JOURNAL OF THE PALAEONTOLOGICAL SOCIETY OF INDIA
VOL. 33, 1988, P.P. 105 - 115.

PALYNOLOGY OF THE KASAULI FORMATION IN THE TYPE AREA IN SOLAN DISTRICT, HIMACHAL PRADESH

RAKESH KAPOOR[1], N.N. DOGRA[2] AND R.Y. SINGH[3]

1. DEPARTMENT OF GEOLOGY, GOVT. POST-GRADUATE COLLEGE, DHARAMSALA, HIMACHAL PRADESH-176 215.
2. DEPARTMENT OF EARTH SCIENCES, KURUKSHETRA UNIVERSITY, KURUKSHETRA-132 119.
3. C.A.S. IN GEOLOGY, PUNJAB UNIVERSITY, CHANDIGARH-160 014.

ABSTRACT

The present paper deals with the study of miofloral assemblage recovered for the first time from the stratotype of the Kasauli Formation in Himachal Pradesh. Altogether 28 species belonging to 22 formgenera of spores and pollen grains have been recovered. Of these, the new taxa are : *Verrucosisporites nishapushapensis*, *Tsugaepollenites kasauliensis* and *Quilonipollenites giganticus*. The kasauli palynological assemblage bears a close resemblance with the palynological assemblage known from the Surma sediments of Assam, Dharamsala beds of Himachal Pradesh and Neogene rocks of Meghalaya and therefore assigned an Early Miocene age. The abundance of pollen grains belonging to family Palmae, together with the occurrence of the megafloral remains of fan palm *Trachycarpus ladakhensis* indicates that the sediments were deposited under definite coastal condition.

INTRODUCTION

The Kasauli Formation, made up of 2200 m thick sandstone and shale sequence, constitutes the youngest stratal unit of the Lower Tertiary sediments in Simla Hills. These sediments are well exposed along Kalka-Kasauli Road section (Text Fig. 1). The outcrops of the Kasauli Formation begin three km beyond the Jangashu village on the road and continue well up to the Kasauli town which is situated on the upper part of the formation. The sandstone units of the formation are massive, yellowish grey to greenish grey in colour and are interbedded with the bluish grey nodular shales. The siltstone horizons that frequently occur in the formation are profusely rich in the leaf impressions and carbonaceous matter.

During the course of micropalaeontological investigation of the Lower Tertiary sediments exposed along the aforesaid road section twenty seven palynological rock samples were collected from the various levels of the Kasauli Formation. Of these, only one carbonaceous shale sample collected near the Inspection Bungalow in Kasauli town has yielded a bountiful assemblage of spores and pollen grains. This report comprises the first record of plant microfossils from the stratotype of the Kasauli Formation. Prior to this, Singh and Sarkar (1984) have described some spores and pollen grains from the Kasauli sediments of Banethi area in Sirmur District, Himachal Pradesh.

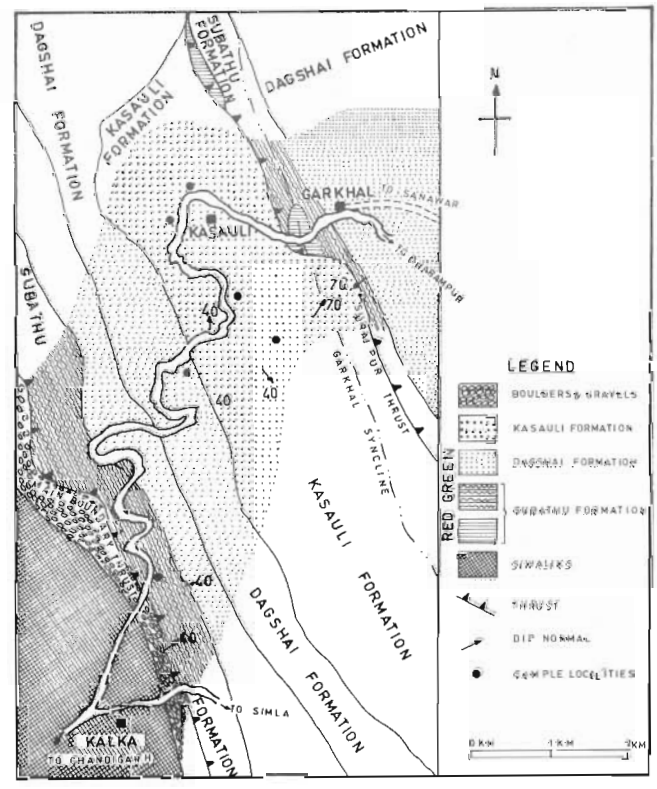

Fig. 1. Geological Map showing Tertiary formations exposed along the Kalka Kasauli Road. (After Kapoor and Singh 1987)

The present palynological assemblage of Kasauli Formation consists of 28 species belonging to 22 form genera of pteridophytic spores and gymnospermous and angiospermous pollen. These taxa are described below, and the age and environment of deposition of the Kasauli sediments is also discussed in the light of miofloral assemblage recovered from this formation. The microslides containing the spores and pollen grains are in the personal collection of first author under the Catalogue Nos. PB/PLKIB1 to PB/PLKIB8.

SYSTEMATIC DESCRIPTION

Genus Cyathidites COUPER, 1953
Cyathidites minor COUPER, 1953
(Pl. I — 2, 4)

Description: Spores subtriangular - triangular, size range 50 - 50 μm. Trilete, Y-rays distinct, raised, extending almost up to the equator, lips thick, exine psilate.

