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Palynology and palaeoenvironment of the Bhuban Formation (Early Miocene) of Ramrikawn, near Aizawl, Mizoram, India

B.D. MANDAOKAR

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

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ABSTRACT

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The palynoflora recorded from the Bhuban Formation (Early Miocene) of Ramrikawn near Aizawl, Mizoram is dominated by pteridophytic spores followed by angiospermous and gymnospermous pollen and fungal remains. The assemblage also contains reworked Permian palynofossils. The presence of *Striatriletes, Malvacearumpollis, Graminidites, Todisporites, Compositoipollenites, Pteridacidites, Tricolporopollenites, Dangripites* and *Spinizonocolpites* shows diversified plant communities. The palynoflora suggests an Early Miocene age for the studied sequence. The present day distribution of families represented in the assemblage and abundance of fungal remains (*Multicellaesporites, Trichothyrites*) indicates tropical-subtropical warm, humid climate. Occurrence of *Spinizonocolpites*, referable to coastal element *Nypa*, suggests near shore environment of deposition. The composition of palynoflora indicates the existence of brackish water swamp and prograding delta complex with fresh water influx.

Key-words— Palynology, Miocene, Ramrikawn, Mizoram, India.

मिजोरम में आइज़ॉल के निकट स्थित रामरिकॉन के भुबन शैलसमूह (आरंभिक मायोसीन) का परागाणुविज्ञान तथा पुरापर्यावरण

भगवानदास दोमाजी मण्डावकर

सारांश

मिज़ोरम में आइज़ॉल के निकट स्थित रामरिकॉन के आरंभिक मायोसीन युगीन भुबन शैलसमूह से अंकित किए गए परागाणुवनस्पतिजात में टेरिडोफ़ाइटी बीजाणुओं की प्रमुखता है, जिसके पश्चात क्रमशः आवृतबीजी एवं अनावृतबीजी परागकण तथा कवकीय अवशेष आते हैं. समुच्चय में पुनः चक्रित परमियन परागाणुपादपाश्म भी उपस्थित हैं : *स्ट्रायाट्रायलिटीज़, माल्वेसीरम्पोलिस, ग्रेमाइनीडाइटीज़, टोडिस्पोराइटीज़, कम्पोज़िटॉयपोलेनाइटीज़, टेरिडेसाइडाइटीज़, ट्राइकॉलपोरोपोलेनाइटीज़, डैंग्रीपाइटीज़, स्पीनीज़ोनोकोलपाइटीज़* की उपस्थिति वैविध्यपरक पादप समुदायों को प्रदर्शित करती है. यह परागाणुवनस्पतिजात इस अनुक्रम के लिए प्रारंभिक मायोसीन आयु को प्रस्तावित करता है. समुच्चय में निरूपित कुलों का वर्तमान वितरण तथा कवकीय अवशेषों (*मल्टीसेल्लीस्पोराइटीज़, ट्राइकोथाइराइटीज़*) की प्रचुरता उष्ण-उपोष्ण, कटिबन्धीय कोष्ण, आर्द्र जलवायु का संकेत करती है. *स्पीनीज़ोनोकालपाइटीज़* की उपस्थिति, जिसे समुद्रतटीय तत्व *नाइपा* से सन्दर्भित किया जा सकता है, निक्षेप का आंशिक तटीय वातावरण प्रस्तावित करता है. परागाणुवनस्पतिजात का संघटन खारे जल अनूप तथा ताजे जल अन्तर्वाह से युक्त पुरःक्रमणी डेल्टा संकुल की उपस्थिति का संकेत करता है.

संकेत शब्द—परागाणुविज्ञान, मायोसीन, रामरिकॉन, मिज़ोरम, भारत.

INTRODUCTION

THE Tertiary sequence of Mizoram is about 5,000 m thick. The entire Mizoram belt has been divided into five geotectonic provinces. A series of transverse faults divide the area into several crustal blocks. It is composed of a series of longitudinal folds arranged in an en-echelon. The anticlines are long, narrow and tight but the intervening synclines are broad and gentle. Along the length of the structure, several reversals in the direction of plunge are observed. The structures are offset by numerous faults and thrusts. The stratigraphic succession exposed in these structures belongs to Surma Group (Ganguly, 1975).

