The Palaeobotanist, **32(2)**: 91-112, 1984.

PALYNOLOGICAL INVESTIGATIONS OF RAMSHAHR WELL 1, HIMACHAL PRADESH, INDIA

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ABSTRACT

The palynofloral assemblage mainly consists of algal colonies — *Pediastrum*, fungal spores and microthyriaceous ascostromata, pteridophytic spores, and gymnospermous and angiospermous pollen grains. In all, 25 species belonging to 20 genera have been recorded. A few microplanktons have also been recovered but they are thought to be reworked. On the basis of the palynological assemblage, three distinct palynological zones have been established within the Ramshahr Well 1. The Ramshahr palynofloral assemblage has been compared with those known from the Mio-Pliocene sediments of India. In addition, the palynological data have been interpreted throwing light on its dating potential, identification of various depth levels and environment of deposition.

Key-words — Palynology, Algae, Microplanktons, Fungal spores, Pollen grains, Mio-Pliocene (India).

सारांश

हिमाचल प्रदेश (भारत) में स्थित रामशहर कुआँ-1 का परागाणविक अन्वेषण – हरीपाल सिंह एवं समीर सरकार

उपलब्ध परागाणविक वनस्पतिजात समुच्चय में मुख्यतया शैवालीय कॉलोनी – पैडिआस्ट्रम, कवकीय बीजाणु, सूक्ष्मथाइरियेसीय ऐस्कोपीठिकायें, टेरिडोफ़ाइटी बीजाणु तथा अनावृतबीजी एवं आवृतबीजी परागकण विद्यमान हैं। कुल मिलाकर 20 वंशों से सम्बन्धित 25 जातियाँ अभिलिखित की गई हैं। कुछ सूक्ष्मप्लवक भी वर्णित किये गये हैं परन्तु इनका अभी पुनः अध्ययन होना है। परागाणविक समुच्चय के आधार पर रामशहर कुआँ 1 में तीन सुस्पष्ट मण्डल बनाये गये हैं। रामशहर परागाणविक समुच्चय की तुलना भारत के मध्यनूतन – अतिनूतन से ज्ञात अवसादों से की गई है। इसके अतिरिक्त उपलब्ध आँकड़ों के माध्यम से सम्भाव्य कालनिर्धारण, विभिन्न गहराइयों पर स्थित स्तरों के अभिनिर्धारण तथा निक्षेपणीय वातावरण पर प्रकाश डाला गया है।

INTRODUCTION

THIS paper is based on the material supplied by Oil and Natural Gas Commission, Dehradun from the Ramshahr Well 1 (1,340 to 2,650 m depth) drilled near Ramshahr, Solon District, Himachal Pradesh. The objective of the investigation was to find out palynological basis for the identification of different stratigraphic horizons and also to know the dating potential of the palynomorphs together with reflection on the environment of deposition. Ramshahr Well 1 drilled by the Oil and Natural Gas Commission, Dehradun is situated at approximately 30°57′14·5″ latitude and 76°52′53″ longitude near Ramshahr in Solon District. The dunes and terrace gravel deposits of recent and subrecent sediments cover the Tertiary rocks in this area. The Tertiary sediments, in turn, rest over the pre-Tertiary rocks, i.e. Shali sediments. The geological setting

in the sub-Himalayan region between Nalagarh (31°2′: 76°43″) and Arki (31°9′: 76°58″) has the following sequence of rocks.

Recent and subrecent—The dunes and terrace gravel deposits.

Tertiary — Siwalik Group
1. Middle Siwaliks
Sutlej Formation
2. Lower Siwaliks
Nalagarh Formation
Kundlu Formation
Sirmur Group
Kasauli Formation
Dagshai Formation
Subathu Formation

.....Unconformity.....

Pre-Tertiary

Very little palynological work has so far been done on the Neogene palynostratigraphy of Himachal Pradesh. Some of the important contributions have been made by Banerjee (1968), Nandi and Bandyopadhyay (1970), Singh and Saxena (1980, 1981), Saxena and Singh (1982), etc.

In the present investigation palynomorphs have been studied morphologically and assigned to various spore pollen genera and species. Based on the qualitative and quantitative analyses of the assemblage, biozonation of the strata has been carried out. An attempt has also been made to compare the palynoflora with the known Mio-Pliocene assemblages of India and on the basis of this the approximate age of these sediments has been determined.

MATERIAL AND METHODS

All together 29 well cutting samples, supplied by the Oil and Natural Gas Commission, Dehradun, from different depths were studied (Table 1). Out of these, 24 samples proved to be productive. Majority of the samples are not very rich in miospores but the preservation of organic matter is reasonably good. The rock samples of Ramshahr Well 1 are mostly claystones or siltstones. In its upper part the claystones and siltstones are very hard, compact, generally ash gray to dirty white in colour while in the lower part they are characterized by having sandy siltstones which are micaceous in nature and brownish to greenish-gray in colour.

The palynomorphs were recovered from the samples by employing the conventional technique of maceration, i.e. HCl, HF, HNO_3 and KOH. The palynofossils were separated by floatation method using Potassium iodide and Cadmium iodide (sp. gr. 2.3) heavy liquid. The slides were prepared in polyvenyl alcohol and mounted in D.P.X. The slides and negatives of the palynomorphs have been deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

SYSTEMATIC DESCRIPTION

Anteturma — *Proximegerminantes* Potonié, 1970

Turma — *Triletes* Reinsch emend. Dettman, 1963

Supra Subturma — *Acavatitriletes* Dettman, 1963

Subturma — *Azonotriletes* Luber emend. Dettman, 1963

Infraturma — *Laevigati* Bennie & Kidston emend. Potonié, 1950

Genus — *Cyathidites* Couper, 1953

Type species — *Cyathidites australis* Couper, 1953.

Cyathidites australis Couper, 1953

(not illustrated)

Remarks — Most of the specimens recovered are ill-preserved and broken.

Botanical affinity — The probable affinity of *Cyathidites australis* lies with the family Cyatheaceae or Dicksoniaceae.

Infraturma — *Muronati* Potonié & Kremp, 1954.

Genus — *Lycopodiumsporites* Thiergart, 1938

Type species — *Lycopodiumsporites agathoecus.*

Lycopodiumsporites palaeocenicus Dutta & Sah, 1970

Pl. 1, fig. 8

Remarks — Specimens referred here as *L. palaeocenicus* Dutta & Sah, 1970 are slightly bigger in size range than those

TABLE 1 — SHOWING LITHOLOGICAL DETAILS OF THE SAMPLES OF RAMSHAHR WELL 1

Sample No.	Location of Sample	Description	Palynomorph Occurrence
1.	1340-45 m	Ash gray claystone, slightly calcareous in nature	(–)
2.	1355-60 m	Ash gray to dirty white hard compact siltstone	(–)
3.	1400-05 m	Gray to medium gray hard compact siltstone with greenish to ash gray calcareous clay	(+)
4.	1460-65 m	Colourless to dirty white, medium to fine grained silty sandstone	(+)
5.	1475-80 m	Gray coloured, hard and compact siltstone, black minerals present	(+)
6.	1840-45 m	Gray, fine grained, loose friable, uncemented sand with few specks of brown silt	(+)
7.	1885-90 m	Light brown, moderately hard compact, sandy siltstone, micaceous in nature	(+)
8.	1930-35 m	Brownish moderately hard compact, sandy siltstone, micaceous	(+)
9.	1955-60 m	Brownish gray, moderately hard fractured silty clay stone	(+)
10.	1975-80 m	Brownish, compact, fine grained silty clay stone	(+)
11.	2005-10 m	Brown, moderately hard, compact argillaceous siltstones	(+)
12.	2021-25 m	Brownish, moderately hard, compact, very fine grained sandy siltstone	(+)
13.	2065-70 m	Brownish, moderately hard compact micaceous siltstone	(+)
14.	2110-15 m	Brownish, fine grained compact clay stone	(+)
15.	2130-35 m	Grayish loose, friable medium grained sandstones	(+)
16.	2155-60 m	Grayish, medium to fine grained sandstone with few mica specks	(–)
17.	2200-05 m	Loose and friable sandstone, fine grained clay stone also present	(–)
18.	2245-50 m	Gray, moderately hard fine grained micaceous sandstone	(+)
19.	2290-95 m	Light gray, moderately hard compact, fine grained micaceous sandstone	(+)
20.	2335-40 m	Gray, loose friable sandy siltstone, micaceous in nature	(+)
21.	2350-55 m	Gray, fine grained sandstones slightly micaceous	(+)
22.	2380-85 m	Earthy gray, moderately hard, compact, very fine grained micaceous sandstone	(+)
23.	2425-30 m	Gray siltstone	(+)
24.	2480-85 m	Light gray, loose fine grained micaceous sandstone	(+)
25.	2515-20 m	Moderately hard siltstone with fine grained clay stone	(+)
26.	2560-65 m	Grayish, coarse grained sandstones micaceous in nature	(+)
27.	2605-10 m	Gray sandstone, slightly micaceous	(+)
28.	2620-25 m	Gray, silty clay stone	(+)
29.	2645-50 m	Light gray, moderately hard, micaceous sandstone	(+)

described by Dutta and Sah from the lower horizons of Cherra Sandstone Stage, Assam. In our case exine is also comparatively thicker.

