A KASAULI PALYNOFLORA FROM BANETHI AREA OF HIMACHAL PRADESH, INDIA

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ABSTRACT

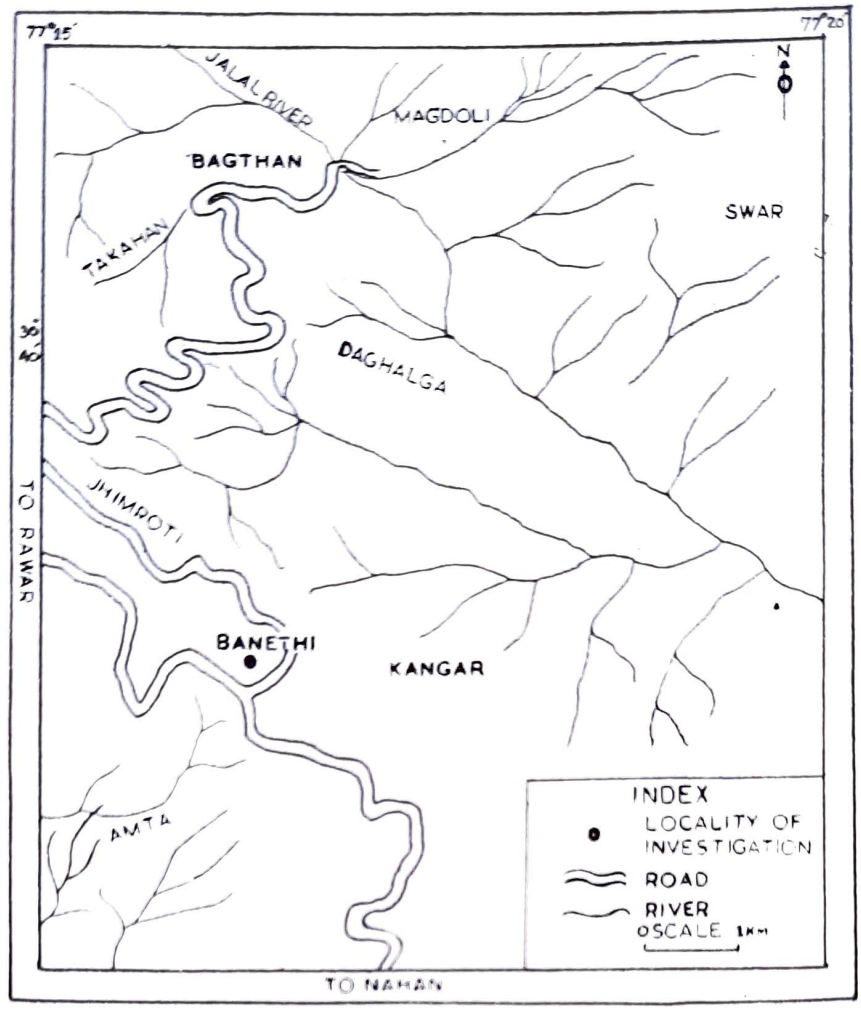
The palynofloral investigation of the Kasauli sediments exposed near Banethi in Sirmur District, Himachal Pradesh reveals the presence of a diversified assemblage. Out of 17 genera and 23 species, 2 species are new. Qualitatively, the Kasauli palynotaxa seem to have affinity with the families: Cyatheaceae, Schizeaceae, Lindsayaceae, Polypodiaceae, Pinaceae, Gramineae, Bombacaceae, Oleaceae, and Liliaceae. Quantitatively the fungal spores, conidia and ascostromata form the dominant elements of this palynological assemblage. Gymnospermous, angiospermous pollen grain and pteridophytic spores are represented by 38, 15 and 5 per cent, respectively. On the basis of the palynological data a subtropical climate has been postulated during the Kasauli times in the present area.

INTRODUCTION

Kasauli Formation is massively developed in Himachal Pradesh. It conformably overlies the Dagshai Formation and can easily be differentiated from the former by having greyish-green, compact, hard and generally micaceous sandstones, mostly of arenaceous nature. Rarely the sandstones are intercalated with siltstones and shaly bands which are purplish or olive-green in colour. It is believed that the Kasauli sediments were deposited under fresh water environments, and perhaps pertain to early Miocene age (KRISHNAN, 1949). Recently MATHUR AND JAIN (1972), KHAN (1973) and MATHUR AND VENKATACHALA (1979) have opined that the Muree sediments of Jammu Kashmir were deposited under brackish water conditions. MATHUR AND VENKATACHALA (1979) have also given the same opinion for the Dharmsala sediments in Himachal Pradesh.

A perusal of the literature shows that the Kasauli sediments are largely unfossiliferous. SAHNI (1953) described a few angiospermic leaves, viz. *Dictyophyllum* sp. from the type locality of Kasauli Formation. In the year 1964, SAHNI recorded *Sabalites microphylla* from the Kasauli Hills. SINGH *et al.* (1973) reported the occurrence of some ill-preserved triporate pollen grains, fungal spores and degraded type of organic matter from the same area. Subsequently, SINGH AND KHANNA (1980) recorded a poor palynofloral assemblage consisting of sponge spicules, fresh water algae *Pediastrum*, pteridophytic spores, gymnospermous and angiospermous pollen grains together with fungal spores. Quantitative estimation of the distribution of various palynomorphs was done by the same authors but they neither described nor illustrated the recovered forms in their paper.

