MIOFLORISTIC EVIDENCES FOR CLIMATIC VICISSITUDES IN INDIA DURING GONDWANA

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ABSTRACT

The climate is in dictating terms to determine the nature of mioflora in a particular place. Plant life is bound to the physical world for water, energy and chemical nutrients and it must adapt to the surrounding conditions in order to survive. Besides, biological environment is also important for a plant community for proper growth. Mioflora is found almost in all types of sedimentary rocks and is an important tool to decipher palaeoclimate. Based on the microfossils it has been inferred that during the Talchir Formation the climate was cold while during the Lower Karharbari the climate was warming up and it again turned cold in the Upper Karharbari. During the Barakar Formation the climate turned congenial for plant growth and there was plenty of rain. During the Barren Measures Formation the climate was dry. In Raniganj Formation the climate was warm and humid with plenty of rain. The Panchet Formation at least in the lower part was also humid but it gradually dried up in the upper part. During the time of deposition of the Jhuran-Jabalpur-Vemavaram-Rajmahal formations there was perhaps a type of climate with periodic rainfall and humidity. The Bhuj Formation and its equivalent in South India witnessed a warmer climate with plenty of rainfall.

INTRODUCTION

Exponents of environmental sciences explore the natural world from many varied angles depending on their training and method of study. The different approaches help us to understand the natural world from many angles. Needless to say that no one method is superior to another and all the methods are complimentary to one another.

Climate generally connotes the external factors which influence plant and animal life. The noted natural scientist, Alexander von Humboldt, even in the middle part of the nineteenth century observed that climate designates in its general sense all changes in the atmosphere which sensibly affect our organs : the temperature, the humidity, the changes in barometric pressure, the calms or the effect of the different winds, the electrical field, the purity of the atmosphere or its contamination with more or less gaseous exhalations, finally the degree of the usual transparence and clearness of the sky which is not only important for the increased heat radiation of the soil but also for the well-being and moods of humans.

Climate of a locality is controlled basically by the amount of solar radiation present in the atmosphere, reflection of the radiation from the temporal and celestial objects like soil, water surface, snow, cloud etc., distribution of land and ocean and their relative distance, and the geomorphological characteristic of the surface.

It is very obvious even to a casual observer that life and climate are closely related to one another. Life is essentially bound to the physical world for three basic needs : water as the only medium to function life process; energy to drive and accelerate life process; and the chemical nutrients which supply the basic substances of life. Water is conspicuous by its inactiveness which makes it a good substrate for life because the organic

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molecules remain relatively stable in this medium. Oxygen performs a noble role in producing energy for the vitality and other biological processes. Its variable presence or absence can influence the level of metabolic activity of the organisms.

The world we live in is neither constant in time nor in space. It is everchanging from glacial to genial, mesophytic to xerophytic, polar to artic forms of climate in some parts or other. The soil which remained frozen in geologically yonder days was laden with blooms in later years.

The climate is in the dictating terms to determine the nature of a plant cover in a particular place. Although the surface of the earth shows a wide variation of habitats but they can all be divided into two broad categories : aquatic and terrestrial. Both of them have their limitation and impose restriction on the organisms. Water plants can only live upto certain depth where the light penetrates to perform the photosynthesis. Besides, they are very susceptible to variation in the salt concentration. Most of them can thrive either in fresh or saline water; only a few can live in the transitional zone. The terrestrial environment, on the other hand, has one acute problem for the plant life because they have to conserve sufficient water to maintain the life process. Moreover, for higher plants, the nutrients that are gathered in the soil should also reach at the tip for manufacturing food.

A plant, since it can not migrate like animals, has to adapt to the surrounding climate in order to survive. The fluctuations of climate create challenging problems to them and can only be squarely dealt with when the organisms adjust themselves accordingly. The physical and chemical nature of the climate is immensely varied and this is the reason for adaptation of plant population in a relatively narrow range of environmental condition. Extreme climatic conditions limit the occurrence of plant life and even within a habitable environment, a plant is adapted to only a few, narrow range of condition. The designs that we observe in the adaptation of organisms reflect the nature of environment that they live in. The adaptation to the environment is made possible by altering or adding some new characters in the organisms which are advantageous to them. Accumulation of new characters gradually leads to evolution of new organisms.

