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Palynofloral investigation of the Kopili Formation (Late Eocene) exposed near Umrongso in North Cachar Hills District, Assam, India

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ABSTRACT

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The palynoflora recovered from the Kopili Formation (Late Eocene) exposed at 8·5 km south-east of Umrongso on Umrongso-Haflong Road, North Cachar Hills, Assam, India is described here. The pteridophytic spores, represented by *Cyathidites, Striatriletes, Todisporites, Polypodiaceaesporites, Lygodiumsporites, Polypodiisporites*, etc., constitute the major part (60%) of the assemblage whereas gymnospermous pollen are poorly represented. The angiospermous pollen (35%) are represented by *Densiverrupollenites, Tricolporopollis, Retitricolporites* etc. Dinoflagellate cysts and fungal remains have also been recorded. Reworked Permian and Triassic palynofossils like *Indotriradites* and *Klausipollenites* respectively are also met with. The palynoflora indicates that the area enjoyed a tropical-subtropical, warm-humid climate and that the deposition of the Kopili Formation took place in a coastal environment with heavy rainfall and sufficient fresh water influx.

Key-words—Palynology, Kopili Formation, Late Eocene, North Cachar Hills, Assam, India.

भारत के असम प्रान्त के उत्तरी कछार पहाड़ी जनपद में उमरांग्सो के निकट स्थित अन्तिम इओसीन युगीन कोपिली शैलसमूह का परागाणुवनस्पतिजातीय अन्वेषण

ज्ञानेन्द्र कुमार त्रिवेदी एवं रमेश कुमार सक्सेना

सारांश

इस शोध पत्र में असम प्रान्त के उत्तरी कछार के उमरांग्सो हाफ़लांग रोड पर उमरांग्सो के 8·5 किमी दक्षिण-पूर्व में अनावरित कोपिली शैलसमूह से प्राप्त अन्तिम इओसीन युगीन परागाणुवनस्पतिजात का वर्णन किया गया है. टेरिडोफाइटी बीजाणु, जिनका प्रतिनिधित्व *साएथीडायटीज़, स्ट्रायाट्रायलिटीज़, टोडिस्पोरायटीज़ पोलीडॉयसीस्पोराइटीज़, लाइगोडियमस्पोराइटीज़, पालीपोडायस्पोराइटीज़* आदि द्वारा किया जाता है, समुच्चय का एक बड़ा अंश (60%) निर्मित करते हैं, जबकि अनावृतबीजी परागकणों का प्रतिनिधित्व अत्यल्प है. आवृतबीजी परागकणों (35%) का प्रतिनिधित्व *डेन्सीवेरूपोलेनाइटीज़, ट्रायकोलपोरोपोलिस, रेटीट्राईकोल्पोराइटीस* आदि के द्वारा हुआ है. घूर्णीकशाभ पुटी तथा कवकीय अवशेष भी अंकित किए गये हैं. पुनः चक्रित परमियन एवं ट्रायसिक परागाणु पादपाश्म-जैसे *इनडोट्रायरेडायटीज़ क्लाऊसीपोलेनाइटीज़* भी क्रमिक रूप से प्राप्त हुए हैं.

परागाणु वनस्पतिजात से प्रदर्शित होता है कि क्षेत्र में उष्णकटिबन्धीय उपोष्ण, आर्द्र-उष्ण जलवायु थी तथा कोपिली शैलसमूहों का निक्षेपण समुद्रतटीय वातावरण में अत्यधिक वर्षा एवं यथेष्ट अलवणीय जल अन्तर्वाह के द्वारा हुआ.

संकेत शब्द—परागाणुविज्ञान, कोपिली शैलसमूह, अन्तिम इओसीन, उत्तरी कछार पहाड़ियाँ, असम, भारत.

INTRODUCTION

THE Kopili Formation, instituted by Evans (1932) after the Kopili River, is made up of shales alternated with thin bands of siltstone, sandstone, argillaceous limestone and strings of coal. This formation conformably overlies the Garampani Limestone Formation and is overlain by Barail sediments. However, in the Umrongso area, the Kopili Formation is covered by alluvial soil. The general stratigraphic set up of the area around Umrongso is given in Fig. 1 (after Samanta, 1971) and the geological map of the area is given in Fig. 2 (after Gangopadhyay, 1970).

Baksi (1962), for the first time, recorded palynofossils from the Kopili Formation of the Simsang River Section, Garo Hills, Meghalaya and named the sequence as Simsang Palynological Zone II. He recognized *Simsangia trispinosa* as a marker for Kopili Formation. Baksi (1974) made eight operational biostratigraphic (palynological) zones in the Tertiary sequence of Assam. He proposed *Monocolpites broadcolpusii-Simsangia* Assemblage Zone (=Simsang Palynological Zone II of Baksi, 1962) for the Kopili Formation (Late Eocene). Sein and Sah (1974) published palynological information from the Kopili Formation of Jowai-Badarpur Road section, Jaintia Hills, Meghalaya and on the basis of palynofossils demarcated this formation from the overlying Barail (Oligocene) sediments. Dutta and Jain (1980) studied acritarchs and dinoflagellate cysts from the Kopili Formation around Lumshnong area, Jaintia Hills, Meghalaya. Tripathi and Singh (1984a, b, 1985), Singh and Tripathi (1987) Tripathi (1989) and Trivedi (1985, 1990) have also published palynological information from the Kopili Formation exposed in Jaintia Hills, Meghalaya.

Lithostratigraphic unit	Lithology	Fossil contents	Age
Soils and alluvium			
	------Unconformity------		
Kopili Formation (500 m)	Shale with thin bands of argillaceous limestone, siltstone, sandstone and strings of coal.	Calcareous shale and argillaceous limestone contain molluscs and rich assemblage of foraminifera. Coal contains microflora.	Late Eocene
Garampani Limestone Formation (127 m)	Foraminiferal limestone with a few layers of marl and calcareous shale.	Highly fossiliferous throughout its entire thickness. Floral and faunal elements present. Foraminifera dominant.	Middle to late Middle Eocene
Mikir Formation (60 m)	Coarse to medium grained sandstone with occasional siltstone, shale and coal.	Apparently devoid of faunal remains Carbonaceous shale and coal contain microflora.	Early to early Middle Eocene
	------Unconformity------		
	Precambrian Complex		

Fig. 1—General stratigraphic set up of the area around Umrongso (after Samanta, 1971).

