Palynostratigraphy of the Kasauli Formation (Lower Miocene), Himachal Pradesh, India

H.P. Singh & Samir Sarkar

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007

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A palynofloral assemblage recovered from the Kasauli sediments contains 33 genera and 40 species of palynofossils which are referable to the following families: Cyatheaceae, Polypodiaceae, Lycopodiaceae, Matoniaceae, Osmundaceae, Podocarpaceae, Pinaceae, Poaceae, Typhaceae, Liliaceae, Nymphaeaceae, Chenopodiaceae, Arecaceae, Asteraceae, Caesalpiniaceae etc. Based on the qualitative and quantitative analyses of the assemblage three palynological zones have been recognised in the sequence. A comparison of the present assemblage with those recorded earlier from the Kasauli sediments shows that the assemblage zones can be extended laterally. The overall palynofloral assemblage suggests that the sediments were deposited under fresh water environment though restricted brackish water influence is discernible. A humid subtropical climate seems to have prevailed during the deposition of Kasauli sediments.

Key-words – Palynostratigraphy, Kasauli Formation, Lower Miocene, India

INTRODUCTION

THE Kasauli Formation is massively developed and well exposed in Shimla hills, Himachal Pradesh. Very little work on the palynology of this formation has so far been done (Singh *et al.*, 1973; Singh & Khanna, 1980; Singh & Sarkar, 1984; Kapoor *et al.*, 1988). A perusal of the published literature shows that the earlier studies on the Kasauli palynofloras have mostly been done on a few spot samples. The present palynostratigraphical investigation of Kasauli Formation on the stratotype was undertaken with the objective to study the palynofloral assemblage in order to explore its application in establishing a palynozonation scheme sequentially. An effort has also been made to reconstruct the vegetation and evaluate environmental conditions during the deposition of these sediments in the Kasauli type locality.

GEOLOGICAL SETTING

The stratigraphic position of Kasauli Formation is given below. It conformably overlies the Dagshai Formation.

Age	Himalayan foot-hills
Lower Miocene	Kasauli Formation (Fluviodeltaic)
Lower Oligocene to Upper Eocene	Dagshai Formation (Coastal transitional)
Upper Eocene to Upper Palaeocene	Subathu Formation ((Marine)

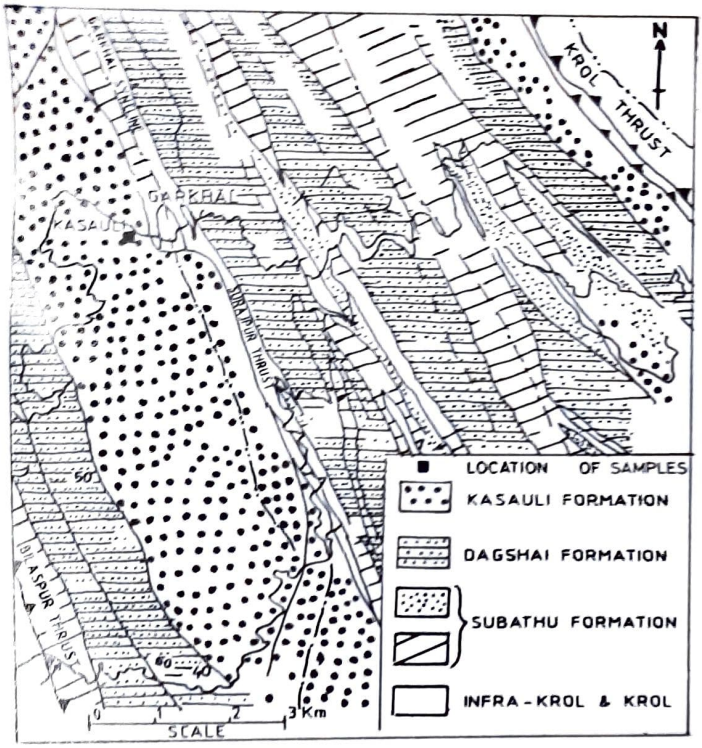
.....Unconformity.....