During the course of the present investigation of the Tertiary sediments of Banethi-Bagthan area, the authors recovered a well-preserved palynological assemblage from the Kasauli sediments near Banethi. As far as the authors are aware, this is the first detailed report on the Kasauli palynoflora (Himachal Pradesh).



Map 1—Showing the location of Banethi, Sirmur district, Himachal Pradesh, India

MATERIAL AND METHOD

Twenty samples collected from the Kasauli Formation exposed near Banethi, Sirmur District, Himachal Pradesh (Map-1) have been investigated. Of these only three samples proved to be productive. Here the succession of sediments mainly consists of greyish-green micaceous sandstones which usually prove unproductive. Therefore, efforts were made to concentrate on the collection of siltstones with thin bards of shales which were observed near Banethi.

The conventional technique of processing the samples with HCl, HF, HNO_3, and KOH was adopted and the palynofossils were separated by specific gravity floatation method using heavy liquid (sp. gr. 2. 3). The slides were mounted in DPX mountant. The slides and negatives of the palynomorphs have been deposited in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

SYSTEMATIC PALYNOLOGY

Anteturma	Proximegerminantes Potonié, 1970
Turma	Triletes Reinsch emend. Dettmann, 1963
Suprasubturma	Acavatitriletes Dettmann, 1963
Subturma	Azonotriletes Luber emend. Dettmann, 1963
Infraturma	Laevigati Bennie & Kidston emend. Potonié, 1956

Genus—**Cyathidites** Couper, 1953
Type Species—Cyathidites australis Couper, 1953

Cyathidites australis Couper, 1953

Remarks—The miospore studied in the present assemblage is subtriangular with broadly rounded apices and slightly convex interapical margin. Trilete mark is very distinct, with long laesurae which generally extend upto about 2/3 of the spore radius. Exine is laevigate and $\pm$ 2 μm in thickness.

Dimensions—Size of the miospore—70 $\times$ 75 μm.

Affinity—Cyatheaceae.

Genus—**Deltoidospora** (Miner, 1935) Potonié, 1956
Type Species—Deltoidospora hallii Miner, 1935

Deltoidospora sp.
Pl. 1, Fig. 5

Description—Miospore subtriangular, apices broadly rounded, interapical margin straight to slightly convex. Trilete, Y-rays distinct, extending almost upto the spore margins, laesurae thin. Distal folds just opposite the trilete rays present. Exine 2 μm thick, two-layered, laevigate.

Dimensions—42 μm in diameter, length of the laesurae up to 17 μm.

Comparison—In *Deltoidospora delicata* Sah (1967) laesurae extend up to the equator and hence it is not comparable. *D. africana* Sah (1967) differs from *Deltoidospora* sp. in having shallow depression on the distal surface. *D. pseudoreticulata* Singh, Srivastava and Roy (1964) possesses bigger size-range and pseudoreticulate structure and therefore is different.

Remarks—Only a single specimen of *Deltoidospora* sp. has been recorded in the present assemblage. Superficially the trilete mark, though not very clearly visible due to the presence of folds on the distal surface just opposite the trilete marks, is easily discernible in differential focussing.

Affinity—Matoniaceae.

Genus—**Lygodiumsporites** (Potonié, Thomson & Thiergart) Potonié, 1956
Type Species—Lygodiumsporites adriennis (Potonié & Gelletich) Potonié, Thomson & Thiergart, 1950

Lygodiumsporites adriennis (Potonié & Gelletich) Potonié, Thomson & Thiergart, 1950
Pl. 1, Fig. 15

Remarks—Only a single specimen of this species has been recorded in the present assemblage. The miospore is subtriangular in shape with distinct trilete mark. Y-rays are open and laesurae extend more than half of the spore radius. Exine is laevigate and $\pm$ 1 μm thick.

Dimensions—Size—55 $\times$ 60 μm.

Affinity—Schizeaceae.

Infraturma MURORNATI Potonié & Kremp, 1954

Genus—**Foveosporites** Balme, 1957
Type Species—Foveosporites canalis Balme, 1957

Foveosporites sp.

Pl. 1, Fig. 12

Description—Miospore subcircular in equatorial view. Trilete mark distinct, Y-rays extending up to the equatorial margin, ray-vertex raised, laesurae thin covered by labra, slightly sinuous. Exine 2 μm thick, foveolate, foveolae small, less than 0.5 μm in size, closely placed and uniformly distributed all over the surface; development of foveolae more on the distal surface than on the proximal side. *Extrema lineamenta* appearing slightly punctured.

Dimensions—Size 58 ×56 μm; length of the laesurae upto 40 μm.

Comparison—*Foveosporites* sp. differs from *F. canalis* Balme (1957) in having closely and evenly placed foveolae on both the surfaces. *F. miocenicus* Ramanujam (1972) possesses a smaller size-range, inconspicuous and shorter Y-rays and larger foveolae. *Foveosporites congoensis* Sah (1967) can be differentiated by its subtriangular shape and smaller size-range.

Affinity—Lycopodiaceae.

Genus—**Lycopodiumsporites** (Thiergart, 1938) Delcourt & Sprumont, 1955
Type Species—*Lycopodiumsporites agathoecus* (Potonié) Thiergart, 1938

Lycopodiumsporites sp.

Pl. 1, Fig. 1

Description—Miospore roundly triangular, apices broadly rounded, interapical margin highly convex. Y-mark distinct, laesurae sinucus, thin, extending more than 3/4 of the spore radius. Exine ±3 μm thick, ornamentation reticulate, muri well-developed on distal side, thin membraneous meshes varying in shape measuring about 5 to 6 μm in size, proximal muri ill-developed, regular meshes imperceptible.

