

## MESOZOIC PLANT FOSSILS FROM THE HIMALAYAS — A CRITIQUE\*

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### ABSTRACT

A reconnaissance of the available literature has shown that the reports of Mesozoic plant fossils from the Himalayas are far too meagre as compared to the peninsula. Undoubted plant megafossils have been reported only from the Tethyan zone, i.e. from Lingshi in Bhutan, Kagbeni in Nepal and Loma in Ladakh. The Mesozoic microflora from the Tethyan zone comprises poorly preserved and mostly unidentifiable spores and pollen. The dinocysts from the Spiti Shale of the Malla Johar area are comparatively well-preserved. In the Lesser Himalayan zone the situation is rather complex. No definite plant megafossils are known from the Krol or the Tal, certain algae-like organisms excepted. There seems to be a good amount of controversy regarding the nature and age of these 'fossils'. A well-preserved palynoflora has been reported from but a single sample in the Krol A (?Infra-Krol) of the Nainital area. The other reports of microfossils (including nannofossils) from the Krol Formation are not convincing enough. Similarly the reports of recovery of palynomorphs from the Lower Tals cannot be totally relied upon as no research paper has come out on these.

*Key-words* — Himalayas, Krols, Tals, Tethyan zone, Palynofossils, Megaplants.

### सारांश

हिमालय से मध्यजीवी कल्प के पादपाशम : एक समालोचना — हरिकृष्ण माहेश्वरी

उपलब्ध साहित्य के अध्ययन से पता चलता है कि प्रायद्वीप की तुलना में हिमालय क्षेत्र से मध्यजीवी कल्प के पादपाशमों का ज्ञान अल्प है। गुरु-पादपाशम केवल टैथियन क्षेत्र में ही पाये गये हैं, उदाहरणतः भूटान में लिंगशी, नेपाल में कागबेनी एवं लद्दाख में लोमा। सूक्ष्म-पादपाशम उत्तर प्रदेश में मल्ला जौहर से ज्ञात हैं। यहाँ से प्राप्त बीजाणुओं एवं परागकणों की जाति एवं/अथवा प्रजाति पहचान पाना प्रायः कठिन होता है। मल्ला जौहर क्षेत्र के स्पिती शैलों से प्राप्त डाइनोपुटीयाँ अपेक्षाकृत सुपरिरीक्षित हैं। लघु हिमालय क्षेत्र में स्थिति वस्तुतः जटिल है। क्रोल अथवा ताल से शैवाल-सदृश अशमों के अतिरिक्त निश्चित गुरु-पादपाशम अभी तक भी उपलब्ध नहीं हुए हैं। इन अशमों की प्रकृति एवं आयु को लेकर काफी मतभेद हैं। यहाँ से केवल सुपरिरीक्षित परागणु-वनस्पतिजात ही प्राप्त हुआ है परन्तु वह भी नैनीताल क्षेत्र के क्रोल-अ (इन्फ्रा-क्रोल) के मात्र एक नमूने से ही। ताल शैल-समूह से प्राप्त सूक्ष्म-जीवाशमों तथा परासूक्ष्म-जीवाशमों के विवरणों पर काफी कुछ निर्भर नहीं रहा जा सकता। इसी प्रकार अघर ताल से प्राप्त परागणविकल्पकों की प्राप्ति पर भी अवलम्बित नहीं रहा जा सकता, चूँकि इन पर अभी तक कोई शोध-पत्र प्रकाशित नहीं किया गया है।

**T**HE Himalayan mountain chain extends for about 2400 kilometres, from Nanga Parbat (9186 m) in the west to Namcha Barwa (7823 m) in the east. The Himalayan mountain system can

be divided into three structural and tectonic (lithological) units which are, from north to south: (i) Tethyan Himalayan Zone, (ii) Central Crystalline Zone, and (iii) Himalayan Zone; the last one comprising

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(a) Lesser Himalaya and (b) Sub-Himalaya.

The Tethyan Himalayan Zone consists of a more or less complete stratigraphic sequence ranging from the Precambrian to the Cretaceous, except for a slight unconformity between the Upper Carboniferous and the Permian. The Central Crystalline Zone separates the Tethyan Himalayan and the Himalayan zones. The Himalayan Zone reveals a more complex geological history. The rocks are generally unfossiliferous except for the Tertiary formations and a few scattered outcrops of Permian and Cretaceous fossil bearing rocks.

The age of the Infra-Krol, the Krol and the Tal formations, sometimes regarded as representatives of the Mesozoic sediments in the Lesser Himalaya, has been a matter of raging controversy. Sporadic and ill-preserved fossil finds have been used to date these sediments. Unfortunately in most of the cases the sampling data are too meagre to be of real help in biostratigraphy and age determination. It is therefore not surprising that some of the geologists stubbornly refuse to take into account these fossil finds, though not all for the same reasons. Valdiya (1975) believes that there was no Mesozoic sedimentation in the Lesser Himalaya.

The genetic affinity of the Himalayan Mesozoic sediments is also a matter of controversy. Gansser (1964, p. 242, fig. 144) has shown extension of Gondwana characters to the north, into the Himalayas. Colchen (1975) extends the Gondwanas in the northern high Himalayas of Nepal. But Crawford (1974) maintains that the northern limit of the Gondwana is still an open question. In recent years plant fossil evidence has been used to support the extension of the Gondwana facies into the Himalayas. These will be examined in this article at the proper place.

