

Significant palynozones of Subathu Formation (Himachal Pradesh) and their bearing on stratigraphy

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The distribution of the Subathu Formation palynozones (Upper Palaeocene-Upper Eocene) in the area of Kalka-Simla and Banethi-Bagthan (Himachal Pradesh) has been discussed. The comparative study of these palynozones shows that they are correlatable which has been inferred from the evidence of lateral distribution of the Subathu assemblages studied from widely separated areas.

Key-words—Palynostratigraphy, Correlation, Subathu Formation, Palaeocene-Eocene (India).

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साराँश

सुबाथु शैल-समूह (हिमाचल प्रदेश) के विशिष्ट परागाणविक मंडल तथा स्तरविन्यास में इनका महत्व

हरिपाल सिंह एवं समीर सरकार

इस शोध-पत्र में कालका-शिमला एवं बनेठी-बगथान (हिमाचल प्रदेश) क्षेत्र में सुबाथु शैल-समूह के परागाणविक मंडलों (उपरि पुरानूतन-उपरि आदिनूतन) का वितरण विवेचित किया गया है। परागाणविक मंडलों के तुलनात्मक अध्ययन से व्यक्त होता है कि इनमें पारस्परिक सम्बन्ध है। यह अनुमान अलग-अलग विस्तृत क्षेत्रों में अध्ययन किये गये सुबाथु समुच्चयों के पार्श्व वितरण के प्रमाणों के आधार पर लगाया गया है।

THE term Subathu was first used by Medlicott (1864) for a conformable sequence of Palaeogene sediments exposed in the Simla Hills, after the town Subathu situated south-west of Simla. Later in 1879, the term 'Sirmur Series' was given to the same stratal sequence by Medlicott himself and the term Subathu was restricted to its lowermost marine sequence. Since then Eocene marine sediments of the Himalayan foothills have been designated as "Subathus".

The rocks of this formation occur as a discontinuous outcrop along the narrow belt in the extrapeninsular region of the Indian subcontinent extending from Jammu in the west to the west of Dehradun in the east. Its maximum development has been observed in the north western region, i.e. Jammu and Kashmir area which thins out south-eastwardly. In Simla Hills, they are conformably overlain by the Dagshai sediments which, in turn, are overlain by the Kasauli succession. The Subathu

Formation is mainly characterized by the predominance of calcareous olive green (oily looking), pale-olive, grey, black and purple shales with subordinate lenticular bands of limestones, siltstones and occasional sandstones. Coaly layers have also been observed at the lowermost horizons at certain places.

Different disciplines have been utilized for the correlation of Subathu sediments of Himachal Pradesh such as animal fossils, lithological variation, mineral content of the rocks, etc. But it is not possible to correlate the entire outcrop of the Subathu Formation on the basis of a single discipline. Moreover, the lithofacies of Subathu Formation varies considerably from place to place which creates problems in correlation. Besides, sediments of this formation are much disturbed due to tectonic activity associated with the Great Himalayan uplift thus complicating the problem of correlation.

Table 1—Lithological comparison between Subathu Formation exposed in Kalka-Simla (Solan District) and Banethi-Bagthan area (Sirmaur District) of Himachal Pradesh