Dimensions—Size 38 ×42 μm; length of the laesurae up to 15 μm.

Comparison—*Lycopodiumsporites* sp. closely resembles *L. elegans* Salujha *et al.* (1972) in overall appearance but the latter is distinct by its comparatively thinner exine with coarsely reticulate ornamentation. *L. exiguus* Salujha *et al.* (1972) differs from the present specimen in having thin exine and microreticulate ornamentation. *L. palaeocenicus* Dutta & Sah (1970) can be differentiated by its straight laesurae, thinner exine and coarser reticulum proximally. *Lycopodiumsporites* sp. is different from any other known species by its thick exine with well-developed muri on distal side and sinuous laesurae.

Remarks—Only a single specimen has been recorded in the present assemblage, therefore, detailed study up to specific level has not been possible.

Affinity—Lycopodiaceae.

Turma	Mongletes Ibrahim, 1933
Suprasubturma	Acavatomonoletes Dettmann, 1963
Subturma	Azonomonoletes Luber, 1935
Infraturma	Laevigatomonoleti Dybova & Jachowitz, 1957

Genus—**Polypodiaceaesporites** Thiergart, 1940
Type Species—*Polypodiaceaesporites haardti* (Potonié & Venitz) Thiergart, 1940

Polypodiaceaesporites sp.

Pl. 1, Fig. 14

Description—Miospores bilateral, oval-shaped. Monolete mark distinct, laesurae thin and straight extending more than half of the longer axis of the spore. Exine thin, ±1.5 μm in thickness. Ornamentation scabrate, denser at periphery, sparse at the central portion delineating a ±oval area.

Dimensions—Observed range: Size 68-74×35-40 μm; length of the leasurae upto 40 μm.

Comparison—*Polypodiaceaesporites* sp. compares favourably with *Polypodiaceasporites tertiares* Sah & Dutta (1968) in having scabrate exine but the latter can be distinguished by its smaller size range as well as by a narrow ridge on the monolete mark. *P. haardtii* Pot. & Ven. (1934) differs from the present specimens by its smaller size and laevigate exine.

Remarks—Only a few specimens of this type have been recorded.

Affinity—Polypodiaceae.

Anteturma	VARIEGERMINANTES Potonié, 1970
Turma	ALETES Ibrahim, 1933
Subturma	AZONALETES (Luber) Potonié & Kremp, 1954
Infraturma	PSILONAPITI Erdtman, 1947

Genus—**Laricoidites** (Potonié, Thomson & Thiergart) Potonié, 1956

Type Species—*Laricoidites magnus* (Potonié) Potonié, Thomson & Thiergart, 1950

Laricoidites magnus (Potonié) Potonié, Thomson & Thiergart, 1950

Pl. 1, Fig. 10

Remarks—The specimens assigned here to this species are slightly smaller in size than those described by Potonié (1950) from the Miocene of Germany. Circular to subcircular pollen grains are highly folded. The exine is thin and laevigate.

Dimensions—Size 60-65 μm.

Affinity—Pinaceae.

Turma	SACCITES	Erdtman, 1947
Subturma	DISACCITES	Cookson, 1947
Infraturma	PINOSACCITI	Erdtman emend. Potonié, 1958

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

Type Species—*Pinuspollenites labdacus* (Pot.) Raatz *ex* Potonié, 1958

Pinuspollenites tenuicorpus sp. nov.

Pl. 1, Figs. 17, 18, 19

Holotype—Pl. 1, Fig. 18, Slide no. 6864, coordinates 13.5×101.

Type Locality—Banethi, Kasauli Formation, Himachal Pradesh, India

Diagnosis—Pollen grains bisaccate, ±haploxylonoid. Central body subcircular to circular in shape, longer than broad vertically, proximally psilate and distally granulose, marginal crest prominent, well-developed distal furrow, thin. Sacci intrareticulate, reticulation coarse, sacci closely attached to the body having a narrow uncovered germinal area.

Description—Pollen grains bisaccate, ±haploxylonoid. Central body ±subcircular, longer than broad vertically, proximal surface psilate and distal surface finely

granulose in ornamentation, marked by distinct, well-developed marginal crest, ±4 μm thick, granulose in ornamentation, dark in colour, slightly stratified in nature, distal germinal furrow narrower, unthickned. Sacci subequatorially attached, very closely placed on the central body along the germinal furrow, ±kidney-shaped in appearance, intrareticulate in ornamentation, reticulum coarse, lumina comparatively larger in the central portion of the sacci, small-sized lumina form a band-like appearance on the marginal region.

Dimensions—Holotype, overall breadth 88 μm; breadth of the body 50 μm; length of the body 61 μm; breadth of the saccus 35 μm; length of the saccus 64 μm.

Observed range—Overall breadth 60 to 90 μm; breadth of the body 35 to 53 μm; length of the body 45 to 65 μm; breadth of the saccus 25 to 40 μm; length of the saccus 45 to 70 μm.

Comparison—*Pinuspollenites tenuicorpus* sp. nov. can be differentiated from *P. labdacus* (Pot) Raatz ex Potonié, 1958 by its body having granulose distal surface, psilate proximal surface and body saccus ratio. *P. pseudolabdacus* Takahashi *in* Takahashi and Kim (1979) differs from the present species by its shorter sacci in comparison to the central body and scabrate marginal cap. *P. taedaeformis* (Zaklinskaja) Ke & Shi, 1978 (vide Takahashi & Kim, 1979) has a bigger size-range.

