle and Upper Siwalik sediments of Bhakra-Nangal road section, Himachal Pradesh comprises fungal remains, pteridophytic spores and gymnospermous and angiospermous pollen grains. Altogether, 27 genera and 36 species have been recorded. Of these, only a single species is new (Fig. 2). Angiospermous pollen grains and fungal-remains constitute the dominent elements, whereas gymnospermous pollen and pteriodphytic spores are comparatively less represented. Moreover, not a single bryophytic spore has been found. The qualitative and quantitative analysis of the present palynofloral assemblage has been discussed below :

Qualitative Analysis

Division—Thallophyta

Fungal spores and epiphyllous microthyriaceous fungi, represented by 10 genera and 18 species, were recovered from almost all the productive levels of the Siwalik sequence. The rich representation of 4 species of *Inapertisporites*, viz., *I. minutus*, *I. vulgaris*, *I. circularis* and *I. ovalis* is quite apparent. Other identified fungal forms are : *Dicellaesporities fusiformis*, *Multicellaesporites* spp. A, B, C, *Pluricellaesporites* sp., *Monoporisporites* sp., *Diporisporites hammenii*. *Phragmothyrites eocaenica*, *P. assamicus*, *Phragmothyrites* sp., *Notothyrites setiferus*, *N. amorphus*, *Aplanosporites robustus*, and *Frasnacritetrus* sp.

Division—Pteridophyta

Pteridophytic spores are represented by 6 genera and 6 species. On the basis of comparative morphology, it appears that they might be related to the following 4 families :

1. *Cyatheaceae*—The spores referred to *Cyathidites australis* seem to be related to the family Cyatheaceae. The present day distribution of this family is restricted to tropical and subtropical climatic belt.

2. *Schizaeaceae*—This family is very poorly represented in the Bhakra-Nangal assemblage. The only species of *Lygodiumsporites*, viz., *L. eocenicus* appears to have affinity with this family. The members of this family chiefly grow in tropical and subtropical regions.

3. *Parkeriaceae*—The spores of *Striatriletes susannae* seem to be related to the family Parkeriaceae. The present day distribution of this family is restricted to tropical to subtropical climatic regions.

4. *Polypodiaceae*—Three forms, viz., *Polypodiaceaesporites* sp., *Polypodiisporites* sp. and *Monolites* sp. can be referred to the family polypodiaceae. This family is cosmopolitan in distribution but rarely occurs in dry region.

Division—SPERMATOPHYTA

Sub-division—GYMNOSPERMAE

Although gymnospermous pollen grains are comparatively less represented, still they form a significant group in some horizons ; 3 genera and 3 species of gymnospermous pollen grains have been recorded and most likely they belong to Pinaceae.

1. *Pinaceae*—This family is represented in the present palynoflora by *Pinuspollenites* sp., *Abiespollenites* sp. and *Cedripites* sp. The members of this family are distributed in subtemperate to temperate clmatic regions.

Sub-division—ANGIOSPERMAE

The angiospermous pollen grains are represented by 8 genera and 9 species. Of these, only 2 genera and 2 species belong to monocotyledons and 6 genera and 7 species belong to dicotyledons.

Class—MONOCOTYLEDONAE

The monocotyledonous pollen grains are represented by 2 families, viz., Palmae and Poaceae.

1. *Palmae*—Pollen grains referred to *Palmaepollenites* sp. show close affinity with the family Palmae. The members of this family are restricted to tropical and subtropical region.

2. *Poaceae*—The representation of this family in the present assemblage is evidenced by the pollen grains referable to *Graminidites media*. Plants belonging to this family are mostly found in drier regions.

