PALYNOLOGY OF THE TATROT-PINJOR SEQUENCE EXPOSED BETWEEN MASOL AND KIRATPUR, IN AMBALA DISTRICT, HARYANA

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Abstract

Palynofloral investigation of the Tatrot-Pinjor (Upper Siwalik) sequence exposed between Masol and Kiratpur in Ambala district, Haryana has been presented here. The palynoflora is represented by 17 genera and 23 species of fungal remains, pteridophytic spores and gymnospermous and angiospermous pollen. Of these, two species, viz., *Araucariacites masolensis* and *Frasnacritetrus siwalikus* are new. The Tatrot palynoflora is represented by 9 genera and 11 species whereas Pinjor palynoflora is represented by 15 genera and 20 species. Eight species are common to both the palynofloras. Although, both Tatrot and Pinjor assemblages are dominated by gymnospermous pollen (61% & 65% respectively), the Pinjor assemblage is distinct in having *Pinuspollenites* (16%) and *Pinjoriapollis* (10.5%) as against their total absence in Tatrot assemblage. The palynoflora indicates prevalence of tropical-subtropical climate with comparatively cooler climate in nearby upland areas during the Pinjor sedimentation. The environment of deposition has been interpreted as fluviatile.

Introduction

The Siwalik Group, developed all along the Himalayan foothills from Pakistan in the west to Burma in the east, constitutes an important and thick sequence of molasse deposits. These sediments form parallel, dissected ridges with varying aerial extent, trending northeast-southwest. The Siwaliks have extensively been investigated, mainly for their rich vertebrate fauna. Various other problems, viz., correlation—biostratigraphically or otherwise, lithostratigraphic classification, environment of deposition etc. kept alive the interest of geologists in these sediments. The fact that the beginning and culmination of the Siwalik sedimentation are associated with the major events of the Himalayan Orogeny makes the study of these sediments even more interesting. The Siwaliks have also been investigated for the demarcation of Neogene-Quaternary Boundary on the basis of faunal, magnetostratigraphic and other evidences and a considerable amount of data is now available on this aspect.

Palynological studies on the Siwalik sediments started rather late and the information available is scanty. Banerjee (1968), for the first time, published a short paper on the Lower and Middle Siwalik palynology of the Bhakra-Nangal area, Himachal Pradesh. This was followed by some more contributions on Lower and Middle Siwalik palynology by Lukose (1969), Nandi and Bandyopadhyay (1970), Venkatachala (1972), Nandi (1972), Mathur (1973), Saxena *et al.* (1984) and Saxena and Bhattacharyya (1987). Nandi (1975) and Ghosh (1977) divided the Siwalik sequence of Jawalamukhi area, Himachal Pradesh into four informal zones on the basis of the characteristic palynofossil distribution. Nandi (1980) provided formal status to these zones by giving the requisite information as per the Code of Stratigraphic Nomenclature of India (1971) and tried to extend them in the various Siwalik sections in Uttar Pradesh, Punjab and Himachal

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Pradesh. Ghosh (1977), Mathur and Venkatachala (1979) and Saxena and Singh (1982a) reviewed the contributions on Siwalik palynology made till then.

The palynological study of the Upper Siwalik sediments started comparatively later. Singh *et al.* (1973) reported the occurrence of *Pinus* type, monosulcate type and inaperturate (nonsaccate) pollen grains in the Pinjor Formation (Upper Siwalik) and surmised subtemperate to temperate climate therefor. Nandi (1975) and Ghosh (1977) mentioned that the basal part of the Upper Siwalik contains a very poor assemblage represented by *Cyathidites*, *Alsophilidites*, *Leptolepidites*, *Pinuspollenites*, *Podocarpidites*, *Monoporopollenites*, *Alnipollenites* and *Tetradomonoporites*, whereas rest of the Upper Siwalik sequence is unfossiliferous. Thereafter, a series of papers on Upper Siwalik palynology were published by the authors proving this sequence palynologically productive (Saxena & Singh, 1980, 1981, 1982a, b; Singh & Saxena 1980, 1981; Saxena *et al.*, 1984; Saxena & Bhattacharyya, 1987). The present contribution is yet another attempt in this direction.

The material for the present study was collected from the Tatrot and Pinjor formations (Upper Siwalik) exposed between Masol and Kiratpur in Ambala district, Haryana. The Tatrot Formation is composed of grey, brown and pale-purple clays and sandy clays interbedded with grey and brown, medium to coarse grained sandstone. This is conformably succeeded by the Pinjor Formation which is made up of purple or pale-red ferruginous clays and sandy clays alternating with grey, green and brown coarse grained sandstones and silty sandstones. Eleven samples (sample nos. 97 to 107) were collected from the Tatrot Formation, of which four samples proved to be productive; whereas twentyfive samples (sample nos. 108 to 132) were collected from the Pinjor Formation, of which ten samples yielded palynofossils. The details of samples are given in Table 1.