Affinity: Cyatheaceae.

Genus Todisporites COUPER, 1958
Todisporites minor COUPER, 1958
(Pl. I — 16)

Description: Spore ± circular in outline measuring 50 x 40 μm. Trilete, rays short extending less than half of the radius. Exine 2 - 3 μm thick, psilate.

Affinity: Osmundaceae.

Genus Alsophilidites COOKSON, 1947
Alsophilidites kerguelensis COOKSON, 1947
(Pl. I — 5)

Description: Miospore ± triangular, 60 x 40 μm in size. Trilete, rays extending almost upto equator, lips thick. Exine 2 μm thick, psilate.

Affinity: Cyatheaceae.

Genus Concavisporites (PFLUG) emended DELCOURT and SPRUMONT, 1955.
Concavisporites triquetrus SAH, 1967
(Pl. I — 12)

Description: Miospore triangular, 50 μm across with rounded apices and deeply concave interapical sides. Trilete, rays reaching up to equator, lips raised and thick. Exine 1 - 1.5 μm thick, leavigate.

Affinity: Cyatheaceae.

Genus Leiotriletes POTONIÉ and KREMP, 1954
Leiotriletes punctatus SINGH, 1977
(Pl. I — 14)

Description: Spore subtriangular - subcircular in outline, 60 x 50 μm in size. Trilete, rays extending up to 2/3 radius. Exine 2 μm thick, intrapunctate.

Affinity: Cyatheaceae.

Genus Leptolepidites COUPER, 1953
Leptolepidites sp.
(Pl. I — 21)

Description: Spores roundly triangular - subcircular, 80 x 50 μm in size. Trilete, rays distinct, extending more than 1/2 of the radius. Exine 1 - 2 μm thick, covered with densely placed verrucae.

Comparison: The present species closely compares with *Leptolepidites* sp. as described by Singh *et al. (1985) from the Barail sediments of Assam and Meghalaya but differs from the latter in having comparatively larger size, and robustly built and highly placed verrucae.*

Affinity: Unknown

Genus Verrucosisporites (IBRAHIM) emended POTONIÉ and KREMP, 1956
Verrucosisporites nishapushapensis n. sp.
(Pl. I — 1, 3, 9, 13, 19, 20, 22)

Holotype: Pl. I, Fig. 3, size 54 x 48 μm

Stratotype: Kasauli Formation, Kasauli (Lower Miocene).

Type Locality: Kasauli Waterworks, Kasauli, Himachal Pradesh.

Diagnostic Characters: Miospores subtriangular - subcircular with rounded apices and straight to convex interapical sides. Size range 30 - 60 μm. Trilete, rays distinct, extending 3/4 of the radius. Exine 1 - 2 μm thick, verrucose to connate.

Comparison: *Verrucosisporites longitatus* Mathur and Mathur (1969) can be differentiated from the present species by its comparatively large-sized laesurae. *Verrucosisporites* sp. described by Rawat (1969) from the Katrol Formation of Kutch is larger in size.

Affinity: Unknown.

Genus Foveosporites BALME, 1957
Foveosporites retiformis SALUJHA, KINDRA and REHMAN, 1978
(Pl. I — 8)

Description: Spore subcircular - subtriangular, 60 x 50 μm in size. Trilete, rays distinct, slightly undulating and reaching up to equator. Exine ± 1.5 μm thick, foveolate, faveolae 1 - 2 μm in diameter.

Affinity: Lycopodiaceae.

Foveosporites sp.
(Pl. I — 23)

Description: Spore subcircular to subtriangular, 90 x 80 μm in size. Trilete, rays reaching up to the equator. Exine 2 - 3 μm thick, foveolate, foveolae circular, up to 3 μm deep.

Comparison: The present species differs form all the known species of the genus in having a comparatively larger size.

Affinity: Lycopodiaceae.

Genus Lycopodiumsporites (THIERGART) DELCOURT and SPRUMONT, 1955
Lycopodiumsporites palaeocenicus DUTTA and SAH, 1970
(Pl. I — 25)

Description: Miospore roundly triangular - subspherical, measuring 70 x 60 μm in size. Trilete, rays straight, extending 1/2 - 3/4 of the radius. Exine 1 - 2 μm thick, reticulate, muri 2 μm high, lumen 2 - 3 μm broad.

Affinity: Lycopodiaceae.

Lycopodiumsporites umstewensis DUTTA and SAH, 1970
(Pl. I — 10)

Description: Spore ± triangular - subtriangular, measuring 50 x 46 μm. Trilete, rays 8 - 10 μm in length, lips thin. Exine up to 1.5 μm thick, reticulate, muri 1 - 2 μm, lumen polygonal to circular in shape.

Affinity: Lycopodiaceae.

Lycopodiumsporites speciosus DUTTA and SAH, 1970
(Pl. I — 7)

Description: Spore broadly subcircular - subtriangular in outline, measuring 50 x 46 μm. Trilete, rays extending almost up to 3/4 of the radial distance, lips thin. Exine 2 - 2.5 μm thick, reticulate both proximally and distally lumen circular and shallow.

Affinity: Lycopodiaceae.

Lycopodiumsporites sp.
(Pl. I — 6)

Description: Miospore roundly triangular - subcircular, measuring 60 x 50 μm. Trilete, rays extending almost up to 3/4 of the radius. Exine 1.5 μm thick, reticulation on both surfaces, interapical sides coarsely reticulate, elsewhere microreticulate. Muri 1 - 2 μm thick in the contact area, lumen 4 - 10 μm across.