Botanical affinity — Lycopodiaceae.

Lycopodiumsporites sp.

Pl. 2, figs 22, 23

Description — Miospores roundly triangular, size range 60-66 μm, interapical margin convex, apices broadly rounded. Trilete mark distinct, Y-rays long and straight, extending up to the equator. Exine 3 μm in thickness, reticulate, muri thin, lumina irregular to polygonal in shape, 7 to 10 μm in diameter.

Comparison — *Lycopodiumsporites* sp. can be compared with *Lycopodiumsporites eocenicus* Venkatachala & Rawat (1972) in general shape and appearance but it differs from the latter in having a long laesurae which extend up to the equator. *Lycopodiumsporites facetus* Dettmann (1963) possesses granulose exine and hence is not comparable with the present specimen.

Botanical affinity — Lycopodiaceae.

Genus — *Striatriletes* van der Hammen, 1956

Type species — Striatriletes susannae van der Hammen, 1956 emend. Kar, 1979.

Striatriletes susannae van der Hammen, 1956 emend. Kar, 1979

Pl. 1, figs 14, 15

Botanical affinity — Parkeriaceae.

Turma — Monoletes Ibrahim, 1933
Infraturma — *Sculptatomonoleti* Dybova & Jachowitz, 1957

Genus — *Polypodiisporites* Potonié, 1934

Type species — Polypodiisporites favus Potonié, 1934.

Polypodiisporites sp.

Pl. 1, fig. 7

Description — Miospores bilateral, bean-shaped, concavo-convex in lateral view. Size range 58-64×46-48 μm. Monolete, laesurae thin, extending up to 3/4 of the longer axis along the concave crest, laesurae bordered by slightly raised ridges. Exine 2 μm thick, ornamentation granulose, grana small, sparsely placed all over the surface.

Comparison — In general shape and size *Polypodiisporites* sp. is comparable to *P. ornatus* Sah (1967) but differs from it in having sparsely distributed grana.

Remarks — Previously monolete polypodiaceous spores with verrucose ornamentation were kept in 3 different genera, viz., *Polypodiisporites* Potonié (1934), *Polypodiites* Ross (1949) and *Verrucatosporites* Thomson & Pflug (1953) but Khan and Martin (1971) suggested that these genera should be treated in one genus, viz., *Polypodiisporites*. Sah (1967), Dutta and Sah (1970) and Rao and Ramanujam (1976) also supported this view that monolete spores possessing verrucose to gemmate or bluntly baculate sculptural elements should be placed under the genus *Polypodiisporites*. The present species, therefore, has been placed under this genus, as it possesses granulose ornamentation of the exine. Saxena (1978, pl. 2, fig. 34) described granulose type of spore under the genus *Polypodiaceaesporites* sp. from Matanomadh area of Kachchh but we suggest that it should be transferred to *Polypodiisporites*.

Botanical affinity — Polypodiaceae.

Anteturma — *Pollenites* Potonié, 1931
Turma — *Saccites* Erdtman, 1947
Subturma — *Disaccites* Cookson, 1947
Infraturma — *Podocarpoiditi* Potonié, Thomson & Thiergart, 1950

Genus — *Podocarpidites* Cookson, 1947

Type species — Podocarpidites ellipticus Cookson, 1947.

Podocarpidites ellipticus Cookson, 1947

Pl. 2, fig. 27

Remarks — The present specimens have a narrower furrow as compared to the size range exhibited by the specimens described by Cookson (1947).

Botanical affinity — Pollen grains are morphologically similar to those of *Podocarpus* of the family Podocarpaceae.

Podocarpidites sp.

Pl. 2, fig. 26

Description — Pollen grain free, anisopolar, tetrasaccate, body of the pollen grain spherical. Exine of the body thin, 1.5 μm thick, marginal ridge absent, psilate. Sacci small in relation to the body, well-separated, variable in shape. Exine 1.5 μm thick, indistinctly intrareticulate.

Dimension — Over all breadth 70 μm; body breadth 48 μm, body length 40 μm; saccus breadth 20-24 μm, saccus length 30-36 μm.

Comparison — *Podocarpidites* sp. can be differentiated from its any other known species in having four sacci. Saccus size is also smaller in comparison to the body size.

Remarks — Only a single specimen has been recovered from the present assemblage and hence its identification up to specific level has not been possible.

Botanical affinity — Podocarpaceae.

Genus — *Pinuspollenites* Raatz, 1938 ex Potonié, 1958

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

Pinuspollenites sp.

Pl. 2, fig. 25

Description — Pollen grains bisaccate, equisaccate. Body spherical to subspherical, marginal cap 3-4 μm thick. Saccus subequatorially attached, small in relation to the body, kidney-shaped. Exine 2 μm thick, intrareticulate ornamentation, heterobrochate, reticulum finer towards the peripheral region.

Dimensions — Observed range: overall breadth 76-80 μm, body breadth 40-60 μm, body length 44-46 μm; saccus breadth 26-30 μm, saccus length 40-44 μm.

Comparison — The present species differs from *P. labdacus* Potonié (1958) in having smaller size of saccus and different saccus-body ratio. Further, it can be compared with *Pinuspollenites* sp. Nandi (1972) in general shape, size and reticulation pattern as found in the saccus. However, the present specimens differ from it in having comparatively thicker marginal cap.

Botanical affinity — Pinaceae.

Genus — *Cedripites* Wodehouse, 1933

Type species — Cedripites eocenicus Wodehouse, 1933.

Cedripites sp.

Pl. 20, fig. 28

Description — Pollen grain bisaccate, flattened. Body circular in outline, margin undulating, marginal frill crescent, 2.5 μm in thickness. Exine laevigate, sacci small in relation to body size, kidney-shaped, intrareticulate ornamentation, meshes larger at the margin and finer towards the root region.

Dimensions — Overall breadth 54 μm; body breadth 44 μm, body length 46 μm; saccus breadth 26 μm, saccus length 35 μm.

Comparison — The present specimen closely resembles *Cedripites parvus* Norton (1963) but differs from it in the presence of thick marginal frill. *Cedripites* sp. Nandi (1972) is different by being bigger in size.

Remarks — Only a single specimen of *Cedripites* sp. has been recovered from Ramshahr Well no. 1. The size of the present specimen is smaller than that given for the type species described by Wodehouse (1933).

Botanical affinity — The overall appearance of this grain seems to be related to *Cedrus* belonging to the family Pinaceae.

Turma — *Aletes* Ibrahim, 1933
Subturma — *Azonaletes* (Luber) Potonié & Kremp, 1954
Infraturma — *Psilonapiti* Erdtman, 1947

Genus — *Laricoidites* (Potonié) Potonié, Thomson & Thiergart, 1950

Type species — Laricoidites magnus (Potonié) Potonié, Thomson & Thiergart, 1950.

Laricoidites sp.

Pl. 1, fig. 16

Description — Pollen grains subcircular to circular, size range 48-52 μm in diameter. Nonaperturate. Exine 2 μm thick, laevigate, a distinct peripheral fold present.

Remarks — The specimens described here as *Laricoidites* sp. resemble very closely with *Laricoidites* sp. Singh (1977). This species differs from all other known species in having a distinct peripheral fold.

Botanical affinity — Pinaceae.

Subturma — *Triptyches* Naumova, 1937

Genus — *Psilatricolpites* (van der Hammen) Pierce, 1961

Type species — Psilatricolpites incomptus (van der Hammen) Pierce, 1961.

Psilatricolpites sp.

Pl. 1, fig. 1

Description — Pollen grains subspherical, size range 30×38-34×42 μm. Tricolpate, colpi small, thin. Exine 1 to 1.5 μm thick, laevigate.

Comparison — This species can be differentiated from *Psilatricolpites* sp. 1 and sp. 2 of

Adegoke *et al.* (1978) by its shorter colpi and bigger in size range. It closely resembles *Psilatricolpites* sp. 3 in colpi structure but differs from it in having bigger size of colpi.

Botanical affinity — Uncertain.

Genus — *Retitrescolpites* Sah, 1967

Type species — Retitrescolpites typicus Sah, 1967.

Retitrescolpites sp.

Pl. 1, figs 5, 6

Description — Pollen grains ± spheroidal, size range 36-45 μm. Tricolporate, colpi long and thin extending almost the whole length. Exine 4-5 μm in thickness, retipilate, surface distinctly reticulate, lumina usually polygonal to hexagonal in shape, pila very distinct, length of the pila varies from 3 to 5 μm.

