Palaeobotanist 49 (2000) · 151-162
0031-0174/2000/151-162 $2.00

Palaeobotanical contributions of BSIP in North-East India : A status report

BIRBAL Sahni Institute of Palaeobotany (BSIP), founded in 1946 at Lucknow by Professor Birbal Sahni's efforts, is the nodal centre for palaeobotanical and palaeo-palynological researches in India. The main objectives of the Institute are:

- To develop scientific application in palaeobotany, including palaeopalynology, in all its botanical and geological aspects,
- To constantly up date the data for international interaction with allied disciplines in earth sciences.
- To co-ordinate with other knowledge centres in areas of mutual interests, such as early life, vegetation dynamics, climate modelling, exploration of fossil fuels, conservation of forests, etc. and
- To publish journal (*Palaeobotanist*), monographs, catalogues, etc. and to disseminate the scientific knowledge all over the world keeping its high international standard.

Palaeobotany—study of the past vegetation, the common ground between Botany and Geology, not only allows glimpses into the evolutionary history of plants but helps us to infer the ages of rock strata and thereby explore the mineral wealth of the earth, particularly coal and oil, to picture the geography of the past and to understand geobiospheric changes over the eons. All these are due to multi-disciplinary approach adopted in palaeobotanical researches and use of modern techniques. Palaeobotanists are training themselves to combine aspects of Botany and Geology and also closely interact with several allied sciences to meet the challenges of multidisciplinary science.

During the early phases, the research activities of the BSIP laid emphasis on the composition of the Indian fossil floras, the form and structure of different taxa, and their distribution in time and space. Gradually, the research activities diversified to encompass for building up palaeoecology and history of the past vegetation and also to understand the genesis of coal/lignite. Attention was also paid to phylogeny and evolution. Biostratigraphic dating of sediments, correlation of surface and sub-surface sections and location of favourable areas for oil/coal prospecting assumed added importance. Currently at the Institute, the studies of fossil plants and palynomorphs and composition and rank of the coal are pursued with modern advanced microscopes and other sophisticated instruments (SEM, Ultracut microtome, MPV-3 microscope, etc.).

The seven states, viz., Assam, Meghalaya, Arunachal Pradesh, Mizoram, Tripura, Manipur and Nagaland, popularly known as 'seven sisters' constitute North-East India. It still has vast unexplored terrain. The palaeobotanical researches were initiated during the formative years of BSIP. Later it constituted a major Thrust Area Programme.

The first record of fossil plants in North-East India dates back to 1928, when Professor Birbal Sahni documented the plant remains from the Tertiary beds of Assam. Later, during 1943-47 Professor Sahni and his associates R.V. Sitholey and G.S. Puri put forth the evidence of plant microfossils (viz., pollen, spores, cuticles, microforaminifera, etc.) in various Cenozoic Tertiary horizons of Assam. The main aim was to study the importance of microfossils in lithostratigraphic demarcations as well as their importance in exploration of hydrocarbons in oil-bearing rocks of the region. This work was first undertaken on behalf of Burmah Oil Company, in connection with an oil exploration programme.

The sedimentary sequences of North-East India have yielded large number of petrified woods, impressions of plant leaves and numerous variety of palynomorphs. Although the occurrence of fossil plants in the region was known since long (Sahni, 1928; Sahni *et al.*, 1947; Lakhanpal, 1948, 1952) but systematic study of these fossils was undertaken at BSIP during late sixties. Since then about 30 scientists from BSIP have worked on various aspects of Palaeobotany in North-East India, of which many have worked for Ph.D. degree also.

At present 15 scientists are involved under various research programmes categorised under following thrust areas:

1. Gondwana supercontinent: regional geology, floristics, terrane accretion, plate tectonics and configuration,
2. Floristics of petroliferous basins,
3. Biopetrology of coals in relation to coal bed methane, and
4. Quaternary vegetation, climate and monsoon.