Plant life must orient suitably to optimize its relationship to the surrounding heterogenous physical environment. The response of plant to the changing condition in the climate may range from passive conformity to the different kinds of homeostasis. The latter includes regulatory responses i.e. increase or decrease of activity of some parts; acclimatory responses to withstand the new factors introduced in the local environment and in the case of failure to endure, migrate to suitable locality.

Besides the physical and chemical environments, there is also the biological environment which influences plant life not in a lesser way than the former ones. Even the biotic environment may be more destructive than the milder changes in physical and chemical environments because organisms have an alternative to migrate to a safer zone in those cases. The biotic environment comprises associated plant and animal communities, symbiotic and antagonist relations with other organisms, birth and mortality rates of different competitive species.

Some of the angiosperms are very much dependent on insects for pollination. Needless to say, this being the most important part for propagation, the failure of the insects to play their role would be terribly catastrophic for the plants. The flowers of some angiosperms are so specially built that they can only be successfully visited by some particular species of insects. In fact, the evolution and subsequent development of angiosperms go side by side with some of the groups of insects e.g. butterfly. They are mutually dependent on one another and destruction of one group will also cause extinction to the other.

The various aspects of physical, chemical and biological environments enumerated above could hardly be visualised while studying the palynological fossils. Following the principle of Hutton that the present is the key to the past, an environmental scientist seeks to explore the depositional environment of bygone days by comparative study of the modern sediments and mode of behaviour of the extant organisms there in. Perhaps some figments of imagination and careless observation to perceive the actual fact distort or provide wrong explanation in some cases. Otherwise, it is an excellent tool to work with and can lead to a reasonable conclusion by deciphering surrounding condition and environment.

Mioflora, as the name implies, includes microscopic spores and pollen grains. Besides, in the broader sense, it also includes algal bodies like diatoms and dinoflagellates; fungal filaments and microthyriaceous ascostromata; microfossils of unknown affinity viz. acritarcha and even tiny animals or their parts : radiolaria, chitinozoa, sponge spicules and hosts of other particles. Super small organisms like bacteria should also be included as one of the components of mioflora.

Mioflora thus embraces a varied substances and can inhabit all possible forms of environments where life can flourish. One inherent drawback of the mioflora to decipher palaeoenvironment is that they hardly represent the whole organism except the diatoms and dinoflagellates. This renders a difficult problem to trace the dispersed spores and pollen grains to their parent plants becaue *in situ* spores are hardly encountered in the rock. So far the Gondwana mioflora is concerned, except a few cases, no dispersed genera could be correlated with the megafossils. So in some cases, deduction of palaeoenvironment by means of mioflora alone may be speculative than elucidative, imaginative than conclusive. Besides, in the case of deep-basin palynostratigraphy many techniques are involved, and mishandling of the data will lead us to astray (Wilson, 1971).

Palynological fossils particularly the spores and pollen grains are not at all representative of the surrounding flora. The pollen of aquatic angiosperms are hardly preserved in the sediments because they are devoid of sporopollenin. Besides, the entomophillous plants which produce less pollen and have no flight mechanism, can seldom reach at the sedimentary basins. The anemophillous plants, on the other hand, produce prolific quantity of pollen and having bestowed with floating devices are able to transport the pollen in long distances. They generally, thus, dominate over the other groups and if proper care is not taken to eliminate this factor, may wrongly depict the flora in the assemblage. Moreover, during diagenesis some pollen grains are destroyed while others are little affected. Bacteria and fungicide are always selective in their attack causing damage only to some groups of pollen.

Mioflora has, however, got one advantage. These fossils are found almost in all types of sedimentary rocks. Sometimes the whole sediment may be made up of palynological fossils only. Thus when other kinds of fossils fail to preserve in most of the cases some forms of mioflora are always there to reveal the sedimentary history of bygone days. The abundance of palynomorphs has, however, its own problem and has been dealt with by Hughes (1975) and Traverse (1975).

It was Medlicott in 1872, who first introduced the word Gondwana after the tribal kingdom of Gond in Madhya Pradesh, in a field report submitted to the Geological Survey of India, Calcutta. Later, Blanford (1873) and Feistmantel (1876) validated the name by publishing it. Gondwanaland as christened by Suess (1875) is supposed to have existed as a super continent from the Silurian to Cretaceous period and encompassed an age of 300 million years. It was, however, on the onset of Permo-Carboniferous glaciation that the floral characteristics of the Gondwana developed. The present paper deals with the mioflora from this episode onward.

