Symposium on Four Decades of Indian Palaeobotany : an introduction

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PLANT fossils form the subject of palaeobotany—an important broad area of research that provides information fundamental for solving certain basic problems in botany. These problems may have a bearing on morphology, taxonomy, ecology, phytogeography and evolution. Palaeobotanists investigate fragmented, disconnected, disjointed plant remains from the distant to immediate past and build an evolutionary pyramid. Plant diversity is the basis for the construction of this pyramid, which many a times got distorted during the geological past due to extinctions. These plant remains represent relics of past vegetation that got entombed in "sedimentary rocks" and were saved from total destruction mostly by carbonification or petrification in suitable depositional environments. But the fossil records which by nature are fragmentarily preserved bring out only random moments of plant history and the entire story has to be reconstructed step by step by investigation, correlation, analysis and synthesis of plant fossil scene.

The present symposium on "Four Decades of Indian Palaeobotany" is aimed to critically analyse the palaeobotanical data generated mostly during the post-Sahni era. Professor Birbal Sahni, the doyen of Indian Palaeobotany and the founder of this Institute envisioned a great potential for plant fossil studies. His own contributions to this science include a wide spectrum of areas like morphology, anatomy, phytogeography, continental drift, phylogeny and evolution. He strived hard to keep the plant fossil studies in the forefront of research and widened the horizons of Palaeobotany. By organizing this symposium we rededicate ourselves to the cause for which this great scientist strived for. He opined that *"the fossil plants represent the debt that botany owes to geology"*. He himself was mixed blend of Geology and Botany. His researches were examples of high scientific calibre and understanding.

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The post-Sahni era witnessed diversification of plant fossil studies, of which the initial effort was mostly concentrated on the morphology and anatomy. Gradually palynological data was utilized for stratigraphical correlation. The palaeobotanical and palaeopalynological studies in the post-Sahni era resulted in accumulation of stupendous data. This enormous data should be utilized for more promising ventures. It is essential to unify, update and revise the generated data base so as to renew the state-of-the-art. It is also important for us to have a retrospection of past achievements and take stock of future avenues. While reviewing the advances in Indian Palaeobotany (1921-1938) Professor Sahni (1938) felt that *"With the inevitable specialization of our age continually threatening to divide us, it is no small gain to science in India that the brief period of seventeen years that we have just reviewed has brought about an era of understanding and cooperation between us, with still higher promise for the future. For the true aim of all science is to unite not to separate."* It is still relevant even after these five decades. The changing phases and development of plant fossil researches are an outcome of Professor Sahni's vision.

I shall focus on some of the selected areas of advance in Palaeobotany.

PRECAMBRIAN PALAEOBIOLOGY

Origin and early evolution of life is a major thrust area which requires attention. Indian records of the Precambrian microbiota have been meagre and not commensurate with extensive Precambrian terrain available for study.

The early life on earth was dominated by prokaryotes which were mainly fermentative. These

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prokaryotes responded to a variety of ecological pressures and developed in specialised niches and subsequently rapidly diversified and invented chemical and biological strategies for survival and wider expansion. Eukaryotes developed as a biological strategy to cope with the advent of oxygen, a highly reactive element which was poisonous to the living system present at that time. It is not yet clear when the eukaryotes appeared as it is very difficult to differentiate a fossilized prokaryotic cell from the eukaryotic one. The early biotic evolution was mostly related to metabolic activities while organismal development was minimal. They could have appeared as early as 2 Ga ago. There are positive evidences at 700 Ma of metaphytes and metazoans.

Though considerable data has been generated from the terminal Precambrian in the Indian subcontinent, the complete stratigraphic biochronology is yet to be developed. There are many areas in the outer and inner sedimentary belts of the Lesser Himalaya, different regions of the Vindhyan Basin in central India and the Bhima, Kaladgi, Kurnool basins of south India, where Precambrian-Cambrian rocks are exposed. These successions can be worked out for developing a biochronology.

