SOME OBSERVATIONS ON THE MICROFLORA OF MIDDLE SIWALIK SEDIMENTS OF MOHAND (EAST) FIELD, HIMACHAL PRADESH

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Abstract

Microfloral studies have been done on 4 samples collected from Mohand (East) field, Himachal Pradesh along the Binj Rao traverse (30°5'30"N 70°57' E). The samples are from different depths from the highest exposed horizon and varying in nature. The samples, as a whole, so far studied are rich in microfloral contents. A preliminary investigation of these microflora shows that it consists of mainly pteridophytic spores, gymnospermous and angiospermous grains are comparatively rare. Pteridophytes are represented by the spores of Lycopodiaceae, Hymenophyllaceae, Schizaeaceae, Gleicheniaceae, Polybotaceae and Gnetaceae etc. Among the angiosperms, monoporate grains of Cyperaceae and monosulcate grains of Palmae are dominant over the polyporate, tricolporate and inaperturate grains.

Gymnosperms are mainly represented by the grains of Pinus sp. A few bisaccate grains of Abies and Podocarpus and monosaccate grains are also present. The samples are of different depths and differ in their pollen contents. Some are rich in pteridophytic spores and others are in gymnospermous grains or wood fragments and palm-type of pollen. These differences show that there may have been floral change during the Middle Siwalik time. As such from the palynological data so far available it may be assumed that during the Middle Siwalik time, there was change in the climatic and edaphic condition causing change of vegetation.

Introduction

The Siwalik System represents an important part of the Tertiary state of India. It takes its name from the Siwalik hill of the Hardwar region between the Ganga and Jamuna rivers extending along the foot-hills of the Himalaya on the east to the Potwari plateau and Bannu plains on the west. These sediments are equivalent to the Manchar System in Sind, the Mekran System in Baluchistan, the Tipam and the Dihing Series in Assam and Irrawady System in Burma. The constitution of the Siwalik System are mainly sandstones, grits, conglomerates and pseud conglomerates, lignites and coal in some cases. It is presumed that the sediments are deposited under non-marine fluviatile conditions (Krishnan 1968).

Lukose (1967) reported the occurrence of microfossils from the Middle Siwalik of Bihar. Banerjee (1966) also published a short report on the occurrence of microfossils from Middle and Lower Siwalik of Punjab. In this paper an attempt has been made to study the spores and pollen from the Middle Siwalik of Mohand (East) field, Himachal Pradesh, India.

Materials and Method

The materials for the present study are obtained through the kind courtesy of the Director, Research and Training Institute, Dehradun. The sample are collected along the Binj Rao traverse (30°5'30"N 70°57' E) from Mohand East field. Only four samples of different depths were studied. The usual technique of processing the sample with HCl, HF, HNO₃, KOH successfully was adopted and the sporiferous materials were separated by floatation with heavy liquid (sp gr. 2.3). The slides were mounted in glycerine jelly and sealed with paraffin.
The spores and pollen grains found from the samples are classified according to the classification proposed by Potome (1956, 58, 60, 68)

Anteturma  *Spores* H. Potome, 1893
Turma  *Triletes* (Remsch) Potome & Kremp, 1954
Subturma  *Azonotriletes* Luber, 1935
Infraturma  *Laveigata* (Bennie & Kidstone) Potome, 1956

Genus *Cyathidites* Couper, 1953
*Cyathidites minor* Couper, 1953
*Description* Spore small, triangular, ends rounded, 28–46 μ in size Trilete mark long, extending almost up to the equator, ends pointed Exine ± 1.5–2 μ thick, laevigate, equatorial folding present (Pl 1, Fig 1)

Genus *Alsophildites* (Cookson) ex Potome, 1956
*Alsophildites* sp
*Description* Spore small, 32–38 μ in size, subtriangular, apices rounded, sides straight to concave Trilete mark long and extending almost up to the equator, ends pointed, flanked by raised margo Exine ± 1.5 μ thick, laevigate (Pl 1, Figs 2, 3)

Genus *Gleichenidites* (Ross) Delcourt & Sprumont, 1955
*Gleichenidites* sp
*Description* Spores triangular, apices rounded, sides concave, 35–40 μ in size Trilete mark long and extended two-third the distance of the equator, subtended by three-arcuate folds, inter-radial area thick Exine ± 3–4 μ thick, laevigate (Pl 1, Fig 5)