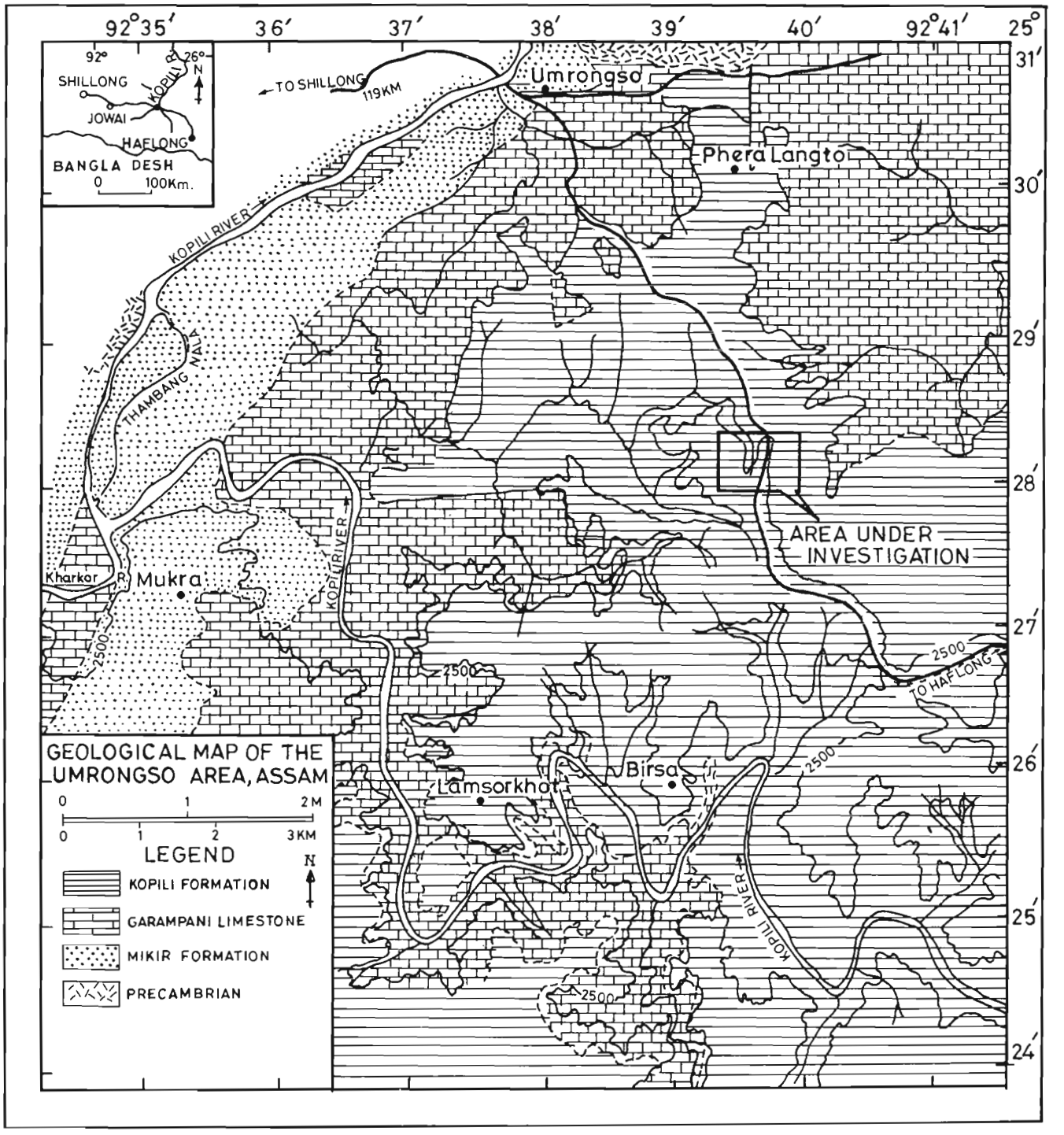

Fig. 2—Geological map of the area around Umrongso, North Cachar Hills, Assam (after Gangopadhyay, 1970).

MATERIAL AND METHODS

Twenty samples were collected from the Kopili Formation exposed in a road cutting, about 8·5 km south-east of Umrongso Town on Umrongso-Haflong Road in North Cachar Hills District, Assam, (Figs 2 & 3). Of these, five samples yielded palynofossils. The stratigraphic position of the samples are given in Fig. 4. For recovery of palynofossils, samples were treated with HCl, HF and HNO_3 followed by 10 % solution of KOH. The material was finally washed with water

