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An interpretation of the palynology and palaeoecology of the Early Miocene Dulte Formation, Mizoram, India

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ABSTRACT

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A palynological study of the Early Miocene sediments of the Aizawl Basin, Mizoram is presented. The Aizawl Basin is part of the North-East India Dulte Formation (Surma Group: Bhuban Subgroup). The significant elements of the palynoassemblage are: *Pteridacidites, Striatriletes, Polypodiisporites* and *Schizaeoisporites* (pteridophytes), *Compositoipollenites, Malvacearumpollis, Spinizonocolpites, Bombacacidites, Ctenolophonidites, Polyporina, Polyadopollenites, Graminidites* (angiosperms), *Cucurbitariaceites, Dicellaesporites* and *Phragmothyrites* (fungi).

The shale contains abundant plant remains and white gastropod shells. The alternation of shale-siltstone, sandstone-claystone and the palynoflora suggest an Early Miocene age for studied sequence. Palaeoecological interpretation based upon recent botanical affinities of the fossil spores and pollen highlights the presence of mangrove, fresh water, swamp and water edge ecological groups. The presence of fungal remains indicates warm and humid climate. The composition of palynological assemblage suggests that Dulte Formation was deposited in deltaic conditions rich in terrigeneous detritus where the fungal elements thrived.

Key-words—Palaeopalynology, Palaeoecology, Palynoflora, Dulte Formation, Early Miocene, Deltaic, Aizawl Basin, Mizoram, India.

भारत के मिजोरम प्रान्त के प्रारंभिक मायोसीन युगीन दुल्ती शैल समूह के परागाणु विज्ञान तथा पुरापारिस्थितिकी का निर्वचन

भगवानदास दोमाजी मण्डावकर

सारांश

प्रस्तुत शोध पत्र में मिजोरम की आइज़ॉल द्रोणी के प्रारंभिक मायोसीन अवसादों का परागाणविक अध्ययन प्रस्तुत किया गया है। आइज़ॉल द्रोणी पूर्वोत्तर भारत के दुल्ती शैलसमूह (सूरमा समूहः भुवन महासमूह) का एक भाग है। परागाणु समुच्चय के महत्त्वपूर्ण तत्व हैं : *टेरिडासाइडाइटीज़, स्ट्रायाट्रायलिटीज़, पॉलीपोडाइस्पोराइटीज़* तथा *शीज़िओइस्पोराइटीज़* (टेरिडोफाइट्स), *कम्पोज़िटॉयपोलेनाइटीज़, माल्वेसीरम्पोलिस, स्पीनोज़ोनोकॉल्पाइटीज़, बॉम्बेकेसाइडाइटीज़, टीनोलोफ़ोनाइडाइटीज़, पॉलीपोराइना, पॉलीएडोपोलेनाइटीज़, प्रेमाइनाइडाइटीज़* (आवृतबीजी), *क्यूकरबाइटेरायासाइटीज़, डाइसेल्लीस्पोराइटीज़* एवं *फ्रैग्मोथाइराइटीज़* (कवक)।

शेल में प्रचुर मात्रा में पादप अवशेष तथा श्वेत गैस्ट्रोपोड कवच विद्यमान हैं। शैल-सिल्टस्टोन, सैण्डस्टोन- क्लेस्टोन, तथा परागाणुवनस्पतिजात से प्रस्तावित होता है कि अध्ययन किए गए अनुक्रम की आयु प्रारंभिक मायोसीन युगीन हो सकती

है। अश्मित बीजाणुओं तथा परागकणों की अद्यतन प्राप्त वानस्पतिक बन्धुता के आधार पर निकाले गए पुरापारिस्थितिकीय निष्कर्ष मैंग्रोव, ताजे जल, अनूप तथा अतिनत जल पारिस्थितिकीय समूहों की उपस्थिति दर्शाते हैं। कवकीय अवशेषों की उपस्थिति आर्द्र तथा नम जलवायु का संकेत करती है। परागाणविक समुच्चय का संघटन प्रस्तावित करता है कि दुल्ती शैलसमूह स्थलजात अपरद में प्रचुर डेल्टीय स्थितियों में वहाँ निक्षेपित थे, जहाँ कवकीय अवशेष फल-फूल रहे थे।

संकेत शब्द—पुरापरागाणुविज्ञान, पुरापारिस्थितिकी, परागाणुवनस्पतिजात, दुल्ती शैलसमूह, प्रारंभिक मायोसीन, डेल्टीय, आइजॉल द्रोणी, मिजोरम, भारत.