The Gondwana or its equivalent succession in Africa, Australia, Antarctica and South America comprises enormous sediment of thousand of metres thick. But the whole succession is conspicuous by the presence of four main divisions indicating different modes of deposition. The basal sediments consist of tillites and varvites showing the indication of an ice age, the succeeding sediments harbour many big coal seams probably formed by the *Glossopteris* flora. The third succession is devoid of any coal and the sediments comprise mostly noncarbonaceous shales and sandstones. The fourth or the last succession also includes no coal seams of economic importance but on the contrary have huge thickness of basaltic lava due to volcanic eruptions for millions of years.

CLIMATE THROUGH GONDWANA TIMES AND PALYNOLOGY

Generally, the Gondwanas in India are grouped into two major subdivisions—the lower and the upper. The Lower Gondwana is characterized by the *Glossopteris-Gangamopteris* flora whereas the Upper Gondwana is dominated by *Dicroidium-Ptilophyllum* flora. The Lower Gondwana is subdivided into Talchir, Karharbari, Barakar, Barren Measures and Raniganj Formations and they are recognized almost in all the major coalfields of India. The different formations of the Upper Gondwana, on the other hand, are differently known in different localities and the exact stratigraphic position of the different formations is not precisely known (Tables 1 & 2).

TALCHIR FORMATION

This formation is generally found in all the major coalfields of India as the lower member of the Gondwana sequence. Besides, it also occurs as small outcrops in West Rajasthan and at places in Subansiri area of Arunachal Pradesh and also probably in the Himalayan region. GHOSH AND MITRA (1975) have recently studied the Talchir sedimentation in detail in Damodar valley basins.

VIRKKI (1936, 1946), POTONIÉ AND LELE (1961), LELE (1964, 1965, 1974), LELE AND CHANDRA (1967, 1973), LELE AND MAKADA (1971, 1972), SRIVASTAVA (1973a, 1973b), KAR (1973) and others have worked out the palynological fossils from the Talchir exposures of different localities. All the assemblages described by them are dominated by monosaccates while the triletes are common and the bisaccates are rare. Among the monosaccates, *Cannanoropollis*, *Parasaccites*, *Caheniasaccites*, *Plicatipollenites* and *Divarisaccus* are common. *Punctatisporites* and *Microbaculispora* mostly represent the triletes.

The uniformity of the various Talchir assemblages in the dominance of monosaccates points out that the climate was more or less similar throughout the peninsular India during that time. The glacial climate, as has been evidenced by tillites and striated pavements to begin with, was perhaps not so severe at the later phases to allow the gymnospermous plants flourish in the neighbouring localities where the ice melted and varvites were formed. Besides, the frequent presence of pteridophytic spores in the assemblages also indicate not so freezing climate and open land places where they could complete their life cycle.

KARHARBARI FORMATION

BLANFORD (1878) recognized this formation and placed it as the upper limit of the Talchir Group, but some geologists do not agree with this placement and often merge it with Barakar Formation of the Damuda Group (ROBINSON, 1967). The Karharbari Formation, in the opinion of GHOSH AND BASU (1969), is lithologically different both from underlying Talchir and overlying Brakar Formations by its presence of reworked Talchir material, the greywacke to subgreywacke composition of its sandstone and a characteristic heavy mineral assemblage dominated by zircon and rutile. Besides the Giridih Coalfield, this formation has also been recognized in number of collieries of Damodar, Mahanadi, Wardha-Godavari and Son Valley basins (PAREEK, 1969).

Mioflora of this formation has been investigated by LELE AND MAITHY (1964, 1969), LELE AND KULKARNI (1969), MUKHERJEE AND GHOSH (1974), MAITHY (1965, 1966, 1968, 1969), BHARADWAJ AND ANAND-PRAKASH (1972, 1974), TIWARI (1973), KAR (1973) and others. It has been observed that there are two distinct palynological zones in Karharbari Formation : the lower zone is dominated by triletes followed by monosaccates as subdominant group while in the upper one, monosaccates are dominant and bisaccates are next in abundance. Amongst the triletes, *Punctatisporites*, *Indotriradites* and *Lacinitriletes* are common and the monosaccates are mostly represented by *Cannanoropollis*, *Parasaccites*, *Plicatipollenites*, *Caheniasaccites* and *Divarisaccus*. Of the bisaccates, *Strotersporites*, *Striatopiceites* and *Limitisporites* are found.

