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Fossil fungi from Miocene sediments of Mizoram and their environmental significance

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Palynological study of the Miocene sediments of Mizoram has shown a diverse assemblage of fossil fungi including spores, hyphae and fruiting bodies along with other biota. About 23 genera of fungal spores have been identified. Of these *Spirotremesporites* represent the first record from India. The overall abundance of fungal spores in the Miocene sediments indicate an aquatic environment of tropical humid climatic conditions.

Presence of microthyriaceous fruit bodies, hypopodia, spores of *Meliola* sp., cf. *Palaeocirrenalia* sp. along with other fresh water forms, rare dinoflagellate cysts and *Concentricystis rubinus* in Bhuban suggest a tropical, humid and fresh water to brackish deltaic environmental condition with local marine influence.

The relative abundance of *Exesisporites* over the other fungal elements in the Bokabil Formation suggests a warming of the climate. The presence of rare dinoflagellate cysts, however, suggest that the minor marine influence was still continuing. The decline of *Exesisporites* with fungal forms and relative abundance of gymnosperm and *Alnus* pollen in the Tipam Sandstone Formation suggest the lowering of temperature and incoming of cooler and drier climatic conditions.

Key words : Palaeomycological flora, Miocene sediments, Mizoram

INTRODUCTION

Fungi, probably originated during the pre-Cambrian and gradually, through evolution, established themselves as an integral part of the present ecosystem. Although the pre-Cambrian evidences of fungi are very rare and ambiguous, Pirozynski andMalloch (1975) have postulated the role of symbiotic relationship of fungi as a factor in the origin of the first land plants. Evidence of the interactions between fungi and the rest of biokingdom throughout the geological pasts in different habitats suggest the role of fungi in the past plant and animal communities (Pirozynski, 1981 ; Pirozynski and Malloch, 1975 ; Stubblefield and Taylor, 1988). The rapidly accumulating literature on paleomycological studies in the recent years indicate the importance of fossil in the stratigraphic and environmental considerations.

Sparks (1967) and Fredriksen (1969) suggested an inverse relationship between fungi and microplankton in deducing nearshore or offshore sediments. The relative abundance of fungal spores demarcated the Neogene marine and continental deposits of Lousiana, USA (Elsik, 1980 ; Muller, 1959). Fungal remains were also found in abundance in sediments where fluctuating water levels periodically exposed substrates to the air (Sherwood-Pike, 1987).

Although, the fossil fungal community as a whole have considerable potential for evaluation of the past ecosystem, sufficient data are still awaiting, concerning the relevance of each of the representative forms. Elsik (1969) highiighted the importance of some fungal taxa for the interpretation of past environment. The significance of epiphyllous fungi in the reconstruction of Holocene environment of Australia has been successfully demonstrated (Dilcher, 1965 ; Lange, 1976, 1978 ; Sherwood-Pike and Grey, 1988). The dominating microthyriaceous taxa on the other hand indicate the prevalence of brackish condition (Selkirk, 1975). The Holocene representative of *Puccinia caricina* on *Carex* (Cyperaceae) from Saskatchewan suggest a climatic change of the area during the late glacial period (De Vries, 1966).

Pirozynski (1990) recently provided informative review of the Quaternary mycology and its potential in the determination of past climatic and biotic conditions. The high value of appresoria or hypopodia of *Gaeumanomyces* sp., a parasite on *Carex peniculata*, in the Quaternary peat bog of Klokkeweel indicate the presence of maximum percentage of Cyperaceae (Pals *et al.*, 1980). Common occurrence of *Gaeumanomyces*, *Buergenerula* and *Clasterosporium* type of hypopodia identify terrestrial palustrine and coastal sediment (Cowley and Colquhoun, 1966 ; Pirozynski *et al.*, 1988).

Palaeomycological studies in India are insufficient. Earlier literature has been reviewed by Jain (1974). The importance of mycoflora in evaluating the Tertiary sedimentary environment has been suggested by Srisailam (1977) and Ramanujam and Srisailam (1978). Ramanujam (1982) has made an informative review of the importance of different members of fossil fungi for evaluating the stratigraphical and environmental condition of the Tertiary sediments of India.

Recently Banerjee (1991) has compiled the records of fossil fungi from the Siwalik sediments of Darjeeling foot hills, Bhutan and Holocene sediments of Bengal Basin with a note on their environmental impact.