The only palynological information from the Tertiary sediments of Mizoram has been published by Hait and Banerjee (1994) which is based on two lignite samples supplied by Prof. D. Chandra of Indian School of Mines, Dhanbad. Detailed palynological study of the Tertiary sequence from Mizoram has so far not been published and hence the present study was undertaken.

MATERIAL AND METHODS

The present investigation is mainly concerned with western flank of the Aizawl Hills. The Ramrikawn locality lies about 10·2 km NNW of Aizawl town near Chandmari (23° 44' 15" N: 92° 43' 25"E) on the right face of the hill slope along Aizawl (Fig. 1).

The Bhuban Formation of the area consists of purple, white, greyish cross bedded and ripple marked sandstones, interbedded with dark grey and maroon shales with carbonaceous streaks. Intraformational conglomerate with pebbles of quartzite occur at places. Fifty samples were collected from the massive claystone, and dark grey to black, splintery shales exposed in a section in Ramrikawn area. These samples were chemically processed to isolate pollen/spores by usual maceration technique. The material, is rich in palynofossils. The slides were prepared in polyvenyl alcohol and mounted in Canada Balsam. Identification, counting and photodocumentation of specimens were done with BH-2 Olympus Research Microscope.

GEOLOGY OF THE AREA

Owing to the inaccessibility of the terrain the geological investigations in Mizo Hills are meagre. The early workers, viz. LaTouche (1891), Hayman (1937) and Franklin (1948) and Das Gupta (1948) reviewed the geology and petroleum prospects of Lushai Hills. Since mid-seventies important contributions to geology and structures of the region have been made (Ganguly, 1975; Ganju, 1975; Das Gupta, 1977; Shrivastava *et al.*, 1979; Nandy, 1980, 1982; Jokhan Ram & Venkataraman, 1983, 1984). A generalised stratigraphic succession of Tertiary sequence in Mizoram is given by the Geological Survey of India (1974) and Ganju (1975).

The area exposes rocks of Middle and Upper Bhuban formations of Bhuban Subgroup (Surma Group) forms western limb of Aizawl anticline. It is characterised by alternate succession of argillites and arenites. The Upper Bhuban sediments occur in the south-eastern extremity of the area along