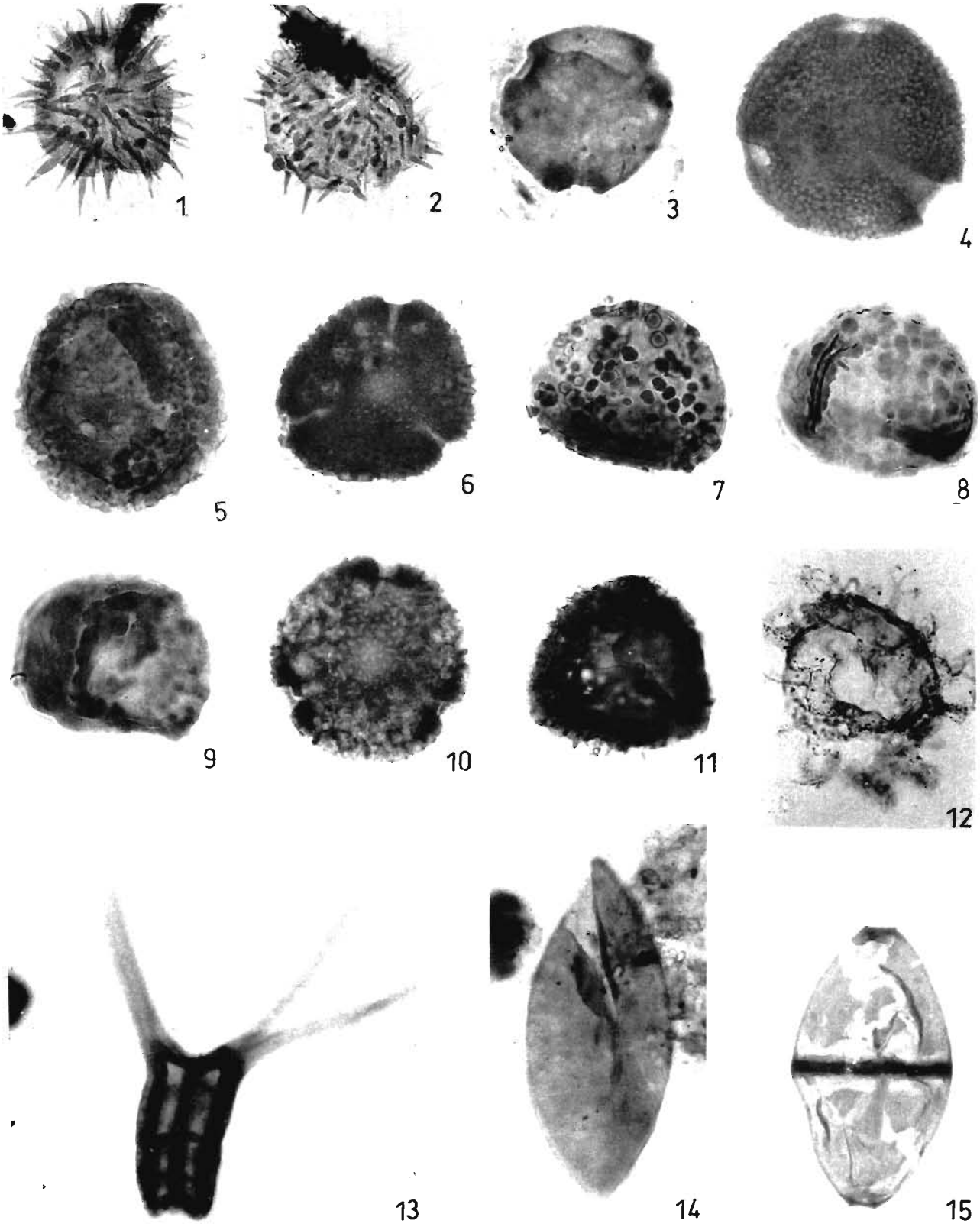

PLATE 1

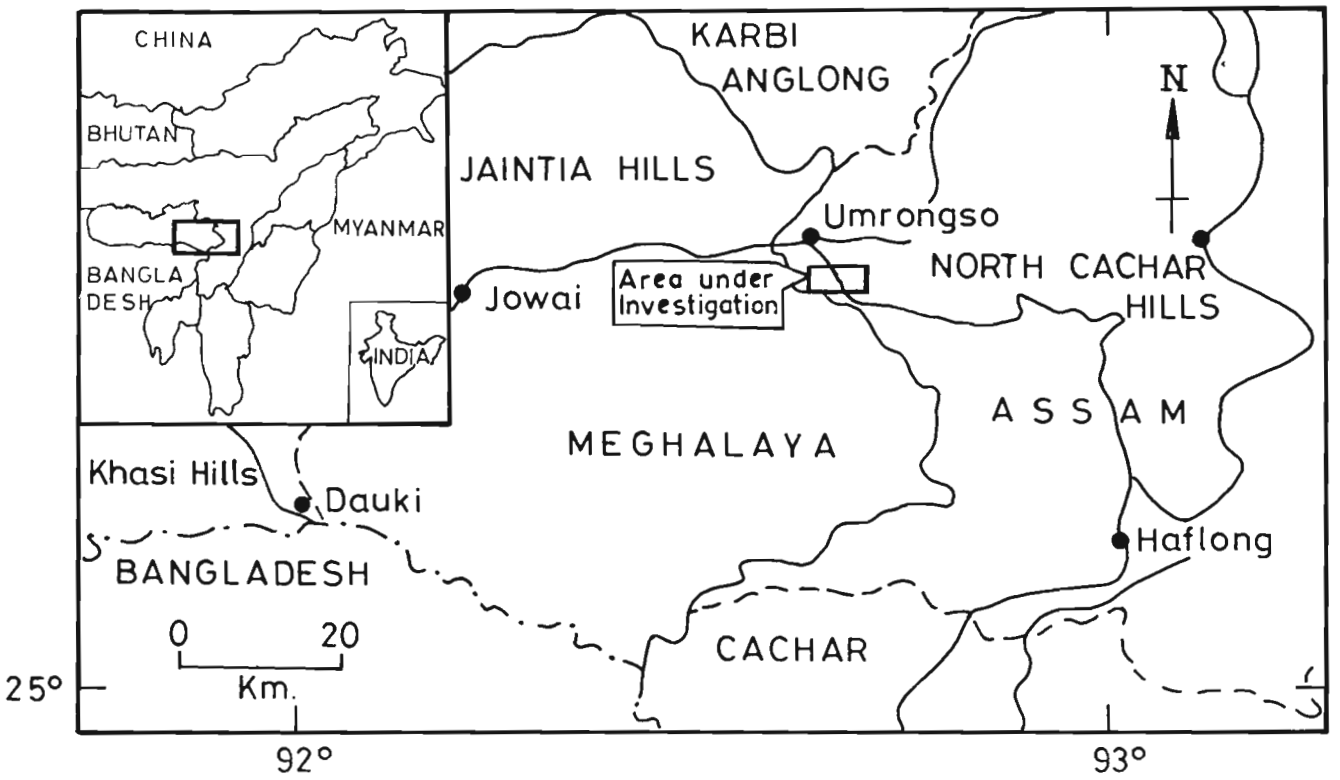

Fig. 3— Location of Umrongso in North Cachar Hills, Assam.

through 400 mesh sieve. The slides were prepared in polyvenyl alcohol and mounted in Canada balsam. Leitz Laborlux S microscope was used for the study and photomicrography. The slides and negatives of the figured specimens have been deposited in the Museum of the Birbal Sahni Institute of Palaeobotany, Lucknow, India.