Class—DICOTYLEDONAE

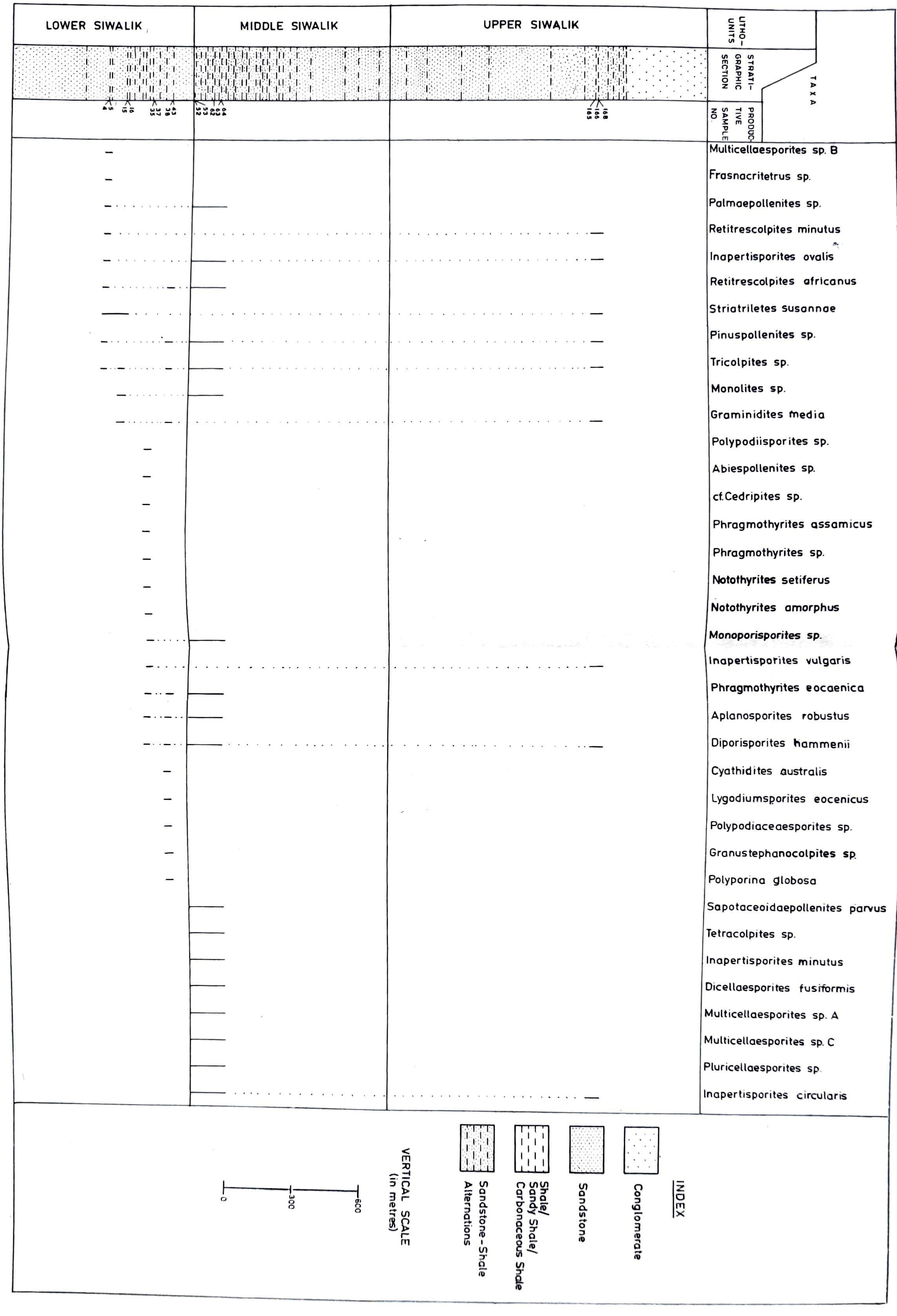
The dicotyledonous pollen grains in the present assemblage are assigned to 6 families.

1. *Oleaceae*—Two species of *Retitrescolpites*, viz., *R. africanus*, and *R. minutus* indicate the presence of this family. This family is principally tropical to warm temperate in distribution.

2. *Chenopodiaceae*—The presence of this family is indicated by the pollen grains of *Polyporina globosa*. The members of this family grow mainly in halophytic conditions.

3. *Sapotaceae*—This family is represented by the pollen grains referable to *Sapotaceoidaepollenites parvus*. The family has tropical to subtropical distribution.

Fig. 2. Showng the stratigraphic distribution of the various palynomorph species in the Siwailk sequence of Bhakra-Nangal area.



LOWER SIWALIK
MIDDLE SIWALIK
UPPER SIWALIK
LITHO-UNITS
STRATI-GRAPHIC SECTION
PRODUC-TIVE SAMPLE NO.
TAXA
4 5 15 16 35 37 38 43
52 53 62 63 64
165 166 168
Multicellaesporites sp. B
Frasnacritetrus sp.
Palmaepollenites sp.
Retitrescolpites minutus
Inapertisporites ovalis
Retitrescolpites africanus
Striatriletes susannae
Pinuspollenites sp.
Tricolpites sp.
Monolites sp.
Graminidites media
Polypodiisporites sp.
Abiespollenites sp.
cf.Cedripites sp.
Phragmothyrites assamicus
Phragmothyrites sp.
Notothyrites setiferus
Notothyrites amorphus
Monoporisporites sp.
Inapertisporites vulgaris
Phragmothyrites eocaenica
Aplanosporites robustus
Diporisporites hammenii
Cyathidites australis
Lygodiumsporites eocenicus
Polypodiaceaesporites sp.
Granustephanocolpites sp.
Polyporina globosa
Sapotaceoidaepollenites parvus
Tetracolpites sp.
Inapertisporites minutus
Dicellaesporites fusiformis
Multicellaesporites sp. A
Multicellaesporites sp. C
Pluricellaesporites sp.
Inapertisporites circularis
INDEX
Conglomerate
Sandstone
Shale/ Sandy Shale/ Carbonaceous Shale
Sandstone-Shale Alternations
VERTICAL SCALE (in metres)
0
300
600

4. *Cruciferae*—Although definite evidence for the occurrence of this family is lacking, still *Tricolpites* sp. may doubtfully be referred to Cruciferae. The members of this family are cosmopolitan in distribution and grow in diverse conditions.