The dominance of pteridophytic spores in the Lower Karharbari indicates that the influence of cold climate was lessening. Perhaps with the warming up of the climate the ice sheets melted and there was virgin land which was occupied by the cryptogams. In Upper Karharbari time, however, the climate was again on the cooler side because the gymnospermous pollen grains were again in dominance. BHARADWAJ (1975) postulated that the Lower Karharbari was cold interglacial and during the Upper Karharbari it was of glacial climate.

BARAKAR FORMATION

This is the most widespread of all Gondwana formations and has a considerable uniformity in lithological character. The geologists generally subdivide this formation into three units : lower, middle and upper. The lower and middle units have thick coal seams whereas the upper unit has hardly any economic coal seams.

Miofloristic studies of the Barakar Formation have been done by BHATTACHARYA, RAYCHOWDHURY AND DATTA (1957), BANERJEE (1958), DE (1960), BHARADWAJ AND TIWARI (1964a, 1964b, 1966), BHARADWAJ AND SINHA (1969), BHARADWAJ AND ANAND PRAKASH (1972, 1973), BHARADWAJ AND SRIVASTAVA (1969a, 1969b, 1971), TIWARI (1964, 1965, 1968, 1971, 1974), MUKHERJEE AND GHOSH (1974), VENKATACHALA AND KAR (1964, 1965, 1966, 1968a, 1968b), MAHESHWARI (1967), KAR (1969, 73), NAVALE AND TIWARI (1968), LELE AND KULKARNI (1969) and others.

The Barakar palynological assemblage, taking as a whole, is dominated by striate bisaccates. KAR (1973) studied number of bore hole cores comprising various Lower Gondwana formations from North Karanpura sedimentary basin. He observed that in the lower part of the Barakar Formation, *Strotersporites*, *Striatopiceites* and *Striatites* dominate the assemblage representing the striate bisaccates. Some monosaccate genera like *Cannanoropollis*, *Barakarites*, *Parasaccits* and *Potonieisporites* are also found in small percentage. The next palynological zone is ushered by the gradual increase of triletes which ultimately reach maximum when there are local seams. The triletes are mostly represented by *Apiculatisporis*, *Lophotriletes*, *Altitriletes*, *Didecitriletes*, *Lacinitriletes* and *Microbaculispora*. The striate bisaccates are represented by *Strotersporites*, *Striatopiceites* and *Striatites*. In the Upper

