Annual Report

2016-2017



Birbal Sahni Institute of Palaeosciences, Lucknow

An Autonomous Institute under Department of Science & Technology
Government of India, New Delhi



BSIP at a *Glance*

Prof. Birbal Sahni, FRS established the Institute in the year 1946 for development of the science of Palaeobotany visualizing its potential to understand the origin and evolution of plant life, and to use the knowledge of fossil plants in resolving various geologic problems, including exploration of fossil fuels. The Institute is named after him as the Birbal Sahni Institute of Palaeobotany (BSIP). It is devoted to develop both basic and applied aspects of Palaeobotany, and has adopted an integrated and multidisciplinary approach for fulfilling its aim and objectives:

- to develop palaeobotany, including palaeopalynology, in all its botanical and geological aspects,
- to constantly update the data for interaction with allied disciplines,
- to co-ordinate with other knowledge centres in areas of mutual interest, such as early life, exploration of fossil fuels, vegetation dynamics, climatic modelling, conservation of forests, etc., and
- to disseminate palaeobotanical knowledge.

BSIP's main mission is to achieve excellence in R&D work through a dedicated scientific team and continuous development of palaeobotany through integrated scientific approach with innovative ideas in basic and applied research; interpret the data gathered in relation to plant life evolution and geological processes; and to understand environmental evolution through time.

Initially, the Institute laid emphasis on fundamental aspects of Indian fossil floras. Later, the research activities were diversified to include biostratigraphic dating, correlation of surface and subsurface sediments, and exploring areas favourable for fossil fuel deposits. The main research work is concerned with the understanding of plant evolution through geological time. Emphasis has been made to derive knowledge about the diversification of Precambrian life, diversity, distribution and inter-basinal correlation of Gondwana and Tertiary floras, coal/lignite quality and to understand the interaction between the climate and change of vegetation in Quaternary Period.

The palaeofloristic scenarios of bygone eras help us figuring out the past climatic and environmental changes. But it is important to tag these climate change events to a time scale. Scientists also study tree-rings to deduce palaeomonsoon/climate. Dating and study of samples of archaeobotanical interest is critical to understand the evolution of culture and civilization. Work is also done on the organic petrology to evaluate the quality of lignites/ coals for their economic utilization, besides depositional conditions. The samples for all these studies are collected from all over the globe including polar (Arctic/ Antarctic) regions.

The museum of the Institute is a rich repository of fossils collected from India and received from all over the world. A special attraction is the foundation stone with 77 fossils embedded by Prof. Sahni which was laid by Pt. Jawaharlal Nehru in 1949. The Institute boats of one of the richest collection of literature on the subject. It also has a herbarium for offering comparison between the past and present vegetation. The Institute has the radiocarbon dating laboratory, the only such national facility in the country. It also has the TL/OSL system useful for precise dating of archaeological artefacts and Quaternary sediments. The IRMS, ICP-MS, GC-MS systems have recently been added for the isotopic and organic geochemical analyses, besides the establishment of Palaeomagnetism laboratory. The Institute holds national/international scientific meets from time to time, and publishes catalogues, atlases, etc. on special occasions, besides an international journal *The Palaeobotanist* periodically.

The Institute, now renamed as Birbal Sahni Institute of Palaeosciences, is presently functioning as an autonomous research organization under the Department of Science and Technology (DST) Ministry of Science and Technology, Government of India.

"*here we study not only fossil plants but also the rocks in which they are found*"

– Birbal Sahni (April 03, 1949)

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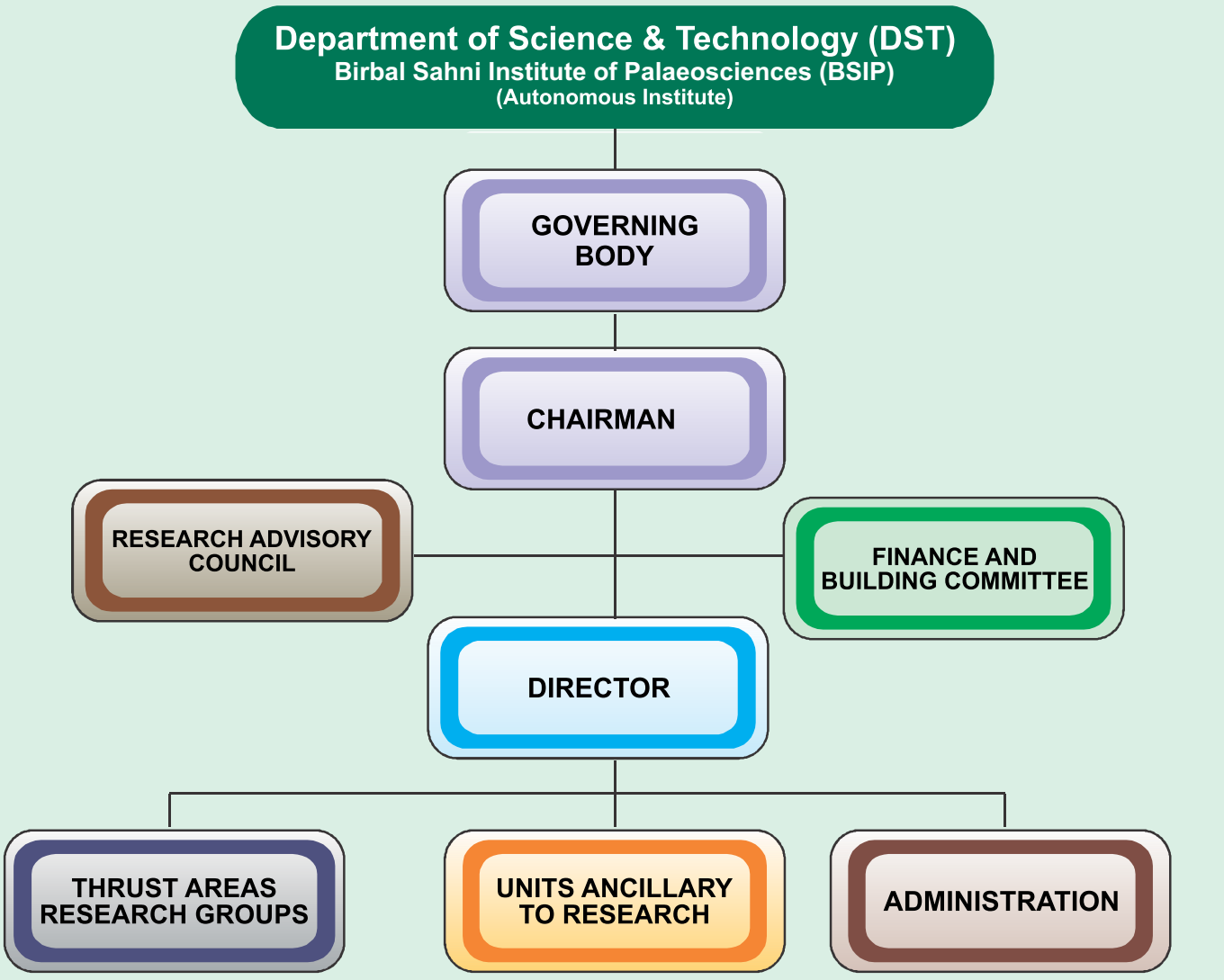
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Organization Structure



Precambrian Palaeobiology
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Palaeozoic-Mesozoic Miofloristics
Terminal Cretaceous-Neogene Megafloristics
Terminal Cretaceous-Neogene Miofloristics
Marine Micropalaeontology
Organic Petrology
Quaternary Palaeoclimate
Polar Research
Dendrochronology
Palaeoethnobotany
Geochronology & Geochemistry

Research Development & Coordination Cell
Publication Division
Knowledge Resource Centre
Museum
Herbarium
Maceration Laboratory
Section Cutting Workshop
Scanning Electron Microscopy
Electronic Data Processing
Photography

Registrar Unit
Finance & Accounts Section
Establishment Section
Scientific Activities Section
Stores & Purchase Section
Works, Building & Maintenance Section
Transport & Guest House

Vigilance Officer
Dr. Mukund Sharma, Scientist-F

Women's Forum
Dr. Anjum Farooqui, Scientist-E
(w.e.f. 04.08.2016)

Central Public Information Officer
Dr. B.D. Singh, Scientist-F

Foreword



I am very pleased to present the 2016-17 Annual Report of Birbal Sahni Institute of Palaeosciences (BSIP). This Institute has come a long way since its inception 71 years ago, and its recent renaming is not just symbolic but signifies a paradigm shift as the mandate of its research activities now includes a variety of biotic and abiotic proxies, with the overall objective of understanding the evolution of floras, faunas, climate, ecosystems at different temporal and spatial scales through time. With the recently set up analytical facilities for Geochemistry (elemental, stable isotopes, organic), mineralogy, palaeomagnetism / environmental magnetism etc., BSIP is now one of the best equipped institutes in the country for palaeoscience research. Several additional areas/facilities are now being developed in the Institute, including ancient DNA studies, interface of Archaeology/Archaeobiology with Geochemistry, and the quantification of trends and extreme events in palaeoclimatic, palaeoecological and time series. Research projects formulated under the new plan period, are truly multidisciplinary and reflect the new vision for BSIP. I feel confident that all these developments will bring transformational changes in BSIP in the coming months and years.

Another recent development is the sanction by the Department of Science and Technology (DST), Government of India for the construction of a new, multi-storey building for the Institute. BSIP has long been facing an acute shortage of space, and the proposed building will go a long way in meeting the Institute's space requirements for new labs, students and scientists. I extend my sincere thanks to DST for this generous support which will help the Institute meet its expanded research mandate.

I acknowledge with thanks the tireless efforts made by the Research Development and Coordination Cell (RDCC) of the Institute in producing this important document, with support from scientists and the technical and administrative staff. On behalf of BSIP and on my own behalf, I also extend my sincere thanks to Prof. Ashutosh Sharma, Secretary DST, Government of India as well as the officers of the AI Division of DST; Prof. Deepak Pental (Chairman) and Members of the Governing Body; Prof. S.K. Tandon (Chairman) and Members of the Research Advisory Council of the Institute for their constant encouragement and support.

(Sunil Bajpai)
Director


BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES
1946
OUR EXPERTISE
Evolution
Morphology & Taxonomy
Biostratigraphy
Palaeobiogeography
Palaeoclimate & Palaeoenvironment
Geochronology & Geochemistry
Organic Petrology
Archaeobotany
Dendrochronology
Aerobiology
Industrial Palynology
Consultancy Services
Contract Research
Contract Training Services (in Palynology and Coal & Lignite Petrology)
Identification of Fossils
Scanning Electron Microscopy
Petrological Analysis
Palynological Analysis of Pre-Quaternary & Quaternary Sediments
Radiocarbon Dating

Research Highlights

Birbal Sahni Institute of Palaeosciences (formerly Birbal Sahni Institute of Palaeobotany), established in 1946, is devoted to development of both fundamental and applied aspects of the evolution of flora and fauna, climates and ecosystems as well as allied Earth System Sciences. Research in Palaeosciences is being conducted on archives ranging in age from Archaean to Anthropocene (>3000 Ma to Recent) with an integrated, multidisciplinary approach. To achieve the targets of the XII Five Year Plan, 14 research projects have been initiated under the umbrella of eight identified Thrust Areas, besides documentation and digitization of data. Some of the significant highlights of scientific research carried out during the year 2016-2017 are summarized as under:

1. Early life and environment: Evidence from Indian Precambrian basins

- Delineation of Precambrian-Cambrian boundary near the top of Bilara Group of the Marwar Supergroup (Rajasthan, India), based on the carbon and oxygen stable isotope studies of the Bilara carbonate.
- Record of stromatolitic microbiota and carbonaceous metaphytic remains from the Rohtas Formation of Karauli-Sapotra-Dholpur sub-basin (Chambal Valley, Rajasthan) of western Vindhyan Basin.
- Record of enigmatic megascopic carbonaceous fossils from the khaki shales of the Saraipali Formation (Singhora Group), a horizon just above the well-dated distinct tuff bed (~1500 Ma) of the Chhattisgarh Supergroup.

2. Phanerozoic terrestrial and coastal ecosystems: Biostratigraphical, palaeoenvironmental, palaeoecological and palaeobiogeographical aspects

- Identification of female fructification *Arberia* in the plant fossil assemblage of the Barakar Formation (early Permian) of the Singrauli Coalfield (MP).
- Record of a plant fossil assemblage (orders Filicales & Glossopteridales) from the Middle Member of the Pali Formation, Johilla Coalfield (MP).
- Significant addition to our knowledge of the *Glossopteris* flora of India, especially that from the Godavari Graben from where the Permian plant fossil records are poor or without complete descriptions.
- Generation of petrographic and geochemical data from the late Permian and early Triassic sediments of Guryul Ravine, Kashmir and their implications for palaeoenvironmental conditions at the Permo-Triassic boundary.
- Determination of Norian-Rhaetian age for the Parsora Formation (of South Rewa Gondwana Basin), based on an overwhelming dominance of *Dicroidium* flora and the evidence of insect galls.
- Record of a new species of fossil wood (*Circoporoxylon kotaense*) from the Jurassic Kota Formation of the Pranhita-Godavari Basin.
- Documentation of spore-pollen assemblages from the Palaeozoic sequences of Singrauli, Johilla, Sohagpur (MP), Tatapani-Ramkola (Chhattisgarh), Godavari Valley (AP), and East Bokaro (Jharkhand) coalfields.
- Record of a dicot fossil wood (*Shorea*) from the Tertiary Tipam Sandstone Formation of Manipur.
- Record of a fossil wood belonging to *Duabanga* (Lythraceae family) from the Deccan Intertrappean beds of Kachchh (Gujarat).
- Report of 11 plant fossil species belonging to tropical dicotyledonous families from the Tertiary sequence (from the Churia Group of Arjunkhola area, western Nepal).
- Discovery of a fossil wood *Connaroxylon dimorphum* gen. et sp. nov. of Connaraceae family from Dhangaon, Mandla district (MP). This represents the oldest fossil wood record of the Connaraceae.
- Exhibition of morphological alterations of organic matter caused by various biological, environmental and depositional factors prevailed during the burial of the lignite-bearing sedimentary successions of Barmer and Nagaur-Bikaner basins (Rajasthan).

- Recognition of 3 cenozones (*Tripilaorites triangulus*, *Retipollenites confusus* & *Proxapertites operculatus*) in the Panandhro lignite deposits, Kachchh Basin (Gujarat), based on the palynomorph frequencies change.
- Evidence of a warm and humid climate during the deposition of sedimentary beds of the Deccan Intertrappean (in Gujarat), based on the fungal remains (spores & fruiting bodies) record.

3. Integrative marine micropalaeontology: Focus on high resolution biostratigraphy, sea level changes, palaeo-oceanographic and palaeoclimatic events

- Record of the earliest stratigraphic occurrence of the genus *Xylocarpus* (a back mangrove genera of Meliaceae family) from the late Thanetian succession (~57 Ma) of Ranikor Barsora, east Khasi Hills (Meghalaya), supporting the 'Out of India' hypothesis for the dispersal of Gondwanan clade from India to SE Asia following India-Asia collision.
- Indication of extreme warming event during the deposition of Palaeogene sequences of the Jarain-Dauki section in Jaintia Hills (Meghalaya), based on two prominent signatures of negative carbon isotope excursions of ~7 per mil.
- Documentation of a rich and diversified calcareous nannofossil assemblage of late Albian to early Maastrichtian age from the subsurface sediments of Jaisalmer Basin (Rajasthan).
- First record of 5 different species of *Halimeda* bioherms (green algae) from the limestones of Long Formation (middle Miocene) exposed in the Butler Bay Section of Little Andaman Island.
- Signatures of change in the runoff due to monsoonal fluctuations, marine incursion and anthropogenic responses during 2000 cal yr., based on diatoms and dinoflagellate cysts from the Vembanad wetland (a Ramsar site of Kerala).

4. Organic petrology: Characterization of solid fossil fuel for depositional and utilizational aspects

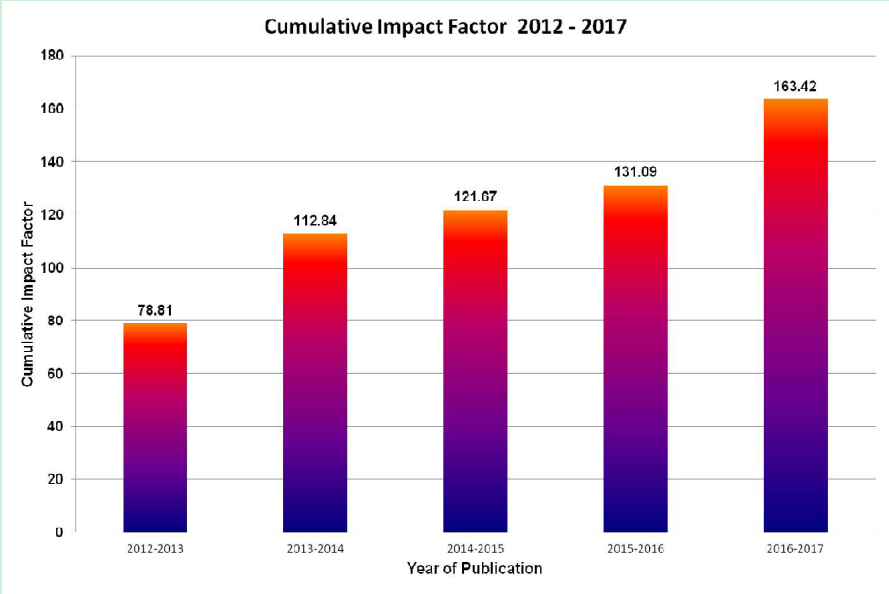
- Characterization of Permian coal from Mallayyapalli region of the Mulug Coal belt (Godavari Valley, AP), based on the petrographic analysis.
- Evaluation of Eocene lignites from the Sonari (Barmer Basin, Rajasthan), Surkha and Khadsaliya (Saurashtra Basin, Gujarat), and Neyveli (Cauvery Basin, TN) mines, based on the petrographic and bulk geochemical parameters.

5. Quaternary palaeoclimate reconstructions, vegetation dynamics and relative sea level changes

- Recognition of tropical mixed deciduous to semi-evergreen forest under 3 climatic regimes in Jokai reserve forest, Dibrugarh (Assam), based on the pollen data from surface and soil profile.
- Demarcation of 4 distinct palynozones in sediment profile from the Kikar Tal, Raebareli district (UP), indicating variability in climatic regime and vegetation pattern during the Holocene.
- Recognition of 3 phases of ecological and climatic changes in the sedimentary lake profiles of Nawabganj (Unnao district) and Sandi (Hardoi district) in UP, based on the multi-proxy data.
- Documentation of peripheral and core mangroves taxa through palynological study of surface samples from the Sundarban Biosphere Reserve.
- Division of the Ladakh region (along Indus Suture Zone) into three morphotectonic segments– Segment 1 indicates erosion dominated asymmetric basins in the Leh region, while Segments 2 and 3 representing higher elevations in the lower reaches of the Indus valley suggest a still continuing uplift.
- Evidence for elevation and grazing pressure as the most significant variables influencing non-pollen palynomorphs deposition in the Darjeeling Himalaya.
- Recognition of 4 magnetic susceptibility zones in a trench cutting section of Ny-Alesund (Arctic); defining alternate stages of colder and warmer phases.
- Analysis of organic carbon and carbon isotope variations within the freshwater lake sediment cores from the Schirmacher Oasis (east Antarctica), which provides evidence for the variation in biological productivity.

- Development of bimonthly standardized precipitation index of May extending back to A.D. 1439 (576-yrs.) in semi-arid Kishtwar region, NW Himalaya, based on annually resolved tree-ring data of *Pinus gerardiana* and *Cedrus deodara*.
- Establishment of dendroclimatic potential of the tropical tree *Toona ciliata* to carry out future tree-ring based long-term climate reconstructions.

6. **Domestication of plants, early farming and ecosystem dynamics during Holocene/ Anthropocene**
   - Evidence for the exploitation of botanical resources by ancient settlers, based on remains from ancient site Biland Khera (Hardoi district, UP).
7. **Geochronological and geochemical parameters for high resolution dating, correlation, palaeoclimatic, tectonic and provenance studies**
   - Dating of samples (barley seeds, carbonate, charcoal, wood, sediments, etc.) from the archaeological sites and lake shores, and also the standard and background samples.
   - Generation of data by the newly installed equipments (ICP-MS, XRD, IRMS, GC-MS, Particle Size Analyzer, TL/OSL reader, HPGe, Isodynamic Magnetic Separator, etc.).
   - Installation of equipments for magnetostratigraphy and magnetic susceptibility measurements.
8. **India-Asia collision and Himalayan uplifts: palaeobotanical and associated biotic signatures from sedimentary records of western Himalaya**
   - Documentation of calcareous nannofossils from the 2 sections near Taruche village (Ladakh); comprising 80-85% reworked late Cretaceous, K-T boundary, and Palaeocene taxa, and the youngest 15-20% elements of late Ypresian age.



Collaborations in several domains of research activity with institutions in India and abroad (Brazil, China, France, Germany, Malaysia, Nepal, Netherlands, Sri Lanka, UK, USA, etc.) have led to significant progress including 125 published papers. Four Ph.D. degrees were awarded during the year. Eight scientists were deputed abroad (Brazil, China, France, Germany) for collaborative studies. One scientist visited Germany under Inter-academy Exchange Programme of INSA, and another scientist participated in the Indian Scientific Expedition to Arctic. Fifteen scientists and two Project Fellows were deputed to attend the various conferences abroad (Brazil, China, Czech Republic, France, Malaysia, Netherlands, Norway, Russia, South Africa, Sweden and USA). Twenty-eight scientists, one Technical and 6 Project Fellows were deputed to attend various national and international conferences/seminars/workshops held in the country. About 75 research papers were presented in these scientific meetings in India and abroad.

An international Brainstorming Session/Workshop on *Quaternary Environments and Climates: Focus on Holocene and Anthropocene* was successfully organized in February 2017. The session was addressed by scientists from Singapore, UK, and eight institutions of India. The topics included climate change in the context of India's growing population, and its hazardous impact at present and during the past (Anthropocene).



Dr. Harsh Vardhan, Honourable Minister, Science & Technology and Earth Sciences, visited the Institute on April 20, 2016

Foundation Day

The Institute celebrated its 70th Foundation Day on September 10, 2016. On this occasion the Chief Guest Dr. K.J. Ramesh, Director General, Indian Meteorology Department (IMD), New Delhi, who is also a member of the Institute's Governing Body, paid rich tributes to Prof. Birbal Sahni, and delivered the "19th Jubilee Commemoration Lecture" on the topic *Science of Climate Change: Challenges and Opportunities for Sustainable Development*. He presented an overview of the Government of India's initiatives to enhance preparedness to tackle climate change. Key features of his lecture included– i) India's involvement for developing climate change model output for next Inter-Governmental Panel for Climate Change (IPCC)'s assessment report (AR-6) by 2021, ii) introduction to 'Climate Services' for the benefit of mankind in addition to 'Weather Services', and iii) parameterization of cyclones in the Bay of Bengal. Dr. Ramesh stressed the need to increase our monitoring capacities for changing climate. India, like other countries, is facing tough challenges from increasing climate vulnerabilities and natural hazards. He added that the modern climate change scenario predicts more intense and more frequent extreme rainfall events, hence there is a need to increase water storage capacity. Dr. Ramesh also stated that timely forecasts of flash-floods and landslides, especially over northwest Himalayan states, can greatly help in management of climate hazards.



Earlier, Director Prof. Sunil Bajpai during his welcome address emphasized on multi-disciplinary approaches by scientists for a holistic understanding of biological evolution, climate and ecosystem changes through time. For this, he stated that modernization of BSIP with state-of-the-art analytical facilities is being undertaken. As a result of ongoing efforts, the research output of the Institute has increased significantly and has become more visible. Prof. Bajpai also announced his future plans to set up an ancient-DNA and palaeomagnetism laboratories.

Founder's Day

The Institute celebrated its legendary Founder Professor Birbal Sahni's 125th birth anniversary on November 14, 2016. On this day, the Institute's staff and distinguished guests from other organizations paid tributes to him by offering *Pushpanjali* on the *Samadhi* of Prof. Birbal Sahni, FRS in the campus. A Memorial Lecture was organized the same day.



Prof. Nigel C. Hughes from the Department of Earth Sciences, University of California, Riverside, USA delivered the "46th Birbal Sahni Memorial Lecture" entitled *Conundrums, Correlations, and Applications: Cambrian and Beyond*. His lecture covered a wide spectrum of issues concerning the Cambrian sequences of Indian Himalayas, which he compared with similar sequences in other parts of the world. Prof. Hughes stated that results from the Indian sequences were not well understood in a proper geological framework until recently because new finds and old data needed to be studied together. The Cambrian time period spans over 56 million years duration of earth's history (541-485 Ma before present). It holds evidence of the advent and diversification of complex multicellular animal and plants life forms on the earth. Prof. Nigel discussed the importance of proper curation of fossil collections and stated that his studies would not have been possible without access to the previous collections. His lecture not only addressed the question of what the world was like during the Cambrian, but also provided insights into how the Himalaya was formed and is being eroded, and how it is strongly influencing the chemistry of the world's oceans. Prof. Nigel referred to his long association with India by remarking that *I am not an Indian geologist but a geologist of India*. Earlier in his welcome speech, Prof. Sunil Bajpai, Director BSIP briefed the audience about the Institute's recent achievements. Many guests and scientists from outside the Institute also attended the function. On this occasion, some of the Institute's medals were also awarded to staff members.

Quaternary Environments & Climates

An International Brainstorming Session/Workshop on *Quaternary Environments and Climates: Focus on Holocene and Anthropocene* was organized at the Institute during February 21-23, 2017. It was aimed to promote the exchange of existing information and knowledge related to climate change uncertainties, past evidences and future adaptations. The event was inaugurated by the well-known historian Prof. Nayanjot Lahiri of Ashoka University (Haryana). In her inaugural speech, Prof. Lahiri narrated several interesting sequences and events in the life of eminent historians/ archaeologists who were involved in rigorously unearthing the Harappan culture in India and the neighbouring countries. Prof. Lahiri stressed the question of how great discoveries take place and stated that there are many unsung and unknown contributors who gave true directions leading to important discoveries of the Indus Civilization. Earlier, Prof. Sunil Bajpai, Director BSIP delivered the welcome address, which was followed by a brief introduction to the theme of the Brainstorming Session by Dr Anjum Farooqui, Organizing Secretary.

The Brainstorming Session dealt with the impact of modern climate change due to global warming which is now becoming visible in the form of changing monsoonal pattern, extreme floods, extreme drought, heat stroke, etc. and which continues to disrupt agricultural practices. The most conspicuous indicators of climate change are the status of ambient temperature, status of monsoon/ precipitation, abrupt extreme climate changes, sea level fluctuations, etc. The state of our economy is largely dependent on the magnitude of such changes. Hence, for a better understanding these changes, sustained studies on climate change of the past and present are needed.

The specific issues and action management related to global climate change with respect to biotic and abiotic responses to climatic change, short and long-term climate changes were addressed by 19 experts in this field from Singapore, UK, and India (PRL, Ahmedabad; NIO, Goa; ASI & JNU, New Delhi; BHU, Varanasi; IISER, Mohali; LU, Lucknow) including BSIP. Several other aspects, such as global temperature rise, warming of oceans, sea level changes, adaptive responses of species, and extreme weather conditions, were also addressed for the benefit of young researchers. Societal impact of the climate change on human health, landscape, agriculture, biodiversity, etc. were also discussed. Planning and practices in the field were addressed as specific needs, successful adaptation policies and action management.



Six technical sessions were organized based on the following five basic issues/questions dealing with the climatic variabilities with respect to geomorphological, biogeographical, meterological, chronological and biological aspects:

- What is Anthropocene in Indian/ South Asian perspective?,
- What are the typical Anthropocene markers?,
- Forcing factors governing monsoonal climate– Tropical versus Polar,
- Quantification of past climate/ecological changes - an emphasize on uncertainty in proxies/ models, and
- Subtelties, nuances, uncertainties of chronological constraints?

The session started with an overview of research work done at BSIP. Nearly 10 senior and 20 young scientists along with over 25 research fellows in the Institute are currently involved in the study of past climate, ecology and vegetation. To understand these aspects of environment, both biotic and abiotic proxies are being studied in the BSIP. The research directions and strategies to understand the climatic variabilities in the past and probable predictions for future changes were discussed.





Prof. John Dearing (UK) discussed the complex social-ecological interactions in the Anthropocene. He stressed the identification of key concurrent trends in climate variations, their rates, assessment of safe operating limits and the tipping points. Prof. RJ Wasson (Singapore) discussed in detail the changing hydro-climate over Himalayas, extreme events, and policy stands. Prof. AP Dimri (New Delhi) discussed the suitability of climate models for understanding the changing environment over the Indian Himalayan region. He underlined the importance of improvised parameterization of models in the wake of fine scale sub-regional processes. A review of various forcing factors / internal feedbacks impacting monsoonal precipitation in India was provided by Dr. PD Naidu (Goa). Prof. R Ramesh (PRL) discussed the importance of calibrating oxygen isotope anomaly for volume effect in calcium carbonate deposits (e.g. speleothems) for its better usage for quantifying past rainfall. The geological history of Varanasi city vis-à-vis Ganga plain was presented by Prof. UK Shukla revealing several hitherto facts.

Prof. SS Naik (Goa) elucidated the pH and temperature changes in Antarctica and Arabian Sea spanning the Holocene/Anthropocene. Prof. DS Singh (Lucknow) presented his research over the Gangotri glacier where he (with his associates) is stying the Anthropocene changes by quantifying Black Carbon inventories. A succinct review of human evolution over the sub-continent was presented by Dr. PS Chauhan (Mohali). Likewise, Dr. SK Manjul (Delhi) presented an overview of archaeological finds recently unearthed from 4MSR, an Indus site from western Rajasthan revealing amazing craft-culture of ancient human settlers between ~2600 to 1900 BCE and migration paths of Harappans arguably linked to changing climate (monsoon) era.

The workshops conducted by Prof. Dearing and Prof. Wasson were attended by a batch of about 30 young scientists/scholars. The burning issues of climate change in the context of India's growing population, and its hazardous impact at present and during the past (Anthropocene) were discussed in detail during the workshop. Discussions included i) short- and long-term climate changes at lower and higher latitudes, ii) orbital forcing of climate change, iii) biotic and abiotic responses to climatic change, iv) global temperature rise, v) warming of oceans and adaptive responses of species, vi) extreme weather conditions and erratic climate, vii) physical, chemical and biotic changes in ecosystems and habitats as well as risks to human health in response to invasive/ alien species overpowering regional biodiversity, viii) mapping of anthropogenic impact on landscape and biodiversity with changes in agricultural strategies in response to climate change, and ix) climate models for strategic planning to sustain or mitigate the climate change responses.



The meeting brought several Quaternary researchers on a single plateform to discuss and debate the complex social-ecological interactions in the Anthropocene. It emphasized the fact that a better understanding of the system dynamics is a major research priority for the sustainable management of landscapes, ecosystems and resources. However, the lack of multi-decadal records represents an important gap in information that hinders the development of research agenda. Without improved information on the long-term and complex interactions between causal factors and responses, it will be difficult to answer key questions about trends, rates of change, tipping points, safe operating spaces and pre-impact conditions. Monitoring and assessment of impact requires long-term databases of parameters. Discussions on the climate changes and their impact on environment including the monsoonal variability of the recent past, effects on the biotic and abiotic proxies and geomorphological changes provided significant insights. Such insights into the trends and forcing mechanisms, whether natural or anthropogenic, behind these climatic anomalies of the recent past (i.e. Anthropocene) are of great help in understanding of future climate predictability.

Outreach Activities












BSIP participated in the India International Science Festival (IISF-2016) organized at National Physical Laboratory, New Delhi during December 07-11, 2016.










The Institute erected an exhibition at Sri Venkateshwara University, Triupati during 104th Indian Science Congress Association meet during January 03-07, 2017.






BSIP hosted a stall in the District Level Science Exhibition and Competition held at City Montessory School, Gomti Nagar (Extension), Lucknow on October 22, 2016.

Research

Thrust Areas and Projects

Thrust Area 1: EARLY LIFE AND ENVIRONMENT: EVIDENCE FROM INDIAN PRECAMBRIAN BASINS

Precambrian Palaeobiology Group

Project- 1.1: Palaeobiological, biostratigraphical and evolutionary aspects of the Precambrian biota: Evidence from Neoproterozoic basins of India

Investigators: Mukund Sharma, S.K. Pandey & A.H. Ansari

In-situ bedding plane bioturbation structures (291 in number), described as *Treptichnus pedum,* have been analyzed from the Nagaur Sandstone (Marwar Supergroup), an established Ediacaran-Cambrian succession. Morphological attributes, palaeoecological parameters and comparison and correlation, based on distribution of *T. pedum,* are concluded. Statistical analyses were performed on size of the specimens to document the possible taxonomical variations at the species level. Data suggest that the entire assemblage belongs to one major group of maker. The structural pattern suggests that these burrows were probably meant for refugia and trapping small benthic organisms. Similarly, sigmoidal scratches characterizing the Lower Cambrian ichnospecies *Monomorphichnus multilineatus* are also recorded from the Nagaur Sandstone from the same locality. Aspects such as mode of preservation, depositional environment, palaeoecology and taphonomy are deduced. Detailed statistical analyses, based on morphological attributes, help to reveal its behaviour and feeding pattern of the causative organism of *M. multilineatus*. Hierarchical Cluster Analysis is performed on the selected characteristics suggesting that the Nagaur specimens belong to ichnogenera *Monomorphicnus* and ichnospecies, i.e. *multilineatus*. Pearson Correlation between thickness and length of individual specimen was positive which indicate that the amount of food required by individual adult specimen was more and thereby requiring more grazing to provide enough food for survival.

Robust high-resolution carbon and oxygen stable isotope studies have been conducted on the Bilara carbonate; 457 samples are analyzed. The δ^{13}C-carb and δ^{18}O -carb in Bilara Group varies from –9.0 to 4.1‰ and from –10.7 to 8.3‰, respectively. Results are compared with well-established Shuram Excursion sites in other parts of the world and found to be similar to Yangtze Gorges platform of South China where Ediacaran δ^{13}C-carb variation profile revealed four negative (EN1, EN2, EN3, EN4) and three positive (EP1, EP2, EP3) excursions. Based on these comparisons, the Pc-C boundary is also inferred near the top of the Bilara Group of the Marwar Supergroup, India.



Large sized carbonate mud mound in the Bilara Group, Marwar Supergroup

Project- 1.2: Meso-Neoproterozoic palaeobiology of Chambal Valley of Vindhyan Basin, Rajasthan

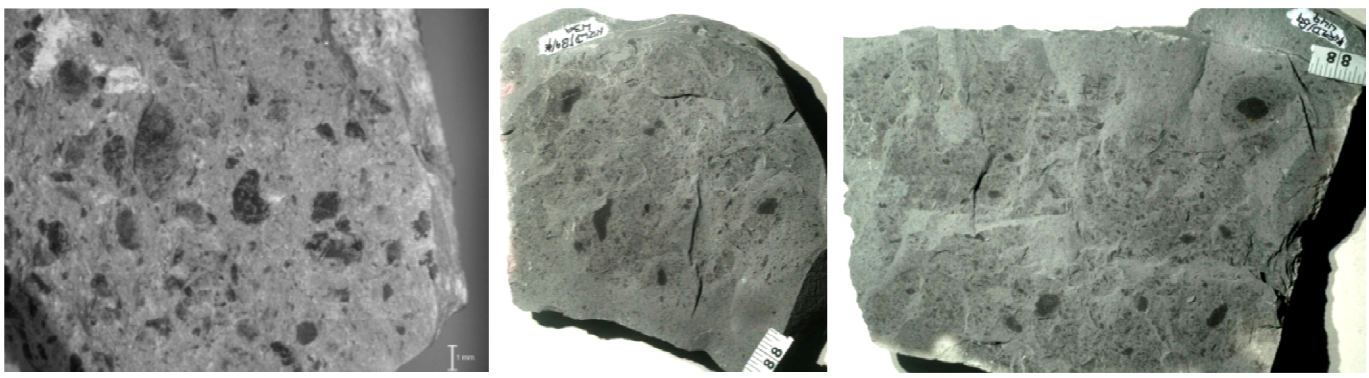
Investigator: Rupendra Babu

The rock samples of carbonate (Tirohan limestones/ breccias) and shale sequences of Semri Group belonging to Karauli-Sapotra-Dholpur sub-basin of western Vindhyan Basin in Karauli district (Rajasthan) have been investigated for biotic remains. Additional medium-sized domal stromatolites (*Collenia columnaris* Fenton. & Fenton) and biogenic structures (oncoides) occur in low diversity and frequency in the carbonate sequences (limestone/dolomite) exposed in Durga mine near Kurgaon. The recovered biotic assemblage in thin sections comprises prokaryotes and eukaryotes (acritarchs). The prokaryotes (4 species, 3 genera) are represented by coccoidal and septate trichomes with and without mucilaginous sheath. The 3 subgroups of acritarchs (7 species, 6 genera) are small-sized leiosphaerids, and spinated and lensoidal structures. *Leiosphaeridia minutissima*, *Eomicrhystridium*, oblong forms of acritarchs, and the dominance of small-sized *Eosynechococcus moorie*, *Myxococcoides minor* of cyanobacteria characterize the present micro-bioentities fossil assemblage. The information from carbonate sequences indicates a tentative late Statherian age based on existing evidences from meta-dolostone and chert (Palaeoproterozoic & Mesoproterozoic) sequences of Canada, China USA, Ontario, Australia and Bihar (in India), and suggests shallow marine and post-depositional thermogenic activity by any natural episodes.



Intercalated thin carbonate bands in Banded Gneisses complex exposed near Ghosia village (Karauli district)

Varied types (subspherical-spherical & leafy) epilithic planktic and benthic metaphytic carbonaceous compressions and impressions have been recorded from the nodules (3-8 cm), intercalated in thick sequence of shales with some bands of limestones, ferruginous shales belonging to uppermost part of Rohtas Formation exposed near Naroli Dang. The overall analysis suggests a latest Statherian age (1650-1600 Ma), and moderately deep marine, quiet lagoonal (spring tide) protected embayment and low energy settings for the deposit.



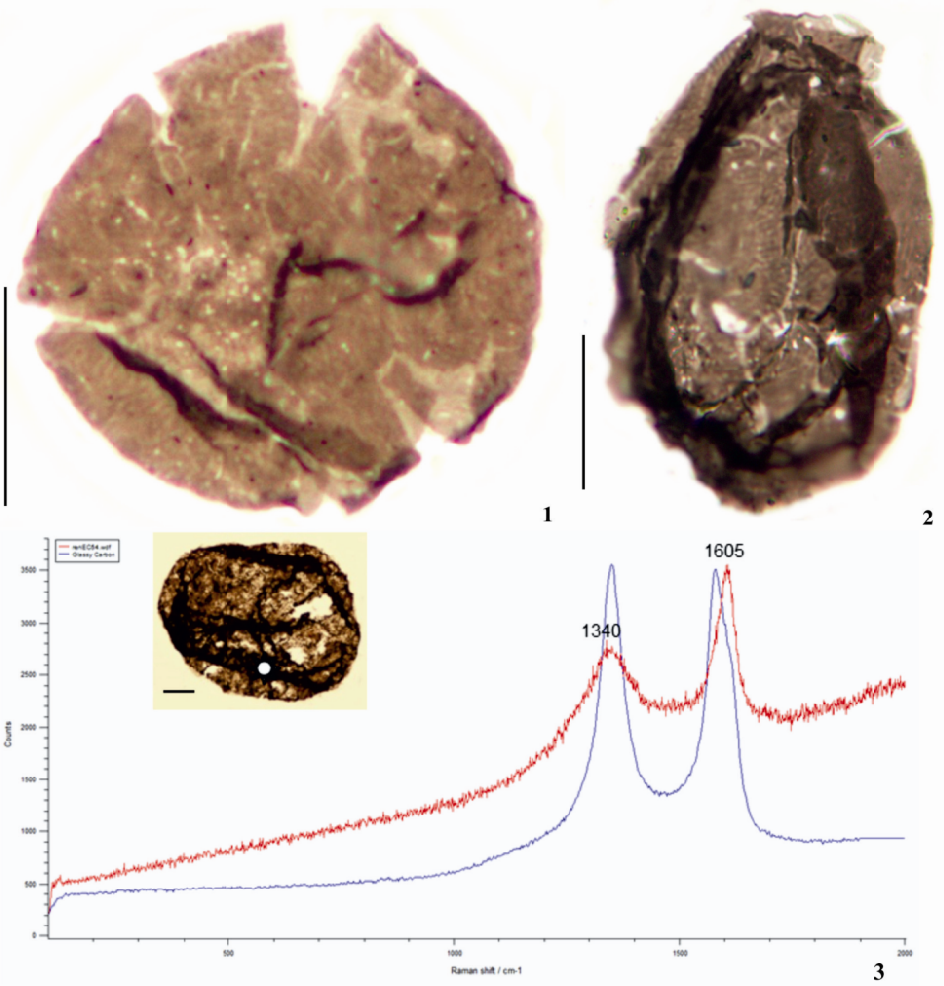
Epilithic meso-megascopic compression and impressions of diversified algal remains from the Semri Group of Naroli Dang (Karauli district)

Project- 1.3: Palaeobiological investigations of the Proterozoic Chhattisgarh Supergroup in Khariar Basin and Barapahar Protobasin

Investigators: Mukund Sharma & V.K. Singh

Different stratigraphic units, namely Singhora and Chandarpur Groups exposed in Mahasamund district (Chhattisgarh) and Bargarh district (Odisha) have been investigated for the palaeobiological evidence. Systematically collected carbonaceous black shales from the mud dominated sequences of the Chaporadih Formation (Chandarpur Group) are examined for the acritarchs and other organic-walled microfossils. A large population of sphaeromorphic acritarch *Valeria lophostriata* - spherical vesicle (>100 µm) with distinct concentric striations adjoining two polar foci that are oppositely located on the spheroidal vesicle are recorded. In the available global records, the *Valeria* has been widely accepted as a eukaryotic fossil, which is ranging from 1650 to 700 Ma, and recorded from the Mesoproterozoic successions of Australia, North China, Siberia, Greenland and North America. Additionally, various enigmatic megascopic carbonaceous fossils are also recovered from the khaki shales of the Saraipali Formation (Singhora Group), a horizon just above the well-dated distinct tuff bed (~1500 Ma). The assemblage is dominated by exceptionally well-preserved mm to few cm long and a few micrometer thick films of varied shapes (circular-oval discoidal forms), having long tubular processes over the entire body. Morphologically, the assemblage is comparable to extant Phaeophyta, Chlorophyta and Rhodophyta divisions of higher algae. Such type of carbonaceous remains is known from the precisely dated sediments of the Knob Lake Group (Canada), Negaunee Iron Formation (Michigan, USA), Changcheng Group (1700 Ma, China) and Olive Shale Formation (~1600 Ma, Semri Group, Vindhyan Supergroup of India).