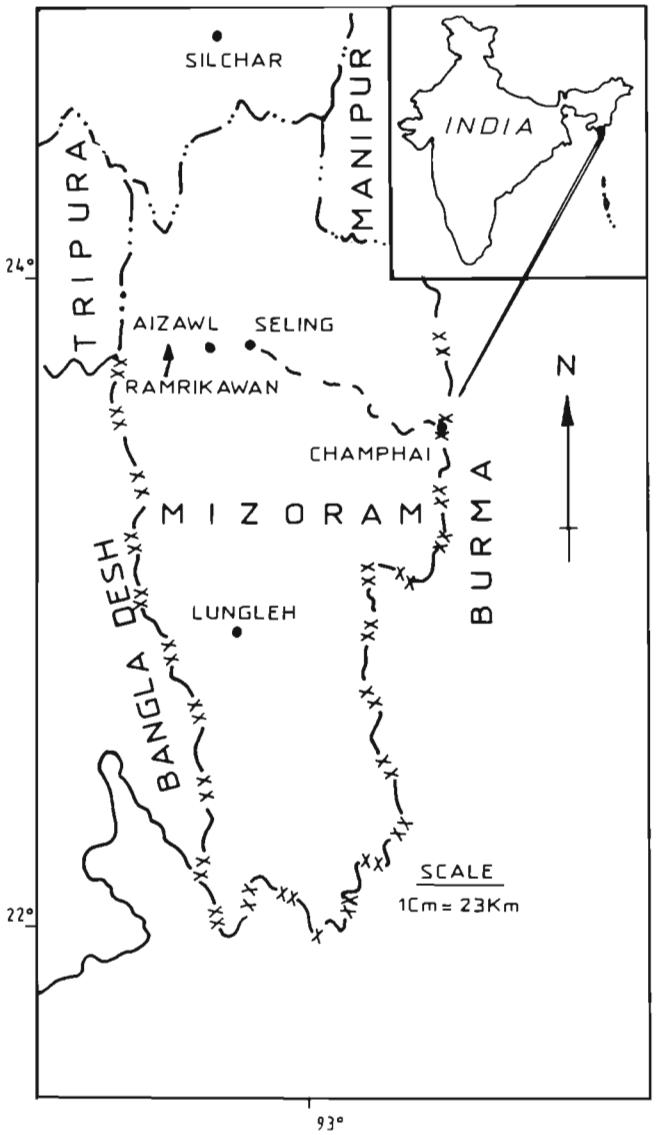


Fig. 1—Showing geological map of Mizoram.

Zemabawk-Tuirial Road section. The rest of the area is covered with the underlying Middle Bhuban Formation. The contact between these two units is conformable and transitional. The same is marked in the field by gradual change in facies i.e. argillaceous to arenaceous sediments. The demarcation and correlation of these two units is difficult owing to more or less uniform lithology and absence of index fossils. The lithostratigraphic succession in the studied area is shown in the Fig. 2 (after Tiwari & Kumar 1996).

Middle Bhuban Formation

This formation in the area is represented by uninterrupted succession of rocks of about 1400 m in thickness. Four lithounits have been identified in this units which in order of succession, are as follows:

1. *Shale-Siltstone Unit*—This is about 250 m thick, predominantly shaly with shale-siltstone alternations and bands of sandstones. The shales in this basal unit are thinly bedded, relatively hard, fine grained and greyish in colour. The shale-siltstone alternations are thinly laminated and exhibit micro-cross laminations. The sandstones are also thinly bedded, but are hard and compact, medium grained and brown in colour. These are highly bioturbated showing evidences of organic activity.

2. *Shale-Sandstone Unit*—This unit is about 350 m thick, predominantly shaly but number of sandstone bands also occur within this unit. The shales are thickly bedded, relatively hard, micaceous, smooth and mainly grey coloured. Few sands of crumpled grey shales also occur in it. At places, shales are micro-cross laminated. The sandstone bands are thin bedded, grey medium grained with worm burrows.

3. *Sandstone-Shale Unit*—The thickness of this unit is 200 m and it is characterised by alternation of thick bedded sandstones and thick dominated shales. The sandstones are thickly bedded, medium to coarse grained, at places, micaceous and show evidences of organic activities suggestive of worm burrows. They are both grey and brown in colour.

4. *Crumpled Shale Unit*—This is the youngest litho-unit of the Middle Bhuban Formation and is about 500 m thick, consisting of shales. Though, shale is the dominant rock type, it also has few pockets of sandstone which are not mapable. The shales are thinly laminated, grey and brown in colour, very fine grained, smooth and crumpled into pieces.

Upper Bhuban Formation

The Middle Bhuban Formation is conformably overlain by Upper Bhuban Formation. The latter in the area is represented by 100 m thick unit which is predominantly arenaceous in character. The contact between the two is transitional.

Formation		Lithology
Upper Bhuban	-	Thickly Bedded Sandstone
——————Gradational Contact——————		
	-	Crumpled Shale
Middle Bhuban	-	Sandstone-Shale alternation
	-	Shale-Sandstone alternation
	-	Shale-Siltstone alternation
Lower Bhuban	-	Not Exposed

Fig. 2—Showing general lithostratigraphic succession of Ramrikawn, Mizoram.

5. *Thickly Bedded Sandstone Unit*—This unit is about 100 m thick and is composed mainly of thickly bedded sandstones of brown colour. Further it is characterised by ripple marks which are bioturbated in nature. This unit, however, contains a few bands of brown coloured fine grained shales which shows closely spaced jointing.

PALYNOASSEMBLAGE

The palynoflora recovered from the Bhuban Formation of Ramrikawn area, Mizoram contains 59 genera and 54 identifiable species. A check list of different species of algal and fungal remains, pteridophytic spores, gymnospermous and angiospermous pollen along with reworked palynofossils is given in Fig. 3.