For recovery of palynofossils, the samples were treated with hydrofluoric acid. The digestion period of samples varied from 5-14 days. Since the samples contain less organic matter/spores-pollen, greater amount (approx. 100 gm) of samples was processed. The organic residue was prepared in polyvenyl alcohol and mounted in canada balsam. The slides and negatives have been deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Systematic Description

Genus—*TODISPORITES* Couper, 1958

Type species—*Todisporites major* Couper, 1958

Todisporites minor Couper, 1958

Pl. 1, Fig. 1

Occurrence—Pinjor Formation.

Affinity—Osmundaceae.

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. 4

Occurrence—Tatrot and Pinjor formations.

Affinity—Parkeriaceae (*Ceratopteris* type).

Table 1

Sample No.	Lithology	Productive/ Unproductive	Formation
132	Purple clay in yellowish-red sandstone	Unproductive	
131	,,	Productive	
129-130	Pale-green clay	,,	
128	Purple clay	,,	
126-127	Grey-purple clay	Unproductive	
125	Grey shaly siltstone	,,	
123-124	Purple clay	,,	
122	Grey clay	,,	
121	Clay in grey-purple sandstone	,,	Pinjor
120	Purple clay	Productive	Formation
119	Greenish-grey clay	Unproductive	
117-118	Pinkish-yellow clay	,,	
114-116	Purple clay	,,	
112-113	Purple, compact, shaly siltstone	Productive	
111	,,	Unproductive	
109-110	,,	Productive	
108	Purple clay	,,	
—Conformable contact—			
106-107	Grey clay	Unproductive	
104-105	Clay bands in grey sandstones	Productive	
103	,,	Unproductive	Tatrot
102	,,	Productive	Formation
100-101	Purple clay	Unproductive	
99	,,	Productive	
98	Argillaceous grey sandstone	Unproductive	
97	Purple clay	,,	

Genus—*TSUGAEPOLLENITES* Potonié & Venitz emend. Potonié, 1958
Type species—*Tsugaepollenites igniculus* (Potonié) Potonié & Venitz, 1934

Tsugaepollenites sp.
Pl. 1, Figs. 7, 13

Description—Pollen grains subcircular in shape. Size range 85-100 μm. Inaperturate, monosaccate, saccus sometimes indistinct. Exine about 1 μm thick, scabrate, margin wavy.

Comparison—*Tsugaepollenites* sp. can be distinguished from *T. igniculus* by absence of rugulate exine of the central body.

Occurrence—Pinjor Formation.

Affinity—Pinaceae.

Remarks—This genus is a common element of Upper Mesozoic palynofloras and its occurrence in the present assemblage is rather unusual and may be attributed to reworking. The poor preservation and scanty representation of these forms further support this contention.

Genus—*PINUSPOLLENITES* Raatz, 1937
Type species—*Pinuspollenites labdacus* (Potonié) Raatz, 1937

Pinuspollenites siwalikus Singh & Saxena, 1981
Pl. 1, Fig. 5

Occurrence—Pinjor Formation.

Affinity—Pinaceae.

Genus—*LARICOIDITES* Potonié *et al.*, 1950 ex Potonié, 1958
Type species—*Laricoidites magnus* (Potonié) Potonié *et al.*, 1950

Laricoidites magnus (Potonié) Potonié *et al.*, 1950
Pl. 1, Fig. 3

Occurrence—Tatrot and Pinjor formations.

Affinity—Pinaceae.

Laricoidites sp.
Pl. 1, Fig. 6

Description—Pollen grains subcircular in shape. Size range 85-110×75-90 μm. Germinal mark absent. Exine 1 μm thick, finely scabrate, irregularly folded.

Comparison—*Laricoidites* sp. can be distinguished from *L. magnus* by its bigger size range and finely scabrate exine.

Occurrence—Tatrot Formation.

Affinity—Unknown.

Genus—*INAPERTUROPOLLENITES* Pflug & Thomson *in* Thomson & Pflug, 1953 emend. Saxena & Bhattacharyya, 1987
Type species—*Inaperturopollenites dubius* (Potonié & Venitz) Pflug & Thomson *in* Thomson & Pflug, 1953

Inaperturopollenites punctatus (Saxena) Saxena & Bhattacharyya, 1987
Pl. 1, Fig. 2

Occurrence—Tatrot and Pinjor formations.
Affinity—Pinaceae.

Inaperturate pollen type
Pl. 1, Fig. 8

Description—Pollen grain oval elliptical. Size 130×68 μm. Inaperturate. Exine 2 μm thick, scabrate.

Comparison—The present specimen resembles *Laricoidites* sp. in all the characters except for size variation.

Occurrence—Pinjor Formation.
Affinity—Unknown.

Genus—*ARAUCARIACITES* Cookson, 1947 ex Couper, 1953
Type species—*Araucariacites australis* Cookson, 1947

Araucariacites masolensis sp. nov.
Pl. 1, Figs. 11, 12, 15

Holotype—Pl. 1, fig. 12, size 67×65 μm, slide no. 9561.
Type locality—Masol, Ambala district, Haryana.
Type horizon—Tatrot Formation, Upper Siwalik.

Diagnosis—Pollen grains oval-subcircular in shape. Size range 60-85×50-65 μm. Inaperturate. Exine up to 1 μm thick, ornamented with grana and small coni, irregularly folded.