Pre-Tertiary rocks

The outcrops of Kasauli Formation are well developed and exposed all along the Kalka - Kasauli road section and are characterised by having compact hard, yellowish - green, highly micaceous sandstones intercalated with bluish grey, siltstones and shales. The shales are generally purplish in colour.

MATERIAL AND METHOD

The present investigation is based on 18 samples collected from 120m thick stratigraphic scarp section exposed near the Kasauli market at Kasauli town in Solan District of Himachal Pradesh (Text-fig. 1). An effort was made to collect samples representing different lithotypes. Ten samples yielded palynofossils. The conventional technique of processing of samples with HCL,HF, HNO3 and KOH was adopted and the palynofossils were separated by specific gravity floatation method using heavy liquid. The slides were prepared in DPX mountant. The slides and negatives of the palynofossils have been deposited in the repository of the Birbal Sahni Institute of Palaeobotany.



Text-figure 1. Geological map of Kasauli area. (after, Bhatia, 1982).

PALYNOTAXA RECORDED IN THE PRESENT ASSEMBLAGE

A check list of different species of algae, fungi, pteridophytic spores, gymnospermous and angiospermous pollen is given below:

A. Pteridophytic spores

Cyathidites australis Couper 1953
C. minor Couper 1953
Alsophilidites kerguelensis Cookson 1947
Dictyophyllidites granulatus Saxena 1978
Foveosporites retiformis Salujha, Kindra & Rehman 1978
Biretisporites meghalayensis Rao & Singh 1987
Osmundacidites sp.
Polypodiisporites tertiarus Dutta & Sah 1970
Leptolepidites rariverrucatus Nandi 1981
Lycopodiumsporites globatus Kar 1985
Todisporites major Couper 1958
T. minor Couper 1958

B. Gymnospermous pollen

Podocarpidites microreticulatus Cookson 1947
Pinuspollenites tenuicorpus Singh & Sarkar 1984
P. crestus Kar 1985
Cedripites sp.

C. Angiospermous pollen

Aglaoreidia sp.
Liliacidites sp.
Graminidites pliocenicus Singh & Saxena 1981
Palaeosantalaceaepites minutus Sah & Kar 1969
Polyporina globosa Sah 1967
Monoporopollenites kasauliensis Singh & Sarkar 1984
Palmidites maximus Couper 1953
Tricolpites sp.
Palmaepollenites nathamunnii Venkatachala & Kar 1969
Palmaepollenites sp.
Compositoipollenites conicus Sah 1967

Plate 1

(All Photomicrographs enlarged ca 500. Coordinates are within brackets.)

1. *Palaeosantalaceaepites minutus* Sah & Kar; Slide no. 11 141 (33x106)
2. *Polyporina globosa* Sah; Slide no. 11 129 (27 x 99)
3. *Compositoipollenites conicus* Sah; Slide no. 11 141 (37x109).
4. *Dicellaesporites* sp.; Slide no. 11 140 (52 x 106).
5. *Polypodiisporites tertiarus* Dutta & Sah; Slide no. 11 142 (36x97)
6. *Osmundacidites wellmanii* Couper; Slide no. 11 39 (64 x 104).
7. *Todisporites minor* Couper; Slide no. 1138 (52x95).
8. *Monolites* sp.; Slide no. 11 143 (35 x 98).
9. *Foveosporites retiformis* Salujha *et al.*; Slide no.11 137 (24 x 110).
10. *Aglaoreidia* sp.; Slide no. 11 136 (60x97).
11. & 12. *Pinuspollenites tenuicorpus* Singh & Sarkar; Slide no. 11 135 (59 x 104); Slide no. 11 134 (27x107).
13. *Cedripites* sp.; Slide no. 11 137 (53 x 108).
14. *Podocarpidites microreticulatus* Cookson; Slide no. 11 135 (42x94).
15. *Lycopodiumsporites globatus* Kar; Slide no. 11 141 (27x108).
16. *Liliacidites* sp.; Slide no. 11 133 (32x112).
17. *Monoporopollenites kasauliensis* Singh & Sarkar; Slide no. 11132 (37 x 107).
18. *Palmaepollenites nathamunnii* Venkatachala & Kar; Slide no. 11 137 (36 x 100).
19. *Palmidites maximus* Couper; Slide no. 11 131 (41 x 111).
20. *Inapertisporites* sp.; Slide no. 11 130 (52 x 108).
21. Angiosperm pollen type; Slide no. 11 141 (67 x 95).
22. *Tricolpites* sp.; Slide no. 11 128 (34 x 95)
23. *Graminidites pliocenicus* Singh & Saxena; Slide no. 11 135 (64 x 100).
24. *Multicellaesporites* sp.; Slide no. 11 134 (68 x 107).
25. *Phragmothyrites eocaenica* Edwards (Kar & Saxena); Slide no. 11 129 (38x 102).
26. *Dicotetradites* sp.; Slide no. 11 126 (36x96).
27. *Pediastrum compactum* Singh & Khanna; Slide no. 11 126 (36 x 96).
28. *Staphlosporonites conoideus* Sheffy & Dilcher; Slide no. 11 130 (65 x 105).