The recent finds of structurally preserved filamentous microfossils from the Archaean Sandur Schist Belt, Dharwar Craton; coccoid and rod-shaped bacteria resembling sulphur reducing bacteria from the Kudremukh Iron Formation; stromatolitic structure of variable morphology from the Sandur Chitradurga and Shimoga supracrustal belts, and Proterozoic microfossils from the Infrakrol sediments have opened new vistas in Precambrian palaeobiology. In India, the Early Cambrian brachiopod and Redlichid trilobite are known from Lolab Valley in Kashmir and the stratigraphically underlying rocks show presence of trace fossils indicating bioturbation. An intensive search is required to find the Ediacaran fauna in India. Many unconfirmed reports of metazoans from 1000 Ma old rocks of Lower Vindhyan from different localities need to be properly examined in relation to palaeomagnetic and stratigraphic evidences as they may represent Pre-Ediacarian fauna. The reported occurrence of metaphyte-metazoans in the Pre-Ediacaran sediments of India (Suket Shale) also indicates possibility of the existence of platforms and shallow marine shelf conditions in the Indian sub-continent which are conducive for their growth at that time. Studies carried out by the Archaean palaeobiology group in the institute have suggested that stabilized continental crust had developed in the Dharwar Craton as early as Archaean which is much before the stabilization of crust in other parts of the world. Researches on prokaryote-eukaryote transition and possibility of recent contaminants in older sediments should be intensified.

During the scientific deliberations to follow, aspects like palaeobiology of Vindhyan sediments and a retrospection on metaphytes and metazoans in India will be discussed at length. I do hope that some new ideas will emerge to understand significant Precambrian evolutionary steps and their bearing on subsequent colonization of land by organisms.

GONDWANA FLORA

The Gondwana Flora of India is a gymnosperm dominated vegetation. The first definite records of plants are found in shales and sandstones overlying the basal Talchir boulder bed, though there are stray reports of spores and pollen from within the tillite. It is not known as to what the vegetation was like during the glacial period. Did the Gondwana Flora evolve from earlier plant communities that survived in protected niches during glaciation or did it evolve from plants that migrated to Gondwana Supercontinent from other phytochorias after glaciation? This is a question still in need of an answer. Commenting on ice age and Glossopteris flora Professor Sahni (1938) wrote *"It would almost seem that exposure to the rigours of the climate had quickened the pace of evolution, as if inducing saltations on a large scale, a sort of natural vernalization affecting not only the individual life-cycle, but the rate of evolution of species possibly through aberrations in the nuclear cycle."* It is also not known as to exactly in which region of the Gondwana Supercontinent the Gondwana flora originated because in the stratigraphical sequence we find that the flora appears almost at the same level in all the continents.

Species of Gondwana mega-plants were usually identified on the basis of gross morphography. In recent years features of cuticle have been extensively used, particularly in India. However, subjective approach of different investigators has brought about an element of uncertainty in the identification of taxa because similar specimens with and without cuticles have mostly been assigned to different species. If a co-ordination between the two groups of species could be arrived at, these species will become biostratigraphically significant. Even dispersed cuticles could be used for stratigraphical correlation at levels where spores/pollen are not known.

Though much palynological work has been done on the Gondwana sediments, yet the identification of taxa is in a state of flux. Most of the taxa, both at species and generic levels, have been instituted on minor variable characters. Practically an attempt has been made to identify consistent characters. A study of *in situ* spores and pollen could provide requisite data. Study of ultrastructure of the exines could also provide much useful information regarding affinities. Once palynological taxa are objectively circumscribed it would be easier to use them, with a high level of confidence, for zonation and correlation as well as to understand evolutionary patterns. Changes in floral composition can be effectively used to decipher palaeoenvironmental regimes. Reconstructions of vegetation that formed coal in the Gondwana grabens need to be accelerated with the help of plant mega- and microfossil studies. Understanding of the form and function of fossil dispersed organs will help reconstruct the 'plant' and their evolution and development.