The present study deals with the fungal remains of the Miocene sediments of Mizoram for the first time. Due to the structural deformations, the entire sedimentary succession of Mizoram has acquired striking stratigraphic interests for the exploration of hydrocarbon (Ganguly, 1975, 1983 ; Ganju, 1975). A brief report of the palynological investigations on these Mizoram deposits has been recently published (Banerjee and Nandi, 1991).

MATERIALS AND METHODS

The material collected from Rengte Anticline is composed of shales, mudstones, siltstones and sandstones in varying proportions. The sediments are lithostratigraphically subdivided into Bhuban, Bokabil and Tipam sandstone formations (Mathur and Evans, 1964). The studied area is near to Kolasib subdivision of Aizwal district of Mizoram. This area is bounded by Buhchang-Bilkhawthlir road in the north, Kolasib in the south, Sherlui stream in the east and Saihapui stream in the west.

The palynomorphs were recovered from the sediments by applying the standard technique of maceration followed by heavy liquid floatation. Slides were prepared either with glycerine jelly and sealing with wax or the organic residues are fixed in Polyvenyle alcohol and mounted in Canada Balsam.

OBSERVATIONS

The palynological analysis of the Miocene sediments of Mizoram revealed an interesting mycofloral assemblage. The assemblage consists chiefly of spores and hypopodia accompanied by hyphae and microthyriaceous fruit bodies. The fungal flora includes 23 genera, some of which show significant species variation. The taxa important in stratigraphic and environmental considerations are presented in this report. The relative abundance of the mycofossils in the Bhuban, Bokabil and Tipam Sandstone formations are indicated in Table 1. The botanical affinity and the climatic conditions suitable for the growth of the extant forms are shown in Table 2.

From the distribution chart (Table 1) it is evident that the mycoflora is generally rich in Bhuban, less represented in Bokabil and sporadic in Tipam Sandstone formations.

In the Bhuban palaeomycoflora the ascospores *Spirotremesporites* (Pl. 1, fig. 2), *Hypoxylonites* (Pl. 1, fig.1) and *Exesisporites* (Pl. 1, fig. 3) are the dominant constituents and first genus is recorded for the first time from India. The

Table 1. Distribution and relat ve abundance of fungal sporomorphs in the Bhuban, Bokabil and Tipam sandstone formations of Mizoram

Taxa Recorded	Bhuban	Bokabil	Tipam
1. *Exesisporites* sp.	++	+++	+
2. *Hypoxylonites* sp.	+++	++	++
3. *Spirotremesporite* sp	++	++	+
4. *Gelasinospora* sp.	++	++	+
5. *Hypopodium* sp.	+++	++	
6. *Pluricellaesporites* sp.	+++	+++	+
7. *Microthyriacite* sp.	++	+	+
8. *Meliola* sp.	++	+	+
9. *Paleocirrenalia* sp. (?)	++	+	
10. *Eoglobella* sp.	+		
11. *Triporicellaesporites* sp.	+		
12. *Fusiformisporites* sp.	+++	+++	++
13. *Mediaverrunites* sp.	+++	+	+
14. *Chaetomium* sp.	++	+++	+
15. *Pleospora* sp.	+++	++	
16. *Paleoamphisphaerella* sp.	++	+	
17. *Tetracocosporium* sp.	+++	+++	+
18. *Papulosporonites* sp.	++		
19. *Multicellaesporites* sp.	+++	+++	++
20. *Didymoporisporonites* sp.	++	+	
21. *Trilobosporonites* sp.	++	+++	+
22. *Dicellaesporites* sp.	+++	+++	++
23. *Dyadosporonites* sp.	+++	+++	
24. *Striadiaporites* sp.	+		
25. *Triangulosporonites* sp.	++	++	

Abundant (+++), Moderate (++), Poor (+)

striking similarity of these genera upto the species level with those reported by Elsik (1976) from Miopliocene of Europe is significant. The other frequently observed fungal spores are *Pluricellaesporites* (Pl. 1, fig. 4), *Fusiformisporities* (Pl. 1, fig. 5), *Pleospora* (Pl. 1, fig. 6), *Multicellaesporites* (Pl. 1, fig. 8) *Dicellaesporites* (Pl. 1, fig. 11), *Dyadosporonites* (Pl. 1, fig. 12), *Triangulosporonites* (Pl. 1, fig. 13), and *Trilobosporonites.*