INTRODUCTION

GEOLOGICALLY the eastern part of Mizoram has remained, until recently, terra-incognita, on account of its inaccessibility and lack of economic mineral content. The only available references to the area are the records of the Assam Oil Company and the Burma Oil Company. The State of Mizoram (Fig. 1) occupies narrow, north-south trending longitudinal ridges, separated by broader valleys. Several of the mountain peak exceed 1800 m in height, the highest being the Blue Mountains (Phawngpui) in the southeastern part of Mizoram. The general ground elevation increases towards the east, from 50 m in the extreme west of the State.

Palynological information from the Tertiary sediments of Mizoram was published by Hait and Banerjee (1994), is based on two lignite samples. Fifty richly diverse taxa were recorded. Mandaokar (2000) studied the palynofloral sequence from the western flank of Aizawl Town, Ramrikawn, near Chandmari, Mizoram. A detailed palynological study of the Tertiary sequence from the Mizoram Basin has not so far been published. The present study reports the results obtained from a collection of palynological rock samples from the Bhuban subgroup in the Dulte area of the Eastern Mizo hills. The objectives were to collate and analyse the total spore and pollen compliments extracted from the Tertiary strata of the Aizawl, Mizoram Basin, and to high light the relevance of the palaeoecological in reconstruction of the area. The present investigation is mainly concerned with the eastern flank of the Aizawl hills. The Dulte Formation lies about 120 km NNE of Aizawl Town (Fig. 1). The area is covered by unconsolidated sandstone alluvium.

GEOLOGY OF AREA

Hayman (1937) reconnoited the Lushai hills in Mizoram State and included a map of the traverses in his report. In 1948 Franklin mapped the Mizo hills from aerial photographs. Das Gupta (1948) reviewed the geology of Mizoram. He considered that the thick succession of Surma Group could referred to be Bhuban and the Bokabil subgroups which is folded into several meridional structures. Since the mid seventies, important contributions have been made to the geological structure of the region (Ganguly, 1975; Ganju, 1975; Nandy, 1980, 1982; Jokhan Ram & Venkataraman, 1983, 1984). A generalised stratigraphic succession of the Tertiary sequence in Mizoram is provided in the Geological Survey of India (1974). A monotonous sequence (7165 m) of arenaceous and argillaceous suites of sedimentary clastics is exposed in Eastern Mizoram. The Bhuban subgroup has been subdivided, on the basis of lithology (sand shale ratio), into two formations: the Dulte