During the last three decades a lot of geological work has been done in the Himalayas by scientists from India and abroad. The regional and local geological surveys have resulted in new palaeontological findings. The reports of plant fossils, however, are far too meagre, particularly those of the Mesozoic times.

Both plant mega- and micro-fossils have been reported from the Mesozoic and so-called Mesozoic formations in the Hima-

layas. Plant megafossils of higher plants are known only from the Tethyan Zone whereas the microfossils and algal remains are reported both from the Tethyan and the Lesser Himalayas.

#### PLANT MEGAFOSSILS FROM THE TETHYAN ZONE

Plant megafossils have so far been reported from Bhutan, Nepal and Ladakh.

The Mesozoic Era is represented in Bhutan by the Lingshi Group of Jurassic-Cretaceous age, which unconformably overlies the Permo-Carboniferous Shodug Formation. The lower horizon of the Lingshi Group — the Mochu Formation — contains a plant bed with: *Equisetites*, *Ptilophyllum*, *Elatocladus*, *Nilssonia*, *Taeniopteris* and *Desmiophyllum* (Chaturvedi *et al.*, 1980).

In Nepal, the plant bed lies in a 10 m thick grey sandstone exposed in a section on the right bank of the Thakkola River near Kagbeni (or Kag). The fossils were first reported by Bordet *et al.* (1964) as cycadophytic fronds and araucarian woods. Bordet *et al.* (1967) and Mouterde (1971) reported: *Nilssonia orientalis*, *Otozamites abbreviatus* and *Ptilophyllum* (*Williamsonia pecten*).

Barale, Bassoullet and Bose (1978) described and illustrated this flora in detail. The revised list of megafossils of the Kagbeni sandstones is: ?*Taeniopteris* sp. cf. *T. spatulata* McClelland, *Ptilophyllum acutifolium* Morris, *Ptilophyllum* sp. cf. *P. cutchense* Morris, and *Araucarioxylon nepalensis* Barale *et al.*

This assemblage is somewhat comparable with that from the lower beds of the Rajmahal Hills in peninsular India but is too poor to be of much use stratigraphically. The section has not been examined palynologically. There is a possibility that the dark grey shales or the silty black shales found intercalated both below and above the plant bed may yield palynomorphs.

In Ladakh, the megafossils have been found in a small hillock along the left bank of the Indus, about 50 km upstream of Loma (Sah & Sharma, 1980; Sharma, Gupta & Sah, 1980). It is possible that the plant fossils occur in more than one hillock as according to Sharma *et al.* (1980, p. 471) 'The sediments containing Gondwana plants are exposed as small detached

hillocks'. The rock types in the area comprise dark quartzite, creamish quartzite, calcareous sandstone, conglomeratic breccia and carbonaceous shale. The plant fossils come from a 50 cm thick zone within the carbonaceous shale. Following fossils have been listed: ?Equisetalean axes, *Cladophlebis* spp., *Gleichenites* spp., *Ptilophyllum cutchense* Morris, *Ptilophyllum acutifolium* Morris, *Pterophyllum* sp., *Taeniopteris* sp., *Podozamites* sp., *Elatocladus* sp. cf. *E. plana* (Feistmantel) Seward, and *Brachyphyllum* sp.

Sharma *et al.* (1980) conclude that 'The presence of the above mentioned floral elements etc. suggests an Upper Gondwana affinity for the fossil assemblage'. Taken at its face value this conclusion makes this report as the first find of Gondwana plants from north of the Indus Suture Zone. This conclusion has resulted in the presumption that the Ladakh plant beds may be detached fragments of Gondwana sediments from the northern margin of the Gondwanaland which is supposedly represented in the Muktinath area of western Nepal (Colchen, 1975). However, neither the Ladakh nor the Nepal floral assemblage has a single genus which is restricted only to Gondwana formations. In fact, Barale *et al.* (1978) while comparing the Nepal assemblage with the Rajmahal one did not find definite Gondwanian link. Thus, while it is possible that the Kagbeni and the Loma floral assemblages may have some inter-relationship, the question of their having genetic affinity with the Gondwana flora is still wide open. In this connection it would be worthwhile to make elaborate megafossil collections from other hillocks in the Ladakh area as well as from Kagbeni. Palynological studies of the carbonaceous shales may also be undertaken.