PALYNOFLORAL ASSEMBLAGE

Algae
Dinoflagellate cysts

Fungal remains
Dicellaesporites sp.
Dyadosporites sp.
Frasnacritetrus sp.

Pteridophytic spores
Cyathidites australis Couper 1953
C. minor Couper 1953
Dictyophyllidites sp.
Intrapunctisporis intrapunctis Krutzsch 1959
Lygodiumsporites lakiensis Sah & Kar 1969
Monolites mawkmaensis Sah & Dutta 1966
Pilamonoletes excellensus Kar 1990
Polypodiaceaesporites tertiarus Dutta & Sah 1970
Polypodiisporites mawkmaensis Dutta & Sah 1970
P. ornatus Sah 1967
P. splendidus Salujha, Kindra & Rehman 1972
Punctatisporites sp.
Striatriletes susannae van der Hammen emend. Kar 1979
S. *multicostatus* Kar & Saxena 1981
Todisporites major Couper 1958
T. minor Couper 1958

PLATE 1

(All photographs are enlarged ca. x 500, unless otherwise mentioned)

1. *Spinizonocolpites echinatus* Muller. Slide no. BSIP-12073/17.
2. *Neocouperipollis kutchensis* (Venkatachala & Kar) Kar & Kumar. Slide no. BSIP-12074/1.
3. *Pellicieroipollis langenheimii* Sah & Kar. Slide no. BSIP-12075/5.
4. *Tricolporopollis matanomadhensis* (Venkatachala & Kar) Tripathi & Singh. Slide no. BSIP-12076/2.
5. *Densiverrupollenites eocenicus* Tripathi & Singh. Slide no. BSIP-12077/4.
6. *Retitriolporites* sp. 1. Slide no. BSIP-12077/8.
7. *Polypodiisporites splendidus* Salujha *et al.*. Slide no. BSIP-12078/18.
8. *Polypodiisporites ornatus* Sah. Slide no. BSIP-12078/17.
9. *Polypodiisporites mawkmaensis* Dutta & Sah. Slide no. BSIP-12074/5.
10. *Retitricolporites* sp. 2. Slide no. BSIP-12075/5.
11. *Indotriradites* sp.. Slide no. BSIP-12079/13.
12. Dinoflagellate cyst, Slide no. BSIP-12076/4.
13. *Frasnacritetrus* sp.. Slide no. BSIP-12080/7. X 1250.
14. *Palmaepollenites nadhamunii* Venkatachala & Kar, Slide no. BSIP-12081/5.
15. *Dyadosporites* sp., Slide no. BSIP-12077/1

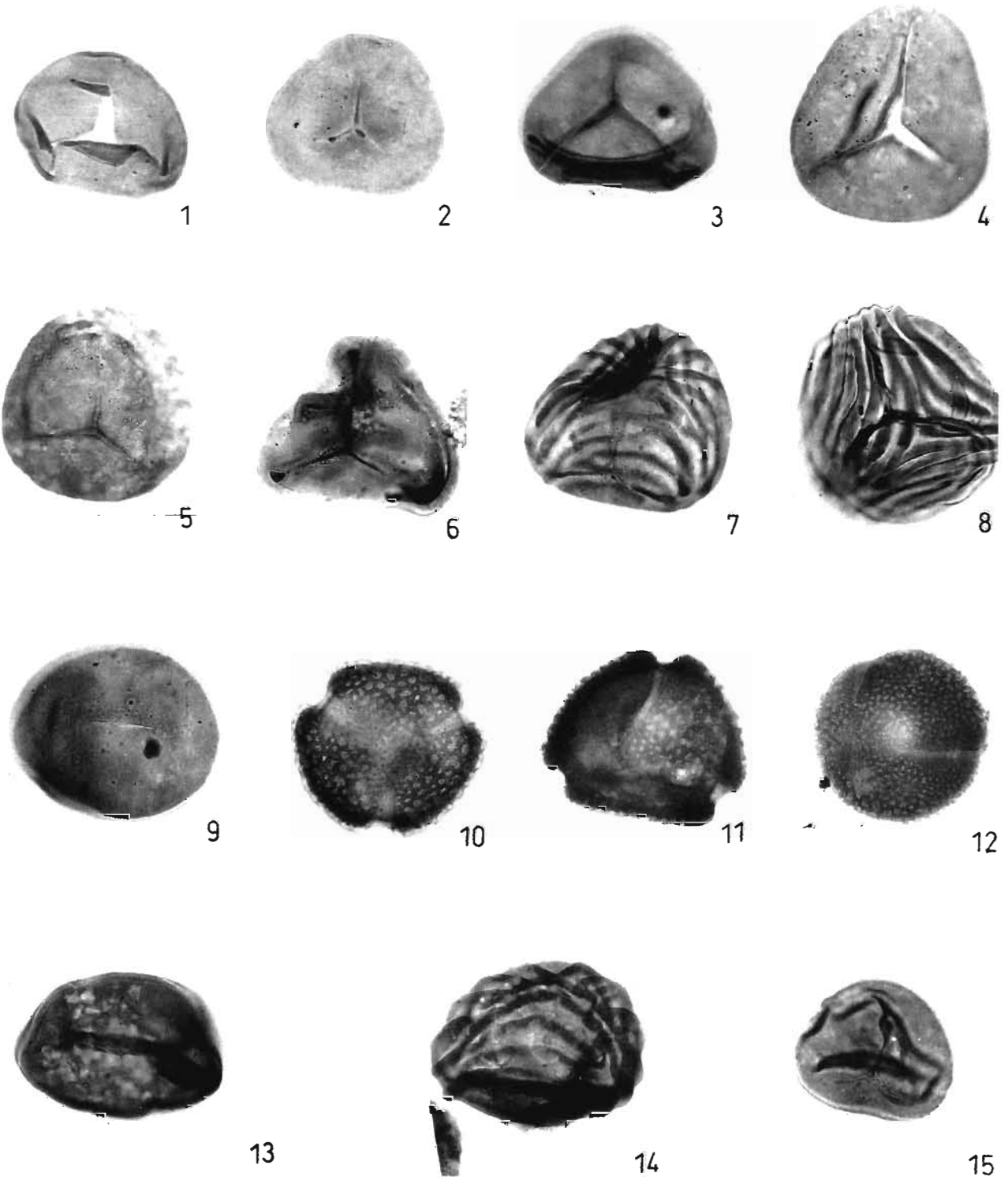

PLATE 2

(All photographs are enlarged ca. x 500, unless otherwise mentioned)

1-3, 15. *Cyathidites minor* Couper. Slide no. BSIP-12077/16; 12082/7; 12077/6; 12078/5.