Comparison — The present specimen can be compared with *Retitrescolpites typicus* Sah (1967) in having similar type of sculpturing pattern. However, it differs from the latter by its smaller size range. It also differs from *R. splendens* Sah (1967) in having thicker exine and coarser reticulum.

Botanical affinity — In general shape and exine ornamentation it shows considerable similarity with the pollen grains of some members of Oleaceae.

Subturma — *Ptychotriporites* (Naumova) Potonié, 1960
Infraturma — *Prolati* Erdtman, 1943

Genus — *Paleosantalaceaepites* (Biswas) Dutta & Sah, 1970

Type species — Paleosantalaceaepites ellipticus Sah & Kar, 1970.

Paleosantalaceaepites ellipticus Sah & Kar, 1970

Pl. 1, fig. 17

Remarks — Only a single specimen of this species has been recovered from the upper part of Ramshahr Well 1.

Botanical affinity — Santalaceae?

Genus — *Tricolporopollenites* Thomson & Pflug, 1953

Type species — Triporopollenites dolium R. Pot.

Tricolporopollenites sp.

Pl. 1, figs 10-12

Description — Pollen grains subcircular, size range 42-48 μm in diameter. Tricolporate, colpi long, thin, overlapping, pore small circular. Exine 2 μm in thickness, laevigate, some peripheral folds present.

Comparison — *Tricolporopollenites* sp. compares favourably with *Tricolporopollenites prolatus* (Pierce) Norton in Norton & Hall (1969) in general appearance but it differs from the latter in having laevigate exine.

Remarks — Most of the pollen grains recovered from Ramshahr Well 1 are found in folded condition.

Botanical affinity — Uncertain.

Turma — *Poroses* (Naumova) Potonié, 1960
Subturma — *Monoporinus* (Naumova) Potonié, 1960

Genus — *Monoporopollenites* Meyer, 1956

Type species — Monoporopollenites gramineoides Meyer, 1956.

Monoporopollenites gramineoides Meyer, 1956

Pl. 2, fig. 21

Remarks — In the present assemblage, exine in most of the pollen grains is folded.

Botanical affinity — Gramineae.

Monoporopollenites sp.

Pl. 2, fig. 35

Description — Pollen grain oval in shape, size 102 μm in diameter. Monoporate, pore circular, 10 μm in diameter, margin of the pore slightly thickened. Exine 2 μm thick, laevigate.

Comparison — The present specimen differs from the other known species by its bigger size.

Remarks — Only a single specimen has been recorded from Ramshahr Well 1.

Botanical affinity — Gramineae.

Subturma — *Polyporines* (Naumova) Potonié, 1960
Infraturma — *Stephanoporiti* (van der Hammen) Potonié, 1960

Genus — *Malvacearumpollis* Nagy, 1962

Type species — *Malvacearumpollis bokonyensis* Nagy, 1962.

Malvacearumpollis rudis Kar, 1979

Pl. 1, figs 2, 3

Remarks — The size of the present specimens are comparatively smaller than the species described by Kar (1979). The number of pores in the specimens recovered from this assemblage are not very clearly discernible due to heavy ornamentation of the exine.

Botanical affinity — Malvaceae.

Malvacearumpollis sp.

Pl. 1, fig. 4

Description — Pollen grains oval, size range 36×38-37×41 μm. Porate, pore small, numerous. Exine 1.5 μm thick, spinose ornamentation, spines small, spine with bulbous base and a pointed tip, sparsely distributed all over body.

Comparison — The illustrated specimen can be compared with *Malvacearumpollis rudis* Kar (1979) in general shape and size but it differs from the latter in having very sparsely distributed small spines all over the surface. It differs from *M. grandis* Sah (1967) in having a smaller size range and less number of spores. *M. africana* Sah (1967) is also distinct by its bigger size range and the shape of spines.

Remarks — Only a few specimens referable to *Malvacearumpollis* sp. have been recovered from Ramshahr Well 1 but are badly preserved.

Botanical affinity — Malvaceae.

Turma — *Jugates* Erdtman, 1943
Subturma — *Polyadites* Pant, 1954
Infraturma — *Oblati* Erdtman, 1943

Genus — *Polyadopollenites* Pflug & Thomson, 1953

Type species — *Polyadopollenites multipartitus* Thomson & Pflug, 1953.

Polyadopollenites sp.

Pl. 1, fig. 13

Description — Polyad consisting of nine pollen grains, oval to circular in shape. Individual pollen grain pentagonal to hexagonal in shape, pollen grains of the outer region are bigger in size than the central one, size range 20-32 μm in length and 12 to 18 μm in width. Exine 2 μm in thickness.

Comparison — The illustrated specimen differs from *Polyadopollenites psilatus* Norton & Hall (1969) in having pentagonal shape of its part pollen with lesser number.

Remarks — The specimen recovered from the Ramshahr Well 1 is not very clear due to dark pigmentation.

Botanical affinity — Mimosae.

ALGAE

Class — Chlorophyceae Kutzing, 1843
Order — Chlorococcales Marchand orth. mut. et emend. Pascher, 1915
Family — Hydrodictyaceae (S. F. Gray) Dumortier orth. mut. CoHN, 1880

Genus — *Pediastrum* Meyen, 1829

Pediastrum compactum Singh & Khanna, 1978

Pl. 2, fig. 33

Remarks — Specimens referred to *P. compactum* from the present assemblage have less number of marginal coenocytes as compared to the range given by Singh and Khanna (1978) for the same species occurring in the Eocene sediments of the Subathu Formation.

Pediastrum diffusus Singh & Khanna, 1978

Pl. 2, fig. 32

Remarks — Specimens recovered from the present assemblage are slightly bigger in

size than those described by Singh and Khanna (1978).

FUNGI

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

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

Phragmothyrites eocaenica Edwards emend. Kar & Saxena, 1976

Pl. 20, fig. 30

Remarks — A large number of microthyriaceous fungal remains have been isolated. Their size ranges in between 70 and 80 μm. The incipient centripetal development of radial walls is the characteristic feature of these forms. In mature ascostromata pores are present.

Botanical affinity — Dilcher (1965) described such type of elements and considered them to be microthyriaceous in nature.

Genus — *Pluricellaesporites* (van der Hammen) Elsik, 1968

Type species — *Pluricellaesporites typicus* van der Hammen, 1959.

Pluricellaesporites sp.

Pl. 20, fig. 24

Description — Darkly pigmented, six-celled spores, size 40×75 μm. Spore wall 2 μm thick, psilate. Monoporate, a stalk present at the basal portion of the spore, 20 μm in length. Central cells are wider than those on the ends, rectangular in shape.

Comparison — The present specimen resembles *P. tenuis* Sheffy & Dilcher (1971) in having six-celled condition but differs from it in exhibiting a bigger size range and absence of constriction between some cells. *Pluricellaesporites*? sp. Elsik (1968) differs in having scabrate and granulose spore wall and smaller size.

Remarks — Due to dark pigmentation, pores of the specimen are not very clearly visible.

Genus — *Inapertisporites* (van der Hammen) Elsik, 1968

Type species — *Inapertisporites typicus* van der Hammen, 1954.

Inapertisporites kedvesii Elsik, 1968

Pl. 2, fig. 36

Remarks — The specimens referred here possess bigger size range than the type specimen.

Genus — *Aplanosporites* Kar, 1979

Type species — *Aplanosporites robustus* Kar, 1979.

Aplanosporites sp.

Pl. 2, fig. 29

Description — Miospores normally subcircular, assuming various forms due to folding; inaperturate. Exine 2 μm thick, laevigate, a tail-like appendage present, 12 μm in length, 4 μm in width.

Comparison — *Aplanosporites* sp. can be easily distinguished from the type species by its smaller tail-like appendage and size.

Remarks — Jen (1958) described a fungal-like spore from the Lower Cretaceous of southern China, which resembles very closely *Aplanosporites*. Kar and Sah (1970) described pollen type I from Vemavaram (Upper Jurassic) which also resembles *Aplanosporites*.

Botanical affinity — Uncertain.

Genus — *Tetraploa* Berk & Br.

Tetraploa sp.

Pl. 2, fig. 37

Description — Conidia unicellular, quadrangular in shape, with four setae, body 26×18 μm in size, wall psilate, setae 48-50 μm long, 4 μm broad at the base, apex pointed.

POLLEN TYPE 1

Pl. 1, fig. 19

Description — Pollen grain spherical to subspherical, 74-76 μm in diameter; porate.

Exine 2 μm thick, undulating, surface densely and coarsely wrinkled.

Remarks — Pollen grains described under pollen type 1 seem to have ulmaceous affinity though it has not been confirmed. In most of the pollen grains pores are not clearly visible.

Pollen type 2

Pl. 2, fig. 34

Description — Pollen grains elliptical in shape, size 64×114 μm, furrow-like structure conspicuous, extending from one pole to another, 16 μm in width. Exine thin, smooth to very finely scabrate.