<i>Kalka-Simla area</i>		<i>Banethi-Bagthan area</i>		Remarks
Palynological zones	Lithology	Palynological zones	Lithology	
<i>Todisporites</i> spp. Cenozoone	Pale olive-green shales, generally arenaceous in nature, siltstone bands present, intercalation of purple shales also observed. Limestones are totally absent.	<i>Todisporites</i> spp. Assemblage Zone	Alternation of calcareous grey and purple shales, generally calcareous in nature. Limestones are completely lacking in this assemblage zone.	In Banethi-Bagthan area purple shales are highly developed as compared to the Kalka-Simla area, otherwise both the horizons have the same lithological features.
<i>Subathua sabnii</i> Cenozoone	Massive to nodular pale olive-green shales with siltstone bands. Shales are slightly arenaceous in nature. In the lower part intercalation of grey shales and in upper part intercalation of purple shales have been observed.	<i>Subathua sabnii</i> Assemblage Zone	Argillaceous limestone with massive developments of grey shales with intercalation of thin bands of purple shales and grey siltstone.	Argillaceous limestone bands have been observed in Banethi-Bagthan area which are completely lacking in Kalka-Simla area. It may be of local importance only. In Kalka-Simla area, the shales are mostly nodular in nature and arenaceous.
<i>Cordosphaeridium multispinosum</i> Cenozoone	Shales of various colours, viz., grey greenish-grey, olive-green, needle like to splintery to nodular in nature. Siltstone bands occasionally present, bands or lenses of limestone or impure shaly limestone have also been observed.	<i>Cordosphaeridium inodes</i> Assemblage Zone	Splintery, purplish shales intercalated with siltstone	In Kalka-Simla area lenses of limestones or impure shaly limestone have been found which are absent in the Banethi-Bagthan area. In other characters rocks of both the places are identical.
<i>Hexagonifera</i> spp. Cenozoone	Olive-green, calcareous splintery shales, greenish grey splintery shales with more pockets and veins of calcite.			In Banethi-Bagthan area <i>Hexagonifera</i> spp. Cenozoone not encountered in any of the sections.
<i>Homotryblium</i> spp.	Olive-green, calc cenozoone splintery shales, containing streaks and veins of calcite lenses, siliceous limestones are common.	<i>Homotryblium</i> spp. Assemblage Zone	Compact, dark purple splintery shales, grey laminated shales intermixed with purplish grey, shaly limestone. Minor partings of white limestone have also been observed in Bagthan section. In Dagalaghat pale olive to purplish shales together with greenish brown siltstone bands are present.	In lithological characters, Subathu sediments of both the areas are almost similar. In Banethi-Bagthan area siltstone bands are present in the shales which are less developed in Kalka-Simla area.
<i>Cleistosphaeridium</i> spp. Cenozoone,	Greenish-grey thinly bedded calc. splintery shales with lenses of limestone, sometimes nodular. At Kumarhatti shales are pale olive-green in colour.	<i>Cleistosphaeridium</i> spp. Assemblage Zone	Laminated dark brown calc. shales dark brown greenish, ferruginous splintery shales. At Dagalaghat some grey to blackish siltstone bands present.	Overall characters of rocks in both the areas resemble closely excepting in the presence of lenses of limestone in the Kalka-Simla area.
Barren Zone	Massive black shales associated with carbonate bands and at times intercalations of purple shale facies.			This horizon has not been observed in the Banethi-Bagthan area.

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(Continued)

Cyclonephelium spp.
Cenozoene
Alternations of shaly limestone, limestone, carbonaceous shales intercalated with small coal bands.

Subathu sections of Banethi-Bagthan area do not expose the entire thickness of the formation. Therefore we have not found these rock types in our present area of investigation.

Table 2—Palynofloral comparison between Kalka-Simla area (Solon District) and Banethi-Bagthan area (Sirmaur District), Himachal Pradesh

Kalka-Simla area, Palynological zones with characteristic species	Banethi-Bagthan area, Palynological zones with characteristic species
<i>Todisporites</i> spp. Assemblage Zone	<i>Todisporites</i> spp. Assemblage Zone
<i>Todisporites dagsbhaiensis</i> , <i>T. kotiensis</i> , <i>T. subatbuensis</i> , <i>Lycopodiumsporites pattamorenensis</i> , <i>L. crossii</i> , <i>L. singhii</i> , <i>Intrapunctisporis intrapunctis</i> , <i>Lygodiumsporites barogensis</i> , <i>Podocarpidites kumarhattiensis</i> , <i>Cyatbidites cooksonii</i> , etc.	<i>Todisporites major</i> , <i>T. minor</i> , <i>T. rarus</i> , <i>Amtaspora pseudotriata</i> , <i>A. indica</i> , <i>Podocarpidites couperi</i> , <i>P. decorus</i> , <i>Graminidites media</i> , <i>Couperipollis pyrispinosus</i> , <i>C. capitatus</i> , <i>Monopollenites kasauliensis</i> , <i>Palmidites noviculatus</i> and <i>P. intrafoveolatus</i>
<i>Subathua sabnii</i> Assemblage Zone	<i>Subathua sabnii</i> Assemblage Zone
<i>Subathua sabnii</i> , <i>Thalassiphora velata</i> , <i>I. pelagica</i> , <i>Cyclonephelium indicum</i> , <i>Oligosphaeridium</i> complex, <i>Cleistosphaeridium diversispinosum</i> , <i>C. disjunctum</i> , <i>C. parvum</i> , <i>Homotryblium tenuispinosum</i> and <i>Hystrichosphaeridium granulatum</i>	<i>Subathua sabnii</i> , <i>S. spinosa</i> , <i>Thalassiphora pelagica</i> , <i>T. velata</i> , <i>Glaphyrocysta divaricata</i> , <i>G. exuberans</i> , <i>Cleistosphaeridium flexuosum</i> , <i>Operculodinium centrocarpum</i> , <i>Distatodinium ellipticum</i> and <i>Striatriletes susannae</i>
<i>Cordosphaeridium multispinosum</i> Assemblage Zone	<i>Cordosphaeridium inodes</i> Assemblage Zone
<i>Cordosphaeridium multispinosum</i> , <i>C. fibrospinosum</i> , <i>C. exilimurum</i> , <i>Subathua sabnii</i> , <i>T. dagsbhaiensis</i> , <i>T. kotiensis</i> , <i>Lygodiumsporites barogensis</i> , <i>Thalassiphora velata</i> , <i>Cyclonephelium spinetum</i> , and <i>Hexagonifera sabnii</i>	<i>Cordosphaeridium inodes</i> , <i>Homotryblium tenuispinosum</i> , <i>H. abbreviatum</i> , <i>H. pallidum</i> , <i>Sentusidinium rioultii</i> , <i>Hystrichosphaeridium tubiferum</i> , <i>Subathua sabnii</i> , <i>S. spinosa</i> and <i>Graminidites media</i>
<i>Hexagonifera</i> spp. Assemblage Zone	
<i>Hexagonifera reticulata</i> , <i>H. chlamydata</i> ,	