4. *Cyathidites australis* Couper. Slide no. BSIP-12076/3.

5. *Intrapunctisporis intrapunctis* Krutzsch, Slide no. BSIP-12077/12.

6. *Lygodiumsporites lakiensis* Sah & Kar, Slide no. BSIP-12083/1

7-8, 14. *Striatriletes susannae* van der Hammen emend. Kar, Slide no. BSIP-12074/9; 12078/10; 12077/5.

9, 13. *Monolites mawkmaensis* Sah & Dutta, Slide no. BSIP-12077/5; 12078/11.

10. *Retitricolporites* sp. 1, Slide no. BSIP-12074/3.

11. *Retitricolporites* sp. 2, Slide no. BSIP-12084/4.

12. *Tricolpites microreticulatus* Belsky *et al.*, Slide no. BSIP-12077/2.

Gymnospermous pollen
Araucariacites australis Cookson ex Couper. 1953
Pinuspollenites crestus Kar 1985

Angiospermous pollen
Densiverrupollenites eocenicus Tripathi & Singh 1984a
Margocolporites sp.
Neocouperipollis kutchensis (Venkatachala & Kar) Kar & Kumar 1987
Palmaepollenites nadhamunii Venkatachala & Kar 1969
Pellicieroipollis langenheimii Sah &Kar 1970
Retitricolporites sp. 1
Retitricolporites sp. 2
Spinizonocolpites echinatus Muller 1968
Tricolpites microreticulatus Belsky *et al.* 1965
Tricolporopollis matanomadhensis (Venkatachala & Kar) Tripathi & Singh 1985
Tricolporopollis sp.
Triporopollenites sp.

Reworked palynofossils
Indotriradites sp.
Klausipollenites sulcatus Kar, Kieser & Jain 1972

DISCUSSION

The palynoflora recorded here consists of 28 genera and 34 species. Of these, 3 genera and 3 species belong to fungi, 11 genera and 16 species belong to pteridophytes, 2 genera and 2 species belong to gymnosperm, 10 genera and 11 species to angiosperms while 2 genera and 2 species belong to reworked palynofossils. Besides, dinoflagellate cysts have also been recorded. Known botanical affinities of various spore-pollen taxa of the Kopili Formation and present day distribution of their extant counterparts are given in Fig. 5.

Quantitative Analysis

For quantitative analysis of the assemblage, 200 or more specimens per sample were counted and from such counts percentage frequency of each taxon was calculated. However, in case of poorly productive samples only 100 specimens per sample were counted. All the taxa of fungal remains were counted together as a group (Fig. 4). Pteridophytic spores (60%) constitute the most dominant element of the assemblage followed by angiospermous pollen (35%), fungal remains (3%) and gymnospermous pollen (2%). The bulk of the pteridophytic spores is constituted by *Cyathidites, Striatriletes* and *Polypodiaceaesporites. Cyathidites* represented by *C. australis* and *C. minor* share 27%, *Striatriletes* represented by *S. susannae* and *S. multicostatus* constitute 13% and *Polypodiaceaesporites tertiarus* represent 10%. Other pteridophytic spore taxa of the assemblage are: *Todisporites* spp. (3%), *Lygodiumsporites lakiensis* (2%), *Polypodiisporites* spp. (2%), *Dictyophyllidites* sp. (1 %) *Monolites mawkmaensis* (1%), *Intrapunctisporis intrapunctis, Pilamonoletes excellensus* and *Punctatisporites* sp. The gymnospermous pollen, being represented by *Araucariacites australis* (0·5%) and *Pinus-pollenites crestus* (1·5%) are poorly represented. Amongst the angiospermous pollen, the most dominant taxa are: *Densiverrupollenites eocenicus* (12 %) and *Tricolporopollis matanomadhensis* (8%). Other angiospermous pollen taxa, viz., *Spinizonocolpites echinatus, Neocouperipollis kutchensis, Palmaepollenites nadhamunii, Tricolpites microreticulatus, Pellicieroipollis langenheimii, Retitricolporites* spp., *Tricolporopollis* sp., *Triporopollenites* sp., *Margocolporites* sp. are poorly represented.

Palaeoclimate and Environment of Deposition

The palynotaxa recorded here are assignable to Schizaeaceae, Parkeriaceae, Cyatheaceae, Osmundaceae, Matoniaceae, Polypodiaceae, Pinaceae, Araucariaceae, Arecaceae, Bombacaceae, Myricaceae, Caesalpiniaceae and Pelliceriaceae. Of these, Schizaeaceae, Parkeriaceae, Cyatheaceae, Matoniaceae, Araucariaceae, Arecaceae, Bombacaceae, Myricaceae, Caesalpiniaceae and Pelliceriaceae have their present day distribution restricted to tropical-subtropical regions. Only Pinaceae is temperate whereas other families are cosmopolitan (Fig. 5). *Tricolporopollis,* referable to Bombacaceae, is a tropical rain forest element which indicated that the area enjoyed heavy precipitation during Late Eocene. Abundance of fern spores is suggestive of warm-humid climate. This is further supported by the occurrence of fungal remains. The above account makes it clear that the area enjoyed a tropical to subtropical, warm-humid climate with heavy rainfall during the sedimentation of the Kopili Formation.

The palynoflora can be divided into various ecological groups, viz., montane, coastal, lowland, fresh water, phytoplankton, ferns and fungi. An analysis of the ecological groups reveals that ferns, low land and fresh water elements are dominant over the other plant groups. The different ecological groups of the assemblage are mentioned below.

1. Montane—*Pinuspollenites crestus.*

2. Coastal—*Spinizonocolpites echinatus, Pellicieroipollis langenheimii, Palmaepollenites nadhamunii, Neocouperipollis kutchensis.*

3. Lowland or Inland—*Tricolporopollis matanomadhensis, Tricolporopollis* sp., *Margocolporites* sp., *Triporopollenites* sp.