*Gleichenidites* cf *concavospira* (Rouse) Srivastava, 1960
*Description* Spores triangular, apices rounded, sides proximally flat, distally concave, 40 μ in size Trilete mark long and extending up to the equator, laesura surrounded by undulated kytom-like structure Exine ± 1.5 μ thick, proximally laevigate, distally granulate (Pl 1, Fig 6)

Genus *Todispentes* Couper, 1958
*Todispentes* cf *phleuates* Sah & Kar, 1969
*Description* Spores circular, 36–44 μ in size Trilete mark long and extending up to the equator, laesura thickened Exine thin, laevigate or infrastructured (Pl 1, Fig 7)
Infraturma: *Apiculati* (Bennie & Kidston) Potonie, 1956

**Genus: Leptolepidites** Couper, 1953

*Leptolepidites* sp

*Description* Spores circular, 40μ in size. Trilete mark not discernible due to the ornamentation. Exine ± 2 5μ thick, verrucate, verrucae globular, ± 4μ-8μ in size, verrucae also present on the equatorial margin, evenly distributed (Pl 1, Fig 8).

**Genus: Macroleptolepidites** Esthei Nagy, 1963

*Macroleptolepidites* sp

*Description* Spores subtriangular, 30μ—32μ. Trilete mark not discernible, covered with conspicuous, differently sized verrucae, being larger on the edge and on the middle portion of the spore, verrucae are 2μ-6μ in size, smaller in the middle of the spore (Pl 1, Fig 9).

**Genus: Concavissimusporites** Delcourt & Sprumont, 1955

*Concavissimusporites* crassatus Delc. et al

*Description* Spores triangular, angles distinctly lobed with concave sides, 40μ×48μ in size. Trilete mark long, laesura open, lips surrounded by folding of the thickened exine. Exine thick, verrucate, verrucae large and dome-shaped (Pl 1, Fig 10).

**Genus: Osmundacidites** Couper, 1953

*Osmundacidites* sp

*Description* Spore circular, 48μ. Trilete mark short, broadly open, ends blunt. Exine thin, connate, coni are 1 5μ-2 5μ broad at the base, uniform throughout the grain (Pl 1, Fig 11).

**Genus: Echinletes** (Van der Hammen 1954) Potonie, 1956

*Echinletes* sp

*Description* Spore subcircular, 20μ×24μ in size. Trilete mark indistinct due to the ornamentation. Exine moderately thick, verru-echmate, verrucae flat and 2μ in size, echinae ± 3μ in size, slightly curved at the tip (Pl 1, Fig 12).

Infraturma *Muovnati* Potonie & Kremp, 1954

**Genus: Rugulatisporites** Pflug in Thom & Pflug, 1953

*Rugulatisporites* sp

*Description* Spore rounded, 32μ in size. Trilete mark long but not clearly discernible. Exine ± 2μ thick, rugulate, rugulae broad and uniformly distributed (Pl 1, Fig 13).

**Genus: Corrugatisporites** (Thom & Pflug) ex Weyland & Grufeld, 1958

*Corrugatisporites* sp

*Description* Spore triangular, apices rounded, sides concave, 44μ in size.
Trilete mark long and extending upto the equator, bordered by thick exine Exine ± 2.5μ thick, corrugated (Pl. 1, Fig. 14)

Genus *Lycopodiumsporites* Thiergart, 1938
*Lycopodiumsporites cf. papillaeспоритes* (Rouse)

*Description* Spore triangular, 32μ–38μ in size, apices rounded Trilete mark long and extending towards the equator, a thin membrane surrounding the spore joins the papillae, ornamentation reticulate, reticulum small homobrochate, about 2μ–3μ in diameter (Pl. 1, Fig. 15)

Genus *Tawocusporites* Stover, 1962
*Tawocusporites segmentatus* Stover, 1962

*Description* Spore subcircular, 42μ×44μ in size Trilete, laesura extend almost the full radius of the spore, lips bifurcated at the end, lips bordering the laesura distinct The central concentric area on the distal side not prominent The outer zones are well developed Exine finely granulate (Pl. 1, Fig. 16)

Genus *Klukisporites* Couper, 1958
*Klukisporites sp*

*Description* Spore subtriangular, apices rounded, 44μ–48μ in size Trilete mark long and extending towards the equator, surrounded by ‘torus’ like thickening Exine ± 2.5μ thick, proximally laevigate, distally broadly reticulate, meshes thick (Pl. 2, Fig. 17)