Comparison: The present species differs from all the known species of the genus in having comparatively thicker exine and variable reticulation.

Affinity: Lycopodiaceae.

Genus Laevigatosporites IBRAHIM, 1933
Laevigatosporites lakiensis SAH and KAR, 1968
(Pl. I — 24)

Description: Spore hemispherical, 80 x 55 μm in size. Monolete, laesura straight, distinct, lips thin, reaching 2/3 diameter. Exine 1 - 1.5 μm thick, psilate.

Affinity: Polypodiaceae.

Genus Polypodiaceaesporites THIERGART, 1940
Polypodiaceaesporites tertiarus DUTTA and SAH 1970
(Pl. I — 11)

Description: Spore monolete with bilateral profile, concavoconvex, 60 x 50 μm in size. Monolete, ray bordered by narrow ridge up to 2 μm high. Exine 2 - 2.5 μm thick with verrucate to scabrate sculpture.

Affinity: Polypodiaceae.

Genus Polypodiisporites POTONIÉ, 1934
Polypodiisporites oligocenicus SAH and DUTTA, 1968
(Pl. I — 15, 17)

Description: Spores bean shaped, measuring 50 - 70 μm in size. Monolete, laesura well developed, often obscured by sculpture. Exine 1 - 2 μm thick, sculptured with dense verrucae, verrucae bulbous at the base and pointed at the top.

Affinity: Polypodiaceae.

Genus Tsugaepollenites POTONIÉ and VENITZ, 1934
Tsugaepollenites kasauliensis n. sp.
(Pl. II — 28-30, 34, 40)

Holotype: Pl. 2, Fig. 28, Size, 68 x 50 μm.

Stratotype: Kasauli Formation, Kasauli (Lower Miocene)

Type Locality: Kasauli Waterworks, Kasauli, Himachal Pradesh.

Diagnostic Characters: Pollen grains ± subcircular - oval, size range 50 - 100 μm. Monosaccate, central body ± circular and compressed, 20 - 30 μm in size, saccus distally folded, beset with vermiculate - rugulate sculpture.

Comparison: The present taxon differs from the genotype as well as *T. enigmatus* and *T. fimbriatus* described by Singh and Kumar (1969) from the Mesozoic sediments of Madhya Pradesh in having comparatively larger size and vermiculate sculpture pattern.

Affinity: The present taxon can be compared with the pollen grains of extant genus *Tsuga*.

Genus: *Podocarpidites* (COOKSON) POTONIÉ, 1958.
Podocarpidites microreticuloidatus COOKSON, 1947
(Pl. II — 46).

Description: Pollen grain bisaccate, measuring 80 x 78 μm sacci large, compressed with central body, central body distally placed, length of the sacci greater than the length of central body.
Affinity: Podocarpaceae

Genus Abiespollenites THIERGART in RAATZ, 1937
Abiespollenites sp.
(Pl. II — 44).

Description: Pollen grain bisaccate, measuring 90 x 50 μm. Central body small, 50 x 40 μm in size, oblate in shape and granulose, sacci larger than the central body, moderately reticulate. Proximal cap well developed. Exine moderately thick.
Affinity: Pinaceae.

Genus *Palmaepollenites* POTONIÉ, 1950
Palmaepollenites eocenicus SAH and DUTTA, 1966
(Pl. II — 27, 32)

Description: Pollen grains oval - elliptical, size range 60 - 70 μm. Monosulcate, sulcus considerably long but not reaching the equator, lips thin and gaping mostly. Exine 1 - 2 μm thick, stratified, usually psilate to faintly sculptured.
Affinity: Palmae

Genus Paimidites CHITALEY Ex. COUPER, 1953
Palmidites plicatus SINGH, 1977
(Pl. II — 31, 33, 36)

Description: Pollen grains oval - elliptical in shape with pointed - rounded lateral ends. Size range 60 - 110 μm. Monosulcate, sulcus long, extending from one end to another, folds well eveloped throughout the length of sulcus. Exine 1 - 2 μm thick, laevigate, sometimes slightly intrastructured.
Affinity: Palmae.

Palmidites assamicus SINGH, 1977.
(Pl. I — 18)

Description: Pollen grain oval-subrounded, measuring 70 -50 μm in size. Monosulcate, sulcus broad, extending from one end to another. Exine 1 - 2 μm thick, laevigate to weakly intrastructured.
Affinity: Palmae.

Genus *Liliacidites* COUPER, 1953.
Liliacidites microreticulatus DUTTA and SAH, 1970.
(Pl. II — 26)

Description: Pollen grain oval - elliptical, measuring 55 x 40 μm in size. Monosulcate, sulcus, distinct, extending almost from one end to another. Exine 1.5 μm thick, microreticulate.
Affinity: Liliaceae.

Liliacidites major SINGH, 1977.
(Pl. II — 35, 37, 38, 42)

Description: Pollen grains oval - elliptical with broad lateral ends, measuring 80 - 110 μm in size. Monosulcate, sulcus distinct, extending from pole to pole. Exine 2 - 3 μm thick. Sexine as thick as nexine. Exine pitted with bacular heads sometimes reticulate.
Affinity: Liliaceae.