Comparison—*Araucariacites masolensis* sp. nov. is closely comparable with *A. australis* Cookson (1947) but can be distinguished from the latter by its finely granulate/conate exine.

Occurrence—Pinjor Formation.
Affinity—Araucariaceae.

Genus—*VERRUALETES* Singh & Saxena, 1984
Type species—*Verrualetes assamicus* Singh & Saxena, 1984

Verrualetes sp.
Pl. 1, Fig. 9

Description— Pollen grain subcircular in shape. Size 100 μm. Inaperturate. Exine 1.5 μm thick, verrucate, verrucae sparsely placed, folds present.

Comparison—*Verrualetes* sp. can be differentiated from *V. assamicus* Singh & Saxena (1984) by its bigger size and sparsely placed verrucae.

Occurrence—Tatrot and Pinjor formations.
Affinity—Unknown.

Genus—*PINJORIAPOLLIS* Saxena & Singh, 1981
Type species—*Pinjoriapollis magnus* Saxena & Singh, 1981

Pinjoriapollis lanceolatus Saxena & Singh, 1981
Pl. 2, Figs. 19, 20

Occurrence—Pinjor Formation.
Affinity—Magnoliaceae

Pinjoriapollis sp.
Pl. 1, Fig. 14

Description—Pollen grain oval-elongate in shape. Size 130×60 μm. Monosulcate, sulcus sometimes not clear due to folding. Exine about 3 μm thick, laevigate.
Occurrence—Pinjor Formation.
Affinity—Unknown.

Genus—*PALMIDITES* Couper, 1953
Type species—*Palmidites maximus* Couper, 1953

Palmidites maximus Couper, 1953
Pl. 2, Fig. 18

Occurrence—Tatrot Formation.
Affinity—Palmae.

Genus—*TRICOLPITES* Cookson ex Couper emend. Potonié, 1960
Type species—*Tricolpites reticulatus* Cookson, 1947

Tricolpites sp.
Pl. 2, Fig. 22

Description—Pollen grain oval in equatorial view. Size 24×16 μm. Tricolpate, colpi long. Exine about 1.5 μm thick, faintly scrobiculate.
Comparison—The present species closely compares with *Tricolpites* sp. described by Jain *et al.* (1973, pl. 2, fig. 47) from Barmer Sandstone, Rajasthan.
Occurrence—Tatrot Formation.
Affinity—Unknown.

Tricolpate pollen type
Pl. 1, Fig. 10

Description—Pollen grain triangular in shape. Size 40×30 μm. Tricolpate, brevicolpate. Exine thin, conate, coni about 0.5 μm high, sparsely placed in the apocolpial region.
Occurrence—Pinjor Formation.
Affinity—Unknown.

Genus—*CUPULIFEROIPOLLENITES* (Potonié) Potonié, 1951
Type species—*Cupuliferoipollenites pusillus* (Potonié) Potonié, 1951

Cupuliferoipollenites sp.
Pl. 1, Figs. 16, 17

Description—Pollen grains oval in equatorial view. Size range 22-25 × 12-15 μm. Tricolporate, colpi extending almost pole to pole, pore distinct. Exine 1 μm thick, finely granulate.

Comparison—*Cupuliferoipollenites ovatus* Venkatachala & Kar (1969) is comparable to the present specimen in shape and general organisation but the latter can be distinguished by its granulate exine.

Occurrence—Pinjor Formation.

Affinity—Unknown.

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. 26

Occurrence—Pinjor Formation.

Affinity—Microthyriaceae.

Phragmothyrites sp.

Pl. 2, Fig. 29

Description—Ascomata subcircular in shape. Non-ostiolate, dimidiate. Size 80×65 μm. Hyphae radially arranged but not distinct, middle cells less elongated than the marginal cells, outer margin thickened.

Comparison—*Phragmothyrites* sp. closely compares with *P. eocaenica* Edwards emend. Kar & Saxena (1976) but the former can be distinguished by its undifferentiated hyphae.

Occurrence—Pinjor Formation.

Affinity—Microthyriaceae.

Genus—*INAPERTISPORITES* van der Hammen, 1954 emend. Saxena & Bhattacharyya, 1987

Type species—*Inapertisporites pseudoreticulatus* Rouse, 1959

Inapertisporites kedvesii Elsik, 1968

Pl. 2, Fig. 24

Occurrence—Tatrot and Pinjor formations.

Affinity—Unknown.

Inapertisporites udarii Gupta, 1985

Pl. 2, Fig. 28

Occurrence—Pinjor Formation.

Affinity—Unknown.

Inapertisporites sp.

Pl. 2, Fig. 21

Description—Fungal spore lanceolate in shape. Size 120 × 70 μm. Unicellate, inaperturate. Spore wall 2 μm thick with many folds, scabrate.

Comparison—Inapertisporites sp. can be differentiated from *I. pseudoreticulatus* Rouse (1959) by its bigger size and scabrate spore wall.

Occurrence—Pinjor Formation.

Affinity—Unknown.