Trilete spore type 1

*Description* Spore large, subcircular, consists of a central body surrounded by additional outgrowths which are 6 in number, subcircular Trilete mark long, grain 66μ×76μ in size Exine ± 1 5μ thick, laevigate, folded (Pl. 2, Fig. 18)

Turna *Monoletes* Ibrahim, 1953
Subturna *Azonomonoletes* Luber, 1935
Infraturma *Psilamonolati* V D Hammen, 1955
Genus *Laevigatosporites* Ibrahim, 1933

*Laevigatosporites ovatus* Wilson and Webster, 1946

*Description* Spores oval to bean-shaped, 49μ in size, the species distinguished by straight and mostly gaping suture, about ½ of the spore length Exine ± 1 5μ thick, laevigate, conspicuously thickened in the middle which appears as an inner body (Pl. 2, Fig. 19)

*Laevigatosporites sp*

*Description* Spores oval to kidney shaped, 30μ–56μ in size Monolete mark ½ of the spore length, closed, subtended by folds Exine ± 2 5μ thick, laevigate (Pl. 2, Figs. 20, 21)
Genus: *Polypodiumasporites* Thiergart, 1938

*Polypodiumasporites* sp

Description. Spores subcircular to bean-shaped, 38μ-54μ in size. Monolete mark extending more than half the longitudinal axis, subtended by folds, laesura thickened, Exine ± 2 5μ thick, infrareticulate (PI 2, Fig 22)

Infraturma: *Ovalis* Potonié, 1956

Genus: *Polypodiumasporites* Potonié, 1934

*Polypodiumasporites* sp

Description. Spores small, oval to bean-shaped, 20μ-24μ in size. Monolete mark long, extending more than half the longitudinal axis, subtended by folds, Exine ± 2 5μ thick, verrucate, verrucae scars and irregularly distributed (PI 2, Fig 23)

*Polypodiumasporites* cf *perveriucatus* Couper, 1953

Description. Spores triangular to subtriangular, 40μ-44μ in size. Monolete mark short, Exine ± 2 5μ thick, verrucate, verrucae also present on the equatorial margin forming a fringe, flat and broad, 2μ-6μ in diameter, uniformly distributed (PI 2, Fig. 24)

Monolete spore type 1

Description. Spores bilateral, monolete, 22μ x 24μ in size. Monolete mark subtended by fold, extending almost the distance of the longitudinal axis, Exine ± 1 5μ thick, gemmate-verrucate, verrucae ± 1 5μ in size, uniformly distributed (PI 2, Fig 25)

Anteturma: *Pollemites* Potonié, 1931

Turma: *Saccites* Erdtm., 1947

Subturma: *Monosaccites* (Chit.) Pot. & Kr., 1954

Genus: *Tsugaepollemites* (Pot. & Vcn.) Pot., 1958

*Tsugaepollemites* sp

Description. Pollen grain circular, monosaccate, 26μ-47μ in diameter, central body 19μ-30μ in size, sacci 2 5μ-7μ broad, equatorially attached. Exine of the central body less prominently ornamented (PI 2, Figs 26, 27)

Subturma: *Disaccites* Cookson, 1947

Genus: *Abietineaepollemites* Potonié, 1956

*Abietineaepollemites* sp.

Description. Grains bisaccate, equisaccate, overall length 46μ x 64μ-90μ. Body spherical to elliptical, 56μ x 44μ-52μ x 32μ in size, thick walled, finely reticulate, saccus spherical to elliptical in shape, proximally equatorially and distally subequatorially attached, 24μ x 56μ in size, infrareticulate, reticulum uniform (PI 3, Figs 31, 32, 34)
Genus *Abiespollenites* Thieigart, 1937

*Abiespollenites* sp

*Description.* Grains bisaccate, whole grain 84μ-100μ in length. Body 44μ-104μ in length and 40μ-52μ wide, infrareticulate. Saccus smaller than the body 36μ × 16μ-44μ × 56μ in size, proximally and distally subequatorially attached, finely reticulate, reticulum uniform (Pl 2, Figs 28, 29)

Genus *Pinuspollenites* Raatz, 1937

*Pinuspollenites* sp

*Description.* Grains bisaccate, equisaccate, overall length 56μ-96μ. Body circular to subcircular, 56μ-64μ in size, finely reticulate. Saccus proximally equatorially and distally subequatorially attached, spherical to subspherical, 40μ × 44μ-44μ × 28μ in size, reticulate, heterobrochate, reticulum becomes finer towards the side (Pl 3, Figs 30, 33)

