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Concepts, limits and extension of the Indian Gondwana—an introduction to the theme

B. S. Venkatachala

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

THE term Gondwana—first used by H. B. Medlicott in 1872—was formally published by Ottokar Feistmantel in 1876. He desired that it be accepted in the same sense as the Silurian or the Jurassic systems of Europe. Fox (1931) states "The name Gondwana System was applied to deposits of conglomerates, sandstones, shales and coal-measures of fluviatile and lacustrine origin which occur in the Indian *Peninsula** and whose geological age ranges from middle Carboniferous to upper Jurassic. The fauna and flora of these Gondwana sediments are largely of terrestrial forms and include some fresh water fishes and amphibians". Lexique internationale defines the Gondwana 'System' as typically freshwater or riverine accumulations of conglomerates, sandstones, shales and coal-measures of Upper Carboniferous to Lower Cretaceous age. The base of the system is marked by a tillite or glacial boulder bed. Stratigraphical Lexicon of Gondwana formations of India (Sastry *et al.*, 1977) also ascribes an earliest Permian to Early Cretaceous time connotation to the Gondwana Sequence comprising a thick series of fluviatile and lacustrine sediments with intercalated plants, and to a lesser extent animal fossils. The sediments are notable for remarkable continuity of fossil floras. These contain a succession of fossil floras which are named as the *Glossopteris*, the *Dicroidium* and the *Ptilophyllum* floras. These floras have characteristic elements and in the course of time the mere presence of these floral associations was considered sufficient to term the entombing sediments as the Gondwana, even if they were primarily of marine origin.

CONCEPT

When marine signatures were discovered in the Indian Gondwana as far back as 1921 in the Umaria marine bed (Sinor *in* Fermor, 1922, p. 14) these were considered to be exceptions and were included as marine intercalations in the predominantly fresh water facies. Thus, the concept of 'marine intercalations' in a predominantly "continental sequence" was initiated. Subsequently more marine horizons were discovered at Manendragarh, Daltonganj and Rajhara establishing marine intercalations. More and more palynological evidences are forthcoming to show that marine sediments are not that infrequent as earlier believed to be in the Indian Gondwana.

Leiosphaerids and other acritarchs have been recorded in association with terrestrial spores and pollen in authentic marine sediments of Early Permian age. Such association has now been discovered in the Talchir sediments of Son-Mahanadi, Satpura, Damodar and Pranhita-Godavari grabens, Palar and Rajasthan basins as well as in the north-eastern India, strongly indicating a marine or near shore environment of deposition. In the Karharbari sediments acritarchs have been recorded from Umaria marine bed. Marine signatures in the form of characteristic leiosphaerid association have also been found in the Barakar, the Barren Measures and the Raniganj formations (Venkatachala & Tiwari, 1988).

Gondwana plant-bearing beds associated with primarily marine sediments have been well documented from the east coast basins and in the Kutch Basin. Even the Kota Formation, *sensu stricto*, in the Pranhita-Godavari graben has a doubtful record of a nannofossil (Bhattacharya, 1981). A large number of additional records of Lower Cretaceous marine sediments is now available from my own palynological studies on surface and subsurface sediments of the east coast (Cauvery and Krishna-Godavari basins). The palaeoecological regimes of these sediments may vary from non-marine to paralic

*Italicised by the present author for emphasis.

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and represent a transition zone where continental and marine facies interdigitate. But are these sediments really Gondwana just because they contain a 'Gondwana' palynoflora? Can a similar flora not occur simultaneously in itracratonic and coastal sediments? It is well known that palynofloras contain both *in situ* and *ex situ* fossils and it is the discriminating interpreter who can use this information for a meaningful palaeoecological interpretation. Mere occurrence of terrestrial fossil does not imply a continental deposition.

The Permian plant beds in Kashmir, that contain Gondwana elements if not a typical Gondwana flora, are sandwiched between marine formations. Gondwana type palynoassemblages are on record from the Permian of Kumaon Himalaya (Tiwari *et al.*, 1984) and Arunachal Pradesh (Srivastava & Dutta, 1977). Should these sediments be attributed the Gondwana connotation?