PALYNOFLORAL COMPOSITION AND ECOLOGICAL INTERPRETATION

Spore-pollen recovered from Ramrikawn samples are rich both in qualitative and quantitative aspects. Out of fifty samples macerated for palynological study, twenty samples yielded palynofossils and most of them are comparable to the extant mangrove pollen and are identified as *Retitricolporites* and *Malvacearumpollis*. However, fresh water palynofossils e.g., *Striatriletes, Pteridacidites, Compositoipollenites* and *Retitrescolpites* have also been recorded in the middle part of Bhuban Formation. The palynofossils are grouped together on the basis of similar habitat and adaptability to similar environment. The presence of microthyraceous fungi viz., *Multicellaesporites, Trichothyrites, Cucurbitariaceites* and *Parmathyrites* are suggestive of warm humid climate. The dinoflagellate cysts viz., *Achomosphaera, Oligosphaeridium, Thalassiphora, Operculodinium, Polysphaeridium* indicate marine influence. Furthermore, the vegetational set-up seems to have changed due to fluctuations in the various natural factors. Palynofossils belonging to Bombacaceae, Caesalpiniaceae, Malvaceae, Arecaceae are reported for the first time and indicate their deposition in a tropical to

Palynomorph assemblages from the Ramrikawn area, Mizoram

Name of palynotaxa

Dinoflagellate cysts

Achomosphaera ramulifera (Deflandre) Evitt, 1963
Operculodinium centrocarpum Wall, 1967
Polysphaeridium subtile Bujak, 1976
Thalassiphora pelagica Eisenack & Gocht, 1960
Tuberculodinium vancampoae (Rossignol) Wall, 1967

Fungal remains

Cucurbitariaceites bellus Kar, Singh & Sah, 1972
Dicellaesporites minutus Kar & Saxena, 1976
Inapertisporites kedvesii Elsik, 1968
Lacrimasporonites levis Clarke, 1965
Multicellaesporites nortonii Elsik, 1968
Parmathyrites ramanujamii Singh *et al.*, 1986
Phragmothyrites eocaenicus Edwards 1922 emend. Kar & Saxena, 1976
Trichothyrites sp.

Pteridophytic spores

Crassoretitriletes vanraadshooveni Germeraad *et al.*, 1968
Dangripites tuberculatus Mandaokar, 1997
Dictyophyllidites sp.
Intrapunctisporites harudiensis Kar, 1978
Lygodiumsporites lakiensis Sah & Kar, 1969
Osmundacidites wellmanii Couper, 1953
Pilamonoletes excellensus Kar, 1990
Polypodiaceaesporites major Saxena, 1978
Polypodiaceaesporites levis Sah, 1967
Polypodiisporites favus Potonié, 1934
Polypodiisporites speciosus Sah & Dutta, 1968
Proxapertites microreticulatus Jain, Kar & Sah, 1973
Pteridacidites vermiverrucatus Sah, 1967
Striatriletes susannae van der Hammen 1956 emend Kar, 1979
Todisporites major Couper, 1958

Gymnospermous pollen

Abiespollenites cognatus Kar, 1985
Piceaepollenites sp.
Pinuspollenites crestus Kar, 1985
Podocarpidites khasiensis Dutta & Sah, 1970
Podocarpidites densicorpus Kar, 1985

Angiospermous pollen

Bombacacidites triangulatus Kar, 1985
Compositoipollenites africanus Sah, 1967
Dermatobrevicolporites dermatus (Sah & Kar 1970) Kar, 1985
Favitricolporites magnus Sah, 1967
Graminidites granulatus Kar, 1985
Hibisceaepollenites splendus Kar, 1985
Lakiapollis ovatus Venkatachala & Kar, 1969
Magnamonocolpites miocenicus Kar, 1985
Malvacearumpollis bakonyensis Nagy, 1962
Palmaepollenites kutchensis Venkatachala & Kar, 1969
Palmidites plicatus Sah & Singh, 1974
Polyporina multiporosa Kar & Jain, 1981
Retitricolporites sp.
Retitrescolpites typicus Sah, 1967
Retipilonapites cenozoicus Sah, 1967
Spinizonocolpites echinatus Muller, 1968
Tricolporopollenites sp.
Tricolpites reticulatus Couper, 1953
Triporopollenites robustus Kar & Jain, 1981

Reworked palynomorphs

Callialasporites trilobatus Dev, 1961
Cuneatisporites rarus Kar, 1968
Densoisporites velatus Weyland & Krieger, 1956
Hindipollenites indicus Bharadwaj, 1962
Klausipollenites decipiens Jansonius, 1962
Klukisporites pseudoreticulatus Couper, 1958
Parasaccites korbaensis Bharadwaj & Tiwari, 1964
Plicatipollenites sp.
Platysaccus sp.
Striatopodocarpites sp.