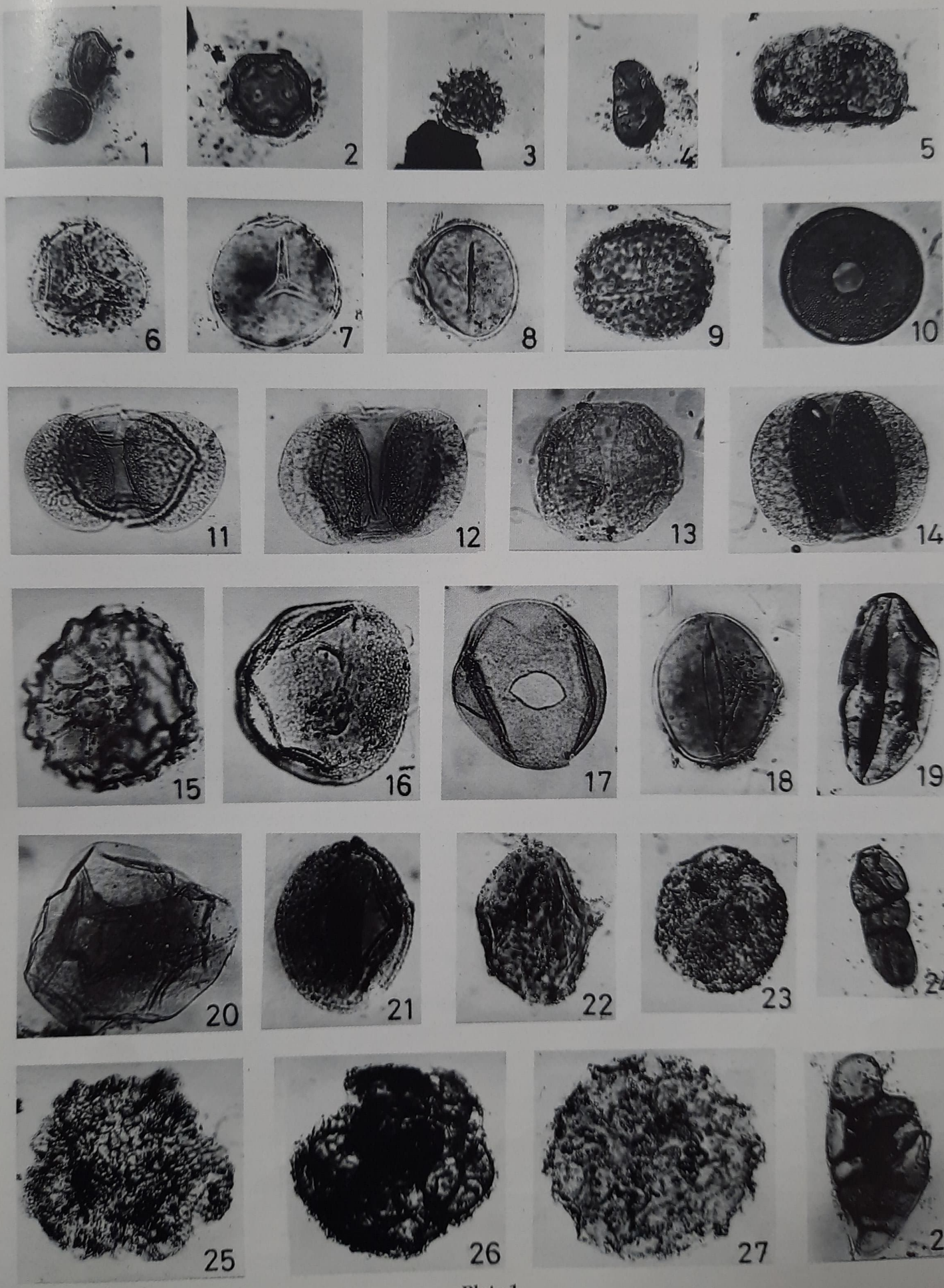


Plate 1

Nymphaeacidites decoratus Venkatachala & Rawat 1973
Dicotetradites sp.

D. Fungal elements

Inapertisporites miocenicus Singh *et al.* 1986
I. ovalis Sheffy & Dilcher 1971
I. subovoideus Sheffy & Dilcher 1971
Phragmothyrites eocaenica Edwards emend Kar & Saxena 1976
Staphlosporonites conoideus Sheffy & Dilcher 1971
S. multicellatus Saxena & Singh 1982
Dicellaesporites elongatus Ramanujam & Rao 1978
Dicellaesporites sp.
Asterothyrites keralensis Rao & Ramanujam 1976
Kutchiathyrites eccentricus Kar 1979
Frasnacritetrus siwalicus Saxena *et al.* 1987

Algae