Genus *Quilonipollenites* ROA and RAMANUJAM, 1978.
Quilonipollenites giganticus n. sp.
(Pl. II — 45, 47)

Holotype: Pl. 2, Fig. 45; Size 80 x 75 μm
Stratotype: Kasauli Formation (Lower Miocene) Himachal Pradesh.
Type Locality: Kasauli Waterworks, Kasauli, Himachal Pradesh.
Diagnostic Characters: Pollen grains circular-subcircular - subspheroidal in lateral view. Size range 65 - 100 μm. Monosulcate, sulcus long extending from pole to pole. Exine thick, sexine thicker than nexine, surface ornamentation reticulate, reticulum with hexagonal meshes, muri moderately thick, lumen 2 - 4 μm across.
Comparison: The present species differs from all the known species of the genus by its very large and coarse reticulate ornamentation.

Genus Rhoipites WODEHOUSE, 1933.
Rhoipites sp.
(Pl. II — 41)

Description: Pollen grain roundly triangular in polar view and ± oval in equatorial view, sides slightly convex. Size 70 x 50 μm. Tricolporate, zonocolpate, colpi fairly deep. Exine 2 - 3 μm thick, sexine thicker than nexine in apertural region. Aperture elongate, ornamentation scabrate.
Remarks: The present species differs from all the known species of the genus in having comparatively larger size.
Affinity: Anacardiaceae.

Genus Impatiensidites SAH, 1967.
Impatiensidites sp.
(Pl. II — 39)

Description: Pollen grain subtriangular – subcircular, 70 x 50 μm in size and angulaperturate, grain probably flattened and narrow, tenuimarginate, colpi short. Exine up to 2 μm thick, distally reticulate in surface view, meshes forming reticulum of large lumen.

Remarks: The present species differs from all the known species of the genus in having subtriangulur – subcircular shape and comparatively thicker exine.

Genus Polyporina (NAUMOVA), POTONIÉ, 1960.
Polyporina globosa SAH, 1967.
(Pl. II — 43)

Description: Pollen grain ± globular, 50 x 30 μm in size, panaperturate, pores vary in number from 15 – 20, circular – slightly ellipsoidal up to 5 μm across, 3 - 5 μm apart. Exine 3 – 4 μm thick, probably punctate.

Affinity: Chenopodiaceae – Amranthaceae.

DISCUSSION

Palynoflora from the Kasauli Formation comprises 28 species belonging to 22 formgenera. Out of this, the pteridophytes constitute 16 species referable to 12 formgenera. The gymnosperms are represented by 3 species in 3 formgenera, among these, 2 species and 2 genera are bisaccate, while monosaccate comprises a single species under the genus *Tsugaepollenites*. The angiosperms constitute the second major group after the pteridophytes. They include 9 species belonging to 7 genera. The monocots form the bulk of the angiosperm assemblage with 6 species referable to 4 formgenera, while 3 genera and 3 species may be assigned to the dicotyledons.

The Kasauli palynoflora can be compared with the Neogene palynofloras described from the different parts of the country. The main contributions in this regard are as follows:

East Coast Miocene Sediments have been palynologically studied by Ramanujam (1963, 1966, 1967, 1982), Deb (1972) and Ramanujan *et al.* (1980) from Neyveli area. The Quilon and Warkalli beds have been worked out by Rao and Ramanujam (1975, 1978, 1979). The subsurface Tertiary sediments of Cauvery Basin were studied by Venkatachala (1974). Kaushal (1980), on the other hand, documented palynofossils from the subsurface Tertiary sediments of well No. 6 Dabka, Gujarat. Baksi (1972) carried out palynological studies in the Bengal Basin and differentiated the sequence into seven palynological zones. His zone V corresponds to Miocene sediments. Likewise, Assam Neogene Sediments have been investigated by Sah and Singh (1977) and the Himalayan Neogene sediments comprising Siwaliks, Kasauli and Dharamsala beds were studied by Nandi (1980), Saxena *et al.* (1984); Singh and Sarkar (1984) and Dogra *et al.*(1985), respectively.

HIMALAYAN REGION

Singh and Sarkar (1984) recorded a palynological assemblage comprising 23 species in 17 genera of Cyatheaceae, Schizeaceae, Lindsayaceae, Polypodiaceae, Pinaceae, Graminae, Bombacaceae, Oleaceae, Liliaceae along with some fungal remains from the kasauli sediments of Banethi area, Himachal Pradesh. They opined a subtropical climate for the Kasauli vegetation. The present palynological assemblage contains commonly shared spore-pollen taxa like *Pinuspollenites, Lycopodiumsporites, Cyathidites, Polypodiaceaesporites* and *Liliacidites*. It is apparent that the palynoflora described by Singh and Sarkar (1984) is dominated by the pteridophytic spores, whereas the present assemblage is characterized by the abundance of pteridophytes and pollen grains belonging to family Palmae. This difference could be due to the restricted inland nature of the basin from which Singh and Sarkar (1984) have recovered their palynological assemblage. Kasauli basin in the Type area, however, was well in continuation with the regressive sea of Palaeogene time, is evident by the occurrence of a large number of pollen grains of the family Palmae in these sediments. This is also supported by the presence of the remains of the fan palm *Trachycarpus ladakhensis* indicating a distinct coastal aspect. The intermountane nature of the basin is further borne out by the fact that the kasauli mioflora contains a considerable population of the pollen grains of the upland gymnosperms.