Fig. 3—Palynoassemblage of Ramrikawn area, Mizoram.

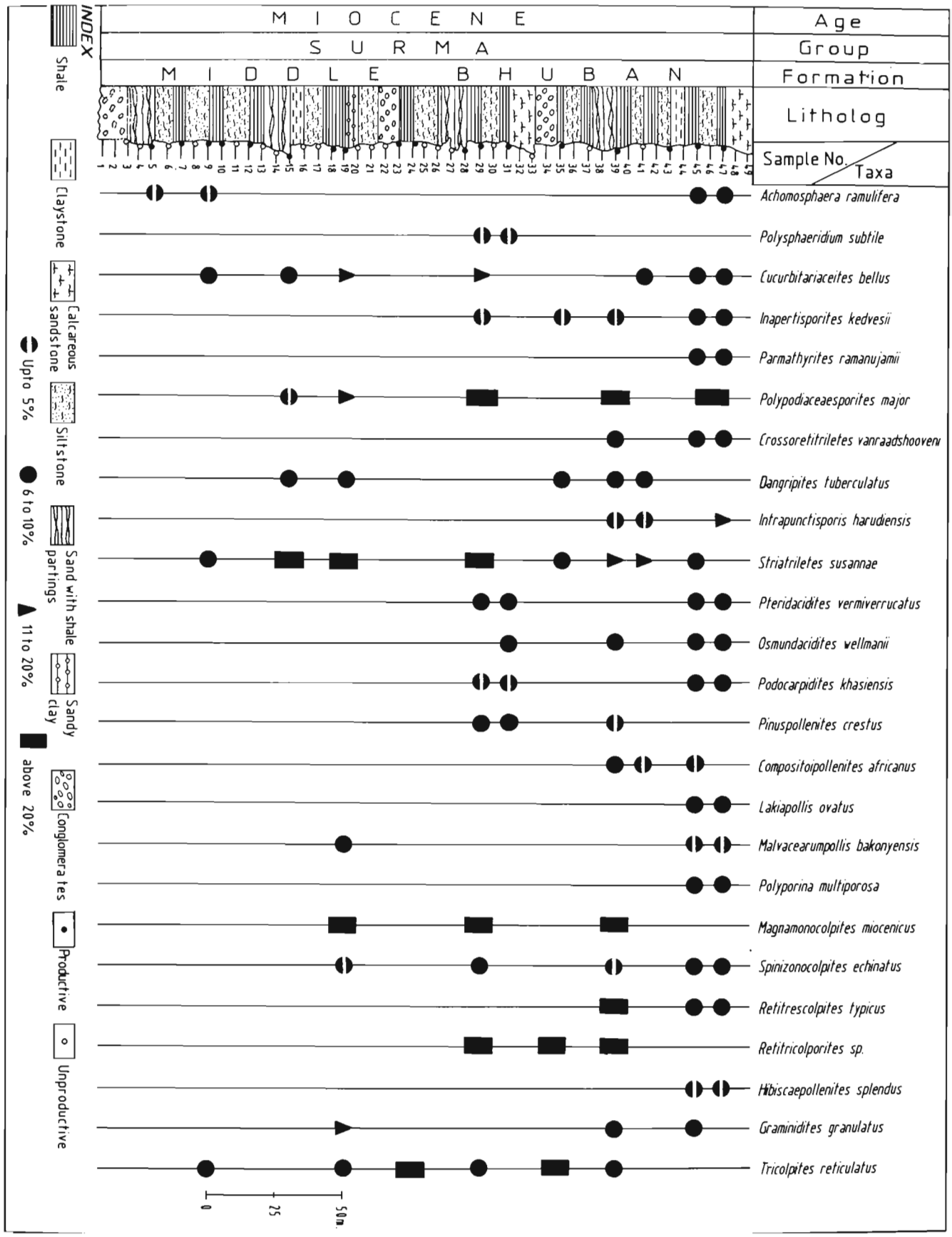
subtropical climate. The percentages of taxa belonging to various ecological complexes (Fig. 4) show their quantitative representation.