5. *Meliaceae*—It is represented by the pollen grains referred to *Tetracolporites* sp. The present day distribution of this family is mostly in tropical to subtropical regions.

6. *Lentibulariaceae-Granustephanocolpites* sp. indicates the presence of this family. The family is cosmopolitan in distribution.

Quantitative Analysis

The overall representation of miospores in the assemblage is as follows : pteridophytic spores (11%), gymnospermous pollen grains (14%), angiospermous pollen grains (39%) and fungal spores and ascostromata (36%).

The frequency of the angiospermous pollen grains in the Lower, Middle and Upper Siwalik Sediments is 41, 35 and 47 per cent respectively. Among the angiospermous pollen grains, some of the significant forms are : *Graminidites media* (33%), *Tricolpites* sp. (15%) *Retitrescolpites* spp. (15%) *Polyporina globosa* (5%), *Granustephanocolpites* sp.

Gymnospermous pollen grains share 15, 13 and 5 per cent of the Lower, Middle and Upper Siwalik assemblages respectively. Amongst the gymnospermous pollen grains alone, *Pinuspollenites* sp. (79%) is the most common element, while other two forms, viz., cf. *Cedripites* sp. and *Abiespollenites* sp. are represented by 14% and 7% respectively. Pteridophytic spores are comparatively less represented in the present assemblage and their occurrence in the Lower, Middle and Upper Siwalik is 11%, 5% and 19% respectively. *Striatriletes susannae* is the most common species sharing about half of the total pteridophytic spores.

The remaining part of the assemblage is represented by a variety of fungal spores, conidia and ascostromata. They dominate in the Middle Siwalik (47%) while in the Lower and Upper Siwalik they constitute 33 per cent and 29 per cent respectively. Among the fungal elements microthyriaceous ascostromata are represented by 29% whereas *Inapertisporites* and *Diporisporites* constitute 28 per cent and 12 per cent respectively.

From the foregoing discussion it is evident that in the Lower Siwalik angiospermous pollen grains are the dominant components followed by fungal, gymnospermous and pteridophytic elements whereas in the Middle Siwalik fungal elements dominate over the angiospermous and gymnospermous pollen grains and pteridophytic spores are comparatively less represented. In the Upper Siwalik, angiospermous pollen grains dominate over the other elements, pteridophytic spores show increase in its frequency and gymnospermous pollen start declining (Fig. 2).

Comparison with earlier recorded palynoflora (Banerjee, 1968) from the same area

A comparison of the present miofloral assemblage with that recorded by Banerjee (1968) from the Lower and Middle Siwalik Sediments of Bhakra-Nangal area has been extremely difficult due to inconsistant status of various taxa recorded in the latter. For example, trilete spores have been referred to families Gleicheniaceae and Polypodiaceae and also to morphographical groups like trilete and trilobate,;

monolete spores have been grouped partly under Polypodiaceae and partly under monolete ; bisaccate pollen grains have been partly referred to *Pinus* and partly to invalid artificial genus *Disaccites* sp. Similarly, angiospermous pollen grains also have been referred variously either to families Palmae, Gramineae (Poaceae) and Compositae or to artificial groups, viz., tricolpate, tetracolpate, polycolpate and pentaporate. It has also been observed that the total percentages of taxa shown in the Lowei Siwalik's histogram comes to 61.5 per cent and in Middle Siwalik to 38.5 per cent (Banerjee, *op. cit.*, p. 173). It therefore appears that the two histograms have been made by counting all spores and pollen grains together irrespective of their occurrence in Lower or Middle Siwalik. Percentages of various taxa thus obtained have been shown in the two histograms and as such they represent the percentagess of the taxa in overall assemblage and not in the Lower or Middle Siwalik separately. For example : 5.5 per cent representation of *Pinus* in Lower Siwalik and 25.5 per cent representation of the same in the Middle Siwalik mean that this much percentages of overall assemblage from Lower and Middle Siwalik are represented by *Pinus* in two respective horizons. It does not mean that 5.5% of the Lower Siwalik or 25.5 percent of the Middle Siwalik assemblages are *Pinus* pollen. Similarly Composite pollen grains which are shown in the Lower Siwalik histogram as 5.5 per cent are infact 5.5 per cent of the overall assemblage and not of the Lower Siwalik assemblage alone. The same applies for all other taxa.