The Confocal Laser Scanning Microscopy and Micro-Raman Spectroscopy based investigations have been performed on the selected OWMs (*Leiosphaeridia, Valeria* & *Jacutianema*) of the Chandarpur Group, and on *Tappania* of the Singhora Group. These studies helped in 3-D reconstructions and inferring detailed organismal morphology, cellular anatomy, taphonomic and preservational history of the microfossils. Micro-Raman study revealed occurrence of Shungite mineral in *Leiosphaeridia* acritarch recorded from the black shale of the Chaporadih Formation. Recorded carbon concentration upto 1610 cm^{-1} (G-band) and 1352 cm^{-1} (D-band) proves the organic nature of above mentioned acritarchs.



1-2) Organic walled microfossils from the ~1.1 Ga old Chandarpur Group: Striated Eukaryotic fossil *Valeria lophostriata* [Scale bars = 25 µm], **3**) Raman spectra of glassy carbon in sphaeromorphic acritarch *Leiosphaeridia tenuissima*

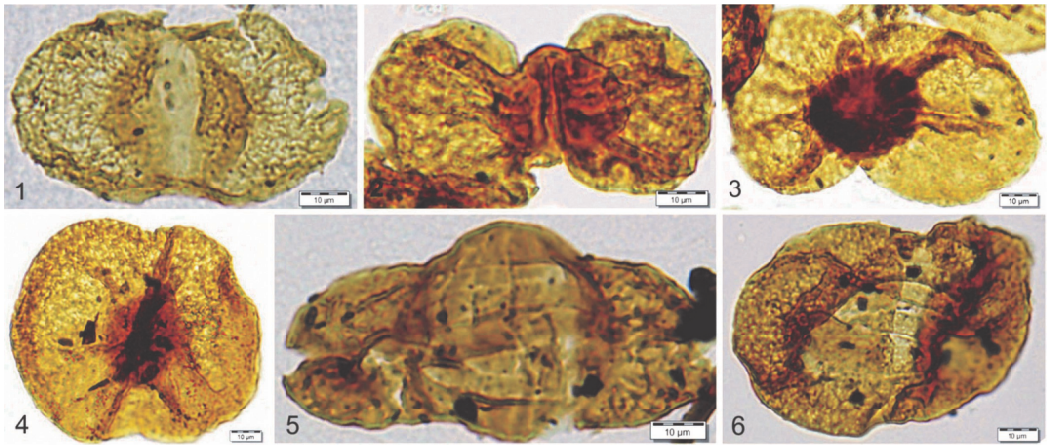
Thrust Area 2: PHANEROZOIC TERRESTRIAL AND COASTAL ECOSYSTEMS: BIOSTRATIGRAPHICAL, PALAEOENVIRONMENTAL, PALAEOECOLOGICAL AND PALAEOBIOGEOGRAPHICAL ASPECTS

Palaeozoic-Mesozoic Megafloristics Group

Project- 2.1: Palaeofloristics and palaeoecology of Palaeozoic rocks of Singrauli and Kuresia coalfields (Son-Mahanadi Basin) and northwest Himalayas (Himachal & Uttarakhand)

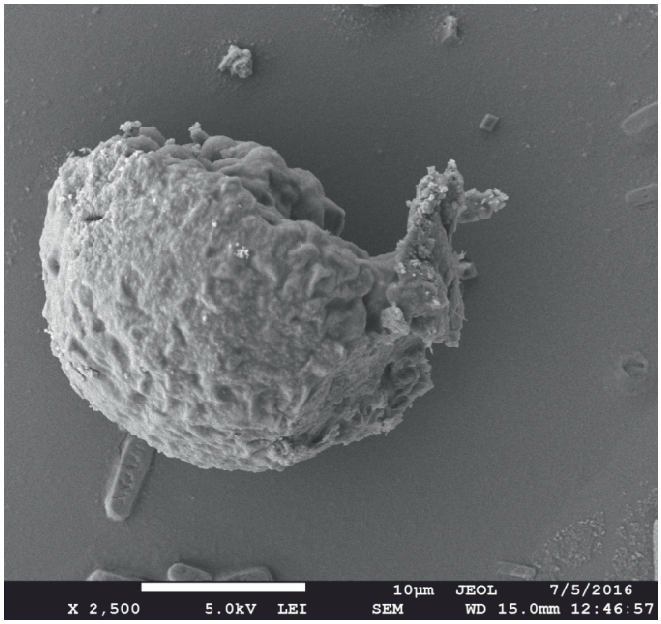
Investigators: K.J. Singh & Anju Saxena

Megafossil specimens (35) collected from Block-B colliery of the Singrauli Coalfield have been processed, photographed and analyzed. The assemblage consists of the genera *Gangamopteris* and *Glossopteris* representing 9 species, and some stem axes. Fragmentary specimens of female fructification *Arberia* have also been identified in the assemblage. Besides, to have a comprehensive picture, few specimens of the colliery and of the Nigahi colliery have been analyzed for their palynological content. Further, a paper on the Permian macro- and miofloral diversity, palynodating and palaeoclimate implications deduced from the coal-bearing sequences of Singrauli Coalfield has been finalized. This work deals with the comprehensive analyses of floral assemblages of the Barakar and Raniganj Formations, and an assessment of palynodating and age of these formations of the coalfield. In addition, a field excursion to the Singrauli Coalfield (MP & UP) has been undertaken, and samples for the megafossil assemblages, palynological and petrological studies are collected from the different coal seams of Barakar Formation exposed in the Amlohri, Kakri and Jayant collieries.



Palynomorphs recovered from the Raniganj Formation of Jhingurdah Colliery, Singrauli Coalfield
1) *Crescentipollenites fuscus*, **2**) *Verticipollenites oblangus*, **3**) *Rhizomaspora indica*, **4**) *Rhizomaspora radiata*, **5**) *Distriatites bilateris*, **6**) *Arcuatipollenites* sp.

The meso- and megafossil specimens collected from the Takche, Poh and Lipak Formations in Spiti area have been studied in detail. The fossil assemblage includes trace fossils, brachiopods, bivalves, corals, impression and compression specimens of small bifurcating axes (?*Cooksonia* & Psilophytes), conifer axes, *Triphyllopteris* sp. and *Diplothmema* sp. Some samples of the Takche Formation (Silurian) have yielded rare occurrence of cryptospores. Samples from the Muth (Devonian) and Po (Carboniferous) Formations have also been subjected for the palynological studies. Very well-preserved trace fossils recorded form the Takche Formation has also been studied in detail.

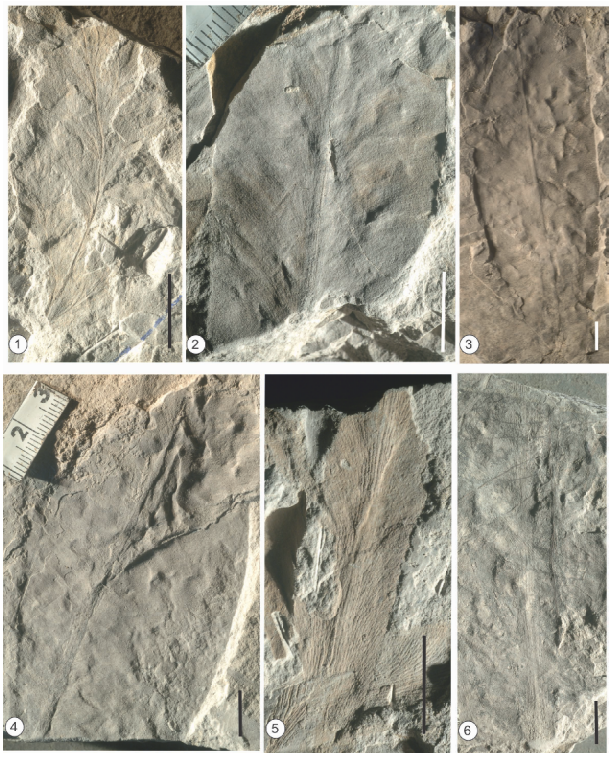


? Cryptospore from the Early Palaeozoic (Silurian) sediments

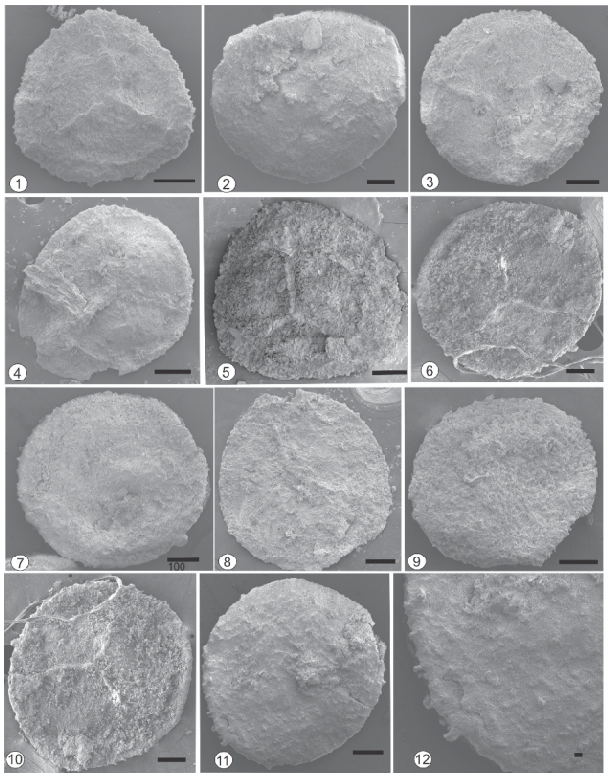
Project- 2.2: Palaeobotanical investigations from Johilla and Sohagpur coalfields, South Rewa Gondwana Basin: Implications for basinal correlation and evolutionary, biostratigraphical and palaeoecological aspects

Investigators: Rajni Tewari, S.S.K. Pillai & Deepa Agnitotri

A well-preserved fossil assemblage comprising the orders Filicales and Glossopteridales has been systematically analyzed for the first time from the Pali Formation (near the Pali village, Umaria district, MP). The assemblage includes *Neomariopteris hughesii*, 15 species of *Glossopteris*, *Vertebraria indica, Utkaliolepis indica* (scale leaf) and dispersed seeds namely, *Cordaicarpus zeilleri, Rotundocarpus striatus, Samaropsis goraiensis* and *Samaropsis feistmantelii*. The palynoassemblage is characterized by the dominance of striate bisaccate pollen grains. The megafloral assemblage of the Pali Formation is comparable with those of non-coaliferous beds of Kamthi and Bijori Formations of Mahanadi and Satpura Gondwana basins, respectively, and to some extent with Pachwara Formation of the Rajmahal Basin. The lithological attributes of the Pali Formation are also shared with these formations. Additionally, the flora is comparable with that of the Raniganj Formation of the Damodar Basin.



Plant megafossils from the Pali Formation of Johilla Coalfield: **1**) *Neomariopteris hughesii*, **2**) *Glossopteris bosei*, **3-4**) *Glossopteris communis*, **5**) *Glossopteris gondwanensis*, **6**) *Glossopteris indica* [Scale bar = 1 cm]



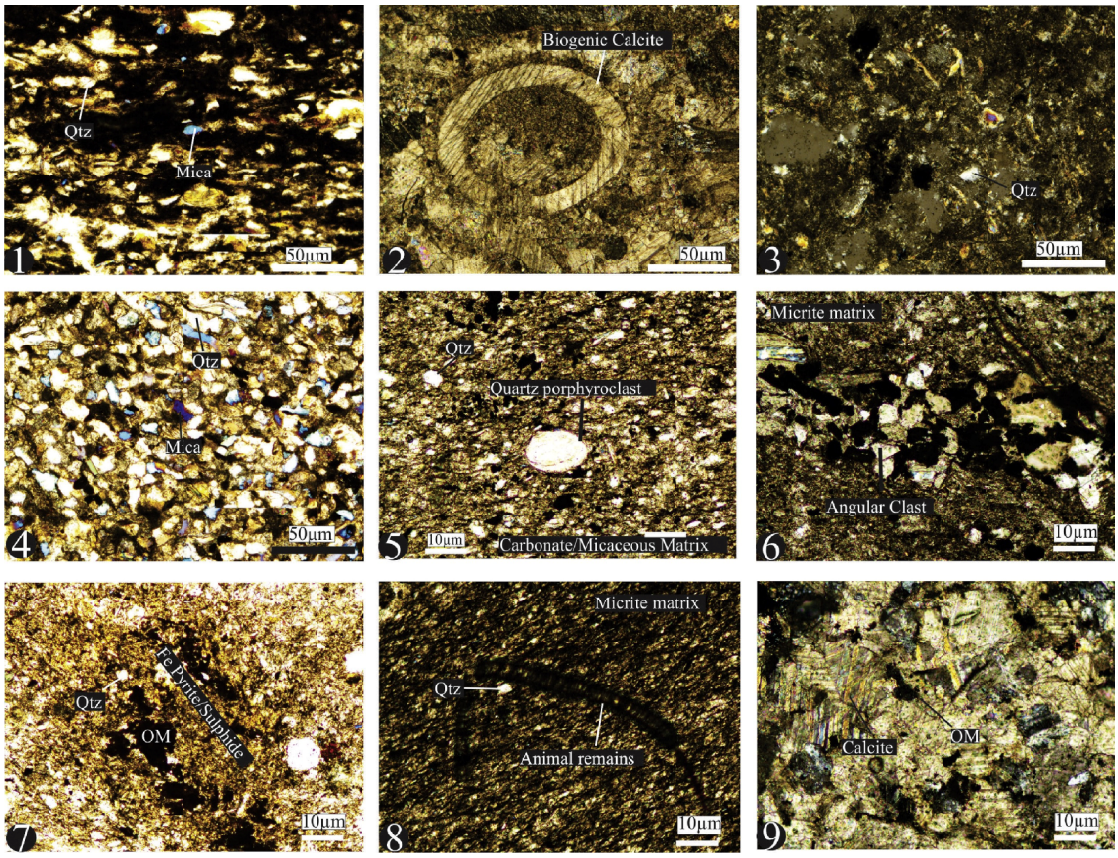
Plant megaspores from the Lower Barakar Formation of Dhanpuri Mine: **1**, **11**) *Barakarella* sp., **2-10**) *Banksisporites* sp., **12**) Enlarged view of ornamentations in *Barakarella* [Scale bar = 100 µm]

Grouping, sorting, cleaning and photo-documentation of the plant fossils collected from the Dhanpuri OCP, Sohagpur Coalfield have been done. *Gangamopteris,* a number of species of *Glos-sopteris, Noeggerathiopsis*, *Buriadia,* equisetalean axes and scale leaf have been tentatively identified. Maceration of rock samples from the Barakar Formation of the OCP yielded a variety of megaspores showing laevigate, granulate, verrucate, connate, baculate and spinate exosporia. On the basis of SEM photographs, the megaspores have been tentatively identified as *Talchirella*, *Jhariatriletes*, *Bokarosporites*, *Banksisporites, Biharisporites, Duosporites* and *Barakarella*. The palynological assemblage shows the dominance of *Scheuringipollenites* and *Parasaccites* along with the sub-dominance of *Plicatipollenites, Faunipollenites, Crescentipollenites*, *Striatopollenites, Tuberisaccites, Potonieisporites* and *Illinites*. The dominance of *Scheuringipollenites* and *Parasaccites* indicates an early Permian age.

Project- 2.3: Mega- and microfloristics of the Permo-Carboniferous sediments of Kashmir Region: Evolutionary, biostratigraphical, palaeoecological and palaeophytogeographical implications

Investigators: Rajni Tewari, S.S.K. Pillai, Deepa Agnihotri & Kamlesh Kumar

Petrography and geochemistry including analysis of major, trace and rare earth elements have been carried out of the late Permian and early Triassic sediments of Guryul Ravine to examine the palaeoenvironmental conditions at the Permo-Triassic boundary (PTB). A visible change in the lithostratigraphy from argillaceous ~carbonaceous mudstone in C Member (late Permian, Zewan Formation) to fine-grained argillaceous siltstone with quartz in D Member (4 m below the Late Permian Event Horizon) is observed. The XRD analysis divulges more terrigenous input below the PTB, which is also reinforced by the dominance of quartz, whereas the dominant clay mineral is illite followed by chlorite. The $K_2O + Na_2O$ *vs.* SiO_2 plot indicates that the sediments at PTB were derived from andesite type of rocks (SiO_2: 52-63%) of intermediate composition. Major oxides SiO_2, CaO, Na_2O and MnO are most abundant in the D Member, whereas E Member is enriched in the Co, Ni, Cu, V and Zn; indicating reducing conditions. Dominance of incompatible elements such as Ti, K, Rb, and Sr in finer shale fraction shows increased reworking of sediments. Moderate weathering is observed at PTB, whereas below the LPEH, physical weathering is more. Y/HO ratio varies from 24 to 51 indicating that REEs are derived from the shale source. The C_{org}:P is <10:1 in the late Permian and >10:1 in the early Triassic Period suggesting that the conditions transformed from oxidizing to reducing [maximum values noticed in sample no. 5 (80:1)], indicating suboxic-anoxic conditions, which may be one of the causes of oceanic redox at PTB.



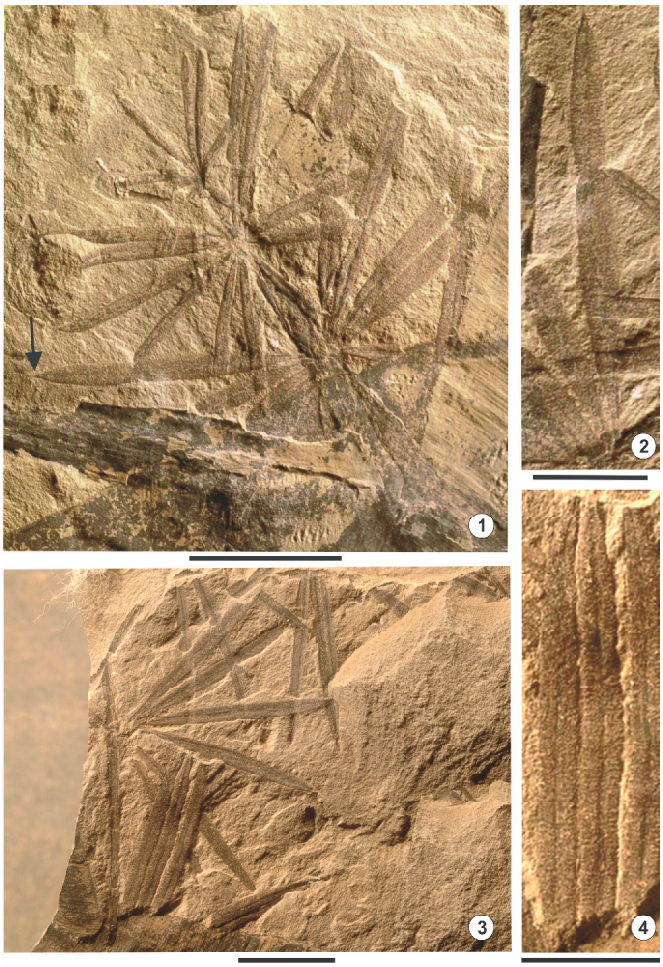
Petrological characteristics of sediments from the PTB section of Guryul Ravine

1) Quartz grains, scattered mica along with OM, **2**) Fine grained calcite matrix, and biogenic calcite formed by replacement, **3**) Mudrock having fine gained calcite with lithic and mica grains, **4**) Argillaceous, calcareous, micaceous, fine grained angular to sub-angular quartz arenite with less OM, **5**) Quartz pophyroclast and lithic grains contained in carbonate/micaceous matrix, **6**) Angular clast (quartz) surrounded by matrix (pilmicrite) with OM, **7**) Fe oxide/sulphide with OM, **8**) Quartz and lithic grains are contained in a fine grain micrite matrix (Biomicrite) and animal remains, **9**) Fine grained perfect twinned calcite (sparite) with less OM

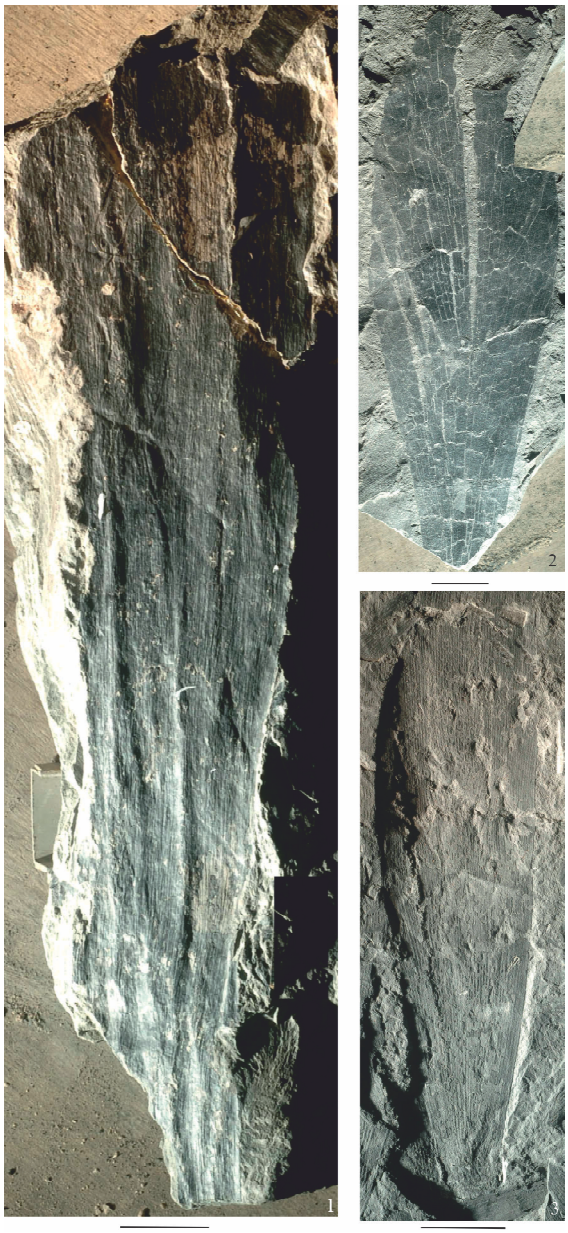
Project- 2.4: Gondwana floristics of India (Wardha-Godavari Basin) and Antarctica: Evolutionary, biostratigraphical, palaeoecological and palaeophytogeographical significance

Investigator: Rajni Tewari

For the first time, a comprehensive analysis of the *Glossopteris* flora from the Barakar Formation of the Prakasham Khani open cast mines II and IV (Manuguru area) has been carried out. The assemblage is well-preserved and represented by pteridophytes and gymnosperms. Pteridophytes comprise *Phyllotheca australis* and equisetalean axes of the order Equisetales, whereas gymnosperms include *Gangamopteris cyclopteroides* and 17 species of *Glossopteris* belonging to the order Glossopteridales, and several leaves of *Noeggerathiopsis hislopi*, besides *Cordaites* sp. of Cordaitales. Northern genus *Cordaites* is recorded for the first time from the area and substantiates earlier records from the Lower Gondwana horizons of India. This study adds to the knowledge of the *Glossopteris* flora of India, especially that of the Godavari Graben from where the plant fossil records are poor or without complete descriptions. The floral assemblage compares fairly well with those recorded from the Barakar Formation of other Lower Gondwana basins of India.



Plant megafossils from the Barakar Formation of Prakasham Khani mine, Manuguru area: **1**, **3**) *Phyllotheca australis* Brongniart, **2**) One of the leaves from fig. 1 enlarged to show an acuminate apex (indicated by an an arrow), 4) Leaves from specimen in fig. 3 enlarged to show striations at right angles to midrib



Plant megafossils from the Barakar Formation of Prakasham Khani mine: **1**) *Cordaites* Unger, **2**, **3**) *Noeggerathiopsis hislopii* Feistmantel

Project- 2.5: Palaeobiology of Mesozoic Gondwana of Pranhita-Krishna-Godavari basins

Investigator: A. Rajanikanth

Circoporoxylon kotaense, a new species of fossil wood, has been systematically described from the Jurassic Kota Formation of the Pranhita-Godavari Basin. A review of the distribution of global records revealed that the genus is widely distributed in both the northern and the southern hemispheres, and favoured clarifications regarding its palaeobiogeography. The distribution of the genus, ranging from the Jurassic to the Miocene, indicates that the limiting factor throughout the species existence was climate. The analysis of fossils in a palaeogeographic context suggests that the extinct genus preferred warm temperate climates.

The early Cretaceous flora from the Gangapur Formation (P-G Basin), east coast of India has been critically studied to understand plant diversity and abundance pattern, as well as palaeoecological and environmental implications. Both the micro- and macrofloras and sedimentological inputs have been considered. The flora is rich and diverse, and consists of bryophytes, pteridophytes, pteridosperms, gymnosperms and angiosperms. The taxonomic diversity and abundance of the micro- and macrofloras exhibits a great disproportion. The microflora shows higher taxonomic diversity and abundance than the macroflora. Overall, the study suggests the abundance of conifers, more particularly by Podocarpaceae. The taphocenosis of the flora suggests that it includes local to regional elements, distributed in the riverbanks, floodplains, back swamps and valley settings. Together, the information from the flora and sedimentology suggests the existence of warm and humid environments.



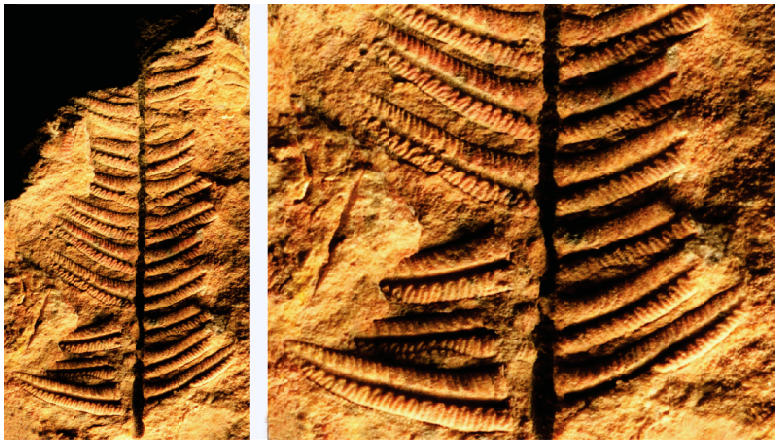
Torreyites sitholeyi Ganju from early Cretaceous of Pranhita-Godavari Basin

Project- 2.6: Mesozoic palaeofloral diversity, biostratigraphy and palaeoclimatic studies in Saurashtra and Kachchh basins

Investigators: Neeru Prakash & Neelam

The upper Mesozoic (Cretaceous– Himmatnagar Sandstone Formation) sedimentary deposits rest unconformably over the Precambrian Erinpura Granite, and are exposed in the Mainland Gujarat (in Sabarkantha district). The flora of Himmatnagar Sandstone is less diversified and relatively inadequately known. A large number of plant fossils occur in the pinkish-purplish shale on the surface of the bedding plane of the Hathmati River section and the yellowish-brown ferruginous sandstone of the northern side of Wanthara Hill. Numerically, the flora is dominated by pteridophytic frond genera *Matonidium indicum* and *Weichselia reticulata* along with the representation of 24% conifers and 7% each of pteridosperms and cycads.

The Himmatnagar assemblage of western India is the youngest floral assemblage of Indian Gondwana, and is lithostratigraphically/palaeofloristically correlatable with the Dharangdhara (Saurashtra Basin), Bansa (South Rewa Basin) and Athgarh Formations (Mahanadi Basin). It is assigned an early Cretaceous (Aptian-Albian) age.



Matonidium indicum Sahni (1936) from the Himmatnagar Sandstone

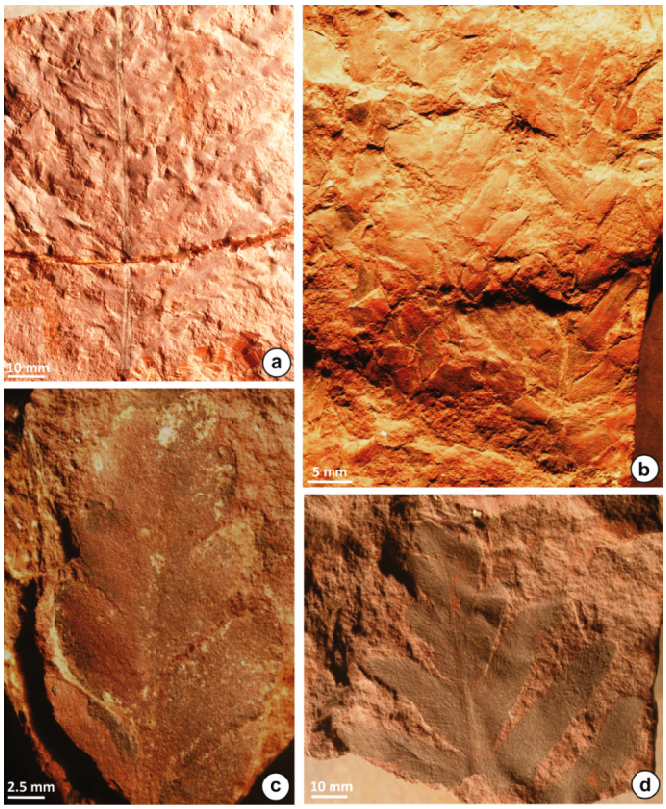
The palaeofloristics of Himmatnagar Sandstone Formation also show resemblance with Barcó (youngest division of Baqueró Formation of Patagonia, Argentina) flora of South America. It is well-established that India was a part of Gondwana assembly (Africa, Australia, Antarctica & South America) and located adjacent to Madagascar. The terrestrial connection between South America and Indo-Madagascar via Antarctica was probably through Kerguelen Plateau or Gunner's ridge that existed until 88 Ma (Chatterjee & Scotese, 2010; Khosla & Verma, 2015). The dispersal of biota might have taken place through the Kerguelen Plateau.

Project- 2.7: Floral diversity, biostratigraphy and palaeoecology of the Triassic sequence from South Rewa (Ramkola-Tatapani Coalfield) and Satpura Gondwana basins

Investigators: A.K. Ghosh & Ratan Kar

There has been a great controversy on the age of the Parsora Formation based on lithostratigraphy and biostratigraphy. Based on the reassessment of palaeofloristics (from Parsora, Beli, Goira, Chicheria & Dhaurai Hill localities) of the Parsora Formation and latest contribution on lithostratigraphy, attempts have been made to resolve the controversy of the age connotation. The plant macrofossil assemblage having an overwhelming dominance of *Dicroidium* and evidence of insect galls suggest a Norian-Rhaetian age for the formation. This is also supported by the earlier contribution on the occurrence of typical Norian to Rhaetian palynoassemblage zones from the bore-hole data. On the basis of present study as well as previous lithostratigraphic and biostratigraphic perception, it has been interpreted that in the South Rewa Gondwana Basin, the Parsora Formation (Norian-Rhaetian age) overlies unconformably on the Tiki Formation of Carnian age.

From the Permo-Triassic section of Tatapani-Ramkola Coalfield of Chhattisgarh, palynological analysis has been carried out in detail that confirm the P/T transition. The macrofloral and megaspore data has been integrated. The Permian palynoassemblage is characterized by *Striatopodocarpites-Crescenti-pollenites* and *Striatopodocarpites-Densipollenites* Assemblage Zones. The early Triassic palynoassemblage is characterized by *Densipollenites-Lunatisporites* and *Falcisporites-Klausipollenites* Assemblage Zones. In addition to publications, work done in this project has been incorporated in a Ph.D. thesis submitted by Ms. Reshmi Chatterjee (BSRS). For further high resolution study of the P/T transition, 31 samples have been collected across the Raniganj and Panchet Formations for isotopic ($\delta^{13}C$) analysis.



Species of *Dicroidium* from the Norian-Rhaetian of Parsora Formation: **a**, **c**) *Dicroidium zuberi*-, **b**, **d)** *Dicroidium hughesii*

Project- 2.8: Morphotaxonomic study of plant fossils from Tekan locality of South Rewa Basin

Investigators: Neeru Prakash & Neelam

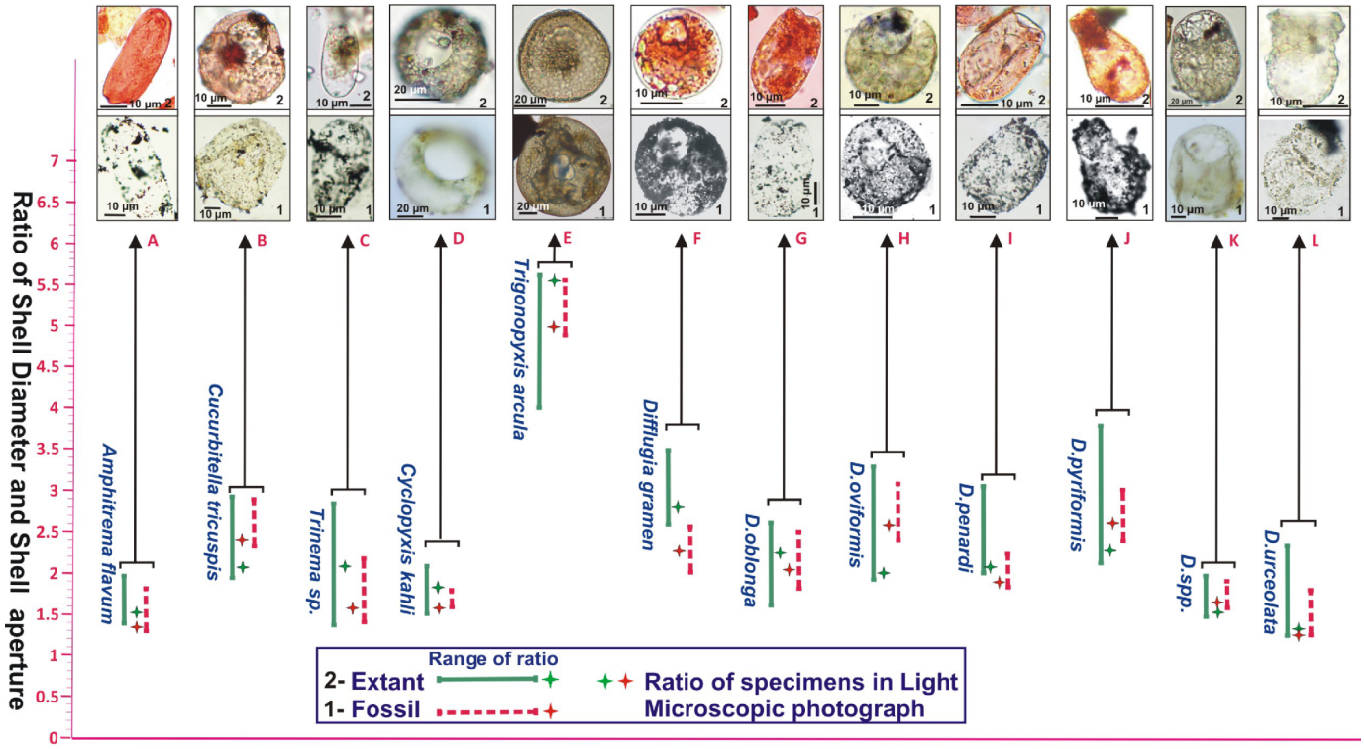
Plant fossils have been collected from 5 m deep pit section. They are mostly preserved as impressions in clay, shale and buff coloured lenticular mudstone. Number of plant fossils belonging to bennettitales, coniferales, caytoniales and pteridophytes are present in the fossil floral assemblage. Within the assemblage, the genus *Zamites* of the order Bennettitales is quite abundant and diversified. This genus has previously been reported mostly from northern hemisphere, and is reported for the first time from the Indian Gondwana Basin.

Palaeozoic-Mesozoic Miofloristics Group

Project- 3.1: Palynology of Gondwana sediments of Satpura-Wardha-Godavari basins: Biostratigraphical, palaeoenvironmental and palaeophytogeographical implications

Investigators: Neerja Jha, Pauline S. Kavali (on deputation abroad) **& Neha Aggarwal**

Palynological analysis of samples from 5 bore-holes of Rampur, Hemchandrapuram and Kothagudem areas (Kothagudem sub-basin), Godavari Graben revealed the presence of Karharbari (Palynozone-I), Lower Barakar (Palynozone-II) and Raniganj (Palynozone-III) equivalent palynofloras. Palynozone-I is dominated by the monosaccate pollen grains (*Parasaccites* spp., *Plicatipollenites* spp.) and triletes (*Callumispora* spp.). Palynozone-II is dominated by the non-striate bisaccate (*Scheuringipollenites* spp., *Ibisporites* spp.) and striate bisaccates (*Faunipollenites* spp., *Striatopodocarpites* spp.). Palynozone-III is characterized by the dominance of striate bisaccates (*Faunipollenites* spp., *Striatopodocarpites* spp., *Crescentipollenites* spp.) along with stratigraphically significant palynomorph species of *Corrisaccites*, *Gutullapollenites*, *Lunatisporites*, *Chordasporites*, *Falcisporites*, etc.). On the basis of palynofloral composition, Palynozones-I, II and III have been assigned to Sakmarian, Artinskian and Lopingian ages, respectively.



Comparative account of ratio between shell diameter and shell aperture in fossil and extant testate amoebae

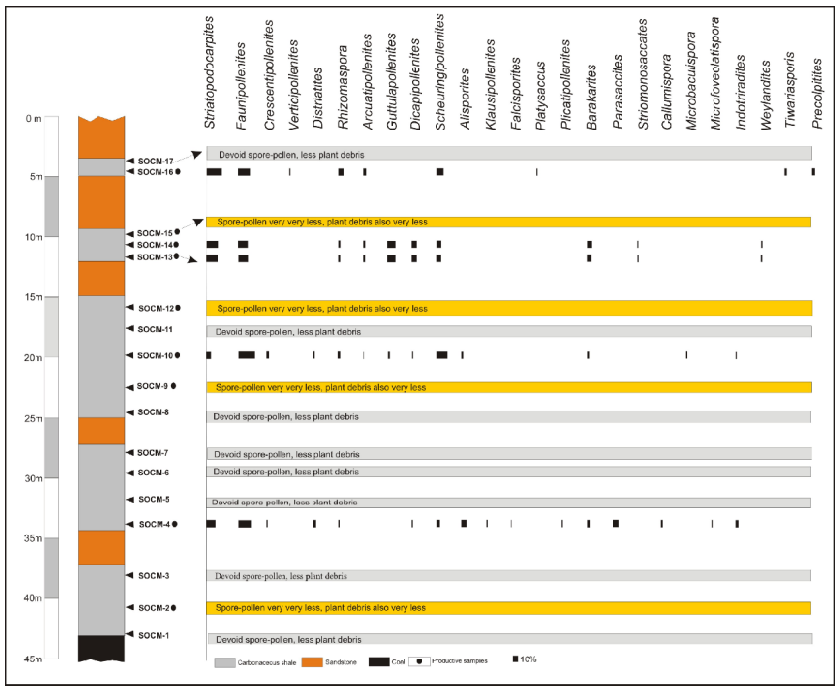
Palynological studies in 601 m deep bore-hole MCP-8 from Chinatalapudi sub-basin (Godavari Graben) revealed the presence of 4 distinct floral assemblages, which fall into 2 groups. Group-I having Palynoassemblages I, II and III is dominated by gymnospermous pollen grains mainly striate bisaccate, and belongs to Raniganj Formation (late Permian). Whereas, Group-II having Palynoassemblage IV is characterised by a high frequency of cingulated-cavate trilete spores along with taeniate bisaccate, which compares well with the palynoflora of Panchet Formation (early Triassic). Thus, the study indicates the presence of Raniganj as well as Panchet equivalent sediments in the sub-basin, and it further supports the earlier studies that the Kamthi Formation represents early Triassic (=Panchet Formation) overlying the Raniganj equivalent sediments with a gradational contact. On the basis of palynoflora and dispersed OM studies, the late Permian deposits have been inferred as fluvio lacustrine with extensive peat-forming conditions. Whereas, early Triassic deposits represent the hot-arid conditions along the river braided systems.

The testate amoebae species in the sediments from northern and southern parts of India deposited during Permian Period have also been explored (with Anjum Farooqui). Twenty-six species have been recorded which belong to the family Arcellidae (6 spp.), Centropyxidae (8 spp.), Trigonopyxidae (2 spp.), Difflugiidae (7 spp.), and one each to Amphitremidae, Hyalospheniidae and Trinematidae. The morphology and morphometry is studied in fossil specimens, and their extant counterparts recorded from sub-tropical lakes in India**.** The dominance of *Centropyxis*, *Arcella* and *Difflugia* species is, in general, recorded in present day ecosystem subjected to varied stresses, like temperature, rainfall, pH, dissolved oxygen, heavy metal content, etc. The statistical analysis of shell morphometry reveals minimum evolution in terms of ratio of shell diameter and aperture.