ENVIRONMENT OF DEPOSITION

Different ecological groups such as montane, lowland, freshwater swamp and water edge, back mangrove and sandy beach elements are represented in palynoassociation of Ramrikawn near Aizawl, Mizoram. The botanical affinities of palynotaxa of Ramrikawn area have been given in Fig. 5, along with their ecological associations.

The botanical affinities and ecological groups of the Mizoram palynofossils show that fresh water swamp and water edge elements are dominant over the low land elements. Most of the palynotaxa which are attributed to extant plants show tropical distribution in the present day moist evergreen rain forests. The dominance and diversity of fungal fruiting bodies indicate warm and humid climate. The presence of *Striatriletes, Pteridacidites, Polypodiisporites, Dictyophyllidites* and *Todisporites* indicates a fresh water swampy environment. The gymnospermous elements represented in the assemblage by Podocarpaceae, Pinaceae and which were woody conifers and got deposited from high land areas. These plants generally flourish in humid climate with high annual precipitation and are derived from long distance. The occurrence of angiospermous pollen *Hibisceaepollenites, Compositoipollenites, Polyporina, Graminidites, Retitrescolpites,* etc.

Fig. 4—Composite histogram showing representation of palynotaxa from Ramrikawn near Aizawl, Mizoram. →


INDEX
Shale
Claystone
Calcareous sandstone
Siltstone
Sand with shale partings
Sandy clay
Conglomerates
Productive
Unproductive
Upto 5%
6 to 10%
11 to 20%
above 20%
MIOCENE
SURMA
MIDDLE
BHUBAN
Age
Group
Formation
Litholog
Sample No.
Taxa
Achomosphaera ramulifera
Polysphaeridium subtile
Cucurbitariaceites bellus
Inapertisporites kedvesii
Parmathyrites ramanujamii
Polypodiaceaesporites major
Crossoretitriletes vanraadshooveni
Dangripites tuberculatus
Intrapunctisporis harudiensis
Striatriletes susannae
Pteridacidites vermiverrucatus
Osmundacidites wellmanii
Podocarpidites khasiensis
Pinuspollenites crestus
Compositoipollenites africanus
Lakiapollis ovatus
Malvacearumpollis bakonyensis
Polyporina multiporosa
Magnamonocolpites miocenicus
Spinizonocolpites echinatus
Retitrescolpites typicus
Retitricolporites sp.
Hibiscaepollenites splendus
Graminidites granulatus
Tricolpites reticulatus
0
25
50m.

represent the floral elements of low land vegetation. The percentage frequency of low land elements is very low in the lower part and gradually decreases toward the top. Back mangrove element *Malvacearumpollis* is low in frequency. It disappears in the middle and reappears at the top. The coastal conditions are supported by the presence of palm pollen (*Palmaepollenites, Spinizonocolpites*). The presence of dinoflagellate cysts (*Operculodinium, Achomosphaera, Tuberculodinium*) suggest marine influence whereas back mangrove elements indicate the existence of brackish water mangrove swamp.

PALYNOFLORAL COMPARISON AND AGE

The present palynoassemblage recovered from the Bhuban Formation Ramrikawn area (Mizoram) compares with those published from the Neogene sediments of south India by Ramanujam (1982), Ramanujam and Reddy (1984) and Rao (1995), from Assam by Kar (1990), Mandaokar (1990) and from Mizoram by Hait and Banerjee (1994). An account of palynoassemblage of Neogene of northeast India has been published by Saxena (1990).