To overcome above, the percentages of the various taxa of Lower Siwalik have been multiplied by 100/61.5.,i.e. 1.63 and those of Middle Siwalik taxa by 100/38.5,i.e 2.6. This provided the percentages of the various taxa in Lower and Middle Siwaliks separately. To bring consistency in the status of various taxa trilete, monolete, trilobate, Gleicheniaceae and Polypodiaceae have been grouped into one as pteridophytic spores; *Pinus, Disaceites* and inaperturate have been grouped under gymnospermous pollen grains ; and Palmae, Gramineae (Poaceae), Compositae, tricolpate, tetracolpate, polycolpate and pentaporate have been grouped together as angiospermous pollen grains. The percentages of various pollen groups, thus obtained, have been compared with those of the present assemblage as shown in table 1. The fungal remains, which constitute 33 per cent of Lower Siwalik and 47 per cent of Middle Siwalik assemblege described herein, are either completely unrepresented in the Banerjee's assemblage or they have not been considered for counting. Igaoring the fungal remains of the present assemblage too, we find the percentages of various groups as shown in brackets against each group (Table 1). The percentages, thus obtained, closely correspond

Table 2. Group-wise comparison of the present Lower and Middle Siwalik assemblages with those reported by Banerjee (1968) from the same area.

Assemblage / Groups	Lower Siwalik		Middle Siwalik	
	Banerjee (1968)	Present Assemblage	Banerjee (1968)	Present Assemblage
Pteridophytic spores	17.1%	11% (16.4%)	13%	5% (9.4%)
Gymnospermous pollen	21.9%	15% (22.4%)	66.2%	13% (24.5%)
Angiospermous pollen	61.0%	41% (61.2%)	20.8%	35% (66.1%)
Fungal remains	0%	33%	0%	47%

to those of Banerjee's assemblage, except for the comparatively less representation of gymnospermous pollen with corresponding increase of angiospermous pollen in Middle Siwalik.

In fact, there is no significant difference as observed between the present Lower and Middle Siwalik assemblages. It is because of the fact that the present Middle Siwalik assemblage could be recovered only from the lowermost level of the Middle Siwalik while remaining portion was found to be completely unfossiliferous (Fig. 2). The Middle Siwalik assemblages of BANERJEE (1968) appears to be derived from the younger levels of the Middle Siwalik hence shows some differences from the present one.

COMPARISION WITH OTHER SIWALIK MIOFLORAS

LOWER SIWALIK—The Lower Siwalik palynoflora has been recorded by VENKATACHALA (1972), MATHUR (1973), NANDI (1975) and GHOSH (1977). VENKATACHALA (1972) mentioned that the Lower Siwalik sediments are characterized by the pollen grains of Palmae and Poaceae(=Gramineae) and *Quercoidites*, *Holoragacidities*, *Cupuliferoipollenites*, *Sapotareoidaepollenites* and *Araceoipollenites*. Of this assemblage, pollen of Palmae and Poaceae are also recorded from the present Lower Siwalik palynoflora.

MATHUR (1973) described an assemblage, consisting of 13 genera, from the Lower Siwalik of Tharukhola-Chepang, northeast of Nepalgange, Nepal. Of this assemblage, *Cyathidites*, *Leiotriletes* (±=*Lygodiumsporites*), *Cicatricosisporites* (±=*Striatriletes*), *Verrucososporites* (±=*Polypodiisporites*), *Pityosporites* (±=*Pinuspollenites*) and *Graminidites* occur in the present assemblage too.

NANDI (1975) and GHOSH (1977) proposed a palynostratigraphic zonation of the Siwalik Group and from Lower Siwalik they recorded 28 spore-pollen genera. Of these, 11 genera, viz., *Cyathidites*, *Cicatricosisporites* (±=*Striatriletes*), *Verrucosisporites*, *Verrucatosporites*, *Polypodiisporites*, *Polypodiidites* (±=*Polypodiisporites*) *Polypodiaceaesporites*, *Laevigatosporites* (±=*Monolites*), *Pinuspollenites*, *Palmaepollenites* and *Monoporopollenites* (±=*Graminidites*) are also found in the present Lower Siwalik assemblage.

MIDDLE SIWALIK—The Middle Siwalik palynoflora has been described by LUKOSE, (1969), NANDI and BANDYOPADHYAY (1970), VENKATACHALA (1972), NANDI (1972, 1975) and GHOSH (1977), LUKOSE (1969) described 11 spore-pollen genera from the Middle Siwalik of Raxaul, Bihar, of which only one type, viz., *Disaccites* sp. (±=*Pinuspollenites* sp.) appears to be common to the present assemblage.

NANDI AND BANDYOPADHYAY (1970) recorded some monoporate, periporate, inaperturate, polycolpate, monosaccate, bisaccate and fungal spore types from the Middle Siwalik. Except for the bisaccate and fungal spore types, none of the types of this assemblage has been recorded from the present Middle Siwalik assemblage.