Pediastrum compactum Singh & Khanna 1978
P. wilsonii Singh & Khanna 1978

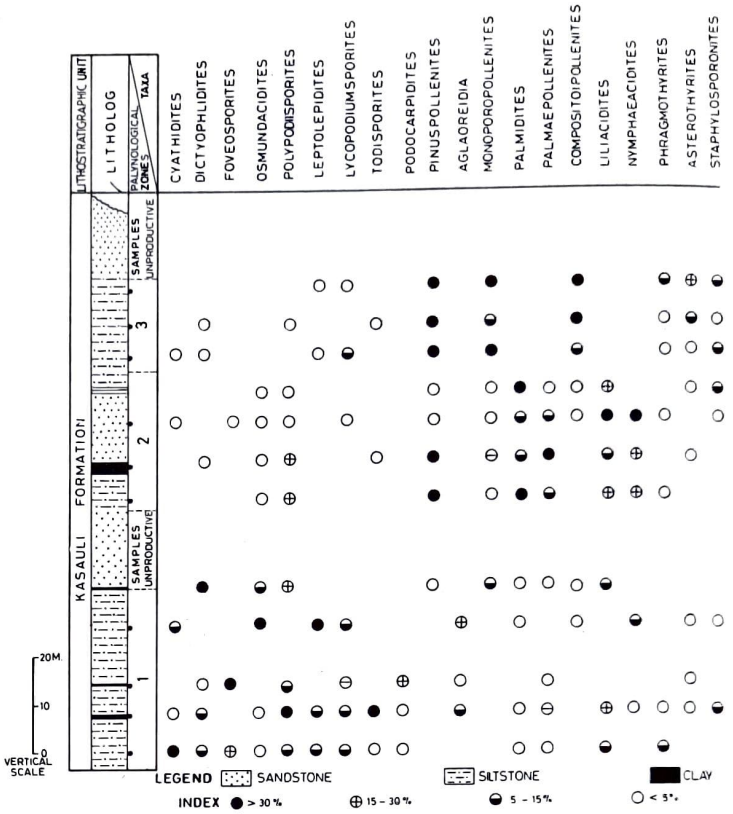
DISCUSSION

The present palynofloral assemblage consists of taxa referable to algae, fungi, pteridophytes, gymnosperms and angiosperms. Pteridophytic spores dominate the assemblage (50%). They are represented by the members of the families, viz., Cyatheaceae, Polypodiaceae, Lycopodiaceae, Matoniaceae and Osmundaceae. Gymnospermous pollen are represented by three genera, viz., *Podocarpidites* (Podocarpaceae), *Pinuspollenites* and *Cedripites* (Pinaceae). Quantitatively these are well represented in the assemblage.