Glossopteris-bearing beds in the pericratonic marine sequences of Kashmir contain an inter-mix of Gondwana, Cathaysia and Angara elements. How does this "mixed" vegetation reflect upon the relative position of the three land masses, land connections or otherwise need to be investigated. Probability of parallel evolution of these plants should be examined afresh. Answers to these questions will reflect upon the Continental Drift hypothesis. A flora that is older than the Gondwana flora of the peninsula is known in the Himalayan region. Extensive and intensive investigation of this flora may throw light on the precursors of the Gondwana Flora.

During this symposium a series of presentations covering an entire gamut of Gondwana plant researches will reflect on the state-of-the-art and futuristic trends. These topics include—morphological trends in Gondwana plants, alien elements in the Gondwana Flora, changing patterns of the Permian Gondwana palynoflora, northern extension of the Indian Gondwana on the basis of palynological evidences, marker palynoassemblage zones through the Indian Gondwana sequence, and distribution and environment of Upper Permian flora and transitional Triassic flora. The recently organised Gondwana workshop on "Concept, limits and extension of the Indian Gondwana" at this same venue came out with newer ideas which have been taken up for study in the institute.

It is envisaged that the future researchers will add much more to our understanding of leaf architecture, cuticular features, fine structure of wood and climatic implications, distribution of spores and pollen in time and space, ornamentation patterns and ecological requirements.

MESOZOIC FLORA

In recent years, the question that has been engaging the minds of biostratigraphers demanding indepth research and an answer, is concerning the upper limit of the Indian Gondwana. Does it range into the Neocomian, or does it end by Norian-Rhaetian? Do we consider the Ptilophyllum Flora as an endemic Gondwana flora or did it occupy much of the Eurasian landmass? In the latter case what was the centre of its origin? These questions need be answered to precisely date the Upper Mesozoic sediments of India. Otherwise, as usual, we shall continue to depend upon far-fetched correlations with floras from different floral provinces such as the Yorkshire Flora.

Upper Mesozoic is the point of time where major diversification of plant groups took place. Cycadophytes that constituted a large part of the vegetation are now represented by a few genera. Several groups, such as, Cycadeoidales, Bennettitales, Pentoxylales, that dominated the Jurassic-Cretaceous scene became extinct no sooner than they diversified. It is necessary to study the cause of this extinction and its evolutionary ramifications. In the present symposium life and time of *Williamsonia* (Bennettitales) and evolutionary reproductive strategies of the Mesozoic plants and their endowment to the modern flora will be discussed. The discussions should help to decipher causes of extinction and evolution of newer strategies.

Several features that characterise modern angiosperms are seen in the Early Mesozoic plants. It is, therefore, very necessary to programme concentrated research on the floras of this period. We are fortunate that we have well preserved floras in the Rajmahal, Kutch, Jabalpur, East Coast of India and other areas. Though fossils occurring in these areas have been mostly catalogued, yet we have not been able to evaluate evolutionary lineages and trends.

Plant groups have appeared in spurts and their extinctions also are in spurts making both the events look dramatic. Stratigraphic boundaries are drawn on the basis of such and other events leading to event stratigraphy. Similarly, plant genera and families are artificial and only reflect our present understanding. When this becomes better and better and the criteria are refined and defined the grouping of named species, genera, etc. gets modified. Thus they always tend to remain dynamic mobile reflecting our understanding of their morphology and status in the evolutionary scale or lineage. In fossils, this is more so because, our understanding of each organ is independent of our understanding of the whole plant.

History of the origin of angiosperms is largely concealed in the Early Cretaceous and the Late Cretaceous sediments. In the recent past there have been major discoveries of early angiosperms from the Cretaceous sediments of Europe and America, but, the occurrence of authentic Cretaceous plant megafossils is yet to be recorded in the Indian sediments. This, in fact, is a challenge that needs to be met squarely. However, sporadic records of angiospermic pollen from Upper Aptian and Albian as well as from Cenomanian to Maestrichtian strata are known from the eastern and southern part of the country. Recent researches in this institute have helped to identify angiospermid pollen (aff *Clavatipollenites*) from the first intertrappean beds of Rajmahal Basin. It is essential to strengthen and widen the scope of this investigation by adopting high resolution character assessment of dispersed pollen so as to trace the antiquity, relationship and evolutionary aspects of the early angiosperms in time and space. This study would also necessitate the development of information on the possible favoured regimes, environments and climates in which the early angiosperms appeared, flourished, diversified and rose to the position of dominance.