The issue is confusing. We either redefine the term 'Gondwana' or abandon it in favour of usage of international time scale, viz., Permian, Triassic, Cretaceous, etc. Should we restrict the term Gondwana to continental facies *sensu stricto* or enlarge the meaning to include both continental and marine facies? Both alternatives have their own inherent strength and weakness. In the former case exceptions would have to be allowed as for the like of Umaria, Manendragarh, Rajhara and Bap beds and such other stratigraphic sequences, which are intercalations in a primarily continental suite of sediments. And what would be the status of fresh water plant beds of Bhuj and Athgarh formations? And once exceptions are allowed, though they prove the rule, the limit of such exceptions and such other extensions becomes a subjective matter and may even over shadow the rule itself. In the latter case, the term Gondwana would serve no useful purpose because it would primarily be then based on the contained floras. With the alleged discoveries of Gondwana taxa in New Guinea, Tibet, Turkey, etc. the day is not far off when the term Gondwana in stratigraphical sense gets extended to some of these areas. After all, many geoscientists subscribe to the idea that these areas formed parts of Gondwanaland. A part of the Tethyan Sequence of Kumaon Himalaya has already been subtly included in Gondwana (Tiwari *et al.*, 1980, 1984).

It is pertinent to examine the situation in other countries. In the Salt Range, Pakistan, marine rather than continental, paludal and lacustrine sedimentation followed the glacial episode. In South Africa, the Karroo Sequence of sedimentary deposits is also distinctly continental. Some marine intercalations at the top of the Dwyka tillite contain *Eurydesma* and *Connularia* (Dickins, 1961; Rillet, 1963). In South America the situation, however, is remarkably different. Marine intercalations occur in the glacial Tubarao Group of Uruguay and Parana basins (Closs, 1969; Rocha-Campos, 1969). These contain goniatite fossils. Goniatites are also recorded from Lower-Middle Pennsylvanian of Peru, Lower-Middle Permian of Colombia and Middle Pennsylvanian of Chubut. Coal seams and carbonified remains of *Glossopteris* flora also occur in the sequence above and/or below the strata containing marine fossils. In western Australia, thick marine Permian sequences are recorded in major basins such as Carnarvon and Canning basins. The Upper Carboniferous of Hunter Valley has glacial varves diamictites, volcanics, shallow marine conglomerates, sandstones, limestone and tuff.

Thus, it is evident that marine sediments occur in all Gondwana countries. The accepted model of a continental facies for the Gondwana Sequence stands challenged. The mere presence of a flora with Gondwanic affinity does not make a sedimentary sequence the Gondwana *sensu stricto*. Exclusion of Gondwana plant-bearing pericratonic beds creates its own problems. The significance of plant-bearing pericratonic beds in the Himalayan region can not be underestimated. Their association with datable marine sediments makes them assuredly important for dating continental facies with similar plant associations. I expect the workshop to closely scrutinize the concept of the term Gondwana and come out with a solution acceptable to most, if not all. It should also examine if it is any more worthwhile to retain this term. I recommend the following three opposite views for discussions:

(i) Under the head Gondwana deposits, only far flung terraines characterised by some aspect of the Glossopteris Flora are considered legitimate. The term should be restricted essentially to those 'austral' deposits found in both geosynclinal and cratonic expression and initiated by the great glacial event (Caster, 1952);

(ii) Gondwana should include all those continental and shallow marine sequences in the southern continents, whose gross lithologic, biologic and tectonic aspects permit reasonable identification with one another (McElroy, 1969);

(iii) The term Gondwana is now redundant in stratigraphic sense and we should now use International terms such as, Permian, Triassic, Jurassic, Cretaceous, etc.

Under the first two alternatives, it is evident that palaeontological uniformity is the major uniting factor. The other uniting factor is the basal glacial episode that is believed to have initiated the Gondwana Sequence of deposits.