Dogra *et al.* (1985) made a preliminary survey of Dharamsala sediments in the Type area and recovered a rich miofloral assemblage. They have recorded 42 species in 25 genera of pteridophytes, gymnosperms and angiosperms. This assemblage corresponds very closely to the present palynological assemblage of the Kasauli Formation. The similarity between the two assemblages is much evident at the specific level. The common taxa recorded in both the assemblages are: *Lycopodiumsporites speciosus, Foveosporites retiformis, Laevigatosporites lakiensis, Cyathidites minor, Alsophilidites kerguelensis, Liliacidites major, Podocarpidites microreticulatus,*

P. microreticuloidatus, Palmaepollenites eocenicus and *Palmidites plicatus*. This taxon comparable at generic level is *Quilonipollenites*. The close proximity of the two localities and similar environment of deposition might be the key factors for this striking identity in the palynofloras.

The palynostratigraphy of the Siwalik sediments of the Panjab Himalaya has been worked out by Nandi (1975, 1980). She instituted four zones from the base to the top in the succession. These are: *Magnastriatus - Palmaepollenites, Polypodiaceaesporites pseudoreticulatus, Podocarpidites ellipticus* and *Alnipollenites* zones. The *Podocarpidites ellipticus* zone recognised by her (1980) contains certain palynotaxa common with the present assemblage. This resemblance of the palynofloras may be due to the immediate younger stratigraphic position of the Siwalik sediments. Dutta and Singh (1980) described some palynomorphs from the Siwalik sediments of Arunachal Pradesh. The palynological assemblage mentioned by them contains two palynotaxa viz., *Lycopodiumsporites* and *Todisporites* similar to the present assemblage. The assemblage of aforesaid authors do contain some recycled Permian palynomorphs as is also seen in the Kasauli assemblage. Saxena and Singh (1982) and Saxena *et al.* (1984) recorded a rich association of spores and pollen grains from Siwalik sediments of Himachal Pradesh. The former described 23 species under 19 form genera from the Pinjore Formation near Chandigarh, while the latter enlisted 36 species belonging to 27 genera from the Bhakra-Nangal area. These assemblages, like the Arunachal Pradesh Siwalik palynological assemblage, also contain common taxa like *Cyathidites, Todisporites, Polyporina, Abiespollenites* etc. owing to their succeeding deposition in the same basin.

NORTH-EASTERN REGION

Baksi (1974) proposed a general palynostratigraphic setting of the sedimentary sequence in Assam-Meghalaya basins. He recognised eight palynological zones in the entire succession. His seventh palynological zone i.e., *Coniferipites-Cicatricosisporites* Assemblage zone instituted in the Surma and Tipam Sediments, contains a number of palynotaxa commonly found in the present assemblage. Some of the significant forms are: *Rhoipites* and *Polypodiaceaesporites*. This resemblance in the mioflora may be explained due to their synchroniety. Similarly, Sah and Singh (1977) made a detailed comparison of biostratigraphic sequence exposed in Meghalaya, Assam and Gujarat basins. The palynomorphs recorded by them from Surma and Tipam sediments correspond very closely to the present assemblage because of the above mentioned factor. The Miocene sediments of the Tulamura Anticline in Tripura State (Salujha *et al.*, 1980) have yielded a prolific and diverse palynoflora that contains several elements common with the present assemblage. Significant among these are: *Cyathidites, Foveosporites, Polypodiaceaesporites, Lycopodiumsporites, Laevigatosporites, Palmaepollenites*, etc. This is obviously due to the similarity in their age, palaeogeography and palaeoecology.

SOUTH INDIA

Venkatachala (1974) recognised 14 palynofloral zones in the Sub-Surface Mesozoic-Tertiary sediments of Cauvery basin. The *Lacrimapollis pilosus* zone of Early Miocene age recognised by him may be compared with the present assemblage.

A broad palynological correlation of kasauli Formation is depicted in Fig. 2.

BIOSTRATIGRAPHIC INTERPRETATION, AGE AND PALAEOECOLOGY

The Kasauli palynological assemblage is comparable with the *Castinipollenites* zone of Kaushal (1980), recorded in the Dabka well No. 6, Gujarat; *Lacrimapollis pilosus* zone of Venkatachala (1974) of Cauvery basin; the lower part of Bengal Palyno zone V of Baksi (1972); palynological assemblage of Surma sediments of Assam (Sah and Singh, 1977); *Coniferipites Cicatricosisporites* Assemblage zone of Baksi (1974) from Meghalaya and with the Dharamsala mioflora in the Type area (Dogra *et al.*, 1985).

Surprisingly, the assemblage does not contain the significant Oligocene taxa, such as *Striatriletes, Meyeripollis, Barringtonia, Foveotricolporites, Myrtaceidites, Triporopollenites, Nyssapollenites*, etc. The Eocene palynological assemblage can be differentiated from the present assemblage by the presence of genera like *Proxapertites, Dandotiaspora, Couperipollis, Polycolpites*, etc. Therefore, the fair similarity of the Kasauli palynological assemblage with the Dharamsala and the Surma miofloras together with other known Neogene assemblages of India suggests its homotaxial relationship. Hence, it is also Early Miocene in age. Broad palynostratigraphic correlation of the Kasauli palynoflora is shown in Fig. 2. Besides, this palynological assemblage is also characterized by:

1. The predominance of Late Palaeozoic monosaccate and disaccate palynomorphs comprising nearly 60% of the total assemblage, clearly indicate the presence of Gondwana source rocks for the formation of the Kasauli sediments.