Project- 3.2: Palynostratigraphy, palaeoclimate and evolutionary trends of palynofloras in Gondwana sequences of Son-Mahanadi–Damodar basins

Investigators: K.L. Meena & Srikanta Murthy

Palynological study of samples from the Sawang Open Cast Mine section of East Bokaro Coalfield, Damodar Basin has been finalized. The recovered palynofossils are characterized by the dominance of *Striatopodocarpites-Faunipollenites* complex. The other stratigraphically significant taxa recorded from the section are– *Guttulapollenites hannonicus*, *Crescentipollenites fuscus, Rhizomaspora indica, R. triassica, Distriatites* sp., *Weylanditites lucifer, Microfoveolatispora gondwanensis, Dictyotriletes invisus, Indotriradites* spp., *Arcuatipollenites pellucidus, Alisporites indicus* and *Klausipollenites schaubergeri*. Other rare palynotaxa include *Parasaccites, Corisaccites, Dicapipollenites, Striomonosaccites, Barakarites*, *Plicatipollenites*, *Scheuringipollenites, Densipollenites, Callumispora, Tiwariasporis, Precolpatites* and *Distriatites*. On the basis of the total palynocomposition, the studied section has been dated as late Permian age. This age correlation also gets support from comparative studies with similar palynoassemblages known from other coalfields of Indian Gondwana basins such as Damodar, Son-Mahanadi, Rajmahal, Wardha-Godavari and Satpura basins, and from known Gondwanan continents.

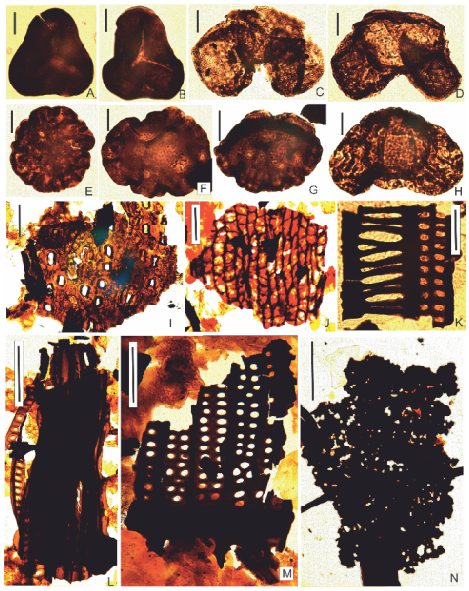


Litholog of the Sawang mine showing sample positions, and distribution of palynotaxa (Dominant: >20%, subdominant: 19-10%, common: 9-5%, fair: 4-2%, poor: <2%)

Project- 3.3: Sedimentary organic matter, palynofloral characteristics and depositional environments of the Early Cretaceous sediments of Kachchh and Saurashtra basins

Investigator: Madhav Kumar

Various types of charcoalified plant organs and other thermally altered palynological remains obtained from early Cretaceous deposits of the Kachchh Basin has been analysed to understand vegetation, climate and wildfire activities. Burial of the fire affected and unaffected plant biomass, preserved in clay, shale and carbonaceous shale of the Bhuj Formation, reveal their production and dispersal in these sediments. Light and SEM microscopic images of these plant remains exhibit least to severe morphological distortions including shrinkage and curling in organs and organelles, porosity in epidermal layers and change in colour (from pale yellow to brown, dark brown & black) because of high temperature effect prior to their burial in these sediments. Botanical affinity of unaltered or thermally altered spores, pollen grains, charcoalified and non-charcoalified woody fragments suggest their derivation from the vegetation constituted mainly by the conifers, cycads, ginkgophytes, tree ferns and other pteridophytes thriving during early Cretaceous in the basin. The relative abundances of such charcoalified and non-charcoalified plant remains recorded from an exposed section along the Khari River of the Bhuj district (Gujarat) provide intensity of fire events and destroying of regional vegetation of the late Gondwana regime.



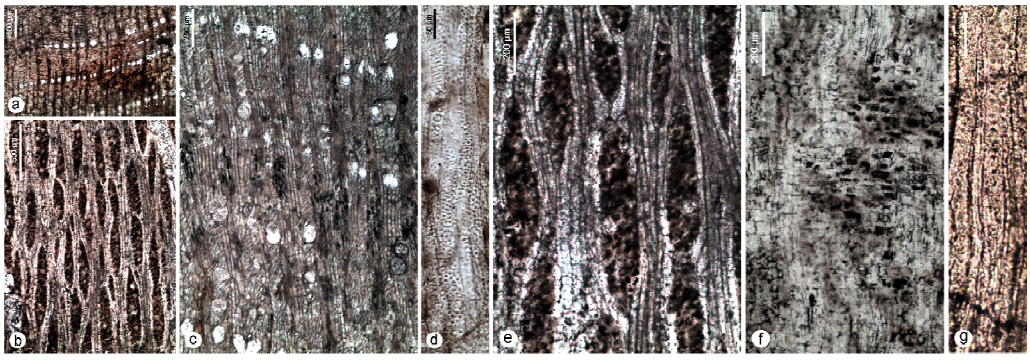
Plant remains affected by high temperature during wildfire: **A**, **B**) Cyatheaceous spores, **C**, **D**, **H**) Distorted bisaccate spores, **E**, **F**, **G**) Distorted pollen grains of *Callialasporites* spp., **I**) Thermally altered stomata showing widening of guard cells and distorted accessory cells, **J**) Distorted cells of epidermal tissue, **K**, **L**, **M**) Thermally altered woody tissues with bordered pits, **N**) Thermally altered perforated woody tissue [Scale bar = 20 µm (A-H), = 150 µm (I-K), = 300 µm (L-N)]

Terminal Cretaceous-Neogene Megafloristics Group

Project- 4.1: Tertiary plant mega remains of northeast India: Floristic and climatic changes

Investigators: R.C. Mehrotra & Gaurav Srivastava

A fossil wood collected from the Tipam Sandstone Formation of Manipur has been systematically described. This is the first fossil record of a dicot wood from Manipur. In addition, many fossil woods have been investigated from the Siwalik of Arunachal Pradesh. The presence of the modern comparable forms of the fossils indicates tropical warm and humid climate in the region during the depositional period.



Shoreoxylon tipamense Prakash & Awasthi, a fossil wood of *Shorea* from the Tipam Group of Manipur

Project- 4.2: Plant mega remains from the Tertiary successions of western India and their bearing on palaeofloristic and palaeoclimatic interpretations

Investigators: R.C. Mehrotra & Anumeha Shukla



1) Fossil leaf of *Aporosa eocenicus* Shukla et al., sp. nov. showing shape size and venation pattern, **2**) Modern leaf of *Aporosa acuminata* showing similar shape, size & venation pattern as in fossil

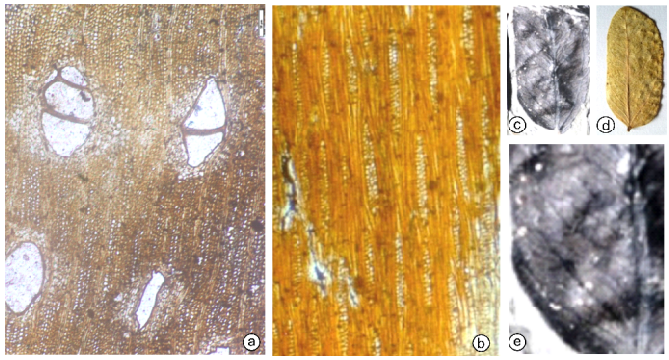
Two fossil fruits collected from the early Eocene sediments of Gurha lignite mine, Bikaner district (Rajasthan) have been investigated, and a paper on the same is finalized. They belong to *Saraca asoca* and *Cajanus crassus* of the Fabaceae family. Besides, a fossil leaf of *Aporosa* of the family Phyllanthaceae, collected from the same lignite mine, is also investigated. Additionally, some fossil woods from the Deccan Intertrappean beds of Kachchh (Gujarat) have been investigated in detail, and one of them was found to be new belonging to *Duabanga* of the Lythraceae family.

Project- 4.3: Siwalik floral diversity and palaeoclimatic changes in the Himalayan Foreland Basin

Investigator: Mahesh Prasad

Fossil wood flora has been described for the first time from upper Miocene sediments of Tanakpur area (Champawat district), Uttarakhand. It comprises 9 species showing modern affinities with extant Dipterocarpaceae, Fabaceae, Euphorbiaceae and Lauraceae families. The flora indicates that tropical evergreen to moist deciduous plants were flourishing in the area during upper Miocene in contrast to the mixed deciduous plants at present. The local extinction of most of the extant species of the fossils indicates that a change in the climate must have taken place since Miocene most probably due to uplift of Himalaya. The Coexistence Approach (CoA) for palaeoclimate estimation suggests that the Tanakpur area enjoyed tropical climate during upper Miocene with mean annual temperature (MAT) 21 to 29 °C, and mean annual precipitation (MAP) 2000 to 2900 mm. The presence of diffuse porous condition in all the fossil woods along with medium to large vessels and abundant parenchyma further suggests the prevalence of tropical humid climate in the region during upper Miocene.

Study of plant megafossils from the Churia Group of Arjunkhola area, western Nepal revealed the occurrence of 16 fossil species belonging to 12 tropical dicotyledonous families. Of these, 11 species are reported for the first time from the Tertiary sequence. The analysis of present day distribution of the comparable extant species of fossils indicates that most of them do not grow



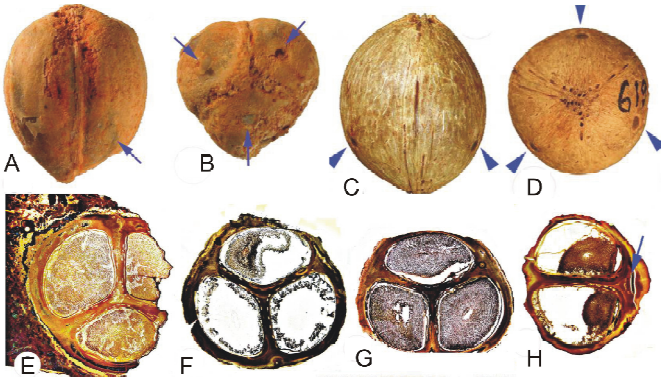
Fossil wood and leaf of an evergreen element, *Albizia lebbek* from Miocene sediments of Tanakpur area: **a**) Cross section showing typical aliform parenchyma , **b**) TLS showing storied xylem rays, **c**) Fossil leaf , **d**) Modern leaf, **e**) An enlarge view of fossil leaf showing details of venation

in and around the area as well as sub-Himalayan zone of India and Nepal; they are presently distributed in the evergreen forests of NE India and SE Asian regions. This suggests that after rise of Himalaya, drier condition was prevailed due to which such moist loving species could not survive there and migrated towards S and SE regions. The dominance of evergreen species in the present megaflora indicates that the evergreen forest was flourishing there during Miocene times as compared to mixed deciduous type of forest at present. The CoA estimation suggests that the studied area enjoyed a tropical climate during Miocene with MAT 20-28.5 °C, warm month temp. 29-34 °C, cold month temp. 15-22 °C, and MAP 1800 to 3200 mm.

Project- 4.4: Megaflora from sedimentary sequences associated with Deccan Traps: Diversification of angiosperms in India

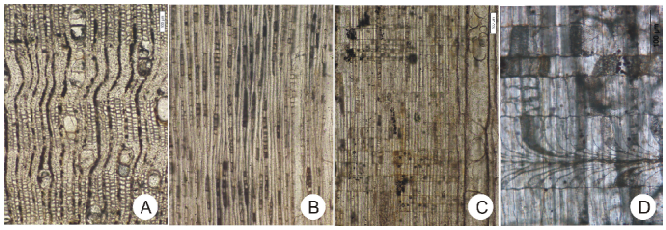
Investigator: Rashmi Srivastava

The indehiscent, trilocular fossil fruits (*Palmocarpon drypeteoides* sp. nov.) have been studied from different localities of central India. These fruits are drupes with distinct germination pores, indicating their affinities with palms. Among extant Arecaceae, closest morphological and anatomical similarities are found among South American genera of subtribe Attaleinae, within tribe Cocoseae, of the subfamily Arecoideae. These fossils are phytogeographically important indicating an early presence of Attaleinae in the Old World tropics and rapid intercontinental dispersal in view of the hypothesized South American origin of the clade.



A, **B**) Endocarps and locule casts of *Palmocarpon drypeteoides*, **E-H**) Anatomical details, **C**, **D**) Fruits of extant *Butia eriospatha* for comparison (arrows indicate germination pores)

A fossil wood *Connaroxylon dimorphum* gen. et sp. nov. (Connaraceae, Oxalidales) from the Dhangaon, Mandla district (MP) has been studied. It is characterized by parenchyma-like fibre bands alternating with normal



Connaroxylon dimorphum: **A**) TS showing alternating zones of thin-walled and thick-walled fibers, **B**) Predominantly uniseriate rays, **C**) RLS heterocellular rays of upright cells and prismatic crystals in chambered fibres, **D**) Radial tubule situated in between modified ray cells arranged in a herringbone pattern

fibres, uniseriate rays of square and upright cells, and radial tubules in the centre of ray cells that are arranged in a herring-bone pattern. This would represent the oldest fossil wood record of the Connaraceae, considerably older than the earliest fossil records of the family's other plant parts, and one of the oldest fossils of the order.

A palm rhizome (*Rhizopalamoxylon nypoides* sp. nov.) has been studied from Sagar district (MP) showing resemblance with *Nypa*. The abundance of palms, including *Nypa* and previously recorded coastal and mangrove elements such as *Acrostichum, Cocos, Sonneratia* and marine algae indicate marine influence and existence of tropical rainforest ecosystem in the vicinity of fossil locality. Additionally, two fossil woods showing resemblance with *Gynocardia* and *Hydnocarpus* (family Achariaceae) have also been studied, besides fossil woods showing resemblance with *Sterculia* (family Malvaceae).

Terminal Cretaceous-Neogene Miofloristics Group

Project- 5.1: Biota from Palaeogene lignite-bearing sequences of western India: Climatic, tectonic, stratigraphic, ecologic and biogeographic signatures

Investigators: Sunil Bajpai, Madhav Kumar, Vandana Prasad, Hukam Singh, Poonam Verma, Shailesh Agrawal & V.V. Kapur

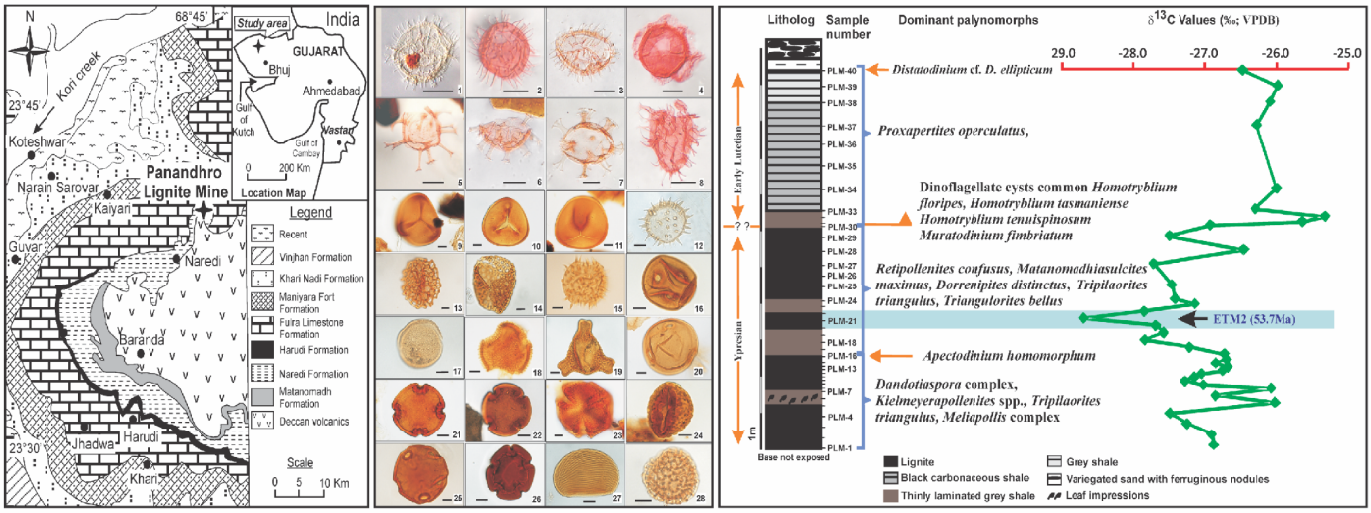
Palynofacies data has been used to characterize the abundances of organic matters preserved in the lignite-bearing sedimentary successions (from 4 pit mining areas) of Barmer and Nagaur-Bikaner basins of Rajasthan. Well-preserved OM and palynomorphs recovered exhibit morphological alterations caused by various biological, environmental and depositional factors prevailed during the burial of lignite, carbonaceous shale, gray shale, mudstones and clay deposits. The OMs are derived mainly from the higher plants, fresh water and marine algae,

accumulated in the lacustrine–coastal deltaic depositional setups during late Palaeocene-early Eocene. The colours of pteridophytic spores and OM depict maturity levels of the host facies, and their preservation potential under dysoxic-anoxic burial conditions.

Palynological studies of the Giral lignite-bearing succession of Barmer Basin revealed the richness in dinoflagellate and pollen-spore contents. Based on dinocyst biostratigraphy, the sediment succession has been dated as Danian-Thanetian (~64-57 Ma). This provided age framework for pollen and spore for the quantitative reconstruction of early Palaeocene climate of western India. Based on the dinocyst abundance and diversity, dispersed OM types and sediment characteristics, the Giral mine sequence has been divided in to 4 palynofacies units; representing 4 distinct depositional environments (open bay, coastal marsh, freshwater marsh & restricted bay). A relative sea level curve has been made for the Danian-Thanetian Giral lignite mine sequence.

recent proposal, that there is no significant age difference between the lignite deposits of the Kachchh and Cambay basins. The results also support a Lutetian age for the previously described vertebrate fossils, including whales, from the Panandhro lignite mine section.

Three cenozones– i) *Tripilaorites triangulus* Cenozone, ii) *Retipollenites confusus* Cenozone, and iii) *Proxapertites operculatus* Cenozone, have been recognized in the Panandhro lignite mine on the basis of palynomorph frequencies change. Additionally, a total 74 morphospecies are used to trace the changes in palaeofloristics and diversity pattern of palaeotropical vegetation across the ETM2. The standing diversity calculated using Range-through method yielded the mean diversity of 27.5 spore/pollen species per sample during pre-ETM2 warming, whereas this diversity increased to 44 spore/pollen species per sample during the ETM2 phase (samples 7-26). Interestingly, the mean diversity per sample of post-ETM2 warming again decreased to

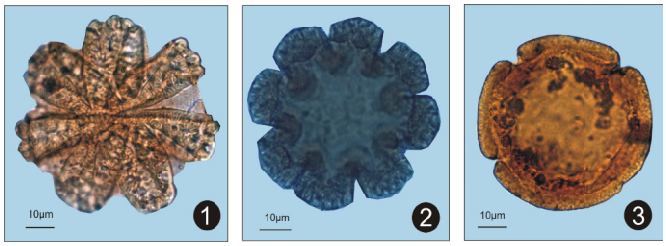


Palynological and stable carbon isotope results of the Panandhro lignite sequence showing ETM2 hyperthermal event

Combined palynological and stable carbon isotope ($\delta^{13}C$) investigations have been compiled in the lignite sequence at Panandhro, Kachchh Basin (Gujarat). Dinoflagellate cysts and associated spore-pollen assemblage assign an early Eocene (Ypresian) age to the lignitic succession. Furthermore, a pronounced negative carbon isotope excursion of about 2.7‰, correlated to the globally significant hyperthermal event, Second Eocene Thermal Maximum (ETM2), is discovered in the middle part of the succession, consistent with the palynological constraints. This is the first record of a hyperthermal event (ETM2) from the basin. The data has regional implications for the age of lignitic sequences across western India as it demonstrates, contrary to a

31.2 spore/pollen species. The distinct increase in taxonomic diversity during high temperatures can be attributed to high level of soil moisture and CO_2 that contributed to success of families typical of wet tropical rainforests in palaeotropical region during extreme warming events.

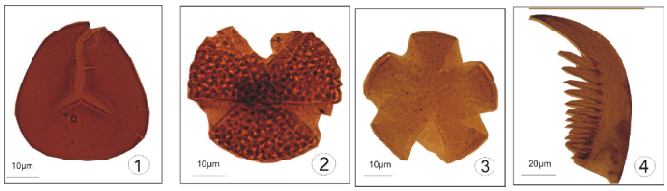
Palynofloral assemblages have been recovered from the sedimentary sequence (Palana Formation) of Gurha lignite mine, Bikaner; comprising a total of 25 genera of angiosperm pollen (in dominance) and pteridophytic spores. Some of the samples indicated the presence of gymnosperm pollen, dinoflagellate cysts and fungal remains. The overall palynofloral assemblage



Palynomorphs from the Palana Formation: **1)** *Ctenolophonodites* sp., **2)** *Polycolpites ornatus*, **3)** *Meliapollis* pollen

demonstrates that the environment of deposition of Palana Formation varied from brackish-water to fresh-water climatic conditions flourished in a tropical-subtropical climate, and it was occurred in a coastal area. Floral evidences even strongly point towards fresh water low land evergreen to tropical to subtropical environment within sub aquatic to swampy angiosperms including fern thick tropical vegetation taxa with mangrove pollen. On the basis of palynofloral evidences, the age of the Palana Formation is assigned as Palaeocene-Eocene.

The palynofloral assemblage of the sedimentary sequences (early Eocene) exposed in Panandhro lignite mine is mainly dominated by Angiosperm families; showing the over dominance of the family Arecaceae. The pteridophytic spores present (in subdominance) in the assemblage are those belonging to the moist and shady habitat taxa. The occurrence of Dipterocarpaceae pollen suggests the existence of rainforest condition in the vicinity of depositional site. The floral elements indicate a mixed forest ecosystem with a variety of cosmopolitan to tropical-subtropical low-land plant communities, along with the profuse occurrence of variety of epiphyllous fungal spores. The presence of rich coastal elements and diverse



Palyno components from the Panandhro lignite mine **1)** *Lygodiumsporites lakiensis*, **2)** *Margocolporites tsukadae*, **3)** *Retistephanocolpites flavatus*, 4) Scalecodont

dinoflagellate cysts in the assemblage are indicative of a probable near shore depositional environment. An increase of terrestrial floral elements and decrease of marine dinoflagellate cysts towards top of the studied section is clearly suggests a progressive change from the marine influenced to a more terrestrial influenced depositional settings.

Project- 5.2: Palynology of the Deccan Volcano-sedimentary Province (Central India) and the Khasi Hills (Meghalaya)

Investigators: R.S. Singh, Ratan Kar & M.F. Quamar

Palynological assemblages have been recovered from the sedimentary beds of the Deccan Intertrappean deposits of Gujarat, which includes marker species of Maastrichtian age (*Mulleripollis bolpurensis Ariadnaesporites intermedius*, *Triporoletes reticulatus*, *Gabonisporites vigourouxii*, *Azolla cretacea* & *Aquillapollenites bengalensis*). However, on upper part of some of the sections includes *Proxapertites, Kielmeyerapollis, Matanomadhiasulcites* and many porate and colporate pollen genus assigned to advanced angiosperms; indicating that the deposition continued during Danian age, the lower most Palaeogene. Fungal remains (spores & fruiting bodies) are also abundantly represented in the assemblages indicating a warm and humid climate during the time of deposition of the sediments. The associated remains of aquatic freshwater ferns (*Ariadnaesporites*, *Azolla* & *Minerisporites*) belonging to Salviniaceae family indicate that the sedimentation took place in small freshwater bodies.

Samples from the Lameta Formation exposed at Nand-Dongargaon village, near Worora town (Maharashtra) have yielded palynomorphs and are being studied for their taxonomical details. The study reflects that the assemblage records taxa from all the plant groups along with the marker species of late Cretaceous. Occurrence of gymnosperm pollen (*Araucaiacites, Podocarpidites, Cycadopites, Belmiopsis* & *Callialasporits*) makes the assemblages distinct from the Deccan Intertrappean assemblages recovered so far.

Project- 5.3: Palynological investigation of the Miocene sediments of Mizoram and Tripura

Investigator: B.D. Mandaokar

Fungal remains have been recorded from the Miocene fossiliferous beds exposed along the road cutting section in the vicinity of Kumarghat locality in north Tripura district. The section is mainly constituted by indurated hard, compact, massive and well-bedded sandstone, siltstone/shale alternations, shale and mudstone, repeatedly occurring in space. The lower part of the shales has yielded a very rich fungal assemblage with around 50 genera and 54 species. Other types, various spores and fruiting bodies of uncertain affinities, are also recorded in the sediments. The fungal remains are comparable to extant taxa belonging to the families Microthyriaceae, Meliolaceae, Trichothyriaceae, Hyphomyceteae, etc. The recorded assemblage suggests that the region experienced a humid climate during the course of sediment accumulation with thick vegetation providing suitable substrate for the growth and proliferation of fungi. Most of the fungal elements indicate a warm humid, tropical to subtropical climate during the time of deposition, though a few have temperate affiliations.

Project 5.4: Palynological investigation of Palaeogene sedimentary rocks of Garo Hills, Meghalaya: Palaeoecological and palaeogeographical interpretations

Investigator: G.K. Trivedi

A palynofloral study of Laisong Formation (lower Oligocene) exposed along Jowai-Badarpur Road, East Jaintia Hills district has been completed. The recovered assemblage is dominated by the pteridophytes and gymnosperms, besides some reworked Gondwana palynofossils. Presence of gymnospermous pollen, viz. *Pinuspollenites* and *Podocarpidites* suggests that the topographically elevated areas were not far away from the basin of sedimentation, and they have been transported from these uplands in the north. The presences of fern spores in fair amount along with the occurrence of fungal remains indicate that the area enjoyed moist, warm-humid, and tropical to subtropical climate. Pollen of family Arecaceae along with spores of family Ceratopteridaceae suggests that the deposition of these sediments might have taken place under coastal environment with fresh water swamps and ponding conditions nearby. The coast might have been bordered by mangroves (*Nypa*) and other coastal elements like *Cocas*. Occurrence of recycled Gondwana palynofossils indicates that the Permian sediments were extensively exposed, however presently they occur in a small patch/exposure at Singrimari (West Garo Hills district), N-W of the area under investigation. The study also records the lower Cretaceous palynomorphs like *Callialasporites*; indicating that these sediments were also existed along with the Permian sediments, and might have been totally eroded and redeposited or may be present in the subsurface.



Rocks of the Laisong Formation exposed along Jowai-Badarpur Road section

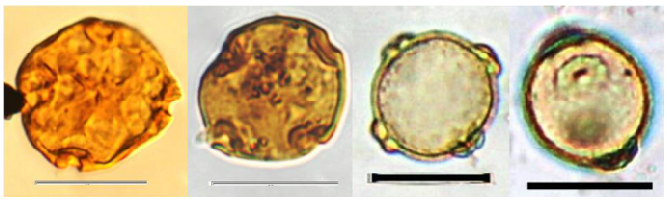
Thrust Area 3: INTEGRATIVE MARINE MICROPALAEONTOLOGY: FOCUS ON HIGH RESOLUTION BIOSTRATIGRAPHY, SEA LEVEL CHANGES, PALAEO-OCEANOGRAPHIC AND PALAEOCLIMATIC EVENTS

Marine Micropalaeontology Group

Project- 6.1: Study of Late Cretaceous-Early Palaeogene successions of South Shillong Plateau: Implications for climate and relative sea level changes

Investigators: Vandana Prasad, Anupam Sharma, Abha Singh & Jyoti Srivastava

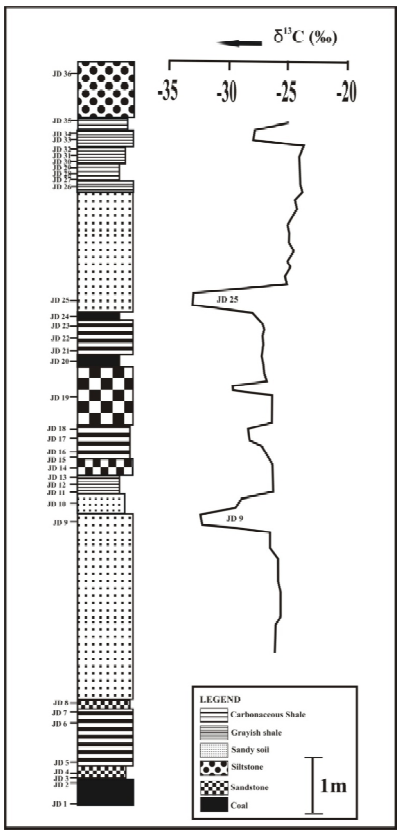
The earliest evidence of genus *Xylocarpus* (a back mangrove genera belonging to the family Meliaceae) has been reported from the late Thanetian (~57 Ma) succession of Ranikor Barsora, east Khasi Hills



Meliapollis minutus-Xylocarpus mekongensis

(Meghalaya). Based on detail morphological and morphometric analyses of fossil genera *Meliapollis,* an attempt has been made to trace the affinity of the fossil taxa with the extant *Xylocarpus* species through nearest living relative analysis. The fossil *Xylocarpus* pollen reported here represent the first reliable earliest record from early Palaeogene record of this genus. Today, *Xylocarpus* is widely distributed in the tropical and subtropical belt of the Indo West Pacific region, but the new fossil record reveals its origin and evolution in the Indian subcontinent during the early Palaeogene time before the India-Asia Collision. Unlike other Meliaceae members, *Xylocarpus* is adapted to brackish water conditions and is found associated with *Avicennia, Rhizophora, Bruguiera, Ceriops* and *Nypa*. Absence of *Xylocarpus* in the fossil records of SE Asia further suggests that this wet and evergreen tropical lineage of family Meliaceae must have originated in Gondwana continents and dispersed from India into SE Asia once the land connection between the Indian and Asian plate was well established during the mid-Eocene (49-41 Ma). The study supports the 'Out of India' hypothesis for the dispersal of Gondwanan clade from India to SE Asia following India Asia collision.

Carbon stable isotope analysis on rocks of the Palaeogene sequences of the Jarain-Dauki (JD) section from Jaintia Hills shows two prominent signatures of negative carbon isotope excursions of ~7 per mill, which is a strong indication of extreme warming event. By virtue of its stratigraphic position it is probably coeval with the well known warming event of Palaeocene-Eocene Thermal Maximum. Here this event is named as 'Jarain Excursion' (JE). The JE is best represented by the two key stratigraphic placed samples of the shallow marine depositional sequence at Jerain. The precise $\delta^{13}C$ values –31.98‰ and –32.51‰ (for samples JD-9 & JD-25,



Carbon stable isotope curve of the rocks of Palaeogene sequences from the Jarain-Dauki section

respectively) is approx. ~7‰ depleted with respect to their upper and lower stratigraphic strata. The study provides an excellent signature of warming in the tropical region during the time interval mentioned above, and this may help in addressing the extreme warming events happened in the past.

Project- 6.2: Calcareous nannofossils from western Indian Jurassic continental shelves: Biostratigraphic, palaeoenvironmental and palaeogeographic implications

Investigators: Jyotsana Rai & Abha Singh

Eleven samples representing the Patcham Formation from Keera Dome (Kachchh Basin) have been studied, and a datable nannofossil assemblage was recorded along with the Ascidian spicules. Record of *Triscutum tiziense* from sample numbers KD-1, KD-3, KD-5 and its absence in KD-6 to KD-11 restricts samples KD-1 to KD-5 to Bajocian (NJ8a – NJ9) age. The occurrence of *Pseudoconus enigma* in sample numbers KD-7 to KD-8 suggests Bathonian (NJ-11 to NJ-12) age. A moderately diversified, reasonably well-preserved nannofossil assemblage comprising 25 nannotaxa are also recorded from upper part of Katrol Formation exposed in Jawahar Nagar section. Only three samples out of ten yielded nannofossils. The nannofossil bearing level is constrained by marker *E. gallicus, H. chiastia, S. bigotii bigotii* and *A. cylindratus* with *Nannoconus* sp. assigning it to NJ 20b *Conusphaera mexicana* Zone of Early Tithonian age. *C. pliensbachensis, D. constans, L. contractus, L. crucicentralis, T. shawensis and S. punctulata* are considered reworked from older levels.

Two new cast of the Bennetitalean genus *Williamsonia*, W. sp. A and *W.* sp. B, along with other fossil flora are reported from the Middle Oxfordian age marker Kanthkot Ammonite Beds from top of Washtawa Formation, Wagad Uplift. These are the only record of the genus *Williamsonia* from marine Upper Jurassic rocks of India, as most of the records of this genus from India belongs to early Cretaceous. Additionally, a field excursion has been undertaken (by JR) around Kachchh Mainland, and samples are collected from the Katrol Formation (overlying Dhosa oolite Lower, Middle, Upper members and base of Umia Formation) represented by sandstone and silty shales with few carbonaceous levels.

A rich and highly diversified calcareous nannofossil assemblage of Late Albian to Early Maastrichtian age from the subsurface sediments of Jaisalmer Basin has been documented. The assemblage includes 222 species belonging to 86 genera and 22 families. The taxonomy of all the species has been done and the synonymy list is revised with the addition of new data. An alpha-numeric zonal scheme (17 Zones) has been proposed in the present study, which will be useful for shallow shelf areas in low latitude.

Project- 6.3: Micropalaeontology of the Subathu sediments of Lesser Himalaya, Himachal Pradesh

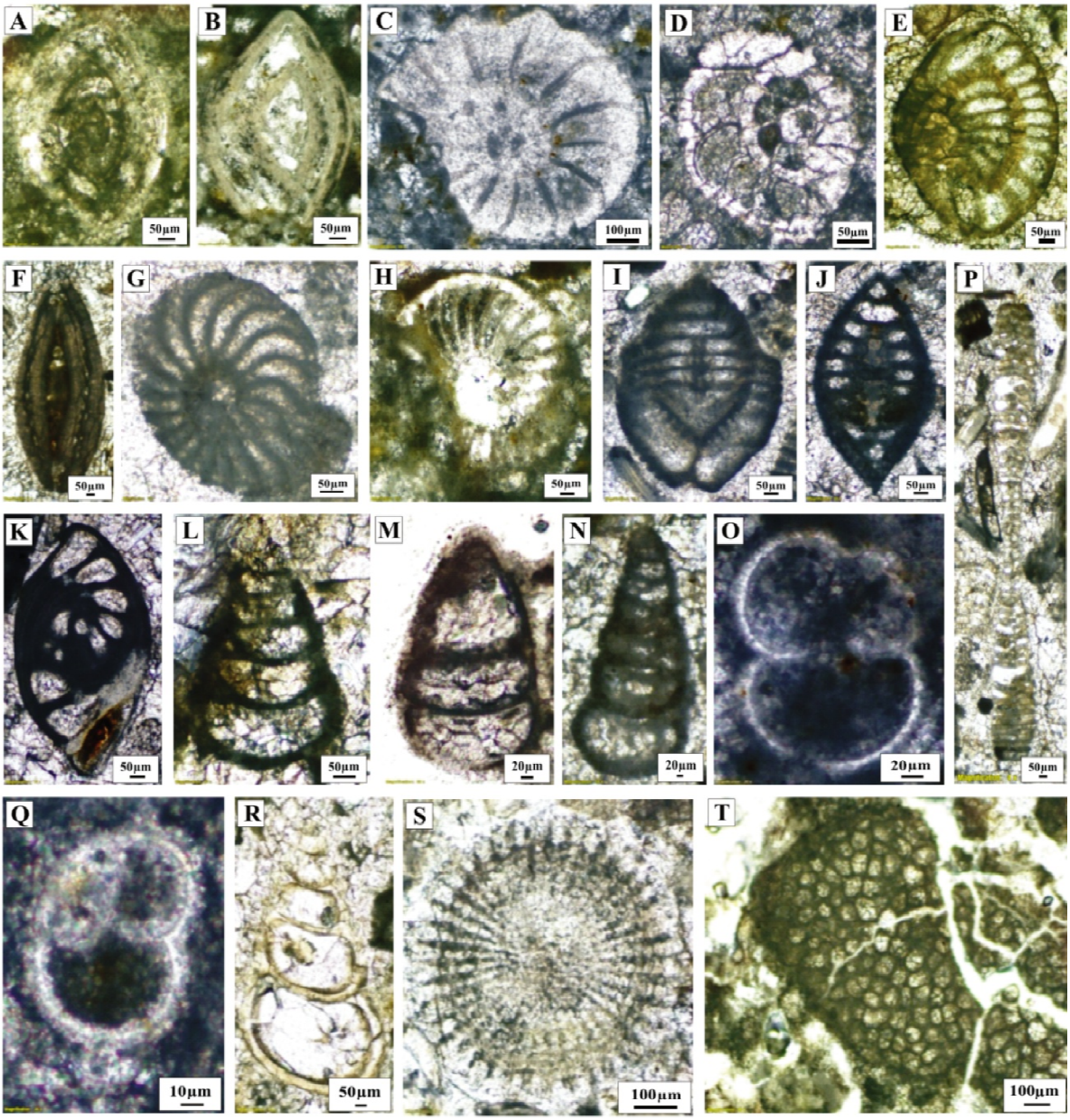
Investigator: V.V. Kapur

The project has been merged with the Project- 13.1 with prior approval of the Research Advisory Council of the Institute.

Project- 6.4: Biofacies analysis of the Cenozoic sediments of Andaman-Nicobar Basin and its implications for palaeogeography, palaeoecology and palaeobathymetry

Investigators: A.K. Ghosh & Abhijit Mazumder

Petrographic thin section analysis of the Pleistocene limestones from Neil West Coast Formation in the west coast of Neil Island reveals that the diversity and abundance of benthic foraminifers are dominant over the coralline algal forms. The detailed analyses of coralline red algae indicate a wide variation of growth forms along with variety of taphonomic features. The taphonomic features *viz.*, disarticulation, encrustation, bioerosion, fragmentation, abrasion and diagenesis are responsible for the suppression of identifying characters of coralline algal taxa. Preponderance of taphonomic features indicates high energy conditions with turbulent water, and an allochthonous or para-autochthonous nature of deposition. The recorded coralline algae as well as foraminifera are generally found in shallow-water setting. During Plio-Pleistocene rapid shallowing of the Andaman-Nicobar Basin took place that resulted in intertidal to near shore environment in contrast to the deep basinal conditions that prevailed during Mio-Pliocene. It has been interpreted that the deposition of Pleistocene limestones



Foraminifers (A-P) from the early Pleistocene of Neil West Coast Formation, Neil Island: **A-B**) *Amphistegina* sp., **C**) *Neorotalia* sp., **D-F**, **I**, **J**) *Operculina* sp., **G**) *Elphidium* sp., **H**) *Assilina* sp., **K**) *Ammonia* sp., **L-N**) *Textularia* sp., **O**, **Q**) *Globigerinoides* sp., and **P**) *Amphisorus* sp. **R**) Gastropod shell, **S**) Echinoid spine, **T**) Coral fragment

at Neil West Coast Formation took place in a near shore environment with high energy condition and increased hydrodynamic activity.

Thin section analysis of Middle Miocene limestones belonging to Long Formation exposed in the Butler Bay Section of Little Andaman Island (Hut Bay) yielded a rich and diversified assemblage of *Halimeda* bioherms (Green Algae) represented by 5 species (*H. tuna*, *H. opuntia, H. fragilis*, *H. cylindracea* & *H. incrassata*). All these species have been recorded for the first time from the Middle Miocene (Serravallian) of India. The record of 5 different species of the genus *Halimeda* from the Serravallian of the Middle Andaman Island is a significant addition to the Neogene halimed flora from this part of the world. Based on preponderance of reefoidal species of *Halimeda* in the present assemblage of halimeds, it has been interpreted that an ancient reef existed in a shallow marine condition during the Middle Miocene in the study area of the Little Andaman Island, and that it might have played a key role in maintaining the carbonate budget at that time.

Project- 6.5: Phytoplankton response to palaeoclimatic fluctuations along the Kerala-Konkan Coast

Investigators: Vandana Prasad, Biswajit Thakur & M.C. Manoj

Vembanad wetland (a Ramsar site of Kerala) is the largest brackish ecosystem in peninsular India which lies in the humid tropical region. A multiple proxy study has been carried out on a well dated sediment core (37 cm, sub-sampled at one cm) spanning up to 225 cal yrs (AD) and located in Cherai region of the wetland. Major, trace and rare earth elements of the bulk sediments have been analysed to determine the source of anthopogenic influence and to investigate the contamination levels since 2000 cal yr. The metal contamination status in the coastal wetland sediments are interpreted using individual and combined metal pollution indices. The predominantly muddy sediment appears to be mainly terrigenous, possibly linked to the REE deposition by the weathering of REE-rich weathered lateritic and charnockitic source rocks. The REE values show an abundance in the order of LREE>MREE>HREE. The increasing heavy element records at 600-1050, 1200, 1500 cal yrs., and recent decades suggest most of them fall under the strong contamination levels. The study demonstrated that the anthropogenic and industrial influences in the site increased in the Vembanad wetland during the recent years.

Based on the diatoms and dinoflagellate cysts, four zones have been identified. The Zone-I (37-28 cm: ~228-673 cal yr) is characterized by marine diatoms indicating prevalence of marine influence at the time of deposition. This is supported by the dinoflagellate and silicoflagellate records during this time. Zone II (27-17 cm: ~682- 1092 cal yr) characterized by the dominance of brackish diatom indicates enhanced freshwater influence due to high monsoonal climatic conditions. The Zone III (16-5 cm: ~1183-1712 cal yr) is marked by the abundance of freshwater pennate diatoms; suggesting lowered water level in the Cherai region. This may be due to lowering of runoff because of low monsoonal precipitation. The Zone IV (5-0 cm: till year 2009) shows considerably high diversity of freshwater diatoms and low turnout marine diatoms; indicating further shoaling of the estuary at Cherai probably due to anthropogenic activities. This study from the Vembanad wetland provides signature for changes in the runoff due to monsoonal fluctuations, marine incursion and anthropogenic responses during 2000 cal yr.