Most of these taxa are noticed abundantly or in moderate frequencies in the Bokabil sediment but sporadically observed in Tipam Sandstone Formation. Some of the spore taxa are moderately or rarely observed in the Bhuban and Bokabil but absent from the Tipam mycoflora. These are *Palaeocirrenalia* (?) (Pl. 1, fig. 14), *Triporicellaesporites* (Pl. 1, fig.9), *Pleospora*, *Palaeoamphis-*

Table 2. Recorded botanical affinity and the climatic conditions for the growth of the extant forms

Name of the Taxa	Botanical Affinity	Environment	Author and year of publication
1. *Exesisporites*		Warm	Elsik, 1969
2. *Hypoxylonites*	*Hypoxylon*	Cosmopolitan	Elsik, 1976
4. *Gelasinospora* type	*Gelasinospora* sp.	Tropical humid	
5. Hypopodium		Terrestrial Palustrine and coastal	Cowley and Colquhoun, 1866 ; Pirozynski *et al.*, 1988
6. *Pluricellaesporites*	*Sporidesmium*	Tropical humid	Ramanujam and Rao, 1978 ; Ramanujam and Srisailam, 1978
7. *Microthyriacites*	Microthyriaceae	Tropical humid	
9. *Paleocirrenalia* (?)	*Cirrenalia*	Brackish	Srisailam, 1977 ; Ramanujam and Srisailam, 1978
12. *Fusiformisporites*	*Cookeina* and *Porodiella*		
15. *Pleospora*	*Pelvetia* sp.	Marine	Sutherland, 1915 ; Wolf and Wolf, 1947
16. *Paleoamphisphaerella*	*Amphisphaerella*	Tropical humid	Ramanujam and Rao, 1978 ; Ramanujam and Srisailam, 1978
18. *Papulosporonites*	*P. preuss*, Mycelia sterilia		
19. *Multicellaesporites*	*Annellophorella*, *Stigmina*		
22. *Dicellaesporites*	*Dactylaria*		

phaerella (Pl. 1, fig. 7). (*Dyadosporonites* (Pl. 1, fig. 12), *Striadiporites* (Pl. 1, fig. 15), *Triangulosporonites* (Pl. 1, fig. 13), *Eoglobella*, and *Papulosporonites*. The forms recorded only from Bhuban Formation are *Microthyriacites* (Pl. 1, fig. 16), *Eoglobella*, *Triporicellaesporites*, *Papulosporonites*, and *Striadiporites*.

DISCUSSION AND CONCLUSION

The palaeomycological data of the Miocene sediments of Mizoram indicate that fungal remains were more abundant in Bhuban deposits as compared to the Bokabil and Tipam sandstone. The overall feature of the fungal