Table 1. Lower Gondwana

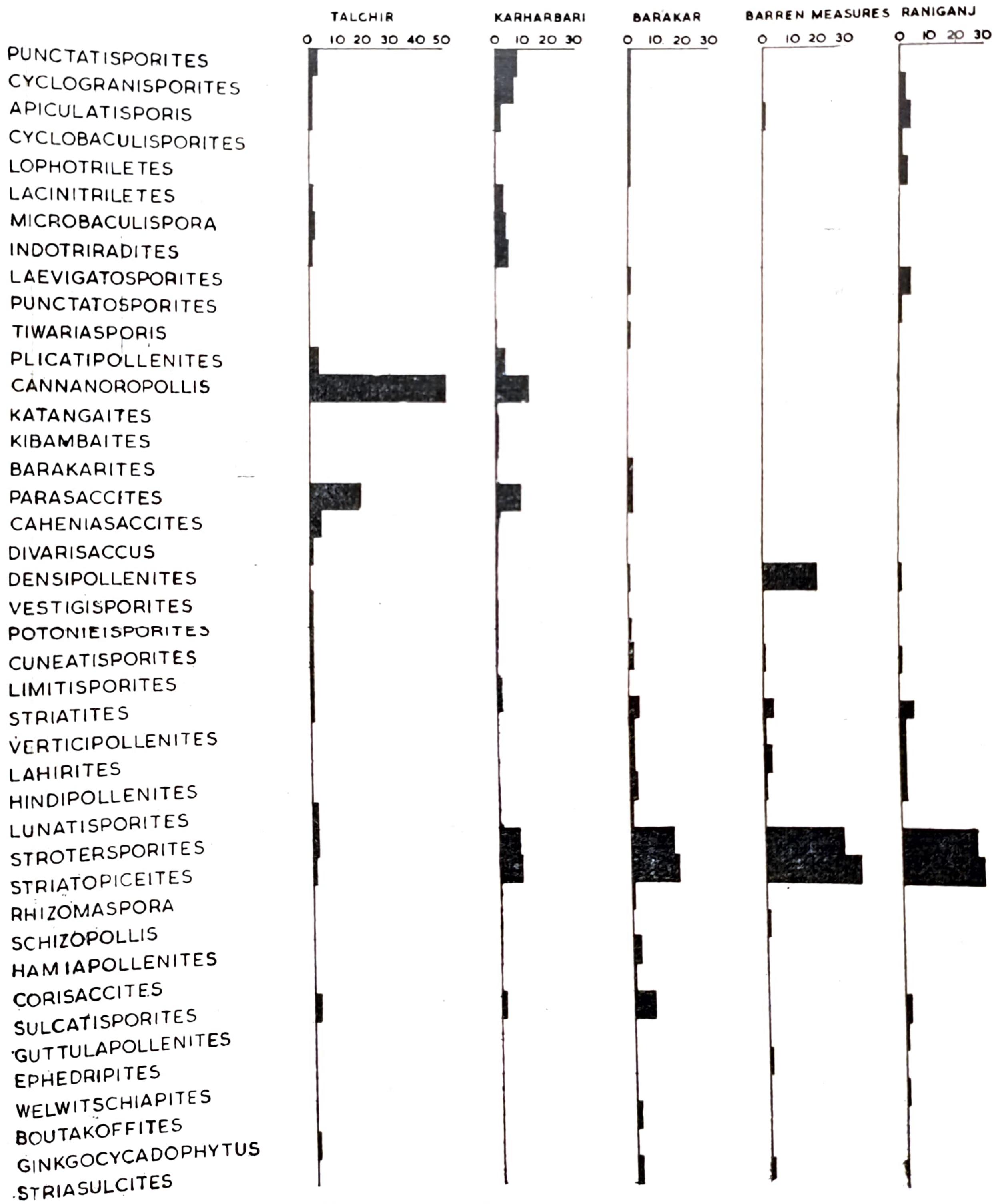
NORTHERN COALFIELDS	MAHANADI AND SON VALLEYS	SATPURA (PACHMARHI)	GODAVARI-NAGPUR AREA	GEOLOGICAL AGE
Raniganj	Pali & Hingir	Bijori	Kamthi and Chintalpudi	Upper Permian
Barren Measures/ Iron stone shale	..	Motur	..	
Barakar	Barakar	Barakar	Barakar	Lower Permian
Karharbari	Karharbari	Karharbari		
Talchir	Talchir	Talchir	Talchir	?Permo-Carboniferous