LIMITS OF GONDWANA

Did this glacial episode occur simultaneously all over the southern landmass? King (1958) suggested that glaciation may be of somewhat different ages in different parts. If so, it would mean that Gondwana sedimentation did not cover the same time span everywhere. Further, there may be more than one glacial episode. For example, the glacigene Itarare Group of Parána Basin shows atleast 6, may be up to 10, glacial episodes. Atleast 3 marine beds lie only a few meters above the tills. The Beacon Supergroup of Antarctica equivalent of the Gondwana Sequence is of Devonian to Jurassic age with continental or possible shallow marine sediments. The youngest glacial beds have been palynologically dated as Early Permian (Barret & Kyle, 1975). The age of formations underlying glacial deposits in Australia, according to palaeontological evidences, vary from latest Visean to Early Namurian to as young as Westphalian (Roberts, 1971; Roberts, Hunt & Thomson, 1976). The ammonoid faunas in sediments overlying the glacial formations are of Sakmarian age. Kemp *et al.* (1977) believe that palynofossils from Australian glacial beds indicate a Missourian-Virgilian age. However, on available evidences, we do ascribe a earliest Permian age for the basal Gondwana beds in India.

The Gondwana sedimentation is believed to have extended only up to the Lower Cretaceous. The reasons for fixing the upper boundary of the Gondwana at this level are obscure. If the term Gondwana Sequence is to be restricted to a particular type of sediments deposited in the Gondwanaland, one has to ask and answer an important question—till what time did the Gondwanaland exist? A time connotation is involved. Do we consider India a part of Gondwanaland even after it drifted? Or, it lost its Gondwana affiliation only after its rendezvous with Eurasia? Palaeomagnetic data has been interpreted to establish that the eastern Gondwana separated from western Gondwana in Hauterivian (120 ma). India separated from eastern Gondwana block of Australia and Antarctica by Santonian (80 ma) and became attached to Eurasia in the Late Miocene (10 Ma).

If the limits of the Gondwana are to be considered in the floral context the main floral provincialism, comprising the elements of the *Glossopteris* assemblage, was mostly confined to the Permian, probably extending into the basal Triassic. The Triassic floras of the world, too, show a provincialism though at a reduced scale. *Pleuromeia*, a characteristic lycopsid of German Bunter, that occurs extensively in the Soviet Union, has been reported in the Australian Triassic, so does its spore—*Aratrisporites*. Even the Late Triassic palynological assemblages recorded from Western Australia (Dolby & Balme, 1977) and from the Tiki Formation of the Son Graben (Maheshwari & Kumaran, 1977; Kumaran & Maheshwari, 1980) have a number of typical central European taxa at generic level. The lycopod megaspores recovered from the Tiki Formation (Banerji, Kumaran & Maheshwari, 1979) show a certain resemblance with the Norian-Rhaetian megaspores from Poland. The Late Triassic faunas from Madagascar and India have distinct northern affinities (Battail, Beltan & Dutuit, 1987; Chatterjee, 1987). The provincialism exemplified in the Permian floras is no more evident even in the Late Triassic.

In the Upper Mesozoic (?Jurassic-Cretaceous) the Indian flora seems to have acquired a definite northern aspect and became a part of Vakhrameev's Indo-European palaeofloristic province extending from Europe to Japan via India and South China. Should the upper boundary of Indian Gondwana not be placed at the latest Triassic? After all before the advent of the Gondwana flora, too, the Carboniferous floras were homogeneous, though floral zones are recognizable (Chaloner & Meyen, 1973). Authentic Jurassic palynological assemblages are not known from intracratonic Gondwana. But the Late Jurassic-Early Cretaceous palynological assemblages from Kutch Basin, and the Early Cretaceous assemblages from Cratonic and East Coast basins have a large number of cosmopolitan palynotaxa, e.g., *Cicatricosisporites, Aequitriradites, Crybelosporites, Foraminisporis, Trilobosporites, Densoisporites, Coptospora, Appendicisporites, Coronatispora* to name a few. In view of the cosmopolitan mega- and palyno-flora occurring in Upper Mesozoic of India, when this land segment had already departed from the Gondwanaland, the upper limit of the Gondwana needs major rethinking. Interestingly, at many places on the East Coast, the Lower Cretaceous sediments constitute a continuous succession with the Upper Cretaceous sediments (Sastri *et al.*, 1975; Kumar, 1983; Venkatachala & Sharma, 1984).