Mesozoic sediments of Ladakh have also yielded algal fossils. Pascoe (1959, p. 1319) recorded the presence of the dasycladaceous alga *Neomeris* in a limestone in the Lingzi Thang area. Pal and Chatterji (1978) have reported a varied algal flora from two horizons of the Indus Flysch Formation, viz., *Orbitolina* limestone near Khalsi (Albian-Cenomanian) and fossiliferous limestone exposed in Raldong Nala near Samdo (Campanian-Maestrichtian). According to Pal and Chatterji (1978) 'the rocks are much disturbed and some times recrystallized

to obliterate the structural details of the fossils'. As such it is difficult to say as to how much reliance can be put on their taxonomic identifications. Following is the list of algal taxa: *Acicularia* sp. cf. *A. comanchense* Johnson, *A. khalsiensis* Pal & Chatterji, *Neomeris deterrae* Pal & Chatterji, *Cayeuxia fruticulosa* Johnson, *Cayeuxia* sp., *Lithophyllum* sp. cf. *L. antiquum* Lemoine, *Thaumatoporella* sp., *Permocalculus budaensis* Johnson, *P. ladakhensis* Pal & Chatterji, *P.* sp. cf. *P. texana* Johnson, *Gymnospora indica* Pal & Chatterji. The authors conclude that the algae were deposited in the shallower part of the continental shelf.

#### PALYNOMORPHS FROM THE TETHYAN ZONE

As far as palynological studies of the Mesozoic sediments of the Tethyan realm are concerned, to my knowledge there are reports from two areas only.

Lukose (1964) reported a 'striated' spore from the 'Upper Mesozoic' of Wakkachu traverse between Kargil and Pashkyum, Ladakh which he named as *Schizea kashmiriensis*. This sporomorph was later renamed as *Schizaeasporites kashmiriensis* by Ghosh and Lukose (1967) who published an illustrated account of the palynomorph assemblage for which they assumed an Upper Jurassic to Middle Cretaceous age. According to Bhandari *et al.* (1977) the palyniferous sample (D5565) originated from the Middle Member of the 'Ladakh Molasse Group' of Tewari (1964). The authors call this member as the Tarumsa Formation. A palynological re-examination of the samples carried out by Bhandari *et al.* has shown the presence of advanced angiospermic pollen associated with typical Upper Mesozoic forms such as *Neoraistrickia*, *Ceratosporites*, *Araucariacites*, *Alisporites* and *Callialasporites*. The Mesozoic forms have been interpreted as reworked into younger sediments. On the basis of the new angiospermic finds the age of the Tarumsa Formation is taken to be Eocene-Miocene.

The other record of the Mesozoic microfossils in the Tethyan realm is from the Malla Johar area, Pithoragarh District, Uttar Pradesh (Jain *et al.*, 1978; Tiwari *et al.*, 1980). Tiwari *et al.* (1980) have reported pollen and spores from the Upper

Triassic-Upper Jurassic succession. Following is the list of genera recorded by them:

*Tetraporina* Naumova  
*Platysaccus* Naumova ex Potonié & Klaus  
*Klausipollenites* Jansonius  
*Callumispora* Bharadwaj & Srivastava  
*Maculatasporites* Tiwari  
*Alisporites* Daugherty  
*Lundbladispota* Balme emend. Playford  
*Parasaccites* Bharadwaj & Tiwari  
*Lophotriletes* Naumova emend. Potonié & Kremp  
*Lunatisporites* Leschik emend. Scheuring  
*Striatopodocarpites*. . . ?  
*Callialasporites* Sukh-Dev  
*Cycloverrurtriletes* Schulz  
*Deltoidospora* Weyland & Krieger emend. Dettmann

There is an illustration of the genus *Densiporites* (pl. 1, fig. 5) but it does not find a mention in the text.

The oldest Mesozoic formation which has yielded palynomorphs is the Kuti Shale (Norian). Palynomorphs have not been nomenclaturally identified except for the genus *Klausipollenites*. Passage Formation (Norian) also has *Klausipollenites* and certain other non-striate bisaccate pollen. The Kioto Limestone (Rhaetic) has genera such as *Callumispora*, *Maculatasporites*, *Lundbladispota*, *Parasaccites*, *Lophotriletes*, *Lunatisporites* and *Striatopodocarpites*. This assemblage in a way indicates an age not younger than the Permian. Unfortunately, two genera, which could thrust the assemblage into the Triassic have not been illustrated. The Spiti Shale (Portlandian) has *Deltoidospora*, *Cycloverrurtriletes*, *Callialasporites* and *Platysaccus* along with unidentifiable non-striate disaccate pollen. Except for '*Callialasporites*' none of the other taxa has any significance as age determiner.

Tiwari *et al.* (1980) while accepting the difficulty in working out the affinities of the Spiti Shale mioflora have presumed a Gondwanic affinity for the Upper Triassic miofloras. Now do we really have a convincing evidence for this? The Kioto Limestone mioflora has to be ruled out of this discussion as it could as well be a reworked one, particularly if the age of the Kioto Limestone is accepted to be Rhaetic on other evidences.

As far as the Kuti Shale and the Passage Formation are concerned the only worthwhile record is of the genus *Klausipollenites* which has been taken as an indicator of Gondwanic affinity. But it has a wide horizontal and vertical distribution as is also accepted by Tiwari *et al.* (1980, p. 41, para 1). They base their argument on the basis of definite occurrences of this genus in the Triassic sediments of peninsular India. But they do not tell us if the genus is absent in the Euramerican or the Angaran Triassic. I may add that our work on the Upper Triassic miofloras of South Rewa Gondwana Basin has shown the presence of typical Euramerican elements there (Maheshwari & Kumaran, 1979; Kumaran & Maheshwari, 1980). I have examined the slides and am not fully convinced of the presence of *Klausipollenites* in the Malla Johar samples. The specimen referred to *Striatopodocarpites* (pl. 1, fig. 13) does not show any apparent striations. *Cycloverrurtriletes* and *Deltoidospora* are wrongly identified. Miospore A (pl. 1, fig. 24) is a foraminifer. On the other hand, specimens of modern organisms are present on some of the slides (see pl. 1, figs 15, 18, 19), e.g. pollen of *Pinus*, fungal bodies, etc. Certain peculiar structures, variously referred to as acritarchs or hystrichosphaerids are also seen. Overall, the Malla Johar spore and pollen assemblage is very poor in quantity and quality.