Table 2. Upper Gondwana

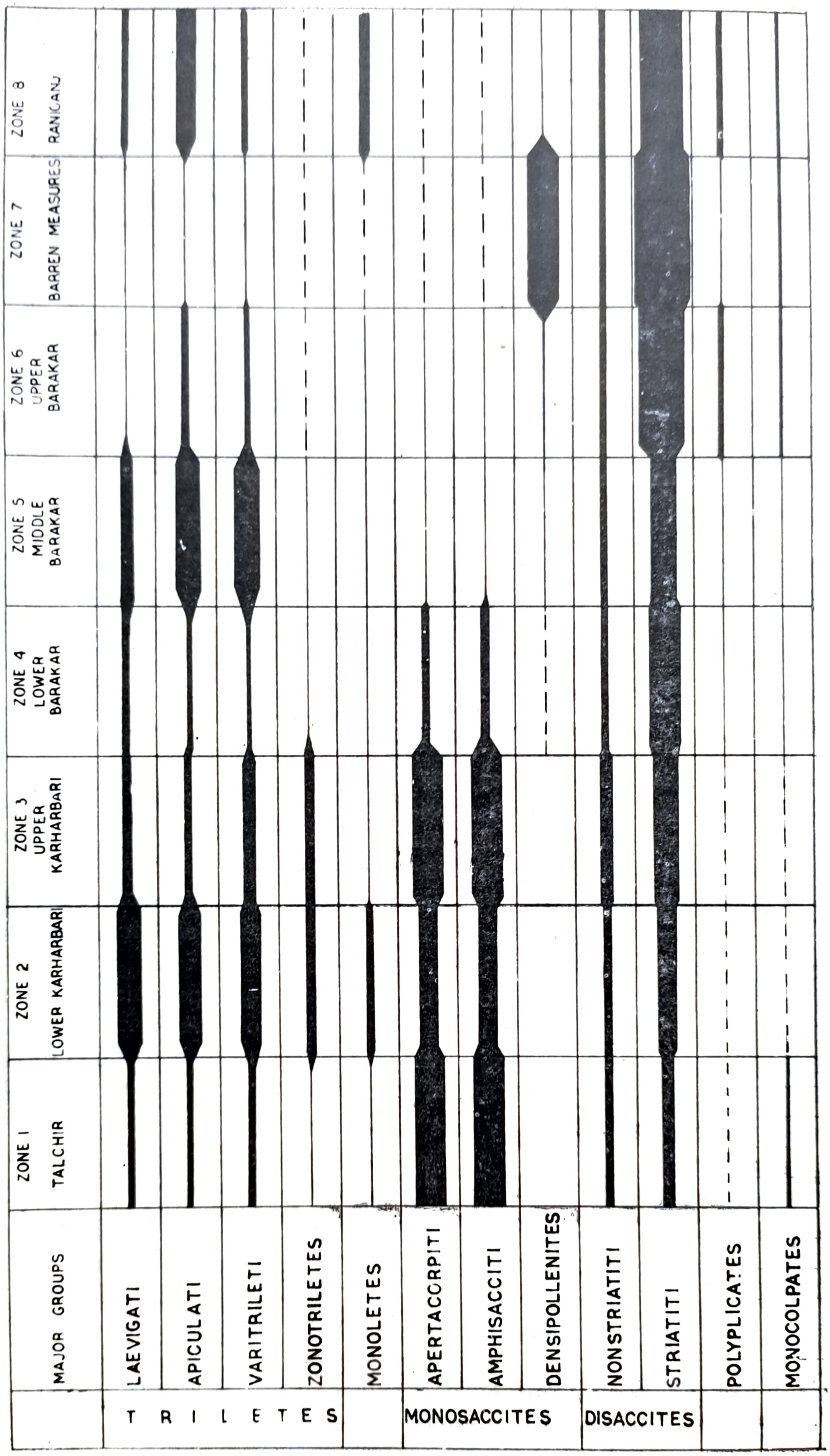
Northern Coalfields	*Mahanadi & Son Valleys*	*Satpura (Pachmarhi)*	*Godavari-Nagpur area*	*Kutch*	*Kathiawar*	*Rajasthan*	*Narmada Valley*	*Chanda-Godavari*	*Trichinopoly*	*Arcot-Chingleput*	*Ongole*	*Rajamundry*	*Bengal-Bihar*	*Geological Age*
..	..	..	..	..	Wadwan sst	..	Lameta Bagh	Pisdura	Ariyalur Trichinopoly	Ariyalur	..	..	Jalangi Ghatal	Upper Cretaceous
..	..	..	..	Bhuj	Wadwan sst. Than plant beds	Parihar	Ahmednagar	..	Uttatur	Sattyavedu Sripermatur	Pavulur	Tirupati	Bolpur	Lower Cretaceous
Supra Panchet (Dubrajpur)			Chikiala	Jhuran	..	Bedesar	Jabalpur	Chikiala	..	..	Vemavaram	Raghavapuram Gollapille	Rajmahal	Upper Jurassic
..	..	..	..	Jumara, Jhurio Kaladongar	..	Baisakhi Jaisalmer	..	..	..	..	..	..	..	Middle Jurassic
..	..	..	Kota	..	..	Lathi	..	Kota	..	..	..	..	..	Lower Jurassic
	Tiki	Denwa, Bagra & Pachmarhi	Maleri	..	..	..	..	..	..	..	..	..	..	Upper Triassic
Panchet	Parsora	..	Yerrapalli Mangli	..	..	..	..	..	..	..	..	..	..	Lower Triassic

Barakar, the triletes again dwindle down in percentage and the striate bisaccate genera predominate (Text-figs. 1 & 2).

The diminishing percentage of monosaccates in the Lower Barakar indicates that the cold climate was gradually replaced by the warmer one. The abundance of pteridophytic spores in association with the coal seams points out that there was abundance of rain and the climate must have been humid upto Middle Barakar. In Upper Barakar, however, there was less rain and humidity as the pteridophytic spores were less represented in the assemblage.