Genus—*POLYCELLAESPORONITES* Chandra *et al.*, 1984

Type species—*Polycellaesporonites bellus* Chandra *et. al.* 1984

Polycellaesporonites bellus Chandra *et al.*, 1984

Pl. 2, Fig. 30

Occurrence—Pinjor Formation.

Affinity—*Alternaria* sp.

Genus—*STAPHLOSPORONITES* Sheffy & Dilcher, 1971

Type species—*Staphlosporonites conoideus* Sheffy & Dilcher, 1971

Staphlosporonites multicellatus Saxena & Singh, 1982

Pl. 2, Figs. 23, 27

Occurrence—Pinjor Formation.

Affinity—Unknown.

Genus—*FRASNACRITETRUS* Taugourdeau, 1968 emend. Saxena & Sarkar, 1986

Type species—*Frasnacritetrus josettae* Taugourdeau, 1968

Frasnacritetrus siwalikus sp. nov.

Pl. 2, Figs. 31, 32, 33

Holotype—Pl. 2, fig. 31, size 75 ×20 μm (including processes), slide no. 9570.

Type locality—Masol, Ambala district, Haryana.

Type horizon—Tatrot Formation, Upper Siwalik.

Diagnosis—Fungal conidia with four processes. Main body oval in shape, dark brown in colour, ornamented with sparsely placed coni and grana, divided into 4 columns, each column terminates into a process. Processes tubular, wider at the base and gradually taper at the apices, nonseptate, smooth.

Dimensions

Length of the conidia 50—60 μm

Size of the body 25—35 μm

Size of the processess 32—45 μm

Comparison—Frasnacritetrus josettae Taugourdeau (1968) differs from *F. siwalikus* sp. nov. by its verrucate body. *F. conatus* Saxena & Sarkar (1968) can be differentiated by its unicellular and rectangular body. *F. taugourdeaui* Saxena & Sarkar (1986) can be distinguished by its spindle shaped, unicellular and granulose body.

Occurrence—Tatrot and Pinjor formations.

Affinity—*Tetraploa* sp. (Dematiaceae).

Frasnacritetrus sp.
Pl. 2, Fig. 34

Description—Fungal conidia with four processes, Main body rectangular in shape, smooth, divided by vertical septa into four columns, each terminating into a process. Processes tubular, broader at the base and taper towards the apices, septate, laevigate.

Dimensions

Length of the conidia 65—100 μm
Size of the body 20-- 30 μm
Size of the processes 30— 70 μm

Comparison—*Frasnacritetrus* sp. is closely comparable to *F. josettae* Taugourdeau (1968) but the latter can be distinguished by its verrucate body wall.
Occurrence—Tatrot and Pinjor formations.
Affinity—*Tetraploa* sp. (Dematiaceae).

Fungal spore type
Pl. 2, Fig. 25

Description—Ascomata circular in shape, dimidiate, non-ostiolate, no free hyphae. Body wall about 3 μm thick, surface shows negative reticulum.
Occurrence—Tatrot Formation.

Discussion

The palynoflora recorded here from the Tatrot and Pinjor formations consists of seventeen genera and twentythree species of fungal remains, pteridophytic spores and gymnospermous and angiospermous pollen grains. Of these, two species, viz., *Araucariacites masolensis* and *Frasnacritetrus siwalikus* are new. The Tatrot palynoflora is represented by nine genera and eleven species whereas the Pinjor palynoflora is populated by fifteen genera and twenty species. Eight species are common to both the palynofloras. The assemblage described in the preceding pages has been obtained from four samples from the Tatrot Formation and ten samples from the Pinjor Formation. The yield of palynofossils is generally poor and only in case of two samples (sample nos. 109 and 129) hundred specimens per sample could be counted. The poor recovery of palynofossils posed some problem for quantitative evaluation of the palynoflora and for this reason composite assemblages from the two formations were considered for this purpose.

An analysis of the Tatrot palynoassemblage shows that it is dominated by gymnospermous pollen grains (61%) followed by fungal remains (20%), pteridophytic spores (11%) and angiospermous pollen grains (8%). The fungal remains are represented by three genera, viz., *Inapertisporites*, *Staphlosporonites* and *Frasnacritetrus*, and four species. The pteridophytic spores are represented by only one species, viz., *Striatriletes susannae*, assignable to Parkeriaceae. The gymnospermous pollen grains are represented by two genera, viz., *Laricoidites* and *Inaperturopollenites* and three species assignable to Pinaceae. The angiospermous pollen are represented by three genera, viz., *Verrualetes*, *Palmidites* (aff. Palmae) and *Tricolpites*, each with one species. The special feature of the Tatrot palynoflora is the nonrepresentation of bisaccate-pinaceous and magnoliaceous pollen grains.