Affinity—Pinaceae.

Turma PLICATES (Naumova) Potonié, 1960
Subturma MONOCOLPATES Iversen & Troels-smith, 1950
Infraturma RETECTINES (Maljavikina) Potonié, 1958

Genus—**Liliacidites** Couper, 1953
Type Species—*Lilacidites kaitangataensis* Couper, 1953

Liliacidites sp.

Pl. 1, Fig. 9

Description—Pollen grain oval-shaped. Monosulcate, sulcus distinct, long, extending more than 2/3 of the longer axis, broader at both the ends, width ±10 μm, sexine slightly thicker than nexine, collumulate, small-sized baculae uniformly and closely distributed, baculae forming negative reticulum all over the surface, lumina variable, circular to oval in shape, measuring less than 1 μm in diameter.

Dimensions—Size 56 ×46 μm; length of the sulcus 45 μm.

Comparison—*Liliacidites kaitangataensis* Couper (1953) can be distingushed from *Liliacidites* sp. by its bigger size and coarsely reticulate exine. *L. ellipticus* Venkatachala & Kar (1969) closely resembles the present specimen in shape and size but differs by its boat-shaped sulcus and finely intramicroreticulate exine. *L. baculatus* Venkatachala & Kar (1969) is distinct by the presence of a funnel-shaped colpus and intrabaculate exine. *L. intermedius* Couper (1953) possesses a very long sulcus, equally thickened sexine and nexine and bigger lumina hence the present specimen is quite different.

Remarks—Only a single specimen of *Liliacidites* sp. is studied. Therefore, it has not been possible to assign it to any specific taxonomic unit.

Affinity—Liliaceae.

Subturma TRYPTYCHES (Naumova) Potonié, 1960

Genus—**Retitrescolpites** Sah, 1967
Type Species—Retitrescolpites typicus Sah, 1967

Retitrescolpites sp.
Pl. 1, Figs. 2,3

Description—Pollen grains subcircular. Tricolpate, colpi long, thin. Exine± 4μm thick, taegillate, retipilariate, sexine thicker than nexine, pila small, 2 to 3 μm in length, closely placed, columella distinct, surface ornamentation reticulate lumina varying considerably in shape and size, muri 1 to 2 μm in width, granulose in nature, grana small, sparsely distributed.

Dimensions—Observed range. Size of the pollen grains 40 ×42 μm to 52 ×56 μm; length of the colpi up to 35 μm.

Comparison—Retitrescolpites sp. compares favourably with *R. splendens* Sah (1967) in overall appearance but the latter can be differentiated by its bigger size and distinct muri formed by free pila. *R. africanus* Sah (1967) differs from the present specimens in having larger size range and broader muri of reticulum. *R. typicus* Sah (1967) is bigger in size and possesses thicker muri, hence the present specimens are quite different.

Affinity—Oleaceae.

Subturma PTYCHOTRIPORINES (Naumova) Potonié, 1960
Infraturma PROLATI Erdtm., 1943

Genus—**Bombacacidites** Couper, 1960
Type Species—Bombacacidites bombaxoides Couper, 1960

Bombacacidites bombaxoides Couper, 1960

Remarks—In the year 1960, fossil pollen grains of Bombacaceae type were described by COUPER (1960) and ANDERSON (1960) under two different names viz., *Bombacacidites* and *Bombacacipites*. COUPER (1960) validly published this genus in the month of September whereas the paper of ANDERSON did not indicate as to in which month was it published. Because of this, *Bombacacidites* Couper is now considered as a senior synonym of *Bombacacipites* Anderson by SRIVASTAVA (1972), who also revised the diagnosis of *Bombacacidites* differentiating it from the genus *Salixipollenites*.

The present specimen referable to *Bombacacidites bombaxoides* Couper, 1960 is slightly bigger than the type specimen described by COUPER (1960) from New Zealand. It is isopolar, tricolporate, subtriangular in shape. The apices of pollen grains are broadly rounded and the inter-radial walls almost straight; colpi are very short, about 7 to 10 μm length, and furrow being 5 to 6 μm wide bordered by a thickened margin. The exine is distinctly stratified; sexine is thicker than the nexine, clavate, clava being small in size and uniform in shape. They are very closely placed on the apices whereas their distribution is sparser on the inter-apical margins. The ornamentation appears tectate on the apices and semitectate on the interapical margin; sexine is ±2μm thick, but nexine is ±.5 μm thick. In surface view the ornamentation pattern appears to be reticulate. The lumina of the reticulation are larger on apocolpia (4 to 5 μm and becoming finer towards the equatorial ridge of mesocolpia (5 to 1 μm). The size of the lumina is comparatively larger in the present specimen than in those described by COUPER (1960).

Dimensions—Size 56 μm in diameter.

Affinity—The pollen grain of *Bombacacidites bombaxoides* shows similarities with those of modern *Bombax* belonging to the dicotyledonous family Bombacaceae.

Turma Poroses (Naumova) Potonié, 1960
Subturma Monoporines (Naumova) Potonié, 1960

Genus—**Monoporopollenites** (Meyer) Potonié, 1960
Type Species—*Monoporopollenites gramineoides* Meyer, 1956

Monoporopollenites kasauliensis sp. nov.
Pl. 1, Figs. 7, 8

Holotype—Pl. 1, Fig. 8, Slide no. 6868, coordinates 3. 6×84.5.

Type Locality—Banethi, Kasauli Formation, Himachal Pradesh, India.