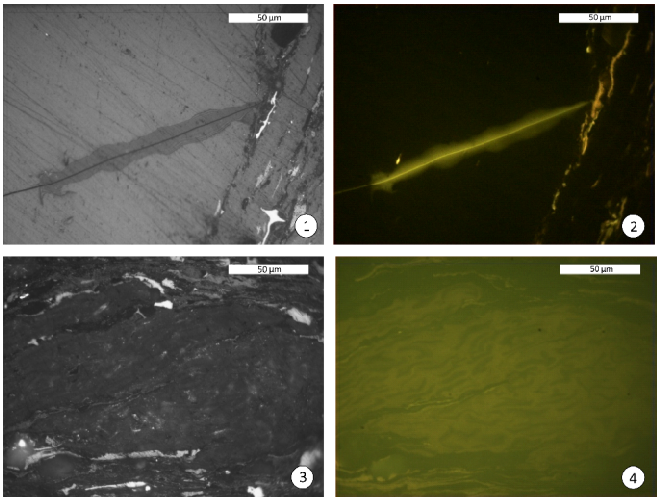
Thrust Area 4: ORGANIC PETROLOGY: CHARACTERIZATION OF SOLID FOSSIL FUEL FOR DEPOSITIONALAND UTILIZATIONALASPECTS

Organic Petrology Group

Project- 7.1: Petrology of coals from Wardha-Godavari Valley Coalfield and its impact on coal bed methane potential and depositional environments

Investigator: O.S. Sarate

The maceral composition and random vitrinite reflectance study ($R_{r\ mean}$%) of the coal seams intersected in bore-hole ML-858, drilled in Mallayyapalli region of the Mulug Coal belt, Godavari Valley, have been worked out. In all, 14 coal seams have been encountered up to a maximum depth of 582.50 m. The $R_{r\ mean}$ values for upper parts of Seams II Top, IIB and IIC vary between 0.48% and 0.49%; indicating the sub-bituminous B stage. Whereas, reflectance fluctuation between 0.51% and 0.54% has been recorded from the top part of Seam IB, Index below IB, IA Top, middle and bottom parts of Seam I and top part of Index above III Seam. The bottom part of Seam IB, IA Bottom, top and middle parts of Seam I, middle and bottom parts of Seam IIB and bottom part of Index above III Seam contain $R_{o\ mean}$ variation from 0.56-0.59%. Similarly, basal parts of Seams II Top and IIC, and the entire IIIB Seam have indicated reflectance variation between 0.60% and 0.63%. The seams with reflectance variation between 0.51% and 0.59% have attained high volatile bituminous C stage. However, the Seams IIIA and III bottom have shown higher reflectance (0.69%), therefore contain coals of high volatile bituminous B rank.



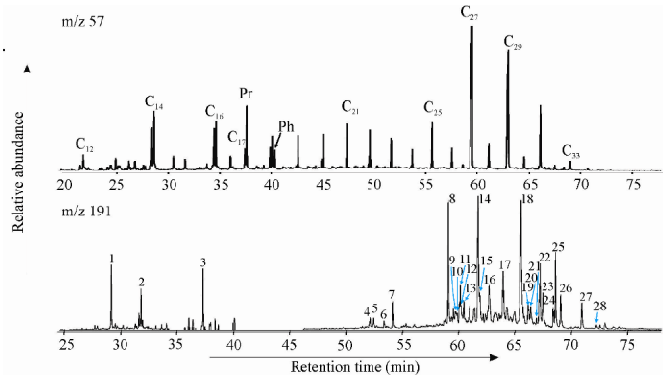
1) Collotelinite showing exsudatinite, **2**) same under fluorescence mode, **3**) sporangial remains with spores, **4**) same under fluorescence mode; in coal of Mallayyapalli region, Mulug Coal belt

The topmost Index above IB and III Top seams contain high amount of mineral matter association indicating their shaly nature. The maceral compositions however, suggest that the Index below IB, IIIB and III bottom seams contain vitric coal type, Index above III Seam has fusic coal type, and the coals representing IA Top and IIIA seams are of mixed type. Seams IIB and IIC contain vitric and fusic types of coal. Similarly, IB and II Top seams contain fusic and mixed types of coal, and the Seams IA bottom and I are characterized by having vitric and mixed coal types. The coal facies based upon the maceral and mineral matter compositions suggests that Seams IB, IA Top, I, IIC, Index above III, IIIB, IIIA and III Bottom have been deposited during alternate oxic and anoxic moor conditions, whereas Seam IA bottom has been subjected to same conditions, but with deviation towards wet moor accompanied with intermittent moderate to high flooding. Similarly, Index below IB Seam has experienced wet moor conditions, whereas Seam IIB has shown maximum climatic variations during the deposition which varied from alternate oxic and anoxic moor conditions to oxic (dry) moor with sudden high flooding with a shift to wet moor with intermittent moderate to high flooding. The II Top Seam however, has witnessed alternate oxic to anoxic moor conditions which changed to oxic moor with sudden high flooding.

Project- 7.2: Organic matter characterization of western Indian lignites through petrological studies

Investigators: B.D. Singh & R.P. Mathews

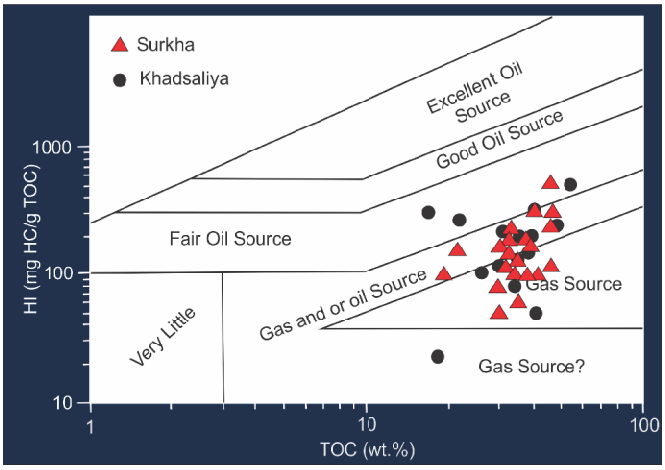
Lignites of the Sonari mine (Barmer Basin, Rajasthan) are characterized by having inherent moisture contents (4.14-19.18 wt.%) and variable ash yields (6.30-23.82 wt.%). The volatile matter yields vary between 33.32 and 44.28 wt.%, and the fixed carbon contents between 29.97 and 44.28 wt.%. Biomarkers study in the lignites shows that the *n*-alkane hydrocarbon fraction (*m/z* 57) is all dominated by a homologous series of C_{12} to C_{33}. Generally, bimodal *n*-alkane distribution is evident with the dominance of short chain and long chain *n*-alkanes. The C_{12} and C_{16} n-alkane hydrocarbons are unusually high in the lignites. The acyclic isoprenoid hydrocarbons (pristane & phytane) are also identified with a dominance of pristane in all the samples; suggesting oxic conditions of deposition. High carbon preference index (CPI: 5.03-9.44) and terrigenous/aquatic ratio (TAR: 5.09-20.01) suggests dominant input of the terrestrial higher plants. The dominance of hopanoids compounds indicates high level of bacterial degradation in the peat biomass. Tetracyclic compound [De-A-fernene (peak no.5)] points towards the presence of pteridophytes in source vegetation. The terpenoid



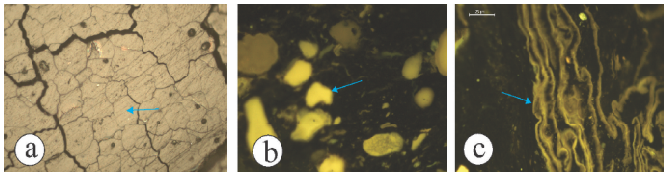
Mass chromatograms showing normal alkanes, isoprenoids (m/z: 57) and triterpenoid (m/z: 191) distributions in Sonari lignite extract

compounds (*m/z* 191) are mainly constituted by the pentacyclic triterpenoids. Further, the T_{max} values (404-430 °C), determined through the Rock-eval pyrolysis, suggest that the lignites are immature to marginally mature in nature. The TOC contents (1.17-54.84 wt.%, av. 24.78 wt.%) and hydrogen index values (32-361 mg HC/g rock) indicating excellent potential of the studied samples to generate gaseous (Type III kerogen) hydrocarbon.

The petrographic results (macerals & huminite reflectance– rank) of the Saurashtra lignite deposits (from Surkha & Khadsaliya mines, Gujarat) have been integrated with palynofacies (particulate OM) and bulk geochemical (proximate, ultimate, Rock-eval pyrolysis & biomarkers) data, and compiled in the form of a Ph.D. thesis (of Mr. V.P. Singh, BSRS). The organic facies, as derived from maceral composition, OM types and biomarker data indicate that the precursors of peat (derived from woody forest vegetation) were deposited in dysoxic-suboxic conditions under deltaic control limno-telmatic to the telmatic regime with mesotrophic to rheotrophic hydrological conditions and brackish water influence. The average T_{max} (Surkha: 416 °C, Khadsaliya: 418 °C), rank (Surkha: 0.31%, Khadsaliya: 0.34% R_r), and the gross calorific (Surkha: 3917, Khadsaliya: 3891 cal/g) values along with the abundance of thermally unstable hop-17(21)-ene and bb-hopanes suggest immature nature of the deposits. The hydrogen index values of the samples vary between 23 and 538 mg HC/g TOC. The hydrocarbon fractions are all dominated by a homologous series of C_{16} to C_{35} *n*-alkanes biomarkers. Overall, the types of kerogen/OM (admixed III-II types) along with high TOC contents (Surkha: av. 35 wt.%, Khadsaliya: av. 33 wt.%) indicates the ability of studied lignite-bearing sequences to generate mix of gaseous/oil hydrocarbons upon maturation.



TOC *vs.* hydrogen index plot of Saurashtra lignite deposits showing potential hydrocarbons source

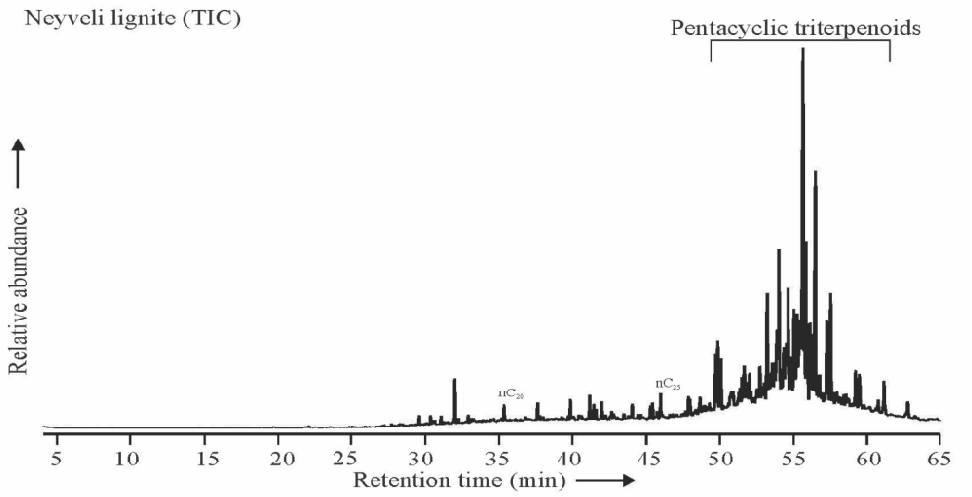


Macerals: textinite (**a**), resinite (**b**) and cutinite (**c**) in Surkha lignite

Project- 7.3: Organic petrographical and geochemical characterization of Tertiary lignite bearing sequences of south India

Investigators: R.P. Mathews & B.D. Singh

The biomarker analysis of Neyveli lignites (from Mine-I) revealed the distribution of *n*-alkane ranging from C_{14} to C_{36}. The distribution is bimodal however, significant contribution from the terrestrial higher plant vegetation. Abundant *n*-C_{25} is suggesting aquatic condition of the depositional setting. Microbial activity in the peat precursor is relatively less prominent. The presence of Olean-12-ene, fernene and the degraded compounds invariably suggest the presence of angiosperms and pteridophytes source vegetation. Hopanoids indicate bacterial degradation of the peat biomass. Compounds with ββ configuration suggest the immature nature of the lignites. The petrographic study of the lignite samples is underway. Besides, the elemental composition of the lignites (from Mines-I & II) has been analysed in the



Total ion chromatogram (TIC) of Neyveli lignite sample

laboratory of CSIR-CIMFR, Dhanbad (with V.A. Mendhe & Subhashree Mishra). The carbon (C) contents in the lignites range from 41.36 to 56.18 wt.%, hydrogen (H) from 4.02 to 7.31 wt.%, nitrogen (N) from 0.46 to 1.82 wt.%, sulphur (S) from 0.39 to 2.78 wt.%, and the oxygen (O) contents from 11.81 to 48.06 wt.%. The H/C atomic ratio for the studied Mine-I samples (1.23-2.06) is slightly higher than the Mine-II samples (1.11-1.89). The O/C atomic ratio of the lignites varies between 0.21 and 0.87 (Mine-I), and between 0.28 and 0.83 (Mine-II). The gross calorific values of the studied lignites range from 2065 to 4254 cal/g with comparatively higher values (3148-4254 cal/g) of Mine-II lignites.

Comparison of the FTIR data of Neyveli (TN) and Panandhro (Gujarat) solid bitumens has also been done, and the results have been finalized. In addition, the study on onshore Warkalli carbonaceous-rich sedimentary sequence from Kerala-Konkan Basin has been documented in terms of its organic matter composition, hydrocarbon source potential, and palaeodepositional environment.

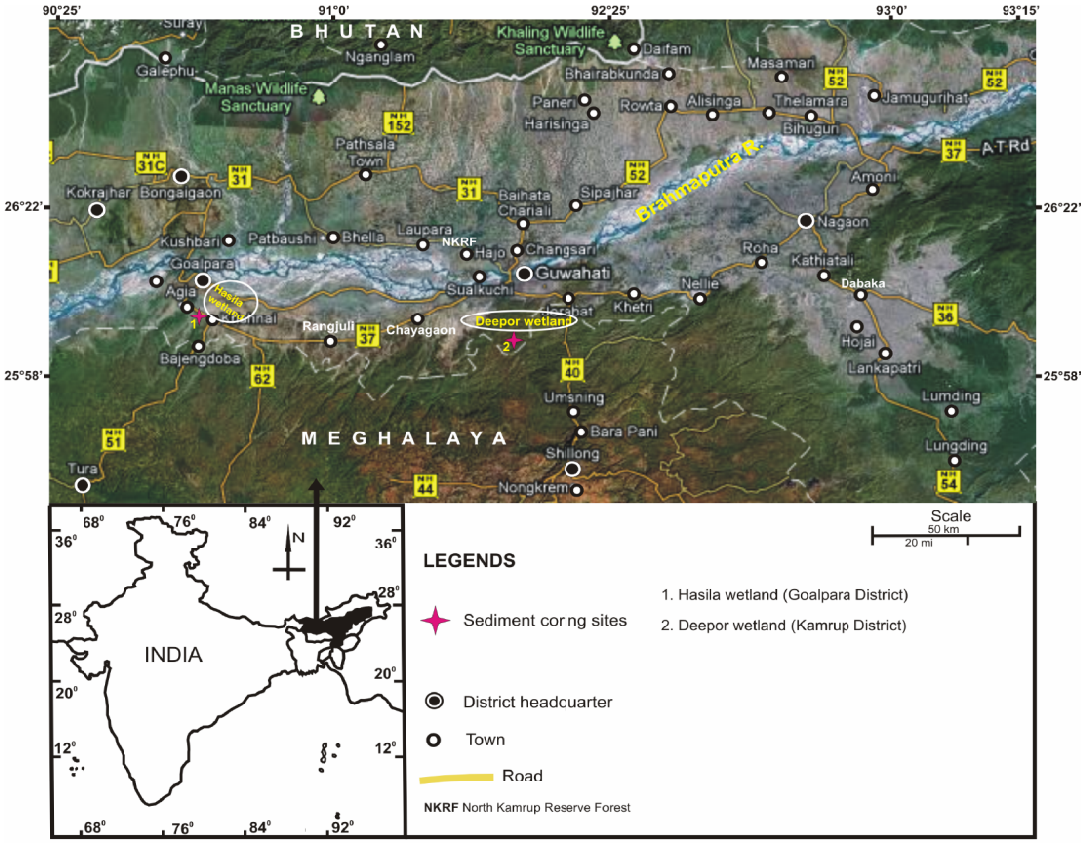
Thrust Area 5: QUATERNARY PALAEOCLIMATE RECONSTRUCTIONS, VEGETATION DYNAMICS AND RELATIVE SEA LEVEL CHANGES

Quaternary Palaeoclimate Group

Project- 8.1: Holocene climatic variations and vegetation succession in endangered wetland ecosystems and adjacent reserve forests in Brahmaputra and Barak valleys, Assam

Investigator: Swati Tripathi

The pollen analysis of soil samples from a 90 cm deep core from Chatla floodplain of southern Assam has provided insights into the changing vegetation and climatic scenario in the region during the late Holocene. The study has revealed that between 1400 and 1100 cal yrs. BP, the occurrences of major riparian tree taxa (*Barringtonia, Syzygium, Duabanga* & Sapotaceae) along with marshy taxa (Cyperaceae & *Polygonum*) indicate humid climate attributable to strong southwest monsoon. An evidence of agricultural practices evinced in the presence of cereal and other cultural pollen taxa. Later, a more humid climate took over during 1100 and 700 cal yrs. BP, as evinced by an exceptional increase in major arboreal group (*Syzygium-Schleichera-Duabanga-Barringtonia-Terminalia*-Moraceae), marshy and aquatics (*Impatiens, Polygonum* & *Lemna*), and annual



Location map showing sampling sites (Deepor and Hasila wetland, Assam)

herbs (Euphorbiaceae & Convolvulaceae); suggesting the consolidation of vegetation around the lake under warm and increased humid climate, which is well corroborated to global MWP that is known between AD 740 and 1150 worldwide. Between 700 to 300 cal yrs. BP, inclination in cereal and other heath land taxa is observed indicating relatively little humid climate, reduction in southwest monsoon precipitation is invoked to explain this which is further supported by a steep fall in major arboreal group, also suggesting an anthropization. From 300 cal yrs. BP onwards, decline in arboreal continued with an exponential rise in cereal and shrubby pollen; displaying the ongoing landscape changes due to human settlement under warm and relatively dry climate.

A reliable modern pollen assemblage has been recovered from 13 surface sediments of tropical deciduous vegetation in Jokai reserve forest, Dibrugarh; signifying existence of open low land forest. Air pollen data partially support the pollen assemblage from surface samples. Pollen data from one trenched 1.2 m deep sedimentary profile suggests the existence of tropical mixed deciduous to semi-evergreen forest under three climatic regimes *viz.*, relatively cool and dry, warm and little humid, and increased warm and humid since 2800 yrs. BP. The presence of cool loving forest taxa namely Magnoliaceae, Lauraceae, *Ilex*, *Mesua ferrea*, *Symplocos spicata*, Ericaceae and *Carya alba* along with *Gleichenia* and *Pteris pentaphyla*, signifies the relatively cool and drier climatic conditions during 2800-2200 yrs. BP.

Project- 8.2: Reconstruction of Quaternary vegetation dynamics and climate change in southern Madhya Pradesh

Investigator: Kamlesh Kumar

Geological field work has been carried out in the limestone caves (Sarva, Bheemkund, Arjunkund & Patal Ganga) and adjoining areas in the Sagar district. Samples have been collected from a 1 ft long limestone deposit (stalactites) hanging on the roof of the Sara cave (situated approx. 80 km SW of Sagar city) at 15-20 ft height. The sediment samples have also been collected from the Bachai Lake, near Bachai village (located towards 10Ú N of Narsinghpur district headquater) and two cores from the Rangari village pond swamp (Chindwara district). The basal part (0-32 cm) of Bachai Lake profile is coarse grain yellow sand with less organic matter, and middle part (32-72 cm) contains yellow-brown coloured silty sand. While the top part (72-97 cm) of the trench is dark brown coloured sandy silt. Three OSL samples are also taken from basal, middle and top parts of the profile. Further work is under progress.



Speleothem in Sarva Cave

Project- 8.3: Quaternary palaeoclimate reconstruction and palaeovegetation dynamics in the central Ganga Plain

Investigators: Anju Saxena, Anjali Trivedi & Kamlesh Kumar

The pollen counting of 14 soil samples from the eight different layers of archeological site, lies in the Hatyaharan village, Sitapur district (UP), has been accomplished to study the vegetation, climate and agricultural pattern in the ancient time. The non-arboreals are more frequent in contrast to the arboreals in all the layers. The cultural pollen are dominant comprising Cerealia pollen (>60 µm) followed by Chenopodiaceae, *Artemisia*, Caryophyllaceae, etc. The important tree taxa recovered into the layers comprising *Acacia nilotica, Holoptelea*, *Syzygium, Aegle*, etc. The samples are full of charcoal particles and phytoliths.

A 2.0 m thick sediment profile from the Kikar Tal, Raebareli district (UP) was studied for the pollen assemblage to infer the vegetation and climate variability scenario during the Holocene Period. Four distinct palynozones have been demarcated based on the palynological succession in the core sediments. The lake profile is corroborated with the chronology of adjacent lake Chaudhari-Ka-Tal. Based on the chronology and corresponding changes in pollen flora, the variability in climatic conditions and vegetation pattern during the Holocene has been studied.

Project- 8.4: Late Quaternary vegetation and climate studies from lakes of Andhra Pradesh and northwest Uttar Pradesh

Investigators: Anjum Farooqui & S.K. Shukla

The sedimentary profiles (~200 cm deep) from Nawabganj (Unnao district) and Sandi (Hardoi district) have been studied using multiproxy data. Palynological analysis is carried out in about 48 samples from Nawabganj and 45 samples from Sandi profiles. The Radiocarbon dates reveal that about 200 cm sediment in both the lakes was deposited since ~ 4000 yrs. BP, and could be divided into three phases of ecological and climatic changes on the basis of palynological assemblage. The quantitative and qualitative results show good diversity in bottom sediments (Phase 1: ~4-2 ka) as compared to upper 100 cm sediment (Phase 2 & 3: 2 ka to present). The tree taxa accounts for 40% in Phase 1, and rest comprised of herbaceous taxa, aquatic pollen and trilete spores. Diatoms and other chlorophyte algal remains along with the fungal spores show intermittent peaks in all the Phases; suggesting stressed ecological conditions related to expansion and contraction of fluvio-lacustrine/lacustrine depositional environment induced by climate changes. However, anthropogenic pressure related to agricultural expanse in the region and loss of natural vegetation cannot be ruled out. In Phase 1, presence of herbaceous taxa like *Artemisia* and other annuals that crop up post-winter season were in abundance along with the calcite loricated phytoflagellates high peaks. Intermittent high peaks of aquatic pollen, thecamoebians and diatoms too support the expansion of lake induced by strengthened precipitation. Magnetic susceptibility and carbon/nitrogen ratios in sedimentary profiles have also been studied along with physico-chemical characteristics of surface sediments from the present-day lake.

Project- 8.5: Vegetation succession and climate change in Garo Hills, Meghalaya and adjoining areas since Holocene

Investigator: S.K. Basumatary

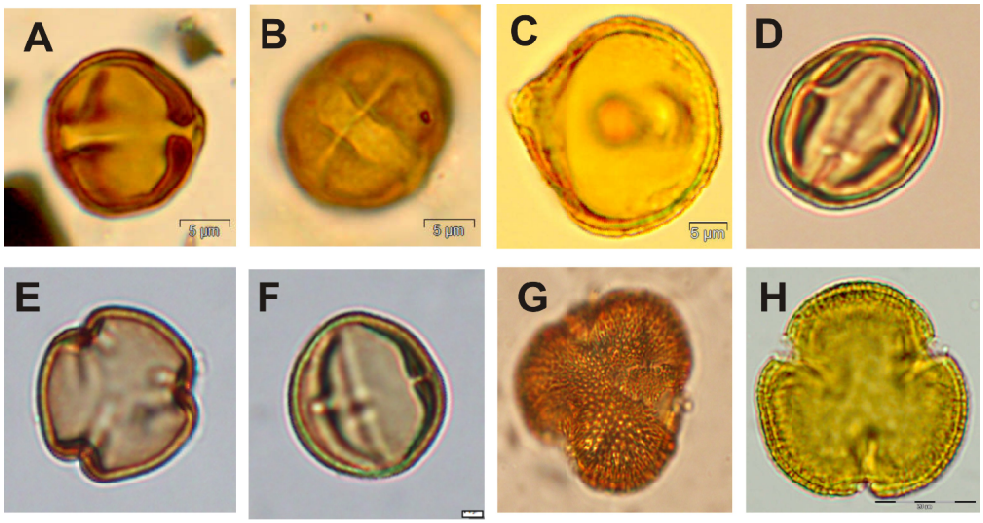
The surface soil and moss cushion samples (50) from the Songsak Reserve Forest of Garo Hills have been studied. The recorded palynodata displayed a tropical *Shorea robusta* (Sal) forest associated with *Albizia*, *Lagerstroemia* and *Elaeocarpus* which exactly reflected the current vegetation. The trace amounts of marshy and aquatic taxa namely, *Polygonum*, Onagraceae and *Nymphoides* are strongly indicative of the perennial water logged condition in the region. The palynological study of 1.5 m sedimentary soil profile from Chandubi Lake of Assam, situated adjacent to the Garo hills, reflected the three palaeovegetation and climatic phases in the region. In the first phase, the *Shorea robusta* forest intermixed with *Dillenia*, *Terminalia* and *Syzygium* under warm and humid climatic conditions is observed in the region. The high value of aquatic taxa namely *Nymphaea*, *Nymphoides* and *Trapa* are indicative of the wider lake condition in response to the high monsoonal activity in the region. However, in the second phase, the comparatively low value of *Shorea robusta* is recorded which is indicative of the forest degradation. The third phase is marked in comparative low value of *Shorea robusta* and increased value of *Melastoma* in region. The presence of cereal pollen is indicative of human activity in and around the studied area.

Project- 8.6: Quaternary mangrove ecosystem dynamics and sea level changes of the Mahanadi Delta and comparative assessment with Sundarbans Delta

Investigator: Shilpa Pandey

The surface sediment samples (45) collected from 2 different Islands (Sudhynakhali & Dobanki) of the Sundarban Biosphere Reserve has been chemically processed to prepare modern analogue. The recovered pollen data exhibits the assemblages that are dominated by mangrove types, but some terrestrial pollen also occur. The pollen assemblages are characterized by a high content (av. 60%) of mangrove and non-mangrove pollen,

in which mangrove pollen (40.33-54.67%) is dominated by *Aegiceras corniculatum*, *Rhizophora mucronata*, and *Ceriops* with the values of 10-18%, 7-15%, and 4-19%, respectively. *Avicennia marina* ranges from 3.2% to 8.5%, the highest level in the system. Mangrove species of *Bruguiera* (1-9%), *A. corniculatum* (1.81-5.00%), *Excoecaria agallocha* (1.81-3.63%), *Rhizophora apiculata* (1-5.6%), and back-mangrove types (0.8-8.5%) also occur in low frequencies. Besides, a total of 57 samples have also been collected, at an interval of 3 cm each, from 1.7 m deep sediment profile from the Jharkhali Island, western part of Sundarbans.



Mangrove pollen recovered from the sediments: **A**, **B**) *Rhizophora mucronata*, **C**) *Sonneratia apetala*, **D**) *Aegiceras corniculatum*, **E**, **F**) *Heritiera fomes*, **G**) *Avicennia marina*, **H**) *Excoecaria* sp.

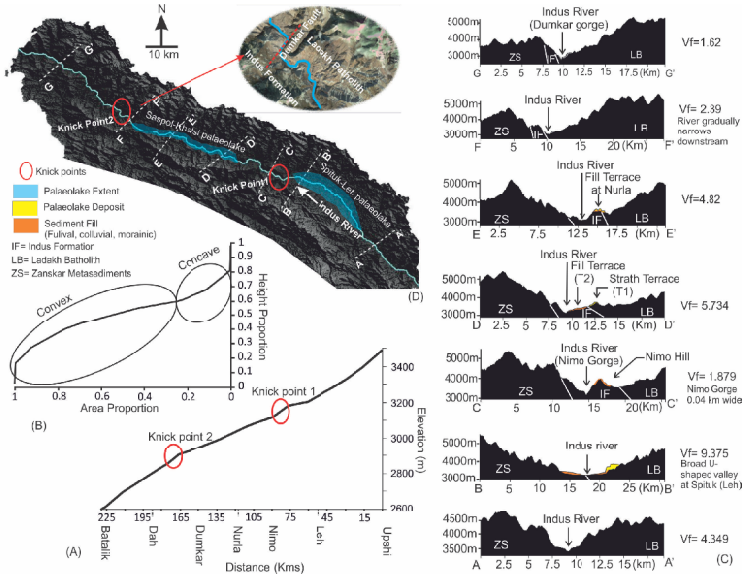
Lithologically, it represents silt and clay. The palynological study is under progress. For AMS radiocarbon dating, 4 samples have been sent to Poland laboratory.

Project- 8.7: Geomorphological and tectono-climatic signatures in Trans and Tethyan Himalaya during Quaternary Period: A multi-proxy approach

Investigators: Binita Phartiyal, Anupam Sharma, S.N. Ali & P. Morthekai

Morphometric analyses aided by GIS and remote sensing have been carried out along the Indus Suture Zone (ISZ) in Ladakh region to understand the role of neotectonics in the evolution of this dynamically active part of the Trans-Himalaya. Upper Indus river catchment (~225 km stretch from Upshi to Batalik) is studied to address landscape development in terms of Quaternary sedimentation and neotectonics along ISZ. Aster-GDEM and ArcGIS are used to derive geomorphic indices of active tectonics such as gradient index, steepness index, asymmetry factor, hypsometry integral, elongation ratio and valley width-height ratio to quantify the recent tectonic activity. Based on morphometric parameters, the region is divided into three morphotectonic segments– Segment 1 indicates erosion dominated asymmetric basins in the Leh region, while higher elevations in the lower reaches of the Indus valley in Segments 2 and 3 suggest a still continuing uplift.

Understanding the sources and compositional characteristics of waters and sediments in the Indus River system is extremely important as its water availability is one of the primary factors for

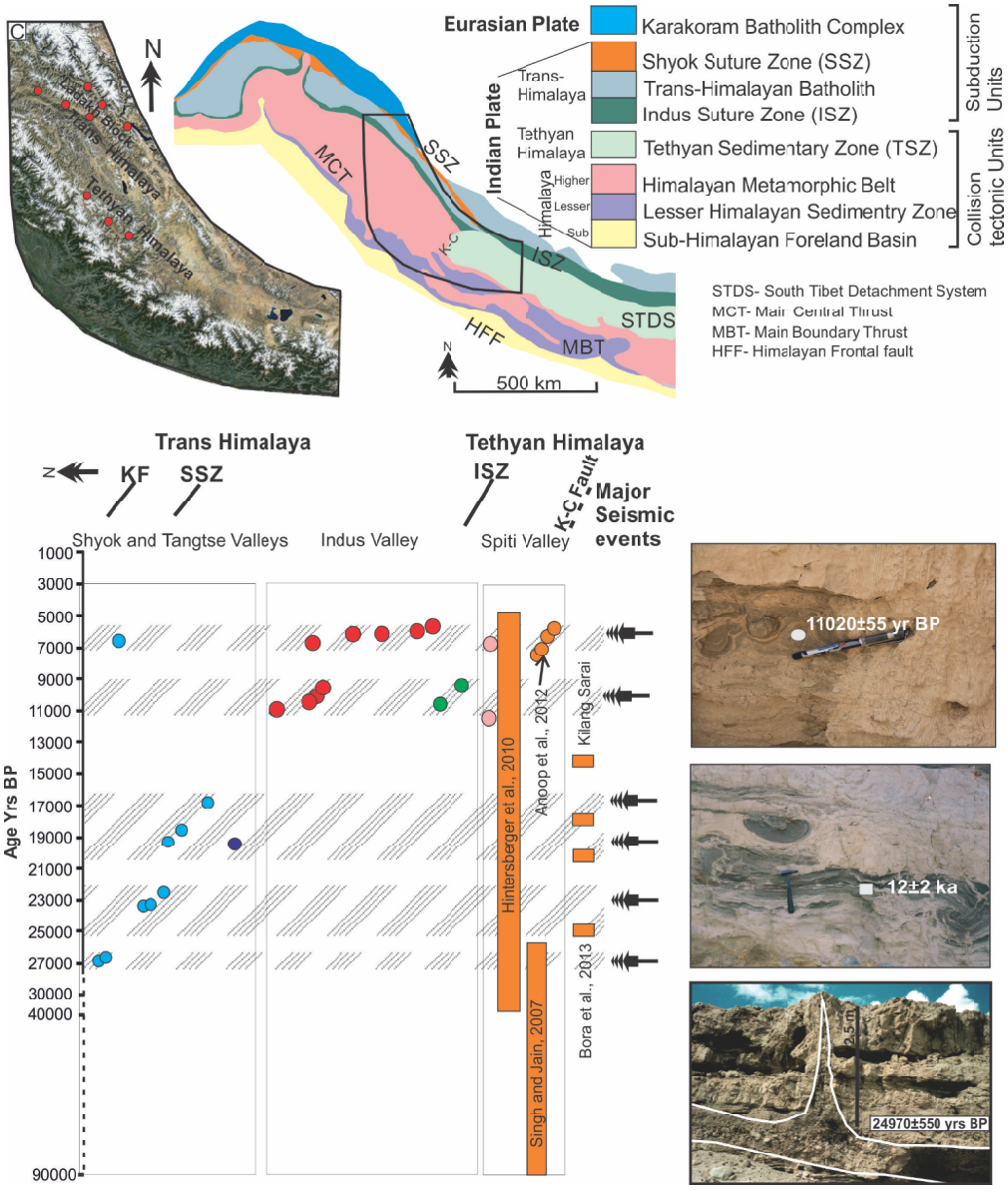


A) River profile along Indus showing Knick Point 1 and Knick Point 2 in red circles coincident with Nimo and Dumkar gorges. Knick points are marked in ASTER GDEM of the study area in red circles, **B**) Hypsometric curve for the Indus catchment showing concave shape in the upper reach till Leh Valley and convex shape in the lower reach, **C**) Cross valley profiles, 7 cross sections (named AA'—GG') are shown in white dash line with respective Vf values, **D**) Spituk-Leh and Saspol-Khalsi palaeolake extent illustrated in ASTER GDEM of the study area and location of the Dumkar Fault [Up: Upshi, L: Leh, Ni: Nimo, Nu: Nurla, Du: Dumkar, Da: Dah, B: Batalik]

sustenance of the irrigation activities and the socioeconomic status of a very densely populated region of the world. Stable isotopic compositions (δD & $\delta^{18}O$) and strontium isotopic ratio ($^{87}Sr/^{86}Sr$) in the Indus River water, its tributaries and its small streams (nallahs) in the Indian territory is studied to understand the regional hydrology, water sources, and catchment processes (evaporation, transpiration, recycling & mixing). The local meteoric water line for the IRS is found to be δD = 7.87 × δ18O + 11.41, which is similar to the Global Meteoric Water Line; indicating meteoric origin of the water and insignificant secondary evaporation in the catchment. The d-excess values are relatively higher because of the contribution of moisture from westerlies; a simple mass balance shows ~26% water in the main Indus channel is contributed by the westerlies originated from the Mediterranean Sea. The Sr isotope ratio in IRS shows contribution from both silicate and carbonate rocks.

A review of the soft sediment deformation structures (which exhibit exogenic nature and are seismically triggered), preserved in the geodynamically active Himalaya has been done. These seismites provide excellent example of the palaeoseimic records of the Quaternary lacustrine and fluvio-lacustrine facie records in the Trans and Tethyan Himalayas. Seismic activity around 27 ka, 23 ka, 17-19 ka, 11-10 ka and 6 ka along the Karakorum Fault and ISZ in the Trans Himalayan region is recorded. While in the Tethyan Himalaya SSDS are recorded reoccurring nine times between 90 ka to 7 ka at intervals with evident records at ~7, ~12 and ~50 ka, although a systematic chronology is still required for the assessment of recurrence intervals of these palaeo-earthquakes.

The Zanskar samples have been prepared for magnetic measurements. Some samples have been sent to establish AMS chronology. A detailed study of seismites found in the Padum section was also done. The chronologies will provide insights into the recurrence time of these palaeo-earthquakes in this region.



Geological map Google image of the area showing studied sites in the Trans and Tethyan Himalaya; schematic sketch of the SSDS concentration at different localities and levels plotted against time in different the Shyok and Tangtse valleys, Indus Valley and Spiti Valley showing the major seismic events from the sites recorded and dated so far, and the photographs of seismites at Khalsi (Indus Valley), Lingti (Spiti Valley) and Tirit (Shyok-Nubra Valley)

Project- 8.8: Late Quaternary climate and glacial history from the western Himalayan region

Investigator: P.S. Ranhotra

Climate reconstruction during end Pleistocene to late Holocene covering the time span since ~16,600 to 3,600 cal yrs BP from the Rukti, Sangla valley, Kinnaur, Himachal Himalaya has been completed. The reconstruction is based on the palynological and magnetic susceptibility data from an exposed section of the lake deposits around Sangla. The study shows that along with the general tree line succession to higher altitudes since early Holocene, the area has also captured the well known late Pleistocene to early-mid Holocene extreme global climatic events but with low intensity. This might be due low resolution of sample size. The dry phase since ~13,270 cal yrs BP is evident by reduced broad-leaved vegetation with decline of *Quercus* (oak) and invasion of *Pinus* (Pine) sp. that can be correlated with the Younger Dryas episode. Subsequently ~11,500 cal yrs BP, advancement of broad-leaved Oak forest at the cost of Pine under the high monsoon regime is also evident by flourishment of Pteridophytes (ferns). *Betula* (Birch) flourished within the vicinity of site indicating lower tree line limits during the early Holocene time. Between the time frame ~8,500 to ~7,800 cal yrs BP, the distinct spike in the magnetic susceptibility values indicates the event that can be linked with the 8.2 ka cool event. However, the pollen data points towards the high lake strand that can indicate the strong westerly influence and low evaporation due to cool conditions. There was subsequent expansion of Pine with gradual decline of Birch and Oak forest till ~3,600 cal yrs BP indicating gradual advancement of the Birch line to higher altitude following the resultant retreat of the glacial body under the averaged warm conditions. The study defines the potential of such Himalayan sites that can uncover the globally known extreme climatic events with their intensity captured by various proxies within a region.

Project- 8.9: Vegetation based reconstruction of Late Quaternary climate of the eastern Himalayas

Investigator: Ruby Ghosh

A modern analogue study of non-pollen palynomorphs (NPPs) from surface samples along a c. 130"3600 m a.s.l. elevation gradient in the Darjeeling has been done to test their efficacy in distinguishing different vegetation zones and correlating grazing activities. These data are also used to check which of the variables (elevation, vegetation type & grazing pressure) is/are most influential for deposition of NPPs and to obtain a NPP modern-analogue model that may assist future regional palaeoecological interpretations. 69 NPPs (consisting of algal, fungal & zoological remains, each identified up to a certain taxonomic rank) and some other plant remains (like phytoclasts, hair bases, wood elements, etc.) are subjected to multivariate statistical methods like discriminant (DA) and redundancy (RDA) analyses to assess their ecological indicative values. DA results showed that NPPs might be efficient predictors that correctly classified 72.6% of the samples to their correct vegetation zones along the elevation. RDA results further proved elevation and grazing pressure as the most significant variables influencing NPP deposition in the Darjeeling Himalaya. Considering the ecological requirements of the studied NPPs, this study also links some NPPs to their corresponding vegetation zones along the rising elevation as well as different grazing pressure and emphasizes the use of modern analogue studies in palaeoecological interpretations.

Study of modern pollen-vegetation and climate relationships from the c. 130"3600 m a.s.l. elevation-vegetation gradient in the Darjeeling, eastern Himalaya is under progress to test the efficacy of the modern pollen data in palaeoclimate reconstructions. Besides, palynological study of the surface soil samples collected along a tropical to temperate (140-4000 m a.s.l.) elevational gradient of the Arunachal Himalayas is also under progress.



Some significant NPPs recovered in the surface samples from Darjeeling Himalaya
1-3) *Spirogyra* spp., **4**) *Zygnema* sp., **5-6**) resting zygospores of Chlorophyta, **7**) *Pseudoschizea* sp., **8-9**) *Inonotus* spp., **10**) *Cyathus* sp., **11**) ascospore from Sordariaceae, **12**) *Gelasinospora* sp., **13**) *Peziza* sp., **14**, **39**) *Podospora* sp., **15**) *Schizothecium conicum,* **16**) *Cercophora* sp., **17**) *Sordaria superba,* **18**) *Nigrospora* sp., **19**) *Arnium* sp., **20**) *Ustulina deusta,* **21**) *Rosellinia* sp., **22**) *Leucocoprinus* sp., **23**) *Coniochaeta ligniaria,* **24**) *Hypoxylon* sp., **25-26**) *Xylaria* spp., **27**) *Sordaria* sp., **28**) Sordariaceae, **29**) *Brachydesmiella* sp., **30**) *Delitschia* sp., **31**) *Spegazzinia intermedia,* **32**) *Spegazzinia tessarthra.* **33**) *Periconia macrospinosa,* **34**) *Russula* sp., **35**) *Geastrum* sp., **36**) *Tilletia* sp., **37**) *Nigrospora* sp., **38**) *Ascodesmis* sp., **40**) *Scleroderma cepa,* **41**) *Diporotheca* sp., **42**) *Canalisporium pulchrum,* **43**) *Cordana musae,* **44**) *Brachysporium* spp., **45**) *Asterosporium* sp., **46**) *Sporormiella* type– ascospore cells, **47**) *Drechslera teres,* **48**) *Glomus* chlamydospores, **49**) *Nigrospora* sp., **50**) *Strobilomyces* sp., **51**) *Schizothecium conicum,* **52**) *Thielaviopsis* sp., **53**) *Endophragmiella* sp., **54**) Conidium of *Clasterosporium* sp., **55**) *Sporidesmium* sp., **56**) *Cookeina* sp., **57**) *Ceriophora palustris,* **58**) Hyphopodium of *Clasterosporium* sp., **59**) *Microthyrium fagi*, **60**) Pycnidia of *Phoma* sp.