H. vermiculata, *H. sabnii*, *Subathua sabnii*,
Homotryblium abbreviatum,
H. tenuispinosum, etc.

Remarks—One of the most interesting features of Banethi-Bagthan palynoflora is the complete absence of the genus *Hexagonifera*.

Homotryblium spp. Assemblage Zone

Homotryblium tenuispinosum,
H. abbreviatum, *Cyclonephelium spinatum*,
Tenua kutharensis, *Oligosphaeridium*
complex, *Cleistosphaeridium diversispinosum*,
Hystrichosphaeridium granulatum, and
Thalassiphora velata

Remarks—In palynofloral composition this horizon is very much similar to both the areas.

Cleistosphaeridium spp. Assemblage Zone

Cleistosphaeridium diversispinosum,
C. disjunctum, *Cyclonephelium compactum*,
C. spinetum, *Tenua simlaensis*,
Trichodinium hirsutum, *Oligosphaeridium*
complex, *Hystrichosphaeridium tubiferum*,
Hystrichokolpoma unispinum,
and *Todisporites dagsbhaiensis*

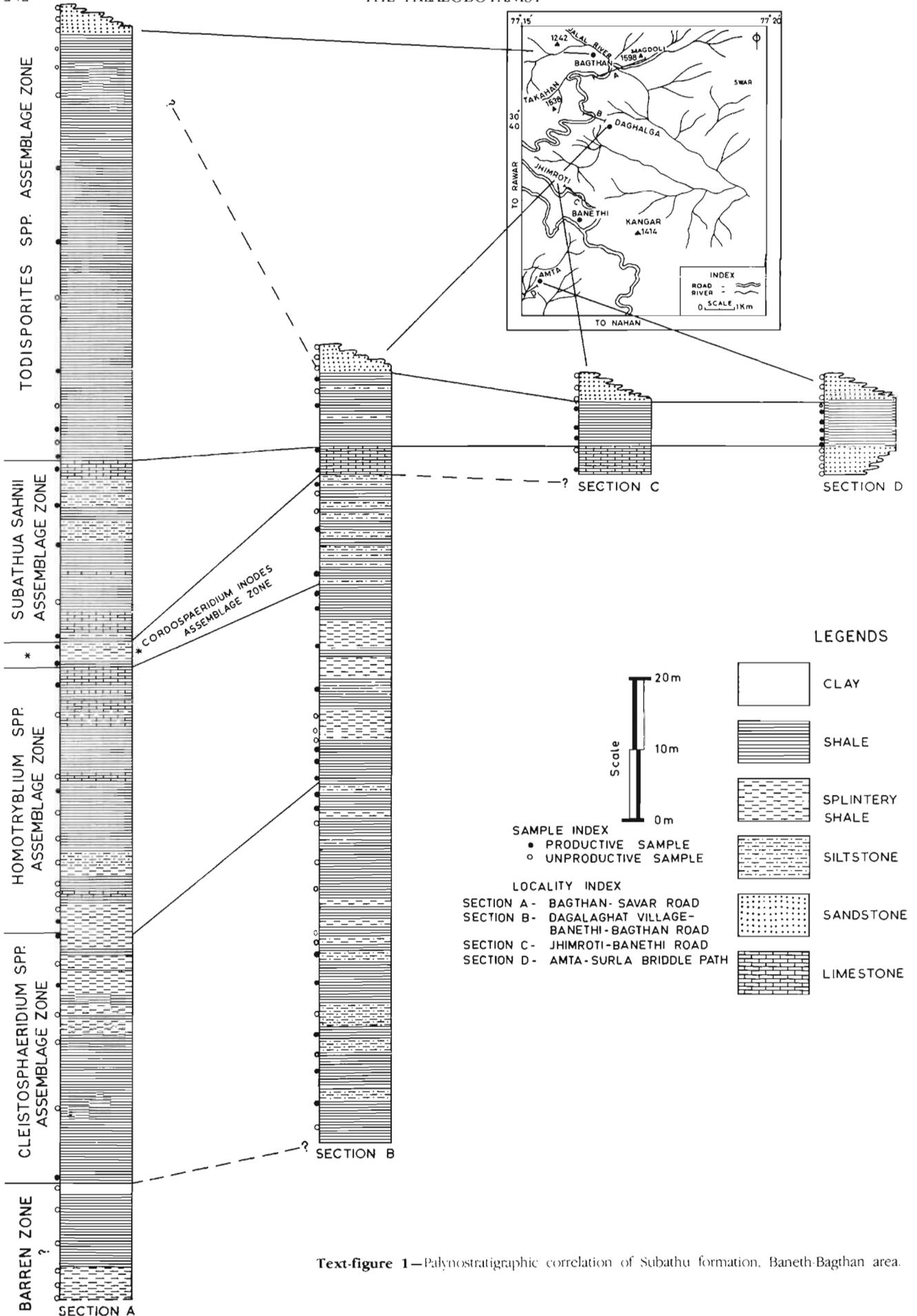
Remarks—Although major forms of this assemblage zone are common to both the places but the Kalka-Simla assemblage is much more diversified than Banethi-Bagthan area.