Under these thrust area programmes studies on fossil microflora for establishing biozonation, correlation, age determination and time boundaries are being carried out. The morphological and anatomical studies of plant megafossils from Pre-Tertiary and Tertiary sequences, interpretation of data for palaeoecology, palaeoclimate and palaeogeography and to trace out the floristic evolution of plant and reconstruction of palaeovegetational scenario are also the objects of these studies. In addition to this, characterisation of coals from

North-East India are also being pursued to assess the quality and rank besides ascertaining their depositional environment.

SIGNIFICANT CONTRIBUTIONS

Some of the significant contributions on plant fossils, spores-pollen analysis and coal petrology made by the scientists of BSIP in North-East India are as follows:

Gondwana (Permian) Sequence

- Palaeopalynology and palynostratigraphy of coal and associated sediments in detail from Siang District, Arunachal Pradesh.
- Discovery of faunal coal balls from Siang District; suggests the autochthonous nature of deposition.
- Recovery of palynofossils, forams, chitinozoa-like fossils, scolecodonts, conodonts and acritarchs from the coal balls; indicates the lagoonal facies with intermittent marine incursions.
- Gondwana equivalent plant megafossils are recorded from Bhareli Formation, West Siang District, Arunachal Pradesh.
- Biopetrology of coals from Kameng District, Arunachal Pradesh, indicates abnormal properties developed due to prolonged tectonic disturbances during the latter phases of Himalayan orogeny.

Mesozoic (Cretaceous) Sequence

- Late Cretaceous palynofossil assemblages were recorded from Gumaghat and Mahadek formations in Meghalaya.
- Late Maastrichtian-Early Danian marker dinoflagellate cysts and calcareous nannofossils were discovered across K/T boundary.

Cenozoic (Tertiary) Sequence

- Palaeopalynology of Palaeocene-Miocene sediments in detail from Assam and Meghalaya for biostratigraphic zonation.
- Palynology of Kharsang well-2, Duarmara-2, Nahorkatia-1, 263, 268 in which commercial reserves of petroleum was proved by Oil India Limited.
- Documentation of dinoflagellate cyst assemblages from Palaeocene-Oligocene sequences for age determination and correlation.
- Record of leaf compressions of mango from Tura Formation, Garo Hills, Meghalaya; suggests that mango originated in North-East India during Palaeocene.
- Fossil woods were discovered from Tipam Group of Mizoram.
- Biopetrology of Oligocene coals in detail from Upper Assam and Nagaland and Late Palaeocene coals from Jaintia Hills, Meghalaya; suggests their genesis to be influenced by putrefaction rather than normal humification process.

SUMMARY OF RESEARCH WORK

The following account summarizes the palaeobotanical, palynological and coal petrological researches carried out in North-East India at BSIP. The major geological sequences (related to the studies) developed in this part of India have been compiled from published literatures (C.S. Raja Rao, 1981- *Coalfields of Northeastern India*, GSI Bull. Series A, No. 45; L.L. Bhandari *et al.*, 1983- *Petroliferous basins of India*, Petrol. Asia J., Vol. VI (4), ONGC).

Gondwana Flora

The Permian Lower Gondwana sediments in the extra-peninsular region of India occur as detached outcrops in the frontal zone of the eastern Himalayan foot-hills, window zone of Sikkim and from the Tethyan domain of Kashmir, Spiti, Nepal and Sikkim. In the eastern Lesser Himalayan Zone the Permian sediments are developed into well-defined tectonic belts known as 'Schuppen belt' in Darjeeling and Jalpaigudi areas in the northern part of West Bengal and continues further east as a persistent litho-tectonic unit in Arunachal Pradesh. These sediments are also exposed in the inner tectonic belt as isolated tectonic windows in the Rangit Valley of Sikkim and Kuruchu Valley in Bhutan.