Remarks — Pollen type-2 compares well with the pollen grains of the family Magnoliaceae. *Magnolia scotica* Simpson (1961) is comparable to the present specimen in shape and appearance but possesses much thinner exine.

Pollen type 3

Pl. 1, fig. 9

Description — Pollen grains subcircular, size 42×45 μm; polycolporate, colpi long, uniformly thick ±40 μm in length, lalongate, ora small. Exine thin ±1.5 μm thick, laevigate.

Remarks — Only a single specimen has been recovered thus the detailed study has not been possible.

Microplankton type 1

Pl. 2, fig. 35

Description — Skolochorate cysts, central body subspherical, size 38 to 42 μm in diameter, periphragm and endophragm closely appressed together, intratabular processes more than 20 in numbers, slender, tubiform, 14-20 μm in length, distally open, flattened with furcating tips. Archeopyle not very clear, paratabulation indistinct.

QUALITATIVE ANALYSIS OF THE ASSEMBLAGE

The Ramshahr Well 1 palynoflora is composed of plant groups belonging to algae, fungi, pteridophytes, gymnosperms and angiosperms. The algal and fungal remains have been recorded in appreciable quantity. The pteridophytic and angiospermic elements form the dominant constituents in the palynological zones A and C; the representation of gymnospermous elements being comparatively low. The palynological zone B is conspicuously rich in having gymnospermous elements. The bryophytic elements have not been recorded. Besides, some forms which could not be identified have been described under *Incertae sedis*.

Systematic botanical analysis of the Ramshahr Well 1 assemblage is discussed below to interpret the possible environment of deposition and palaeoclimatic conditions which might have existed at that time.

1. Algae

The algal forms represented by *Pediastrum* are found only in the palynological zone A. It is represented by two species, viz., *P. compactum* and *P. diffusus*. They constitute an important part of the assemblage from 1,400 to 1,845 m level. Different types of microplanktons have also been recorded from palynological zones A and C.

2. Fungi

Fungal spores and epiphyllous microthyriaceous fungi are present in almost all the productive samples. Among the microthyriaceous fungi *Phragmothyrites eocaenica* is well represented. Most of them are found in germling condition. A large number of fungal conidia and spores have also been recovered from different depth levels, viz., *Inapertisporites kedvesii*, *Pluricellaesporites* sp., *Tetraploa* sp., etc. But it seems difficult to assign any definite affinity to them.

3. Pteridophyta

Pteridophytic spores constitute one of the most important elements in all the samples studied. Miospores assignable to four families have been identified, viz., Lycopodiaceae, Cyatheaceae, Polypodiaceae and Parkeriaceae.

The family Lycopodiaceae is represented by the presence of *Lycopodiumsporites palaeo-*

cenicus and *Lycopodiumsporites* sp. The members of this family are found in both tropical and temperate regions, mostly favouring moist and humid climate.

Cyathidites australis is related to the family Cyatheaceae. This family is tropical to subtropical in distribution.

Miospores described under the genus *Polypodiisporites* compare with those of *Polypodium* belonging to the family Polypodiaceae. The distribution of the family is restricted from tropical to subtropical regions. They prefer moist climate. The family Parkeriaceae is represented by the occurrence of high frequency of costate spores. The forms have been described under *Striatriletes susannae*. The members of this family prefer marshy habitat.

4. Gymnosperms

The Ramshahr Well 1 assemblage represented by palynological zone B is dominated by gymnospermous elements. Gymnospermous pollen grains recovered from this well are related to two families: Pinaceae and Podocarpaceae.

In the family Pinaceae two genera, *Pinuspollenites* and *Laricoidites*, are well represented. The present day distribution of this family is in temperate regions of the world. Genus *Podocarpidites* is referable to the family Podocarpaceae, most probably to the genus *Podocarpus*. It is found in tropical and temperate zones of the southern hemisphere.

5. Angiosperms

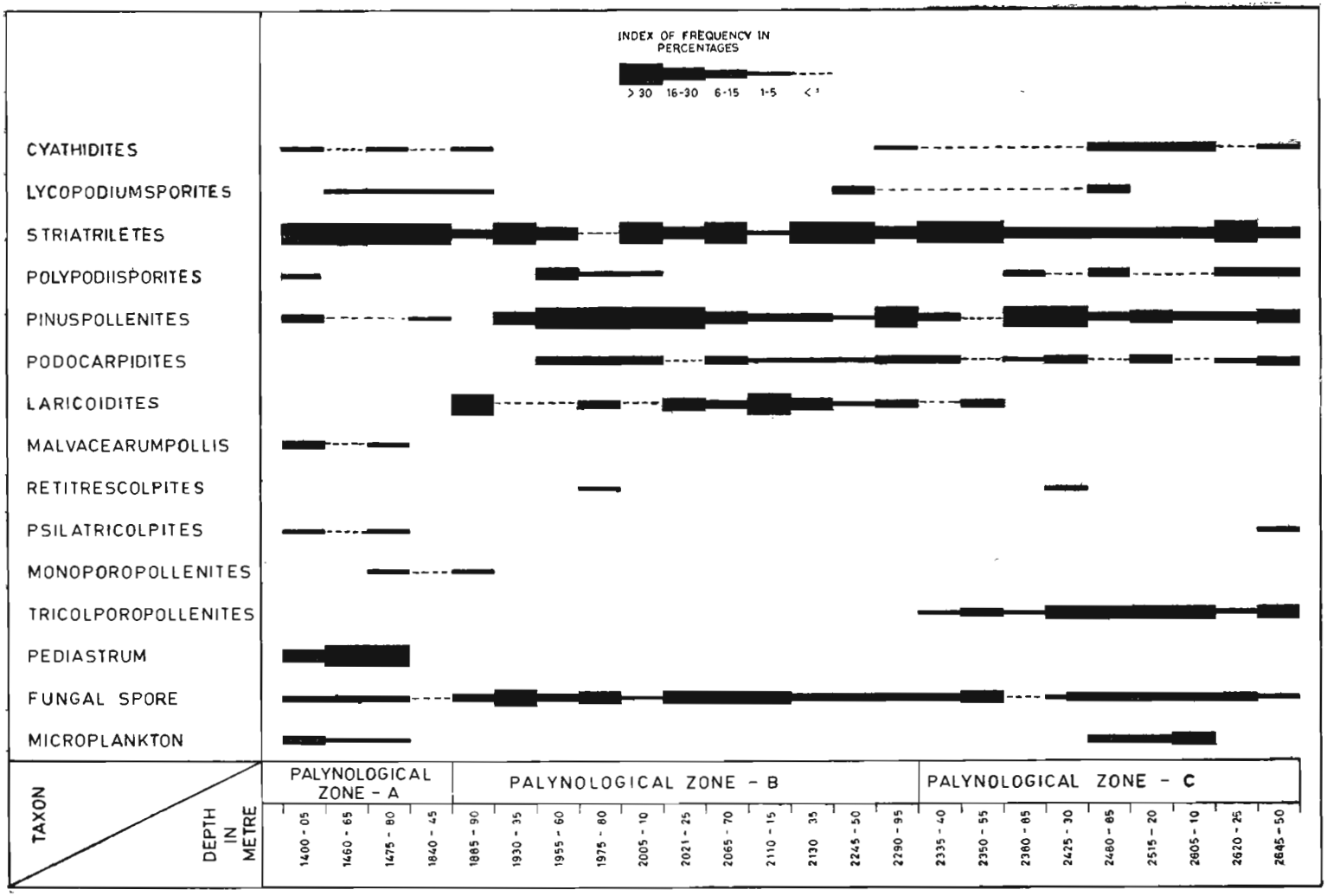
The palynological zones A and C of Ramshahr Well 1 assemblage have the following angiosperms forms: (i) *Tricolporopollenites*, (ii) *Retitrescolpites*, (iii) *Psilatricolpites*, (iv) *Malvacearumpollis*, and (v) *Polyadopollenites*. The other forms show very low frequency of occurrence. Among the angiospermous pollen the monocots, represented only by the presence of *Monoporopollenites*, are less represented than dicots.

The dicots form an important constituent which is represented by the families Mimosae, Malvaceae, Oleaceae and Santalaceae? etc. The families, viz., Mimosae and Malvaceae are richly represented in the present day tropical and subtropical vegetation of the world. Pollen grains referred to *Retitrescolpites* sp. have undoubted oleaceous affinity. This genus has a wide geographical distribution ranging from tropical to warm temperate climate. *Ulmus* and *Magnolia* type of pollen grains have also been recorded but they have been placed under *Incertae sedis* because the number of pollen grains is too less for proper identification and morphological study. Members of the families, viz., Ulmaceae and Magnoliaceae are found both in tropical and temperate regions.