VENKATACHALA (1972) mentioned palynomorphs belonging to Malvaceae, Betulaceae, Anacardiaceae, Pinaceae and Polypodiaceae from the Middle Siwalik. Out of the above, the latter two families have been recorded from the present assemblage too.

NANDI (1972) described Middle Siwalik assemblage from Mohand (East) field in Saharanpur district of Uttar Pradesh. This assemblage contains spores and pollen of Lycopodiaceae, Hymenophyllaceae, Schizaeaceae, Gleicheniaceae, Polypodiaceae, Cyatheaceae, monoporate (Cyperaceae) monosulcate (Palmae), polyporate, tricolporate, inaperturate types along with *Pinus* sp., *Podocarpus* sp. *Abies* sp. and monosaccate pollen. The present assemblage shows resemblance with this assemblage in the common occurrence of polypodiaceous spores and monosulcate, tricolporate, and *Pinus* type pollen grains. *Klukisporites*, *Concavissimisporites* and *Tsugaepollenites* recorded by Nandi (*l.c.*) may be reworked Mesozoic spores.

Nandi (1975) and Ghosh (1977) recorded 30 spore-pollen genera from the Middle Siwalik sediments, of which only two genera, viz., *Laevigatosporites* ($\pm$=*Monolites*) and *Pinuspollenites* have been recorded from the present Middle Siwalik assemblage.

Upper Siwalik—The Upper Siwalik palynoflora has been reported by Singh, Khanna and Sah (1973), Nandi (1975), Ghosh (1977), Saxena and Singh (1980, 1981, 1982a, b) and Singh and Saxena (1980, 1981).

Singh, Khanna and Sah (1973) reported *Pinus* type, monosulcate type and inaperturate (non-saccate) pollen grains from the Pinjor Formation, of which only the first type has been recorded from the present assemblage.

Nandi (1975) and Ghosh (1977) reported a very poor assemblage consisting of *Cyathidites, Alsophilidites, Leptolepidites, Pinuspollenites, Podocarpidites Monoporopollenites, Alnipollenites* and *Tetradomonoporites*. Of these, 2 genera, viz., *Pinuspollenites* and *Monoporopollenites* ($\pm$=*Graminidites*) are also common to the present assemblage.

Saxena and Singh (1980, 1981, 1982a) reported a rich assemblage from the Pinjor Formation exposed near Chandigarh. This assemblage compares with the present one in the common occurrence of *Striatriletes, Pinuspollenites, Graminidites* and *Inapertisporites*. However, complete absence of inaperturate pollen in the present assemblage and their dominance in the Pinjor palynoflora, is striking and may be attributed to the stratigraphical and geographical disparity of the two assemblages.

Singh and Saxena (1980, 1981) described an assemblage from the Upper Siwalik sediments of Gagret-Bharwain Road section in Una district, Himachal Pradesh. This assemblage compares with the present one in the common occurrence of *Pinuspollenites, Graminidites* and *Inapertisporites*. However, the absence of inaperturate palynomorphs like *Laricoidites*, and *Verrualetes* in the present mioflora and that of pteridophytic spores, and tricolpate pollen in Gagret-Bharwain assemblage are the major differences between the two, which cannot be overlooked.

Another Upper Siwalik palynoflora has been described by Saxena and Singh (1982b) from the Hoshiarpur-Una Road section. This assemblage resembles the present assemblage in common occurrence of *Pinuspollenites, Graminidites* and *Inapertisporites*. Inspite of the above similarities, the present assemblage differs from the Hoshiarpur-Una section's assemblage in the higher percentage of angiospermous pollen, poor representation of bisaccate pollen and complete absence of inaperturate palynomorphs.

SUMMARY AND CONCLUSIONS

From the foregoing account following conclusion can be derived.

(i) The present Siwalik assemblage from the Bhakra-Nangal area is a mixed one consisting of fungal remains (both spores and bodies), pteridophytic spores and gymnospermous and angiospermous pollen grains. There is no positive evidence of the presence of bryophytic spores.

(ii) The pteridophytic spores are represented by 6 genera and 6 species belonging to families Cyatheaceae, Schizaeaceae, Parkeriaceae and Polypodiaceae. These spores show an overall representation of 11% and in Lower, Middle and Upper Siwaliks 11%, 5% and 19% respectively.

(iii) The gymnospermous pollen grains are represented by 3 genera and 3 species related to Pinaceae. Their overall percentage comes to about 14% and in Lower, Middle and Upper Siwaliks 15%, 13% and 5% respecitvely.