EXTENSION

If we decide to retain the term Gondwana and also agree to its upper and lower limits, the question naturally will arise as to the geographical distribution of the Gondwana.

As of today, the Gondwana sedimentation within the prescribed time and ecological limits *sensu* Fox (1931) is believed to have been laid down only on the Gondwanaland. The term Gondwanaland was conceived by Edward Suess in 1885 and readily adapted by subsequent workers for a Palaeozoic supercontinent that is believed to have comprised all the southern continents including India. Atleast, during the entire Permian and most of the Mesozoic India is believed to have been an integral part of this supercontinent. But what were the northern limits of the Indian segment is the question that is confounding the geoscientists today. With the introduction of the concept of individual, dyanamic crustal plates, the controversy is warming up. Now it is no more fashionable to regard the northern boundary of India coincident with the Main Boundary Fault, the Central Crystalline Axis or even the Indus Suture Zone. The concept of 'Greater India' is gaining momentum. What was the extent of 'Greater India'? Some would include the whole of Tibet and take the northern boundary to the Tien Shan Mountains. Others would place it along the Bangon-Nujian. In one of the reconstructions, Iran, Afghanistan, Indo-China, etc. are placed north of India. This question has to be discussed dispassionately and multidisciplinary data need be sifted and interpreted. Can palaeontology help?

Crawford (1974) concluded that the distribution of fossil cladoceran *Daphinopsis* and reptile *Lystrosaurus* in the Early Triassic points to an association of Tibet with Inner Mongolia, India, Antarctica and Australia. Another important evidence in support of Tibet and India association is derived from the discovery of a Glossopteris Flora in southern Tibet (Hsü, 1976). Perhaps distribution of pollen and spores may provide additional evidences. Hence, there is sufficient incentive to probe further in this matter. Most important is to identify coeval continental suites for palaeontological investigation. A real understanding of the Cathaysian and Angaran palynofloras is not only a prerequisite but the nomenclature and taxonomy of palynofossils in these assemblages have to be redefined and translated to Gondwana and Euramerican usages to achieve a meaningful comparison. The taxonomy and nomenclature of plant megafossils should normally not present much problem, but even there the bias to recognize familiar taxa has to be overcome. The bias of the investigator specialising in Indian, Russian, American, Chinese or for the matter of fact, any other floras would decide on the identification of a fossil taxa to either *Glossopteris* or *Pursongia* or *Zamiopteris*. Examples are several. Similarity in external morphology of an isolated plant organ, from different palaeogeographical and palaeo-ecological regimes, does not necessarily mean that they represent the same plant. Search should be made for other related organs to verify and confirm such presence. The ground rule is not to start with preconceived ideas or notions. Attempts should be made to evaluate objective speciation that has occurred in nature rather than introduce our own regional biases. Subjectivity always gives rise to problems in all areas of human activity and it is no exception in Gondwana stratigraphy, palaeontology and palaeobotany.

PALAEOCLIMATE

Glossopteris is an undoubted temperate plant. If similar leaves are discovered in tropical regimes, one has to be doubly sure before assigning such leaves to the *Glossopteris* plant. The climate was frigid during the glacial period. Palynological information shows that in the Talchir it became very cold and dry and ameliorated during Lower Karharbari when the first coals were laid down in a cold and humid climate. In the Upper Karharbari, the climate again deteriorated and became very cold and dry. During the Damuda period it was mostly warm and humid. It is also true because most of our coals in great thickness are deposited in the later Permian. In the Lower Triassic it is interpreted to have become cold and humid though no coals have been laid down (Bharadwaj, 1975).