Angiospermous pollen constituting about 35 per cent of the total assemblage are represented by the members of Poaceae, Typhaceae, Liliaceae, Nymphaeaceae, Chenopodiaceae, Arecaceae, Asteraceae and Caesalpiniaceae. Quantitatively, monocot pollen are the major constituents of the angiosperm assemblage.

The remaining part of the assemblage is represented by the fungal spores, conidia, and ascostromata of microthyraceous fungi. *Kutchiathyrites* and *Asterothyrites* are present in high percentage in the older horizons whereas *Frasnacritetrus* is abundant in the younger horizons. Colonial alga *Pediastrum* occurs between 25-30 m level in large numbers.

The sequential distributional pattern of palynofossils in the Kasauli section (Text-fig. 2) leads to the recognition of three palynological zones wich are described below in ascending order of stratigraphy. The relative abundance and vertical ranges of spores and pollen are used for palynostratigraphic zonation.



Text-figure 2. Distribution of significant palynotaxa in Kasauli Formations from type locality.

Palynological Assemblage Zone - 1

The lowermost part of the stratigraphic section (up to 38 m) is represented by the Palynological Assemblage Zone -1. This zone is characterised by the presence of the following palynotaxa: *Cyathidites australis, Dictyophyllidites granulatus, Foveosporites retiformis, Leptolepidites rariverrucatus, Lycopodiumsporites globatus, Podocarpidites microreticulatus, Palaeosantalaceaepites minutus, Palmidites maximus, Palmaepollenites* sp., *Nympheacidites decoratus, Asterothyritus keralensis* and *Kutchiathyrites eccentricus.*

Quantitatively pteridophytic spores are very common (55%) whereas angiospermous pollen are common but their percentage is restricted to (35%). Gymnospermous pollen are represented sporadically.

Palynological Assemblage Zone-2

Palynological Assemblage Zone-2 covers a thickness of 40m running from 38 m to 76 m of the section. The palynoflora in this zone is highly diversified. Angiosperm pollen genera, viz., *Liliacidites, Nympheacidites, Palmaepollenites, Palmidites, Graminidites* are the major elements of this assemblage. Pteridophytic spores represented by *Osmundacidites, Alsophilidites* and *Polypodiisporites* are not very common. Gymnospermous pollen taxa, viz., *Pinuspollenites* and *Cedripites* are quite common, however, *Podocarpidites* registers a sharp decline in this horizon. Fungal spores

and conidia are present at all levels. The lower part of Palynological Assemblage Zone-2 is characterised by a very high percentage of Palm pollen which gradually declines towards the top.

Palynological Assemblage Zone -3

This palynological assemblage zone has a low palynofloral diversity. It covers a thickness of 20m representing upper part of the section. *Pinuspollenites* pollen along with *Monoporopollenites* and *Compositoipollenites* are overwhelmingly dominant. Pteridophytic spores are present sporadically. Fungal conidia viz., *Frasnacritetrus* are present in much higher quantity at all levels of the section.

The Kasauli plant megafossil data is poorly known. Sahni (1953, 1964) described *Sabalites microphylla, Dictylophyllum* and some other ill preserved leaf impressions from the Kasauli Formation of Shimla hills. Mehra *et al.* (1990a) have recovered impressions of leaves from the Dagshai Formation near Kumarhatti, Shimla hills. They have also found impressions of leaves and flowers tentatively referable to Fabaceae and Moraceae from the Kasauli Formation (1990b). From the almost equivalent strata in Jammu, Sharma and Gupta (1972) have described leaf-impressions comparable to *Artocarpus.*

Based on palynological and megafossil data though meagre, it is apparent that the vegetation pattern during the Early Miocene was subtropical and humid. *Pinus* seems to have established its identity as an early settler which proliferated well and its pollen have been recovered from wider strata (Lower Miocene) of Western Himalaya. The Kasauli palynofloral assemblage suggest the occurrence of a rich subtropical vegetation in this region. The flora chiefly consists of such taxa, viz., *Nymphaea, Typha, Lycopodium, Polypodium,* Palm which are generally found in humid and moist subtropical climate. Montane element of the palynoflora, viz., *Cedrus* might have blown in from the higher northern Himalayan ridges. A large number of microthyraceous ascostromata along with fungal spores and conidia supports our observation that a moist subtropical climate was prevalent during the deposition of the Kasauli sediments in the present area. The occurrence of low salinity loving plants like palm, *Chenopodium* etc. is suggestive of the presence of a restricted brackish water or a coastal influence. This evidence is further supported by the megafossil records (Sahni, 1953, 1964) from the same locality.