4. Fresh Water—*Striatriletes susannae, S. multicostatus.*

5. Ferns—*Lygodiumsporites lakiensis, Dictyophyllidites* sp., *Cyathidites australis, C. minor, Punctatisporites* sp., *Todisporites major, T. minor, Intrapunctisporis intrapunctis, Monolites mawkmaensis, Polypodiaceaesporites tertiarus, Polypodiisporites ornatus, P. splendidus, P. mawkmaensis, Pilamonoletes excellensus.*

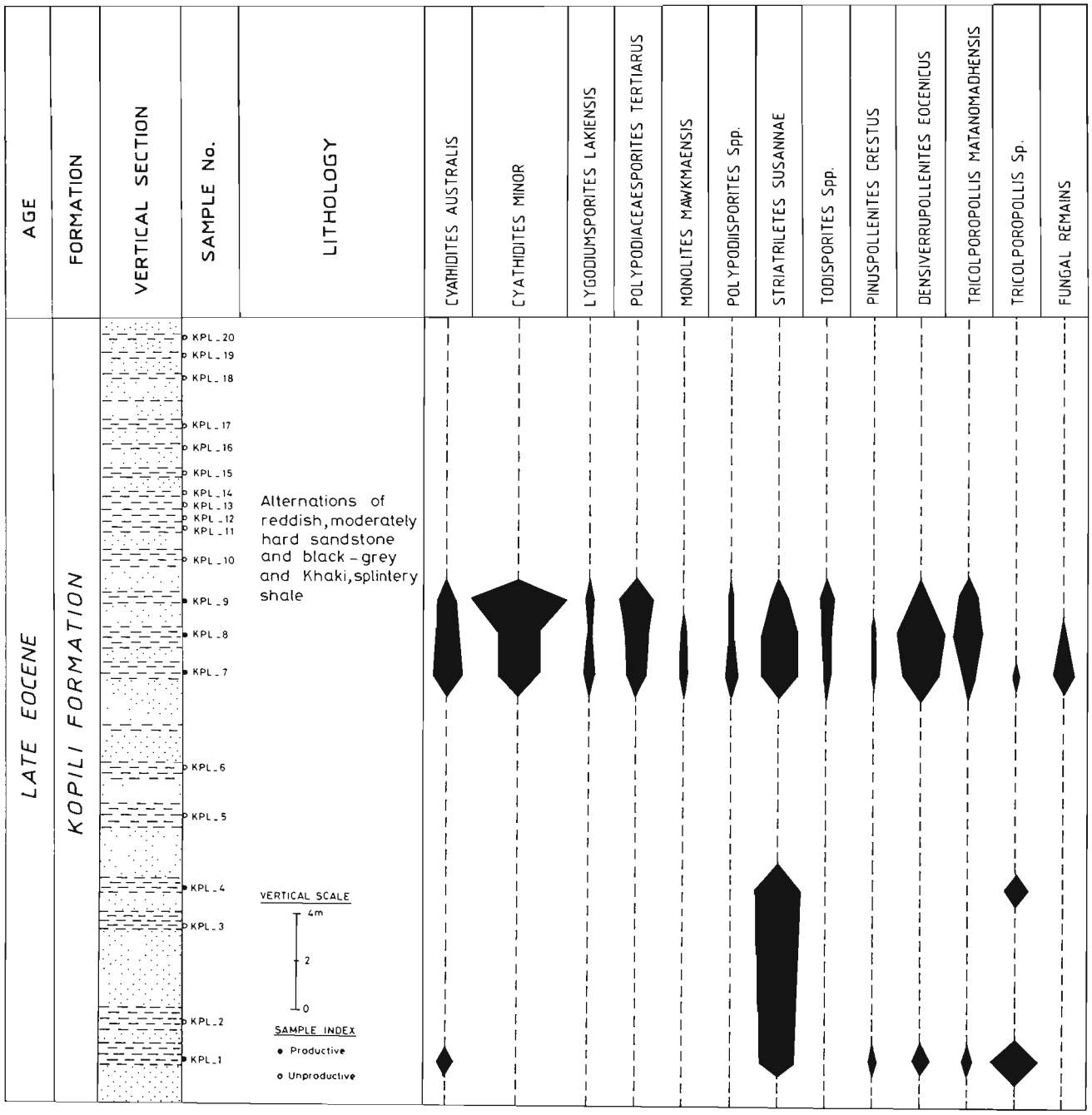

Fig. 4—Vertical distribution of palynotaxa in the Kopili Formation.

6. Fungal elements—*Frasnacritetrus* sp., *Dyadosporites* sp., *Dicellaesporites* sp.

7. Phytoplankton—This group includes dinoflagellate cysts.

Abundance of *Striatrilites,* referable to *Ceratopteris* (Parkeriaceae), indicates ponding conditions in close proximity. Coastal elements, viz., *Nypa* (*Spinizonocolpites*), *Pelliciera* (*Pellicieroipollis*) and other arecaceous plants constituted coastal vegetation. Ferns and lowland flora thrived behind the coastal plants and their spore-pollen were carried to the depositional site by water channels. Presence of dinoflagellate cysts indicates marine influence. Temperate elements (*Pinuspollenites*) suggest that topographically elevated area was not far away from the basin of deposition. The overall vegetational composition indicates deposition in a coastal environment with sufficient fresh water influx.