Cyclonephelium spp. Assemblage Zone

Cyclonephelium compactum, *C. spinatum*,
C. divaricatum, *Tenua simlaensis*,
T. kutharensis, *Trichodinium hirsutum*,
Oligosphaeridium complex, *Cleistosphaeridium diversispinosum*,
C. disjunctum, etc.

Remarks—This assemblage zone has not been observed in any of the sections of Banethi-Bagthan area. Lithological data also supports this view.

Realizing these limitations, systematic palynological investigations of this succession were started at the Birbal Sahni Institute of Palaeobotany, Lucknow about a decade ago. Very detailed palynostratigraphical investigations were carried out in the Kalka-Simla area of Simla Hills, Himachal Pradesh and a number of papers have been published. Important contributions have been made by Singh *et al.* (1978), Khanna *et al.* (1979), Khanna and Singh (1981), etc. On the basis of qualitative



Text-figure 1—Palynostratigraphic correlation of Subathu formation, Baneth-Bagthan area.

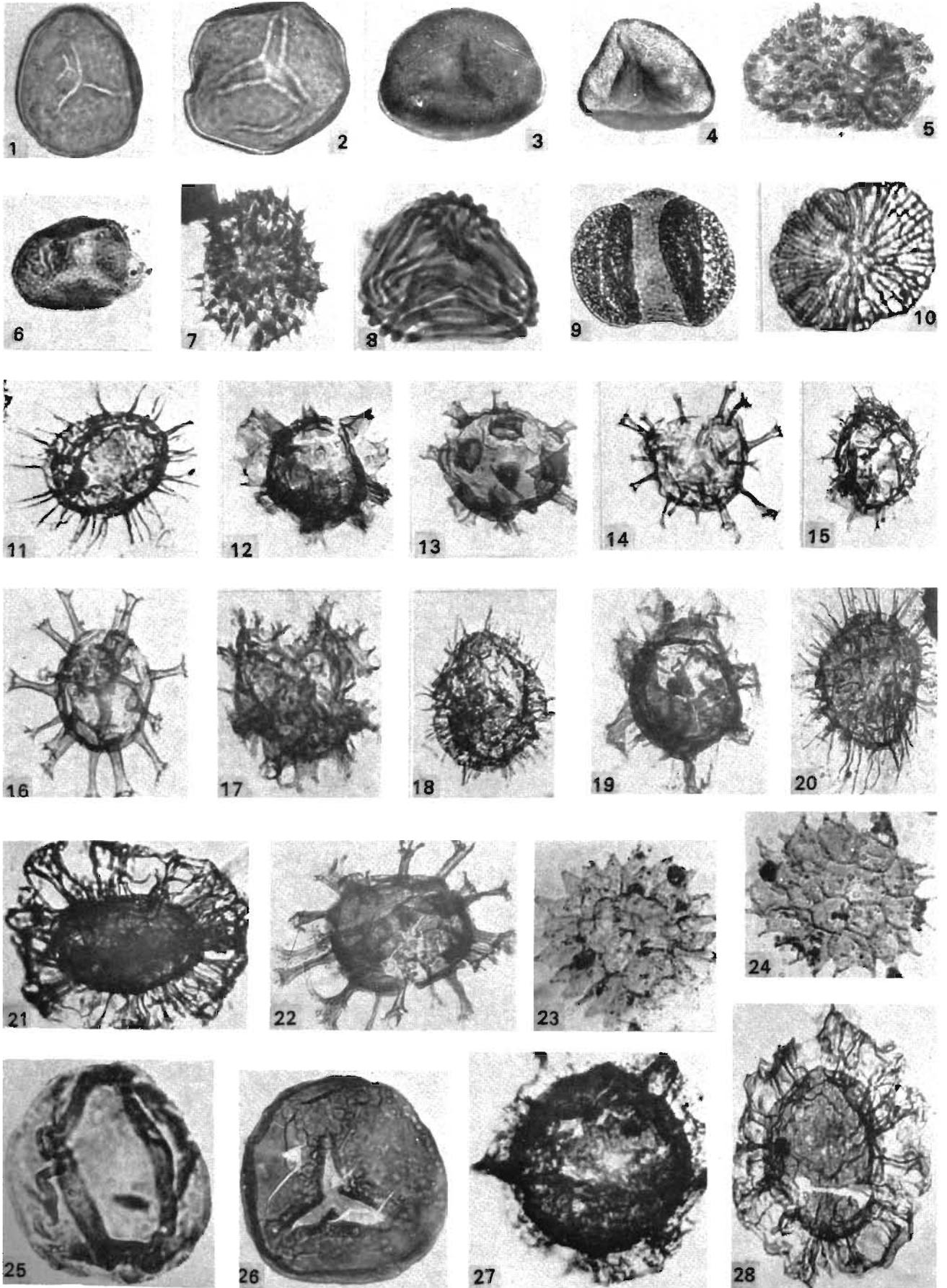


PLATE 1

and quantitative analyses of the palynological data, the following seven cenozones and one barren zone have been established (Singh *et al.*, 1978) in Subathu Section. Their ascending order of stratigraphy is as under:

8. *Todisporites* spp. Cenozoone
7. *Subathua sabnii* Cenozoone
6. *Cordosphaeridium multispinosum* Cenozoone
5. *Hexagonifera* spp. Cenozoone
4. *Homotryblium* spp. Cenozoone
3. *Cleistosphaeridium* spp. Cenozoone
2. Barren zone
1. *Cyclonephelium* spp. Cenozoone

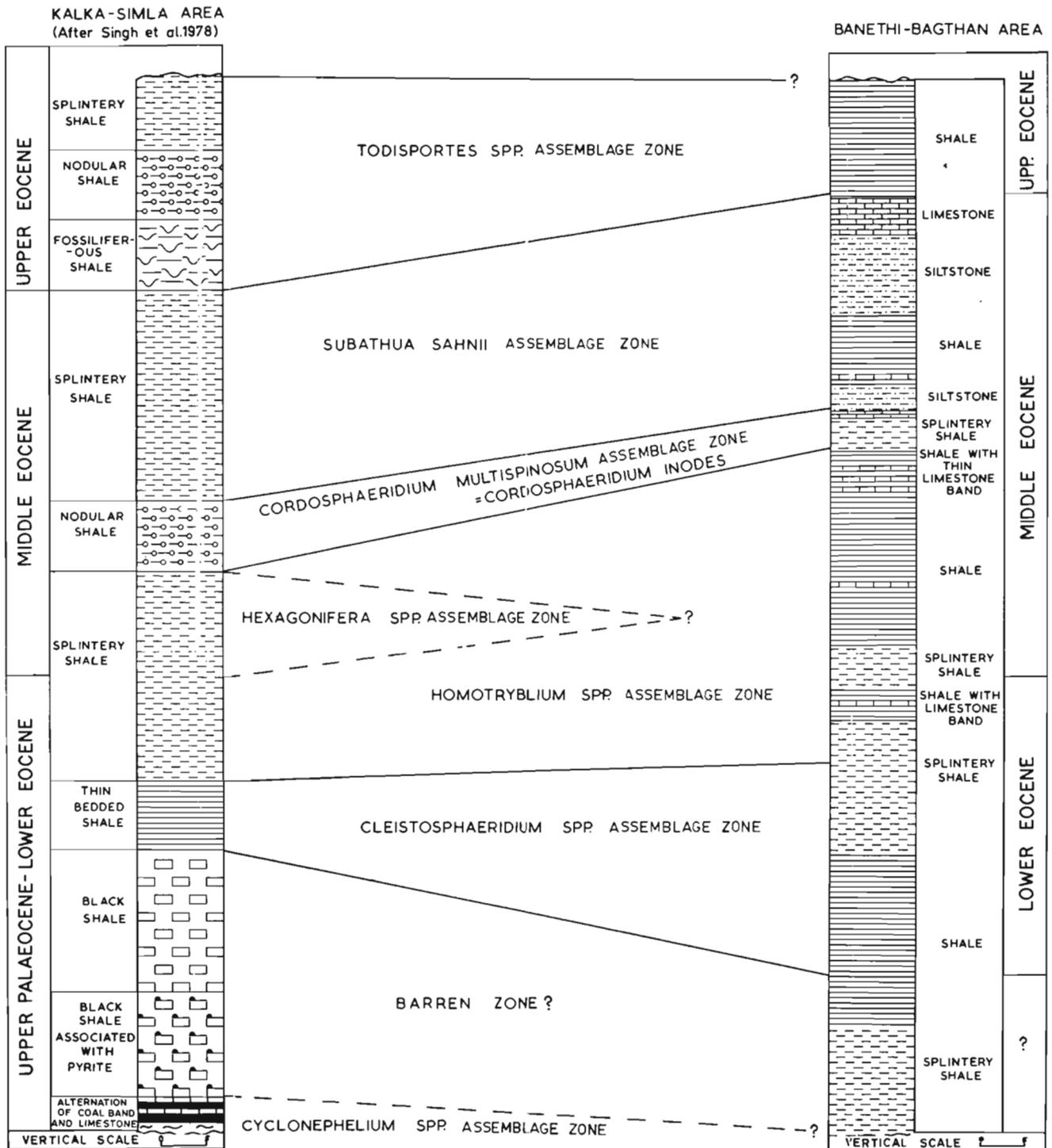
Singh *et al.* (1978) have also recognized two subzones, viz., *Pediastrum* spp. subzone, *Hystrichokolpoma* spp. subzone in one section. Kuthar nala section near the Subathu town has been designated as the standard reference section. Khanna *et al.* (1978) correlated eight measured sections of Subathu Formation in the Kalka-Simla area on the basis of distinctive palynological assemblages. They have traced lateral continuity of the palynological zones of the standard reference section in the different sections located from north-east to south-west in the Simla Hills, viz., Kummerhatti, Dagshai, Dharampur A, Dharampur B, Dharampur C, Jabli and Koti. Dharampur A section has been correlated with the stratigraphic horizon of the type section