The Pinjor palynoflora is also dominated by gymnospermous pollen (65%) followed by fungal remains (19%), angiospermous pollen (13%) and pteridophytic spores (3%). The fungal remains are represented by five genera, viz., *Phragmothyrites*, *Inapertisporites*, *Staphlosporonites*, *Polycellaesporonites* and *Frasnacritetrus* and nine species. The pteridophytic spores are represented by two genera, viz., *Todisporites* and *Striatriletes* each having a single species. These are assignable to Osmundaceae and Parkeriaceae respectively. The gymnospermous pollen are represented by five genera, viz., *Tsugaepollenites*, *Pinuspollenites*, *Laricoidites*, *Inaperturopollenites* and *Araucariacites*, each with a single species. Of the above genera, first four are assignable to Pinaceae whereas fifth one has affinity with Araucariaceae. Amongst the gymnospermous pollen, inaperturate pollen constitute 72% and saccate pollen (mostly bisaccate) share 28%. The representation of saccate pollen in the Pinjor palynoflora broadly separates it from the Tatrot palynoflora of this area. The angiospermous pollen are represented by three genera, viz., *Verrualetes*, *Pinjoriapollis* and *Cupuliferoipollenites* and four species. Of these, *Pinjoriapollis* is best represented. Inspite of subordinate representation of the angiospermous pollen in the present Tatrot and Pinjor palynofloras, comparatively higher (10.5%) frequency of *Pinjoriapollis* in the Pinjor palynoflora and its absence in the Tatrot is a significant difference between the two. A group-wise distribution of the palynofossils in the Tatrot and Pinjor palynofloras is given in Table 2.

Table 2

Botanical groups	Tatrot	Pinjor
Fungal remains	20%	19%
Pteridophytic spores	11%	3%
Gymnospermous pollen (saccate)	0%	18%
Gymnospermous pollen (inaperturate)	61%	47%
Angiospermous pollen	8%	13%

Palaeoclimate — In spite of the poor recovery of palynofloras from the present Tatrot and Pinjor sequences, their analysis provides some clue for interpreting the palaeoclimate.

The Tatrot assemblage is represented by Parkeriaceae, Pinaceae and Palmae. All these families have present day distribution in tropical-subtropical region, except for Pinaceae which is distributed in subtropical-subtemperate region. The climate during Tatrot sedimentation therefore appears to be largely tropical-subtropical. The subtemperate elements, whatsoever, appear to be derived from the upland areas adjacent to the depositional site. The presence of a number of species of fungal remains indicate warm and humid conditions. This is supported by the red and brown colouration of the sediments which is suggestive of warm-humid conditions (Schwarzbach, 1963).

The Pinjor assemblage is represented by Osmundaceae, Parkeriaceae, Pinaceae, Araucariaceae and Magnoliaceae. Except for Pinaceae and Magnoliaceae, all the above families have present day distribution in tropical subtropical region suggesting this type of climate. The temperate-subtemperate elements appear to be derived from the rising

Himalayas. The good representation of temperate elements, i.e. bisaccate and magnoliaceous pollen, indicates further cooling in the area. A comparatively cooler climate is also indicated by less red and brown colouration in Pinjor sediments than that in the Tatrot sediments.

Environment of deposition—The Siwalik sediments, as a whole, are believed to be largely fluviatile deposits. However, doubts have been expressed from time to time, regarding some marine influence during Siwalik sedimentation (Talukdar, 1982). Saxena and Sarkar (1983) discussed this point and ruled out any possibility of marine influence atleast in the five Siwalik sections studied by them in Chandigarh and Himachal Pradesh. They explained that some of the dinoflagellate cysts recovered by them are reworked from the neighbouring Subathu (Eocene) sediments. In the present assemblage too, we did not recover any microfossil indicating marine influence. This indicates that the present Tatrot-Pinjor sequence was deposited in entirely fresh water conditions. That the deposition of Tatrot-Pinjor took place in a basically fluviatile environment has also been inferred on sedimentological and vertebrate fossil evidences (Gaur and Chopra, 1984).

Palynofloral Comparison

The Upper Siwalik palynoflora has been reported by Singh *et al.* (1973), Nandi (1975), Ghosh (1977), Singh and Saxena (1981), Saxena and Singh (1982a, b), Saxena *et al.* (1984) and Saxena and Bhattacharyya (1987).

Singh *et al.* (1973) reported the occurrence of *Pinus* type, monosulcate-type, inaperturate (non-saccate) pollen from a carbonaceous shale of Pinjor Formation exposed in the vicinity of Chandigarh. All these types have also been recorded from the present 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* is common to both the assemblages. Hence the two assemblages are not comparable.

Singh and Saxena (1981) described 10 genera and 14 species of gymnospermous and angiospermous pollen and fungal remains from the Upper Siwalik sediments exposed along Gagret-Bharwain Road section in Una district, Himachal Pradesh. Of these, six genera, viz., *Pinuspollenites*, *Laricoidites*, *Araucariacites*, *Verrualetes*, *Inapertisporites*, and *Frasnacritetrus* are common between the two assemblages. This shows that the two assemblages are largely comparable.

Saxena and Singh (1982b) reported 25 genera and 31 species from the Upper Siwalik sediments exposed along Hoshiarpur-Una Road in Hoshiarpur district of Punjab and Una district of Himachal Pradesh. Of these, *Todisporites*, *Pinuspollenites*, *Laricoidites*, *Inaperturopollenites*, *Verrualetes*, *Palmidites*, *Inapertisporites*, *Staphlosporonites* and *Frasnacritetrus* are common to both the assemblages. The assemblage closely compares with the present Tatrot assemblage than with Pinjor assemblage. The important genus *Pinjoriapollis* of the present Pinjor assemblage is absent from the Hoshiarpur-Una assemblage.