Dinoflagellate cysts recorded from the Spiti Shale of Malla Johar (Jain *et al.*, 1978) are also not well-preserved but are characteristic enough for age determination. Important dinocyst taxa recorded are:

*Oligosphaeridium anthophorum* (Cookson & Eisenack) Davey  
*O. pulcherrimum* (Deflandre & Cookson) Davey & Williams  
*Lithodinia* sp.  
*Sentusidinium* spp.  
*Pareodinia ceratophora* Deflandre  
*Prolixosphaeridium* sp. cf. *P. torynum* (Cookson & Eisenack) Eisenack & Kjellstrom  
*Gonyaulacysta jurassica* (Deflandre) Norris & Sarjeant  
*Tubotuberella apatela* (Cookson & Eisenack) Ioannides *et al.*  
*Adnatosphaeridium aemulum* (Deflandre) Williams & Downie

*Oligosphaeridium dictyophorum* (Cookson & Eisenack) Davey & Williams, and  
*Omatia montgomeryi* Cookson & Eisenack

Mehrotra and Sinha (1980) have discovered dinoflagellate cysts from the Sangcha Malla Formation of Malla Johar. Some authors have raised Sangcha Malla to the rank of a group which includes a lower Jhangu Formation and an upper Balcha Dhura Formation. Mehrotra and Sinha report does not give precise information about the stratigraphic location of the samples within the Sangcha Malla Formation (or group), but possibly the samples represent both Jhangu and Balcha Dhura formations. According to Mehrotra and Sinha (1980) the microplankton found by them indicate an Upper Cretaceous age for the former and possible Eocene age for the latter. It may be of interest to recall that Jain *et al.* (1978) found no dinoflagellate cysts in the Sangcha Malla Group, but they recovered a rich radiolarian assemblage which suggests a Cretaceous 'affinity' even for the Balcha Dhura Formation. In the absence of illustrations, it is not possible to verify the dinoflagellate identifications and hence are listed below:

*Odontochitina cribropoda* Deflandre & Cookson  
*Systematophora schindewolfi* Neale & Sarjeant  
*Oligosphaeridium complex* Davey & Williams  
*Diphyes colligerum* Davey & Williams  
*Cordosphaeridium inodes* (Klumpp) Davey & Williams  
*C. exilimurum* Davey & Williams  
*Acrosphaeridium diktoyplokus* Eaton  
*Hystriochokalpoma* Klumpp  
*Hystriochosphaeridium* Deflandre emend. Davey & Williams  
*Homotryblum* Davey & Williams  
*Cleistosphaeridium* Davey *et al.*  
*Gonyaulacysta* Deflandre

#### PLANT MEGAFOSSILS FROM THE HIMALAYAN ZONE (LESSER HIMALAYA)

Mesozoic plant fossils in the Lesser Himalaya were first reported by Wadia (1919) in the form of impressions on black shales of the Lower Tals. No details of this report were probably ever published.

Bhargava (1969) reported "algal pisolites" from the Krol E of Nigali Synform, Himachal Pradesh.

Raha and Gururaja (1970) found stromatolites associated with the Mussoorie Phosphorite Member, till then believed to be the basal unit of the Tal Formation. Raha (1971) designated the Phosphorite Member as the topmost unit of the Krol Formation in the Mussoorie area. Raha (1971) recognised 5 types of stromatolites which he thought "appear to have affinity with the late Palaeozoic to early Mesozoic forms". It would, however, seem that his remarks on the age were interpolated on the basis of data other than his own.

Mithal and Chaturvedi (1972) reported the occurrence of certain peculiar structures in the limestones of the upper Krols, possibly Krol C, exposed on the Rajpur-Mussoorie Mule Track south-east of Mussoorie Town. The authors compare these structures with the external form of the red algae Solenoporaceae. These structures are vaguely similar to Bird's eye structure of Pisolitic dolomite (see Singh *et al.*, 1980, pl. 1, fig. 2; pl. 2, fig. 4).

Fuchs and Sinha (1974, p. 573) reported the occurrence of high growing branching stromatolites in the Krol E near All Saint's College, Nainital. Singh and Rai (1977) have recorded the presence of stromatolite taxa *Conophyton garganicus* Koroljuk, *Colonnella* sp. and *Baicalia baicalica* Krylov from the Upper Krol sediments of Nainital area. This find is considered as indicative of a middle Riphean age for the Krol Formation.