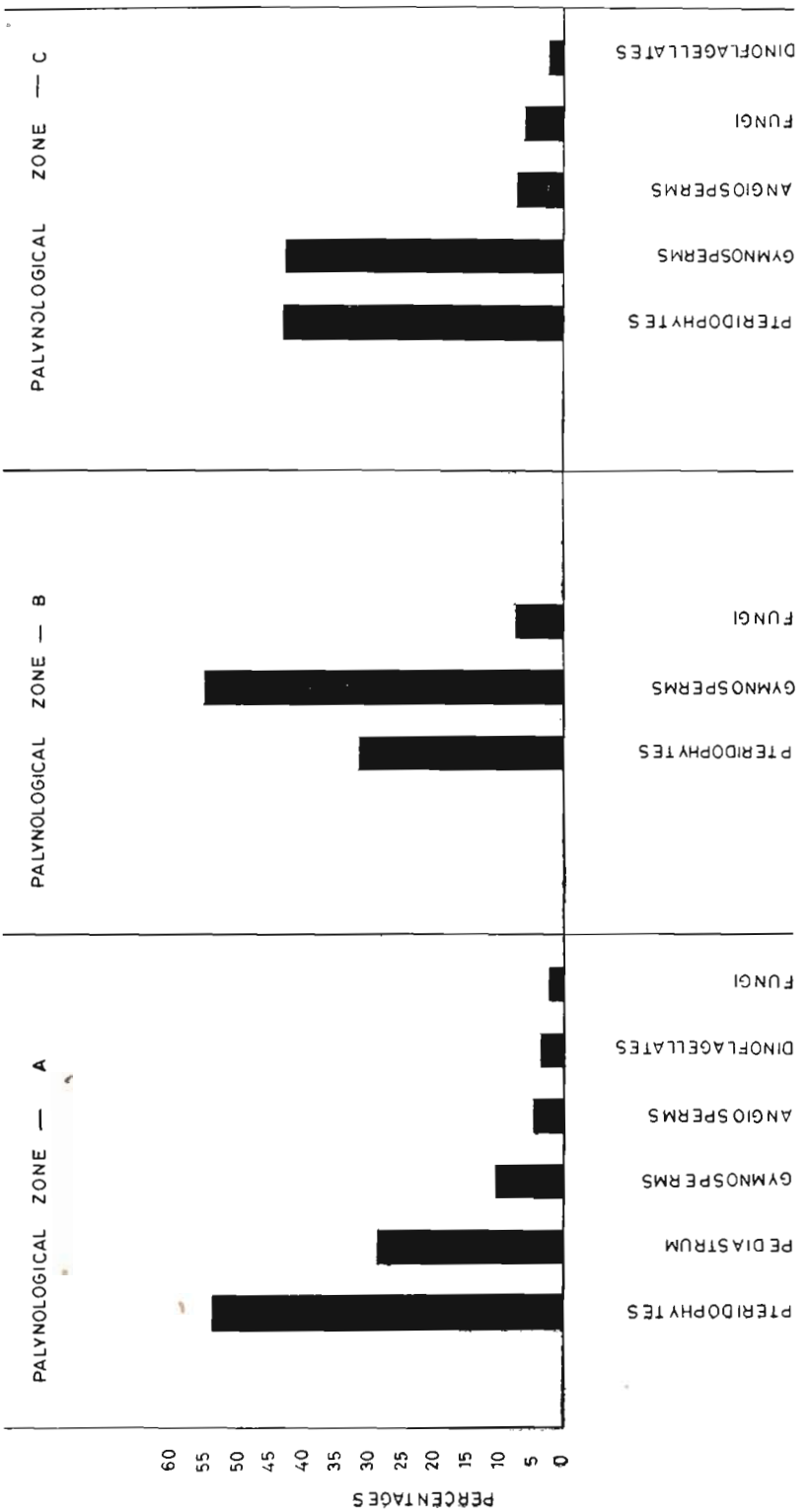
QUANTITATIVE ANALYSIS OF THE ASSEMBLAGE

The present palynological assemblage comprises pteridophytic spores, gymnospermous and angiospermous pollen grains, fungal spores, microthyriaceous ascostromata and algal colony. All these forms have been placed under 20 dispersed genera and 24 species. Among them 4 genera and 5 species belong to pteridophytes, 4 genera and 5 species to gymnosperms, 7 genera and 9 species to angiosperms, and 3 genera and 3 species to fungi. Algae are represented by two species of *Pediastrum*. Few forms have been described under *Incertae sedis*. The distribution of various plant groups in Ramshahr Well 1 has been shown in Text-fig. 1.

The stratigraphic interval covered by palynological zone A is characterized by the abundant occurrence of pteridophytic spores (53%) followed by fresh water algae *Pediastrum* (28%). The gymnospermous and angiospermous pollen grains constitute 10 and 4 per cent respectively of the assemblage. Among the pteridophytic spores *Striatriletes susannae* is the most dominant form and constitutes about 80 per cent of the pteridophytic assemblage. *Lycopodiumsporites* (8%) and *Polypodiisporites* (8%) are also very common. Of the gymnosperms, inaperturate pollen grains, viz., *Laricoidites* sp. (60%) is the most common form although bisaccate forms are also present in appreciable amount. The angiosperms (4%) are poorly represented in this zone. Among the angiospermous pollen grains *Monoporopollenites gramineoides* (65%) is the most common.



TEXT-FIG. 1 — Distribution of palynomorphs in Ramshahr Well 1, Himachal Pradesh, India.



TEXT-FIG. 2 — Distribution of various plant groups in Ramshahr Well 1, Himachal Pradesh, India.

TABLE 2 — FREQUENCY DISTRIBUTION OF PALYNOMORPHS IN RAMSHAHR WELL 1, HIMACHAL PRADESH

Samples Position at Depths / Palynomorphs	1400-05 m	1460-65 m	1475-80 m	1840-45 m	1885-90 m	1930-35 m	1955-60 m	1975-80 m	2005-10 m	2021-25 m	2065 75 m	2110-15 m	2130-35 m	2445-50 m	2290-95 m	2335-40 m	2350-55 m	2380-85 m	2425-30 m	2480-85 m	2515-20 m	2605-10 m	2620-25 m	2645-50 m
Cyathidites australis	2·5		3		2·5										7					7	11	8·5		5
Lycopodiumsporites		5	4·5	5·5										15						7				
Palaeocenicus																								
Lycopodiumsporites sp.	+				4·5															6				
Striatriletes susannae	40	35·5	38·5	92	12	50	20		34	27	30	12	60	60·5	23	68	58	20	17	20	16·5	25	56	24·5
Polypodiisporites sp.	2·5		+				20	7	4·5									4·5		12			8	7·5
Podocarpidites ellipticus							10	15	13		12	4	3		7	7		5			5		5	10
Podocarpidites sp.												+												
Pinuspollenites sp.	13·5			2·5		25·4	40	35	34	31	28	8	12	3	38	15		62	51	7	22	8·5	13	27
Cedripites sp.																								
Laricoidites sp.					65			15	10	17	10	56	10	6	10		7							
Psilatricolpites sp.	2·5		1·5																	+				2·5
Retitrescolpites sp.		+		+																				
Paleosantalacaepites ellipticus			+																					
Tricolporopollenites sp.																								
Monoporopollenites gramineoides			2·5		2·5										41	13		16	30	22·5	28	6	18	
Monoporopollenites sp.				+																				
Malvacearumpollis rudis	6·5		5																	+				
Malvacearumpollis sp.	+			+																				
Polyadopollenites sp.		+																						
Pediastrum spp.	18	52	39																					
Phragmothyrites eocaenica		+			+						+							+			+			
Inapertisporites kedvesii	4·5	5	4		13·5	24·6	10	28	4·5	25	20	20	15	12·5	15	6	22	4		10	12	11·5	12	5·5
Pluricellaesporites sp.					+																			
Aplanosporites sp.			+																		+			
Microplanktons	10	2·5	2·0																	7	11	16·5		

+, Denotes the presence of palynomorph in the same but not encountered in count.

On the other hand, palynological zone B is characterized by the abundance of gymnospermous pollen grains (54%) followed by pteridophytic spores (30%). Among the gymnospermous pollen grains bisaccate pollen, viz., *Podocarpidites ellipticus* (35%) and *Pinuspollenites* sp. (45%) are the dominant forms. Inaperturate pollen grains of *Laricoidites* sp. constitute about (20%) of the assemblage. A few angiospermous pollen grains have also been recovered in this horizon but their number is so poor that they remain unrepresented in the percentage count.

In palynological zone C the occurrence of pteridophytic spores and gymnospermous pollen is almost at the same level, i.e. 42.5 per cent each. Among the pteridophytic spores *Striatriletes susannae* (75%) is highly represented; other forms, viz., *Cyathidites australis* (7%), *Lycopodiumsporites palaeocenicus* (8%) and *Polypodiisporites* sp. (10%) are common forms. Gymnospermous pollen grains are mostly represented by bisaccate pollen grains, viz., *Podocarpidites ellipticus* (45%) and *Pinuspollenites* sp. (55%). Inaperturate pollen grains are poorly represented in this zone. The angiospermous pollen constitute about 7 per cent of the palynological assemblage. Among the angiosperms *Tricolporopollenites* sp. is overwhelmingly dominating (85%). *Malvacearumpollis rudis* (5%) and *Psilatricolpites* sp. (5%) have also been represented. Fungal spores and microthyriaceous ascostromata constitute about 6 per cent of the assemblage. Dinoflagellate cysts (2%) are also present.