Diagnosis—Pollen grains circular to subcircular in fully flattened condition. Monoporate, pore 3 to 10 μm in diameter, oval to circular in shape, annulus present, 2-3 μm thick, dark brown in colour, rim gradually thinning out towards the marginal region. Exine 1.5 to 2 μm thick, laevigate.

Dimensions—Holotype 80 μm in diameter. Observed range: size 5 to 80 μm in diameter.

Comparison—*Monoporopollenites kasauliensis* sp. nov. closely compares with *M. gramineoides* Meyer (1956) described from the Neogene sediments of south India by Rao and Ramanujam (1976) in shape and by the presence of an annulus surrounding the pore but the latter differs from the present species by its smaller size range and infrapunctate exine and hence in not comparable.

Remarks—Most of the pollen grains of *M. kasauliensis* sp. nov. are found in very much folded condition.

Affinity—Gramineae.

Genus—**Graminidites** Cookson, 1947
Type Species—*Graminidites media* Cookson, 1947

Graminidites media Cookson, 1947
Pl. 1, Fig. 6

Remarks—Only a single specimen of *G. media* has been recovered. The specimen is subsphaerical in shape, monoporate with a small pore which is 6 μm in diameter. The exine is ±1 μm thick, finely granulose. Few folds are also present.

Dimensions—Size 38 μm in diameter.

Affinity—Gramineae.

Fungal Remains

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

Inapertisporites circularis Sheffy & Dilcher, 1971
Pl. 2, Fig. 21

Remarks—The fungal spores are subspherical in shape and inaperturate. The spore wall is psilate and ± 1 μm thick. Most of the specimens observed in the present

assemblage are slightly bigger than those described by SHEFFY AND DILCHER (1971) from the Claiborne Formation.

Dimensions—Size range 12-16 μm.

Affinity—GRAHAM (1965) opined that *I. circularis* belongs to the order Ustilagenales, class-Basidiomycetes. However, DILCHER (1965) observed that it resembles the conidiospores of *Pelicothallos villous* Order-Microthyriales, Family-Trichopelteae.

Inapertisporites subovoideus Sheffy & Dilcher, 1971.
Pl. 2, Fig. 22

Remarks—Only a single specimen has been recorded in the present assemblage. It is an egg-shaped unicellular spore with a flattened apex. The wall is psilate and less than 1 μm in thickness.

Dimensions—Size of the spore 8 × 19 μm.

Affinity—Uncertain.

Inapertisporites ovalis Sheffy & Dilcher, 1971
Pl. 2, Fig. 20

Remarks—Only a single specimen has been recorded from the Kasauli assemblage. The spore is oval-shaped, non-septate, dark brown in colour. The spore wall is smooth, ±1 μm thick.

Dimensions—Size of the spore 6 × 11 μm.

Affinity—Uncertain.

Genus—**Staphlosporonites** Sheffy & Dilcher, 1971
Type Species—*Staphlosporonites conoideus* Sheffy & Dilcher, 1971

Staphlosporonites conoideus Sheffy & Dilcher, 1971
Pl. 2, Fig. 27

Remarks—The present specimens are bigger in size than those described by SHEFFY and DILCHER (1971). Seven or more cells are clustered in a compact cone-shaped structure which is two cells wide at the middle, tapering to a single cell conditions towards one of the ends. Each cell is subspherical in shape with ±1.5 μm thick wall and psilate in nature, a number of folds present in each cell.

Dimensions—Observed range: overall size 55 × 85 to 60 × 80 μm. Size of the individual cell 11 × 20 to 12 × 22 μm.

Affinity—Unknown.

Staphlosporonites sp.
Pl. 2, Fig. 31

Description—Twelve or more cells arranged in a compact oblong structure, dark brown, two cells wide at the middle. Single cell, tapering towards one end. Wall psilate ±1 μm thick, individual cells subcircular in shape, inaperturate.

Dimensions—Size 40 × 126 μm; size of the individual cells 15 × 20 μm.

Comparison—The present specimen can be distinguished from other known species by its very large size.

Affinity—Unknown.

Genus—**Parmathyrites** Jain & Gupta, 1970
Type Species—Parmathyrites indicus Jain & Gupta, 1970

Parmathyrites indicus Jain & Gupta, 1970
Pl. 2, Fig. 24

Remarks—The specimen described here as *P. indicus* possesses a flattened ascostromata which is subcircular in shape. The radiating hyphae are connected with each other throughout the length and form a single-layered thick pseudoparenchymatous body. The cells of the central portion are squarish, whereas the marginal cells are long and rectangular. From each marginal cell a single spine arises which is broader at the base and pointed at the apex. The spines are 15 to 20 μm in length and 3 to 4 μm in breadth.

Dimensions—Size of the ascostromata 75 μm in diameter.

Affinity—Microthyriaceae.

Parmathyrites sp.
Pl. 2, Fig. 30

Description—Ascostromata flattened, subcircular, dimidate, one-layered thick, radiating hyphae forming a pseudoparenchymatous structure, central cells not well-defined, peripheral cells longer, rectangular, marginal cells spinose. Spines small, ± 4 μm long, base of the spines thickened.

Dimensions—Size of the ascostromata 68 μm in diameter.

Comparison—Parmathyrites indicus Jain & Gupta (1970) resembles the present specimen in general organisational pattern and shape but the former can be distinguished by its very long spines present along the periphery. *Parmathyrites* sp. is distinct from other known species by its very small marginal spines which are thickened at the base.