2. The high frequency of the pollen grains of upland gymnosperms, such as, *Abies*, *Pinus*, *Alisporites*, possibly *Quilonipollis* and Tsuga are characteristic of a temperate climate.
3. The pteridophytic elements in the vegetation are constituted by the taxa like *Cyathea*, *Alsophila*, *Todea*, *Polypodium*, *Verrucosisporites*, etc. pointing towards a considerable humidity in the atmosphere.
4. The presence of pollen grains of families like Palmae and Liliaceae in the assemblage indicates a coastal aspect of the deposition. This is further evident by the presence of numerous fragments of fronds of fan palm *Trachycarpus ladakhensis* in these sediments.
5. The presence of some dicot pollen grains of families like Chenopodiaceae - Amranthaceae and *Impatiense* and *Rhoipites*, suggests their contribution in the mioflora through the vegetation growing mainly on the surrounding stripe of the land immediate to the basin of deposition.

Thus, it can be envisaged from all the above evidences that the Kasauli sediments were laid down in an intermountane basin having some sort of a distant connection with the sea. The profile of this basin seems to be somewhat similar to the present day Chilka lake of Orissa or Astmudi backwaters of Kerala State where the surrounding upland was covered with the thick meadows of *Rhododendron*, *Berchimia*, *Populus* and *Quercus*. Further, the jungles of fan palm *Trachycarpus* were perhaps present on the coastal stripe immediately surrounding the backwater. While, the xerophytic herbs and shrubs of Chenopodiaceae and Amranthaceae were comprising the undergrowth on the cliffs, mounds or sand dunes present in between. It was also not impossible that the pollen grains of hydrophytic vegetation like *Impatience* were drained to the basin through the fresh water streams descending from the nearby hills.

CONCLUSION

Since the Kasauli assemblage bears a close correspondence with the Early Miocene palynological assemblages known from the Surma sediments of Assam (Sah and Singh, 1977), Dharamsala beds of Himachal Pradesh (Dogra *et al.*, 1985) and *Coniferipites - Cicatricosisporites* zone of Baksi (1974) recognised in the Neogene rocks of Meghalaya, it is Lower Miocene in age.

Further, this assemblage is spectacularly rich in the population of pollen grains referable to the family

LITHIC UNITS	AREAS / AGE	WESTERN HIMALAYA		WEST COAST, GUJARAT BASIN	CAUVERY BASIN		BENGAL BASIN	MEGHALAYA		ASSAM
		KASAULI PRESENT WORK	DHARAMSALA Dogra et al (1985)	KOSHAL, (1980)	VENKATACHALA, 1974		BAKSI, 1972	GARO HILLS NANDI & SHARMA (1982)	KHASI HILLS BAKSI, 1974	SAH & SINGH (1977)
KASAULI FORMATION	LOWER MIOCENE	Cyathidites minor, Todisporites minor, Alsophilidites kerguelensis, Liliacidites major, Tsugaepollenites kasauliensis, Pinuspollenites sp. Rhoipites sp, Alisporites indicus, Lycopodiumsporites spp., Podocarpidites ellipticus, Polypodiaceaesporites oligocenicus, Quilonipollenites giganticus, Polyporina globosa	Palmaepollenites spp, Podocarpidites spp, Lycopodiumsporites spp, Cyathidites spp, Foveosporites spp, Retipilonapites spp, Palmidites plicatus, Liliacidites spp. Microfoveolatosporis polyapperturata Pinuspollenites sp.	CASTANIPOLLENITES ZONE	TRICOLLAREPORITES ECHINATUS ZONE	Malvaceaerumpollis Paucibaculatus Sub-zone	BENGAL PALYNOLOGICAL ZONE-V	POLYGONACEAE PITES ZONOIDES SUB ZONE	CONIFERIPITES-CICATRICOSISPORITES ASSEMBLAGE ZONE	Upper part. Labiplanktonia lobata, Alsophilidites sp. Striatriletes sp Middle part Striatriletes sp Lygodiumsporites Lakiensis, Grujaniaspora delicata Lower part Seniasporites minutus, Cyathidites minor, Alsophilidites sp.
						Verrucatosporites bullatus Sub-zone				Podocarpidites microreticuloidatus, Graminidites sp
					Lacrimapollis pilosus zone			CICATRICOSISPORITES-PALMAEPOLLENITES ASSEM. SUB ZONE		
DAGSHAI FORMATION	EO-OLIGOCENE	FOSSILS NOT RECOVERED								

Fig. 2. Broad Palynological Correlation of Kasauli Formation of Himachal Pradesh

Palmae, thereby indicating the accumulation of enclosing strata under the definite coastal environment. This is also borne out by the fact that the Kasauli Formation contains numerous fragments of the leaves of the fan palm *Trachycarpus ladakhensis.*

That the Kasauli basin was of intermountain nature and supporting a luxuriant growth of the temperate vegetation on the upland areas is evident by the occurrence of leaf impressions of Quercus, Berchimia, Ziziphus, Populus etc., in the sediments.

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EXPLANATION OF PLATES

(All magnifications Ca x 500)

PLATE I

1, 3, 9, 13, 19, 20, & 22. *Verrucosisporites nishapushapensis* n. sp. PB/PLK1B8 135-30, PB/PLK1B_3 128-7, PB/PLK1B_5 132.5-19, PB/PLK1B_4 133.25-43.5, PB/PLK1B_3 129-30.75, PB/PLK1B3 129-35.75, PB/PLK1B_4 133.25-43.5.

2 & 4 *Cyathidites minor* Couper, 1953, PB/PLK1B5 132.75 - 36, PB/PLK1B_3 136.5 - 27.

5. *Alsophilidites Kerguelensis* Cookson, 1947 PB/PLK1B_8 136.5 - 33.5.

6. *Lycopodiumsporites* sp. PB/PLK1B_3 134.5 - 53.