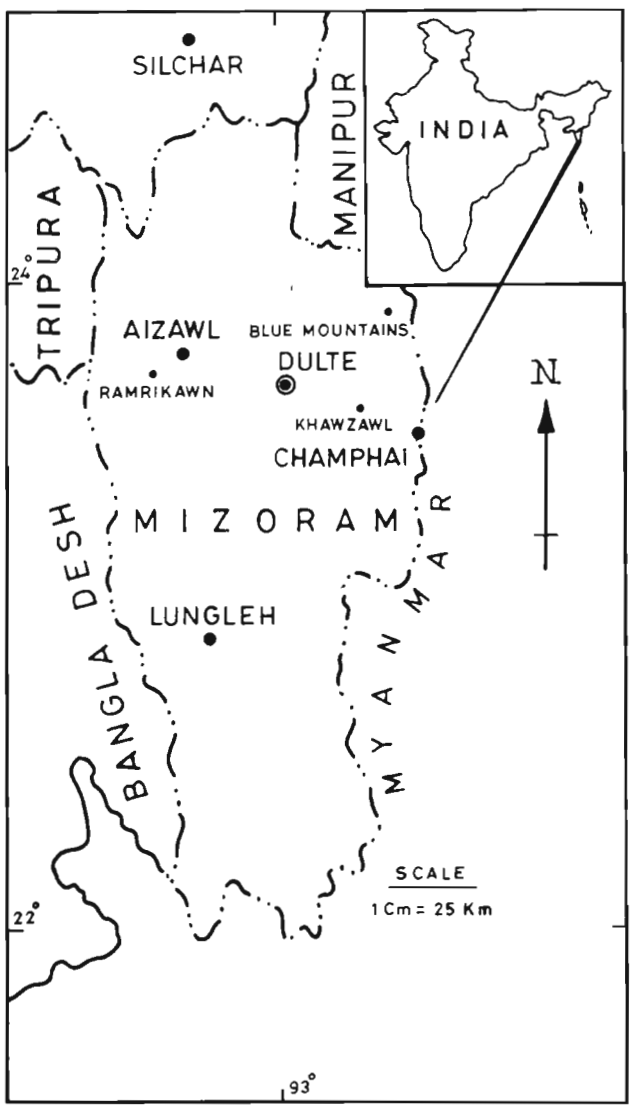

Fig. 1—Showing location map of Mizoram.

and the Keifang formations (Shrivastava *et al.*, 1979). These have not, however, been correlated to the subdivisions of the lower, middle and upper Bhuban Formation in western Mizoram. Therefore, the stratigraphic equivalence of the subdivisions of eastern Mizoram with those of western Mizoram remain to be established. The generalised stratigraphic succession of the area is given in Fig. 2 (after Shrivastava *et al.*, 1979).

Dulte Formation—The Dulte Formation sediments are informally named after Dulte Village. The type section of this formation extends from Dulte to Khawzawl (Fig. 1). It is the development of highly undulatory deeply incised valleys, formed by erosion of the major claystone constituents, leaves major sandstone units standing out as prominent hillocks. The formation consists predominantly of massive to thinly bedded claystone, subordinate sandstone and sandstone-claystone alternations. The claystone is greenish grey, moderately hard, ? micaceous (like), non-calcareous and occasionally silty. Towards the base it becomes more arenaceous, exhibiting micro-cross laminations. The sandstone is thick to thinly bedded, very hard, dark grey to grey, weathering to yellowish brown, fine grained and micaceous ?-like. Calcareous encrustations on the sandstone are also observed. The Dulte Formation consists of 5275 m thick sequence of shale-siltstone and sandstone-claystone alternations, showing the features of turbidites (Shrivastava *et al.*, 1979). The cross lamination of sandstone and interference ripple with tadpol nest structure indicate marine to deltaic environment of deposition.

MATERIAL AND METHODS

The material for the present palynological investigation was collected from the Dulte Formation exposed in 2 km from Dulte Village, along the Dulte-Keifang Road in Aizawl District, Mizoram. Altogether, 25 samples were collected from greyish shale and siltstone bands within the sandstones. Of these, fourteen samples yielded palynofossils. The stratigraphic position of the samples is shown. For recovery of palynofossils, samples were treated with HCL followed by HF and HNO_3. After acid treatment, the samples were thoroughly washed with water and then treated with 10% KOH solution for 5-10 minutes, followed by repeated washing with water through 400 mesh sieve to remove all traces. Macerated preparations were mounted in 2 cm coverslips using polyvinyl alcohol. Pollen-spore from the slides prepared as above were identified and counted using a BH-2 microscope. A total of 58 species and 52 genera were identified in the 25 samples studied. Of these, 24 species in 24 genera are spores (Algae, fungi or pteridophytes) and 34 species and 28 genera are pollen. By counting a hundred individuals in each of the samples, the relative abundance of the determined species and genera were ascertained. Selected examples of the spores and pollen were then included in a palynological diagram (Fig. 4.) More than 15% as abundant, 10-15% is common, 6-9% is less common and 3-5% is uncommon and less than 1-2% is rare.