The generalized sequence of Permian sediments in North-East India is as follows:

Abor volcanics
Bhareli Formation
Gensi Formation
Garu Shale
Rangit Pebble Slate
----------Unconformity----------
Miri Formation

The Permian sediments in Arunachal Pradesh occur as superficial nappe overriding the autochthonous Siwalik Group (Miocene to Oligocene) along the Main Boundary Fault (MBF) and are in turn overridden by the older rocks of Miri Formation along a prominent thrust as a result of which the sediments are highly deformed and exhibit gross lithological variation. The general dip of the rocks is towards north bringing apparently the younger rocks under the older ones near the thrust.

The palynological studies carried out in Lesser Himalayan sedimentary sequences in North-East India are by Dutta *et al.*

(1988), Srivastava *et al.* (1988) and Srivastava and Bhattacharyya (1990, 1996). They recorded several trilete, monolete spores and monosaccate pollen from Siang, Kameng and Subansiri districts in Arunachal Pradesh. Anand-Prakash *et al.* (1988) described the occurrence of faunal coal balls and later Srivastava and Bhattacharyya (1998) recorded Early Permian palynofossils from the coal balls of West Siang District. Singh and Bajpai (1990) reported some plant megafossils from the Lesser Himalayan sedimentary sequences of the region.

The inferences drawn on the basis of pollen assemblages and mircofossils, like acritarchs, foraminifera, scolecodonts, conodonts and chitinozoa-like structures, suggest that these sediments in Siang and Subansiri districts were deposited in marginal swamps that were subjected to periodic marine incursions. The occurrence of coal balls further indicates that at least the Permian sediments in Siang and Subansiri districts are autochthonous in nature and contrary to the Permian sediments of peninsular India which are believed largely to be allochthonous deposits. These studies further suggest a closer link with Fossil Cliff Formation and Calythara Formation of Early Permian in Australia. A palaeophytogeographic provincialism between Northeastern India and Western Australia is also suggested on the basis of above data. Further studies are required to assess the floral provinces which might throw light on configuration of Gondwana continents.

Plant megafossils from West Kameng District, Arunachal Pradesh indicate the presence of true representative of *Glossopteris* flora (Tewari & Srivastava, 2000). The flora is recorded by one species of *Gangamopteris, Noeggerathiopsis, Samaropsis, Vertebraria* and ten species of *Glossopteris* and compares with the floristic composition of Lower Barakar Formation of peninsular India.

Under IGCP Project-411 on Geodynamics of Gondwanaland derived terranes in East and South Asia, palaeogeographical distribution of plant fossils from North-East India and other south-east Asian regions, viz., China, southern Tibet, Malaysia, Thailand, New Guinea, Kashmir, Bhutan were examined (Srivastava & Tewari, 1999). The study indicates that shifting of terranes and palaeogeographical position of microcontinents are related with the presence of mixed floras during Permian in south-east Asia.

Mesozoic Flora

The Cretaceous sedimentary sequences exposed in the southern part of the Shillong Plateau is given below:

Langpar Formation
Mahadek Formation
Jadukata Formation
Sylhet Trap

The outcrops of Sylhet Trap in Garo Hills have been correlated with Rajmahal Trap and has been assigned Lower Cretaceous age. Kar and Singh (1986) recorded some Middle-Late Cretaceous palynoflora from Gumaghat and Mahadek formations from Meghalaya.

Investigation on marine phytoplankton (dinoflagellate cysts and calcareous nannofossils) has been carried out from Dawki, Cherrapunji and Therriaghat areas of Khasi Hills, Meghalaya by Jain *et al.* (1975), Jain and Garg (1991) and Garg and Jain (1993, 1995, 1996). These studies have provided the required refinement in age control and have helped in precise demarcation of Cretaceous-Tertiary Boundary (KTB) in the Um Sohryngkew Section. Documentation of Global Zonal Markers amongst rich nannofossil and dinocyst assemblages across iridium-spike bearing clay layer illustrates definite presence of Terminal Maastrichtian and basal Danian sequence in this section (Garg & Jain, 1995, 1996).