Genus *Podocarpidites* Couper, 1953

*Podocarpidites* sp

*Description.* Grains bisaccate, equisaccate, overall length 48μ-64μ. Body spherical to subspherical, with thick margin, 40μ × 56μ in size, finely reticulate, saccus proximally and distally subequatorially attached, margin slightly undulate, finely reticulate, distally inclined (Pl 3, Fig 35)

Genus *Cedripites* Woodhouse, 1933

*Cedripites* sp

*Description.* Grains bisaccate, parvisaccate, overall length 102μ. Body 102μ-76μ, ellipsoidal, margin undulate. Saccus very small, 24μ × 48μ in size, subtriangular, proximally equatorially and distally subequatorially attached. Exine finely reticulate throughout the body, reticulum denser towards the margin (Pl 3, Fig 36)

*Turma Monocolpates* Iversen & Tjoel-Smith, 1950

Subturma *Retectmes* (Malawkina) Potonjč, 1956

Genus *Palmaepollensites* (Chutailey) ex Couper, 1953

*cf Palmaepollensites*

*Description.* Grains elliptical with almost rounded ends, 56μ × 36μ in size. Monocolpate, colpus 36μ, long, lips thickened. Exine thin uniformly foveo-reticulate (Pl 3, Fig 38)

Subturma *Monoptyches* (Naumova) Potonjč, 1958

Genus *Palmaepollensites* Potonjč, 1951

*Palmaepollensites* sp

*Description.* Grains bilateral, 40μ in size, elliptical, ends rounded. Monosulcate, sulcus long and bordered by thick exine. Exine ± 1.5μ thick, psilate (Pl 3, Fig 37)
Infraturma *Longaperti* Ramanujam, 1966
Genus *Longapertites* Hoeken-Klmkenberg, 1964
*Longapertites* sp.

**Description** Grains spherical, 26μ in size Monocolpate, colpus narrow, running more than 2/3 rds the greatest circumference of the grain Exine ± 1.5μ thick, finely pitted (Pl 3, Fig 40)

Monocolpate Pollen type 1

**Description** Grains sub-spherical, 36μ × 28μ in size Monocolpate, colpus short, lips thickened, ends blunt Exine ± 2.5μ thick, verrucate, verrucae irregular in shape and evenly distributed (Pl 3, Fig 39)

Turma *Poroses* Potonié, 1960
Subturma *Monoponenes* Naumova, 1939
*Monopollemtes* sp

**Description** Grains bean-shaped, 30μ × 40μ in size, monoporate, pore-ulceroid, rounded Exine ± 1.5μ thick, coarsely infranestructured (Pl 3, Fig 41)

Subturma *Polyponenes* Potonié, 1960
Genus cf *Almpollemtes* Potonié, 1931
cf *Almpollemtes* sp

**Description** Grains small, 22.5μ in size, pores 5 in number, angular, without annulus Exine folded (arcs) in between the pores Exine thin, psilate (Pl 3, Fig 42)

Subturma *Ptychoptomonenes* Naumova, 1937 ? 1939
Infraturma *Prolan Erdiman* 1943
Genus *Tricolporopollemtes* Thomson & Pflug, 1953
*Tricolporopollemtes* sp 1

**Description** Grains sub-circular, 36μ in size Tricolporate, pore rounded, colpi short, surrounded by thick exine Exine ± 1.5μ thick, psilate (Pl 3, Fig 43).

*Tricolporopollemtes* sp 2.

**Description** Grains sub-circular, 40μ × 46μ in size Tricolporate, pores rounded, colpi short, exine ± 2μ thick, proximally psilate, distally verrucate, verrucae small, flattened, evenly distributed (Pl 3, Fig 44)

Incertae sedis

**Description** Grains sub-circular, 60μ × 48μ in size, furows 16 in number, reaching to the pole, thin but prominent Exine thin, laevigate (Pl 3, Fig 45)

**Discussion**

The microflora recovered from the samples collected from Mohand (East) Field, Himachal Pradesh, India are mainly represented by the spores ofpterid-
Phytes and pollen grains of gymnosperms and angiosperms. The pteridophytic
spores are abundant and represented by the spores comparable to Polypodiaceae,
Schizaceae, Lycopodiaceae, Cyatheaceae, etc., The gymnospermous pollen also
are rich and related to Podocarpus, Pinus, Abies, Picea, Cedrus and Tsuga type and
the angiosperms are comparable to Palmae, Liliaceae, Betulaceae, etc. Angiosper-
mous pollen are fewer in comparison to pteridophytic spores and gymnospermous
pollen. Presence of Schizaceae, Lycopodiaceae and Polypodiaceae type of spores
indicate tropical marshy vegetation, whereas spores of Cyatheaceae and
Gleicheniaceae type are indicative of tropical to sub-tropical dry climate. Occur-
rence of Palmae and Liliaceae type of pollen show that the climate at that time
was humid to drier, temperate to sub-tropical Betulaceae, Podocarpus, Pinus,
Abies, Picea, Cedrus and Tsuga represent sub-tropical to temperate climate.