designated as *Todisporites* spp. Cenozoone whereas the Dagshai Section represents the upperpart of the *Cordosphaeridium multispinosum* Cenozoone, *Subathua sabnii* Cenozoone and *Todisporites* spp. Cenozoone. The Kummerhatti Section possesses all the cenozones of the standard reference section excepting the *Hexagonifera* spp. Cenozoone. Lithostratigraphically the cenozones of this section are comparatively thinner but biostratigraphic horizon corresponds to its equivalent horizon with reference to the standard reference section. Lower part of Dharampur B section has been equated with the upper part of the *Cordosphaeridium multispinosum* Cenozoone of the type section. Likewise Dharampur C section represents two palynological zones, viz., *Cleistosphaeridium* spp. Cenozoone and *Homotryblium* spp. Cenozoone whereas Koti Section is represented only by the *Cordosphaeridium multispinosum* Cenozoone of the standard reference section. The Jabli Section has been equated with the palynological zones, viz., *Cleistosphaeridium* spp. Cenozoone, *Homotryblium* spp. Cenozoone, *Cordosphaeridium multispinosum* Cenozoone, *Subathua sabnii* Cenozoone and *Todisporites* spp. Cenozoone. The *Hexagonifera* spp. Cenozoone has not been observed in this section. They have established two subzones, viz., *Pediastrum* spp. subzone and *Hystrichokolpoma granulata* subzone but it is assumed that they are of local significance because

PLATE 1

(All photomicrographs are enlarged Ca. × 500 unless otherwise mentioned).

1. *Todisporites minor* Couper; Slide no. BSIP 6860; Coordinates 5 × 69.
2. *Todisporites rarus* Sarkar & Singh; Slide no. BSIP 6860; Coordinates 21 × 96.5.
3. *Amtaspora pseudostriata* Sarkar & Singh; Slide no. BSIP 6861; Coordinates 20.4 × 110.5.
4. *Amtaspora indica* Sarkar & Singh; Slide no. BSIP 6860; Coordinates 21 × 96.5.
5. *Couperipollis pyrripinosus* Sarkar & Singh; Slide no. BSIP 6861; Coordinates 15 × 74.
6. *Osmundacidites mollis* (Cookson & Dettmann) Dettmann; Slide no. BSIP 8423; Coordinates 14.5 × 118.2.
7. *Couperipollis pyrripinosus* Sarkar & Singh; Slide no. BSIP 6861; Coordinates 2.1 × 85.8.
8. *Striatriletes susannae* (van der Hammen) Kar; Slide no. BSIP 6928; Coordinates 10 × 81.5.
9. *Podocarpidites couperi* Sarkar & Singh; Slide no. BSIP 6915; Coordinates 21.5 × 102.2.
10. *Phragmothyrites eoacaenica* Edwards; Slide no. BSIP 6921; Coordinates 5.8 × 104.
11. *Operculodinium centrocarpum* (Deflandre & Cookson) Wall; Slide no. BSIP 6917; Coordinates 21 × 80.
12. *Hystrichokolpoma cinctum* (Klumpff.) Damassa; Slide no. BSIP 6895; Coordinates 14 × 107.
13. *Homotryblium abbreviatum* Eaton; Slide no. BSIP 6911; Coordinates 11.8 × 116.
14. *Homotryblium pallidum* Davey & Williams; Slide no. BSIP 6917; Coordinates 5.8 × 83.6.
15. *Spiniferites membranaceus* (Rossignol) Sarjeant; Slide no. BSIP 6903; Coordinates 7 × 102.
16. *Homotryblium tenuispinosum* Davey & Williams; Slide no. BSIP 6903; Coordinates 19.5 × 78.5.
17. *Spiniferites supparus* (Drugg) Sarjeant; Slide no. BSIP 6826; Coordinates 3 × 101.
18. *Cleistosphaeridium flexuosum* Davey *et al.*; Slide no. BSIP 6926; Coordinates 15.5 × 117.8.
19. *Hystrichokolpoma cinctum* (Klumpff) Damassa; Slide no. BSIP 6896; Coordinates 15 × 101.5.
20. *Cleistosphaeridium diversispinosum* Davey *et al.*; Slide no. BSIP 6898; Coordinates 7.8 × 108.2.
21. *Adnatosphaeridium vittatum* Williams & Downie; Slide no. BSIP 6924; Coordinates 15 × 73.5.
22. *Hystrichosphaeridium arborispinum* Davey & Williams; Slide no. BSIP 6924; Coordinates 4 × 99.
23. *Pediastrum diffusum* Singh & Khanna; Slide no. BSIP 8422; Coordinates 6 × 77.8.
24. *Pediastrum wilsonii* Singh & Khanna; Slide no. BSIP 8421; Coordinates 14.5 × 106.2.
25. *Laricoidites himalayensis* Sarkar & Singh; Slide no. BSIP 6925; Coordinates 5.2 × 89.
26. *Todisporites major* Couper; Slide no. BSIP 6927; Coordinates 15 × 73.5.
27. *Subathua sabnii* Khanna & Singh; Slide no. BSIP 6907; Coordinates 5 × 117.5.
28. *Glaphyrocysta exuberans* (Deflandre & Cookson) Stover & Evitt; Slide no. BSIP 6923; Coordinates 105 × 85.