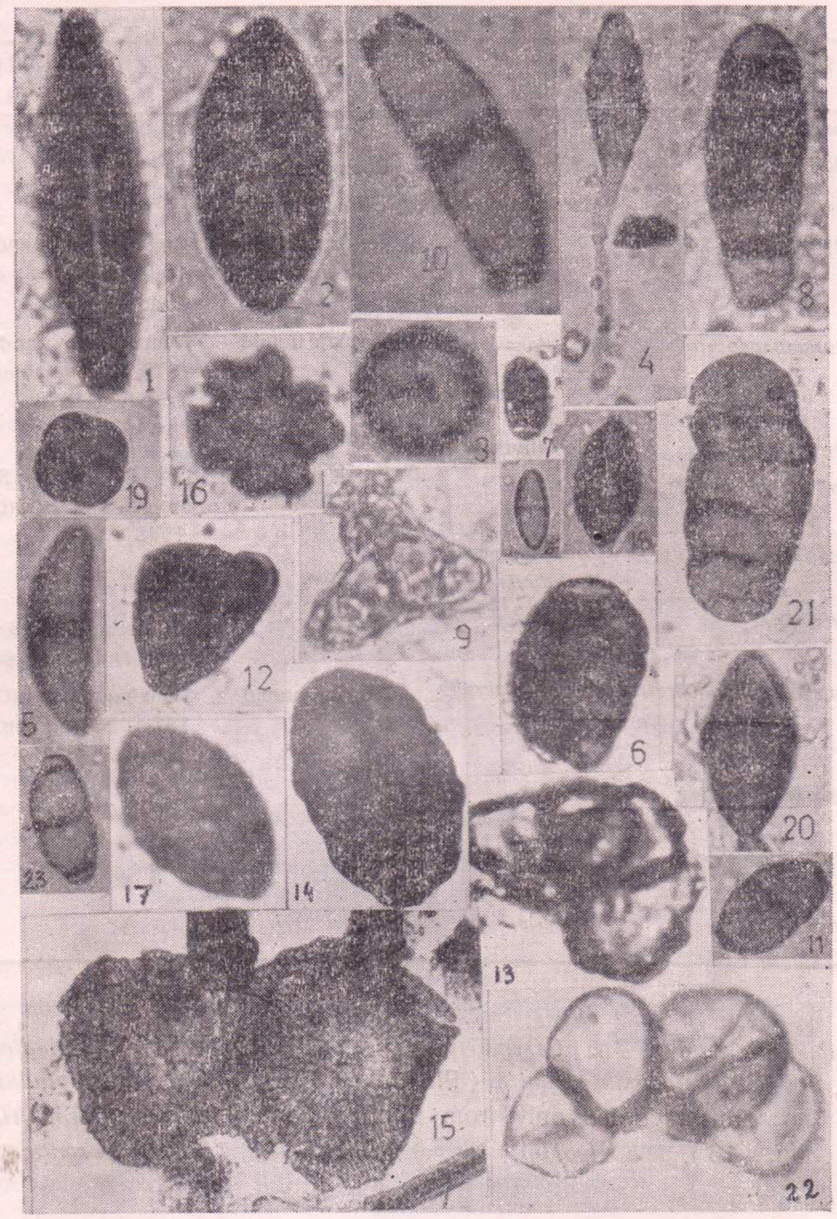

Plate 1 : Figures 1-24 ; (For explanation see page 87)

Explanation of Plate

1. *Hypoxylonites* sp. x 1200 ; 2. *Spirotremesporites* sp. x 1200 ; 3. *Exesisporites* sp. x 750 ; 4. *Pluricellaesporites* sp. x 750 ; 5. *Fusiformisporites* sp. x 750 ; 6. *Pleospora* sp. x 750 ; 7. *Paleoamphisphaerella* sp. x 500 ; 8. *Multicellaesporites* sp. x 1200 ; 9. *Triporicellaesporites* sp. x 1000 ; 10. *Dicellaesporites* sp. x 1200 ; 11. *Dyadosporonites* sp. x 750 ; 12. *Triangulosporonites* sp. x 1000 ; 13. *Paleocirrenalia* (?) sp. x 1000 ; 14. *Striadiporites* sp. x 750 ; 15. *Microthyriacites* sp. x 1200 ; 16. Hypopodium type x 750 ; 17. *Gelasinospora* sp. x 500 ; 18. *Chaetomium* sp. x 500 ; 19. *Tetracocosporium* sp. x 750 ; 20. *Mediaverrunites* sp. x 1000 ; 21. *Meliola* sp. x 1200 ; 22. *Paleocirrenalia* type x 1200 ; 23. *Multicellaesporites* type x 750 ; 24. Fungal spore type x 500 ;

assemblage in Bhuban, indicates a tropical nearshore, aquatic environment (Muller, 1959 ; Elsik, 1930). This was further confirmed by the presence of higher concentrations of fungal spores over the microplankton. Similar conclusions were drawn earlier by Sparks (1967) and Frederiksen (1969). Microthyriaceous fungi too point towards the tropical humid climate (Dilcher, 1965 ; Selkirk, 1975). The tropical humid climate is also suggested by the presence of *Exesisporites*, *Hypoxvlonites*, *Palaeoamphisphaerella* and *Spirotremesporites*. Similar observations were made by Elsik (1976), Ramanujam and Rao (1978), Ramanujam and Srisailam (1978). The rare to moderate presence of conifer and *Alnus* pollen in the Bhuban and Bokabil deposits suggest that the cold loving gymnosperms and angiosperms just began to appear in the distant high altitude areas.

The fungal flora from the Bokabil sediments is similar to that of the Bhuban Formation.

The low percantage of *Exesisporites* and abundance of *Alnipollenites* represent cooler and drier climate as suggested by Elsik (1969, 1976). This was further confirmed by abundance of high altitude representatives such as gymnosperm pollen grains, *Alnipollenites*, *Betulaepollenites* and the fungal spore of *Gelasinospora* (Van Geel, 1978) as well as a decrease in the frequency of microplankton and scarcity of halophytic representatives.

The geological evidence suggests that the mobile belt of the Northern Himalayas and its foot hill regions including the Shilong massif and Arakan Yoma Ranges in Burma underwent considerable upheaval due to geotectonic activity during the Miocene resulting in climatic and vegetational changes (Ganguly, 1983). The palaeomycological data provide support to this contention.

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