The question we have to answer is—Can spores and pollen by themselves, in the absence of knowledge about their parent plants, provide reliable climatic inferences? Corroborating evidences are always needed to sponsor an idea or to sustain a hypothesis. There is not enough supporting research which can relate exinal or organisational manifestations in spores and pollen to climate. For example, in the cold temperate Talchir Formation, a radial monosaccate pollen association is dominant. *Per contra* palynological suites in the northern hemisphere containing radial monosaccate *Nuskoisporites/Cordaitina* do not represent even a cool phase. Taeniate forms may be taken as representing seasonal fluctuation in Gondwana but in the Late Permian Flowerpot Formation of Oklahoma from where they are also recorded, there is no evidence of seasonal fluctuations. However, if we examine the megafloral assemblages, we observe that as compared to the coal-forming vegetation of the northern hemisphere, the Indian Permian megafloral assemblages contain relatively few kinds of plants, though in innumerable numbers, a condition that postulates a cool or cool-temperate climate throughout. Tropical floras, as we know, contain largely diversified floral assemblages including a large variety of taxa. This, in fact, is the climatic zone in which maximum speciation occurs. The presence of annual rings in the wood and the deciduous nature of the leaves in the Indian Permian also support the contention of a cool temperate climate. That the climate did not get too severe is evident from the fact that some of the trees attained considerable size. The reduction in size of leaves in the basal Triassic and the epidermal features of many of the Triassic leaves point to a climate where availability of moisture was relatively poor. Sedimentological studies also do not seem to support a cold, humid climate for the basal Triassic. Infact, the climate could have been warm, if not arid.

PROBLEMS OF DATING AND ZONATION OF GONDWANA SEQUENCES

One of the major problems in the Indian Gondwana stratigraphy has been the lack of uniformity in the usage of various terms. So far, no reasonable chronostratigraphic classification is available and the time connotations to various lithostratigraphic units have been mostly arbitrary. Most of the sediments being continental, biostratigraphic zonation has of necessity to be based on plant micro- and megafossil records. However, these can not be satisfactorily compared with standard biostratigraphic zones of the northern hemisphere because of the vast difference in floristic composition of the two. Even plant megafossil and microfossil zones in the same basin or in the same lithounit do not interlink. This seems to be due to lack of botanical understanding of relationship between mega- and micro-fossils an area in which extended research is needed. In dispersed spores and pollen it is rather much more difficult to know what morphographic characters are intrinsic to each species and what are incidental. Great emphasis should be laid on the study of *in situ* spores and pollen and the information so derived must be incorporated in delineating species of dispersed palynotaxa. This will enable us, to be rid of the situation where genera and species of southern microfossils are referred to characteristic northern taxa while the megafossil records of the two areas are totally different. However, I do not mean that taxa of palynofossils, or for that matter, those of plant megafossils, should be differentiated on geographical basis. This will be just as bad as differentiating taxa on the basis of geological occurrence. For example, diploxylonoid pollen with a small, circular, dark central body is referred to the genus *Platysaccus* in the Permian and to the genus *Podocarpidites* in the Mesozoic. Plant fossils are to be used for dating the sediments and for phytogeographical inferences and not *vice-versa.*

But all the same, we should be vary of determining ages of sediments on the basis of similarity of taxa based on dispersed organs of plant megafossils. Or, we shall end up with dubitable age assignments. For example, the apparent similarity between the Yorkshire Jurassic floras and the Upper Mesozoic floras of India from Rajmahal, Satpura and East Coast has led to Middle-Late Jurassic age assignments to the Indian sediments. We know now for sure from palynological, foraminiferal and radiometric dates, these sediments were laid down during the Early Cretaceous.

The criterion for dividing the Gondwana Sequence into Lower, Middle and Upper Gondwana also requires a fresh look. If one goes into the views of the recent proponents of the three-fold classification of the Gondwana (Lele, 1964; Saksena, 1974), it is apparent that they were guided by the major floral changes. The Lower, Middle and Upper Gondwana were related to *Glossopteris, Dicroidium* and *Ptilophyllum* floras. While, the chronological value of the plant fossils is unsuspected neither we can justify subdividing lithological unit nor any useful purpose would be served by such a three-fold or even a two-fold division of the Gondwana.