The palynofloral changes in the composition of the assemblages are easily discernible from the older to younger horizons. The dominance of pteridophytic spores in the early part of the succession is replaced progressively by the predominant occurrence of gymnospermous and angiospermous pollen in the upper part. The upper part of the Kasauli section shows the dominance of grass pollen indicating a shift towards drier climate.

A detailed comparison of the present assemblage with some of the earlier recorded Kasauli palynofloral assemblages reveals interesting relationship. Singh *et al.* (1973) recovered some ill-preserved triporate pollen grains, fungal spores and degraded type of organic matter from the type locality of Kasauli Formation. Detailed comparison could not be possible due to insufficient data. Singh and Khanna (1980) recorded a poor palynofloral assemblage from the Kasauli sediments of Baroti -Barog road section. The most significant feature of the assemblage is the abundance of sponge spicules (27%). Other palynofossils recorded from this assemblage are *Palmaepollenites* complex (12%), *Podocarpidites* complex (17%), fungal spores (17%), *Pediastrum* (9%); colporate pollen complex (6%) and monoporate pollen complex (6%). The overall resemblance is quite striking with the present assemblage excepting the presence of sponge spicules. This may be due to the difference in depositional environment controlled by basinal factors.

Singh and Sarkar (1984) described 17 genera and 23 species of pteridophytic spores, gymnospermous and angiospermous pollen, fungal spores, conidia and ascostromata from the Kasauli sediments exposed near Banethi in Sirmaur District of Himachal Pradesh. Quantitatively, fungal spores, conidia and ascostromata constitute the dominant elements of this palynological assemblage followed by gymnospermous pollen (38%), angiospermous pollen (15%) and pteridophytic spores. Many taxa at generic level, viz., *Cyathidites, Foveosporites, Lycopodiumsporites, Pinuspollenites, Liliacidites, Monoporopollenites, Graminidites, Inapertisporites, Staphlosporonites, Frasnacritetrus* are common between the two assemblages. Distributional pattern of palynofossils suggest that Banethi sediments are correlative with some part of the middle and upper horizons of the Kasauli stratotype succession.

Kapoor *et al.* (1988) reported 28 species belonging to 22 form genera of pteridophytic spores, gymnospermous and angiospermous pollen from the Kasauli sediments exposed at Kasauli town. Of these, *Cyathidites, Todispoites, Alsophilidites, Leptolepidites. Foveosporites, Lycopodiumsporites, Polypodiisporites, Podocarpidites, Palmaepollenites, Liliacidites* and *Polyporina globosa* are common with the present assemblage. Many significant palynotaxa of the above assemblage, viz., *Polypodiaceasporites, Tsugaepollenites, Quilonipollenites. Impatiensidites, and Rhoipites* are not found in the present investigation. Similarly most significant palynotaxa, viz., *Pinuspollenites, Monoporopollenites* and *Com-*

positoipollenites represented in the middle and upper horizons of the present succession are absent in the assemblage published by Kapoor *et al.* (1988). A comparative study of both the assemblages reveals that a close similarity of the former with the Palynological Zone - 1 of the present succession is discernible. Based on the collective evidence discussed here it is evident that the Kasauli palynozones exhibit lateral continuity over widely separated areas in Himachal Pradesh; a phenomenon which can be used for palynological correlation. The present palynological assemblage exhibits a close correspondence with the Miocene assemblages known from the earlier studies (Sah & Singh, 1977; Dogra *et al.*, 1985; Baksi, 1974; Singh & Saxena, 1981; Saxena & Singh, 1982; Saxena *et al.*, 1984) from different basins of India. The assemblage recorded here confirms a Lower Miocene age for the Kasauli Formation indicated earlier by Krishnan (1949).

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