(iv) The angiospermous pollen grains are represented by 8 genera and 9 species. Of these, 2 genera and 2 species belonging to Palmae and Poaceae are of monocotyledons while 6 genera and 7 species belonging to Oleaceae, Chenopodiaceae, Sapotaceae, Cruciferae, Meliaceae and Lentibulariaceae are of dicotyledons. The angiospermous pollen share 39% of the overall aseemblage and 41%, 35% and 47% respectively of Lower, Middle and Upper Siwalik assemblages.

(v) The fungal remains also constitute an important group in the assemblage, being represented by 10 genera and 18 species. Of these, *Inapertisporites*, represented by four species, is most common. Fungal remains constitute about 36% of the overall assemblage and 33%, 47% and 29% respectively of the Lower, Middle and Upper Siwalik assemblages.

(iv) The special feature of the present assemblage is the complete absence of inaperturate pollen grains which are found in most of the Siwalik palynofloras described earlier. Because of the absence of inaperturate pollen, gymnospermous pollen grain register lower percentage. This may be due to the stratigraphical and/or geographical disparity between the present assemblage and other ones.

(vii) A group-wise comparison of the present Lower and Middle Siwalik palynofloras with those described earlier by BANERJEE (1968) from the same area reveals that the frequency of the major groups of both the floras closely correspond in Lower Siwalik, while in Middle Siwalik, the present palynoflora shows a comparatively higher percentage of angiospermous pollen with corresponding decrease of gymnospermous pollen.

(viii) A comparison of the present Upper Siwalik assemblage with already known Upper Siwalik palynofloras reveals the overall comparatively poor representation of gymnospermous pollen grains in the former. This is probably due to the absence of inaperturate pollen grains. The frequency of the bisaccate gymnospermous pollen of the present Upper Siwalik mioflora corresponds with that of the Pinjor Formation (Upper Siwalik) mioflora from near Chandigarh.

(ix) No sharp change could be observed in the gross palynofloral constituents of the Lower and Middle Siwalik assemblages of the present flora. It may be due to the position of productive Middle Siwalik samples near the contact of Lower-Middle Siwalik so that the difference in the stratigraphic positions of the two assemblages remained very less and as such the difference between the two assemblages is also very less and insignificant.

(x) The mioflora shows complete absence of any element showing positive indications of marine or brackish water influence and as such a fluviatile environment of deposition for these sediments can safely be suggested. Some marine dinoflagellate cysts recorded in the present assemblage have been considered as reworked.

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EXPLANATION OF PLATES

(All photomicrographs are enlarged *ca* x 500 unless otherwise mentioned; Coordinates of specimens in slides refer to the stage of Olympus microscope no. 208125).

PLATE-1.

1. *Cyathidites australis* Couper; Slide no. 6837, coordinates 65 × 87.
2. *Lygodiumsporites eocenicus* Dutta & Sah; Slide no. 6838, coordinates 19. 5 × 87. 2.
3. *Striatriletes susannae* van der Hammen emend. Kar; Slide no. 6839, coordinates 7 × 91.
4. *Polypodiaceaesporites* sp. ; Slide no. 6840, coordinates 13. 5 × 115.
5. *Monolites* sp.; Slide no. 6841, coordinates 3 × 119.
6. *Polypodiisporites* sp.; Slide no. 6842, coordinates 22 × 86. 2.

7, 8. *Pinuspollenites* sp. ; Slide no. 6843, coordinates 18 × 88; 16 × 88.

9. *Abiespollenites* sp.; Slide no. 6842, coordinates 16.5 × 85.
10. cf. *Cedripites* sp.; Slide no. 6844, coordiantes 16 × 112.2.
11. *Palmaepollenites* sp.; Slide no. 6845, coordinates 12 × 93.
12. *Tricolpites* sp.; Slide no. 6846, coordinates 6.8 × 112.
13. *Retitrescolpites africanus* Sah; Slide no. 6846, coordinates 8 × 104.5.