Saxena and Singh (1982a) published 19 genera and 23 species from the Pinjor Formation (Upper Siwalik) exposed near Chandigarh. The genera common between the two assemblages are: *Todisporites*, *Striatriletes*, *Pinuspollenites*, *Laricoidites*, *Araucariacites*, *Palmidites*, *Pinjoriapollis* and *Inapertisporites*. A comparative study reveals that both the assemblages are closely comparable.

Saxena *et al.* (1984) recorded palynoflora from the Lower, Middle and Upper Siwalik sediments of Bhakra-Nangal section, Himachal Pradesh, of which eight genera and eight species were from the Upper Siwalik. Four genera of this assemblage, viz., *Striatriletes*, *Pinuspollenites*, *Tricolpites* and *Inapertisporites* have also been recorded in the present assemblage. However a close comparison could not be possible, as the Bhakra-Nangal palynoflora is very scanty.

Saxena and Bhattacharyya (1987) recorded palynoflora from the Lower Siwalik (Nahan) and Upper Siwalik sediments exposed along road sections in Kala Amb-Nahan area, Sirmaur district, Himachal Pradesh. Of these, 11 genera and 14 species have been reported from Upper Siwalik. The present assemblage very much resembles to this assemblage in common representation of *Pinuspollenites*, *Laricoidites*, *Inaperturopollenites*, *Palmidites*, *Pinjoriapollis*, *Inapertisporites*, *Staphlosporonites*, and *Polycellaesporonites*. However, *Todisporites*, *Striatriletes*, *Tsugaepollenites*, *Verrualetes*, *Tricolpites*, *Cupuliferoipollenites*, *Phragmothyrites* and *Fraxnacritetrus* of the present assemblage are absent from Kala Amb-Nahan assemblage of Sirmaur district, Himachal Pradesh.

The above comparison reveals that this assemblage is only comparable to the assemblages from Pinjor Formation (Upper Siwalik) exposed near Chandigarh (Saxena and Singh 1982a) and the Siwalik sediments of Kala Amb-Nahan area of Sirmaur district, Himachal Pradesh (Saxena and Bhattacharyya, 1987).

Conclusions

(i) The present Tatrot and Pinjor palynofloras from the Masol-Kiratpur section consists of fungal remains, pteridophytic spores, gymnospermous and angiospermous pollen grains. There is no positive evidence of the presence of bryophytic spores.

(ii) In Tatrot palynoflora, the fungal remains are represented by three genera and four species (20%), pteridophytic spores by one genus and one species (11%) assignable to Parkeriaceae, gymnospermous pollen by two genera and four species (61%) assignable to Pinaceae and angiospermous pollen by three genera and three species (8%).

(iii) In Pinjor palynoflora, fungal remains are represented by five genera and nine species (19%), pteridophytic spores by two genera and two species (3%) assignable to Osmundaceae and Parkeriaceae, gymnospermous pollen by five genera and five species (65%) assignable to Pinaceae and Araucariaceae and angiospermous pollen by three genera and four species (13%).

(iv) The major difference between the two palynofloras is the representation of *Pinuspollenites* (16%) and *Pinjoriapollis* (10.5%) in the Pinjor assemblage as against their total absence in the Tatrot assemblage.

(v) The palynoflora shows complete absence of any element indicating a marine or brackish water influence. This and the other evidences suggest the prevalence of a fluviatile environment of deposition.

(vi) The present day distribution of the families represented in the assemblage shows prevalence of tropical-subtropical climate. The temperate-subtemperate elements, viz., *Pinjoriapollis* and *Pinuspollenites* appear to be derived from the nearby upland areas of the rising Himalaya. It also suggests a comparative cooling in the area during Pinjor sedimentation. This is also supported by lithological evidence.

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Explanation of Plates

(All photomicrographs are enlarged *ca.* ×500. Coordinates of the specimen refer to the stage of the CENSICO microscope no. 13160).

Plate 1

1. *Todisporites minor* Couper, Slide no. 9557, coordinates 43.0 × 105.5.
2. *Inaperturopollenites punctatus* (Saxena) Saxena & Bhattacharyya, Slide no. 9558 coordinates 43.4 × 106.8.
3. *Laricoidites magnus* (Potonié) Potonié *et al.*, Slide no. 9559 coordinates 68.5 × 100.4.
4. *Striatriletes susannae* van der Hammen emend. Kar, Slide no. 9560, coordinates 47.2 × 106.9.
5. *Pinuspollenites siwalikus* Singh & Saxena, Slide no. 9561, coordinates 41.2 × 95.7.
6. *Laricoidites* sp., Slide no. 9562, coordinates 53.5 × 112.3.

7,13. *Tsugaepollenites* sp., Slide no. 9561, coordinates 57.3 × 112.4 ; Slide no. 9559 coordinates 70.5 × 111.8.

8. Inaperturate pollen type, Slide no. 9559, coordinates 42.5 × 105.6.
9. *Verrualetes* sp , Slide no. 9563, coordinates 45.2 × 104.3.
10. Tricolpate pollen type, Slide no. 9564, coordinates 46.0 × 100.9.