Text-fig. 1. Percentage of different spore-pollen genera in the Lower Gondwanas of India.



Text-fig. 2. Distribution of major spore-pollen groups and eight different palynological zones in the Lower Gondwana of India.

Barren Measures

The Ironstone shale is well developed in Raniganj, Jharia and Karanpura Coalfields. It has a monotonous sequence of grey and black carbonaceous shales, sometimes micaceous and containing carbonates of iron but no workable coalseams. Sandstones are found only at the base or on top.

Palynological fossils from the Barren Measures have been worked out by Bharadwaj, Sah and Tiwari (1965), Kar (1966, 1968a, 1968b, 1968c, 1972, 1973) and others. The assemblage is dominated by the striate bisaccates generally represented by *Strotersporites* and *Striatopiceites*. In the middle part, *Densipollenites*, a monosaccate genus, is found in abundance. The triletes and monoletes, though present in the assemblage, are hardly encountered within the counted specimens.

The absence of pteridophytic spores in appreciable percentage throughout the Barren Measures perhaps indicates a relatively drier and less humid climate than the Barakar Formation. The abundance of *Densipollenites* in this formation and its meagre representation in immediate lower and upper formations also speaks with eloquence that the climatic condition was rather different and probably this genus could thrive only in comparatively drier condition.

Raniganj Formation

This formation is best developed in the Raniganj Coalfield at the eastern end and has a number of workable coalseams. The equivalent sediments in Nagpur-Godavari valley is known as Kamthi Formation and is devoid of any economic coalseams (Robinson, 1967).

Palynological assemblage of this formation has been worked out mostly at the Damuda basin by Sen (1944), Ghosh and Sen (1948), Bhattacharya, Raychowdhury and Datta (1957), Bharadwaj (1962), Bharadwaj and Tiwari (1966), Bharadwaj and Salujha (1964, 1965a, 1965b), Salujha (1965), Kar (1968a, 1969a, 1969b, 1973) and others. The assemblage dominated by striate bisaccates mostly represented by *Strotersporites* and *Striatopiceites*. The trilete and monolete spores representative of cryptogams are also found in good percentage throughout the assemblage. Their percentage generally increases where there are thick coalseams. The monosaccates, polyplicates and monocolpates are rarely encountered within the counted specimens.

The common occurrence of pteridophytic spores in good percentage in the assemblage reveals that the climate was warm and humid with good amount of rain. The reappearance of pteridophytes in Raniganj obviously indicates that the climate was wetter than Barren Measures and was very much favourable for the luxuriant plant growth throughout this formation.

Panchet Formation

This formation is also well developed at the eastern part of Raniganj Coalfield. Equivalent formations are recorded in the Upper Son Valley as the Parsora Formation and in the Nagpur-Chanda area as the Mangli beds.

Spores and pollen grains have been described from the Panchet Formation of Raniganj Coalfield by Srivastava and Pawde (1962), Satsangi, Chandra and Singh (1968), Kar (1970a, 1970b), Sarbadhikari (1972), Banerji and Maheshwari (1974, 1975), Maheshwari and Banerji (1975) and Bharadwaj (1975). It has been observed by Kar (1970b) that the Panchet assemblage could be distinguished from the underlying Raniganj Formation by its dominance of pteridophytic spores, which Bharadwaj (1969) named as

Decisporis mioflora. Similar observation has also been made by SRIVASTAVA and PAWDE (1962), SARBADHIKARI (1972) and BHARADWAJ (1975).

It was generally believed that during Panchet Formation, India witnessed rather an arid or semi-arid condition (PASCOE, 1959; WADIA, 1961; TRIPATHI AND SATSANGI, 1964). But the good percentage of triletes in the Lower Panchet goes against this contention as the cryptogams could hardly flourish in desert condition. On the contrary, it seems that the climate was warm and humid with sufficient amount of rainfall for the growth of ferns and fern allies. It may be mentioned here that the fossil vertebrates described from this formation are mostly of semiaquatic in nature (ROBINSON, 1967). This finding also strengthens the supposition that there was plenty of water in the surroundings during the time of deposition.

A Middle-Upper Triassic palynological assemblage has been described by CHANDRA AND SATSANGI (1965) and BHARADWAJ AND SRIVASTAVA (1969) from Nidpur, Gopad valley, Madhya Pradesh. The assemblage is dominated by the nonstriate bisaccates and the triletes are rearely met with. The scarcity of pteriodophytic spores indicates that the climate was less humid and the rainfall was also not so plenty as was previously.