Remarks—Only a single specimen has been recorded in the present assemblage. Due to preservational factor some pore-like structures have been developed in the ascostromata which are of secondary origin. Most of the spines are found in broken condition.

Affinity—Microthyriaceae.

Genus—**Callimothallus** Dilcher, 1965
Type Species—Callimothallus pertusus Dilcher, 1965

Callimothallus pertusus Dilcher, 1965
Pl. 2, Fig. 32

Remarks—Ascostromata are circular to subcircular in shape with crenate or irregular margin.Free mycelium has not been observed.Hyphae join to form a single-layered pseudoparenchymatous body. The central cells of the ascostromata are small, measuring about 3-4 μm, polygonal to irregularly angled, comparatively thicker than the peripheral cells. The peripheral cells are radially arranged and bigger in size. They are rectangular to squarish in shape. Almost all the central and peripheral cells possess a single pore. The pore is circular and ±1.5 μm in diameter. Each pore is easily discernible at the base of an individual cell.

Dimensions—Observed range: Size of the ascostromata 85 to 100 μm in diameter.

Affinity—Microthyriaceae.

Genus—**Notothyrites** Cookson, 1947
Type Species—Notothyrites setiferous Cookson, 1947

Notothyrites amorphus Kar & Saxena, 1976
Pl. 2, Figs. 28, 29

Remarks—The present specimens resemble *N. amorphus* in overall appearance, but the structure of the ascostromata is not very clear due to badly preserved condition. The ascostromata is subcircular in shape with uneven margin, circular ostiole measuring about 10 μm in diameter and surrounded by thickened margin is present in the centre of the ascostromata. The specimens lack distinct parenchymatous appearance.

Dimensions—Observed range: size of the ascostromata 56 ×60 μm to 70 ×88 μm.

Affinity—Microthyriaceae.

Genus—**Tetraploa** Berk & Br.

Tetraploa aristata
Pl. 2, Fig. 34

Remarks—Fungal conidia described here as *Tetraploa aristata* are very common in the Kasauli assemblage. Most of the specimens have been found in degraded condition. The conidia are quadriseriate. The body of conidium is oblong to rectangular in shape. The body-wall is granulose and very dark in colour. The grana are very small and closely placed. There are four setae present, each arising from the corner of the body at one end. The setae are broader at the base and narrower towards the apex. They may be septate or aseptate. The length and breadth of the setae vary considerably.

Dimensions—Observed range : Size of the body 20 ×14 to 24 ×17 μm; length of the setae 75 to 80 μm; width of the setae 3 to 4 μm (at base).

Affinity—Uncertain.

INCERTAE SEDIS

Pollen type-1
Pl. 1, Fig. 16

Description—Pollen grain oval-shaped with rounded lateral ends. Size 50 × 40 μm. Monocolpate, colpus long, 51 μm in length, extending from one pole to another, narrower in the middle part and wider at both the ends giving a dumb-bell-shaped appearance, width of the colpus ±5μm in the middle and ±13μm at the poles, lips of the colpus very thick, dark brown in colour, 7 to 8 μm in width. Exine ±2μm thick, sexine and nexine equally thick, finely granulose.

Remarks—Due to lack of sufficient specimens for detailed study, its taxonomic status cannot be ascertained precisely.

Pollen type-2
Pl. 1, Fig. 13

Description—Pollen grain oval-shaped in equatorial view. Size 29 ×49 μm.

Tricolporate. Colpi long, straight, extending more than ½ of the longer axis, pore small, inconspicous. Exine thin, ± 1 μm thick, very faintly granulose.

Pollen type-3

Pl. 1, Fig. 4

Description—Pollen grain subcircular in equatorial view, Size 53 μm in diameter. Tricolporate, colpi long, extending from one pole to another, thin, uniformly broad, pore small ora lalongate. Exine thin, ±2μm thick, baculae and coni present all over the surface, ± 5 μm in length.

Pollen type-4

Pl. 2, Fig. 23

Description—Pollen grains subcircular, size range 38 to 44 μm in diameter. Monosulcate, sulcus 30 to 32 μm long and 4 to 6 μm in width. Exine thin, ±1.5 μm thick, spinulose in ornamentation, spines 2-3 μm long, closely distributed all over the surface.

Fungal spore type-1

Pl. 1, Fig. 25

Description—Specimen oval-shaped, unicelled, wall±1.5 μm thick, wavy margin, surface scabrate to faintly reticulate, few tubercles present, one end of spore slightly raised like a protuberance, measuring about 10 μm in width.

Dimensions—Size of the spore 46×70 μm.

Fungal hyphae type-1

Pl. 1, Fig. 33

Description—Monoserial chain of cells. Size 180 μm in length, hyphae pointed at one end, cells 4 μm wide at one end and widening to 10 μm at the other end of the hyphae. Cells variable in length and width, wall±2 μm thick, septae generally all split open in one direction.

Sponge spicules

Pl. 2, Fig. 26

Remarks—Sponge spicules are monoaxon, 50-70 μm long. In most of the cases they are found in clusters.