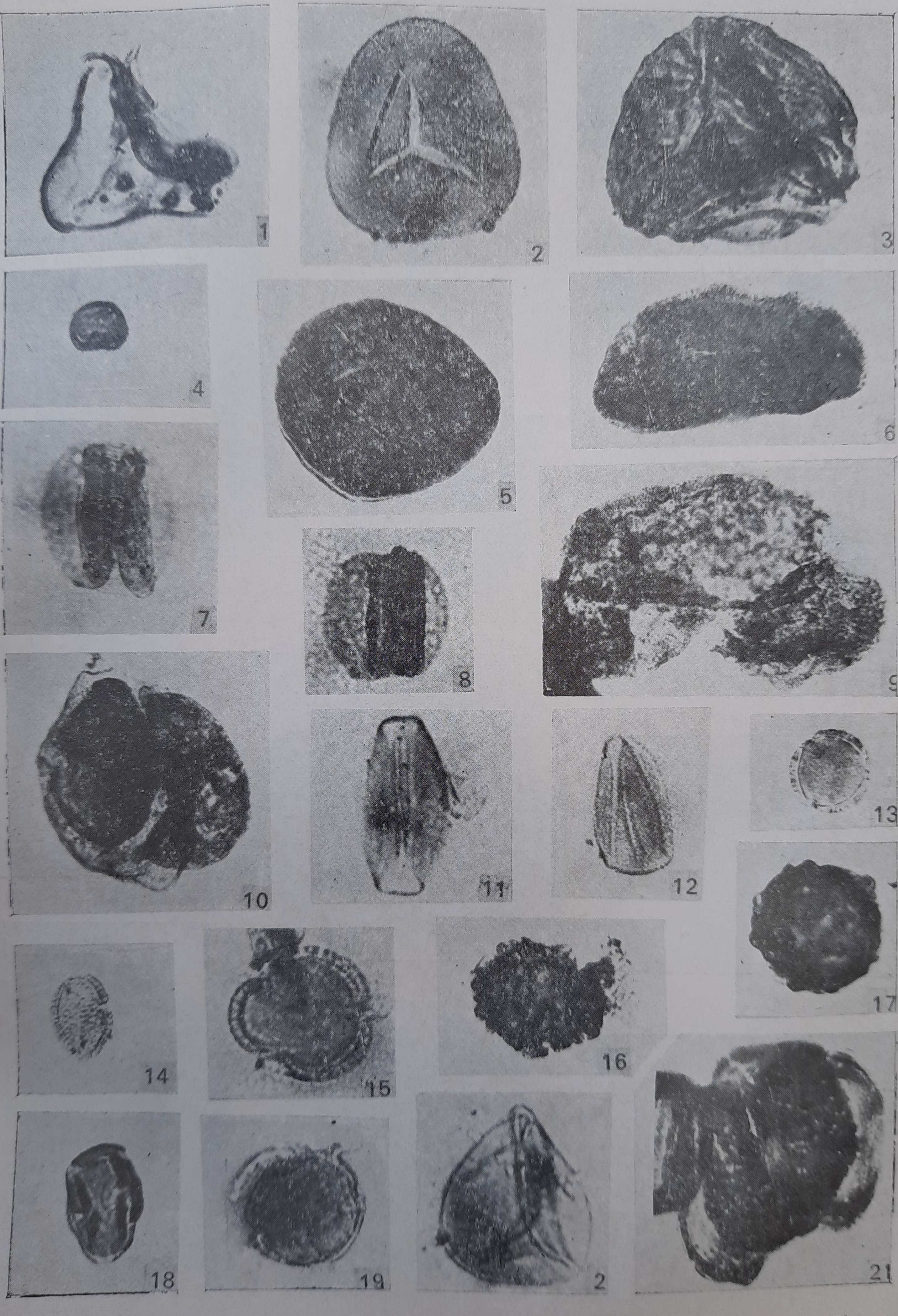
14, 15. *Retitrescolpites minutus* sp. nov., Slide nos. 6847, coordinates 3.5 × 96; 6848, coordinates 3.5 × 69 × 1000 (Holotype).

16, 17. *Granustephanocolpites* sp.; Slide no. 6849, coordinates 13.5 × 103; 10 × 86.3.

18. *Sapotaceoidaepollenites parvus* Sah; Slide no. 6850, coordinates 17.8 × 95.5, × 1000.
19. *Tetracolporites* sp.; Slide no. 6851, coordinates 16.5 × 103.
20. *Graminidites media* Cookson; Slide no 6852, coordinates 5.5 × 106.5.
21. *Polyporina globosa* Sah; Slide no. 6849, coordinates 10 × 86.3.

PLATE-2.