Name of Taxa		Botanical affinities
Montane elements		
Podocarpidites	-	Podocarpaceae
Piceaepollenites	-	Pinaceae
Pinuspollenites	-	Pinaceae
Low land elements		
Lakiapollis ovatus	-	Bombacaceae
Bombacacidites triangulatus	-	Bombacaceae
Polyadopollenites ramanujamii	-	Caesalpiniaceae
Malvacearumpollis bakonyensis	-	Malvaceae
Hibisceaepollenites splendus	-	Malvaceae
Compositoipollenites africanus	-	Asteraceae
Fresh water swamp and water-edge elements		
Crassoretitriletes vanraadshooveni	-	Schizaeaceae
Osmundacidites wellmanii	-	Osmundaceae
Pteridacidites vermiverrucatus	-	Adiantaceae
Striatriletes susannae	-	Parkeriaceae
Polypodiaceaesporites levis	-	Polypodiaceae
Polypodiisporites major	-	Polypodiaceae
Dictyophyllidites sp.	-	Matoniaceae
Lygodiumsporites lakiensis	-	Schizaeaceae
Mangrove elements		
Malvacearumpollis bakonyensis	-	Malvaceae
Retitricolporites sp.	-	Avicenniaceae
Sandy beach/coastal elements		
Palmaepollenites kutchensis	-	Arecaceae
Spinizonocolpites echinatus	-	Arecaceae
Palmidites plicatus	-	Arecaceae
Graminidites granulatus	-	Poaceae
Polyporina multiporosa	-	Chenopodiaceae

Fig. 5—Botanical affinities of Ramrikawn area.

Kar (1990) studied palynoflora from the Tipam-Surma units of Rokhia bore-hole no. 1, Gojalia bore hole no. 1, and Baramura bore hole no. 2, drilled in Tripura by Oil and Natural Gas Commission. These assemblages show broad similarity with the present assemblage. The presence of some of the marker forms like *Malvacearumpollis, Pteridacidites, Hibisceaepollenites* and *Compositoipollenites* indicates striking similarity between the two. Gymnospermous pollen mostly represented by *Pinuspollenites, Podocarpidites* and *Abiespollenites* are commonly found in the Miocene sediments of these two areas. Mandaokar (1990) also recorded *Pinuspollenites* and *Piceaepollenites* from the Miocene sediments around Maibong, Assam. The Upper Miocene age pertains to Quilon beds consist of richly fossiliferous limestones with intercalations of calcareous clay, carbonaceous clays and sands of south India (Ramanujam, 1982; Ramanujam & Reddy, 1984). A comparison of the present palynoflora with those of south India shows that fungal elements like *Dicellaesporites, Multicellaesporites, Cucurbitariaceites, Phragmothyrites* and *Inapertisporites* are common to both the assemblages. These genera occur throughout the Tertiary sequence and therefore, are not useful for stratigraphic considerations. The palynoassemblage of the Quilon sediments indicates a tropical humid climate with heavy precipitation during the Miocene epoch of Kerala. In this context the botanical affinities of palynotaxa like *Lygodiumsporites, Polypodiaceaesporites, Palmaepollenites, Bombacacidites* and *Polyadopollenites* indicate tropical climate. There is no significant change from the past to the present climatic conditions. Hait and Banerjee (1994) studied two lignite samples from Mizoram and recorded a palynoassemblage containing brackish water and back mangrove palynotaxa like *Palmaepollenites, Polyporina, Retitricolporites, Zonocostites, Meliapollis, Palaeocoprosmadites,* etc. suggests an Early Miocene age. The palynoassociation in the Kalarakod bore hole (Eocene to Early Miocene) studied by Rao (1995), shows the presence of *Pteridacidites, Malvacearumpollis, Compositoipollenites, Chenopodipollis* and dominance of *Striatriletes* and *Quilonipollenites*. The above elements have also been observed in the present assemblages. The palynoassemblage from Mizoram can be compared with the Bengal palynozone-V (Baksi, 1972). The palynozone-V of Bengal Basin contains Histrichosphaerids and Dinoflagellates. The presence of brackish water back mangrove elements indicates marine influence in both the assemblages. The gymnospermous pollen grains are present in the Mizoram assemblage. They are wind blown upland taxa. An Early Miocene age has been suggested to Ramrikawn sediments on

the basis of the similarity of the assemblage with those of Tipam Sandstone and Girujan Clay palynofossils like *Polypodiisporites, Polypodiaceaesporites, Cyathidites, Lycopodiumsporites, Compositoipollenites* and *Graminidites* (Banerjee & Uniyal, 1980).