BIOSTRATIGRAPHICAL ANALYSIS OF ASSEMBLAGE

On the basis of palynological investigations of the samples of Ramshahr Well 1 between depths of 1340-2650 m, three palynological zones have been identified. Each palynological zone is represented by a distinct assemblage although quantitative representation of palynofossils is generally not rich in most of the samples. The palynological assemblages of these zones have been categorized as A, B and C.

Palynological Zone-A

The palynological zone-A has been identified between 1400 and 1845 m depth levels. This zone is represented mainly by pteridophytic spores and fresh water alga *Pediastrum*. The dominance of *Striatriletes susannae* and *Pediastrum* sp. is the most striking feature of this zone. *Cyathidites australis* and *Lycopodiumsporites palaeocenicus* are also commonly found in this palynological zone. Different types of gymnospermous and angiospermous pollen, viz., *Pinuspollenites* sp., *Psilatricolpites* sp., *Malvacearumpollis rudis* etc. are quite common. *Monoporopollenites gramineoides*, *Polyadopollenites* sp. and *Paleosantalaceaepites ellipticus* are sporadically present. The presence of microplanktons in this zone is also noteworthy.

Palynological Zone-B

The palynological zone-B ranges from 1845-2295 m depth levels. It is represented mainly by gymnospermous pollen grains followed by pteridophytic spores. Angiospermic pollen grains are also found in this zone but their frequency is very insignificant. The frequency of occurrence of fungal spores and sclerotia is quite high. Microplanktons have not been observed in this zone. *Podocarpidites ellipticus*, *Pinuspollenites* sp. and *Laricoidites* sp. are the dominant forms in this zone. The frequency of *Striatriletes* is comparatively low as compared to the palynological zone-A. *Polypodiisporites* sp. is commonly found. Angiospermic pollen grains, viz., *Monoporopollenites gramineoides* and *Retitrescolpites* sp. are sporadically present. Young microthyriaceous fungal forms are abundantly present in this zone.

Palynological Zone-C

This zone ranges from 2295-2650 m depth levels. It is represented mainly by pteridophytic spores and gymnospermous pollen grains. A high percentage of angiospermous pollen has been recorded from this zone. *Striatriletes susannae* is the dominant taxon in this zone followed by *Pinuspollenites* sp. and *Tricolporopollenites* sp. *Cyathidites australis*, *Lycopodiumsporites palaeocenicus* and *Polypodiisporites* sp. are commonly found in this zone. The most interesting feature of this palynozone is the presence and common occurrence of *Tricolporopollenites*

sp. Its presence is restricted to this zone only. Microplanktons of unknown affinity have also been observed in this zone.

The distributional pattern of spores and pollen grains reveals that *Polyadopollenites*, *Malvacearumpollis* and *Tetraploa* are restricted to palynological zone-A. Alga *Pediastrum* is also strictly restricted to palynological zone-A. The frequency of occurrence of *Striatriletes susannae* varies considerably in different horizons though they are widely distributed. Pollen grains of *Pinuspollenites* and *Podocarpidites* are represented almost at all depth levels but their occurrence in palynological zone-B is quantitatively striking. Their frequency sharply declines near and at the contact zones B and A. Same distributional pattern is also exhibited by *Laricoidites*. It attains its climax in the upper most part of zone B. In the palynological zone-C the restricted occurrence of angiospermic pollen grains *Tricolporopollenites* whose affinities are not certain, is noteworthy. The frequency of *Tricolporopollenites* tends to sharply decline towards the upper horizons of palynological zone-C, vanishing completely in the lower part of zone B. *Polypodiisporites* sp. is also found quite commonly in the lower most part of zone C.

Palynomorphs in common between the palynological zones A and C are *Cyathidites*, *Polypodiisporites*, *Striatriletes*, *Lycopodiumsporites*, *Pinuspollenites*, *Psilatricolpites* and microplanktons.

The samples from the lowermost portion of the well contains a rich assemblage of pteridophytic spores, and gymnospermous and angiospermic pollen grains. The gymnospermous pollen grains dominate the middle portion with rare occurrence of two type of angiospermic pollen grains. Gymnospermous pollen grains decline in number giving way to pteridophytic and angiospermic pollen grains in the upper part of Ramshahr Well 1. Regarding the distributional pattern of fungal spores and sclerotia a gradual increase in their numbers has been observed from zone C to zone B. In fact, zone B is the richest in having epiphyllous fungi.

The qualitative and quantitative analyses of the spore pollen genera and their mode of distribution show that the vegetation under investigation belongs to two climatic types. The floral assemblage contains elements usually characteristic of subtropical and temperate regions. The assemblages of palynological zones A and C exhibit similarity in having some common forms whereas zone B is quite distinct palynologically. The temperate elements representing colder climate in all the palynological zones A, B and C (subtropical-tropical) seem to have come from the high hills lying mostly on the northern side.

ENVIRONMENT OF DEPOSITION AND PALAEOECOLOGY

Based on the distribution of palynomorphs in the Ramshahr Well 1, it seems possible to recognize two types of palynoassemblages, one conforming to the terrestrial mixed type and the other to the terrestrial type. The former, typified by palynological zones A and C, contains elements of terrestrial and aquatic habitat. The terrestrial forms are further of mixed type, representing subtropical, tropical as well as temperate elements. The temperate elements mainly of gymnospermous affinity seem to have been derived from the high hills which got preserved along with the local subtropical-tropical forms growing in close proximity to the basin. The aquatic forms are represented by the high frequency of *Pediastrum* in palynological zone-A indicating fresh water environment of deposition. The abundant occurrence of pteridophytic spores along with tropical angiosperm pollen grains indicates a moist tropical vegetation at that time. Microplanktons represent the aquatic habitat and seem to have been recycled from the Subathu sediments in this zone.

The second palynological assemblage is of terrestrial type only. It is being typified by palynological zone B. The assemblage is characterized by a significant change in its composition. The dominance of coniferous pollen grains indicates colder and drier climate. The percentage of pteridophytic spores and angiospermic pollen grains becomes less significant. The present palynological evidence indicates fresh water environment of deposition for palynological zone-B as well.

The palynoassemblage of palynological zone-C is comparable to palynological zone A excepting in the absence of *Pediastrum*

and some other forms. Here also the occurrence of microplanktons is suspected to be recycled from the Subathus. Thus the entire sequence under investigation has been thought to be deposited under fresh water environment of deposition.

Palynofloral Comparison

Palynological information published from the Mio-Pliocene sediments of northern India is rather meagre. However, a comparison of the Ramshahr Well 1 assemblage with other Mio-Pliocene assemblages known from the different equivalent sedimentary horizons of India has been carried out in order to assess the dating potential of the palynomorphs.

Himachal Pradesh — The palynofloral assemblage recorded from the Lower and Middle Siwalik sediments of Bhakra-Nangal area (Banerjee, 1968) is poorly preserved. However, the dominance of gymnospermous pollen grains a feature which is so very characteristic of the Middle Siwalik of Bhakra-Nangal is also exhibited by the present assemblage.

A qualitatively rich palynofloral assemblage has been reported by Nandi (1975) from various formations of Siwalik rocks in Himachal Pradesh, recognizing four palynofloral assemblages. The Ramshahr Well 1 assemblage resembles the one described from the zone III (Nandi, 1975) which is of Middle Siwalik age. Many forms, viz., *Pinuspollenites*, *Podocarpidites*, *Cyathidites*, *Polypodiisporites*, *Polyadopollenites* are in common between the two assemblages. Composition of palynological zone I and palynological zone II of Nandi (1975) differs considerably from the present assemblage both qualitatively and quantitatively inspite of the fact that some forms, viz., *Cyathidites*, *Polypodiisporites*, *Monoporopollenites*, *Pinuspollenites*, *Podocarpidites*, etc. are commonly shared by these assemblages.

Recently Singh and Saxena (1981) reported a palynofloral assemblage from the Upper Siwalik sediments exposed along Gagret-Bharwain Road Section in Una District, which consists of 10 genera and 14 species along with few reworked phytoplanktons. Although a few forms, viz., *Pinuspollenites*, *Laricoidites*, *Aplanosporites* and *Inapertisporites* are common between the two assemblages but the most distinctive features of the Gagret-Bharwain assemblage is the complete absence of pteridophytic spores.