It is much more important to recognise lithological units of the rank of a formation and to delimit their spatial distribution. More often than not same formational names, with few exceptions, are applied to coeval units in different grabens. How far is it reliable and in conformity with the code of stratigraphical nomenclature? Lithological units with similar basic characteristics can not be expected to occur in different grabens or basins unless the tectonic and sedimentological history are comparable. Most of the formations lack reliable type sections, and their upper and lower contacts are not usually apparent. The Karharbari Formation is an example. It was recognised on the basis of contained floras (*Botrychiopsis* and *Buriadia*) but later workers assigned lithological characters to it. But not all agree that Karharbari Formation can be identified lithologically in all the basins from where it has been reported, which makes the status of this formation suspect. It seems to be becoming quite common to change the definition or diagnosis of a recognised formation on the basis of subsurface data. The Kamthi, the Dubrajpur and the Parsora formations are such examples. In the Kamthi Formation, *sensu lato*, are now included carbonaceous Infra-Kamthi; in the Dubrajpur Barakar equivalent beds of Rajmahal and in the Parsora the upper part of the Pali Formation. I expect the workshop to re-examine the necessity of incorporating such changes on the basis of the information which is not available in type or reference sections. Slight carelessness or bias in assigning a palaeontological sample to a formation as well as the identification of a taxon either to one or the other, may drastically change the biozonation and age assignment.

A refinement in age determination of various formations is much needed. To date the Talchir-Barakar, Barren Measures and Raniganj formations as Lower, Middle and Upper Permian seems to be more due to convenience in the same way as the Lower, Middle and Upper Gondwana were dated as Permian, Triassic and Jurassic-Lower Cretaceous. It is made to appear as if the 'Lower Gondwana' formations represent the whole of the Permian System in most of the basins. There is every likelihood that a part of the sequence may be missing.

The floras usually being monotonous successions, absolute age determinations need to be introduced wherever possible to firm up age assignments. If few such dates are made available, ages of associated, overlying and underlying sediments can be calibrated. Intercalated marine fauna and terrestrial tetrapod fauna can also be of help in age determinations. In the Pranhita-Godavari Graben many of the litho-units have datable vertebrates which are associated with plant megafossils. In the Son Graben too, the Tiki Formation has datable fauna in some of the horizons. The significance of plant-bearing beds in the Himalayan region cannot be underestimated. They are specially important for precisely dating continental formations, as they are associated with well dated marine sediments. It is necessary now to tie up all available biostratigraphic evidences to understand and interpret the stratigraphy and ecology in a synergistic approach.

In using the mega- and micro-fossils for correlating and dating Gondwana of different basins and grabens, possibility of localization of certain floras should also be kept in view. For example, the typical Karharbari biozone is developed only in the Giridih Coalfield. Elsewhere it is recognised more on extraneous grounds rather than on the presence of the genera *Botrychiopsis* and *Buriadia*. The *Dicroidium* biozone is developed only in South Rewa Basin; there is no definite evidence of the presence of this genus in any other basin. The plant association of the Nidhpur beds too, is a localised development apparently without any comparative fossil flora elsewhere in India. It can not be satisfactorily used for age correlation unless we insist that the ubiquitous Triassic genus *Dicroidium* is present in this assemblage. In such cases the taxonomic identification of such crucial taxa must always be objective. Does the absence of forked rachides in Nidhpur pteridosperm leaves has any meaning? Is it not possible that these leaves represent precursors of the genus *Dicroidium* which is definitely represented only in the Parsora Formation *sensu stricto*? Does the Nidhpur floral assemblage not answer to the '*Thinnfeldia*' *callipteroides* Oppel-Zone of Australia that spans the Permian-Triassic boundary? It may even represent the unconformity between the Raniganj and Maitur formations in the Raniganj Coalfield.