Another interesting problem relates to the major extinctions and changes at the Cretaceous/Tertiary boundary. While the extinctions was abrupt in animal groups, the plant world witnessed hardly any mass extinction. Are these changes related to the meteoritic impact or extensive volcanic activity? These are the questions that need answers.

DECCAN INTERTRAPPEAN FLORA

The Deccan Trap episode appears to have commenced in the Terminal Cretaceous and holds the key to understand the K-T transition. The flora of the intertrappean sediments is represented by angiospermous woods, leaves, flowers and fruits, besides charophytes and marine algae. Recent studies suggest near synchroneity of the basal basaltic flows in the central, eastern and southern sectors of the Deccan Province. New palynological data integrated with palaeontological and stratigraphical data help to establish stratigraphic correlation between inland continental, marginal offshore and paralic marine sections in which the basalts themselves or their tuffaceous derivatives are encountered. Data derived from the Deccan intertrappeans do not indicate any evidence of mass extinction in the flora along the Cretaceous-Tertiary boundary.

CENOZOIC PALAEOBOTANY

The Tertiary floras register a remarkable qualitative change because of the incoming of a variety of angiosperms and by the abrupt decline of gymnosperms. The decline of gymnosperms from the position of dominance may be related to changes in climate or to the tough competition faced from the vigorously and rapidly evolving group of angiosperms or both. Systematic information on this aspect needs to be developed.

The Palaeogene flora of India has witnessed several changes, particularly during the Palaeocene-Eocene time. Several genera either migrated or faced extinction. The extinction patterns in India may be related to two main causes—(i) Latitudinal changes because of continental drift, and (ii) Palaeoenvironmental condition of sedimentation. It is possible that the relative position of Malaysia and India may have facilitated several inter-continental migrations. The available palaeobotanical and palynological data needs to be re-examined in global perspective in order to understand the possible migratory pathways particularly keeping in view the then geographic locale of the Indian sub-continent.

The Palaeogene floras in India have been quite diverse. They have been related to moist deciduous, wet semi-evergreen and tropical evergreen forests growing mostly under tropical climate. Evolution of the Neogene floras has been largely influenced by the orogeny of the Himalaya. The mid-Miocene orogeny of the Himalaya led to the proliferation of several gymnospermic groups and appearance of several subtropical angiospermic elements. At this juncture the influence of Sino-Japanese and Indo-Malayan floras and their contribution to the development of Neogene floras poses several questions. The Pliocene floral diversification is related to climatic changes and increasing continentality. Distinct floras of tropical, sub-tropical and temperate climate dry/moist/wet are known from the country The problems associated with these floras are of regionalism, endemism and migration/extinction in response to physical and climatic factors which need to be worked out indepth so as to unravel the history of the modern flora of India.

It is also essential to trace the evidences of C_4 and CAM (Crassulacean Acid Metabolism) system plants during the Cretaceous-Tertiary periods. The evolution of these plants is usually attributed to the response to atmospheric changes. Isotopic studies may suggest changing relative frequencies of photosynthetic pathways through time. This may help in understanding development of plant groups adopted to arid environments.