Germeraad *et al.* (1968) critically studied the occurrence pattern of *Crassoretitriletes* in pantropical areas and suggested that the genus occurs in the lower Oligocene and extends upto Miocene. The presence of *Pteridacidites, Malvacearumpollis, Compositoipollenites* is considered important in the Ramrikawn assemblage of Mizoram. *Hibisceaepollenites* is indicative of Early Miocene. It is also a dominant element in the Khari Nadi Formation, Kutch (Kar, 1985), and Surma Group of Meghalaya (Rao *et al.*, 1985) but it is poorly represented in the Mizoram Basin. *Pteridacidites* and *Compositoipollenites* have been recorded from the Miocene sediments of Rusizi Valley, Burundi (Sah, 1967). Thus the presence of *Pteridacidites, Malvacearumpollis, Compositoipollenites, Hibisceaepollenites, Crassoretitriletes* and dominant element such as *Striatriletes* in the present assemblage indicates an Early Miocene age.

DISCUSSION

The present assemblage consists of dinoflagellate cysts, pteridophytic spores, gymnospermous and angiospermous pollen grains. The dinoflagellate cysts are dominant in the lower part of the sediments which progressively decrease in the middle and upper part. They are important constituents of the Middle Bhuban Formation. The pteridophytic spores mainly represented by *Striatriletes* are dominant throughout the sequence. The gymnospermous pollen are very low in frequency. The brackish water back mangrove taxa in the present sequence of Bhuban Formation indicate the prevalence of coastal marine environment of deposition. *Palmaepollenites* and *Spinizonocolpites* show a close proximity to the shore line. The fresh water elements represented by *Proxapertites, Pteridacidites, Striatriletes* appear to have been transported to the site of deposition. The low land palynological assemblage generally comes from the families Caesalpiniaceae, Bombacaceae, Malvaceae and Asteraceae. These groups of pollen are poorly represented. The genus *Osmundacidites, Crassoretitriletes, Lygodiumsporites, Striatriletes* and *Dictyophyllidites* represent tropical fresh water swampy assemblage. These elements are well represented and related to their important contribution during sedimentation. High altitudinal floral elements in the present assemblage are mostly represented by gymnospermous pollen like *Podocarpidites, Pinuspollenites* and *Piceaepollenites*. The contribution of gymnospermous pollen and phytoplankton to the assemblage are poor, perhaps the high altitudinal gymnospermous pollen could not reach in large number to the site of deposition. The depth of the sea also hindered the phytoplankton population to a certain extent.

The occurrence of reworked Permian palynofossils in the present palynoassociation is significant to decipher the palaeogeography of the region. It seems that during Miocene, with the upheaval of the Himalayas, the Gondwana rocks were extensively exposed in the neighbourhood. These sediments were eroded by various agencies and got redeposited along with the Miocene sediments. As the marine conditions disappeared gradually, the erosion of older rocks were in full swing due to instability of the geological conditions. It may be mentioned here that at present in Mizoram there are no Gondwana exposures. These rocks are seen at Singrimari, Meghalaya and their presence has also been postulated in subsurface at Karbi-Anglong District Assam. It seems that during Miocene, Gondwana sediments were prevalent from Arunachal Pradesh to Mizoram.

The fungi are mostly represented by epiphyllous elements and they are found in insignificant numbers. Their contribution slightly increases but they are never more than fifteen percent in any of the samples. It seems that the sediments were not exposed to seasonal dry condition and thereby minimising the fungal activities. An analysis of the ecological requirement of the angiosperm species reveal that almost all of them favour a flood plain or swamp environment. It is widely accepted that plant association of such habitat is primarily controlled by edaphic factors and do not form a part of vegetation. The composition of the palynological assemblage indicates the existence of swamp, brackish water and prograding delta complex with fresh water influx.

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