However, calcareous algae reported by Kumar (1978) from the oolitic limestone of Krol D exposed near Solan, Himachal Pradesh apparently do not indicate an age older than Permian. The taxa listed by Kumar (1978) are:

*Dvinella comata* Khvorova  
*Sphaerocodium bornemanni* Rothpleitz  
*Atractyliopsis* sp.  
*Girvanella* sp.  
*Permocalculus* sp.  
*?Zaporella* sp.  
*Diplopora annulata* (Schafh), and  
*Teubiphytes* sp.

He concludes that 'on the basis of overlap of the recorded ranges of all the discussed species of algae found in Krol limestone, it can be inferred beyond doubt that the

age of Krol Formation is not older than Permian. It is likely that this sequence may be Permo-Triassic although the upper limit is open to discussion'. I have a query. Is it possible to infer the age of a great thickness of sediments simply by computing the age of a part at the top?

Patwardhan (1978) reported the discovery of fossils belonging to the problematic group 'Moravamminids' from the chert-Phosphorite horizon of the Lower Tals of Mussoorie area. Bhatia (1980, p. 81) believes that these fossils 'can, with equal certainty, be assigned to certain Jurassic-Cretaceous dasycladacean algae'—*Cylindroporella* Johnson. According to Bhatia (1980), certain animal fossils reported by Ahluwalia (1978) from the same horizon are infact algae. While *Palaeobiogerina* (?) of Ahluwalia (1978, fig. 1b) is same as the Patwardhan fossil, *Archaeodiscus* (?) and indeterminate *Pachyphloia* (Ahluwalia, 1978, fig. 1a, c) 'appear to be close to distorted sections through discs or primary branches of *Clypenia*, a Jurassic-Palaeocene alga'. Bhatia goes on to suggest a Lower Cretaceous age for the Lower Tal. However, the carbonaceous shales of Lower Tals have yielded the lamellibranch *Posidonia*, and were assigned a Jurassic age (Shrivastava, 1972). The genus *Posidonia* ranges in age from Lower Carboniferous to Upper Jurassic.

Tewari and Kumar (1967) recorded algal fossils (*Neomeris*) from the shell limestone at Nilkanth. This limestone constitutes the topmost unit of the Upper Tal Member of the Tal Formation and has been named as the Manikot Shell Limestone by Dhaundiyal and Kumar (1976, cited in Kumar & Dhaundiyal (1980)). Some authors have raised this limestone to the status of a formation, e.g. Nilkanth Formation of Singh (1974, in Mussoorie-Nilkanth area), Singtali Formation of Mehrotra *et al.* (1976, at Singtali). Singh (1979) believes that this limestone unit is not a part of the Tal Formation *sensu stricto* and is actually separated from the latter by a major hiatus. Bhatia (1980) sounds sceptic about Singh's hypothesis.

Kalia (1974, 1976) reported an algal assemblage from the Manikot Shell Limestone exposed in the southern limb of the Garhwal Syncline near Bansi in the Dugadda

area. She identifies the presence of following taxa:

- Parachaetes lamellatus* Konishi
- Gymnocodium bellerophontis* (Rothpleitz) Accordi
- Permocalculus anantii* Kalia
- Anthracoporella spectabilis* Pia
- A. mercuri* Elliott
- Mizzia bramkampi* Rezak
- Pseudoepimastopora* sp. cf. *P. likana* (Kochansky & Harak) Elliott
- Pseudovermiporella sodalica* Elliott
- P. cylindrica* Kalia
- Diploporella*
- Veleitella triplicata* Kochansky-Devide
- Epimastopora*
- Hikorocodium elegantae* Endo
- H. sp.* cf. *H. transversum* Endo, and
- Ortonella morikawae* Endo

According to the author algal forms are indicative of a Permian (Guadalupian) age. Algae have also been reported from the Manikot Shell Limestone exposed in the northern limb of the Garhwal Syncline near Singtali on Rishikesh—Dev Prayag road (Mehrotra *et al.*, 1976). Following taxa are described and illustrated:

- Gymnocodium bellerophontis* (Rothpleitz) Pia
- G. sp.* cf. *G. nodosum* Ogilvie-Gordon
- Permocalculus forcepianus* (Johnson) Elliott
- Parachaetes* sp.
- Anatolipora singtaliensis* Mehrotra *et al.*
- Clavaphysoporella elegantannulata* (Endo & Kanuma) Endo
- Eogoniolina* sp. cf. *E. undulata* Endo
- Epimastopora* sp.
- Gyroporella symmetrica* Johnson
- Mizzia veleitana* Schubert
- Oligoporella nipponica* Endo
- Pseudoepimastopora krishnaswamyi* Mehrotra *et al.*
- Anchicodium* sp.
- Hikorocodium transversum* Endo
- Ortonella gracilis* Johnson, and
- Succodium hikorocooides* Endo

Just like Kalia (1976), Mehrotra *et al.* (1976) also believe that the Manikot Limestone algae are suggestive of a Permian age. According to the latter authors the presence of *Mizzia veleitana* clearly indicates an Upper Permian Age. This created an anomalous situation as till then the age of the Tal Formation was believed to be between Triassic and Cretaceous. To counter this

anomaly Mehrotra *et al.* (1976) came out with an interesting hypothesis that 'the Garhwal Thrust probably passes below the Singtali Formation and that the Singtali Formation (a part of Tal Formation of earlier workers) should be included into the Lower Binji unit of RAVI SHANKAR and GANESHAN (1973)'. However, Kumar and Dhaundiyal (1980, p. 65) consider that the limestone at Singtali is of the same age as the Manikot Shell Limestone.