Text-figure 2—Palynostratigraphical correlation of Subathu sediments of Kalka-Simla and Banethi-Bagthan area, Himachal Pradesh.

they are not laterally traceable.

Prompted by the successful application of palynological fossils in correlating different sections of Sabathu Formation in Kalka-Simla area the present authors have carried out an extensive palynostratigraphical investigation in the Banethi-Bagthan area of Sirmaur District, Himachal Pradesh in order to find out the potentialities of the

established palynozones of Kalka-Simla area. On the basis of recovered palynofossils five distinct palynological zones have been established in this area. In ascending order of stratigraphy they are: *Cleistosphaeridium* spp. Assemblage Zone, *Homotryblium* spp. Assemblage Zone, *Cordosphaeridium inodes* Assemblage Zone, *Subathua sahnii* Assemblage Zone and *Todisporites*

spp. Assemblage Zone. Four measured sections, viz., Dagalaghat Village-Banethi-Bagthan Road Section, Jhimroti-Banethi Road Section, Bagthan-Savar Road Section and Amta-Surla Briddle Path Section, have been correlated. Among these sections, Bagthan-Savar Road Section has been designated as the standard reference section because it is the thickest among all the four studied sections. Besides, it contains all the assemblage zones established in the present area of investigation. Considering the Bagthan-Savar Road Section as the standard reference section and on the basis of recovery of various palynological assemblages, it has been possible to equate different parts of the Subathu sediments with the stratigraphic horizons of this section.

The Dagalaghat Village—Banethi-Bagthan Road Section represents *Cleistosphaeridium* spp. Assemblage Zone, *Homotryblium* spp. Assemblage Zone, *Cordosphaeridium inodes* Assemblage Zone, *Subathua sabnii* Assemblage Zone and *Todisporites* Assemblage Zone in ascending order of stratigraphy. The assemblage zones of this section have been correlated with the corresponding assemblage zones of the standard reference section. However, the *Subathua sabnii* Assemblage Zone is associated with a comparatively thinner strata.

The Subathu sediments represented in the Jhimroti-Banethi Road Section have yielded two types of palynological assemblages which are similar to the assemblages of *Subathua sabnii* and *Todisporites* spp. Assemblage zones. Therefore, the stratigraphic horizons of this section containing *Subathua* and *Todisporites* rich assemblages have been correlated with the *Subathua sabnii* and *Todisporites* spp. Assemblage zones of the Bagthan-Savar Road Section. It is also proposed that the lower part of this section is equivalent to the upper part of the *Subathua sabnii* Assemblage zone of the standard reference section.

The Amta-Surla Briddle path section represents only a part of the Subathu sediments and the palynological information from the sediments allows its correlation with the *Todisporites* spp. Assemblage zone of the standard reference section. Palynostratigraphic scheme of correlation of four measured sections of the Subathu Formation is presented in Text-fig. 1.