Project- 8.10: Quaternary vegetation and climate change in north and northwestern regions of Chhattisgarh

Investigator: M.F. Quamar

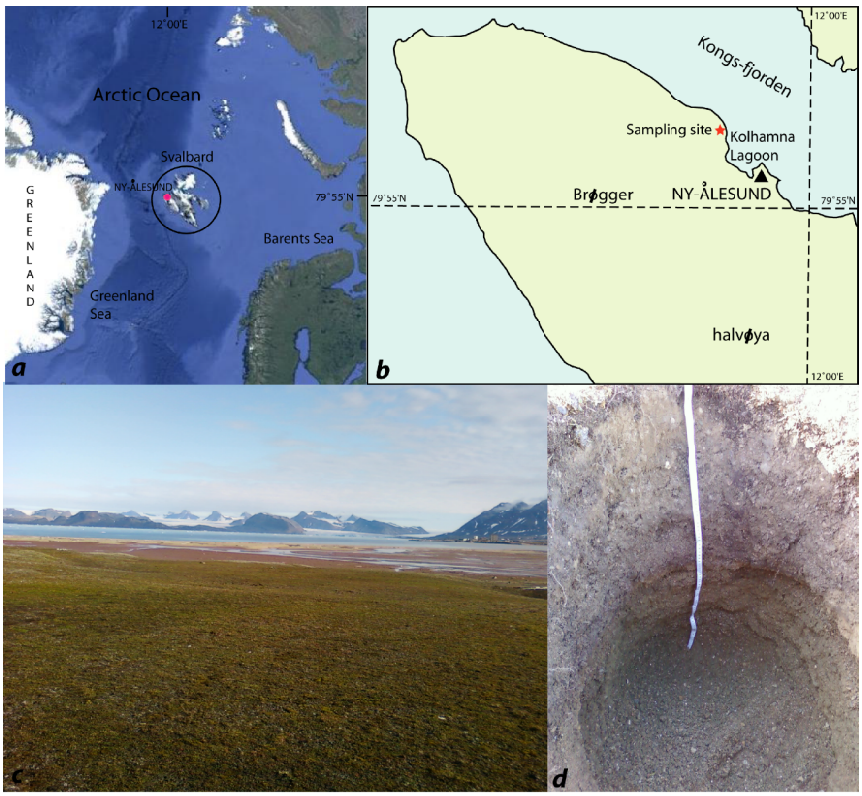
Pollen analysis of a 2.1 m deep lacustrine sediment profile from the Kodamsar Lake, Kartala forest range of Korba district has been completed. The study demonstrates that open mixed tropical deciduous forest under warm and moderately humid climate with moderate monsoon precipitation occurred in the region during Phase I. Subsequently, during Phase II, with increase in monsoon precipitation mixed tropical deciduous forest replaced the open mixed tropical deciduous forest under a warm and humid climate. Finally, during Phase III, with further increase in monsoon precipitation dense mixed tropical deciduous forest succeeds the mixed tropical deciduous forest under a warm and relatively more humid climate.

Polar Research Group

Project- 9.1: Deciphering the Quaternary climate history of the Polar Regions: Multi-proxy studies from Antarctica and Arctic

Investigators: Ratan Kar, Abhijit Mazumder & Pawan Govil

Palynological studies on 72 surface samples (sediment & moss polsters) around Ny-Alesund, Svalbard (Arctic) have been completed to interpret the pollen-vegetation relationship in the region. The pollen yield is found to be extremely poor, and whatever little is recovered is found to be compatible to the ground vegetation and represented the local niches of the herbaceous ephemeral taxa. The sediment samples (20) from a 1 m long trench cutting section have been further studied to understand the palaeoclimatic changes in and around Ny-Alesund. Magnetic susceptibility measurements have been undertaken, and on the basis of variations in the susceptibilities, the trench can be divided into 4 zones– Zone I (100-75 cm; 19132-15455 yrs. BP) shows an increased concentration of magnetic minerals, Zone II (75-55 cm; 15455-11777yrs. BP) is characterized by sharp decrease in the magnetic susceptibilities throughout the zone, Zone III (55-30 cm; 11777-7045 yrs. BP) shows an overall increase in the magnetic susceptibility, however in the interval from 45-40 cm (organic-rich layer), a considerable decrease in the concentration of magnetic minerals is observed, and Zone IV (30-0 cm; 7045 yrs. BP to Present) is marked by the continuous decrease in the concentration of magnetic mineral, thereby showing low values of ÷If. The changes throughout the profile as revealed by distinct magnetic variations define alternate stages of colder and warmer phases.



a) Map showing location of Svalbard, **b**) Map showing location of Ny-Alesund and Brogger Peninsula, **c**) Field photograph of the study area, **d**) Dug trench for sampling

The lake sediment cores from Schirmacher Oasis (east Antarctica) retrieved during the 32nd ISEA are being used for micropalaeontological and geochemical studies to decipher the climatic changes that have occurred in the immediate past in the area. The work involves use of several climate proxies to extract century to millennial scale dataset from the lacustrine deposits. Four freshwater lake sediment cores from the Oasis (one core from Proglacial Lake, 2 from Landlocked lakes & one from Epishelf Lake) have been analyzed. These sediment samples at an interval of 2 cm are analyzed for the organic carbon and carbon isotope variation within the core profile, which provides the variation in biological productivity. The epishelf sediment core does not yield any organic carbon. The other sediment cores samples also contain a very small amount of organic carbon. These core samples cover the time span from ~3000 to ~17000 yrs. BP. The core top was absent, which may be due to loss of upper part of the sediment during the collection of the cores or because the core has been collected from the peripheral part of the lake, which did not contain the recent sediments. Furthermore, three sediment cores from Larsemann Hills (collected during 35th ISEA) are used for sedimentological analysis to understand the environment and depositional setting in the lake basin. In addition, around 100 samples are used to analyse the grain size variation on particle size analyser. The samples have also been prepared for the organic matter and isotopic analyses.

Project- 9.2: Study of Quaternary climatic conditions of the Polar Regions using integrated multi-proxy data

Investigator: Vartika Singh

The study of spheroidal carbonaceous particles (SCP) is also being done along with the other micro-organic contents. The SCPs are opaque black particles commonly ranging in size from 2-20 µm and occasionally be larger than 50 µm. The SCPs are transported like pollen grains, because of more or less similar size and shape, mostly by the wind. The analysis of size range of SCPs provides an evidence of distance of the probable source, which could be both local and far off. During the winter easterly and south-easterly winds dominate over Svalbard and bring anthropogenic Arctic haze. Evaluation of air mass trajectories and the seasonal movement of the atmospheric polar front show that Svalbard is affected by long-distance transport from industrial areas of Europe and Canada. Also, research and field work has been conducted in the High Arctic Region of Ny-Alesund (Svalbard). Sediment samples are collected by trenching of the Quaternary sequence, and sampling is done at varying thickness, at 5-10 cm interval depending on the grain size of sediments, i.e. close sampling is done for fine grained sediments.



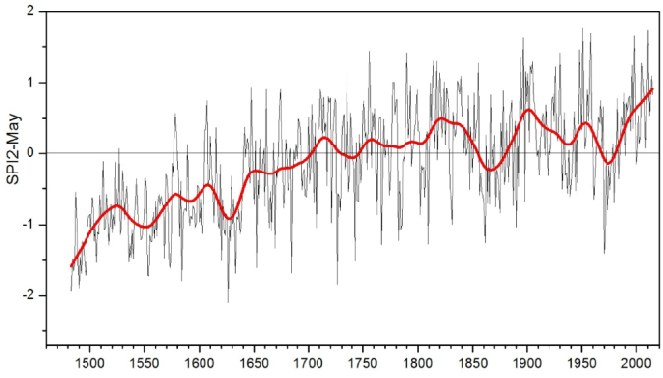
Grab sediment collection onboard the boat Tiesten from Kongsfjiorden in Ny-Alesund (Svalbard): Movement of Tiesten in Kongsfjiorden (top left), various equipments used for different measurements (top right), lowering of the grab for fjord sediment sampling (bottom left), and grab sampler containing the collected sediment sample (bottom right)

Dendrochronology Group

Project- 10.1: High-resolution palaeoclimatology of western Himalaya

Investigator: K.G. Misra

The tree-ring samples of *Cedrus deodara* and *Pinus gerardiana* from various semi-arid localities of Kishtwar (J&K) have been analyzed, and found sensitive to precipitation. However, the understanding on precipitation is very poor due to the availability of limited observed precipitation records over the region. The precipitation records of Kishtwar showed that most of the annual precipitation occurs from December-May of which ~27% falls in April-May alone. Using annually resolved tree-ring data of *Pinus gerardiana* and *Cedrus deodara* bimonthly standardized precipitation index of May (SPI2-May) extending back to A.D. 1439 (576-yrs.) in semi-arid Kishtwar, NW Himalaya is developed. The most significant feature of the reconstruction is wet conditions in the end of the reconstruction with 1994-2014 being the wettest 21 year in the past 576-years. The present reconstructed data is similar with other tree-ring-based hydrological records from the cold arid to semi-arid NW Himalaya and Karakoram; indicating towards regional wetting in recent decades. The increased wetting could be implicated to the anomalous behaviour of glaciers in the NW Himalaya and Karakoram opposite to the general receding trends in the central and eastern Himalayas. Additionally, tree-ring samples of *Betula utilis* and *Juniperus polycorpus* from high elevation sites of Lahul-Spiti, Himachal Pradesh are processed, and crossdating of the samples are in progress.



SPI2-May reconstruction (A.D. 1439-2014). The thick line superimposed over the reconstruction is 40-year low pass filter

Project- 10.2: Tree-ring analysis from high altitude areas of Himalayan region: A comparative approach with emphasis on the eastern sector

Investigator: S.K. Shah

Tree-ring analysis of *Larix griffithiana* from Sikkim and Tawang district, Arunachal Pradesh has been made for multi-tree-ring parameters. The tree-ring studies of *Toona ciliata* Roem. (Toon) from the subtropical wet hill forests of Kalimpong, eastern Himalaya has been revised with improved and robust methodology. The winter temperature and current years April precipitation and April-May drought exhibit direct relationship with the ring–width chronology when correlated with monthly or seasonal climate data. The correlation and seasonal correlation analysis shows positive relationship of tree growth with mean minimum temperature of winter (October-February) is most significance. The observation of the tree–growth and climate showed that optimum temperature, precipitation and soil moisture together modulated the increase growth of Toon in the region. This study clearly establishes the dendroclimatic potential of this tropical species to carry out future tree-ring based long-term climate reconstruction. Besides, cross dating is also done for tree-ring samples of *Cedrus deodara* and *Pinus gerardiana,* previously collected from two sites of Himachal Pradesh.

Thrust Area 6: DOMESTICATION OF PLANTS, EARLY FARMING AND ECOSYSTEM DYNAMICS DURING HOLOCENE/ ANTHROPOCENE

Palaeoethnobotany Group

Project- 11.1: Palaeoethnobotany: Ancient man, plants and environment in northern, eastern and northwestern India

Investigators: Chanchala Srivastava & A.K. Pokharia

The palaeoethnobotanical investigations on carbonized grains, seeds and fruits collected from archaeological site Biland Khera, Hardoi district (UP) is continued. Crop remains and their associates recovered from the ancient site belong to cereals, millets, pulses, oil-seeds, weeds and wild taxa. In addition to assemblage recovered during 2015-16, *Lens culinaris*, *Salmalia malabaricum*, *Andropogon* sp., *Medicago* sp., *Polygonum* sp., *Rumex* sp., *Solanum* sp., and *Fimbristylis* sp. are the new finds.

Thrust Area 7: GEOCHRONOLOGICAL AND GEOCHEMICAL PARAMETERS FOR HIGH RESOLUTION DATING, CORRELATION, PALAEOCLIMATIC, TECTONIC AND PROVENANCE STUDIES

Geochronology and Geochemistry Group

Project- 12.1: Carbon dating and its application in Quaternary studies

Investigator: C.M. Nautiyal, Rajesh Agnihotri & team

Varieties of samples (barley seeds, carbonate, charcoal, wood, sediments, etc.) have been routinely dated using the conventional beta-counting of benzene prepared by trimerization of CO_2 extracted from organic and inorganic carbon contained in the samples. The Radiocarbon lab continues to provide ~150 ^{14}C dates annually; nearly half of them are for outside users. As the conventional ^{14}C dating requires larger amounts of carbon (several 10s to 100s of grams of natural sample at times), while Accelerator Mass Spectrometry (AMS) ^{14}C dating requires only ~1 mg of purified carbon without compromising accuracy and precision of obtained ^{14}C date, the BSIP's C-14 dating facility has recently made a new glass-vacuum line for extraction, purification of CO_2 and finally converting it to graphite powder (mg-level) which is used as target for AMS ^{14}C dating. In addition, C-14 laboratory is soon getting a fully automated multi-graphite preparation facility equipped with comprehensive

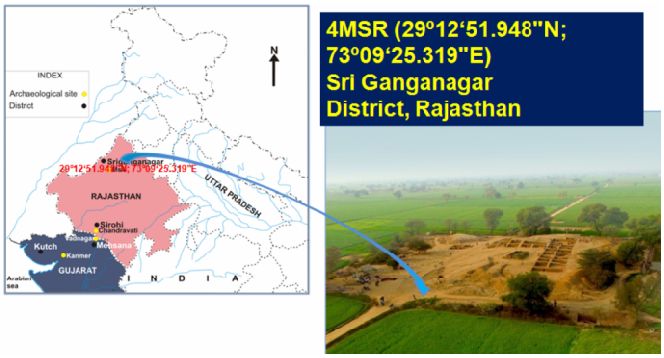




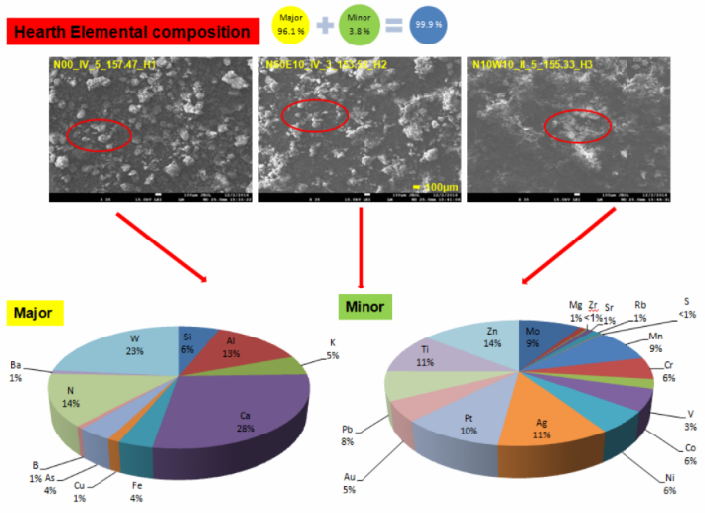


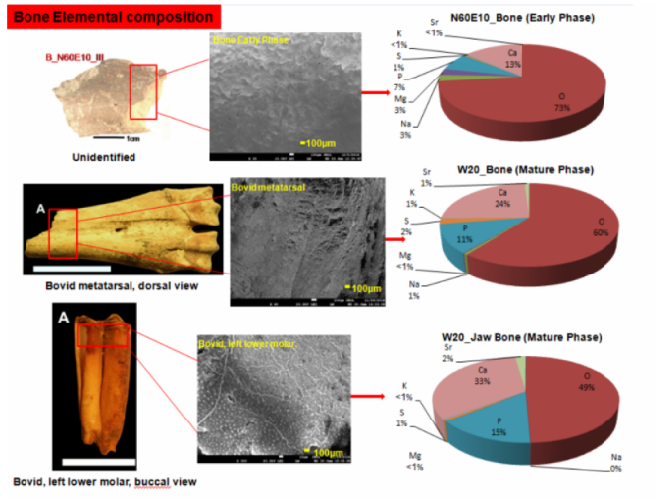
diagnostic stable isotope measurement capability of carbon, nitrogen and sulphur to fingerprint dateable material for its suitability of ^{14}C dating. The automated system will enhance throughput of graphite-target preparation greatly and reduce the cost of AMS ^{14}C dating. C-14 laboratory is also upgrading its pre-processing wet chemistry laboratory, which is a pre-requisite for obtaining a reliable ^{14}C date.

Geochronology of the archaeological site (4MSR in Anupgarh, western Rajasthan) has been ascertained by ^{14}C dating both by AMS and conventional beta counting. Constrained by seven AMS and three conventional ^{14}C dates the habitational over the site appears to be extending from early to mature phase (between ~2900 & ~1800 BC). Variety of samples such as soil-sediment, pottery pieces, hearth residues, ceramic and bone pieces, inorganic layers of the 4MSR site are analysed for chemical composition using Energy Dispersive Spectroscopy technique. SEM images are also taken to examine texture and morphology. Preliminary results are encouraging and indicate that ancient humans were having good knowledge of metals for metallurgical (industrial) activities as evident from series of hearths connected with flame-channeling devices and water-tanks used for metal forging. Agriculturally, the early habitational phase was dominated by barley based crops which tend to diversified crops towards the mature phase. Stable C isotopes have been measured throughout (depth-wise) to characterize all the habitational layers (total 15) found between modern



humus and bed-sediment. Typical $\partial^{13}C$ of soil organic matter found in habitational layers of the site varied between –19.2‰ and –27.2‰. The $\partial^{13}C$ of agricultural grains of barley-wheat (C3 type) ranges from –20.3‰ to 24.9‰. Typical $\partial^{13}C$ of millet based crops varying ~ -8.5‰. Obtained results thus show signatures of that mixed type agricultural practices as also revealed by ethno-botanical data.



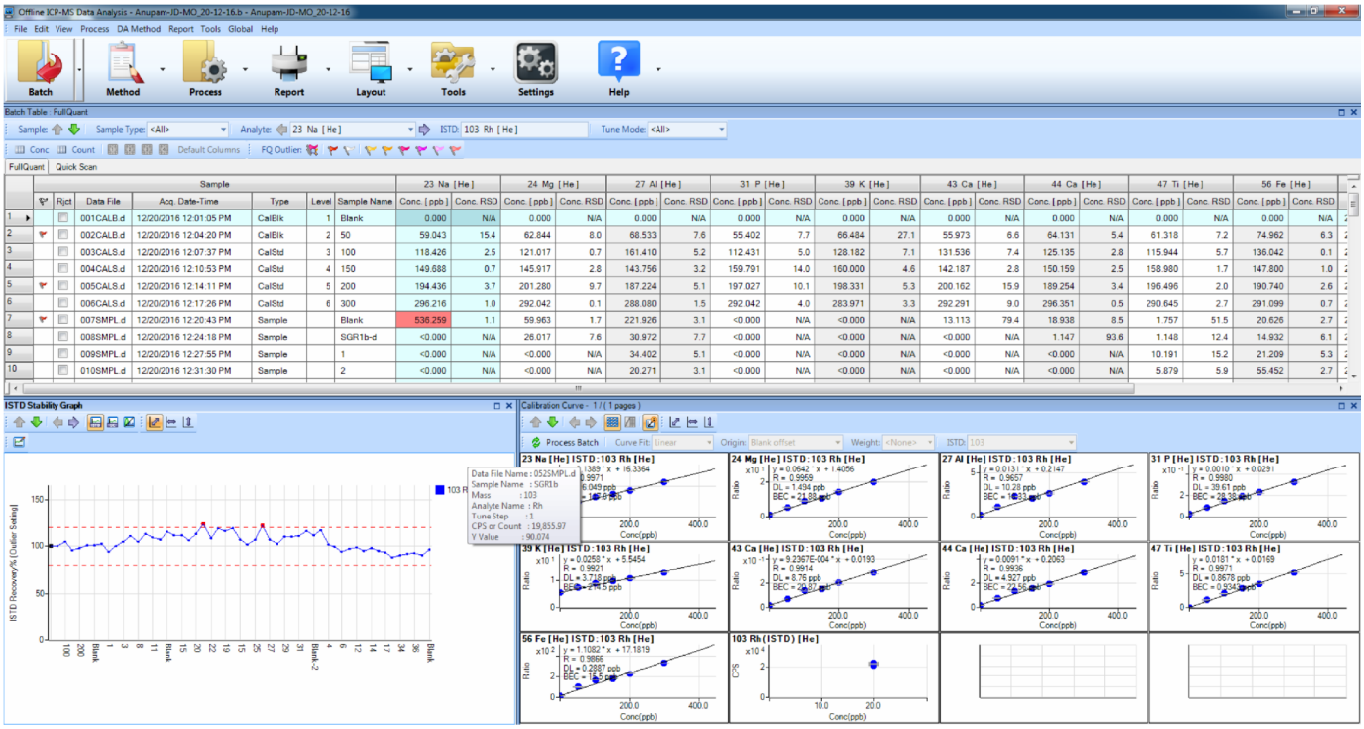


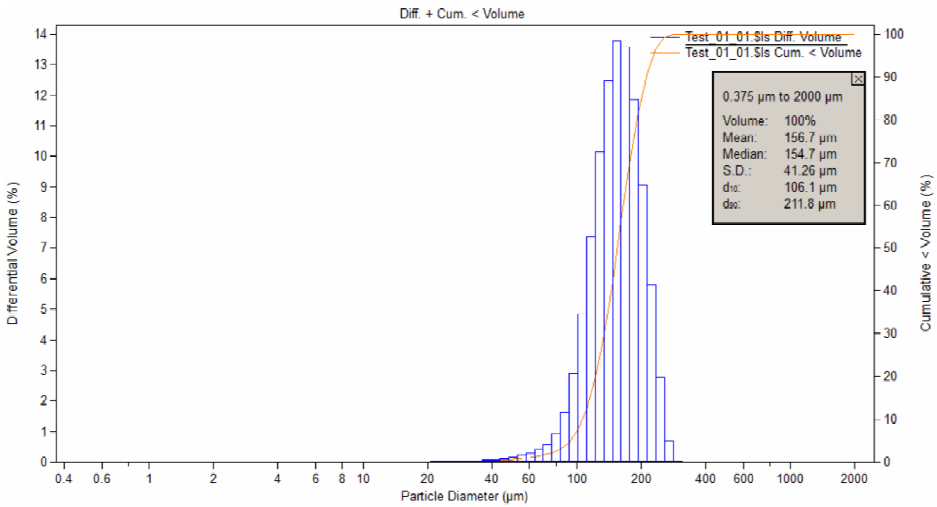
Project- 12.2: Development of OSL, geochemical and stable isotope laboratories

Investigators: Anupam Sharma, Rajesh Agnihotri, Pawan Govil, Kamlesh Kumar, Shailesh Agrawal, S.N. Ali, R.P. Mathews, Manoj M.C. & P. Morthekai

The establishment and development of any state of the art laboratory is an ongoing process, wherein preparation of specifications, procurement of major instruments along with its accessory items, meeting of continuous power and water supply, maintenance of equipments, etc. go hand in hand. The equipments purchased in the first phase are running in order, and data are continuously generating by the installed equipments (ICP-MS, XRD, IRMS, GC-MS, Particle Size Analyzer, TL/OSL reader, HPGe, Isodynamic Magnetic Separator, etc.). The fabrication work for hosting the XRF, pellet preparation machine, mico-drill and development of mineralogical (bulk, heavy & clay mineral separation and analysis) is in process. Besides, the process of procurement of some additional instruments such as Nutrient Analyzer (Auto Analyzer) and Automated Dish-Washer is initiated. After meeting all the technicalities, these units will be procured and placed in the laboratory.

The sediment samples from different terrestrial (from different parts of India) and marine (from Arabian Sea) sections have been powdered and prepared according to international digestion protocol, and analysed using the ICP-MS (Inductively Coupled Plasma-Mass Spectrometry). The calibration of machine with reference to widely established reference material (standards) is





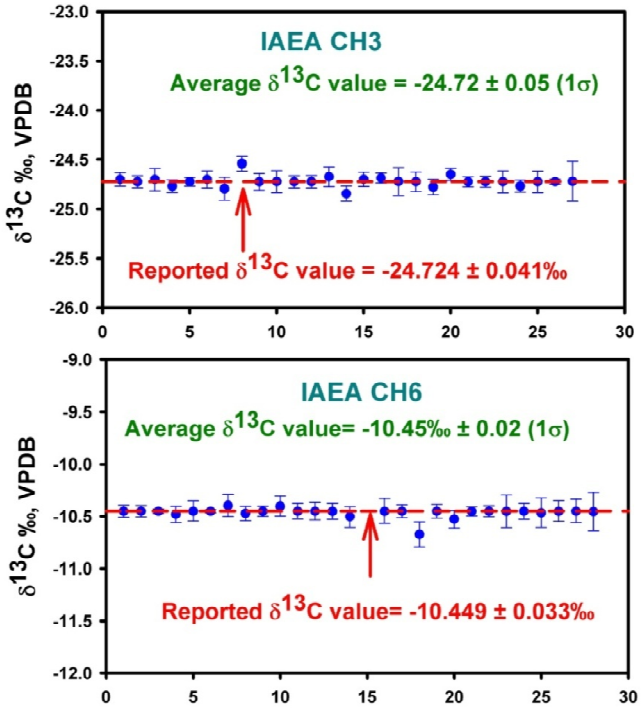
done prior to each batch of samples as shown in the Fig. Over all, approx. 700 samples are analysed for major, trace and rare earth elements to understand the palaeoclimatic variations, provenance establishment and earth surface/subsurface processes. Additionally, the sediment samples (1500 odd samples from the surface & subsurface) have been analysed by the XRD (X-ray Diffractometry) to understand the mineralogical composition of the terrestrial and marine sequences. Besides, sediment samples (approx. 500) from these sequences are also analysed using the Beckman Laser Particle Size Analyzer (LPSA) to quantify the grain size distribution and to understand the depositional environment. All the samples are prepared according to the international protocol for the analysis.



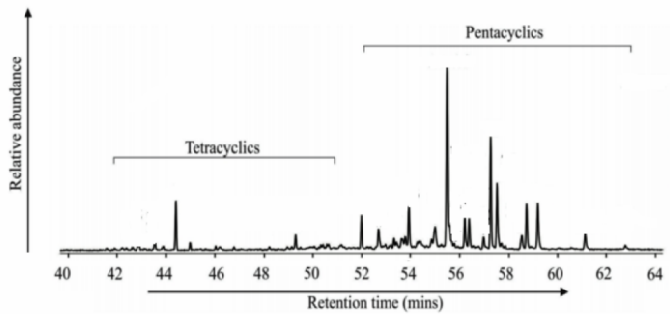
Newly installed Laser Particle Size Analyzer (Beckman make)

Installation of the IRMS (Isotope Ratio Mass Spectrometer) and its successful calibration for some additional parameters have been done. N-C isotope mode (for plants, soil sediments, etc.) has been run for around 400 samples, and the data has been validated and cross checked. C isotope mode (for plants, lignites, soil sediments, etc.) has been run for around 6000 samples, and the data has been also validated and cross checked. In the Gas Bench mode (C & O isotope), ~1000 carbonate samples which includes carbonate nodules from the Ganga Plain, foraminifera and Precambrian carbonates, have been analysed with very good precision. Samples ranging from peat, lignite, hard rock, sediments and modern plants so far have been analyzed. The diagram shows the quality of analysis done, which clearly indicates that we have achieved very high precision and long-term reproducibility of international standards CH3 and CH6 during the course of analysis.

The biomarker analysis included the lipid extraction fraction, and its fractionation into aliphatic, aromatic and NSO fractions. Each fraction is then analyzed by the GC-MS (Gas Chromatography-Mass Spectroscopy). The



process of organic geochemical analysis is a tedious and time taking process. Extraction of the lipid and fractionation will take about 5 days for a sample. Till now, 182 samples (lignite, shale, carbonaceous shale, lake sediments, etc.) have been analyzed in the setup, and some data has been interpreted. The interpretation of the data for several sample sets is on the way.



Triterpenoid distribution in Khadsaliya lignite (Saurashtra Basin) sample

The Luminescence Dating facility has been working well and interesting results have come. As HPGe gamma spectrometer is yet to produce reliable numbers to estimate dose rate, dose measurements have been going on. Attempts to estimate the dose rate using ICP-MS are going on. Thus far (since February 2015), we have prepared (both coarse & fine grains, depends on the nature of sample) and measured for dose from over 130 samples. Efforts have been initiated to yield good results from– i) time-resolved luminescence from the dirty quartz, ii)

attempt to directly date diatom frustules, and iii) the effects of violet laser and blue diodes in the feldspar samples. Additionally, 60% of work has been completed towards standardization of luminescence ages from the Institute. The approach is dating and comparing these ages from 5 samples from lake sediments of south-eastern Tamil Nadu. These 5 samples are from alternative depth of other 5 samples that has been already dating from PRL. We compare the ages of these samples from our Institute obtained from fine-grains and coarser-grains for internal consistency as well. Standardization complete once our lab reproduce a blind sample from Risoe-DTU, Denmark as an Inter Laboratory Comparison.



Recently procured X-Ray Fluorescence (XRF) equipment (Model No. PANanalytical: PW4400/40)

Thrust Area 8: INDIA-ASIA COLLISION AND HIMALAYAN UPLIFTS: PALAEOBOTANICAL AND ASSOCIATED BIOTIC SIGNATURES FROM SEDIMENTARY RECORDS OF WESTERN HIMALAYA

Project- 13.1: Biota from sedimentary sequences of Indus-Suture Zone, Ladakh Himalaya: Biostratigraphical, palaeoenvironmental and palaeogeobiographical implications

Investigators: **Sunil Bajpai, Madhav Kumar, Jyotsana Rai, Anupam Sharma, Gaurav Srivastava, Shailesh Agrawal & V.V. Kapur**

Two sections near Tarutze/Taruche village have been found productive for calcareous nannofossils, and sampled at a closer interval for high-resolution integrated biostratigraphy. The nannofossil assemblage comprising of 80-85% reworked late Cretaceous, K-T boundary elements and Paleocene taxa, and youngest 15-20% elements of late Ypresian age are notable. The age of the assemblage is constrained by the presence of *Coccolithus subpertusus*, *Discoaster kuepperi*, *D. paelikei* (within NP9: 55.86-57.21 Ma, Thanetian to Ypresian), *Sphenolithus radians* and *S. editus*. These species are compatible with an age corresponding to nannofossil zones NP11- NP12 (Ypresian, 50.6-53.5 Ma). Additionally, the calcareous nannofossil biostratigraphy from Basgo Formation, Ladakh and its implication in interpreting/deducing timing of India-Asia collision and Himalayan uplifts has been documented.

Thrust Area 9: PREPARATION OF BOOKS, CATALOGUES, ATLASES, DATABASES, DIGITIZATION OF LIBRARY, MUSEUM, HERBARIUM AND OTHER HOLDINGS

Project- 14.1: An atlas of Vindhyan stromatolites

Investigator: Mukund Sharma

Manuscript on the atlas of Vindhyan stromatolites has been completed. A few field photographs are to be included before final submission to the press.

Project- 14.2: Revision of Indian species of *Glossopteris*

Investigators: K. J. Singh & Anju Saxena

Text part of the old monograph on *Glossopteris* (Chandra & Surenge, 1979) has been completely digitized. Documentation work for the few more species of *Glossopteris* has also been done.

Project- 14.3: A catalogue on Upper Gondwana (Jurassic-Cretaceous) plant megafossils of India

Investigators: Neeru Prakash & Neelam

The relevant literatures have been consulted, and prepared the reference cards along with their abstracts. Database has been prepared indicating author's name, year of publication, abstract, locality, Formation and age. Generic diagnoses of Mesozoic genera have also been included in the catalogue.

Project- 14.4: An annotated bibliography on Indian Gondwana palynology

Investigators: Neerja Jha & Neha Aggarwal

Palynological literature has been collected on Indian Gondwana. Their abstracts have been added or noted. Editing and abbreviation of abstracts in order to bring out the matter in a concise form have been finalized and published.

Project- 14.5: Tertiary plant megafossils from India (2006-2017)

Investigator: Rashmi Srivastava

The preparation of references and generic/specific details of the megafossils genera described from 2006 onwards are being continued. Further work is in progress to finalize the draft of the catalogue.

Project- 14.6: Calcareous nannofossil records from India

Investigators: Jyotsana Rai & Abha Singh

All the calcareous nannofossil species data from the recent published papers have been added, and the catalogue is finalized.

Project- 14.7: Pollen flora of tropical deciduous forest, Assam, Northeast India

Investigators: Swati Tripathi

Forty plant species belonging to arboreal and non-arboreal group have been studied in great detail under light microscope in order to generate characteristic pollen morphological features. Some of the tree constituents of tropical forest like *Ceiba, Bombax, Sterculia, Mangifera, Cassia, Lagerstroemia, Bougainvillea* and *Erythrina* have been analyzed through field emission SEM. Pollen morphometry of herbaceous and shrubby taxa like *Tagetes, Chrysanthemum, Ixora, Murraya, Calotropis*, etc. have also been studied under light microscope. Comparison and interpretation of finer morphological features of these plant species are in progress.

Work other than Institute Projects

Confocal Laser Scanning Microscopy (CLSM) based investigation has been performed on the different species of mat-forming filamentous microfossils *Oscillatoriopsis viz*., *O. breviconvexa, O. longa, O. media, O. obtusa* belonging to the Oscillatoriacean family of cyanobacteria. Such microfossils were documented from the Proterozoic carbonate facies of the Salkhan Limestone (Vindhyan Supergroup) and Saradih Formation (Chhattisgarh Supergroup). CLSM images in the present study show the 3-D morphology of *Oscillatoriopsis*, which cannot be recorded accurately in light microscopic studies.

V.K. Singh & Mukund Sharma

A review paper pertaining to the Permian palaeobiodiversity and geology of Ib-River Basin (Odisha) has been finalized to deduce and reconstruct the palaeovegetation, biostratigraphy, palaeoclimate, palaeoenvironment and the landscape of the basin. The floral composition suggests the prevalence of temperate climate with a slight change from warm moist to warm dry conditions during the deposition of Barakar Formation, and warm and humid during the deposition of Lower Kamthi sediments. Reconstructions of vegetational diversity during the Barakar and Lower Kamthi Formations around the basin have also been attempted. The status of unclassified Barakar and Kamthi Formations has been redefined. Apart from megafloristics, the palynological and petrological aspects of the basin are also discussed. Possible marine incursions and marine marginal environment in the Ib-basin during Permian are also overtly summarized on the basis of records of acritarchs, typical marine ichnofossils and evidences of wave activity in Lower Gondwana sediments of the basin.

K.J. Singh & Anju Saxena

The sedimentological studies in borecore A/333 (from Kothagudam sub-basin of Godavari Basin) have been done, and three intervals are documented. Interval 1 is distinguished by the moderate water level, low energy and depleted oxygen conditions; interval 2 is characterized by high water level along with the pre-eminence of amorphous and degraded terrestrial; and interval 3 predominated by charcoal is illustrated by the lowest water level in the paleomire with highly oxidizing conditions.

Neha Aggarwal & Biswajeet Thakur

The plant macro- and microfossils have been reported from the early Eocene sequence exposed at a new fossil locality (between Tarkeshwar village & Mandavi; lat. 21°22'35"N & long. 73°07'35"E) in Tarkeshwar lignite mine area (Surat district, Gujarat). The megafossils comprise fossil woods, leaves, fruits, seeds and leaf cuticles; revealing the occurrence of several phytogeographically significant taxa of Meliaceae, Rhamnaceae, Actinidiaceae, Clusiaceae, Sapindaceae,

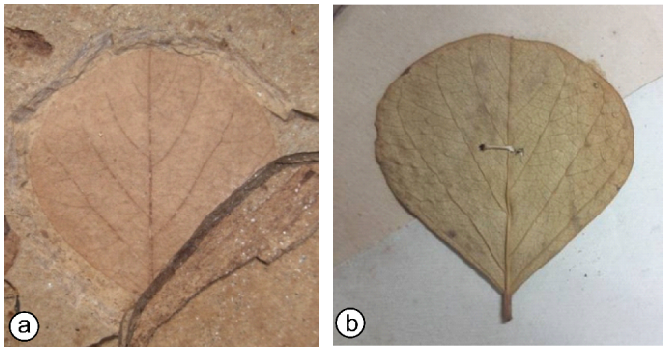


Leaf of *Terminalia tomentosa* (Combretaceae) from Cambay Shale Formation: **a**) Fossil leaf , **b**) Modern leaf

Ebenaceae, Combretaceae and Lythraceae families, and taxa probably belonging to the Family Cyperaceae. The palynofloral assemblage comprises mainly angiosperm pollen grains, followed by the pteridophytes, besides dinoflagellate cysts and few fungal remains. The overall floral assemblage suggests a prevailing tropical warm and humid climate with moist deciduous to evergreen forest, during the deposition of the Cambay Shale. The dinocysts along with foraminiferal linings clearly indicate a marine environment, whereas the pollen of family Arecaceae is indicative of a near-shore environment. Also, insect feeding damage on early Eocene Cambay Shale Formation fossil leaves is reported for the first time. Even though not abundant and a low diversity, but overwhelmingly made by specialized feeders rather than generalist herbivores.

Mahesh Prasad & Hukam Singh

The plant fossils from the late Tertiary sediments of Mahuadanr Valley (Jharkhand) have been studied, and an attempt has been made to deduce palaeoclimate and phytogeography of the region. The study on fossil leaves revealed the occurrence of 8 new taxa– *Anamirta cocculus* (Menispermaceae), *Heritiera acuminata* (Malvaceae), *Sterculia roxburghii* (Sterculiaceae), *Ammora chittagonga* and *Aglaia edulis* (Meliaceae),



Leaf of *Canavalia rosea* (Fabaceae): **a**) Fossil leaf , **b**) Modern leaf

Conavalia rosea (Fabaceae), *Woodfordia fruticosa* (Lythraceae), and *Croton* sp. (Euphorbiaceae). It is concluded that most of the comparable species of the fossils are distributed in moist deciduous forest of mainly north-east Indian region. The habit, habitat and the present-day distribution of the comparable species of the fossil indicate that a tropical mixed deciduous forest was flourishing in and around the valley during sedimentation as compared to usually dry deciduous forest at present.

Mahesh Prasad & S.K. Singh

Palynoflora of the Madhwali Nadi section near Matanomadh (Kachchh, Gujarat) has been studied. The palynoassemblage is well-represented by algae, fungi, pteridophytes, gymnosperms and angiosperms. Palynologically, the whole sequence is dominated by marine dinoflagellates cysts, followed by terrestrial pollen and spores, thus in general indicating marine depositional environment with terrestrial inputs. However, the frequency change of dinocysts and spores-pollen taxa within the sequence indicates the episodic sea level changes. The area enjoyed warm, moist-humid, tropical climate, and based on recovered dinocysts assemblage an early Eocene age has been assigned to these sediments.

G.K. Trivedi & P.S. Ranhotra

Palynological study has been carried out on the Infratrappean sediments encountered in bore-hole located near the Ashtona village, Yeotmal district (Maharashtra). Presence of several species of *Aquillapollenites*, *Azolla cretacea, Gabonisporis*, and presence of marine dinoflagellate taxa, *Pierceites* suggest Maastrichtian age for the sediments. The study revealed rich and diverse assemblage of angiosperm pollen of tropical nature. Numerical abundance of mangrove pollen *Spinizonocolpites* (Nypa), and large number of *Pierceites deccanensis* dinoflagellates in the sediments indicated brackish marine depositional setting close to low lying coastal rain forest in central India during late Cretaceous. The study also provides earliest evidence of Dipterocarpaceae from late Cretaceous. Fossil pollen of Dipterocarpaceae and Arecaeous palm *Pigafetta* in the late Cretaceous sediments of Indian subcontinent provides evidence for the evolution of these tropical rain forest elements in the peninsular India and their dispersal to SE Asia post India Asia collision, and hence strongly supports the 'Out of India Hypothesis'.

Vandana Prasad, Anjum Farooqui, Srikanta Murthy, O.S. Sarate & Sunil Bajpai

Biomarker analysis has been conducted on the Lower Gondwana shale samples from Kachinappalli and Chintallapudi areas of the Godavari Basin. The data interpretation is underway. Besides, organic geochemical study of the Antarctica lake sediments is under progress.

R.P. Mathews

Diatom abundances and their size variations have been used to infer the palaeoproductivity changes of the Southern Ocean over the glacial interglacial time scale. A paper is finalized on the size variation of centric diatom *Thalassiosira lentiginosa* (Janisch) Fryxell using surface sediments and four sediment cores spanning over the last 42 cal ka BP. The conclusive evidences suggest that both modern and past size changes of *T. lentiginosa* are strongly correlated with sea-surface temperature and sea ice presence rather than the iron availability. Moreover, data of a deep sea sediment core from the Indian subtropical region of the Southern Ocean has been used for size variation and absolute abundance of pennate diatom *Fragilariopsis kerguelensis* (O'Meara) Hustedt over the last 42 cal ka BP; suggesting that sea-surface temperature was main parameter which regulated the size of *F. kerguelensis*.

S.K. Shukla

The palynological dataset on Kathali wetland and vicinity forest area of Meghalaya has been generated in order to characterize the modern pollen depositional pattern in relation to existing vegetation. The overall

palynodata is suggestive of the tropical deciduous forest admixture with the evergreen taxa, which fully coheres with extant vegetation. Pollen clumping in the palynoassemblage is highly significant, and suggests their local origin and entomophilous nature.

S.K. Basumatary & Swati Tipathi

The palynology of yellow rain samples procured from three different localities of Lucknow predicts moderate to rich frequency of pollen/spores. The palynodata are observed to be varying at different dates of collection. The palynoassemblage is found to be mixture of pollen and spores including angiosperms, gymnosperms (conifers), pteridophytes (ferns) and fungal spores. Insect body parts are also observed in the assemblage.

Swati Tripathi

Logistic coordination has been made for the Field Workshop on Astrobiology in Ladakh (Spaceward Bound India 2016) organized jointly by the Institute, Mars Society Australia, NASA AMES, Inspired Journeys New Delhi and TATA Motors. Ten days field expedition in Ladakh (during August 2016) comprising 31 members (scientists, students, educators & media) from USA (NASA & related institutes), Australia, Sweden and India followed by one day public presentation and press event in New Delhi was done. The expedition was a big success.