The Palaeocene-Eocene palynoflora is known mainly from coal and lignite deposits of Meghalaya, Assam, Kutch, Cambay, Rajasthan and other basins. This palynoflora is dominantly characterised by swamp dwellers. The Neogene sediments of India are predominantly river deposits and the change in edaphic condition could have also led to the temporary disappearance of the swampy vegetation which dominated the Early Palaeogene. This is the likely explanation for the absence of *Spinozonocolpites-Nypa* during the Upper Palaeogene and Lower Neogene. It appears again in the Quaternary sediments of India and *Nypa* is still extant in some parts of the Indian coastal areas such as Andamans and Sunderbans. This riverine depositional process might also explain the occurrence of Permian, Early Cretaceous and Palaeogene reworked pollen in the Neogene sediments. The occurrence of these reworked pollen in younger sediments have been the reason for apparent extension of some of the Palaeogene taxa into the Neogene.

The tropical Tertiary sediments are replete with a diversity of pollen types; only some of them are useful as stratigraphical and ecological markers. Distributional anomalies of taxa in East and West Coast should be analysed for deciphering provincialism, endemism and migration patterns of vegetation in the subcontinent. It is of utmost importance to identify marker fossils and catalogue them with annotated stratigraphical and ecological notes.

The age of the Cuddalore Sandstone and associated lignite deposits has been a matter of controversy. It has been suggested that typical Eocene palynofossils recorded from the subsurface of the Cauvery Basin occur in the Neyveli Lignite and the lower age limit of the Cuddalore Sandstone may extend to Eocene and the formation may be time transgressive. Recent palynological data suggest a Late Palaeocene to Eocene age to the Neyveli Lignite deposits. Such palynological investigations on Ratnagiri, Kerala and Rajasthan lignites on the West Coast and associated sediments will help to correlate different sedimentary sequences and for preparing palaeogeographical reconstructions.

Using an integrative approach Siwalik sediments exposed in the Himalayan foot-hills and in Nepal were recently studied. The plant micro- and mega-fossil data integrated with palaeomagnetic and stratigraphic data indicate semi-evergreen vegetation and fresh-water swampy conditions of deposition. Such efforts are further needed in many basins.

Some of the presentations in this Symposium will discuss—Palaeogene-Neogene flora of peninsular India, Himalayan orogeny and Tertiary flora, Stratigraphy of Tertiary palynological succession in northeastern and western India and palynology, palaeoecology, correlation and age of Neyveli lignites and associated sediments. I am optimistic that these presentations will definitely create more awareness to formulate better research programmes.

QUATERNARY VEGETATIONAL PATTERNS

Study of palaeoclimate and phytogeography of the Quaternary period involves an interdisciplinary approach that involves Geology, Meteorology, Oceanography, Geophysics, Geochemistry, Archaeobotany, Palynology, Tree-ring analysis, etc. Data obtained from these varied disciplines are integrated and ultimately understood in geochronological frame work. In India, investigations for understanding palaeoclimates have been carried out on Quaternary deposits in parts of the Himalaya, the arid zone of Rajasthan and some parts of western India.

The time scale considered to be meaningful for understanding different aspects of the climatic problem are 0-1,000 years, 0-30,000 years and 0.1 Ma. The interval of 0-30,000 years is considered to be the most important as the effects can be examined during a major change in climate. Here the ^{14}C dates provide a geochronological frame work for precise interpretations. Phytogeographic and palaeoclimatic models based on plant megafossils, palynofossils and tree-ring analysis need to be designed to unravel the record of the last 40,000 years.

Studies of past climates provide opportunities to examine the interaction between the atmosphere, oceans, cryosphere and the land surface. Climatic changes have a direct bearing on the evolution of the biosphere, evolution of man and his cultures. Palaeoclimatic research documents changes in floral development, sedimentological indices and geomorphological parameters as a consequence of atmospheric variations. Often it is necessary to correlate clay layers within sandstone bodies to identify water-bearing horizons in a basin. Palynology can help in working out a unified biostratigraphic zonation for the aquifers.

The tree-ring studies offer an exciting opportunity for lengthening and extending the spatial coverage of high resolution information which will specially be useful in studying decadal to century scale climatic variations. Conifers have distinct annual growth-rings which show a high degree of environmental sensitivity. In tropics, teak has the potential for the reconstruction of past rainfall. These studies may provide information about the glacial/interglacial phases of the recent past and their probable feedback links to the monsoon climate.