PALYNOASSEMBLAGE

The geological section from the Dulte Formation is a mixture of shale-siltstone, clay, siltstone-sandstone alternation, includes organic matter. The palynoassemblage extracted from the section encompasses 58 identifiable species in 52 genera. The palynoflora recorded from the Dulte is dominated by pteridophyte spores and angiosperm pollen. Gymnosperm pollen and fungal spores are also present. The dinoflagellate cysts are also present in lower part of sediments which progressively decrease in the middle and upper parts. They are important constituent of Surma Group, Bhuban Subgroup, Dulte Formation, Aizawl Basin, Mizoram. A check list of the different spore and pollen species which represent algae, fungi, pteridophytes, gymnosperms and angiosperms, as well as

Group	Sub-Group	Formation (informal)	Lithology	Thickness in ft (m)
S U R M A	B H U U B A N	D U L T E	Predominantly argillaceous, comprising massive to thinly bedded claystone and subordinate sandstone and sandstone-claystone alternation. Claystone: Massive to thinly bedded, greenish grey to grey, moderately hard, micaceous occasionally, silty and with micro-cross laminations. Sandstone: Thick to thinly bedded, dark grey to grey, weathering to yellow brown, fine grained occasionally silty and micaceous.	17,300 ft (5275 m)
			Base not exposed	

Fig. 2—Generalised stratigraphic succession of the Surma Group (after Shrivastava *et al.*, 1979).

Algal spores
Achomosphaera ramulifera (Deflandre) Evitt, 1966
Oligosphaeridium complex Davey & Williams, 1966
Operculodinium centrocarpum Wall, 1966
Thalassiphora pelagica (Eisenack) Eisenack & Gocht, 1960

Fungal spores
Cucurbitariaceites bellus Kar *et al*., 1972
Dicellaesporites minutus Kar & Saxena, 1976
Diporisporites curvatus Ramanujam & Rao, 1978
Dyadosporonites constrictus Kar, 1979
Fusiformisporites crabbii Rouse, 1962
Inapertisporites kedvesii Elsik, 1968
Lacrimasporonites longus Kar, 1979
Phragmothyrites eocaenicus Kar & Saxena, 1976

Pteridophyte spores
Crassoretitriletes vanraadshovenii Germeraad *et al*., 1968
Cyathidites australis Couper, 1953
Dangripites tuberculatus Mandaokar, 1997
Gleicheniidites senonicus Ross, 1949
Intrapunctisporis intrapunctis Krutzsch, 1959
Lycopodiumsporites umstewensis Dutta & Sah, 1970
Lygodiumsporites lakiensis Sah & Kar, 1969
Polypodiaceaesporites levis Sah, 1967
Polypodiisporites mawkmaensis Dutta & Sah, 1970
Pteridacidites africanus Sah, 1967
Schizaeoisporites phaseolus Delcourt & Sprumont, 1955
Striatriletes susannae Van der Hammen, 1956

Gymnosperm pollen
Pinuspollenites crestus Kar, 1985
Podocarpidites ellipticus Cookson, 1947
Podocarpidites khasiensis Dutta & Sah, 1970

Angiosperm pollen
Araliaceoipollenites psilatus Dutta & Sah, 1970
Bombacacidites bombaxoides Couper, 1960
Chenopodipollis miocenica Kar & Jain, 1981
Compositoipollenites sentis Sah, 1967
Ctenolophonidites costatus Van Hoeken Klinkenberg, 1966
Cupuliferoipollenites ovatus Venkatachala & Kar, 1969
Engelhardtioidites minutiformis Ramanujam & Reddy, 1984
Favitricolporites retiformis Sah, 1967
Graminidites granulatus Kar, 1985
Malvacearumpollis bakonyensis Nagy, 1962
Monoporopollenites gramineoides Meyer, 1956
Paleorubiaceaepites psychotria Biswas, 1962
Paleosantalaceaepites ellipticus Sah & Kar, 1970
Palmaepollenites plicatus Sah & Kar, 1970
Palmaepollenites ovatus Sah & Kar, 1970
Pellicieroipollis langenheimii Sah & Kar, 1970
Polyadopollenites miocenicus Ramanujam, 1966
Polyporina globosa Sah, 1967
Retipilonapites cenozoicus Sah, 1967
Retitrescolpites crassimurus Sah, 1967
Retitrescolpites bellus Sah, 1967
Retitrescolpites oblongus Sah, 1967
Rhoipites bradleyi Wodehouse, 1933