Cenozoic Flora

The Cenozoic rocks cover about 70% of the area in North-East India and it has the biggest onshore receptacles of Palaeogene-Neogene sediments. The palynostratigraphic, palaeoecologic and source rock studies in this area have helped to establish a large data base for facies analysis, age determination and correlation of rocks for oil and coal-bearing sedimentary sequences. Some of the papers in this volume (by Kar; Saxena, etc.) provide detail information on palynological investigations of Tertiary sedimentary sequences of North-East India.

In the Tertiary deposits of Assam-Arakan Basin there is a distinction between a shelf facies and a geosynclinal facies; this is more pronounced in the Lower Tertiary than in the Upper. The shelf facies occurs beneath the western part of the Bengal alluvium, in the Shillong Plateau, in part of the North Cachar Hills, in the Mikir Hills and beneath the alluvium of Upper Assam. The geosynclinal facies occurs in Arakan, the Surma Valley, Manipur, part of the North Cachar Hills, and the Naga Hills.

The states of Assam, Meghalaya and adjoining territories of Nagaland, Arunachal Pradesh are endowed with coal-bearing formations. The coal belts of Garo and Khasi Hills of Meghalaya and Mikir Hills of Assam formed on platform areas peripheral to the shield. The major stratigraphic divisions of Tertiary sedimentary sequences (known as Jaintia Series) in these stable shelf areas are as follows:

Kopili
Sylhet Limestone:
  Prang Limestone/Siju Limestone
Nurpuh Sandstone |
Umlatdoh Limestone | Tura Sandstone
Lakadong Sandstone |
Lakadong Limestone
Therria Sandstone

The coalfields of Upper Assam, Nagaland and Arunachal Pradesh, formed in the peri-cratonic down-warps in a zone of 'Schuppen'. The coal measures (exposed in a narrow linear belt) flanking the Naga-Patkoi hills, extend from Haflong in the SW to Namchik-Namphuk in the NE. Considerable search for oil in Upper Assam (Oligocene and Miocene productive horizons) has also been carried out in parts of this belt of 'Schuppen'. This mobile belt is characterised by intense orogenic movements during Tertiary geotectonic cycle. The regional frame work of the Tertiary sediments in the area is given below:

Alluvium	
----------Unconformity----------	
Dihing Group	Plio-Pleistocene
Dhekiajuli beds	
Dupi Tila	Mio-Pliocene
Namsang beds	
----------Unconformity----------	
Tipam Group	Miocene
Girujan Clay	
Tipam Sandstone	
Surma	
Bokabil	
Bhuban	
----------Unconformity----------	
Barail Group	Oligocene
Tikak Parbat Formation	
Baragolai Formation	
Naogaon Formation	
Disang Group	Eocene
Jaintia Series:	to
Kopili	Palaeocene
Sylhet	
Therria	
Langpar	

The occurrence of palynofossils and its importance in Miocene sediments of Upper Assam was proved by Professor Sahni and his associates during 1943-47. Bose and Sah (1964) recorded mega- and microfossils from Laitryngew coal seam, Meghalaya. The palynostratigraphical studies in Cherra Formation of the Shillong Plateau were carried out by Sah and Dutta (1966, 1968, 1974) and Dutta and Sah (1970, 1974). Based on qualitative and quantitative analyses of the recorded palynoassemblages, three palynozones were identified in this sedimentary formation and one palynozone in the overlying Lakadong Limestone. Significant contributions to the palynology of Tura Formation, Garo Hills have been made by Sah and Singh (1974), Singh (1977), Singh and Singh (1978), Saxena *et al.* (1996) and Tripathi *et al.* (2000).

The age of the Tura Formation as well as that of the Cherra Formation, both forming the basal succession of the Tertiary in the marginal portion of the Shelf (Sah & Kar, 1972) was disputed since long. The correlation of strata based on microfloral assemblage indicates a close correspondence between the two and a Palaeocene age was assigned. Palynostratigraphical investigations demonstrate a 'striking parallelism' in the palaeogeographical development of the southern foot-hills of the Garo, Khasi and Jaintia Hills of Meghalaya during Palaeogene.