Binita Phartiyal

Jangalgali breccia unit (JBU), the oldest volcanogenic rock unit in the Himalayan foreland basin, has been studied from 5 different, however stratigraphically equivalent localities of Jammu region. The field and thin section slides of JBU reveal that quartz and plagioclase are the two most common minerals, and sanidine, magmatic zircon, rutile, hornblende and biotite are present as accessory phases. Petrographic signatures show that quartz and K-feldspar are set in a fine-grained cryptocrystalline glassy matrix and do not represent any preferred orientation. The euhedral hexagonal dipyramidal quartz phenocrysts, irregularly shaped inclusions having high volatile contents and no signatures of transport/reworking in phenocrysts prior to deposition are the prominent petrographic features of JBU. The mineral grains arrangement varies between tight-fitted fabric geometry to more open-chaotic packing. Overall, the field relationship, texture, mineralogy along with mineral chemistry, and presence of high gas and silica content in the host magma, support the volcanic origin of the JBU litho unit, which has wider implications towards understanding the timing of India-Asia collision as well as geodynamic evolution of the Himalayas.

Anupam Sharma & M.K. Shukla

Pollen analysis of a profile comprising 72 samples from Biskim, Uttarakhand has been completed. The interpretation in terms of temporal and spatial vegetation dynamics and climate change is in progress.

M.F. Quamar & S.N. Ali

Transfer function model has been carried out using modern pollen-climate calibration set from temperate region of west Arunachal Pradesh. The model is applied to Holocene fossil pollen records from the region to reconstruct past climate (temperature of the coldest month, MTCO) for the last 9558 cal yrs. BP. This work has been carried out on the pollen data generated by Nivedita Mehrotra.

S.K. Shah

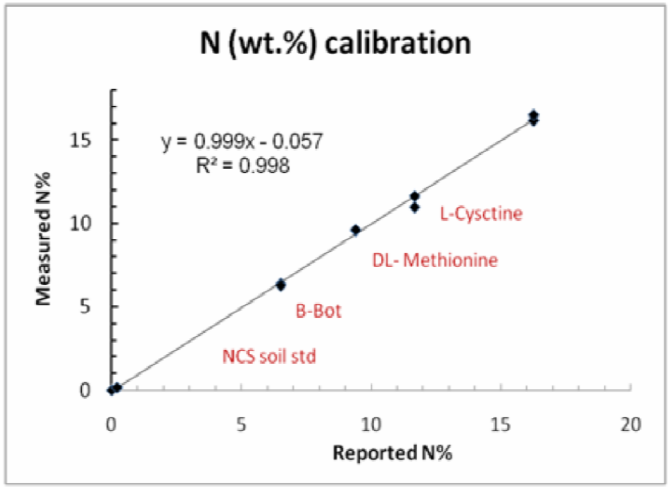
A review of tree-ring studies in Kashmir Himalaya has been done, and a tree-ring based analysis carried out on various tree species at different sites. The manuscript is finalized.

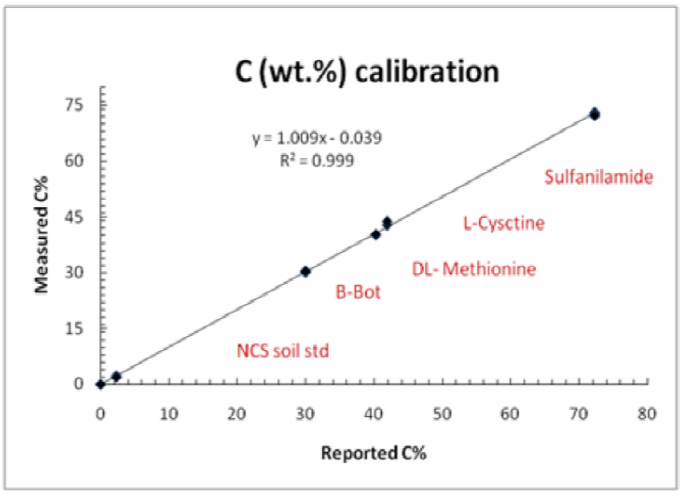
Nivedita Mehrotra, S.K. Shah & Uttam Pandey

Stable isotopic, clay mineralogy (XRD), trace elements (ICP-MS), magnetic susceptibility, pollen studies and optical dating have been done on the samples from south-eastern Tamil Nadu to interpret the palaeo-data. All these data are analyzed using constrained ordination analysis (RDA; redundancy analysis) and the lake was inferred to have been closed only after 1600 AD and was quasi-open prior to that period. Also the human activities seem to be increasing after 1873 AD. This pilot study has opened up more questions rather than concluding anything.

P. Morthekai

Procedures for measuring carbon (C) and nitrogen (N) contents in solid and dried natural or synthetic samples have been set up using Elemental Analyser (EA, Thermo® 1112) with variety of laboratory standards. The EA at the C14 laboratory is now being used for geochemistry and diagnostic purpose, i.e. determining C content of samples being processed for conventional radiocarbon (C14) dating by beta counting. Reproducibilities for C and N content measurements are generally within ~2%. Primary calibrations for measurements are routinely carried out using Sulfanilamide standard by changing its amount taken





for analysis, whereas accuracy of C and N content measurements were ascertained using variety of synthetic standards having varying range of concentrations as shown in the Figure.

In order to assess/preempt changing weather/ monsoon patterns over India, time-series data of different climate indices have been investigated. For instance, in the back drop of 2013 mid-June heavy-rainfall related massive calamity over Uttarakhand, a study is undertaken to assess role of various natural and anthropogenic forcing factors responsible for recurring extreme and abrupt high rainfall events mainly in early summer period over the region. Major findings of this study could be summarized as– i) upward trend in June-July rainfall and its relationship with regional May temperatures, ii) monsoonal rainfall (June-September) showing covariance with interannual variability in Eurasian snow cover extent during the month of March, and iii) enhancing tendency of anomalous high rainfall events during negative phases of Arctic Oscillation. Additionally, in order to assess vulnerable zones over northwest Himalayas where extreme rainfall related hazards are more probable, past flood records have been catalogued and synthesized.

Rajesh Agnihotri



Newly installed instruments for the palaeomagnetism study

Collaborative Work

Biostratigraphic and palaeoclimatic investigations of the Mesozoic sequences of Jaisalmer Basin, Rajasthan— Fossiliferous Mesozoic rocks in the basin are displayed as isolated outcrops and are represented as Lathi, Jaisalmer, Baisakhi, Bhadesar, Pariwar and Habur Formations in ascending order. The Baisakhi Formation is divisible into three Members– Lanela, Ludherwa and Rupsi. The Lanela Member is exposed in the west of Baisakhi village, and comprising of grey to black shale (very often ferruginous) with thin intercalations of variegated sandy siltstone along with streaks of gypseous clay, carbonaceous bands and rare plant remains. The plant fossils collected from the Lanela Member have been identified as *Williamsonia* (bennettitales), *Taeniopteris* (Cycads), *Pagiophyllum* and *Elatocladus* (conifers). Morphotaxonomic study is being carried out (by NP & Neelam).



Bada Bag Member Type section, behind Bada Bag Cenotaph

A field excursion has been conducted (by JR) to the Jaisalmer Basin to collect samples from various Mesozoic Formations and mark contacts of Formations and various Members. Besides, 6 samples representing the upper part of Bara Bag Member at its type section of Jaisalmer Formation yielded moderately preserved and less diverse nannofossil assemblage, and indicated Bathonian age on the presence of *Ansulasphaera helvetica*, *Discorhabdus criotus*, *D. striatus*, *Lotharingius contractus*, *L. hauffii*, *L. velatus*, *Polypodorhabdus escaigii* and *Watznaueria barnesae*. Some reworked taxa of Pleinsbachian to Bajocian age are also recorded *viz.*, *Bussonius prinsii*, *Crepidolithus granulates*, *Diductius constans*, *Parhabdolithus marthae* and *Triscutum tiziense*.

Sunil Bajpai, Jyotsana Rai, Neeru Prakash, Abha Singh & Neelam
[under **MoU with GSI** (Western Region)]

To understand the advent of eukaryotes in deep time the high spatial resolution morphological and geochemical studies *viz.*, FIB-TEM, FIB-SEM and Nano SIMS on the morphologically complexed organic-walled microfossils recorded from the >1.65 Ga old Chitrakoot Formation are in progress.

V.K. Singh & Mukund Sharma
[& David Wacey **(Univ. of Bristol, UK)**]

Under Chinese Academy of Sciences Presidents' International Fellowship Initiative— Detailed study of several aspects of the Lantian biota (Ediacara) has been attempted. Special emphasis is laid on the origin of macro-eukaryotes and palaeobiological diversity, palaeoecology and taphonomic biases of the Lantian biota which is rich in abundance of oldest megascopic multicellular metaphytes and metazoans. One-sixth part of the visit tenure was utilized in field work, significantly in the study of fossils found in Lantian area, Huangshan district (South Anhui Province), and the Cryogenian to Cambrian succession of the Yangtze Gorge Platform, South China. Newly collected and in-housed specimens of the Lantian Formation have been investigated and photo-documented representing affinity of metazoans and metaphytes. Several collected specimens are examined by FESEM and BS-SEM. Two independent hypotheses are being tested to ascertain their affinities with ancestral forms of sponges or with ontogeny/morphogenesis of soft bodied animals of Scyphozoan/hydrozoa affinity in the deep time around 600 Ma.

S.K. Pandey
[**& Xunlai Yuan** (Nanjing Institute of Geology & Palaeontology, China)]

Rich and diversified palynomorphs have been recovered for the first time from the ammonoid *Cyclolobus walkeri* bearing top bed of the Gungri Formation, Lingti Road section, Spiti Valley. The assemblage reveals the dominance of striate bisaccate pollen grains along with *Densipollenites indicus*; suggesting a late Permian age for the strata. However, First Appearance Data (FAD) of some early Triassic palynomorphs in the assemblage suggests latest Permian (Changxingian) age for the sequence. The FAD in the youngest bed of the Gungri Formation also clearly suggests the existence of PTB in the 'ferruginous layer' lying above the Gungri Formation exposed along the Lingti Road

section. The palynoflora bears similarity with those of the late Permian non-marine peninsular Indian Lower Gondwana horizons and other Gondwanic continents along with those found in the west Tethyan margin including Pakistan and Israel.

Rajni Tewari
[**& Shreerup Goswami** (Ravenshaw Univ., Cuttack)
& Micheal Brookfield & Jeremy Williams
(Univ. of Massachusetts, Boston, USA)]

Fifty-four samples (provided by MB) have been macerated from the P/T boundary mud section of Spiti which have yielded good assemblage of palynomorphs. Work is in progress.

Rajni Tewari & S.S.K. Pillai
[& Micheal Brookfield (Univ. of Massachusetts, Boston, USA)]

Work has been initiated regarding palynological investigation of the P-T (Permian-Triassic) boundary sections in China and India. Out of 66 samples, 27 samples have been macerated and the rest are under progress.

Neha Aggarwal
[**& G.M. Bhat** (University of Jammu)]

Paleobotanical and palynological studies of the Brazilian Late Paleozoic and Mesozoic Gondwanan floras and their correlation with the Indian ones— Collection and processing of samples from the Silurian (Rio Ivaí Formation), Devonian (Ponta Grossa Formation), Late Pennsylvanian (Aquidauana Formation) and Permian (Serra Alta/ Teresina Formations) sequences, from the areas surrounding Cuiabá (Mato Grosso State) and Campo Grande (Mato Grosso do Sul State), in the western border of Paraná Basin have been carried out. The slides are being examined and inferences being drawn and finalized. Besides, slides from the repositories are also being examined in the Laboratory of Paleobotany and Palynology of the Institute of Geosciences (São Paulo). Also, visited the Laboratory of Palynology, Institute of Geosciences (Porto Alegre), and had discussion and documentation with Prof. Paulo Alves de Souza regarding palynological correlation study of the Lopingian level between the Paraná Basin, the Paganzo Basin and the Indian Gondwanan basins.

Further, macrofloristic, lithostratigraphic and palynostratigraphic studies of the northeastern border of Paraná Basin (State of São Paulo) has been carried out and finalized. A putative scheme of macrofloral succession is formally proposed for Itararé Group, which comprises of five associations. The older four associations of the Itararé Group sequence are of Pennsylvanian age while the youngest is of Asselian-Sakmarian age. Apart from these, comparative study of the some Late Palaeozoic macroflora from India and Brazil has also been carried out, and the results of which have been finalized.

Pauline S. Kavali
[& M.E.C. Bernardes-de-Oliveira
(University of São Paulo, Brazil)]

Some palm leaves collected from the Eocene sequence of Ladakh have been investigated. They belong to Coryphoid palms of the sub-family Coryphoideae.

R.C. Mehrotra & Gaurav Srivastava
[**& S.C. Tripathi** (GSI, Lucknow)]

Several leaves collected from the Laisong Formation (late Eocene-early Oligocene) of Nagaland have been investigated. They are identified as *Cynometra* of the family Fabaceae, and *Artocarpus* of the family Moraceae. A manuscript on the same has been finalized.

R.C. Mehrotra & Gaurav Srivastava
[**& Kapesa Lokho** (WIHG, Dehradun)]

Several fossil leaves collected from the Siwalik sequence of Nepal have been identified for palaeoenvironmental analysis by applying Coexistence Approach.

R.C. Mehrotra & Gaurav Srivastava
[**& K.N. Paudayal** (Tribhuvan Univ., Kathmandu, Nepal)]

Earth Life Transitions Program (of NSF)— *Stratigraphic refinement, systematic and biogeographic relationships of the late Cretaceous-Paleocene Deccan biota of India*: The re-examination of Deccan fossil woods herein include the oldest known occurrences of some orders, families or genera, namely Lamiales (Oleaceae), Achariaceae (*Hydnocarpus*-like wood), Anacardiaceae, Simaroubaceae (*Ailanthus*-like & *Simarouba*-like woods); subfamilies Leeoideae (Vitaceae), Myrtoideae (Myrtaceae) and Planchoideae (Lecythidaceae); tribe Castilleae (Moraceae), tribes Grewioideae; and Sterculioideae (Malvaceae). These first fossil records have been discussed with reference to other macrofossil and pollen records of the same or related clades. They complement the recent work on the oldest known *Olea* and Connaraceae. In addition, a review paper on fossil dicotyledonous woods of Deccan Intertrappean flora has been finalized. Also a reinvestigation of several species of *Arecoidocarpon* (palm fruit) was undertaken.

Rashmi Srivastava
[& E. Wheeler, Steve Manchester & Selena Smith (USA)
& Pieter Baas (Netherlands)]

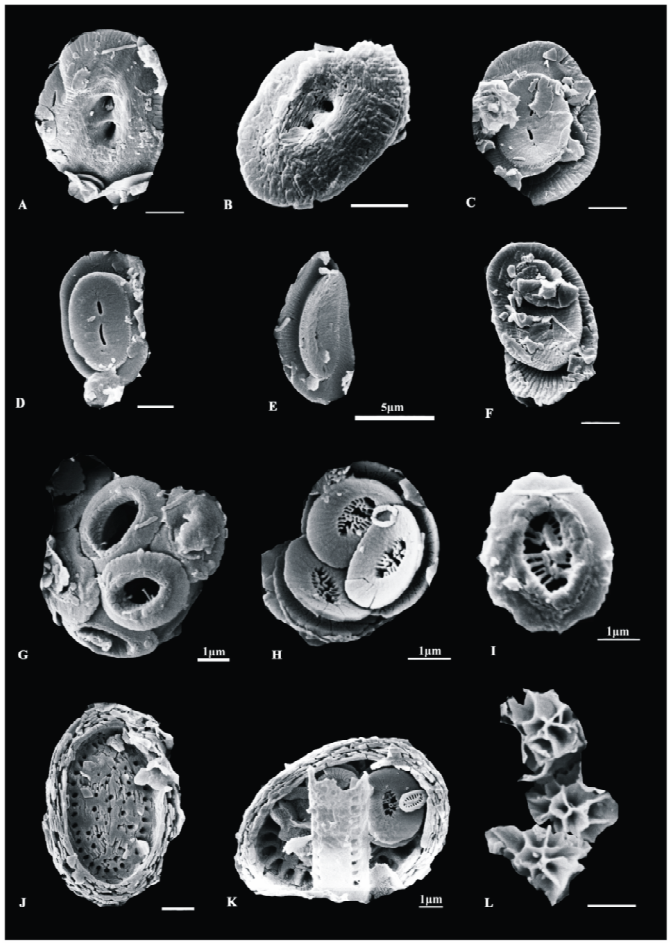
Stratigraphy, facies and depositional architecture of the Subis Limestone, Niah, Sarawak, Malaysia— Both grab and subsurface samples collected from the Debstone quarry have been undertaken to check nannofossil productivity. Though most of the samples either proved barren or very poorly productive, but 2 samples (one surface bearing number HSQ6 & the other representing depth 1040-1060 m) showed its presence. The list of nannofossil taxa recorded are– *Calcidiscus leptoporus, C. premacintyrei, Coccolithus pelagicus, Cyclicargolithus abisectus, C. floridanus, Discoaster deflandrei, Helicosphaera euphratis, Reticulofenestra bisecta, R. minuta, R. pseudoumbilica, Sphenolithus capricornutus, S. conicus, S. heteromorphus, S. moriformis, Triquetrorhabduls milowii, Thoracosphaera saxea*, Ascidian spicules, *Monnotia* sp.; indicating a broad age NN1-NN6 (Ma 24-12), early-middle Miocene.

Jyotsana Rai
[& M.C. Poppelreiter (SEACaRL, Malaysia),
Mu Ramkumar (Periyar Univ., Salem)
& S.B. Bing (Univ. Teknologi PETRONAS, Malaysia)]

Work on the study of sediment cores (Site 1404 & 1405) of Oligocene-Miocene transition for Post Cruise Research of IODP Expedition 342 has been finalized. A draft manuscript has been prepared.

A.K. Ghosh & Arindam Chakraborty
[& John Barron (USGS)
& Shipboard as well as shore based Scientists
(of IODP Expedition 342)]

Under Newton-Bhabha Fellowship programme— A total of 123 samples from 7 outcrops on different islands of Andaman have been analyzed for the calcareous nannofossils. Three outcrops on Havelock Island yielded *Sphenolithus heteromorphus* and *Helicosphaera ampliaperta* indicating the presence of the NN4 zone of Martini (1971, early-middle Miocene). The samples from two outcrops on Neil Island yielded abundant and well-preserved nannofossil assemblage indicative of a late Tortonian age (late Miocene). This is determined by the presence of *Discoaster bergrennii/quinqueramus* and absence of *Amaurolithus primus*. The samples from two outcrops on Car Nicobar Island yielded well-preserved nannofossils of early Zanclean age (early Pliocene). The age has been determined by the presence of *Ceratolithus armatus* and *C. cristatus*. The relatively rare occurrences of *Discoasters* in the sediments and absence of *Amaurolithus* indicates oligotrophic water in the late Miocene sections of Neil Island. The presence of unusual



SEM images of calcareous nannofossils from the Mio-Pliocene of Andaman and Nicobar Islands: **A**) *Helicosphaera sellii*, **B**) *Helicosphaera* sp., **C-F**) *Helicosphaera carteri*, **G**, **I**) *Reticulofenestra* sp., **H**) *Reticulofenestra* sp. (<3 µm), **J**) *Pontosphaera discopora*, **K**) *Pontosphaera multipora* with small reticulofenetsrid, **L**) *Sphenolithus abies* [Scale bar = 2 µm except otherwise mentioned]

assemblage compositions, with abundant sphenoliths, alongside common siliceous diatoms, indicates high productivity surface waters and probably upwelling palaeoenvironmental conditions in the late Miocene sections of Neil Island.

Arindam Chakraborty & A.K. Ghosh [& Paul Bown & Jeremy Young (Univ. College of London)]

The diatoms in calc tuff sediments from Pune region (Maharashtra) have been studied in order to get information about the variations in primary productivity in calcareous sediments. It is found that a few localities have high abundance of *Synedra ulna* with low turnout of *Cymbella*, *Stauroneis*, *Surrirella*, etc. In the Aneghat-A and B localities, *Synedra ulna* is the dominant species recorded. In the Dariya Kanhur locality, *Pinnularia gibba*, *Gomphonema*, *Cymbella*, *Achnanthidium*

minutissimum are recorded in abundance with varying proportions of *Synedra ulna*, *Navicula*, etc. The diatoms from Wadi Bhuteswar locality showed high diversity.

Biswajeet Thakur
[& P.K. Sarkar (Fergusson College, Pune)]

Twenty drill cutting samples of CLPL Barracuda oil exploration well at Mannar Basin, Sri Lanka belonging to claystone and sandstone layers, inter-trapped between intermittently discharged dense volcanic flows originated from Deccan volcanic eruptions, have been studied. Well-diversified, good to moderately preserved nannofossil assemblage of 112 species, belonging to 56 genera, representing latest Cretaceous to late Paleocene age are recorded. Nearly 47% of the species shows sign of extinction as a result of K-Pg mass extinction, while 3% had sustained the crisis. Newly evolved species after KTB show a significant reduction in their size; indicating the effect of higher stress conditions prevailed in the ecosystem. Recovery followed up by extinction favoured oligotrophic species over eutrophic species.

Abha Singh
[& P.A.S.R.D. Perera (Univ. of Peradeniya, Sri Lanka)]

The geometries of pore structure and fractal dimension characteristics of Karharbari and Barakar coals collected from the East Bokaro Coalfield (Damodar Basin) have been investigated, using low-pressure and temperature of N_2 adsorption/desorption isotherms, technological properties, total organic carbon (TOC), vitrinite reflectance (R_o%), and SEM studies. The FHH (Frenkel-Halsey-Hill) model has been used to obtain the fractal dimensions (D_1 & D_2) with different controlling parameters like volatile matter, TOC, pore structure, surface area and pore size in signifying the coalbed methane plays.

B.D. Singh
[& V.A. Mendhe & Associates (CSIR-CIMFR, Dhanbad)]

Under Research Training Fellowship of Developing Countries (RTF-DCS) scheme of NAM S&T Centre-DST— The lignite and associated lignitic clay/shale samples from the Miocene sequence (Saouef Section in central NE Tunisia) of Tunisia have been analysed, using petrographic and palynofacies parameters. The petrographic study includes assessment of macerals, and estimation of rank through huminite reflectivity. The palynofacies analysis incorporates the distinctive assemblage of palynological organic matter in these sediments. Further as a part of the scheme, visited Dhanbad and had discussions with coal researchers at



Way to Moonidih underground coal mine



Coal bed methane production field, Durgapur (WB)

ISM University and both campuses of CSIR-CIMFR, besides Moonidih underground coal mine (Jharia Coalfield) and CBM production field site around Durgapur (WB).

B.D. Singh
[& Malek Radhwani (University of Tunis, Tunisia)]

A palynological study has been carried out in surface sediments and shallow sedimentary cores from Pulicat lagoon post floods in Chennai after heavy rainfall in 2015. Biotic forms preserved in sediments along with physico-chemical characteristics reveal indicator species of diatoms as indicators of extreme events.

Anjum Farooqui
[& Harini Santhanam (IISc, Bengaluru)]

The recent trends in Late Quaternary researches, particularly, for the Holocene period focused on reconstructing the past climate dynamics, fluctuations in the intensity of the southwest monsoon (SWM) and applications of these datasets for predicting future trends has been reviewed. During the years 2010-2015, the published data, although shows chronological constraints,

by covering different physiographies of India, which presently display a highly variable climate from hot to cold desert and from high to low rainfall region. An integrated multidisciplinary, multiproxy data provide a comprehensive understanding of the trend in climate change, from moist mid-Holocene to dry late Holocene conditions from the Indian subcontinent although with a slight variation in time brackets which is attributed to external forces responding to varied landscape, geographical setting and altitudinal changes.

Anjum Farooqui & Binita Phartiyal
[& Hema Achuthan, V. Gopal & A. Lone
(Anna Univ., Chennai)]

Rivers in Himalaya respond to tectonics and climate of the region on different spatio-temporal scales. A brief account of Indian contribution, on the study pertaining to the fluvial record from Himalaya during 2011-2015 has been documented. Total number of papers published in SCI journals and edited books are 64 where authors have mainly focused on the understanding of (i) extreme events and their terrain responses in Himalaya, (ii) records of river aggradation-incision and the forcing factors, and (iii) geomorphic indicators of neotectonic deformation. Emphasis has also been made towards understanding the development of frontal belt of the Himalaya, sediment production, storage and delivery in the wedge.

Binita Phartiyal
[& Pradeep Srivastava (WIHG, Dehradun),
Yogesh Ray (NCAOR, Goa)
& Y.P. Sundriyal (HNB Garhwal Univ., Srinagar)]

A work pertaining to the study based on palynology, granulometery and chronology of the sediment profile of Nikahari Tal (lake), Ganga Plain, located north of Ropan Chhapra village in Deoria district (UP) has been finalized. The work has resulted as multi-proxy records of vegetation and monsoon variability from the lacustrine sediments of eastern Ganga Plain since 1350 A.D.

Anju Saxena
[& D.S. Singh (Lucknow University, Lucknow**)**

Under Chinese Academy of Sciences Presidents' International Fellowship Initiative— A 6.00 m continuous sediment core via several piston cores from the margin of the Bosten Lake, south-west China has been procured. Total 300 samples are gathered in 2 cm intervals. The chemical analysis of 4 m core is accomplished by heavy liquid method. The chemical analysis and pollen counting of the remaining 2 m core is under way.

In aggregate, 23 family and 15 species have been recovered from 10 soil surface samples gathered from the surrounding of the Shaunghizi Lake, Yunnan. The major chunk of pollen shower (about 78.3%) is constituted of arboreal including gymnosperms and angiosperms. Among the trees, *Pinus* and *Abies* are the predominated followed by *Picea*, *Querecus*, *Betula* and *Alnus*. The herbaceous taxa is represented in low values (0.5-1.8%), and substantiate their actual presence in the herbaceous complex. Fern spores shows miscellany. The aquatic taxa are represented by *Botryococcus* and *Zygnyma*gynospore. The poor representation of non arboreals is due to less pollen productivity and poor pollen preservation in the sediment. The pollen assemblage portray the true picture of the regional vegetation mosaic of the lake and the adjoining surrounding highlands, reflecting a needle leaved woodland flourished led by *Pinus* and complemented by few broad-leaved elements as *Quercus*, *Alnus*, *Betula*, etc.

Anjali Trivedi
[& Chen Sen Li (Institute of Botany, Beijing, China)]

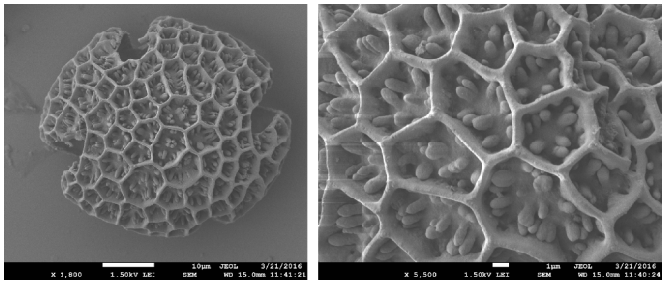
The chemical processing of 11 m core from the Aiding Lake, northwest China have been completed at 10 cm interval**.** The microscopic studies are in progress.

Anjali Trivedi
[& Yao Yi Feng (Institute of Botany, Beijing, China)]

The chemical composition of fossil resins from middle-late Eocene lignite samples of the western margin of Bengal Basin has been chemically analyzed to infer their botanical affinity. The terpenoid content of the resins has been characterized using GC-MS. sesquiterpenoid and triterpenoid components show close affinity with those in extant dammer (Dipterocarpaceae) resin (class II) and indicate the common occurrence of dipterocarps in the forest growing under warm tropical climate in the area at that time. Rich palynofloral assemblages dominated by Dipterocarpaceae pollen grains recovered from the lignite samples corroborate the chemical data.

Ruby Ghosh
[& Subir Bera (Univ. of Calcutta, Kolkata)]

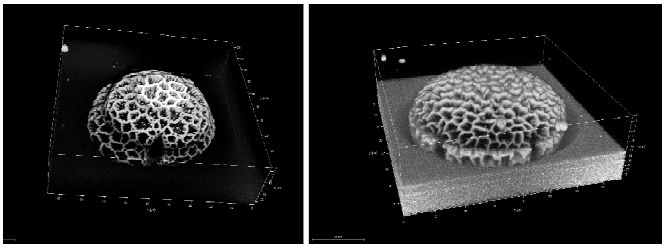
The detailed pollen morphometric analysis of *Bougainvillea* species (*B. glabra* Choisy, *B. peruviana* Bonp., *B. spectabilis* Willd., & *B. buttiana* Holttum & Standl.) have been performed using both light microscope and field emission scanning electron microscope. The data on the aspect has been finalized.



FESEM image of polar view (left) and enlarged view (right) of sexine of *B. buttiana* var. Chitra showing loosely packed bacula

Swati Tripathi
[& Shilpi Singh & R.K. Roy (CSIR-NBRI, Lucknow)]

The palyno-morphological differentiation among the four species of *Ceiba* (*C. speciosa*, *C. pentandra*, *C. insignis* & *C.* x *insignis*) and two varieties of *Bombax ceiba* of family Malvaceae have been performed through LM, FESEM and CLSM. Documentation of the results is under progress.



CLSM images of *C. insignis* (left) and *C.* x *insignis* (right)

Swati Tripathi, V.K. Singh & Anjum Farooqui
[& Shilpi Singh (CSIR-NBRI, Lucknow)]

Fifty surface sediment samples from the Manas National Park, the gateway of the Indo-Burma hotspot region, have been analysed palynologically in order to explore the relationship between the pollen assemblage in sediments and contemporary vegetation patterns.

Swati Tripathi, S.K. Basumatary,
S.K. Bera & R.C. Mehrotra
[& G.C. Sarma (Gauhati Univ., Guwahati)]

The palynological and chronological records have depicted four distinct phases of vegetation succession, contemporary climate and human occupation in Loktak Lake (Ramsar site) sequence, Manipur for the last 2,325 cal yrs BP.

Swati Tripathi, Biswajeet Thakur & C.M. Nautiyal
[& Y.R. Singh (Manipur University, Imphal)]

Palynological studies of 30 sediment samples from different small cores collected from Krishna Delta have been completed.

Shilpa Pandey
[& K. Nageswara Rao (Andhra Univ., Visakhapatnam)]

The pollen analysis of about 40-50 m core is under progress to reconstruct Late Quaternary climate variability and sea-level changes in the western Rann of Kachchh, Gujarat.

Shilpa Pandey
[& M.G. Thakkar (Kachchh Univ., Bhuj)]

Spring (March-June) precipitation has been reconstructed since AD 1840 for the Rara National Park, western Nepal Himalaya using *Abies spectabilis* tree-ring width. The reconstruction accounts for 35.8% of the total variance of the instrumental precipitation from 1958 to 2012 and captured distinct wet and dry variability. In addition, 53 tree core samples of *Pinus wallichiana* have been cross-dated for tree-ring analysis from western Nepal Himalaya and prepared 405 years (1611-2015) tree-ring chronology. Further analysis of the data is in progress.

S.K. Shah
[& D.R. Bhuju & N.P. Gaire (Tree-ring Society of Nepal)]

Collaboration was established for comparative analysis of tree-ring and speleothem records from India over the last millennium as a pilot study. There shall be amalgamation of existing and further generated data of both the proxies.

S.K. Shah
[& Ashish Sinha (California State Univ. Dominguez Hills, USA]

The study of carbonaceous particles is being done. The scanning electron microscope equipped with an energy dispersive X-ray spectroscope (EDS) has been used for quantitative estimation of the concentrations of C, O, Na, Cl, Al, Si, S, Cl, K, Ca, Ti, Mn, and Fe.

Vartika Singh
[& Neelu Singh (NCAOR, Goa)]

Very-high frequency climatic fluctuations in SE Asia: Comparison and contrast with Global Model— A manuscript entitled 'A 30 ka volcanic event across Serravallian-Tortonian boundary: Implications on tectonics, climate and stratigraphic correlation' has been prepared. We interpreted that the ash layer (encountered in the vicinity of Mukah, eastern Malaysia) was deposited in coastal plain-swamp-shallow, high-moderate energy seasonal fluvial channel-lacustrine environmental setting, wherein atmospheric fallout and eroded material from regoliths formed over older basement, and volcanic rocks of hinterland mixed to produce the ash layer sandwiched between thick-very thick coal beds. Pre-existent volcanic chamber that was active for a long time, periodic explosive activity from the same conduit and a major explosive activity that recycled early-formed crystals and silicic-felsic magma (rhyolite-dacite) during the major effusive event are also inferred. Prevalence of intensive chemical weathering, supported by wet-humid climate, relative tectonic quiescence before the major effusive event, and luxuriant vegetation in the monotonously horizontal, geographically vast coastal plains akin to present day in the region before and after the event is also inferred.

Anupam Sharma, Jyotsana Rai & Vandana Prasad
[**& Mu.Ramkumar** (Periyar Univ., Salem),
M. Santosh & S.S. Li (China Univ. of Geosciences, Beijing),
R. Nagarajan (Curtin Univ., Sarawak, Malaysia),
M. Manoj & D. Menier (Univ. de Bretagne Sud, Vannes Cedex, France)
& S. Numair & M.C. Poppelreiter (Univ. Teknologi Petronas, Tronoh, Malaysia)]

The concentration of nine metals *viz.*, Fe, Cu, Pb, Sn, Ni, Zn, Cd, Cr, and Ba have been analyzed under Toxicity Characterization Leaching Procedure, Waste Extraction Test and Synthetic Precipitation Leaching Procedure in various components of the mobile phones. Redundancy analysis applied on data suggests that 5 factors– part of the mobile, manufacturer, year of make, model and various leaching tests, explain 34.66% of the variance. The study suggests that the e-waste from mobile phones must be considered as hazardous waste due to potential adverse impact of toxic metals on human health and environment, however systematic extraction and recycling could reduce the demand of metal mining.

P. Morthekai & Anupam Sharma
[& Meenakshi Hira & Anurag Linda
(Central Univ. of HP, Dharamshala)
& Sudesh Yadav & Sushil Kumar (JNU, New Delhi)]

The quartzs from Himalayan and Alps regions are 'dull' in terms of luminescence response to the radiation dose, whereas those from Peninsular India and Australia are 'bright'. The reason for this phenomenon is yet to be understood. A striking balance need to be achieved while making aliquots with sufficient number of quartz grains. That balance depends on the degree of heterogeneity of bleaching and the dullness of quartz grains. This study investigates to find out whether a right balance can be achieved or not, if yes, then what should be the size of the aliquot. Seven samples have been used in such a way that 6 samples are from trans-Himalayan region which are already having ^{14}C (AMS) ages, and one sample from Krishna river delta as a 'control sample' (KD 03) in terms of well bleachedness and brightness. We made 3 types (~1000 grains - bigger aliquot, BA; ~500 grains, MA & ~100 grains, SA) of aliquots from each sample and measured palaeo-dose from each of these types. The spread (over-dispersion, %) in the data is observed to be increasing from BA to SA via MA, whereas the palaeo-dose is showing a decreasing trend. Both these trends are not observed in KD 03. Single grains were not yielding any positive results and the acceptance rate was much <1 grain/100 grains. The ages from bigger and medium sized sub-samples (BA & MA) are over-estimated compared to the ^{14}C ages. It is found that the degree of heterogeneity decides the size of the sub-sample to get reliable OSL estimate.

P. Morthekai, Randheer Singh, Debarati Nag,
Binita Phartiyal, S.N. Ali & Anupam Sharma
[& Naveen Chauhan & Anil Shukla (PRL, Ahmedabad)]

Ordination techniques such as principal component analysis, correspondence analysis and their canonical versions, such as redundancy analysis (RDA) and canonical correspondence analysis (CCA), have been applied to understand the variance in the biotic data (abundance of pollen, diatom, etc) and the abiotic driving force from geochemical data set. The manuscript on the aspect has been finalized. One more manuscript has been documented to vegetation history and archaeobotany.

P. Morthekai & S.N. Ali
[& Deepika Tripathi (Univ. of Allahabad)]

Activation energy of a synthetic long lasting phosphor [X, Yb^{3+}:$CaGa_2O_4$ (X=0, Eu^{3+}, Br^{3+}, Cr^{3+})] has been calculated using thermoluminescence (TL) Our role in this work was to measure the band-gap of this new material. This work has been finalized.

P. Morthekai
[& Sunil Singh (BHU, Varanasi)]

Antiquity of Harappan civilization has been

investigated using luminescence dating on the pottery pieces collected during ASI's excavation in Bhirrana. As only fine-grain technique is possible and the signal used is feldspar, the luminescence measurement and analysis are not that straightforward as those of quartz. Hence, we worked and published towards the chronology of two pottery pieces. These ages are the key to validate the radiocarbon ages which in turn be used to push the antiquity to 6000 yrs. BC.

P. Morthekai
[& Navin Juyal (PRL, Ahmedabad) & Anindya Sarkar (IIT, Kharagpur)]

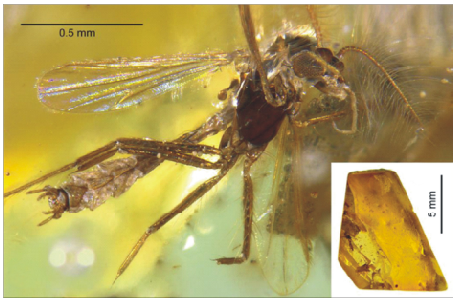
A first representative of Tipulomorpha from the early Eocene Indian amber deposits (Cambay) has been described. The new finding is the representative of the subgenus *Dicranomyia* (Diptera, Limoniidae) which is worldwide distributed today and comparatively frequent in Eocene Baltic amber. The representatives of *Dicranomyia* are numerous in Baltic amber, but not described from early Eocene Cambay amber. The new described species is the first representative of *Dicranomyia* in Cambay amber. This is also the first representative of Tipulomorpha in this kind of resins.



Tipulomorpha (Diptera)

Hukam Singh
[& Iwona Kania, Wieslaw Krzeminski & Frauke Stebner (Bonn Univ., Germany)]

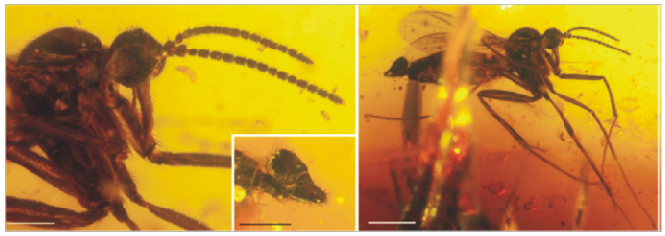
The first specific record of a Chironomid of the tribe Tanytarsini has been presented from early Eocene Cambay amber, India. The oldest known extinct tanytarsine (and non-biting midge) genus, *Gujaratomyia* Gi³ka *et* Zakrzewska, gen. nov., is described on the basis of adult males of *G. miripes* Gi³ka *et* Zakrzewska, sp. nov. The species displays an unusual leg structure with unique leg ratios and tibial armature. The character combination of the head and genital apparatus supports the hypothesis that *Gujaratomyia* and *Cladotanytarsus* Kieffer, 1921 are members of a common group within the subtribe Tanytarsina. Cambay amber has been dated to the early Eocene (52-53 Ma), it is thus contemporaneous with Fushun amber from China and slightly older than the amber from the Baltic region. As in many other amber deposits, Chironomidae are the most common dipteran inclusions in Cambay amber, in which five subfamilies have been found so far.



Non-biting midge (Diptera)

Hukam Singh
[& Marta Zakrzewska, Frauke Stebner, Mateusz Puchalski **& Wojciech Gilka** (Bonn Univ., Germany)]

One new genus and 3 new species of *Lygistorrhinidae* (a small dipteran group) in early Eocene Cambay amber from Gujarat have been reported, which significantly increase our knowledge about this group in the Eocene. *Lygistorrhina indica* n. sp. is the oldest fossil known from this extant genus. *Indorrhina sahnii* n. gen. et sp. shows morphological similarities to each of the two extant genera *Lygistorrhina* and *Asiorrhina*. *Palaeognoriste orientale* is the third species known from a group that has only been recorded from Eocene Baltic amber before. The latter finding reveals faunal links between Cambay amber and the probably slightly younger



Dipteran group superfamily Sciaroidea (fungus gnats) of the infraorder Bibinomorpha insects

Baltic amber, adding further evidence that faunal exchange between Europe/Asia and India took place before the formation of Cambay amber. Members of *Lygistorrhinidae* can be found in tropical to temperate warm forests today. They can be easily recognized by the distinct wing venation, with a lack of the stem and sometimes also the base of the fork of M veins, and generally an elongate proboscis which is presumably for feeding from flowers. Apart from that however, ecology and distributions of the species remains largely unknown. The reconstruction of the Eocene palaeoforest in India depicts a tropical rain forest which fits well with the ecological requirements of extant representatives of *Lygistorrhinidae*.

Hukam Singh
[& Frauke Stebner, Jes Rust (Bonn Univ., Germany) **& David Grimaldi** (American Museum of Natural History, NY, USA)]

Sponsored Projects

1. **Project— Linking vadose zone microbial ecology and geochemistry in sediments core from alluvial Mahi River, western India** (Sponsored by DST, New Delhi; No. SR/S4/ES-565/2011)

   Investigators: **Anupam Sharma** (Co-PI) **& Shazi Farooqui**

   Three sediment cores and two sedimentary sequences have been analyzed for texture, mineralogy and geochemistry of the lower Mahi river catchment of the mainland Gujarat. [The project has been terminated mid-way because of the completion of PI's tenure].