Bhatia (1980) has analysed the taxonomy of algal forms reported by Kalia (1976) and Mehrotra *et al.* (1976). From his report it would seem that there are only three species of algal fossils. Rest are animal fossils. The algal species recognized by Bhatia are:

1. *Archaeolithothamnium* sp.
  - 1969 *Lithothamnium nilkanthensis* Tewari & Kumar, *nomen nudum*
  - 1974 *Misellina* sp.: Kalia, pl. 1, fig. 3.
  - 1976 *Parachaetes* sp.: Mehrotra *et al.*, pl. 1, fig. 5.
  - 1980 *Archaeolithothamnium* sp.: Bhatia, fig. 3, p. 6.
2. *Halimeda* sp.
  - 1974 *Neoschwagerina* cf. *N. craticulifera* (Schwager): Kalia, pl. 1, figs 4-6.
  - 1976 *Hikorocodium elegantae* Endo: Kalia, pl. 3, figs 3, 4.
  - 1976 *Gymnocodium bellerophontis* (Rothpleitz) Pia, 1920: Mehrotra *et al.*, pl. 1, fig. 1.
  - 1976 *Gymnocodium* cf. *nodosum* Ogilvie-Gordon: Mehrotra *et al.*, pl. 1, figs 2, 3.
  - 1976 *Clavaphysoporella elegantannulata* (Endo & Kanuma) Endo, 1961: Mehrotra *et al.*, pl. 1, fig. 8.
  - 1980 *Halimeda* sp.: Bhatia, figs 1, 4a, c.
3. *Neomeris* sp.
  - 1976 *Pseudoepimastopora* cf. *likana* (Kochansky & Herak) Elliott: Kalia, pl. 2, figs 7, ?8.
  - 1976 *Eogonolima* cf. *E. undulata* Endo, 1957: Mehrotra *et al.*, pl. 2, fig. 14.

These algal remains alongwith animal fossils such as, *Millepora*, *Diplocava*, *Corymbopora* and echinoid spines are said to indicate a Maestrichtian-Danian age (Bhatia, 1980, p. 94).

#### PALYNOMORPHS FROM THE HIMALAYAN ZONE (LESSER HIMALAYA)

The first microfossils from the Lesser Himalaya were reported from the carbona-

ceous shale assumed to be belonging to the Krol 'Series' (Sitholey *et al.*, 1954). As the Krols were till then understood to be totally unfossiliferous, there probably was a nagging doubt in the mind of the authors about the genetic relationship of this carbonaceous shale.

The area was therefore revisited twice to ascertain the exact source of the carbonaceous shale. According to Lakhanpal *et al.* (1959) the carbonaceous shale is exposed in a gulch where the rock sequence is disturbed by local slips and displacements. 'The shale bed is intercalated with bluish limestone and purple, grey and green shales. These beds overlie quartzites and greyish slates exposed along the road cutting near the main boundary fault separating these older formations from the Tertiary Nahansandstones'. They placed the carbonaceous shale in Krol A. However, later authors have placed the carbonaceous shale in the Infra-Krol (Fuchs & Sinha, 1974; Bhargava, 1979).

Whereas Sitholey *et al.* (1954) found only a few palynomorphs alongwith pieces of tracheids and cuticles, Lakhanpal *et al.* (1959) listed 18 species of miospores, one seed type, and 4 types each of tracheids and cuticles. Sah *et al.* (1968) reinvestigated the microfossils and recognized 13 genera of palynomorphs. Unfortunately they did not go into taxonomy at the species level. Following is a list of species identified by Lakhanpal *et al.* with nomenclatural changes and modifications by Sah *et al.*

Lakhanpal <i>et al.</i> , 1959	Sah <i>et al.</i> , 1968
<i>Calamospora</i> sp.	<i>Calamospora</i>
<i>Planisporites parvus</i>	<i>Apiculatisporites</i>
<i>Dictyotriletes</i> sp.	
<i>Laevigatosporites minor</i>	<i>Laevigatosporites</i>
<i>Striatites sewardii</i>	<i>Striatites</i>
<i>S. renisaccatus</i>	<i>Striatites</i>
<i>S. kumaonensis</i>	
<i>Striatites</i> sp.	
<i>Lunatisporites</i> sp.	<i>Striatopiceites</i> sp.
<i>Striatopodocarpites fusus</i>	<i>Strotersporites</i>
<i>S. gondwanensis</i>	
<i>Pityosporites potonieii</i>	<i>Cuneatisporites</i>
<i>P. (Florinites) ovatus</i>	<i>Sulcatisporites</i>
<i>Succinctisporites ovalis</i>	
<i>Alisporites phaseolosaccatus</i>	<i>Alisporites</i>
<i>Platysaccus tenuis</i>	
<i>P. crassimarginatus</i>	<i>Triadispora</i>
<i>Platysaccus</i> sp.	
	<i>Platysaccus</i>
	<i>Voltziaceae</i> spores
	cf. <i>Schizopollis</i>

According to Sah *et al.* (1968) the assemblage is dominated by non-striate bisaccate pollen. This plus the presence of the genera *Voltziaceasporites* and *Triadispora* lead them to presume a lowermost Triassic age for this mioflora. In its looks the mioflora is strikingly similar to that of the Raniganj Formation of peninsular India. I, therefore, decided to verify the taxonomic identifications. Unfortunately it would seem that the material and the slides have either been misplaced or lost and are not available for study.