Palaeocene-Miocene succession exposed along the Jowai-Sonapur-Badarpur Road, shared by Meghalaya and Assam, was investigated palynologically by Sein and Sah (1974), Tripathi and Singh (1984, 1988), Singh and Tripathi (1986), Trivedi (1985), Rao *et al.* (1985), Singh *et al.* (1986) and Saxena *et al.* (1987, 1996). Cenozones were established in this road section and palaeoenvironmental interpretations were made. Kar and Kumar (1986) established two cenozones in Lakadong Sandstone of Khasi Hills, Meghalaya. Mandal (1987) and Kumar (1994) described palynoassemblages from coal and associated sediments of Lakadong Sandstone of Jaintia Hills, Meghalaya. Mehrotra (1981, 1983) and Mehrotra and Sah (1981) published palynostratigraphical works on the Mikir Formation of Mikir Hills, Assam.

Rao (1986), Rao *et al.* (1985), Saxena *et al.* (1987), Singh *et al.* (1986, 1991) and Mandaokar (1993, 1995) recorded Oligocene palynofossils from Jowai-Badarpur Road section, Jaintia Hills and Makum Coalfield, Assam. Kar (1990-91) studied Mio-Pliocene palynoflora from sub-surface sediments of Gojalia, Baramura bore-core. Kar *et al.* (1994) studied palynofossils from Nahorkatiya, Duarmara and Kharsang bore-cores and deduced the age of various sedimentary sequences on the basis of marker palynotaxa. Later oil occurrence was reported in Kharsang area.

Lower to Middle Eocene microfossils were recorded from West Siang District, Arunachal Pradesh (Jain & Dutta, 1978). Dutta and Jain (1980) documented dinoflagellate cysts assemblage from Jaintia Hills and suggested demarcation of Palaeocene-Eocene Boundary at the contact of Lakadong Sandstone and Umlatdoh Limestone.

The Middle Siwalik palynofloras from Arunachal Pradesh covering the Kameng, Subansiri and Siang districts were described by Singh and Tripathi (1990). Early Tertiary palynotaxa from different successions exposed in Siang District were reported by Tripathi and Singh (1992).

Plant fossils of North-East India are known from the following formations:

Tura (Garo Hills, Meghalaya)
Lakadong Sandstone (Khasi Hills, Meghalaya)
Tikak Parbat (Makum Coalfield, Tinsukia District, Assam)
Tipam Sandstone (Assam, Nagaland, Tripura and Mizoram)
Girujan Clay (Tirap District, Arunachal Pradesh)
Namsang (Deomali, Arunachal Pradesh)

Upper Tertiary sediments (Siwalik – Siang District, Arunachal Pradesh)

The first two formations are of Upper Palaeocene to Lower Eocene in age, while the third one is of Oligocene. The fourth and fifth belong to Middle Miocene and Upper Miocene respectively, whereas the last two formations range in age from Miocene to Pliocene. The Palaeogene flora is mostly represented by fossil leaves and occasionally by fruits and seeds, while the Neogene flora is dominated by fossil woods.

Lakhanpal (1955, 1956) first described a few leaf impressions from the Tura Formation of Damalgiri, Garo Hills. Later on Bose and Sah (1964) described a palm leaf from Lakadong Sandstone of Cherrapunji, Khasi Hills. Ambwani (1992) updated the flora by adding some more new forms. Recently, Mehrotra *et al.* (1998) recorded leaf impression of *Mangifera* (mango) from Tura Formation, Garo Hills and they opined that mango originated in North-East India during Palaeocene.

A rich plant fossil assemblage from Oligocene deposits (Tikak Parbat Formation) of the Makum Coalfield was described by Awasthi and Mehrotra (1995), which indicates the existence of tropical evergreen to moist deciduous forests in the vicinity during the period. Presence of mangrove elements in the assemblage is suggestive of deltaic, lagoonal deposition of coal seams and associated sediments in the region.