DISCUSSION

The Kasauli palynoflora of Banethi (believed to be of early Miocene age) consists of taxa belonging to fungi, pteridophytes, gymnosperms, angiosperms and sponge spicules. The most striking feature of the present assemblage is the overwhelming dominance of the sponge spicules in some stratigraphic levels of the Kasauli succession. The palynofloral assemblage comprises 17 genera and 23 species, of these, 2 species are new. The Kasauli palynoflora is dominated by the fungal spores, conidia and ascostromata of epiphyllous fungi. They are represented by *Inapertisporites circularis, I. ovalis, I. subovoideus, Staphlosporonites conoideus, Staphlosporonites* sp., *Parmathyrites indicus, Parmathyrites* sp., *Callimothallus pertusus, Notothyrites amorphus* and *Tetraploa aristata.*

Gymnospermous elements constitute an important aspect of the assemblage (38 per cent) qualitatively but they are not much diversified. Only two forms have been identified, viz., *Pinuspollenites tenuicorpus* sp. nov. and *Laricoidites* sp.

Angiospermous elements, constituting about 15 percent of the total assemblage, are represented by *Monoporopollenites kasauliensis* sp. nov., *Graminidites media* ,*Bombacacidites bombaxoides*, *Retitrescolpites* sp. and *Liliacidites* sp. Besides, some forms have been described as pollen-types. The remaining 5 per cent of the assemblage is represented by the pteridophytic spores, viz., *Cyathidites australis*, *Polypodiaceaesporites* sp., *Lygodiumsporites adriennis*, *Deltoidospora* sp., *Foveosporites* sp., and *Lycopodiumsporites* sp. The probable affinity of the spore/pollen genera with their respective modern families indicates the presence of the following families. Polypodiaceae, Cyatheaceae, Schizeaceae, Lindsayaceae, Pinaceae, Gramineae, Bombacaceae, Oleaceae and Liliaceae.

The Kasauli palynological assemblage, though not diversified qualitatively, clearly indicates that the majority of its constituents belong to subtropical climate. It also suggests a humid type of vegetation. The abundance of gymnospermous bisaccate pollen grains in the present assemblage seems to be also due to the blown in elements from the elevated upland surrounding the area of deposition. On the basis of the abundant occurrence of gymnospermous pollen grains, fungal spores and ascostromata it seems reasonable to assume that a moist subtropical climate prevailed during deposition of the Kasauli sediments in the present area of investigation.

The present palynological information also supports the earlier views of SINGH AND KHANNA (1980) that the degraded nature of the organic matter indicates a fluvio-deltaic environment of deposition in a fast sinking basin.

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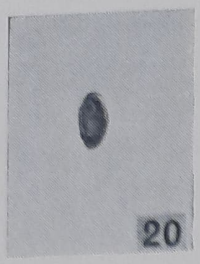
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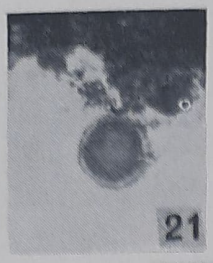
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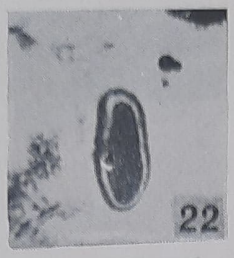
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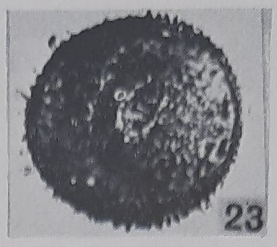
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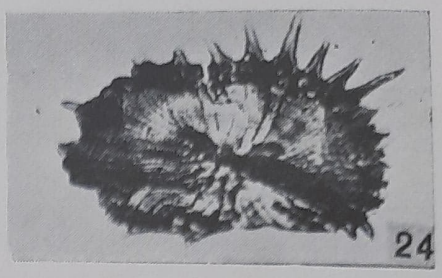
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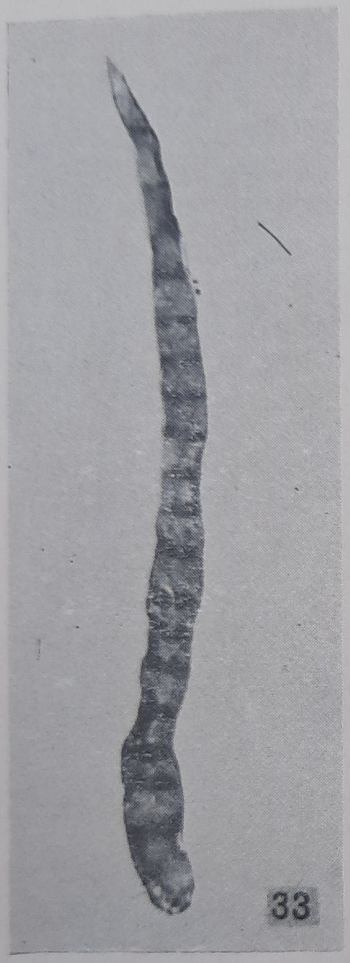
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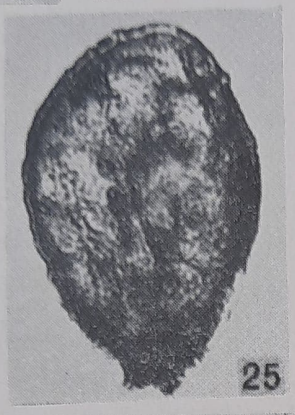
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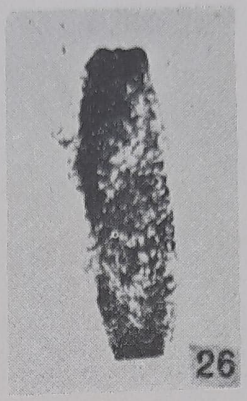
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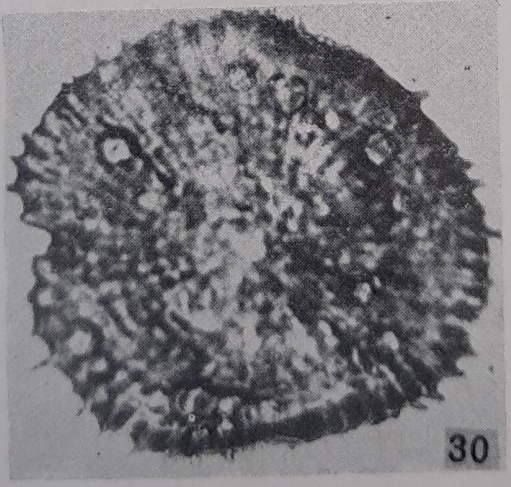
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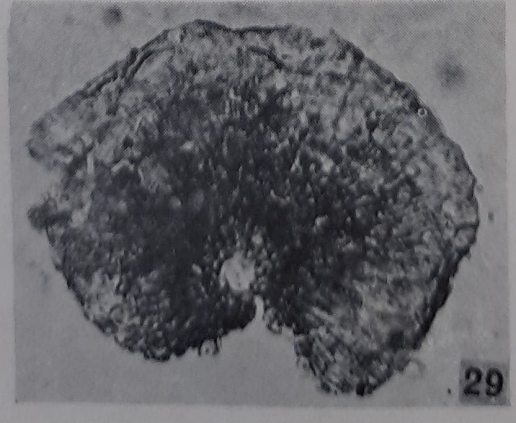
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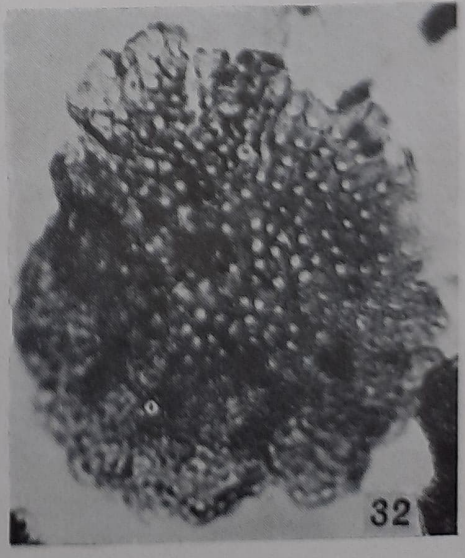
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EXPLANATION OF PLATES