Rhoipites kutchensis Venkatachala & Kar, 1969
Sapotaceoidaepollenites obscurus Sah, 1967
Sparganiceaepollenites polygonalis Thiergart, 1937
Spinizonocolpites echinatus Muller, 1968
Tricolpites crassireticulatus Dutta & Sah, 1970
Tricolpites reticulatus Kar, 1979
Trisyncolpites ramanujamii Kar, 1979
Umbelliferoipollenites constrictus Venkatachala & Kar, 1969

Incertae sedis
Leaf tissue
Woody tissue
Fibrous tissue
Amorphous organic matter

Fig. 3—Palynoassemblage from Dulte Formation, Mizoram.

fibrous tissue, leaf tissue, woody tissue and amorphous organic matter are listed in the Fig. 3.

RESULTS

Palynofloral Composition and Age

From the analysis we can deduce that pollen of angiosperm shrubs and trees forms a major component of the pollen and spore assemblage. In the present study only a few herbaceous pollen taxa were found, for example. *Graminidites* (Poaceae) and *Chenopodipollis* (Chenopodiaceae). Relative abundance of these two taxa in the Early Miocene is extraordinarily low (2-4%). and the gymnosperm species determined in the study (2 %), are of coniferous pollen (Fig. 4). The relationship between the relative abundance of gymnospermous type pollen in the Early Miocene continues into younger strata with increasing dominance of *Pinuspollenites* and *Podocarpidites*.

The alternation of the shale-siltstone and shale-sandstone ratio in the Eastern Mizo hills has been identified as Miocene in age (Shrivastava *et al.*, 1979). The ostracod and mollusc content in the Dulte Formation is considered to be Middle Miocene in age (Tiwari & Kumar, 1996). Early Miocene age was inferred by the presence of *Crassoretitriletes, Trisyncolpites* and *Bombacacidites* (Mandaokar, 1990) to Maibong Assam. A recent palynological study of Ramrikawn quarry, Aizawl District, Mizoram (Mandaokar, 2000) provides evidence that, over a another wider area, the palynoflora varies from Oligocene to Early Miocene in age. Germeraad *et al.* (1968) critically studied the occurrence pattern of *Crassoretitriletes* in pantropical areas and suggested that genus generally occurs in the lower Oligocene and extends up to the Miocene. *Pteridacidites, Malvacearumpollis, Compositoipollenites* and *Chenopodipollis* are significant among the genera recovered from Dulte Formation and indicative of an Early Miocene age. These four genera are also dominant elements in the Khari Nadi Formation of Kachchh in Kar (1985). the Surma Group Meghalaya, and in Cachar, Assam (Rao *et al.*, 1985). It is interesting to note that *Pteridacidites* and *Compositoipollenites* have also been recorded from Miocene sediments in the Rusizi Valley, Burundi (Sah, 1967). Thus the presence of *Pteridacidites, Malvacearumpollis, Compositoipollenites*, and the presence of other elements such as *Striatriletes* and *Crassoretitriletes* may be useful indicators of Early Miocene age.

Depositional Environment

Total counts of the palynoflora, as well as counts of the taxa indicating different habitats, have been made. The palynoflora have been grouped together under Montane, fresh water, low land, swamp and water edge, Back mangrove, mangrove, sandy beach and algal based on the general habitat of present day representatives as indicated in Fig. 5.