The early part of the Neogene flora is very characteristic as this was the time when maximum floral diversification and exchange occurred in North-East India. During the Early Miocene the Indian Plate had established its land connection with the Asian Plate. As a result a number of new families appeared in this part of the country. Amongst them Dipterocarpaceae is very important as it is considered as the marker of Neogene of India. It is generally believed that it originated in south-east Asia from where it spread in all the directions and reached India via Myanmar. Plant megafossils from the Tipam Group of Assam, Nagaland, Mizoram and Arunachal Pradesh are reported by Prakash and Tripathi (1968, 1969, 1970, 1974, 1975), Prakash and Awasthi (1970, 1971), Prakash and Lalitha (1978), Lalitha and Prakash (1980), Awasthi and Mehrotra (1990, 1993, 1997) and Prakash *et al.* (1994). There was no major change in the floral composition during Pliocene except the addition of a few more taxa (Singh & Prakash, 1980; Lakhanpal *et al.*, 1981; Awasthi & Mehrotra, 1993).

The floral assemblage suggests that a tropical evergreen to moist deciduous forests existed during Neogene also. However, certain taxa disappeared from this part of India after Pliocene. Several Malayan and African elements entered India during Miocene and flourished here under the equable climate until Pliocene. Then suddenly by the end of Pliocene they got extinct not only from this region but from the entire Indian subcontinent due to the gradual decrease in mean annual temperature and precipitation, probably caused by further uplift of Himalaya and northward sinking of the Indian Plate. Being sensitive to the changing environments these taxa which were growing so luxuriantly in North-East India failed to regenerate thereafter (Awasthi & Mehrotra, 1997).

The Indian flora during Palaeocene-Eocene has witnessed significant changes. During this period a number of taxa either migrated or faced extinction. This may be associated with the relative position of the Indian subcontinent permitting migration of floras. Palaeobotanical data is to be generated to trace the migratory pathways.

The Neogene flora in India has been largely influenced by the orogenic activities, especially the Himalayas which witnessed frequent climatic changes during this period. As a result regionalism, endemism and migration/extinction of floras are observed. An in depth study is required to trace the history of the modern flora of India.

Coal Petrology

In Northeastern India workable coal deposits are associated with the Tertiary sediments of Late Palaeocene Lakadong Sandstone Member, Sylhet Limestone Formation and Middle Member of Tura Formation, Jaintia Group, respectively in Khasi, Jaintia and Garo Hills of Meghalaya and Oligocene Tikak Parbat Formation, Barail Group in Assam, Arunachal Pradesh and Nagaland. In addition, Gondwana coals are found in Elephant Flat area of Kameng District, Arunachal Pradesh.

Misra *et al.* (1987) studied moderately to highly crushed Gondwana coal samples from Elephant flat area. The rank of the coals on the basis of reflectance analysis (Ro max. 2.0-2.3%) was found to be of semianthracite stage. Their macerals were highly homogenized and became markedly anisotropic, besides the liptinite macerals were difficult to identify. On the basis of coal characteristics, it was presumed that the coals were formed in a humid climate within a deltaic regime and the site of vegetal accumulation experienced occasional marine incursions due to tectonically controlled subsidence during the peat formation. A prolonged tectonic disturbance in the area during the later phases of the Himalayan orogeny was inferred to be responsible for the abnormal properties (in comparison to normal Gondwana coals) developed in these coals.

Navale and Misra (1979) carried out a preliminary petrological study of Tertiary coals from Dilli-Jeypore Coalfield. Later, Misra (1992) and Misra and Ahmed (2000) made detailed petrographic investigations, both under normal and fluorescence modes, on Oligocene coals from Makum and Dilli-Jeypore coalfields, Upper Assam and Borjan (Nazira) Coalfield, Nagaland and Late Palaeocene coals from Bapung, Sutunga and Jarain areas in Jaintia Hills.