Punjab — Saxena and Singh (1980) recorded a rich palynofloral assemblage from the Pinjor Formation (Upper Siwalik) near Chandigarh. A comparison between the two assemblages reveals that some forms, viz., *Cyathidites*, *Striatriletes*, *Podocarpidites*, *Pinuspollenites*, *Cedripites*, *Laricoidites*, *Inapertisporites* are shared by both the assemblages. However, the Pinjor assemblage is distinctly different by having abundant occurrence of *Laricoidites* complex and Magnoliaceous of pollen grains besides having some other characteristic forms.

Uttar Pradesh — The Mohand East field (Middle Siwaliks) assemblage has been described by Nandi (1972). The spores of pteridophytes represented by Polypodiaceae, Schizeaceae, Lycopodiaceae, Cyathiaceae etc. have been recorded. The gymnospermous pollen grains are represented by *Podocarpus*, *Pinus*, *Abies*, *Picea*, *Cedrus* and *Tsuga* type. Angiospermic pollen grains are less in number. They are represented by two families: Palmae and Liliaceae. The elements common between the two assemblages are *Cyathidites*, *Polypodiisporites*, *Pinuspollenites*, *Podocarpidites*, *Cedripites* and *Tricolporopollenites*. The present assemblage is largely comparable to the one described from Mahand though it lacks some of the important forms occuring in the latter, viz., *Gleicheniidites*, *Todisporites*, *Leptolepidites*, *Tsugaepollenites* and *Abiespollenites*, etc.

Bihar — Lukose (1969) reported miofloral assemblage from Raxaul (Middle Siwaliks) in Bihar which consists of pteridophytes, gymnosperms and angiosperms. The spores-pollen referable to the following genera, viz., *Polypodium*, *Schizea*, *Lygodium*, *Pteris*, *Podocarpus*, *Abies*, *Picea*, *Pinus* and *Tsuga* have been reported. The angiosperms are represented by the pollen grains of Myricaceae, Juglandaceae, Magnoliaceae, Mimosae and Moraceae. The Ramshahr Well 1 and Raxaul assemblages are comparable in having common occurrence of some pteridophytic and gymnospermous pollen grains; however, the former lacks the presence of Myricaceae, Juglandaceae and Moraceae, etc.

Bengal — A comparative study of the present assemblage and Bengal Basin palynological zones V and VI (Baksi, 1975) reveals general development of some similar trends such as the abundance of small tricolpate, tricolporate pollen grains and the presence of few dinoflagellates and hystrichosphaerids. The index elements of conifer pollen and Parkeriaceae spore association which begin to appear in palynological zone V (Bengal Basin) are also found in palynological zones A and C of the present assemblage. Thus the Ramshahr Well 1 palynofloral assemblage representing palynological zones A and C compares very much with the Bengal palynological zones VI (Baksi, 1971) in the dominance of coniferous pollen grain — Parkeriaceous spore assemblage along with tricolpate and tricolporate pollen grains and may be dated as Middle-Upper Miocene in age.

Palynological zone B of the Ramshahr Well 1 is mostly comparable to the Bengal palynological zone V mainly by the dominance of coniferous pollen and parkeriaceous spores. This part of the sequence belongs to Miocene age. As such it can perhaps be suspected to be of Lower Miocene age as well. This palynological observation needs to be corroborated by the geological evidence which is not available for consideration.

Assam — The Ramshahr Well 1 assemblage is comparable to the Simsang palynological zone IV of Simsang River section (Baksi, 1962) which is considered to be of Miocene age. The spore pollen assemblage of this zone is characterized by the abundant occurrence of two winged pollen of conifers, frequent occurrence of ribbed spores which are related to Parkeriaceae and Schizeaceae and pollen grains of Polygonaceae. Small bordered spores *Densexinosporites minuta* and remains of microthyriaceous fungus, tricolpate and tricolporate pollen grains are also found in this zone.

The Ramshahr Well 1 assemblage is distinct in the absence of *Densexinosporites* and polygonaceous type of pollen grains. The common features between these two assemblages are the dominance of bisaccate pollen grains and costate spores, presence of tricolpate and tricolporate type of pollen grains, and occurrence of few dinoflagellates and hystrichosphaerids (thought to be reworked by Baksi, 1962).

Tamil Nadu — The miofloral assemblage of Neyveli lignite is considered to be of Miocene in age. Palynofloral assemblage reported by Dev (1972) does not resemble the Ramshahr Well 1 assemblage excepting by the presence of tricolporate pollen grains.

Kerala — The Cannanore lignite palynoflora (Potonié & Sah, 1958) represented by the pteridophytes and angiosperms have the following constituents, viz., *Lycopodiumsporites*, *Cyathidites*, *Polypodiites*, *Inaperturopollenites*, *Monoporopollenites*, *Monosulcites*, *Cupuliferoidaepollenites* and *Polyadopollenites*. Most of these forms are common between the Ramshahr and Cannanore assemblages. The only distinctive feature of the present assemblage is the presence of bisaccate and other coniferous pollen grains. The Warkali Lignite mioflora (Ramanujam, 1960, 1962) which is believed to be Miocene age differs from the Ramshahr Well 1 assemblage in the absence of bisaccate coniferous pollen grains.

CONCLUSIONS

1. Palynological contents of the Ramshahr Well 1, Himachal Pradesh, though not very rich quantitatively as well as qualitatively, have been utilized for the identification of its various depth levels. Consequently, three palynological zones A, B and C have been established.

2. On the basis of the comparative study of Ramshahr Well 1 assemblage along with others known from the possibly equivalent geological horizons in India it seems possible to assign Middle-Upper Miocene age to the sequence encompassed by palynological zones A (1400-1845 m) and C (2335-2650 m).

Palynological zone B (1845-2295 m) is very distinct by the preponderant occurrence of coniferous pollen grains particularly represented by the members of Abietineae indicating definite Neogene affinity with the assemblage. However, it seems difficult to date this part of the sequence with precision even though the comparative study of this assemblage points out that it may perhaps belong to Lower Miocene age. If this contention is true then it is an anomalous

position which may possibly be explained by involving some complex geological event. Alternatively, if this sequence is presumed to be regular and the change in the composition of the assemblage is due to climate, even then there are no palynological taxa which indicate other than Neogene affinity. Hence the exact status of palynological zone B remains an open question.

3. The sediments seem to have been deposited under fresh water conditions. The recovery of reworked microplanktons in palynological zones A and C indicative of brackish environment seems to have been derived from the Subathu sediments.

ACKNOWLEDGEMENTS

The authors are extremely thankful to the authorities of O.N.G.C., Dehradun for providing the material for the present study and for permiting us to publish the results.

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EXPLANATION OF PLATES

(All photographs are *Ca.*× 500. The coordinates of specimens in slides refer to the stage of Olympus microscope no. 2081).

PLATE 1

1. *Psilatricolpites* sp.; slide no. 6883, coordinates 18 × 114.
2, 3. *Malvacearumpollis rudis* Kar; slide no. 6873, coordinates 3.9 × 90.5, coordinates 12 × 77.
4. *Malvacearumpollis* sp.; slide no. 6873, coordinates 5.6 × 98.9.
5, 6. *Retitrescolpites* sp.; slide no. 6880, coordinates 16 × 77.8; slide no. 6875, coordinates 7 × 93.
7. *Polypodiisporites* sp.; slide no. 6875, coordinates 13.9 × 96.8.
8. *Lycopodiumsporites palaeocenicus* Dutta & Sah; slide no. 6881, coordinates 2.9 × 107.5.
9. Pollen type-3; slide no. 6882, coordinates 3.8 × 113.5.
10-12. *Tricolporopollenites* sp.; slide no. 6884, coordinates 11 × 83.9, coordinates 10.5 × 84; coordinates 7 × 111.9.
13. *Polyadopollenites* sp.; slide no. 6894, coordinates 5 × 76.4.
14, 15. *Striatriletes susannae* (van der Hammen) Kar; slide nos. 6871, coordinates 11 × 112.2; 6893, coordinates 7 × 76.8.
16. *Laricoidites* sp.; slide no. 6874, coordinates 11 × 92.2.
17. *Palaeosantalacipites ellipticus*; slide no. 6871, coordinates 10.6 × 96.6.
18. *Tricolpites* sp.; slide no. 6874, coordinates 7 × 112.2.
19. Pollen type-1; slide no. 6883, coordinates 97 × 17.5.
20. Microplankton type-1; slide no. 6871, coordinates 18.6 × 91.9.