High resolution palynostratigraphy can help work out history and causes of deterioration of the mangrove ecosystem. In deltaic sediments of Bengal and Orissa dated 6,000-7,000 years B.P. and younger, pollen analysis has brought out phases of mangrove development and deterioration. Human influence on the deterioration of mangrove ecosystem is recorded at 3,000 years B.P. resulting in soil erosion and subsequent degeneration of mangrove forests.

The Shola forest that established itself in the south Indian montane region started gradually receding around 7,000 years B.P. Palynological studies suggest that anthropogenic factors were probably responsible for such deterioration. Pollen researches on Sat Tal, Naukuchia Tal, Bhim Tal and Rewalsar Lake areas helped to reconstruct the climate of these regions. Likewise pollen studies on forests of Annamalai Hills, Silent Valley, Chilka Lake contributed to understand ecosystem changes. Similarly, palynological studies on Rajasthan Desert suggest the existence of arid conditions and strong winds around 20,000 years B.P.

Various aspects of tree ring researches, palaeoclimatic oscillations in western Himalaya, Holocene history of mangrove vegetation, and patterns of vegetation in the inter-montane Kashmir Basin will be discussed during the following days and I am sure that the presented data will serve to prepare palaeoecological models.

Additional data will be generated in coming years to understand the glacial/interglacial phases of recent past and their probable link with the past climate. Data on fine resolution palynostratigraphy will throw light on palaeoenvironments. Computer aided programmes should be formulated for ecological modelling and related aspects.

ARCHAEOLOGICAL PLANT REMAINS

Plant remains, such as seeds, fruits, cuticles and wood charcoal of cultivars, weeds and wild species recovered from archaeological excavations provide information about the subsistence pattern of a cultural level. Through archaeobotanical investigations it is possible identify plants that are endemic to India and those that have been introduced from alien cultures. These studies reflect on agriculture, forestry, medicine, economics and culture of the society at that particular period of time and thus help write the chronological history of interaction between Man and Biosphere.

Archaeobotanical studies have helped to identify grains of wild and cultivated rice from the Neolithic levels, 7-6 millenium B.C., at Koldihwa near Allahabad, which constitute the earliest record of cultivation of rice in the world. Finger-millet has been found at Hallur in Karnataka around 1,800 B.C. Signatures of viticulture by the Harappans at Rohira in Punjab have been found in the form of grape seeds and vine-stem charcoals. The Harappans who populated the area around 2,300-2,000 B.C. also maintained ornamental plants and grew vegetable crops. Cultivation of drug-yielding plants is noticed at 1,000-200 B.C. in the Ghaghra Valley.

The presentation on the archaeological plant remains in ancient cultural and socio-economical dynamics of the Indian subcontinent will reflect some of the recent trends in archaeobotanical, ecological and ethnographic studies.

BIOPETROGRAPHIC STUDIES

Fossil fuels are non-renewable resources and need planned exploration and exploitation. This necessitates the need of an indepth knowledge of coal and lignite characterization and rank assessment, to understand their economic suitability for specific application in a particular industry or area. The information can be acquired mainly through chemical and biopetrographic studies. Biopetrographic methods have a distinct advantage over chemical assessment, as these provide requisite information in a relatively shorter time and through much simpler techniques using light microscopes.

Biopetrographic assessment of Permian and Tertiary coals is expected to provide information regarding the nature, rank and abundance of various maceral groups. A relative position of maceral groups and rank will in turn help in determining various properties of coal, particularly the coking potential for working out a blending scheme between high grade and low grade coals, which can help in substantially increasing the life of prime coking coal reserves of the country. Further, the dominance of hydrogen-rich liptinitic contents in a particular coal is likely to indicate its suitability for liquification (hydrogenation).