Palynofossils can be a valuable indicator of past climate, especially where they can be related to extant taxa. The distribution pattern of the fossil taxa recorded (Fig. 3) are indicative of a tropical to subtropical climate. The Dulte Formation palynoflora have affinities with 21 extant families. Of these, nine families are restricted to tropical or subtropical climates, six families are cosmopolitan, four families are restricted to the tropics and two families have temperate associations (Fig. 5). The presence of spores or pollen of Schizaeaceae, Parkeriaceae, Polypodiaceae, Caesalpiniaceae. Ctenolophonaceae, Oleaceae and Rubiaceae in the assemblage indicates that a tropical climate prevailed at the time of deposition. Fern spores and the occurrence of tropical rain forest elements (Ctenolophonaceae, Oleaceae) provide supporting evidence of a climate with a high rainfall. Most of the fossil taxa attributed to pollen and spore can be pollen and spores of extant plants that have a tropical or subtropical distribution and are present in moist evergreen rain forests.

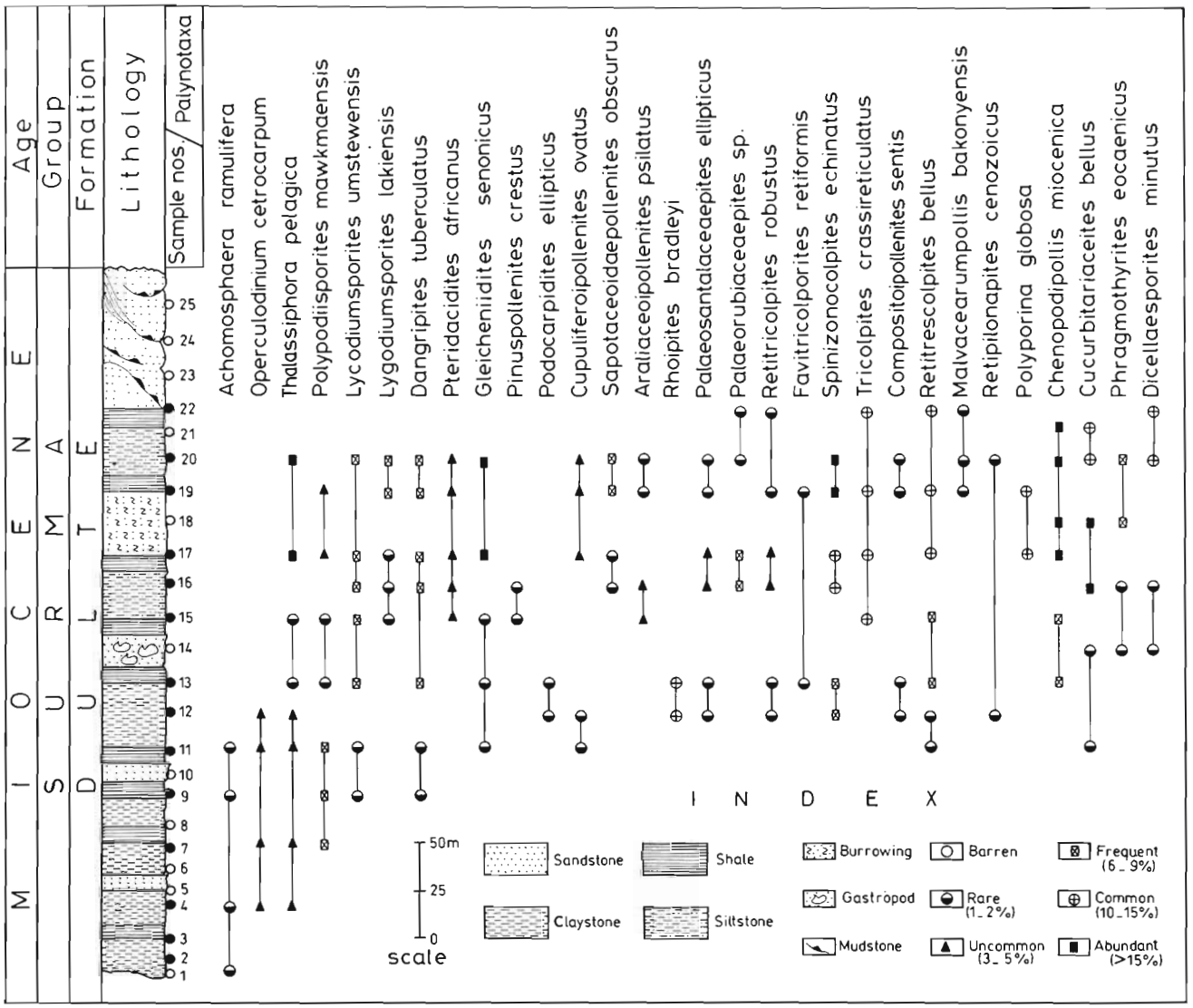

Fig. 4—Diagram showing relative frequency of palynotaxa from the Dulte Formation (Aizawl Basin), Mizoram.

PALAEOGEOGRAPHY AND PALAEOCLIMATE

Fossil spores and pollen are valuable in palaeoecological analysis, and in interpreting the palaeogeography prevailing palaeoclimatic conditions at the time of deposition. The palaeoecological interpretation, in particular, depends on the comparison of the fossil palynomorphs with their nearest living relatives. The percentage of the different spore and pollen taxa present in the assemblage is also to be taken into account in deciphering palaeoecological condition of deposition. Besides, the productivity of the pollen of the producing plant should also be considered to find out the percentage in the assemblages. The fossil pollen and spore forms recorded in this study are not from their extant relatives. Therefore, it has been possible to make the significant inferences: (1) During the deposition of the