According to Krishnan (1968) the Siwalik sediments might have been
derived from north as well as from south. Occurrence of spores and pollen of
different geographic region also support this view Ghosh & Ghosh (1958) and
Rawat (1964) have recorded the occurrence of fossil woods of Anisoperoxylon
and Dipterocarpoxylon from the Middle Siwalik of Jawalamukhi, Punjab and
Mohand (West) and suggested that these could not have been carried to the basin of
deposition by any other means than through water. Present day Dipterocarpaceae
mainly occur in tropical evergreen well drained rain forest preferring more of soil
moisture and high humidity (Ghosh & Ghosh, 1958). The occurrence of similar
type of spores and pollen from Middle Siwalik of Bihar (Lukose, 1968) and from
that of Punjab (Banerjee, 1968) also support the views of Krishnan.

Although abundant spores and pollen have been recovered from the present
samples but each individual sample differ in their microfloral contents. Total
four samples have been studied and their positions are different from the highest
exposed horizons. Of the four samples two are collected from Lower Middle
Siwalik sediments of Mohand (East) Field which show abundant spore but poor
pollen content. Remaining two samples, collected from Upper Middle
Siwalik sediment of Mohand (East) Field show abundant spore and pollen content.
Gymnospermous pollen are dominant over the angiospermous pollen and
pteridophytic spores. From the occurrence of different types of pollen content and geological position it may be concluded that the sediments have
been deposited under fresh water condition from different geographical horizons
and a great climatic change occurred during their deposition, i.e. during
Upper Miocene to Lower Pliocene time.

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MICROFLORA OF MIDDLE SIWALIK 383

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Explanation of Plates

PLATE 1
1 Cyathidiites minor Couper x 1500 2-3 Cyathidiites cf. minor Coupe x 700 4 Aluspollemites sp x 1000 5 Gleichenioides sp x 1000 6 Gleichenioides of Conocisporites (Roues) Srivastava x 1000 7 Triporate of plantae Sah & Kar x 700 8 Leptolepidites sp x 1500 9 Microleptolepidites sp x 1000 10 Conocisporites crassatus Dele et al x 1000 11 Osmundacisporites sp x 1000 12 Echitnletes sp x 700 13 Rugulatisporites sp x 1000 14 Carynagopites sp x 700 15 Ipsopodophytspores x 1000 16 Taurocuspites cf. segmentatus Stoves x 1000

PLATE 2
17 Kukuljanites sp x 1000 18 Taurocuspitespores x 1000 19 L amnestygites annatus Wilson & Webster x 700 20-21 Lamgatopites sp x 700 22 Longatopites sp x 700 23 Polydopterospores sp x 700 24 Polydopterospores of foraminificus Couper x 1000 25 Monolete spores x 1000 26-27 Taurocuspites sp x 700 28-29 Abiespollemites sp x 700

PLATE 3
30-33 Poaopodophytspores sp 31-32 & 34 Abiesnepodophytspores sp x 700 35 Podocarpus sp x 700 36 Cedrastites sp x 700 37 Palaeopodophytspores sp x 700 38 Palaeopodophytspores sp x 700 39 Monolete spores x 1000 40 Longatopites sp x 700 41 Monopodophytspores sp x 1000 42 of Aluspollemites sp x 700 43 Triporate sp x 1000 44 Triporate sp x 700 2 x 700 45 Insetida zed x 700
PLENARY SESSION

Resolution

It was unanimously resolved

(i) to standardise the palynological nomenclature,

(ii) to prepare a dictionary of descriptive terminology,

and (iii) to compile a catalogue of valid genera and species according to the International Code of Botanical Nomenclature.

It was further resolved that paleopalynology having acquired a significant role in Stratigraphy, the subject be included in the curricula of studies in Botany and Geology at the Master's degree level in the Universities in India.