PLATE 2

21. *Monoporopollenites gramineoides* Meyer; slide no. 6881, coordinates 17 × 89.5.
22, 23. *Lycopodiumsporites* sp.; slide nos. 6876, coordinates 15 × 88.2, 6877, coordinates 3.9 × 90. 8.
24. *Pluricellaesporites* sp.; slide no. 6890, coordinates 18 × 100.
25. *Pinuspollenites* sp.; slide no. 6879, coordinates 2 × 82.5.
26. *Podocarpidites* sp.; slide no. 6890, coordinates 15.5 ×95.
27. *Podocarpidites ellipticus* Cookson; slide no. 6890, coordinates 11.2 × 86.9.
28. *Cedripites* sp.; slide no. 6875, coordinates 8.4 × 87.8.
29. *Aplanosporites* sp.; slide no. 6890, coordinates 18 × 98.2.
30. *Phragmothyrites eocaenica* Edward; slide no. 6878, coordinates 7.8 × 116.8.
31. *Callimothallus pertusus* Dilcher; slide no. 6882, coordinates 17.5 × 97.
32. *Pediastrum diffusus* Singh & Khanna; slide no. 6872, coordinates 8.2 × 78.8.
33. *Pediastrum compactum* Singh & Khanna; slide no. 6884, coordinates 11.2 × 108.9.
34. Pollen type-2; slide no. 6809, coordinates 15 × 66.
35. *Monoporopollenites* sp.; slide no. 6877, coordinates 3.9 × 85.5.
36. *Inapertisporites kedvesii* Elsik; slide no. 6871, coordinates 3 × 98.
37. *Tetraploa* sp.; slide no. 6874, coordinates 16 × 80.

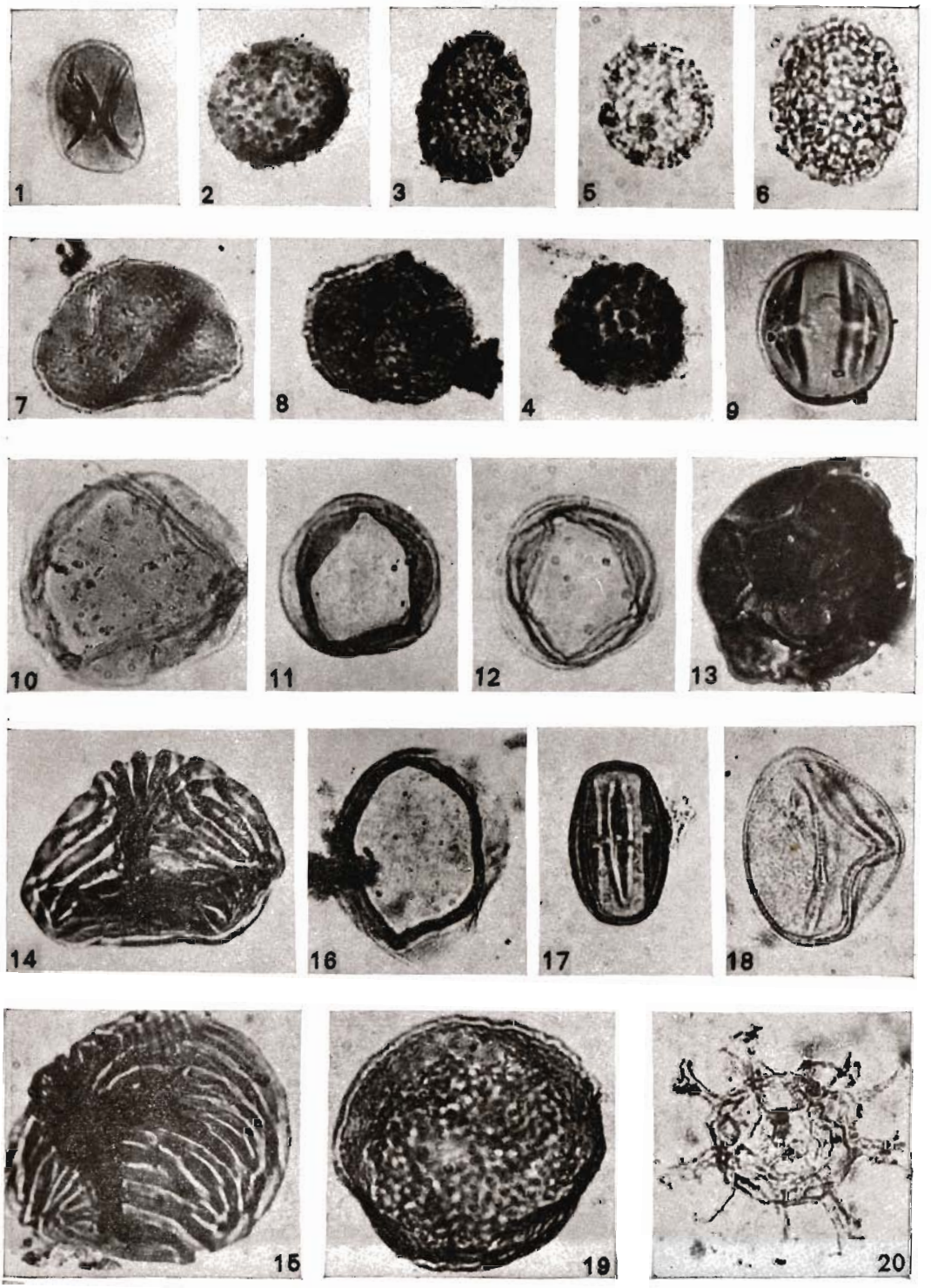

PLATE 1

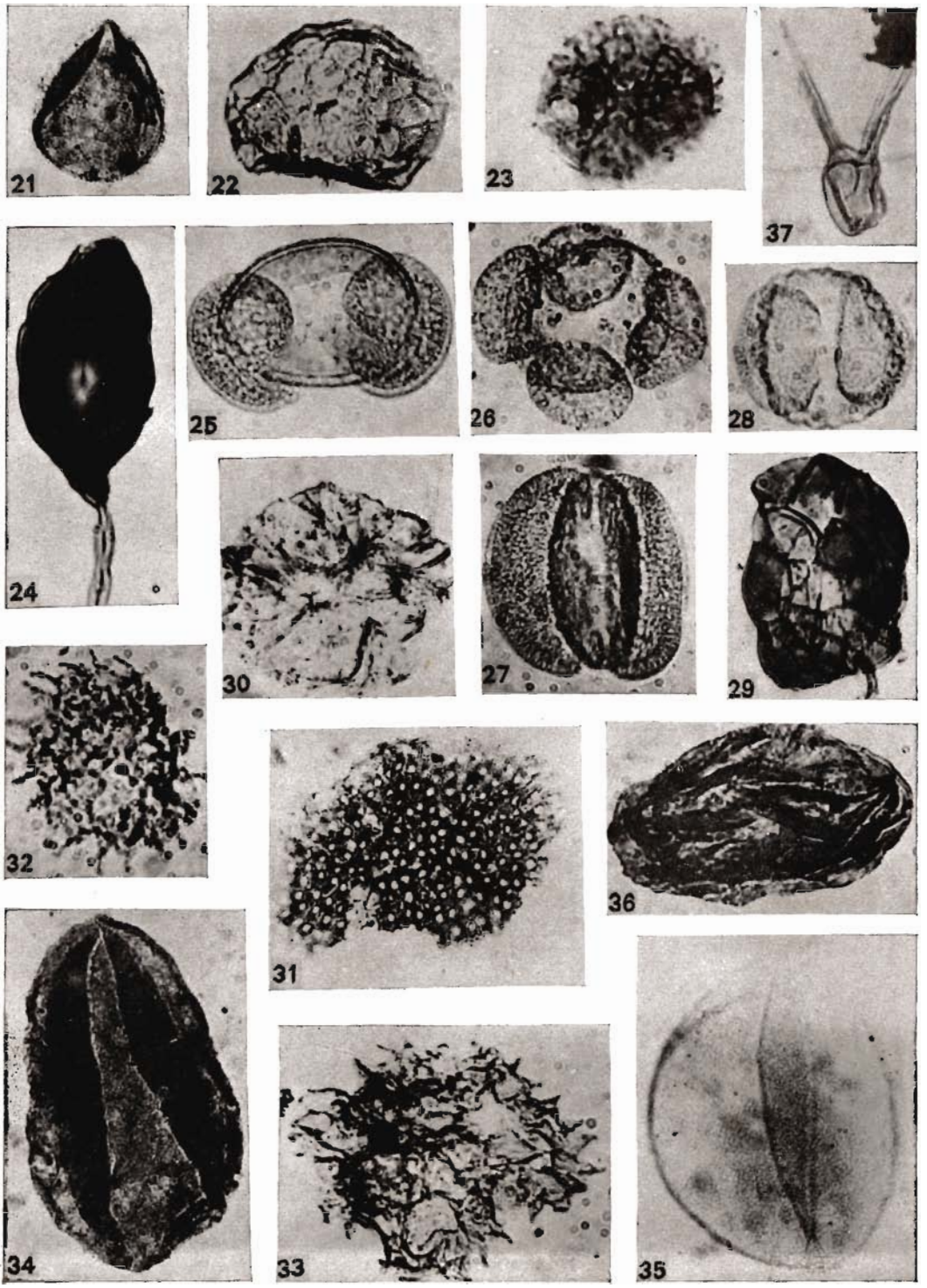

PLATE 2