2. **Project— High resolution palaeoclimatic studies from Bay of Bengal** (sponsored by MoES, New Delhi; No. MOES/SIBER/NIO(RN)/11, w.e.f. 29.03.2012)

   Investigators: **Jyotsana Rai, Vandana Prasad & Premraj Uddandam**

   Northern Bay of Bengal receives huge precipitation and runoff during summer monsoon and forms suitable archive to study the monsoon fluctuations in the past. A 2.3 m sedimentary core has been retrieved onboard SSK-35, off Mahanadi at 56 m water depth, to study the variation in the past runoff and palaeoproductivity changes. 1.5 m core is analysed for the palynofacies and dinoflagellate cysts studies. The sedimentary organic matter is dominated by the structured and degraded plant remains throughout the core. The cyst assemblage is characterized with the dominance of protoperidinioids followed by the gonyalaucoides. The assemblage is composed of the autotrophic species of *Bitectatodinium spongium*, *Spiniferites bentori*, *S. mirabilis* and *Tuberculodinium vancompoae*. The heterotrophic species includes *Brigantedinium simplex*, *B.* spp., cyst of *Protoperidinium latissinum*, *Trinovantedinium applanatum*, *Lejeunecysta oliva*, *Selenopemphix quanta*, *S. nephroides*, *Echinidinium* spp. *Votadinium calvum*, *Stelladinium robustum, S. stellatum, S. abei*, *S.* sp1. Preliminary results suggest a nutrient-rich environment, supporting the dominance of protoperidinioids in the studied region.

3. **Project— Late Quaternary climate and glacial study from Dokriani and adjoining area, upper Bhagirathi Valley, Western Himalaya** (sponsored by DST, New Delhi; No. SR/DGH/44/2012, w.e.f. June, 2013)

   Investigators: **P.S. Ranhotra, Amalava Bhattacharyya, Mayank Shekhar & Ipsita Roy**

   A 247 years tree-ring chronology (1767-2014 AD) of Chir-pine (*Pinus roxburghii*) has been developed from Mahi Danda near Uttarkashi, and reconstructed the winter Standardized Precipitation Evapotranspiration Index since 1767 AD for the region. The study shows extreme drought and wet events identified during late 18th, 19th and 20th century that coincides with the well-known Asian and south Asian feminine conditions of 18th and 19th centuries. ~8-16 year cyclicity was dominant in the early 19th century, and the high frequency cycles of ~2-8 years reflecting that the ENSO mode of variability was prominent during 19th century.

   Tree-ring chronology of 399 years (1615-2014 AD) has been developed from the tree-ring cores of Fir (*Abies spectabilis*) growing on the morainic deposits at the higher reaches within the Dokiriani Glacier Valley. Correlation of ring width chronology with the climate shows positive correlation with the winter temperature, and the correlation with the glacial fluctuation records cannot be significantly established due to lack of instrumental glacial data for significant years on annual basis. The results, combined with tree-ring chronologies of other species from other Himalayan regions, have been finalized.

4. **Project—Past climate change and tree line dynamics based on tree-ring data from the Himalayan region** (sponsored by DST, New Delhi; No. SB/S4/ES-621/2012, w.e.f. June, 2013)

   Investigators: **S.K. Shah, Amalava Bhattacharyya & Uttam Pandey**

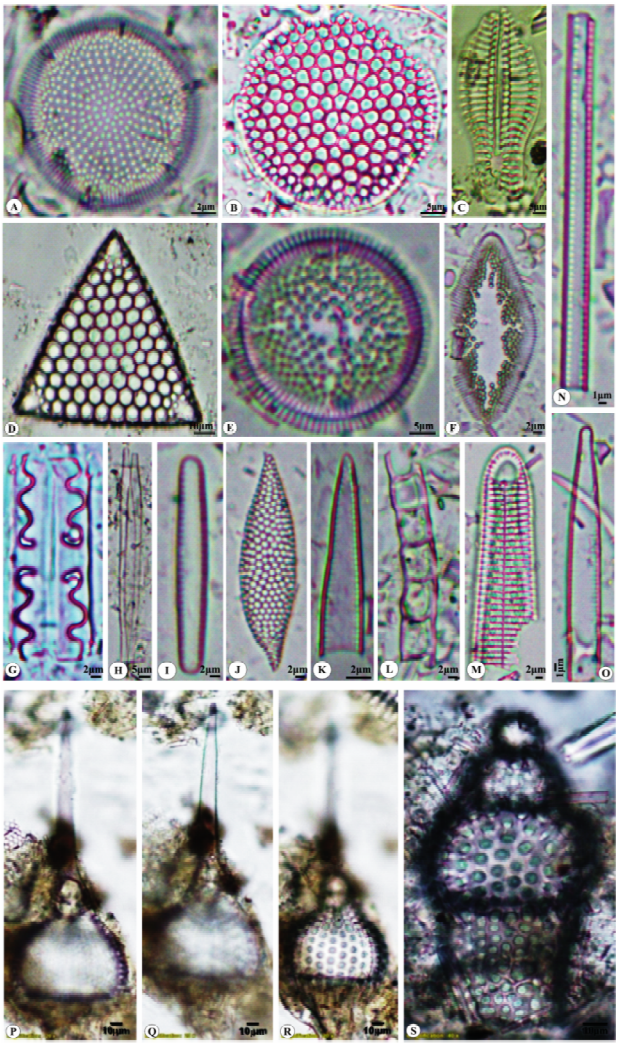
   Tree core samples of *Abies pindrow, Picea smithiana* and *Pinus wallichiana* collected from the Kashmir Valley have been processed. Various instrumental and gridded climate data are scrutinized and processed from the valley and adjoining regions. A 312 years spring (April-June) precipitation spanning 1699-2010 C.E. is reconstructed from Lidder Valley of Kashmir Himalaya using tree-rings chronologies of *Cedrus deodara*. Ten tree-ring chronologies of *Abies pindrow* (Fir) from high altitude regions of Lidder forest division are also prepared. Besides, review work of previous tree-

ring studies carried out in Kashmir Valley is compiled and finalized.

5. **Project— Diversity and palaeoecology of the benthic and planktic biotic assemblages from the Neogene sequence of Andaman and Nicobar Islands** (DST Inspire Fellowship: Grant- IF120842/ 2013-14)

Investigators: **Arindam Chakraborty & A.K. Ghosh**

The age derived from the assemblages of diatoms, radiolarians and calcareous nannofossils from the three outcrops of Havelock Island (Kalapathar, Lacam Point & South Point) is correlatable to the warming phase of the Miocene that took place in the middle Miocene, known as Middle Miocene Climate Optimum (MMCO, ~17-15 Ma). The early middle Miocene was warmer than today when the CO_2 level rose abruptly from ~400 to ~500 ppm, with the rise of global temperature (~4 °C). From the present study, it is evidenced by the dominance of warm planktonic diatoms.



Diatoms (A-O) and radiolarians (P-S) from late early to early Middle Miocene of Havelock Island: **A**) *Cestodiscus* sp. cf. *C. kugleri*, **B**) *Coscinodiscus radiatus*, **C**) *Diploneis crabro*, **D**) *Triceratium favus*, **E**) *Cestodiscus* sp., **F**) *Cestodiscus peplum*, **G**) *Grammatophora angulosa*, **H**) *Nitzschia* sp., **I**) *Thalassionema nitzschioides* var. *obtusa*, **J**) *Rossiella paleacea*, **K**) *Synedra* sp., **L**) *Chaetoceros* sp., **M**) *Gephyria media* var. *ornata*, **N**) *Thalassiothrix longissima*, **O**) *Cavitatus jouseana*, **P-R**) *Calocycletta costata*, **S**) *Stichocorys wolfii*

The data sets generated in this project have been complied in the form of a Ph.D. thesis. The dissertation includes the first comprehensive study of multiple siliceous and calcified microfossils belonging to benthic and planktonic communities from different Neogene outcrops of Andaman and Nicobar Islands, ranging in age from late early Miocene (Burdigalian) to early Pliocene (Zanclean). The calcareous nannofossils and the siliceous radiolarians recovered have been utilized for precise age determination. Apart from that diatoms and foraminifers have also been considered for the determination of age of the sediments. For palaeoecological interpretation, all the available siliceous (diatoms, radiolarians, silicoflagellates & sponge spicules) and calcareous (calcareous nannofossils, benthic calcareous algae, benthic & planktonic foraminifers) microfossils in different assemblages have been taken into consideration.

6. **Project—Palynological investigations of mangroves from South Andaman Island, India: Implications in vegetation change, palaeoclimate and sea-level fluctuations during late Quaternary** (Sponsored by DST, New Delhi; No. SR/FTP/ES-97/2012, dated 17.07.2013)

Investigator: **Shilpa Pandey**

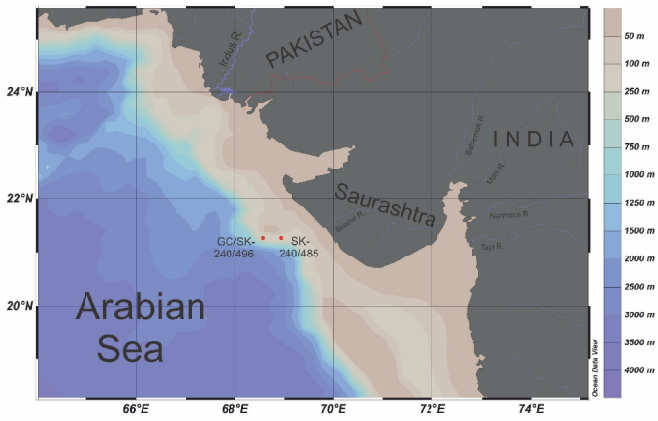
The pollen analysis of 18 surface samples collected from different areas of the South Andaman has been carried out to understand modern pollen distribution of the area. Pollen spectra show close linkages between modern pollen and local vegetation. High percentages of mangroves (*Rhizophora mucronata*, *Sonneratia*, *Bruguiera*, *Gymnorrhiza, Avicennia marina*, *Aegiceras corniculatum*, *Excoecaria agallocha* & *Heritiera fomes*) are well-reported, whereas mangrove associates pollen (*Acanthus ilicifolius*, *Acrostichum aureum* & *Phoenix paludosa*) are poorly represented in the surface sediments. Besides, palynological analysis of 1.5 m core collected from Manjeri has been analysed. The results show moderate frequencies of core and mangrove associates. Among core mangroves such as *Rhizophora mucronata, Sonneratia apetala, Aegiceras corniculatum, Acanthus, Xylocarpus, Heritiera fomes,*

Excoecaria agallocha, Terminalia and *Avicennia marina* are represented in high values and mangrove associates as *Barringtonia*, *Lumnitzera*, *Terminalia, Palmae*, *Pongamia pinnata*, etc. are encountered in moderate frequencies.

7. **Project— High resolution palaeoclimatic and palaeoceanographic study on eastern Arabian Sea off Saurashtra based on foraminifera and their geochemical signature** (Sponsored by DST, New Delhi; No. SR/FTP/ES-53/2013, dated 22.11.2013)

Investigators: **Pawan Govil & Syed Azharuddin**

Two marine sediment cores samples have been used for analysis of organic matter and the isotopes ($\partial^{13}C$, $\partial^{15}N$), total organic carbon (TOC) and total nitrogen (TN). Furthermore, $\partial^{18}O$ and $\partial^{13}C$ analysis of planktonic



foraminifera (species *G. ruber*) has been completed on three marine sediment cores using GasBench of IR-MS. The study from sediment core SK-240/485 (water depth 88 m) reveals three major periods of climatic variations during the Holocene, which are marked by abrupt shifts in productivity and sea level. The foraminiferal (planktonic & benthic foraminiferal abundance, i.e. PFA & BFA) and $CaCO_3$ (wt%) records display a major change at 8-7.5 Ka BP, whereas the mineralogical (quartz, calcite & aragonite) record shows a major shift around 7.5-7 Ka BP, lagging approx. by 500 years. The early Holocene was marked with the low foraminiferal abundance and low abundance of quartz in sediment. During mid-Holocene, the results show increase in abundances of calcite and both PFA and BFA. During the late Holocene (after 4 Ka BP), the calcite dominated over aragonite, and foraminiferal abundance also increased.

The studies from other sediment core SK-240/496 using the PFA, BFA, stable isotope, TOC, TN and sand percentage reveal a major change in the biological productivity and sedimentary influx of NE Arabian Sea during the early-middle Holocene (~10-4 Ka BP). The sand %, chemical and biological dataset demonstrate an abrupt change in oceanic environment within a small window of time (around 7-6.5 Ka) during the early-middle Holocene. PFA and BFA responded to climate change around 7 Ka that was 500 years earlier than recorded in organic chemical composition (TOC, TN) and sand % at around 6.5 Ka.

8. **Project— Studies on the late Quaternary vegetation and climate change in Jammu and Kashmir, India on the basis of pollen proxy records** (Sponsored by DST, New Delhi; No. SR/FTP/ES-81/2013, dated 20.01.2014)

Investigator: **M.F. Quamar**

Twenty-five surface samples/moss cushions (moss polsters) have been collected for palynological analysis from the open areas of Reasi district. These samples are being used to investigate the relationships between extant vegetation and modern pollen spectra, which serve as modern analogue, thereby contributing to precise interpretation of fossil pollen records for the reconstruction of Quaternary palaeoclimate in the study area. The pollen analysis reveals that the pollen of *Pinus* sp. (av. 69.29% pollen), amongst the conifers, dominates the pollen rain, which could be attributed to its high pollen productivity and exceptional pollen dispersal efficiency. However, *Cedrus* sp. and *Podocarpus* sp. have average 16.45% and 5.27% pollen in the total pollen rain, respectively. The other conifers as well as the broad-leaved taxa have average 1.16% and 4.53% sporadic pollen, respectively in the total pollen rain which could be either due to their poor pollen dispersal efficiency or poor preservation in the substrate. Tubuliflorae (av. 25%), Poaceae (av. 6.26%), Cerealia and other culture pollen taxa (av. 7.68%) are the other prominent taxa of the pollen rain revealing their actual composition on the ground vegetation.

The pollen analysis of the samples (50) collected from Akhnoor is in progress. The preliminary investigation reveals that the conifers especially *Pinus* sp. dominate the pollen rain; however. the broad-leaved taxa are scatteredly recorded. Similarly, the non-arboreals are also not well recorded in the pollen rain. Tubuliflorae (Asteraceae) is encountered in high frequency in a few samples, however, the rest of the terrestrial herbaceous elements are meagre except Amaranthaceae, etc.

9. **Project— Palaeofloristics of Lower Gondwana sediments of India and Brazil with special reference to palaeowild fire and its palaeoecological, palaeoclimatological and biostratigraphical significance** (Sponsored by DST, New Delhi; No. Ind/Brazil/P-06/2013, w.e.f. 01.04.2014)

Investigators: **Rajni Tewari & Deepa Agnihotri**

Macro-charcoal, as direct evidence of palaeo-wildfires, is a common constituent throughout an Early Permian (Cisuralian) inertinite-rich coal seam from the Dhanpuri coal mine (Barakar Formation, Sohagpur Coalfield, MP). The continuous presence of macro-charcoals within this particular seam demonstrates that fires occurred repeatedly in the source vegetation of the seam. Based on these, an anatomical assessment of the diversity and taxonomic composition of the vegetation, which experienced wildfires and contributed to the formation of peat/coal, is provided. The vegetation that experienced regular fires was dominated by gymnosperms, with a minor component of pteridophytes. The results also support previous studies, which suggest a pyrogenic origin for the high inertinite contents of many Permian coals within Gondwana.

A field excursion was undertaken in Octavio Fontana mine, Criciuma city, and Comunidade Santana Open Cast Mine, Urrussanga City, Santa Catarina State, Brazil for collection of plant fossils and macro-charcoal for palaeofire studies. White Column, Serra do Rio do Rastro, Santa Cantarina, which is considered as classical geologic section of the Gondwana in Brazil was also visited and rock samples from the Rio do Sul Formation (late Carboniferous), Palermo Formation (early Permian), Irati Formation (middle Permian), Serra Alta (middle Permian) and Rio do Rasto (late Permian) have been collected for microspore, megaspore and macro-charcoal studies.



Contact between Rio do Rastro and Teresina Formations, exposed at Serra do Rio do Rastro, Lauro Muller, Santa Catarina state, Brazil

10. **Project— Vegetation succession and climate oscillation since late Quaternary from northern Assam, northeast India: A multiproxy analysis** (Sponsored by DST, New Delhi; No. SB/EMEQ-225/2014, w.e.f. 24.07.2014)

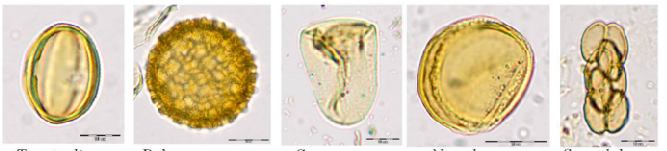
Investigator: **S.K. Basumatary**

A 1.2 sedimentary soil profile from the Hahila wetland has been pollen analysed. The palynodata display the three palaeovegetation and climate phases in the region. The first phase displayed a tropical deciduous forest composed of *Salmalia*, *Syzygium*, *Dillenia* and *Terminalia* under warm and humid condition. The presence of marshy and aquatic taxa is indicative of the wider perennial water logged condition in response to the high rainfall activity. The second phase reflected comparatively lower values of arboreal and aquatic taxa.



View of Hahila wetland, Nagaon District, Assam

The appearances of cerealia along with other cultural pollen (*Brassica* & *Coriandrum*) are indicative of the anthropogenic activity. The third phase showed the deteriorated vegetation as evidence of the low arboreal and aquatic taxa. The high value of cerealia in the assemblage is strongly indicative of the human activity in the region.



Terminalia sp. *Polygonum* sp. Cyperaceae *Nymphaea* sp. *Saccolobus* sp.

Pollen and non-pollen palynomorphs of 20 Rhino dung samples collected from Orang wildlife sanctuary and Manas national park have been studied. The high value of grass pollen along with rich grass phytoliths

confirmed that the grasses are the primary food plant of Rhino. The presence of diatom and thecamoeba in the assemblage is indicative of the ingestion of huge amount of water and water logged condition. The coprophilous fungal spores are also observed in the samples. The dataset will be helpful to serve as a guideline for palaeoecological and palaeoherbivory studies in and around the region. In addition, the palynological study on bat guano samples from Kunduli Cave of Nagaon district has been done. The palynodata revealed a tropical mixed deciduous forest composed of *Salmalia*, *Terminalia*, *Albizia* and *Syzygium* in the region, which exactly reflected the present-day vegetation setup.

11. **Project— Chronology and climate implications of late Quaternary glaciations in the upper Dhauliganga and Alaknanda valleys, central Himalayas, India** (Sponsored by DST, New Delhi; No. SR/FTP/ES-23/2013, w.e.f. August 2014)

    Investigator: **S. Nawaz Ali**

A ~3 m pit profile has been excavated at an altitude of around 4000 m asl and sampled for multiproxy studies. Pollen analysis of 72 samples has been done. Loss on Ignition and magnetic susceptibility of the samples has also been studied. Besides, the $\delta^{13}C$ analysis of de-carbonated fractions in the profile has been done, and the values were found to vary from –28.0 to –24.3‰ covering a range of 3.7‰. The $\delta^{13}C$ values show a distinct depth trend. For instance, at 296 cm depth the value is –27.7‰, which shows gradual enrichment in ^{13}C up to 282 cm with a value of –25.7‰. The $\delta^{13}C$ value abruptly decreases to –28.0‰ at 270 cm. Following this, the values again shows increase trend up to 256 cm with a value of –26.9‰. In between 256 and 200 cm height, the $\delta^{13}C$ values remain between –27.0 and –25.9‰ with distinct fluctuation. Post 200 cm is characterized by abrupt increase in $\delta^{13}C$ values up to 190 cm, and the values shifted from –26.9 to –24.3‰. This specific trend is also followed by the abrupt recovery in $\delta^{13}C$ values (–26.2‰) up to 180 cm depth. These recovery trends persist up to the 142 cm depth (–27.5‰) with distinct fluctuation in $\delta^{13}C$ values. Subsequently, the values again decrease up to 80 cm depth with a value of –25.6‰. In between, 80 to 2 cm, the $\delta^{13}C$ values ranging between –27.6 and –25.6‰ where the more negative value observed at around 16 cm (–27.6‰). At the top of the profile, the $\delta^{13}C$ value is –26.8‰. The average $\delta^{13}C$ value of the 25 modern soil sediments is –26.6‰. This specific value of the modern sediments is very close to the value observed in the top part of the section.

The chronology of the profile is being developed with the help of 7 OSL dates. The dose of the samples is already calculated and the dose rate analysis is being carried out on the ICP-MS. Lateral moraines of the most extensive (preserved) glaciation along the Drunagiri Valley have been identified at Ruing village. Eight OSL samples have been collected to develop the chronology of this glaciation. This will help in understanding the role of ISM/WD in the glacier dynamics of the region.

12. **Project— Palaeoclimate and lake history of Tapovan, Gangotri glacier valley, Garhwal Himalaya** (Sponsored by DST, New Delhi; No. SR/DGH-56/2013, w.e.f. October, 2014)

    Investigators: **P.S. Ranhotra, Amalava Bhattacharyya & A.K. Pal**

The tree-ring chronology developed for three tree species shows the chronologies of *Pinus wallichiana* around 400 yrs., *Betula* around 200 yrs., and *Cedrus* around 500 yrs. old. The correlation of chronology of pine with the climate shows significant positive relationship with the winter temperature. For Birch and *Cedrus* the development of tree-ring and climate relationship is under progress. The results of the pine chronology combined with the tree-ring chronologies of other species from other Himalayan regions have been documented.

Overall, the analysis of the modern pollen dispersal within the Gangotri Valley shows a continuous decline in the pollen frequency of *Cedrus* and *Pinus* from their forest limits to higher altitudes. *Cedrus* pollen was found most dominant in the sample collected within the medium forest of *Cedrus deodara* near Gangotri town. *Betula* shows the maximum frequency of pollen near its forest and low frequency at the altitudes higher and lower than its limit. *Juniperus* is in low frequency in the samples of higher altitudes and very sparse at the lower altitudes. The other broad-leaved taxa, namely *Alnus, Corylus, Carpinus, Juglans, Ulmaceae*, etc. are in fair numbers in the samples of lower altitudes due to their proximity to their present growth limits.

13. **Project— Developing snowfall reconstruction for the Lahul-Spiti region and its association with glacier dynamics** (Sponsored by DST, New Delhi; No. SR/DGH-76/2013, w.e.f. November, 2014)

    Investigators: **K.G. Misra, A.K. Yadava & Vikram Singh**

A field trip was undertaken to collect annual tree-ring samples in the form of increment cores from living

and dead trees from various high altitude climate sensitive steep slope sites to develop high resolution long term snowfall pattern over the Lahul-Spiti region, Himachal Pradesh. The samples are collected from the tree species of *Betula utilis, Cedrus deodara*, *Juniperus polycorpus* and *Pinus wallichiana*. The high altitude tree-ring samples of *Betula utilis* are crossdated and found sensitive to temperature. All the *Cedrus deodara* samples are also crossdated and showing good correlation with precipitation and expected to provide long term snowfall pattern over the region. The *Juniperus polycarpos* trees growing over different high-altitude tree-line sites are collected. A millennium long ring-width chronology of *Juniperus polycarpos* is developed and expected to provide robust long term climate records and snowfall pattern over the region.

14. **Project— Palaeobotanical and sedimentological studies on Indian and Sri Lankan basins with special reference to Gondwana flora, their palaeoenvironmental and palaeogeographical implications** (Sponsored by Indo-Sri Lankan Govt.; No. INT/SL/P-002, w.e.f. 11.11.2014)

    Investigators: **Neerja Jha & Neha Aggarwal**

Palynofacies analysis has been carried out in borecore VEM-1 from Vemanpalli area of Chinnur Coalfield (Godavari Basin), south India. Analysis indicates that the sediments are rich in AOM (amorphous organic matter) and charcoal, and organic matters are of 4 distinct palynofacies association. Palynofacies-A has been identified by the dominance of AOM and the subdominance of charcoal. Palynofacies-B has been recognized by the dominance of AOM along with good percentage of degraded terrestrial and charcoal. Palynofacies-C is acknowledged by the dominance of charcoal along with very less percentage of AOM. Palynofacies-D is distinguished by the dominance of structured terrestrial along with good percentage of charcoal. Palynofacies A-D are reflecting the depositional settings in a distal dysoxic-anoxic deep basin, dysoxic conditions in proximal settings, suboxic conditions in proximal settings, and shallowest oxidizing continental shelf, respectively.

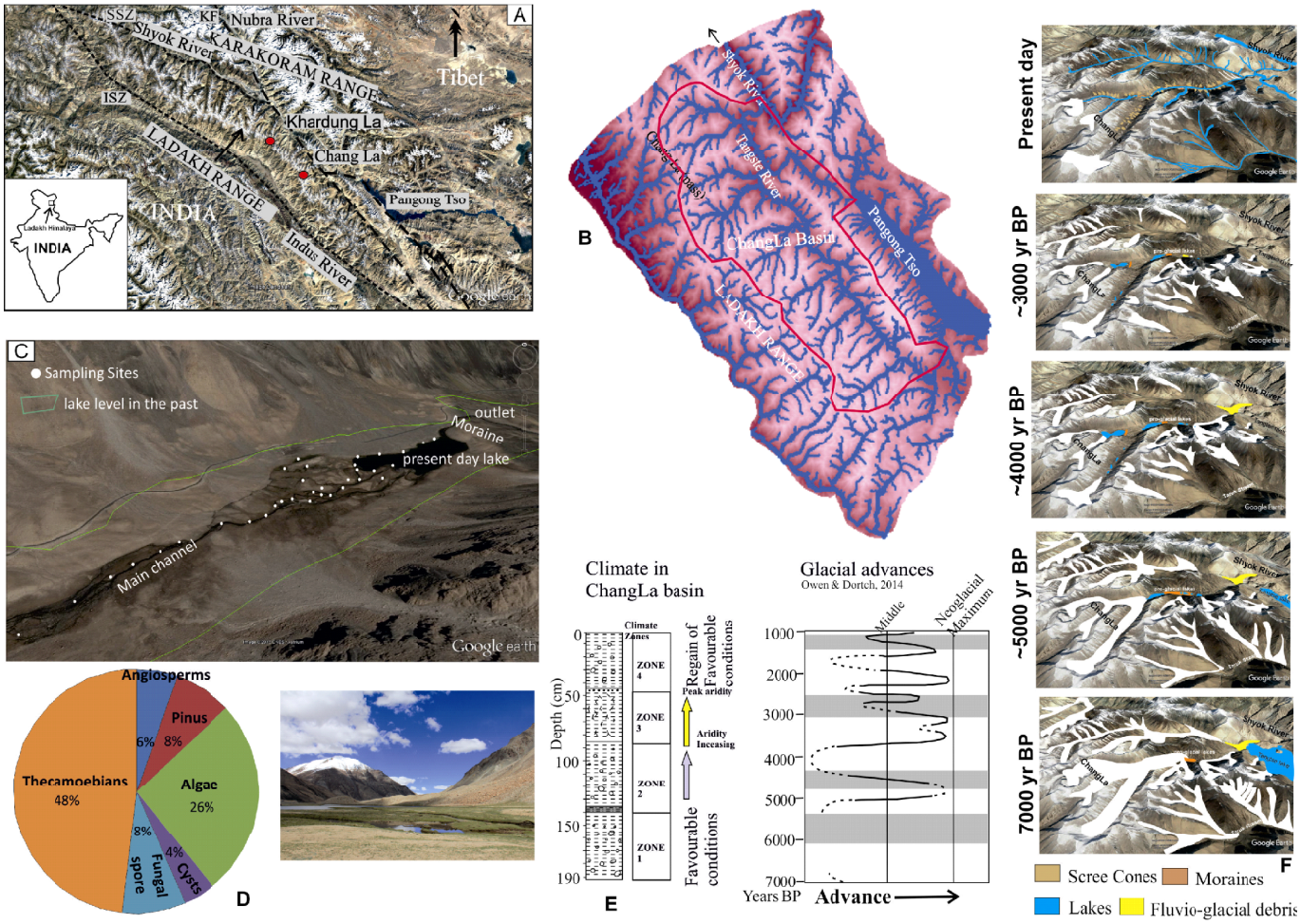
Palynofacies studies have also been carried out in Tabbowa beds of Sri Lanka to understand the palaeodepositional environments. Palynofacies-I has been distinguished by the dominance of terrestrial phytoclasts along with subdominance of gymnospermous pollen grains, which indicates its proximity to terrestrial source and dysoxic oxic conditions in fluvio-deltaic settings. Palynofacies-II included a majority of gymnospermous palynomorphs followed by terrestrial phytoclasts, which indicates slow and steady low-energy settings such as a marsh or a swamp. Palynofacies-III is distinguished by the dominance of opaque phytoclasts; reflecting a deposition in distal environmental condition. Therefore, dysoxic-oxic, moderate to high-energy conditions have been attributed to Palynofacies-III. Palynofacies-IV has been characterized by the dominance of AOM followed by terrestrial and opaque phytoclasts, which represents a reducing (dysoxic to anoxic) environment.

15. **Project— Characterization of glacial lake deposits of Ladakh, NW Trans Himalaya: Implications on landscape evolution and palaeoclimate** (Sponsored by DST, New Delhi; No. SR/DGH-69/2013, w.e.f. 22.11.2014)

    Investigators: **Binita Phartiyal, Anjum Farooqui & Priyanka Joshi**

Geomorphic and sedimentological studies have been conducted on the Chang La (5,200 m) catchment of the Ladakh Range. The range is ~570 km long with parts in Tibet, India and Pakistan, separating the Indus and the Shyok valleys in the downstream side, the Tangtse and Indus Valley in the middle stretches and cut by Indus River at near Nyoma and Loma (upstream), where the river is seen flowing north of this range. The rock type exposed belongs to the Ladakh Range (Ladakh batholith) and Shyok Suture Zone. The Chang La area is a typical glaciated area with the snow cover during winter months and only at the summit and passes during the summer time. Erratics, huge boulders, moraines, enormous amount of rock debris and wide valleys with flat areas are seen. Three streams join to make the main Chang La stream. There are some pro-glacial lakes present in this region which are spotted in the area, although there is no such glacier in the area as of today.

High resolution sampling has been done and the samples have been analyzed for mineral magnetic data (susceptibility & ARM) along with the Loss on Ignition data of all the 3 pit sections. Diatoms frustules in thecamebian tests have been recently reported from the lake. These lakes drain off in form of Chang La stream which becomes narrower and flows in a gorge before joining the Tangtse River, a tributary of the Shyok River. Being a high-altitude and a cold dessert, enormous amount of unconsolidated sediment (generated due to frost action/ physical weathering) lies loose on the high-angled slopes and the valley floor damming the drainage and forming lakes. The glaciers are absent from the region, but the



A) Google earth satellite imagery depicting the Ladakh Range and its tectonic divisions; Inset– site location in the map of India, **B**) Drainage basins of the largest-ChangLa of the Ladakh range, **C**) Location of the sampling sites of Lake 2 marked in the Google Earth Satellite imagery; Photograph of Tsoltak Lake 2, **D**) Comparison of the climatic history and the summary of glacier fluctuations in Himalaya and Karakoram (Röthlisberger & Geyh's, 1985b; Owen 2009) light gray bands indicate times of rapid climate changes after Mayewski et al. 2004; **E**) Schematic representation of the retreating glacier and lakes versus time in the ChangLa basin

moraines and these lakes can tell us about the glacial history of these areas through time.

16. **Project— Analysis of Holocene climate variability using multi-proxy data around Chorabari Glacier (Kedarnath), western Himalaya, India** (CSIR-UGC NET Fellowship, UGC Grant No. F. 2-24/2014(SA-1)

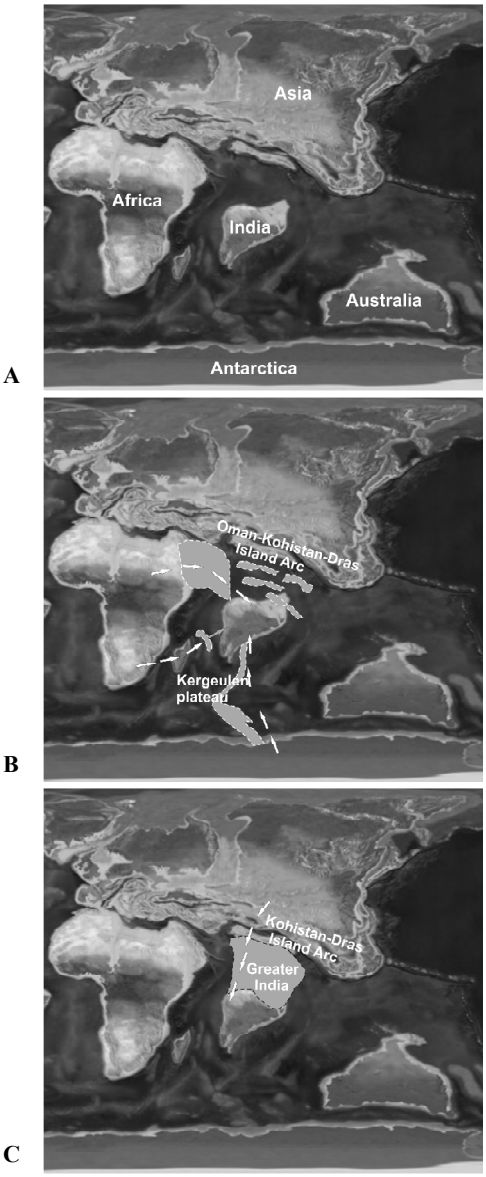
Investigators: Kriti Mishra & Ratan Kar

The surface samples (20) collected from two different elevations of kame-terraces have been palynologically analysed to understand the modern pollen-vegetation relationship. The study reflected the predominance of extra regional arboreal, especially conifers, over the local non-arboreal taxa. To decipher the past climatic changes in the Kedarnath region during the Holocene, a 2 m deep profile dug on the left kame terrace is taken up for multi-proxy studies. Palynology, along with geochemistry and magnetic susceptibility has been used to reconstruct the temporal climatic changes. The chronology of the profile has been established with the help ^{14}C dates. The palynological assemblages have provided important inferences regarding the palaeovegetation succession and contemporary climatic fluctuations in the region during the mid and late Holocene. The pollen spectrum thus obtained has been divided into 4 pollen zones based on the frequency distribution of the arboreal and non-arboreal taxa. On the basis of major fluctuations in the past vegetation, and comparison with magnetic susceptibility and geochemical results, the palaeoclimatic history of the Kedarnath region is indicative of the high variability of Holocene climate.

17. **Project— Palaeogene vertebrate fauna from the lignite associated sedimentary sequences of western India: Investigations of evolutionary and biogeographic aspects** (Sponsored by DST, New Delhi; No. SR/FTP/ES-49/2012, implemented during 2014-15)

Investigator: **V.V. Kapur**

A thorough review has been carried out to evaluate the present state of knowledge of the late Cretaceous-Palaeocene terrestrial fossil data from the Indian subcontinent, and its affinities with coeval fauna from erstwhile Gondwanan and Laurasian continents. The findings reiterate that faunal exchange via the Kohistan-Dras Volcanic island arc system might have taken place, involving only the small-sized elements, and suggest that we need to re-evaluate models postulating direct connections (particularly in the north of India). Further, the fossil data on large vertebrates can be viewed in terms of a pandemic Gondwanan distribution, implying that the vicariance model fits well in the case of a northward drifting Indian plate that eventually became isolated from the erstwhile Gondwanan continents. However, to clearly understand the degree of biogeographic connectivity or isolation of the Indian subcontinent during the late Cretaceous, additional and complete vertebrate fossils are required from the entire Cretaceous-Palaeocene interval of India and the erstwhile Gondwanan landmasses (particularly Africa & Madagascar).

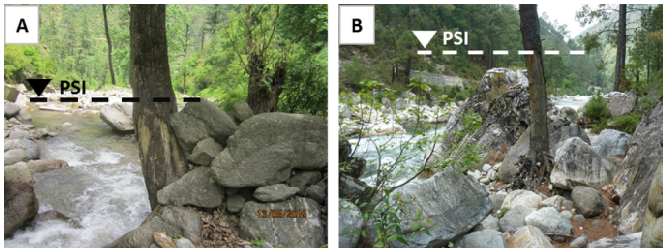


Palaeobiogeographic reconstructions of the late Cretaceous (Maastrichtian) showing: **A**) An isolated Indian subcontinent, **B**) Postulated Gondwanan connections with the Indian subcontinent, **C**) Postulated Laurasian connections with the Indian subcontinent [Maps modified from reconstructions by Ron Blakey, NAU Geology (https://www2.nau.edu/rcb7/065Marect.jpg)]

18. **Project— Indian Himalayas Climate Change Adaptation Programme (IHCAP): Vulnerability, risks and hazards assessment in Kullu district, Himachal Pradesh** (Indo-Swiss Project, w.e.f. 09.01.2015)

Investigators: **Mayank Shekhar & Amalava Bhattacharyya**

Palaeoflood events based on tree-ring analyses have been reconstructed to derive a regional flood frequency in Kullu District, H.P. The results suggest that the occurrence of floods in the district is recurrent with a marked seasonality and a cyclic natural variability in flood frequency at multidecadal scales, as well as distinct spatial representativeness. Flood hazards and associated risks have been clearly underestimated in the region in previous studies and are based on the systematic records alone. The present studies also demonstrate that a regional flood frequency approach is suitable to optimize the information gathered from tree-rings and that flood frequency can thus be analyzed for larger regions. The approach used here can be implemented in the other, poorly gauged regions and thus contribute to climate change adaptation policies in undocumented environments such as the Indian Himalayan region.

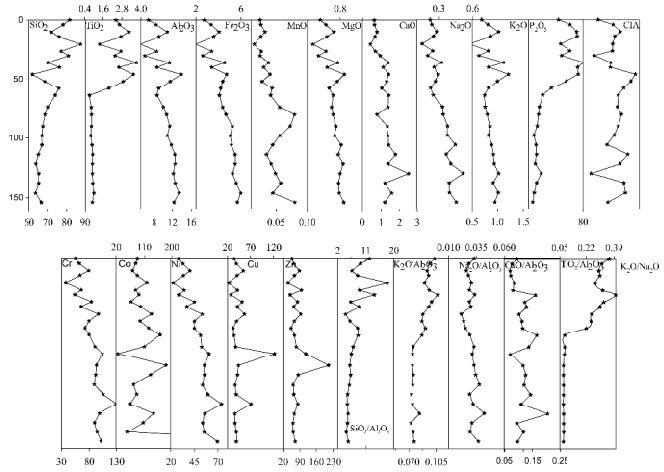


Examples of scars used as palaeostage indicators (PSI) of past floods. The trees are growing in the floodplain of a tributary stream (**A**) and in the main channel (**B**) of the Thiertan River in the valley

19. **Project— Multiproxy palaeoclimatic studies of Quaternary lake sediments from southern Madhya Pradesh, India** (Sponsored by DST, New Delhi; No. SR/FTP/ES-16/2014, w.e.f. 27.02.2015)

Investigator: Kamlesh Kumar

Geochemistry, mineralogy and isotopic studies have been completed from a sediment profile (1.56 m deep) collected from the Nonia pond of Barheta Village (Narsinghpur district). In this profile, three AMS dates were obtained– the base of the profile is ~5,214 ±51 years, while top of the profile is dated as 900 ±21 years. The major, trace and their elemental ratios are shown in the figure. Besides, prepared the samples from 80 cm profile (Baharia Village trench), situated near Kanhar Village dam ~14 km SW of Chindwara district, for geochemistry,



Major oxide, trace elements variation along the profile

mineralogy and stable isotopes studies. The trench is made on the eastern margin of the dam, and samples are collected at 5 cm interval, while the upper part is sampled at 2 cm interval. Total 30 samples have been collected from the profile. Two OSL samples are also collected at 30 cm and 73 cm from the base. The basal part of the profile consists of grey to black color stony sediment, while 72 cm of the profile comprises yellowish-black calcretized clay. The top 5 cm have black clay with fresh water molluscan shell with rootlets. A sediment core of 60 cm is also collected from pond near Bahariavill (near Kanhargaon dam).

20. **Project— Mangrove dynamics and relative sea level changes during late Quaternary in Godavari delta** (Sponsored by DST, New Delhi; No. SR/FTP/ES-84/2014, w.e.f. 17.03.2015)

Investigator: Jyoti Srivastava

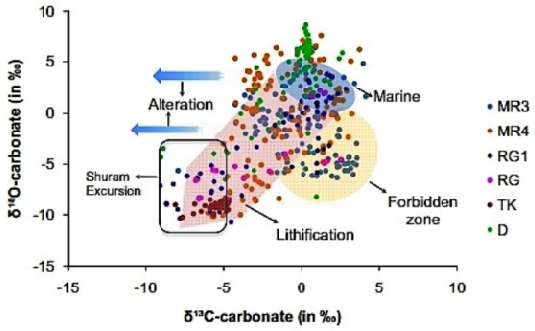
Textural analysis of sedimentary soil cores (2-4 m deep) from Coringa mangrove wetland shows the overall predominance of fine silty clay with intermittent phases of sand. The results show high salinity in the clayey core sediment (av. 3.0 psu & max. 5.2 psu) resulting in accumulation of salts in the root zone or at the soil surface when the capillary water evaporates. However, the intermittent sandy zones, which have larger pore sizes between soil particles, show lower salinity (av. 0.7 psu & max. 1.5 psu) due to percolation and capillary translocation of salts. Restriction of freshwater input to the estuaries by damming water for agriculture and various other purposes coupled with weak monsoonal pattern allows excess water evaporation from exposed wetland. Thus, low energy rivers/streams flowing in gentle relief deposits fine silty clay sediments in the wetlands that act as reservoirs of high salt accumulation.

The past sediments show the presence of diverse species of mangroves (*Sonneratia, Ceriops, Bruguiera, Rhizophora, Kandelia, Aegiceras, Excoecaria, Nypa* & *Achrostichum*) along with their associates (*Aegialitis, Derris, Barringtonia,* Combretaceae, *Thespesia*, Palmae & Chenopodiaceae) which suggests favorable salinity for survival of mangroves in the ecosystem. High percentage of *Avicennia* and *Suaeda* in surface and sub-surface sediments points to an increase in salinity which in turn is vulnerable for mangrove forests. A wide range of hinterland taxa in the deeper sediments marks the presence of a dense forest beyond the mangroves in the past. Absence of these in the surface and sub-surface sediments is attributed to intense anthropogenic activity in the studied area which could be traced through the presence of Cerealia *pollen* and abundance of cuticle of grasses.