11,12,15. *Araucariacites masolensis* sp. nov., Slide nos. 9565, coordinates 56.0 × 106.5 ; Slide no. 9561, coordinates 48.0 × 96.8 ; Slide no. 9566, coordinates 60.2 × 105.9.

14. *Pinjoriapollis* sp., Slide no. 9561, coordinates 43.4 × 111.6 ; 9565, coordinates 56.0 × 112.5.

16,17. *Cupuliferoipollenites* sp., Slide no. 9561, coordinates 43.4 × 111.5; Slide no. 9565, coordinates 56.0 × 112.5.

Plate 2

18. *Palmidites maximus* Couper Slide no. 9566, coordinates 42.2 × 109.5.

19,20. *Pinjoriapollis lanceolatus* Saxena & Singh, Slide No. 9566, coordinates 38.5 × 105.5 ; Slide no. 9565, coordinates 43.0 × 103.5.

21. *Inapertisporites* sp., Slide No. 9568, coordinates 42.6 × 118.4.

22. *Tricolpites* sp., Slide no. 9569 coordinates 48.0 × 104.7.

23,27. *Staphlosporonites multicellatus* Saxena & Singh, Slide no. 9570, coordinates 69.5 × 100.9 ; Slide no. 9571 coordinates 45.7 × 95.7.

24. *Inapertisporites kedvesii* Elsik, Slide no. 9569 coordinates 44.0 × 105.7.

25. Fungal spore type, Slide no. 9559, coordinates 35.3 × 95.3.

26. *Phragmothyrites eocaenica* Edwards emend. Kar & Saxena, Slide no. 9568, coordinaies 60.0 × 115.5.

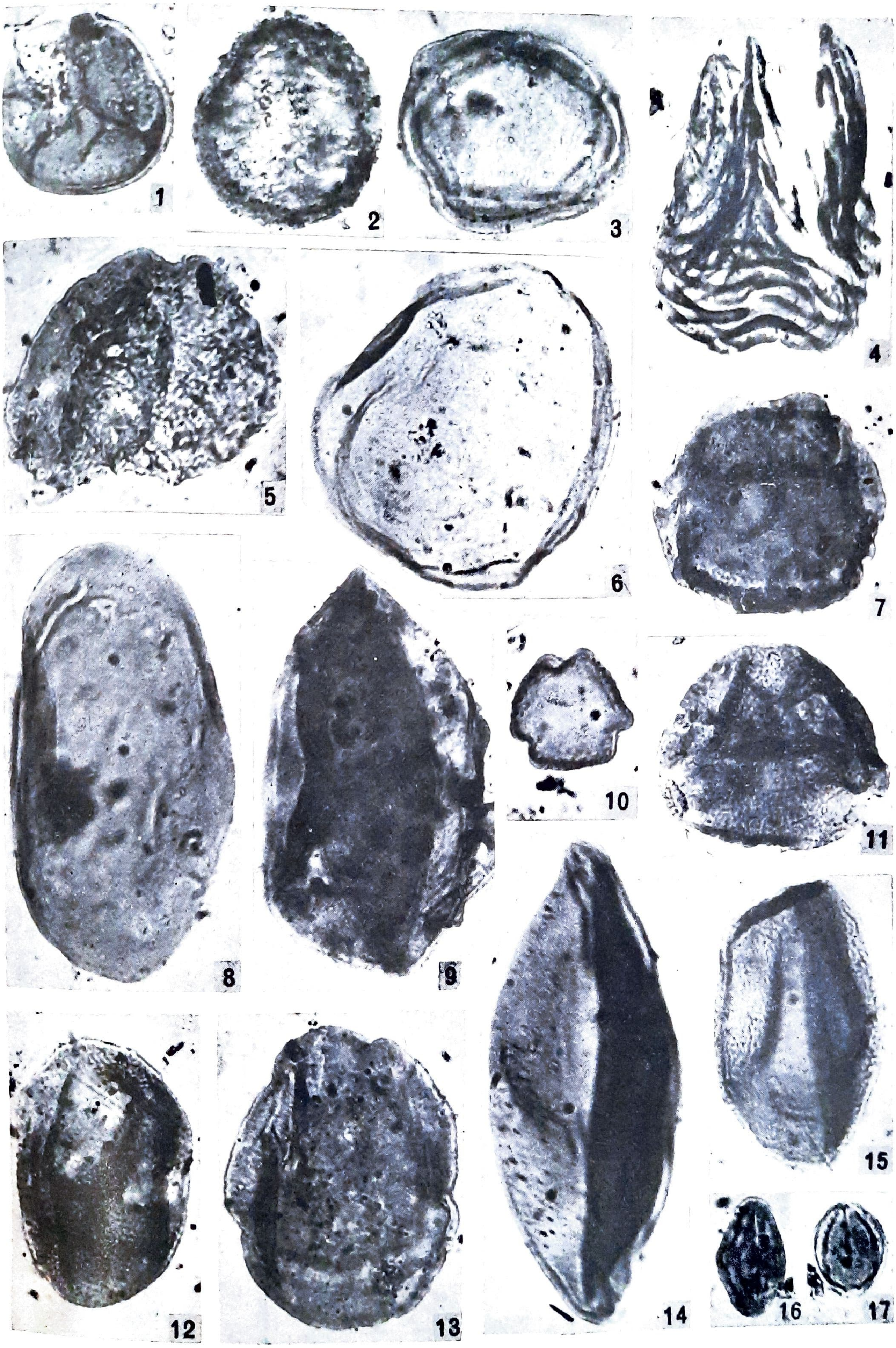
28. *Inapertisporites udarii* Gupta, Slide no. 9572 coordinates 62.5 × 116.3.