The significance of spore-pollen assemblages in demarcating the Upper Jurassic/Lower Cretaceous boundary needs be re-examined. Whether the boundary is represented by qualitative or quantitative changes has to be expressly determined. Do the spore-pollen assemblages reflect on the presence of Jurassic in the peninsular Gondwana? And how does the megafossil record reflect on this boundary? These are some of the major questions that need to be answered, particularly with reference to the age of the Rajmahal intertrappean beds as there is a recent report of a Lower Jurassic plant megafossil assemblage in the upper part of the Dubrajpur Formation (Sengupta, 1985). We have a radio-metric date of ± 105 ma for some of the Rajmahal traps. Palynologists are also veering around a Lower Cretaceous age (Maheshwari & Jana, 1983). As a matter of fact, there is overwhelming evidence to support a Lower Cretaceous age to all the Upper Mesozoic plants beds. A detailed investigation of their field relationship with associated marine beds will definitely provide a sequential age to these formations.

In recent years the Australian connection of the Indian Gondwana floras is becoming more apparent. *Dulhuntyispora dulhuntyii*, an endemic western Australian Upper Permian pollen, which is not known from any of the Indian Gondwana palynological assemblages, has now been discovered, albeit in reworked form, in the Oliogocene-Miocene of Assam and Miocene of Tripura. The pollen genus *Marsupipollenites* has also been found in Permian of Arunachal Pradesh, Rajmahal Hills and Son Graben. The Carnian-Norian palynological assemblages from Australia (Dolby & Balme, 1977) and India (Maheshwari & Kumaran, 1978; Kumaran & Maheshwari, 1979) depict great similarities. Such occurrences can be used to work out the India-Australia fit. Reworked palynofossils otherwise too have great significance, as they are indicative of the presence of litho-units that may not be exposed or have been completely eroded. These may also indicate palaeodrainage patterns. The Mesozoic sedimentary sequences of the Kutch Basin contain a large number of reworked radial monosaccate as well as bisaccate striate pollen, but no where in Kutch or Gujarat Permian or even Triassic sediments have been exposed. From where did these reworked pollen originate? Does it reflect on the India-Africa fit? or, it has a bearing on the concept of a Indus sub-plate? Reworked palynofossils may also provide an additional parameter to record hiatuses/unconformities. Reworked Permian pollen are found only in the grabens or associated basins on the East Coast. The significance of this find needs attention.

There is some evidence to show that Permian sedimentation did not cease within the Raniganj Formation but probably continued in the Panchet Group as well. In the basal beds of the Maitur Formation in the Raniganj Coalfield, we observe that the *Glossopteris* species, particularly *G. conspicua* Feistmantel and *G. elongata* Dana and *Schizoneura gondwanensis* Feistmantel continue apparently without introduction of any new element. Palynologically also a definite change is observed only above the Raniganj-Maitur boundary. Whether this change is related to the Permian-Triassic transition needs a thorough study. The distribution of the estheriid fauna should also be utilized for this purpose.

Lastly, but in no way less important, are the plant megafossils and microfossil zonal successions and their relations. Presently we have a great many palynological zonal schemes. Most of the zones are based on relatively unimportant proportional distribution of subjectively identified palynotaxa of generic level which probably may reflect local facies changes. A review and synthesis of these palynological zones is urgent. These should further be correlated with plant megafossil and palynological zones of other areas associated with reliable marine invertebrate faunas. Relationship between palynological zones, faunal zones and chronostratigraphic units will help in bringing about a precision in age control. However, the identification of 'northern' microfossil taxa reported from Indian Gondwana is suspect because we do not know if they migrated from the north or are the result of parallel evolution. Can they be used for age determinations? At least the Permian taeniate pollen seem to be the result of parallel evolution as the plant megafossil record, though much less complete, does not support such a cosmopolitan distribution of gymnospermous taxa during the Permian.

These are only some of the many problems that I have outlined or dared to identify. वादे वादे जायते तत्वः—"*Only deep and continued discussion will bring out the truth*". I am sure we will all muster up courage to face criticism, answer questions on our rationale and also accept newer evidences in the spirit of science and revise old concepts. We will never see the elephant if we view it as a fan, pillar or a snake.

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