LATHI FORMATION

This is succeeded by the marine Jaisalmer Formation and comprises soft, variegated or red sandstones with thin lenses of shale. There are also a few bands of buff-coloured limestones.

A palynoflora has been described by SRIVASTAVA (1966) and LUKOSE (1972) from this formation. The assemblage is dominated by the gymnospermous pollen grains mostly represented by *Classopollis*.This genus belongs to the family Cheirolepidaceae and was either produced by *Cheirolepis* (HOERHAMMER, 1933) or *Brachyphyllum* (KENDALL, 1949). They grew in coastal region and withstood less rain.

JHURAN-JABALPUR-VEMAVARAM-RAJMAHAL FORMATIONS

Most of the workers regard Jhuran Formation as Upper Jurassic but opinion differs on the placement of Jabalpur, Vemavaram and Rajmahal formations. Some workers place them in the Upper Jurassic while others assign them to the Lower Cretaceous. Without going to the controversy, the palynological assemblages have been dealt here together for the sake of convenience.

Mioflora from the Jhuran Formation has been investigated by VENKATACHALA, KAR AND RAZA (1969) while that of Jabalpur by DEV (1961), SINGH (1966, 1970, 1972), BHARADWAJ, KUMAR AND SINGH (1972), BHARADWAJ AND KUMAR (1974a, 1974b), MAHESHWARI (1973, 1974, 1975) and others. The mioflora from Vemavaram has been described by RAMANUJAM (1957) and KAR AND SAH (1970) and the Rajmahal microfossils are known from the work of RAO (1943), VISHNU-MITTRE (1954) and SAH AND JAIN (1965).

The assemblage in all the localities is dominated by gymnospermous pollen grains mostly represented by *Callialasporites*, *Araucariacites*, *Laricoidites* and *Podocarpidites*. The pteridophytic spores are not uncommon and *Cyathidites*, *Gleicheniidites* and *Osmundacidites* are occasionally found.

The overwhelming dominance of gymnospermous pollen grains during Upper Jurassic time and the subdued percentage of pteridophytic spores in all the assemblages indicate a climate with less rainfall and humidity. Perhaps it was an extreme climate with marked seasonal variations.

Bhuj Formation

This formation forms the uppermost Gondwana exposure in Kutch and is succeeded by Deccan trap. It has massive sandstones with intercalation of carbonaceous shales and rarely coal.

Mioflora of this formation has been worked out by Singh, Srivastava and Roy (1964), Venkatachala (1967, 1969a, 1969b, 1970), Venkatachala and Kar (1969, 1972), Venkatachala, Kar and Raza (1969a, 1969b) and other workers. The assemblage in some sections is dominated by *Callialasporites* representing the gymnosperms while in others pteridophytic spores are found in abundance. The triletes are found in fair percentage in all the assemblages and are mostly contributed by *Impardecispora*, *Bhujiasporites*, *Cyathidites* and *Concavissimisporites*.

The good representation of cryptogams in the Bhuj Formation reflects a climate with plenty of rainfall and humidity.

Jain and Subbaraman (1969) described a miofloral assemblage from the Dalmiapuram Formation where the spores are found next in abundance to the microplanktons. This also indicates a similar type of environment.

Venkatachala, Sharma and Jain (1972) also found good representation of cryptogamic spores in *Microcachryidites antarticus* and *Coptospora cauveriana* cenozones belonging to Lower Cretaceous sediments in the subsurface of Cauvery basin.

Thus throughout the Upper Gondwana in Lower Cretaceous, the climate was congenial to the cryptogams to flourish as one of the most important components of the flora. The warm and humid climate with good amount of rainfall favoured them than any other groups of plants.

After this period, a catastrophic event followed. The volcanic eruption started with all its abominable force to erupt the molten magma from the interior of the earth for millions of years and enveloped a major part of the Gondwana on the western and southern sides of India. But the subsurface data investigated by Biswas (1959, 1963), Sen Gupta (1966) and Baksi (1972) show that on the eastern side, in Bengal basin, after the continental Bolpur Formation (Lower Cretaceous) which rests unconformably on Rajmahal trap, the Ghatal, and Jalangi Formations (Upper Cretaceous) follow apparently without any break in sedimentation.

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