The coals are bright unbanded and rich in vitrinite with common to frequent association of framboidal and granular pyrite (syngenetic/biogenic) and calcite (syngenetic) concretions. Structured and non-structured inertinites (fusinite and semifusinite) are normally in subordinate amounts, however sometimes, especially in the coals of Garo and Jaintia Hills, they are rather in moderately high proportions. In general, clastic minerals are only in low amount. In these Tertiary coals desmocollinite, perhydrous vitrinite (sapropellinite-II and humosapropellinite), liptodetrinite and resinite macerals constitute the major proportion by volume. Alginite (*Botryococcus*) maceral is also present sporadically in most of the studied coals. The maceral assemblage recorded in the coals suggests their genesis to be influenced by putrefaction rather than normal humification process as is the case in normal humic coals. The rank of the coals on the basis of vitrinite reflectance ranges between high-volatile bituminous C and B stages (Misra, 2000).

Bright unbanded coals with high to very high vitrinite, poor sporinite contents and common to frequent occurrence of fungal remains are indicative of their formation predominantly from deciduous angiospermous forest vegetation associated with mangrove plant communities under humid tropical climate. The peat formation proceeded in an anoxic alkaline mileau under subaqueous conditions in near-shore back swamps and lagoons (Oligocene coals) as well as in estuarine back swamps (Late Palaeocene coals).

Quaternary Palynology

Palynological study on recent sediments of North-East India is very sporadic. Pollen analysis of two samples from Upper Pleistocene sediments by Gupta (1971) depict a composition of Assam subtropical hill forest in Tockalai region during the time. On the basis of pollen spectra from Khasi and Jaintia Hills areas of Meghalaya, Gupta and Sharma (1985) found that the general pattern of forest types has been faithfully represented in modern sediments of the region.

Pollen analytical results from sediments of Mikir Hills, Assam (Bera, 2000) reflect a mixed assemblage of cryptogams and phanerogams. The phanerogams are of subtropical to temperate in origin. Although the study of sediments does not fully cohere with the present day set-up of vegetation, the permutation and combination of pollen data would be valuable for tracing the Quaternary vegetational history and changes in the palaeoclimate and ecology in and around Mikir Hills.

The data generated through mega- and microfossils, dispersed organic matter (DOM) and coal petrological studies from Northeastern India requires further inter-disciplinary interaction for the source rock evaluation and exploitation of hydrocarbons and solid fossil fuel in the area. Efforts are continued for inter-institutional collaborative research programmes at Birbal Sahni Institute of Palaeobotany with other advance research centres like Geological Survey of India, Coal India Limited, Oil India Limited, Oil and Natural Gas Commission, Wadia Institute of Himalayan Geology, National Geophysical Research Institute, etc. in order to evaluate the source rock potential on the basis of palaeobotanical studies.

FUTURISTIC APPROACH

- Further palaeobotanical studies are required to assess the floral provinces which might throw light on configuration of Gondwana continents.
- Extensive and intensive investigations are required to search the precursors of the Gondwana flora.
- Detailed study of marine phytoplankton and palynofacies from Late Cretaceous-Palaeogene sequences for dating, correlation, precise demarcation of time boundaries and palaeoenvironment.
- An in depth study is required to trace the history of the modern flora of India.
- Detailed biopetrographic investigation of Tertiary coals to ascertain their genesis and economic suitability and to ascertain the prospect of oil shales in Cenozoic sediments.
- Inter-disciplinary interaction and inter-institutional collaborative research programmes are being planned.

This special issue of the *Palaeobotanist* embodies the results of the studies carried out at BSIP during the last few years. Some papers are review of the earlier work and others are based on new data emerging from the extensive studies done by the scientists of BSIP. We hope that the students and researchers involved in the studies of North-East India will find the present issue a most comprehensive palaeobotanical account.

Acknowledgements—*We are thankful to AK Srivastava, RK Saxena, Rahul Garg, BK Misra, SKM Tripathi, RC Mehrotra and SK Bera of BSIP for providing the information.*

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