Palynostratigraphic correlation of the Subathu sediments of Banethi-Bagthan and Kalka-Simla areas of Himachal Pradesh (Text-fig. 2) shows that the Subathu Formation is conformably overlain by the Dagshai Formation in the Kalka-Simla area. Similar situation is maintained in all four sections of the Subathu presently investigated in the Banethi-Bagthan area. It is interesting to note that the lithological similarity of the Subathu sediments in both the areas is very striking (Table 1) as is

exhibited by the presence of calcareous green, purple or grey coloured splintery shale, carbonaceous shale, siltstone and limestone bands separated from each other by the shales and siltstones. In the uppermost part of the Subathu shales tend to become purplish in colour. However, the basal horizons of the Subathu Formation of Kalka-Simla area are characterized by having mostly alternation of shaly limestones, carbonaceous shales intercalated with small coal bands. Few older corresponding horizons have not been found in the Banethi-Bagthan area. The lower most Subathu palynological assemblage of Kalka-Simla area possesses the *Cyclonephelium* spp. Cenozoone. This palynozone has not been encountered in the Banethi-Bagthan area. Palynological investigations show that out of the seven palynostratigraphical zones established within the Subathu (Singh *et al.*, 1978) of Kalka-Simla area, only five have been located in the Banethi-Bagthan area. The palynological composition of each zone within the Subathu Formation of Kalka-Simla area is also reflected in the corresponding zones of the Banethi-Bagthan area (Table 2).

The lowermost palynological zone of the Subathu succession in the Banethi-Bagthan area is the *Cleistosphaeridium* spp. Assemblage Zone. It shows a close palynofloral similarity with the *Cleistosphaeridium* spp. Assemblage Zone of the Subathu in the Kalka-Simla area. *Glaphrocysta divaricata* (= *Cyclonephelium divaricata*), *Cleistosphaeridium diversispinosum*, *Lingulodinium macherophorum*, (= *C. disjunctum*), *Homotryblium tenuispinosum*, *Oligosphaeridium complex* and *Subathua sabnii* are the important taxa common to both the assemblages.

Homotryblium spp. Assemblage Zone, the next palynozone of Subathu Formation (Banethi-Bagthan area) shows a close correspondence in palynofloral composition with the *Homotryblium* spp. Cenozoone of the Kalka-Simla area. The stratigraphically important forms common to both the palynozone are *Cleistosphaeridium diversispinosum*, *Homotryblium tenuispinosum*, *H. abbreviatum*, *Hystrichosphaeridium tubiferum* and *Subathua sabnii*. In ascending order of stratigraphy, the third palynological zone of the Subathu Formation in Banethi-Bagthan area is *Cordosphaeridium inodes* Assemblage Zone. This assemblage zone has been equated with the *Cordosphaeridium multispinosum* Cenozoone of the Kalka-Simla area on the basis of identical lithology and overall similar palynofloral composition. The corresponding levels of the Subathu Formation at both the places have abundant occurrence of the genus *Cordosphaeridium*. *Homotryblium tenuispinosum*, *H. abbreviatum* and *Subathua sabnii* are common to both the assemblages. *Hexagonifera* spp. Cenozoone in

between the *Homotryblium* spp. Cenozoone and *Cordosphaeridium multispinosum* Cenozoone of the Subathu succession in Kalka-Simla area has not been located in the present area of investigation.

The fourth palynological zone of the Subathu Formation in the Banethi-Bagthan area is *Subathua sabnii* Assemblage Zone. This assemblage zone has been correlated with the *Subathua sabnii* Cenozoone of the Kalka-Simla area on the basis of the dominance of *Subathua sabnii*, *S. spinosa* and *Thalassiphora pelagica*, etc.

The next assemblage zone of the Subathu Formation is represented by *Todisporites* spp. Assemblage Zone in both the areas together with similar composition of palynofossils. This assemblage zone at both the places is characterized by having exclusively pteridophytic spores, gymnospermous and angiospermous pollen grains. Thus it is quite apparent from the above facts that the five palynological zones of the Banethi and Bagthan areas have a close relationship with the five palynofloral zones of the middle and upper part of Subathu Succession of Kalka-Simla area of Simla Hills. On all possible counts they can be assumed to be representing the lateral continuation of the Kalka-Simla palynozones. Based on their close resemblance these palynozones have been correlated as given below:

Kalka-Simla area	Banethi-Bagthan area
<i>Todisporites</i> spp. Cenozoone	= <i>Todisporites</i> spp. Assemblage Zone

<i>Subathua sabnii</i> Cenozoone	= <i>Subathua sabnii</i> Assemblage Zone
<i>Cordosphaeridium multispinosum</i> Cenozoone	= <i>Cordosphaeridium inodespinosum</i> Assemblage Zone
<i>Homotryblium</i> spp. Cenozoone	= <i>Homotryblium</i> spp. Assemblage Zone
<i>Cleistosphaeridium</i> spp. Cenozoone	= <i>Cleistosphaeridium</i> spp. Assemblage Zone

From the foregoing discussion it is evident that lateral continuation of the Subathu palynozones over widely separated areas in Himachal Pradesh is a significant phenomenon which can reliably be used in palynological correlations.

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