7. *Lycopodiumsporites speciosus* Dutta and Sah, 1970, PB/PLK1B_5 134.5 - 27.75.

8. *Foveosporites retiformis* Salujha, Kindra and Rehman, 1978, PB/PLK1B_3 127 - 17.

10. *Lycopodiumsporites umstewensis* Dutta and Sah, 1970, PB/PLK1B_3 123 - 7.5.

11. *Polypodiaceaesporites tertiarus* Dutta and Sah, 1970, PB/PLK1B_4 127.5 - 28.5.

12. *Concavisporites triquetrus* Sah, 1967, 126-12.75.

14. *Leiotriletes punctatus* Singh, 1977, PB/PLK1B_5 134.25 - 36.

15.17. *Polypodiisporites oligocenicus* Sah and Dutta, 1968, PB/PLK1B_5 130 - 38, PB/PLK1B_3 130.5 - 5.5.

16. *Todisporites minor* Couper, 1958, PB/PLK1B_5 124.75 - 25.5.

18. *Palmidites assamicus* Singh, 1977, PB/PLK1B_5 134.25 - 38.

21. *Leptolepidites* sp. PB/PLK1B_5 127.5 - 21.

23. *Foveosporites* sp. PB/PLK1B_3 130-29.

24. *Laevigatosporites lakiensis* Sah and Kar, 1969, PB/PLK1B_3 129.5 - 42.

25. *Lycopodiumsporites palaeocenicus* Dutta and Sah, 1970, PB/PLK1B_3 134.7.5.

PLATE II

26. *Liliacidites microreticulatus* Singh, 1977, PB/PLK1B_3 128.5 - 55.25.

27. & 32*Palmaepollenites eocenicus* Sah and Dutta, 1966, PB/PLK1B_3 123.5, PB/PLK1B_8 126.5 - 33.5.

28-30, 34. 40. *Tsugaepollenites kasauliensis* n. sp., PB/PLK1B_8 125.25 - 33.25, PB/PLK1B_8 136.25 - 32.5, PB/PLK1B_3 130.5 - 12, PB/PLK1B_3 132.5-19, PB/PLK1B_3 125 - 34.5.

31, 33 & 36. *Palmidites plicatus* Singh, 1977, PB/PLK1B_4 127.5 - 28.5, PB/PLK1B_3 133-46, PB/PLK1B_5 112-29.

35, 73, 38 & 42. *Liliacidites major* Singh, 1977, PB/PLK1B_3 129.5 - 75, PB/PLK1B_3 122 - 47, PB/PLK1B_5 133 - 19, PB/PLK1B_3 134.25 - 38.

39. *Impatiensidites* sp. PB/PLK1B_4 126 - 18.75.

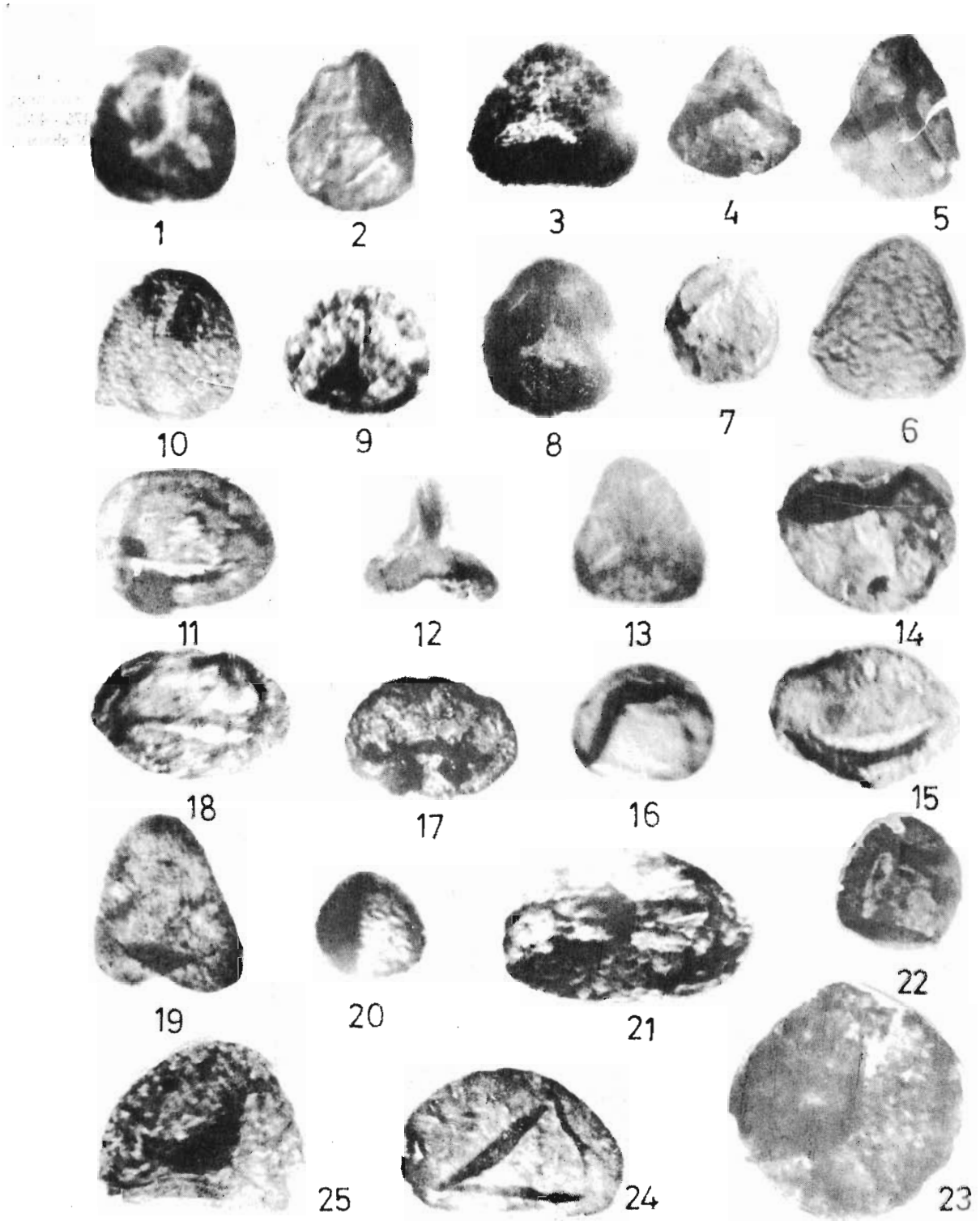
41. *Rhoipites* sp. PB/PLK1B_4 134.5 - 21.