In this connection it will be in order to recollect that Tewari and Singh (1980) have deduced a Permian age for the Infra-Krol on the basis of a varied megaflora collected by them from the Infra-Krol sediments of the Jeolikot-Bhowali section. This find lead them to postulate 'that the lower age limit of the Krol Formation cannot go beyond the Triassic period as the immediately underlying Infra-Krol sediments are positively of Permian age'. I do not agree. To say that the Infra-Krols are of Permian age is not sufficient to postulate on the age of the Krols. We should know which stage or which part of the Permian is represented by the Infra-Krols? If the list of megafossils given by Tewari and Singh (1980) is taken at its face value then the assemblage may not be younger than the Lower Permian meaning thereby that the Krol sedimentation started within the Permian. But one solitary report can not be taken as a basis for assigning age to a complete unit. One does wish that Tewari and Singh had given the exact geographical and stratigraphical location of their specimens. The megaflora reported by Tewari and Singh could have come from the same bed from which Sitholey *et al.* got microfossils. In view of great importance of the megafossil find the specimens should have been described and illustrated in detail and with precision. Publication of good illustrations can not but be overemphasized because not every body gets a chance to have a look at the original specimens for verification of taxonomic identifications. For example, Shrivastava and Venkataraman (1975) have reported a mioflora from the Blainis and assigned it a Carboniferous age. However, reproduction of their photo-illustrations is such some of the forms look those of the Mesozoic *Circulina-Classopollis* complex.

Had the illustrations been good there would not have been a doubt.

There are a couple of reports on the occurrence of nannofossils in the Krol sediments. Tewari (1969) reported nannofossils from the contact of Krol B and Krol C of the Solan area. Sinha (1975) reported the presence of nannofossils in the green shale of Krol B exposed in the south-eastern flank of Pachmunda Syncline near Solan, Himachal Pradesh. He identifies the following types:

*Zycolithus concinnus* Martini  
*Tetralithus* sp. cf. *T. gothicus* Deflandre  
*Lucianorhabdus cayeuxi* Deflandre  
*Micula staurophora* Vekshina  
*Lithraphidites carniolensis* Deflandre  
*Discorhabdus* sp.  
*Deflandrius* sp.  
*Tergestiella margereli* (Noel) Reins, and  
*Microrhabdus orbitosus* Shumenko

On the basis of the occurrence of the above nannofossils Sinha (1975, p. 75) suggests 'that the stratigraphic range of Krol B horizon extends from Oxfordian (J<sub>3</sub>Oxf) to Danian (Cr<sub>2</sub>dn)'. However, from the chart showing stratigraphic distribution of different species (Sinha, 1975, p. 76, fig. 5) it is clear that the age of the nannofossil assemblage under question could only be from Coniacian to Campanian. But, the Himalayan question is how many of these forms are really nannofossils? According to Jafar (1980) "Among four forms documented under the high-power light microscope, only single one is genuine but indeterminate coccolith; the biogenic nature of other three remains doubtful. All the three forms documented under the transmission electron microscope are true coccoliths but only a single form permits specific identification with known range of upper Tithonian-Campanian".

Ghosh and Srivastava (1962) reported palynomorphs from the Infra-Krol, Krol and Tal formations. The samples came from the section along Rajpur-Mussoorie Mule Track, but they have not given the exact locations of their samples. They referred the palynomorphs to the families Schizaeaceae, Polypodiaceae, Selaginellaceae, Podocarpaceae and Pinaceae. However, from the photographs these forms seem to have a three-dimensional figure on a scale much more than I have ever

observed in Palaeozoic or Mesozoic palynomorphs. By referring these palynomorphs to extant families of plants, the authors have, probably unintentionally, projected the true picture that the forms are contaminants, either from recent or sub-recent deposits.

Recently Geological Survey of India (in Roy Chowdhury, 1979) have reported plant microfossils from the Krol and the Tal. However, as no descriptions or illustrations are given the report is presented here for whatever it is worth.

The Lower Tal shales at Durmala, Mussoorie Synform, Uttar Pradesh contain mainly algal and fungal remains, hystriospheres, some acritarchs and a few pteridophytic spores. A few tricolpate grains with faint colpi have also been found. The microflora is assigned a post-Jurassic age.

The Lower Tals at Maldeota, Mussoorie Synform contain acritarchs, spores and pollen grains, fungal spores and wood tracheids with simple as well as bordered pits. The taxa are:

*Baltisphaeridium*, *Crossosphaera*, *Cymatiosphaera*, *Granodiscus*, *Leiosphaeridia*, *Michrhystridium*, *Tasmanites*, *Laevigatosporites*, *Polypodiites*, *Schizaeosporites*, *Foveomonolites*, *Triletes*, etc.