Dulte Formation subtropical to tropical climatic conditions developed; (2) The existence of *Pinuspollenites, Podocarpidites* indicative that there were highlands around the sedimentation region; (3) Woody plant cover consisting of *Engelhardtia* (Juglandaceae); *Bombacacidites* (Bombacaceae); *Polyadopollenites* (Caesalpiniaceae); Arecaceae probably covered the slopes and lowlands. Shrub forms Myricaceae, *Cupuliferoipollenites* (Fagaceae) constituted the underforest community; (4) The presence of angiosperms such as *Favitricolporites* (Nyssaceae), and *Engelhardtioidites* (Juglandaceae), *Retitrescolpites* (Oleaceae) suggest that there were lowland forests interrupted by lakes with extensive surrounding wetlands. Palynomorphs of forest vegetation covering the

Fossil palynotaxa	Affinities with modern Taxa
Montane	
Pinuspollenites crestus	Pinaceae
Podocarpidites khasiensis	Podocarpaceae
Podocarpidites ellipticus	Podocarpaceae
Cupuliferoipollenites	Fagaceae (Castanea)
Engelhardtioidites	Juglandaceae (Engelhardtia)
Umbelliferoipollenites	Umbelliferae
Lowland	
Bombacacidites	Bombacaceae (Bombax)
Faviotricolporites	Nyssaceae
Lygodiumsporites lakiensis	Schizaeaceae (Lygodium)
Polyadopollenites ramanujamii	Caesalpiniaceae
Retitrecolpites bellus	Oleaceae
Fresh water swamp and water edge	
Compositoipollenites	Asteraceae
Crassoretitriletes vanraadshovenii	Schizaeaceae (Lygodium)
Ctenolophonidites	Ctenolophonaceae (Ctenolophon)
Graminidites	Poaceae
Malvacearumpollis	Malvaceae (Thespesia)
Retipilonapites	Potamogetonaceae (Potamogeton)
Schizaeoisporites	Schizaeaceae (Schizaea)
Sparganiaceaepollenites	Sparganiaceae (Sparganium)
Striatriletes	Parkeriaceae
Trisyncolpites	Caesalpiniaceae (Poinciana)
Back Mangrove	
Araliaceoipollenites	Araliaceae
Rhoipites	Anacardiaceae (Melanorrhoea)
Mangrove	
Spinizonocolpites echinatus	Arecaceae
Malvacearumpollis bakonyensis	Malvaceae
Sandy Beach	
Palmaepollenites	Arecaceae
Polyporina	Chenopodiaceae (Chenopodium)
Algal	
Achomosphaera ramulifera	
Oligosphaeridium complex	
Operculodinium centrocarpum	
Thalassiphora pelagica	