43. *Polyporina globosa* Sah, 1977, PB/PLK1B_3 130-29.

44. *Abiespollenites* sp. PB/PLK1B_5 127-26.

45. & 47.*Quilonipollenites giganticus* n. sp. PB/PLK1B_5 129 - 17, PB/PLK1B_5 130.5 - 36.

46. *Podocarpidites microreticulatus* Cookson, 1947, PB/-PLK1B_3 130 - 31.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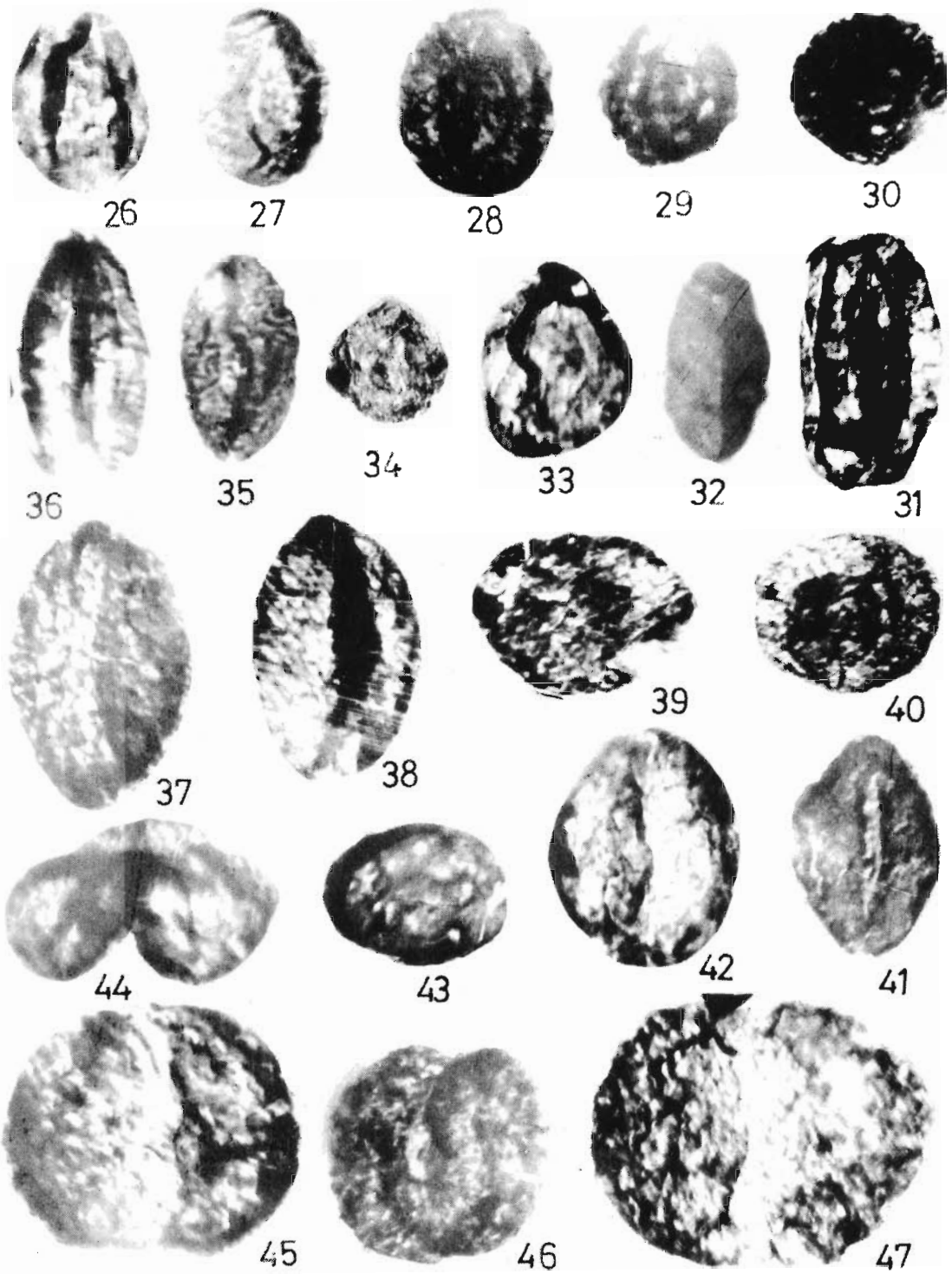
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