Botanical group/Family	Palynotaxa	Present day distribution
Division—Pteridophyta		
Schizaeaceae	*Lygodiumsporites lakiensis* *Intrapunctisporis intrapunctis* *Punctatisporites* sp.	Tropical to subtropical
Parkeriaceae	*Striatriletes susannae* *S. multicostatus*	Tropical
Cyatheaceae	*Cyathidites australis, C. minor*	Tropical to subtropical
Matoniaceae	*Dictyophyllidites* sp.	Tropical
Osmundaceae	*Todisporites minor, T. major*	Temperate and tropical regions
Polypodiaceae	*Monolites mawkmaensis,* *Polypodiaceaesporites tertiarus,* *Polypodiisporites ornatus,* *P. mawknaensis, P. splendidus,* *Pilamonoletes excellensus*	Cosmopolitan
Division—Spermatophyta **Subdivision—Gymnospermae**		
Pinaceae	*Pinuspollenites crestus*	Temperate
Araucariaceae	*Araucariacites australis*	Tropical
Subdivision—Angiospermae **Class—Monocotyledonae**		
Arecaceae	*Spinizonocolpites echinatus,* *Palmaepollenites nadhamunii,* *Neocouperipollis kutchensis*	Tropical to subtropical
Class—Dicotyledonae		
Bombacaceae	*Tricolporopollis matanomadhensis* *Tricolporopollis* sp.	Tropical to subtropical
Caesalpiniaceae	*Margocolporites* sp.	Tropical to subtropical
Myricaceae	*Triporopollenites* sp.	Tropical
Pelliceriaceae	*Pellicieroipollis langenheimii*	Tropical
Incertae sedis	*Densiverrupollenites eocenicus,* *Retitricolporites* spp. 1 and 2, *Tricolpites microreticulatus*	

Fig. 5 —Spore-pollen taxa of the Kopili Formation and present day distribution of their extant counterparts.

Reworked Palynofossils

The occurrence of Permian palynofossils, viz., *Indotriradites* sp. in the present assemblage and also in the previously recorded Kopili assemblages (Trivedi, 1985, 1987, 1990) indicates that the Permian sediments were extensively exposed in this region during Late Eocene. However, presently there occurs a small patch of Lower Gondwana deposit at Singrimari in Garo Hills, north-west of the area under investigation. This could possibly be the source area for the

Permian palynomorphs. The present study also records the occurrence of Early Triassic palynomorphs, viz., *Klausipollenites sulcatus* which indicates that these sediments also existed along with Permian sediments. Reworked palynofossils of Permian age have so far been recorded from the Tertiary sediments of Assam, Meghalaya and Bangladesh (Datta & Banerjee 1979). However, Sharma *et al.* (1986) recorded both Permian and Early Cretaceous palynofossils from Barpathar Well No. 1 of Upper Assam.

Palynofloral Comparison

A comparison of the present Kopili palynoflora with the other Kopili assemblages recorded so far has been discussed below. Baksi (1962) proposed Simsang Palynological Zone II for the Kopili palynoflora of the Simsang River Section, Garo Hills, Meghalaya. He recognized *Simsangsia trispinosa* as a marker for the Kopili Formation with frequent occurrence of *Laevigatosporites kopilia* and *Acolporites spinulosa*. These taxa are, however, absent from the present Kopili assemblage. Dominance of *Cyathidites*, *Striatriletes*, *Densiverrupollenites* and *Tricolporopollis*, absence of gemmate syncolpate pollen *(Meyeripollis)* and presence of dinoflagellate cysts are features of this assemblage. The palynoflora of Simsang Palynological Zone II (Baksi, 1962) and present Kopili palynoflora are therefore not comparable which may be due to their deposition in different types of environment.

Sah and Dutta (1968), while working on the palynostratigraphy of the Tertiary sedimentary formations of Assam, noted the occurrence of the following palynotaxa in the Kopili Formation viz., *Retialetes emendatus* (insignificant), *Biretisporites triglobosus, B. deltoidus, Monosulcites wodehousei, M. rarispinosus, Polygalacidites clarus, Polycolpites cooksonii, Monolites mawkmaensis, Triorites communis, Palmaepollenites eocenicus, P. communis, Triporopollenites vimalii, Polypodiisporites oligocenicus, P. speciosus, Cupuliferoidaepollenites liblarensis, Talsiipites mundus, Favitricolporites complex, Stereisporites psilatus, Anacolosidites luteoidus* (insignificant), *Schizaeoisporites digitatoides* (insignificant), *Tetracolporites paucus* (insignificant), *T. onagraceoides, Cyathidites minor, Stereisporites assamensis, Rhoipites nitidus, Tricolpites levis, Ilexpollenites ornus, Polypodiaceaesporites tertiarus, Polyporina globosa, Nyssapollenites barooahii*, etc. The taxa common between the present Kopili assemblage and that recorded by Sah and Dutta (1968) are: *Cyathidites minor, Monolites mawkmaensis, Polypodiaceaesporites tertiarus, Polypodiisporites, Palmaepollenites, Triporopollenites* and *Monosulcites* (= *Neocouperipollis*).

Salujha *et al.* (1972) studied palynoflora from the Rewak Formation (=Kopili Formation) of Garo Hills Meghalaya. Besides, they also studied palynoflora from the Tura, Siju and Darik formations. The present Kopili assemblage could not be compared with the Rewak assemblage of Garo Hills as Salujha *et al.* (1972) did not list the palynofossils formation-wise.

Baksi (1974) proposed eight operational biostratigraphic (palynological) zones in the Tertiary sequence of Assam. Of which *Monocolpites broadcolpusii-Simsangia* Assemblage Zone corresponds to the Kopili Formation (Late Eocene). The present assemblage conforms with this zone of Baksi (1974) more on negative evidences than on the positive ones, e.g., absence of *Retialetes, Schizosporis* (*Proxapertites* group), polycolpate pollen, ornamented tricolpate and tricolporate (*Paleocaesalpiniaceaepites* and allied taxa) pollen and onagraceous pollen (*Tetracolporites, Triorites*). *Biretisporites* and *Polypodiisporites* are present in good percentage in the above mentioned zone whereas only the latter taxon occurs in the present assemblage.

Salujha *et al.* (1974) recovered the following palynotaxa from the Kopili Formation of Khasi and Jaintia Hills, Meghalaya : *Foveosporites spectabilis, Lycopodiumsporites insignis, Inaperturopollenites mirabilis, Peltandripites fastidiosus, Neocouperipollis exsertus, Tricolpites strigosus, Stephanocolpites emendatus, Nyssapollenites laudabilis, Simsangia rustica and Micrhystridium proprium*. Only one genus, i.e. *Neocouperipollis* of this assemblage has been recorded in the present assemblage.