(All photomicrographs enlarged *ca* ×500, unless otherwise mentioned).

PLATE-1

1. *Lycopodiumsporites* sp.; Slide no. 6865, coordinates 21.2 ×95.2.
2,3. *Retitrescolpites* sp. Slide nos. 6865, 17.4 ×111; 6863, coordinates 4.2 ×91.2.
4. Pollen type—3; Slide no. 6863, 20 ×73.8.
5. *Deltoidospora* sp.; Slide no. 6864, 15.8 ×84.6.
6. *Graminidites media* Cookson; Slide no. 6866, 13.8 ×16.5.
7,8. *Monoporopollenites kasauliensis* sp. nov.; Slide nos. 6865, 8.2 ×104.4; 6868, 3. 6 ×84.5 (Holotype).
9. *Liliacidites* sp.; Slide no. 6865, 14 ×95.
10. *Laricoidites magnus* (Potonié) Potonié, Thomson & Thiergart; Slide no. 6863, 9 ×18.
11. *Bombacacidites bombaxoides* Couper; Slide no. 6863, 13 ×95.
12. *Foveosporites* sp.; Slide no. 6864, 7.8 ×74.5.
13. Pollen type-2 ; Slide no. 6865, 9.5 ×32.5.
14. *Polypodiaceaesporites* sp.; Slide no. 6865, 21 ×113.9.
15. *Lygodiumsporites adriennis* (Potonié & Gelletich) Potonié, Thomson & Thiergart; Slide no. 6864, 19 ×76.
16. Pollen type-1; Slide no. 6865, 9.5 ×32.5.
17,18.19. *Pinuspollenites tenuicorpus* sp. nov.; Slide nos. 6866, 18.8 ×95.9; 6864, 13.5 ×101 (Holotype), coordinates 16 ×107.

PLATE-2

20. *Inapertisporites ovalis* Sheffy & Dilcher; Slide no. 6868, 14.2×101.4.
21. *Inapertisporites circularis* Sheffy & Dilcher, Slide no. 6868, 1.5×73.8.
22. *Inapertisporites subovoideus* Sheffy & Dilcher; Slide no. 6868, 13.5×113.
23. Pollen type-4; Slide no. 6863, 18.2×115.2.
24. *Parmathyrites indicus* Jain & Gupta; Slide no. 6869, coordinates 15.5×110.5.
25. Fungal spore type-1; Slide no. 6865, 15×77.
26. Sponge spicule; Slide no. 6870, 15.2×88.8.
27. *Staphlosporonites conoideus* Sheffy & Dilcher; Slide no. 6869, 3×9.5.
28,29. *Notothyrites amorphus* Kar & Saxena; Slide nos. 6869, coordinates 1.5×88; 6868, 10.5×102.8.
30. *Parmathyrites* sp.; Slide no 6868, 15.8×76.
31. *Staphlosporonites* sp.; Slide no. 6868, 1.5×92.
32. *Callimothalus pertusus* Dilcher; Slide no. 6868, 19.5×112.5.
33. Fungal hyphae type-1; Slide no. 6867 , 20.5×99.9.
34. *Tetraploa aristata;* Slide no. 6867, 4.5×118.5.