29. *Phragmothyrites* sp., Slide no. 9573 coordinates 63.0 × 109.4.

30. *Polycellaesporonites bellus* Chandra *et al.*, Slide no. 9574, coordinates 43.0 × 99.8.

31,32,33. *Frasnacritetrus siwalikus* sp. nov., Slide no. 9570, coordinates 40.5 × 106.9 ; Slide no 9575, coordinates 41.5 × 101.5 ; Slide no. 9576, coordinates 63.0 × 110.8.

34. *Frasnacritetrus* sp., Slide no. 9577, coordinates 28.5 × 113.5.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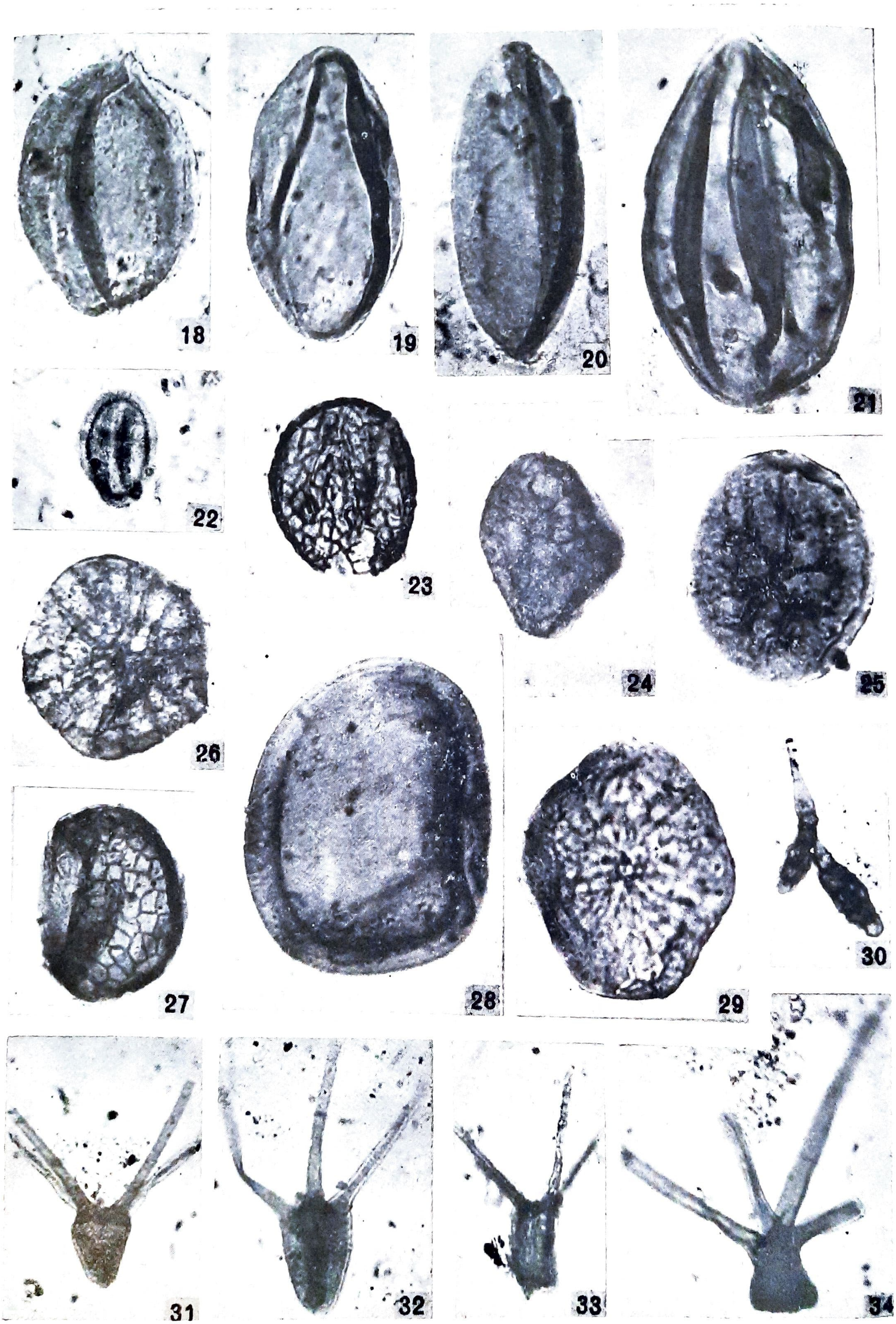
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