Sein and Sah (1974) recovered the following palynoassemblage from the Kopili Formation (Late Eocene) of Jowai-Badarpur Road, Jaintia Hills, Meghalaya: *Retitrescolpites* sp., *Tricolpites* sp., *Monolites mawkmaensis, Lycopodiumsporites* sp., *Retitricolporites* sp., *Todisporites* sp., *Osmundacidites* sp. and *Cicatricosisporites macrocostatus* (=*Striatriletes*). A good percentage of *Polycolpites* recorded by them is not met with in the present assemblage. Only *Striatriletes* (*Cicatricosisporites macrocostatus*), *Todisporites, Monolites mawkmaensis* and *Retitricolporites* are common between the two assemblages.

Dutta and Jain (1980) reported dinoflagellate cysts and acritarchs from the Kopili Formation. They proposed Microplankton Assemblage D for the base of the Kopili Formation overlying the Prang Limestone Member of the Sylhet Formation in the area around Lumshnong, Jaintia Hills, Meghalaya . The assemblage recorded by them is as follows : *Homotryblium plectilum* (97 %), *H. oceanica, Glaphyrocysta exuberans, G. divaricata, Distatodinium* sp., *Hystrichokolpoma rigaudiae, H. unispinosum, Cordosphaeridium exilimurum* and *Hystrichostrogylon membraniphorum*. The present assemblage is, however, poor in dinoflagellate cysts.

The palynoassemblages described by Tripathi and Singh (1984a, b, 1985), Singh and Tripathi (1987) and Tripathi (1989) from the Kopili Formation (Late Eocene) consist of *Dandotiaspora dilata, D. telonata, Lygodiumsporites eocenicus, Todisporites major, Osmundacidites* sp., *Corrugatisporites* sp., *Striatriletes susannae, S. paucicostatus,*

S. attenuatus, Verrucatosporites sp., *Sciadopityspollenites* sp., *Neocouperipollis* sp., *Palmidites plicatus*, *P. obtusus*, *Pinjoriapollis magnus*, *Retitrescolpites* sp., *Tricolporopollis ruber, Densiverrupollenites eocenicus. Lakiapollis assamicus, Gouyaulacysta* sp., *Apteodinium* sp., *Turbiosphaera filosa, T. proximata, Homotryblium plectilum, Cordosphaeridium exilimurum, C. multispinosum, Polysphaeridium subtile, P. giganteum, P. ornamentum, Operculodinium centrocarpum, O. major, Adnatosphaeridium vittatum, Callimothallus pertusus, Phragmothyrites eocaenica*, *Phragmothyrites* sp., *Paramicrothallites* sp., *Microthallites* sp., *Diporisporites* sp. The taxa common between the above and the present assemblages are: *Striatriletes susannae*, *Lygodiumsporites, Todisporites major, Neocouperipollis, Tricolporopollis* and *Densiverru-pollenites eocenicus.*

Trivedi (1985) recorded the following assemblage from the Kopili Formation: *Podosporites tripakshii, Podocarpidites khasiensis, Pinuspollenites* sp., *Pellicieroipollis langenheimii, Striatriletes susannae, S. microverrucosus, Osmundacidites cephalus, Cyathidites minor, Polypodiaceaesporites chatterjii, Laevigatosporites lakiensis, Polypodiisporites* sp., *Dictyophyllidites granulatus, Lygodiumsporites lakiensis, Foveotriletes* sp., and *Verrutriletes* sp. The taxa common between the present assemblage and the one recorded by Trivedi (1985) are *Cyathidites minor*, *Lygodiumsporites lakiensis, Polypodiisporites, Polypodiaceaesporites, Striatriletes susannae, Pellicieroipollis langenheimii* and *Pinuspollenites.*

Trivedi (1987) made a detailed study of the Kopili palynoflora from Jowai-Badarpur Road, Jaintia Hills, Meghalaya and recorded 87 genera and 139 species including algae, fungi, bryophytic and pteridophytic spores and gymnospermous and angiospermous pollen besides reworked palynofossils. The taxa common between this and the present assemblage are: *Cyathidites australis, C. minor, Todisporites major, T. minor, Intrapunctisporis intrapunctis, Lygodiumsporites lakiensis, Monolites mawkmaensis, Pilamonoletes excellensus, Polypodiaceaesporites tertiarus, Polypodiisporites mawkmaensis, P. ornatus, P. splendidus, Striatriletes susannae, S. multicostatus, Araucariacites australis, Pinuspollenites crestus, Neocouperipollis kutchensis, Palmaepollenites nadhamunii, Spinizonocolpites echinatus, Pellicieroipollis langenheimii, Margocolporites, Densiverrupollenites eocenicus,* besides some reworked forms like *Klausipollenites sulcatus, Indotriradites* sp. and *Callialasporites trilobatus.*

Kar *et al.* (1994) recorded the following assemblages from the subsurface Kopili Formation of Upper Assam: *Lygodiumsporites eocenicus, Osmundacidites kutchensis, Striatriletes susannae, Pteridacidites vermiverrucatus, Neocouperipollis kutchensis, Polybrevicolporites cephalus, Retistephanocolpites kutchensis, Meliapollis ramanujamii, Arecipites intrapunctatus, Proxapertites* spp. and dinoflagellate cysts. The taxa common between the present Kopili assemblage and that recorded by Kar *et al.* (1994) are *Lygodiumsporites, Striatriletes, Neocouperipollis,* besides dinoflagellate cyst. Fungal remains and reworked palynofossils are either absent or are not recorded by Kar *et al.* (1994) while these are represented in the present assemblage.

CONCLUSIONS

From the foregoing discussion the following conclusions may be derived:

(i) The palynoflora indicates a tropical-subtropical, warm-humid climate with heavy precipitation during the sedimentation of the Kopili Formation.

(ii) The environment of deposition has been interpreted as coastal with ponding conditions nearby and sufficient fresh water influx.

(iii) The palynoassemblage shows homotaxiality with the Kopili assemblage recorded from the Jowai-Badarpur Road section of Jaintia Hills, Meghalaya.

(iv) The occurrence of Permian palynofossils in the Kopili sediments is due to reworking. The source area of these palynofossils may be the Permian exposures in Singrimari, Garo Hills, Meghalaya.

(v) Occurrence of Triassic palynomorphs in the present assemblage indicates existence of Triassic sediments which might have been totally eroded and redeposited or may be present in the subsurface.

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