Fig. 5—Distribution of modern pteridophyte, gymnosperm and angiosperm with spores or pollen taxa comparable to the fossil palynotaxa.

slopes and high lands surrounding the lake were carried by rivers and winds into wetlands; (5) The presence of non arborescent angiosperm pollen, for example, Poaceae and Chenopodiaceae is rare in Dulte Formation and suggests that open areas of land that were not swampy were possibly restricted in the depositional environment.

DISCUSSION

The palynoflora recorded from the Dulte Formation dominated by pteridophyte spores and angiosperm pollen. Gymnosperm pollen and fungal spores are also present. They are important constituent of the Middle Bhuban ? subgroup. Interpretation of the depositional environment is based on

available lithological and palynological information obtained from the Aizawl Basin.

The presence of *Striatriletes, Polypodiisporites, Crassoretitriletes, Pteridacidites, Intrapunctisporis* and *Glecheniidites* is indicative of fresh water swamp or pond conditions near the site of deposition. Of the modern fern families represented by fossil spores in the Aizawl Basin. Schizaeaceae and Polypodiaceae are predominant. The pteridophyte families Schizaeaceae, Polypodiaceae and Pteridaceae have an extensive distribution, predominantly in the tropics and contribute to the undergrowth of dense moist forest (Kubitzki, 1990). The majority of fossil angiosperm pollen recorded from the site represents land plants. Pollen comparable with that of extant Arecaceae represents both mangrove (*Spinizonocolpites*) and more inland conditions (*Palmaepollenites*). The clay horizon shows a high percentage of pollen referable to *Retitrescolpites, Sapotaceoidae pollenites, Cupuliferoipollenites, Araliaceoipollenites* and *Malvacearumpollis*. The presence of spicules and pyrite granules in the clay are indicative of deposition under mangrove conditions. The presence of a diversity epiphytic microthyriaceous fungi spores is also indicative of high precipitation. These elements suggest that the area of deposition was probably near a shore line. The proximity of shallow marine conditions are indicated by the occurrence of dinoflagellate cysts. It is proposed that the palaeoenvironment might have been similar to the present day environment of the Aizawl area. *Cupuliferoipollenites, Umbelliferoipollenites, Engelhardtioidites* are taxa associated with drier and more temperate environment. *Pinuspollenites* occurs in the topmost surface soil at the northern end of the site. It is possible that the pollen was transported by air currents from a northern pine forest, high altitudinal gymnospermous pollen could probably have reached the site of deposition in large numbers. *Pinuspollenites, Piceapollenites* and *Podocarpidites* were also recorded from the Miocene sediments around Maibong, Assam (Mandaokar, 1990).

The fragments of leaf and wood tissue, amorphous and pyritized woody particles associated with the spores and pollen in the sediments, show a gradual and alternating recurrence of reducing environments. These tissues, however, are well preserved but not definitely identifiable to the genus level. The tissue preservation could be attributed to local flooding of the swamp. This interpretation is consistent with the sedimentological characteristics of the associated strata. The fragments of these tissue indicate the occurrence of forest fire during the deposition of the sediments. It is significant to infer a fluviomarine condition and the surrounding area sustained thick vegetation

CONCLUSION

On the basis of palynological study evidence, the Aizawl Basin was mainly inhabited by tropical to subtropical moist evergreen rainforests. The abundance of fungal remains, palm pollen and pteridophytic spores also indicates warm and humid climate. The alternation of shale-siltstone, sandstone-claystone and palynoflora present indicate an Early Miocene age. The terrestrial angiosperm pollen are comparatively more abundant in the lower part of the section, while the mangrove pollen are less present throughout the assemblage. The composition of the palyno-assemblage suggest that the Dulte Formation was deposited in deltaic conditions, rich in terrigenous detritus where fungal taxa thrived.

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