Studies on the biodiagenesis of lignites will help in deciphering coalification trends, genesis, palaeoenvironmental condition and economic suitability of a deposit. In addition to this, dispersed organic matter (D.O.M.) studies on some oil source rocks are designed to enhance our understanding regarding the evolution of source material under various processes of degradation. Recent organic petrological studies on Raniganj (Permian) coals suggested susceptibility of these coals to spontaneous combustion. Spectral fluorescence studies on coals help to distinguish resinite types. More efforts are needed to delineate various stages in organic matter maturation.

Some of the presentations in the present symposium deal with—Himalayan coals, their nature, formation, composition and rank; temporal and spatial variation of the type and rank of Gondwana coals and genesis of Indian Tertiary coals and lignites.

FOSSIL FUEL SOURCE ROCK STUDIES

Most of our coalfields are confined to the Palaeozoic and Tertiary basins whereas the known oilfields are restricted to the Tertiary basins only. Recently, hydrocarbons have been discovered in the Cambrian sediments of Rajasthan. Palynostratigraphic, palaeoecological and source rock studies of the fossil fuel-bearing strata are very important. It is necessary to establish a large data base.

Professor Birbal Sahni while requesting Prime Minister Jawaharlal Nehru to lay the Foundation-Stone of the Institute of Palaeobotany highlighted the importance of fossil plant studies in coal and oil exploration and said "...*Today the study of fossil plants, pursued with modern techniques and with due regard to its repercussions upon all the bordering sciences, already occupies a respectable place among the sciences and fully deserves the support that it is now receiving all over the world. It not only allows us glimpses into the evolutionary history of plants, but helps us more and more accurately to tell the ages of strata and thereby to explore the mineral wealth of the earth, particularly coal and oil.*" Now we know that palynological study helps to understand and correlate coal and hydrocarbon bearing sediments. Palynofossils and other vegetal remains of the past also help interpret ancient environmental condition favourable for organic matter accumulations and their conversion to fossil fuels by transformation and subsequent thermal alteration. Quantitative distribution of palynofossils mostly determines the approximate location and configuration of near-shore marine deposits which happen to be the locale for formation and accumulation of hydrocarbons. Generation of hydrocarbons is related to the occurrence and nature of organic matter in source sediments. The main source for hydrocarbons is vegetal debris including phytoplankton, marine and terrestrial algal and lipid-rich land plant remains. Palynology affords an effective tool in stratigraphic geology and can be exploited in tapping organic fuel resources. Evaluation of hydrocarbon source rock potential necessitates recognition of type and amount of organic matter contained in the sediment and the level of thermal alteration.

Biozonation, correlation and dating of sedimentary formations on the basis of dinoflagellate cysts, nannoplankton are emerging as useful tools in identifying promising hydrocarbon rich sediments. Such studies are already in progress on the sediments of Cauvery, Palar and Krishna-Godavari basins and Meghalaya areas. Marine Cretaceous-Tertiary deposits encompassing reefoidal limestones reflect algal life and their role in carbonate sedimentation.

Some of the presentations in this symposium are related to fossil dinoflagellate cysts, siliceous microfossils, nannofossils and calcareous algae and the data will help to demonstrate their utility in establishing time boundaries, sedimentary environments and palaeo-oceanographic interpretations.

Integrated palynological research involving spore-pollen-phytoplankton studies, organic matter facies using both transmitted and reflected light microscopy is needed to decipher environmental and source rock regimes. This new dimension will certainly augment interpretative palynological study.

To sum up I quote Professor Sahni (1922) "*The rapid expansion of the domain of botany within the last few decades makes it impossible for any one of us to keep a vigilant eye on all the newly acquired territory. While this tends to restrict our fields of activity, and inevitably deprives us of a certain width of outlook it has, let us hope, brought a corresponding gain in a power of critical vision. But from time to time, and of late more often than heretofore, it becomes necessary for us, lest we become permanently short-sighted, to lift up our eyes and cast at the horizons of the kingdom.*

Even of our little province, occasional bird's-eye views, divested of confusing detail, will not infrequently be of value for they will help in tracing the main directions of past work; in bringing out in relief lines of work that have borne fruit; and, above all, in striking out new paths into obscure and more promising fields".

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