Bisaccate pollen allied to Podocarpaceae and tricolpate grains like *Castanea* are most significant in this assemblage. An Upper Jurassic-Lower Cretaceous age is assigned.

#### DISCUSSION

From the foregoing it is evident that as far as Mesozoic Palaeobotany of the Himalayas is concerned, not much work has been done and whatever has been done, most of it is open to doubt or to more than one interpretation. In the Tethyan Himalaya, of course, we have the satisfaction of knowing that undoubted megaplant remains of Mesozoic age do occur. The reports of Mesozoic plant microfossils in the Tethyan Himalayan Zone are also reliable, though there definitely is some reworking. The genetic affinity of the Tethyan Himalayan sediments, however, is a different matter altogether. I agree with Barale *et al.* (1978) that there are no compulsive evidences to believe that the Kagbeni flora has a Gondwanic affinity. Similarly I find no evidence to guide me to believe that the Ladakh

megaplant remains or the Malla Johar microflora has exclusive Gondwanian relationship. But all the same these finds are interesting and most encouraging. These suggest that fossils are there for one with a will to find them.

As far as the Lesser Himalayan Zone is concerned, the situation is rather complex. There is as yet no consensus as to whether Mesozoic sedimentation took place in the area or not. Usually Nagthat, Blaini and Infra-Krol were considered to be of Palaeozoic age, while Krol and Tal were taken as representing the Mesozoic sediments. Of course fossil finds have been variously interpreted to suit one's own fancy about the age of the Krol and the Tal formations. Some examples!

Lakhanpal *et al.* (1959) palynologically dated the Krol A carbonaceous shale of the Nainital area (laterly supposed to be within the Infra-Krol) as of Permian age. A restudy of the same slides suggested a lowermost Triassic age to Sah *et al.* (1968). Meanwhile Ghosh and Srivastava (1962) had earlier dated Krol A and Krol D as of Triassic age on the basis of certain pollen types, which I am afraid have been derived from recent or subrecent sediments. Sinha (1975) believes that the Krols may be even younger in age and that the Krol B red shale extends from Oxfordian to Danian. On the other hand, there are reports of the occurrence of middle Riphean columnar stromatolites in the Upper Krol (Singh & Rai, 1977) to the occurrence of Mississippian stromatolites and Precambrian algal oncolites in Krol D (Bhargava, 1979). The whole situation is confounded by the reported failure of Austrian palaeontologists to find any thing but 'primitive' forms of no stratigraphic significance in the Krols (Fuchs & Sinha, 1974). It should be remembered here that Lakhanpal *et al.* (1959) and Sah *et al.* (1968) also could not recover any microflora from the Blaini Boulder Bed, Infra-Krols and Krol of the Sirmur, Simla, Chakrata, Mussoorie and Nainital areas, except for that one lucky find, from near Brewery.

Situation is not much encouraging in the Tals too. Ghosh and Srivastava (1962) date the Lower Tal as Jurassic on the basis of a single 'schizaeaceous' spore which most probably belongs to an extant plant. Shrivastava and Mehrotra (1974) report that

they have found some angiospermous pollen in the Lower Tals and hence these could be as young as Albian-Late Aptian. Kalia (1974, 1976) and Mehrotra *et al.* (1976) put up a strong case for an Upper Permian age for the overlying Upper Tal. Thus, we had a situation where the lower sediments were seemingly younger than the upper sediments. So, Bhargava (1979) came up with an original idea that may be after all the fossils reported by Kalia, and Mehrotra *et al.* did not originate in the Shell Limestone but in the allochthonous Boulder Slate of the Bijni Unit. Thus if we accept Bhargava's opinion about the Shell Limestone fossils and my own views about the Ghosh and Srivastava microspore, then the Tal become devoid of any known plant fossils. But, Bhatia (1980) would like us to believe that only if the fossils were correctly identified there would not have been an incongruity about the age of the Upper Tal which he feels is Maestrichtian-Danian. On the other hand Kumar (1980) opines that 'some part of Tal Formation may be Pre-Cambrian in age'. His opinion is based on the report of a stromatolitic limestone

from the lower part of the Tal Formation at Pasi Tiba, near Mussoorie (Sharma, 1976).

From Bhatia's (1980) discourse one point emerges very distinctly that in the Lesser Himalaya the palaeontologists are having difficulty in deciding fundamental questions, such as whether a 'fossil' is actually a fossil or not, and if it is a fossil, whether it is an animal fossil or a plant fossil. Here I have in mind Mithal and Chaturvedi's Solenoporaceae, Kalia's fusulinids and algae, Mehrotra *et al.*'s algae and Patwardhan's moravaminids. Sinha's nannofossils also come within the ambit of this comment.

Seeing all these pitfalls, I feel that in a complicated area like the Himalaya, only a multidisciplinary concerted effort may take us out of the Lesser Himalayan tangle. It should involve a large scale remapping, establishment of type and reference sections, systematic collection of stratigraphically located samples in a profile, fool-proof laboratory processing and a little conservatism in arriving at conclusions. All the reported fossil finds must be verified at more than one laboratory.

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