22. *Inapertisporites minutus* van der Hammen; Slide no. 6853, coordinates 106.5 × 18.5, × 1000.
23, 24. *Inapertisporites vulgaris* Sheffy & Dilcher; Slide no. 6840, coordinates 21.5 × 91; ascus containing ascospores; coordinates 19 × 85.5.
25. *Inapertisporites circularis* Sheffy & Dilcher; Slide no. 6854, coordinates 18 × 96.
26. *Inapertisporites ovalis* Sheffy & Dilcher; Slide no. 6850, coordinates 5.8 × 111, × 1000.
27. *Monoporisporites* sp.; Slide no. 6855, coordinates 17.4 × 101.5.
28. *Diporisporites hammenii* Elsik; Slide no. 6856, coordinates 4 × 94.
29. *Dicellaesporites fusiformis* Sheffy & Dilcher; Slide no. 6850, coordinates 14.5 × 78.5.
30. *Multicellaesporites* sp. B.; Slide no. 6857, coordinates 12.5 × 108.5.
31. *Multicellaesporites* sp. C.; Slide no. 6845, coordinates 10.5 × 100.
32. *Multicellaesporites* sp. A; Slide no. 6845. coordinates 6 × 84.
33. *Plnricellaesporites* sp. ; Slide no. 6849, coordinates 14 × 75.5.
34. *Phragmothyrites eocaenica* Edwards Kar & Sexena ; Slide no. 6849, coordinates 20 × 89.
35. *Phragmothyrites assamicus* (Kar, Singh & Sah) comb. nov.; Slide no. 6842, coordinates 12 × 110.
36. *Phragmothyrites* sp.; Slide no. 6858, coordinates 12 × 93.
37. *Notothyrites setiferus* Cookson; Slide no. 6859, coordinates 1 × 1134.
38. *Frasnacritetrus* sp. ; Slide no. 6843, coordinates 20 × 112.
39. *Notothyrites amorphus* Kar & Saxena ; Slide no. 6844, coordinates 2.5 × 108.
40. *Aplanosporites robustus* Kar; Slide no. 6840, coordinates 19 × 86.5.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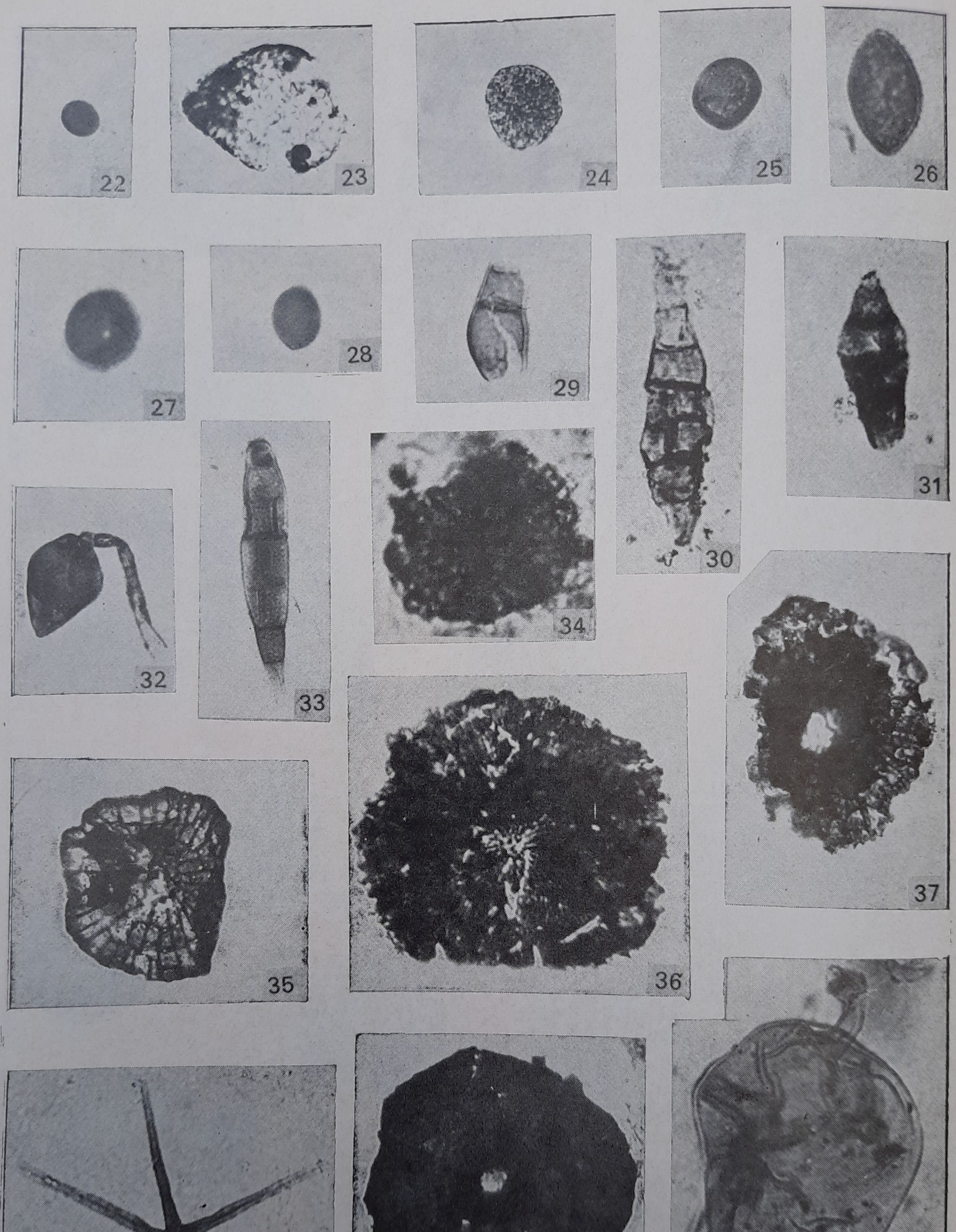
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