21. **Project— High resolution stable isotopic and geochemical studies of the Late Neoproterozoic-Early Cambrian Bilara Group, Marwar Supergroup, Rajasthan to understand the contemporary carbon cycle and the Shuram enigma** (Sponsored by DST, New Delhi; No. SR/FTP/ES-107/2014, w.e.f. March, 2015)

Investigator: **A.H. Ansari**

The carbonate sample powders have been analysed for carbon and oxygen isotope for 457 samples. The carbon isotope data demonstrated 4 high negative carbon excursion with alternative 3 positive excursion that matches to Doushantuo Formation of China in terms of vertical δ^{13}C-carb profile. Therefore, Bilara Group can be considered as a time equivalent to Doushantuo Formation which is Ediacara in age. Also, the profile



Carbon isotope vs. oxygen isotope plot of carbonate samples from Bilara Group

comparison of 2 similar profiles suggests that in the upper part of Bilara Group (Pondlo Formation) Precambrian-Cambrian boundary is present. This work is drafted and finalized. The stable isotope work also showed that carbonate was deposited in marine environment that went through alteration while lithification. Till now this study has been able to indicate the occurrence of enigmatic Shuram Exursion based upon the <–6‰ values (around –9‰) similar to Shuram Formation, etc. The study provides an alternative hypothesis for the origin of Shuram Excursion according to which most of the Shuram sites were situated near equator or high pressure area where rainfall was high during the period between 570-555 Ma. This resulted into high terrestrial weathering derived carbon input into the nearby oceanic basin that produced highly negative δ^{13}C-carb. The analysis of trace metals has already been completed, however the interpretation part is yet to be done.

22. **Project— Reconstruction of climate and dating of geo-hazards related to hydro-geomorphic evidences from Sikkim Himalaya based on tree-ring proxy** (Sponsored by SERB DST, New Delhi; No. SR/FTP/ES-127/2014, w.e.f. 27.08.2015)

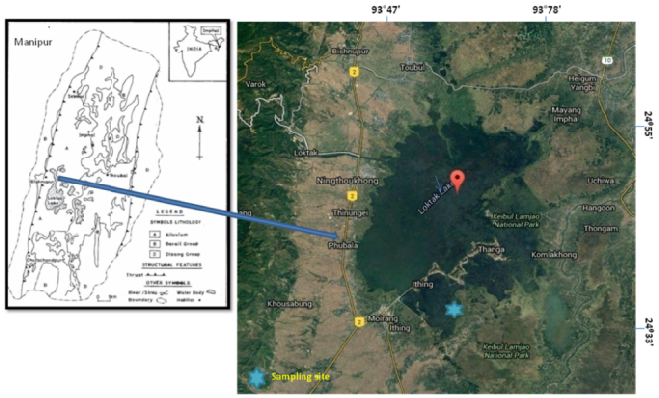
Investigator: **Mayank Shekhar**

A field excursion was carried out in and adjoining areas of north Sikkim, and around 500 tree cores have been collected from diversified trees of both conifers and broad leaf taxa. The conifers belong to *Larix griffithiana, Abies densa*, *Juniperus indica, Tsuga dumosa* and *Picea smithiana* species, and broad-leaved trees are *Betula utilis* and *Rhodendron* species. The cores of all samples have been mounted in wooden frame, and the upper surface of these cores have been polished using different grade sand papers. Further, skeleton plots are made for cross dating. All the tree-ring sequences are dated for the development of chronology. Further, individual sample cores are checked to find out any signals of natural hazards.

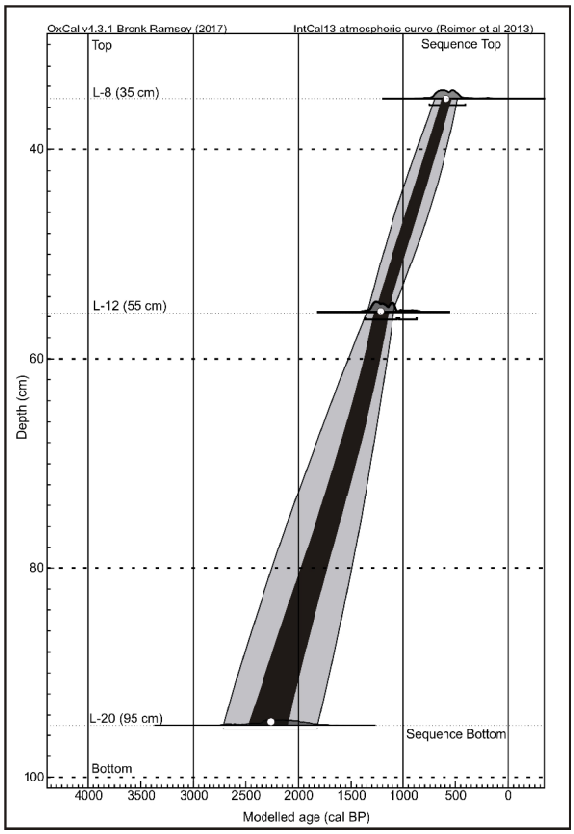
23. **Project— Late Quaternary vegetation and climate oscillation from endangered wetlands and surroundings reserve forests of Manipur, northeast India: based on pollen and NPP records** (Sponsored by SERB DST, New Delhi; No. SR/FTP/ES-141/2014, w.e.f. 13.08.2015)

Investigator: **Swati Tripathi**

A total of 38 surface soil samples from Loukaipat area of Bishnupur district, a part of Indo-Burma region, have been pollen analyzed (interpretation is in progress).



Location map showing sampling site
(source: Nautiyal and Chauhan 2009 and Google earth).



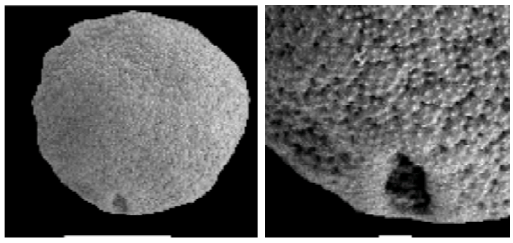
Bayesian age-depth model of the Loktak Lake sequence. Calibrated age distributions of the three ^{14}C dates are plotted with their calibrated medians shown in open circles

Maceration of soil samples from a 250 cm deep trench sedimentary profile procured from Keibul Lamjao National Park of the district has been completed. The sedimentary profile was radiocarbon dated to 24,148 cal yrs. BP (late Pleistocene). Pollen and NPP counting along with photography of the same are under progress. In addition, a paper entitled 'Vegetation history, monsoonal fluctuations and anthropogenic impact during the last 2,325 yrs from Loktak Lake (Ramsar site), Manipur, northeast India: A pollen data based syntheses' has been revised as per the referees' comments.

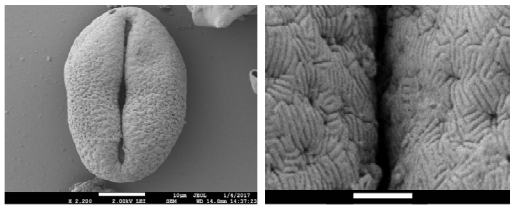
24. **Project—Quantitative reconstruction of the Palaeogene climate of palaeo-equatorial region based on Indian palynological records** (Sponsored by MoES, New Delhi; No. PO(GeoSci)/ 36/2014, w.e.f. August, 2015)

Investigators: **Vandana Prasad, Madhav Kumar, S. Jeyakumar, A.K. Mishra & Mahi Bansal**

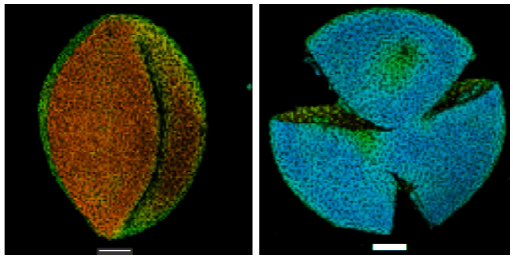
A comparative study of fossil pollens recovered from the Vastan (early Eocene) and their Nearest Living Relatives has been carried out to infer the palaeobiogeography of tropical plants. Based on the phylogenetic studies by combining the morphological data of extant and fossil pollen grains, the recorded palynofossils show high affinity to the families of Dipterocarpaceae, Euphorbiaceae (*Mallotus*) and Ebenaceae. All the three clades come under the dominant plant families of SE Asian rain forest and possess a disjunct distribution in other continents– *Mallotus* (tropical Africa, Madagascar, India, tropical Australia & throughout west pacific), Dipterocarpaceae (India, Sri Lanka, Africa, South America, Madagascar & Seychelles), and Ebenaceae (South America, Africa, Australia, Madagascar & India). Absence of early records of Dipterocarpaceae and Ebenaceae from SE Asia and presence of their high diversity in India during early Eocene indicate evolution and diversification of these clades during warm and humid climate of early Eocene on Indian subcontinent and their migration to excessive wet climatic zones of SE Asia after the India Asia collision. The present study supports 'Out-of-India hypothesis' and provides a better understanding to trace their evolutionary lineage and biogeography.



Mallotuspollenites vastanensis



Diospyrospollenites indicus

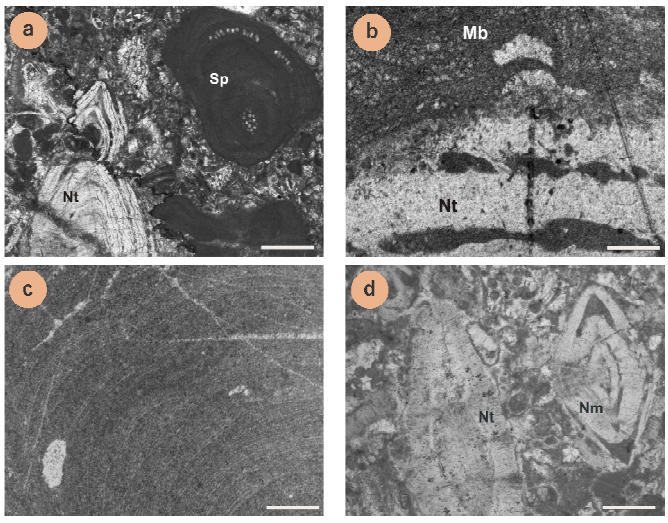


Dipterocarpous costatus

25. **Project—Facies dynamics of Palaeocene-Eocene carbonates from Meghalaya, N-E India: Palaeoenvironmental implications** (Sponsored by SERB DST, New Delhi; No. SR/ FTP/ES-143/2014, w.e.f. 09.09.2015)

Investigator: **Suman Sarkar**

Over 200 samples from various carbonate successions outcropping on the Jowai-Badarpur Road (Jaintia Hills) and areas near Cherrapunjee (Khasi Hills) have been thin-sectioned and studied extensively for analyzing the facies dynamics of carbonates belonging to the Sylhet Limestone Group. In addition to the microfacies



Microfacies components of the Prang Formation: **a**) *Sporolithon lugeoni* (Sp) with sori and nummulitid (Nt) in packstone matrix (Scale bar = 1 mm), **b**) Melobesioid coralline algae (Mb) encrusting a nummulitid foraminifer (Nt), **c**) *Lithothamnion* sp. (Scale bars = 200 µm), **d**) *Nummulites millecaput* (Nm) with another nummulitid (Nt) in grainstone-packstone facies [Scale bars = 2 mm]

analysis, multiple palaeoecological parameters like water depth and nutrient regime have also been worked out for palaeoenvironmental reconstruction. The palaeocommunities with special emphasis on calcareous algae and benthic foraminifera have been analyzed to understand their position and roles in the trophic system of Meghalaya ecosystems during the Palaeocene-Eocene time slices. Larger benthic foraminifera have been studied for getting new insights into phenomena like the larger foraminiferal turnover, providing important baseline data for correlations with European taxa and also other regions of the world.

Abundant coralline red algae have been recorded in addition to a wide variety of larger benthic foraminifera. Assemblages of calcareous green algae including multiple species of *Halimeda* and *Ovulites* have also been recorded. Several small benthic foraminifera like smaller miliolids and rotaliids have been observed. Many new species of *Nummulites* and *Miscellanea* have been recorded in the current study that has increased the specific diversity of the foraminiferal assemblages reported from this region. The major facies types are dominated by grainstones, packstones and rudstones with occasional wackestones, framestones, bindstones and floatstones.

26. **Project—Changes in the biosphere across the transition of Mesoproterozoic-Neoproterozoic succession of Buxa Formation, Sikkim, Lesser Himalaya and its correlation with coeval successions** (Sponsored by SERB DST, New Delhi; No. SR/FTP/ES-151/2014, w.e.f. 09.09.2015)

Investigator: **Shamim Ahmed**

In the NE part of lesser Himalaya, an isolated patch of sedimentary succession, comprising the Buxa Formation of Proterozoic age, is named as Ranjit Tectonic Window. There are no direct radiometric dates available for this sedimentary succession, yet it is considered as Meso-Neoproterozoic succession. To ascertain its age, a palaeobiological investigation of Buxa Formation has been undertaken. The preliminary stable carbon and oxygen isotopic investigations of the samples have been completed to assess the signals of palaeoproductivity in Meso-Neoproterozoic. C isotope value of carbonate ranges from 0 to +2.5‰ which suggest this part of Buxa Group was deposited between Mid-Meso to Terminal Proterozoic. During this period DIC was decreased, isotopic sensitivity was high and biological productivity was spread from shallow to deep sea surface. The δ^{13}C-carbonate value in this study, therefore, reveals the transition of the early Proterozoic isotopic stasis followed by increased primary productivity that led the positive increase in the δ^{13}C-carbonate value. This study shows no lithification alteration in δ^{13}C-carbonate. However, δ^{18}O -carbonate was fairly altered. The restriction of carbonate production and precipitation in shallow marine environment resulted in close environmental coupling even though organic production in deep-shelf environment remains uncharged by carbonate carbon. This kind of spatial decoupling between organic and inorganic production and burial was consistent with spatial distribution of carbonate precipitation. The study of organic carbon and trace metal is in progress.

27. **Project— Late Quaternary biotic-abiotic interactions from the Harshad estuary, Gujarat, India: Implications on palaeoproductivity and climate** (Sponsored by SERB DST, New Delhi; No. SR/FTP/ES-149/2014, w.e.f. September, 2015)

Investigators: **Biswajeet Thakur & Priyanka Seth**

The diatoms and palynofacies have been studied in the samples collected from different environmental settings (semidiurnal region & old tidal flats) in the Harshad estuary. It is aimed to study the variations in primary productivity (diatoms), palynofacies, dinoflagellate cysts and physico-chemical properties in the estuary. C and N analysis was also carried out to identify the interaction of biotic and abiotic components in different microenvironments (inner, middle & outer regions) of the estuary. The diatoms are mainly dominated by marine-brackish forms with varying proportions of centric and pennate morphotypes. It was found that the diatoms have selective criterion for different environmental settings and that they behave differently in microenvironments of the estuarine complex in the upper, middle and lower settings. The palynofacies component showed high percentage (<35%) of *Botryococcus* with variable proportions of foraminiferal linings, cuticular remains, and degraded organic matter; indicating the cessation of primary productivity in this region. Based on the palynofacies, it is inferred that oligotrophic system prevails in the Harshad estuary.

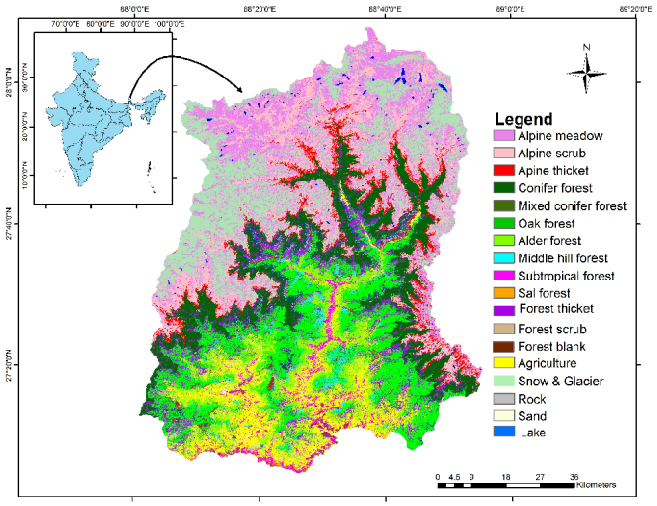
Twelve nannofossil taxa record with Ascidian spicule (*Micrasacidites* spp.) and reworked Cretaceous taxa indicate the existence of older sediments in the vicinity. The study (with Jyotsana Rai) shows that the estuarine complex consists of mixed environments from different watersheds which supply sediments of different ages to recent sediments. Different source provenances affected by tidal influences in the Harshad estuary also account

for differential primary productivity. Hence, it can be inferred that the nutrient and sediment supply from varying channels originating from different source rocks play a major role in differentiating estuarine environments and their proximal-distal trends.

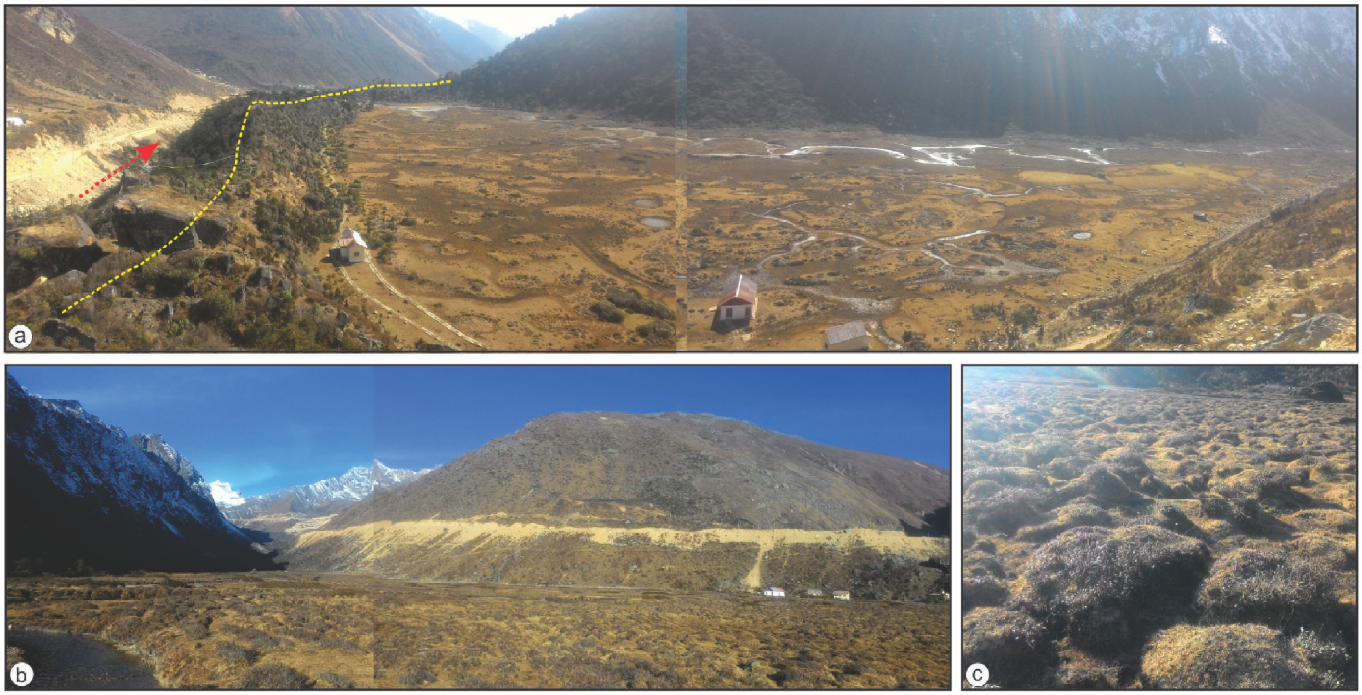
28. **Project—Glacial chronology, palaeoclimatic reconstruction and their climatic implications in the Thangu Valley, Sikkim Himalaya, India with special emphasis on luminescence characteristics of feldspar and quartz** (Sponsored by DST, New Delhi; No. SB/DGH-89/2014, w.e.f. September, 2015)

Investigators: **S. Nawaz Ali, Anupam Sharma, P. Morthekai & Jyotsana Dubey**

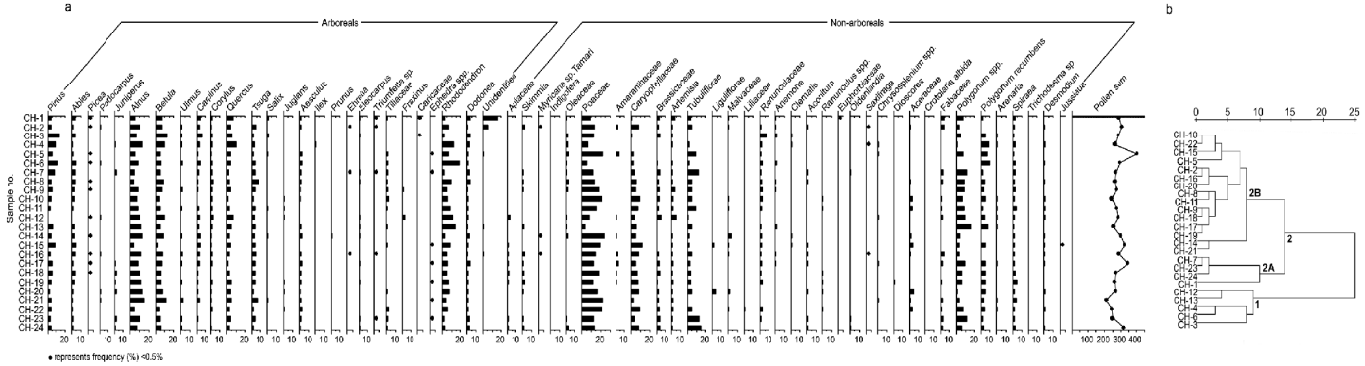
Geomorphological features along the Lashar Valley (Thangu, Chopta & Kalip) have been mapped in the field.



Land use land cover map of Sikkim, derived by supervised classification of Landsat 8 imagery of November 2014 (Satellite data with minimum snow cover and minimum cloud cover)



a) Synoptic view of the Chopta valley, **b**) Most prominent earth hummocks present in the area, **c**) Closer view



a) Frequency distribution of the terrestrial pollen taxa in the surface samples from the Chopta valley (pollen sum is also represented in the right), **b**) Results of cluster analysis on the pollen data based on squared Euclidean distance and minimum value

Based on the relative position of the lateral moraines, morphology, vegetation cover and soil formation, 4 events of glaciations have been identified. The moraine stratigraphy shows a progressive decrease in the magnitude of the glaciations. Besides, glacier-related geomorphic landforms have been identified and mapped in order to understand the evolution of different landscapes.

Studies on the modern pollen palynomorphs (PP) distribution complemented with non-pollen palynomorphs (NPP) and stable carbon isotopic data of soil organic matter in the Chopta Valley, North Sikkim have been undertaken. 24 surface soil samples have been collected from both the windward and leeward sides of the slope, but they did not show any significant difference in the palynoassemblages. The average value of $\delta^{13}C$ is 26.6‰, which clearly indicates a C3 dominated vegetation in this valley, which is also corroborated by the palynological data. However, signatures of upthermic wind transport are evident from the significant presence of extra-local and regional forest elements in the palynoassemblages. NPP data indicated grazing activity in the valley and is in conformity with the present day scenario. Further, cluster and redundancy analyses done on the PP and NPP data broadly grouped the samples according to the location of collection to some extent and reflected the relationships among the taxa with the extant vegetation. This study provides a basis for future palaeovegetation and palaeoclimate reconstruction from the region.

29. **Project—Provenance and environmental records of lake sediments from Kerala, Southern India using a suite of geochemical proxies** (Sponsored by SERB DST, New Delhi; No. SR/FTP/ES-153/2014, w.e.f. September, 2015)

Investigator: **Manoj M.C.**

A 14.2 long sediment core has been collected from the Vellayani Lake (Thiruvananthapuram) to study the provenance, environmental variability and to reconstruct the palaeomonsoon variation during the late Quaternary. It is the 2nd largest freshwater lake in Kerala with a water-spread area of about 5.5 km^2. The lake is shallow (2-6 m), oriented almost parallel to the coastal line, bordered by steep to moderately steep hillocks, and is fed by the Karamana river and several minor channels including Pallichal Thodu. The Vellayani Lake lies ideally under the influence of SW monsoon. To a depth of 140 cm, the core consisted of dark brown clay rich in organic materials, which is followed by light brown clayey silt between 140 to 550 cm which also contain the root and leaf remnants in the sediments. The bottom part of the sediment (between 550 & 1400 cm) consisted of layers of white sandy silt followed by silty clay with calcareous Mollusc shells. The field observations and preliminary record suggest that the 14 m of the sediment core may represent the past Quaternary sedimentation history. This proposed study will give a new evolutionary model and reveal the tectonic history of this terrain. Additional well-dated multiple proxy records would greatly help in resolving the timing of the climatic events as well as the physical mechanisms involving in the sediment deposition to the study area.

30. **Project— Fossil Sirenia (Mammalia) in the Oligocene and Miocene of Kutch, India** (Sponsored by National Geographic Society, USA; Award No. W466-16)

Investigators: **Daryl P. Domning** (Howard Univ., Washington DC) **& Sunil Bajpai**

Prospection was undertaken in a number of Oligocene and Miocene vertebrate fossil localities in Kutch (= Kachchh), Gujarat State, India, where fossil Sirenia (sea cows: dugongs, manatees, and their relatives) of three genera and four species had previously been discovered. New specimens probably representing two species have been collected, including one skull of each, plus additional isolated bones and a partial skeleton associated with one of the skulls. All of these species represent the Subfamily Dugonginae. Significantly, the roughly contemporaneous fossil sirenian faunas of Kutch and Madagascar seem to have no taxa in common; but one new and unpublished specimen from Madagascar may prove to represent one of the Kutch taxa, and may also be related to a later and more derived species from Mexico. Overall, the Tertiary Indian Ocean sirenians show high diversity as well as



Excavation of the skeleten of a Miocene sirenian (sea cow) in Kachchh

intriguing connections to the Mediterranean and points west, and they are promising subjects for taxonomic, palaeoecological, and palaeozoogeographic studies.

31. **Project— Analysis of plants and human relationship since late Pleistocene from Dzukouv Valley, Nagaland, northeast India** (Sponsored by SERB DST, New Delhi; No. YSS/2015/001193, w.e.f. 04.11.2015)

Investigator: **Sandhya Misra**

All the sub-surface sediment samples collected from the Dzukouv Valley and adjoining regions have been processed for both biotic (pollen/spore & phytolith) and abiotic proxy (grain size, clay mineralogy, XRD, carbon isotope & palaeomagnetism) analyses. Samples of two trenches SDI and SDZI have been analysed for bulk carbon isotope and magnetic susceptibility. Grain size analysis and biomarkers study of SDZI have also been carried out. To understand the varying morphology of phytoliths among bamboos, leaves and sheath of 29 species of bamboos have also been processed. Besides, palynological investigation of honey was taken up to understand the foraging pattern of honey bees (*Apis cerena* & Stingless bee). Palynological investigation is in progress.

32. **Project—Mesozoic fluvial and coastal deposits of Jaisalmer Basin, Rajasthan: Palaeoclimatic, palynostratigraphic and palaeobiogeographic implications based on fossil floras** (Sponsored by SERB DST, New Delhi; No. SB/EMEQ-161/2014, w.e.f. 29.01.2016)

Investigators: **Neelam & Raj Kumar**

Relevant literature of the Mesozoic sequence of Jaisalmer Basin has been consulted, and a field excursion has undertaken to various sections in Jaisalmer and adjoining areas, namely Akal National Park (Lathi Formation), Bhadasar escarpment section (Baisakhi Formation), section showing contact of Lanela Member and Kaladongar Member (Bhadesar Formation), hills at Pariwar village (Pariwar Formation), and outcrop at Habur and Kanoi villages (Habur Formation). A number of plant megafossils and palynological samples have been collected. Identification and morphotaxonomic investigation of the megafossils, and chemical processesing of surface samples for palynological study have been initiated.

33. **Project—Late Quaternary palaeoclimatic/sea level changes and anthropogenic responses from estuarine complexes of western India: A multi-proxy approach** (Sponsored by SERB DST, New Delhi; No. SB/EMEQ-244/2014, w.e.f. January, 2016)

Investigators: **Biswajeet Thakur & Priyanka Seth**

The Quaternary sediment deposits in Gujarat region represent versatile depositional units in terms of marine, fluvial and aeolian landforms, which gives vital evidence for the processes controlled by climate or tectonics. Field work was carried out in different estuaries of Gujarat (Dhadhar, Sabarmati & Harshad) bearing different climatic regimes. 15 grab samples and one core are collected from the Sabarmati estuary, while in Dhadhar estuary 20 samples and one core are collected. In the Harshad estuary, one core is collected from older tidal flat unit. The samples have been processed for diatoms and palynofacies analysis. The different estuaries responded differently in terms of diatoms abundance and assemblages. The Sabarmati estuary is amongst of the polluted localities and here the pollution tolerant diatoms are recorded in high frequencies comprising chiefly of *Navicula*, *Nitzschia* and *Synedra ulna*. The Dhadhar estuary is less influenced by human intervention and the diatom diversity is high, comprising chiefly of *Surirella*, *Pinnularia*, indicating natural selection of diatoms by the environment.

34. **Project—Subsistence pattern, vegetation dynamics and climate change during Harappan (Indus) and subsequent cultures in north-western India: A palaeoethnobotanical approach** (Sponsored by SERB DST, New Delhi; No. EMR/2015/000881, w.e.f. 10.02.2016)

Investigators: **A.K. Pokharia & Shalini Sharma**

The macrobotanical samples from Chandravati (Sirohi district) and 4MSR (Ganga Nagar district) in Rajasthan have been examined under the stereo binocular microscope, and segregated them. Segregated samples are sorted and identified as per the taxonomical classification up to species level on the basis of their morphological characters and photo-documented. A total 24,357 macrobotanical remains are recorded out of 58 samples from the Chandravati. The identification of remains from 4MSR is in progress. Moreover, charcoal, grains (barley & rice) and soil sediment from these archaeological sites are dated at Radiocarbon laboratory of BSIP (India) and Gliwice Radiocarbon laboratory (Poland) to reconstruct chronology of the cultural horizons and also to know about the actual time of arrival of crop in this region.

35. **Project—Macro- and micro-phytodiversity and behavioral pattern of pollen deposition in and around endangered wetlands of Assam: A palaeoecological and conservational perspective** (Sponsored by SERB DST, New Delhi; No. EMR/2014/000233, w.e.f. 26.02.2016)

Investigators: **Abhijit Mazumder, S.K. Bera & Amulya Saxena**

The basic aim of the project is to generate pollen depositional model to assess pollen-vegetation relationship in the Brahmaputra flood plain including the assessment of the status and types of pollen degradation (including anthropogenic aspects) as well as to generate multiproxy data from endangered wetlands adjoining forests to interpret the vegetation status and corresponding depositional environment. The project staffs [Junior Research Fellow (AS) & Project Assistant] have been



Collection of core within Rani Reserve Forest, Assam

appointed, and basic training on maceration has been given. A field trip around Guwahati (including Deepol Beel, Rani Reserve Forest, Jarasal RF, Jalukbari RF & Teteliya Forest) has been undertaken to collect polliniferous materials, surface and core samples. In addition, living flowering plant species are also procured as reference collections and pollen study.

36. **Project—Investigation of high altitude climate variability during Holocene around Hamtah Glacier, Lahaul-Spiti, western Himalaya, India** (DST-Woman Scientist Scheme, No. SR/WOS-A/EA-1018/2015, w.e.f. 18.03.2016)

Investigator: **Ruchika Bajpai** [Mentor: **Ratan Kar**]

Extensive field work has been undertaken in and around the Chandra Valley (Lahaul), and collected 35 surface samples from the eastern extremity of the Lahaul Valley (Battal) upto the central part (Gramphu), and 32 surface samples via Rohtang Pass upto Kothi, to generate modern pollen-vegetation relationship of the area and to understand the human-environment interactions. Further, took traverse around Samudra Tapu Glacier, which is the main source of Chandra River, for identification of potential sampling sites for trenching. One such place (possible palaeolake) was located where an exposed section is cleared up to a depth of 138 cm, and samples are collected at 3 cm interval each. The surrounding vegetation is studied, and 10 surface samples are also collected around the trench to develop the modern analogues. The maceration of the sediment samples has been completed and the palynological analysis is under progress. Palynological studies of a 130 cm thick core from the Chandra Tal Lake (4,300 amsl) is further being undertaken jointly with the School of Environmental Sciences, JNU. In addition, a Ph.D. thesis works on the topic 'Investigation of the Holocene climate variability from the glacial sites in Lahaul Valley, western Himalaya' has been finalized.

37. **Project—Analysis of Holocene climate change in Tripura and Mizoram based on pollen, environmental geomagnetism and isotope data** (DST-Woman Scientist Scheme, No. SR/WOS-A/ES-18/2014, w.e.f. 21.03.2016)

Investigator: **Nivedita Mehrotra**

The palynological data of surface sediment samples from Tripura has been analyzed to understand the modern vegetation and climate in the area, and the data is finalized. Palynological and environmental geomagnetism data of 2 sub-surface sediment profiles from Chari Lam and Srinagar (Tripura) are also analyzed, and the results are documented. A field work has been carried out and 4 sub-surface sediment profiles are collected from various parts of Mizoram. About 20 moss cushion samples are also collected from various sites in Mizoram for modern vegetation studies based on modern pollen data. Historical documents are surveyed from various archival resources in Aizwal to understand the routes of human migration into Mizoram, and vegetation changes due to anthropogenic activities through time. Existing Archeological records are surveyed to identify impacts of human settlement in Mizoram during Holocene, and changes in the population distribution and impacts on vegetation and land cover changes. In addition, a Ph.D. thesis entitled 'Analysis of Quaternary climate change in North-East India based on multi-proxy data' is compiled and documented.

38. **Project—Tree growth response of selected tree species of timber line to climate variability across the Indian Himalayan Region** (Under NMHS program, MoEF & CC; No. 1882/XII-86/ 2016, w.e.f. May 2016)

Investigators: **P.S. Ranhotra, Amalava Bhattacharyya & Utsa Singh**

A field work has been conducted to Chopta-Tungnath area of Uttarakhand for the collection of the tree-ring and surface palynological samples. The tree-ring samples are collected from *Abies*, *Betua* and *Rhododendron*. Processing of samples has been done. Initial studies show that the *Abies* with longest chronology of ~300 years, and *Betula* with longest chronology of ~180 years are suitable for the climatic reconstruction of the area. The sediment samples have been chemically macerated and pollen analysis is in continuation.

39. **Project—Palyno-biozonation and palaeo-climatic reconstruction of Permo-Mesozoic sediments. West Bokaro Coalfield, Damodar Basin** (Sponsored by SERB DST, New Delhi; No. SB/EMEQ/-139/2014, w.e.f. 12.07.2016)

Investigator: **Srikanta Murthy**

Palynological study carried out for samples collected from the Bokaro River section near Danea area from West Bokaro Coalfield, Damodar Basin. The recovered palynomorphs are characterized by the dominance of enveloping type of monosaccate pollen mainly *Densipollenites* and sub-dominance of *Faunipollenites* spp.–*Striatopodocarpites* spp. complex. The other stratigraphically significant taxa recorded from the section are *Guttulapollenites hannonicus*, *Crescentipollenites fuscus, Arcuatipollenites (A. pellucidus, A. ovatus, A. damudicus), Alisporites asansolensis*, *Verticipollenites gibbosus, Striatites rhombicus*, *Platysaccus densicorpus, Chordasporites* sp., *Parasaccites (P. perfectus, P. densicorpus)* and *Horriditriletes* sp. On the basis of the total palynocomposition, the studied section has been dated as latest Permian age. This age correlation also gets support from comparative studies with similar palynoassemblages known from other coalfields of Indian Gondwana basins.

40. **Project—Pliocene Arctic Climate Teleconnections (PACT):** A joint Indo-Norwegian climate research project in Polar Regions (Sponsored by MoES, New Delhi; No. Indo-Nor/PS-8/2015, w.e.f. September, 2016)

Investigators: **Vandana Prasad, Anjum Farooqui, Salman Khan & Pranav Raj Tyagi**

A study has been initiated (in collaboration with NCAOR, Goa & Geological Survey, Norway) to assess the mid-Pliocene warming signature in high latitude. Test samples of ODP core 911-A from the Yermak Plateau (Arctic region) were received to check the dinoflagellate cyst productivity during mid-Pliocene. They did not result in high yield of marine dinoflagellates due to dilution with high terrigenous material in the sediments. Additionally, samples from key Pliocene locations ODP 910-C have been taken up for the dinoflagellate study. Since the preservational conditions of dinoflagellate cysts are not good, new non-acid palynological processing of samples are devised.

The samples of ODP core 910 has been partially pollen analyzed in a time bracket of 3-3.2 Ma (mid-Pliocene Epoch). The overall palynological results reveal a high percentage of broad leaf temperate taxa (*Alnus, Corylus, Betula, Carpinus, Quercus*); suggesting a relatively warmer temperate climate in the Arctic region supporting the vegetation that grows well in frost free climatic conditions. However, a decreasing percentage from 38-23-21-17 during 3.24-3.16 to 3.08-3.04 Ma, respectively shows a gradual decrease in moisture/ temperature variability. Similar synchronous trend of high to low percentage of trilete pteridophytic and bryophytic spores along with fungal spores is observed. The study is also supported by moderate percentage of dinoflagellate cysts, poorly preserved brackish water centric diatoms indicating the paralic sediment deposition. The inferred warm temperate climate in the Arctic polar region during the mid-Pliocene and its consequences on the Asian monsoon system is potentially important for understanding the impacts of global warming in the near future.

41. **Project—Analysis of the Early Eocene amber from Cambay and Kachchh basins, Gujarat, India: Palaeoecological, environmental and climatic significance** (Sponsored by SERB DST, New Delhi; No. EEQ/2016/000112, w.e.f. March 2017)

Investigator: **Hukam Singh**

Literature survey on the theme of the project has been initiated along with the processing of some earlier collected amber samples.

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Quamar MF, Ali SN, Kumar K, Meena NK, Sharma A & Bera SK – Monsoonal variations from the "Core Monsoon Zone (CMZ)" of India during the Late Quaternary: A multiproxy approach. *TWAS-ROCASA Young Scientists' Conclave*, Bengaluru, December 2016 (Abstract: 23).

Rai J, Pandey DK, Fürsich FT, Alberti M, Mulye C & Bhosle S – Integrated calcareous nannofossil-ammonite biostratigraphy of Katrol Formation (Jawahar Nagar section), Kachchh, western India. *Nat. Conf. & 33rd Conv. Indian Assoc. Sedimentol.*, Varanasi, November 2016 (Abstract: 89-90)

Roy I, Ranhotra PS, Shekhar M, Bhattacharyya A, Agrawal S, Patil SK, Nautiyal CM & Pal AK – Holocene climate and glacial study from Dokriani, western Himalaya: A multi proxy approach. *Nat. Conf. Himalayan Cryosphere*, Bengaluru, January 2017 (Abstract No. 44).

Sharma M & Singh VK – Megascopic Carbonaceous remains fro Proterozoic basins of India: lessons in evolutionary biology. *Natn. Conf. & Field Workshop Precambrians of India,* Jhansi, November 2016 (Abstract: 107).

Sharma S, Pokharia AK, Agnihotri R, Pande PC & Manjul SK – Preliminary ethnobotanical investigations to understand early to mature Harappan human settlement history from the vicinity of Ghaggar River channel (western Rajasthan, India). *Natn. Sem. Emergence of Language, Culture & Technologies*, Udaipur (Abstract: 8).

Shekhar M & Bhattacharyya A – A tree-ring based January-April discharge reconstruction of Zemu Chuu, North Sikkim Eastern Himalaya. *Nat. Conf. Himalayan Cryosphere*, Bengaluru, January 2017 (Abstract: 53-54).

Shukla Y & Sharma M – Microbially induced sedimentary structure (MISS) from the Bhima basin, Karnataka. *Natn. Conf. & Field Workshop Precambrian of India,* Jhansi, November 2016 (Abstract: 114).

Singh VK & Sharma M – Confocal laser scanning microscopy (CLSM) based investigation on cyanobacterial microfossil *Oscillatoriopsis*. *Natn. Conf. & Field Workshop Precambrians of India,* Jhansi, November 2016 (Abstract: 115).

Singh VP, Singh BD, Singh MP, Mathews RP, Dutta S, Mishra S & Mahesh S – Investigation of lignite deposits from Saurashtra Basin: their depositional history and hydrocarbon potential in western India. *Nat. Geo-Res. Scholars Meet*, Dehradun, June 2016 (Abstract: 146-147).

Thakur B & Rai J – Biotic responses in Harshad estuary, Saurashtra: A tidal analogue. *9th NABS Nat. Conf. New Biological Res.*, Chennai, August 2016 (Abstract: 252).

Deputation to Conferences/Seminars/Workshops

Abroad

M.F. Quamar participated in the *European Pollen Database (EPD) Meeting & Training Workshop* held at Aix-en-Provence, France during June 01-03, 2016.

Shilpa Pandey participated in the *International Workshop PAGES Land 6K– Land Cover and Land Reconstructions* held at University of Utrecht, The Netherlands during June 14-16, 2016.

Chanchala Srivastava, A.K. Pokharia & Shalini Sharma participated in the *17th Conference of the International Workshop Palaeoethnobotany* held at Paris, France during July 04-09, 2016.

Arindam Chakraborty participated in the *Workshop on Stable Isotopes in Fossils and Organic Compounds from Lake Sediment Records* held at University of Southampton and National Oceanographic Centre, UK during July 28-29, 2016.

Sunil Bajpai participated in the *4th International Meeting of IGCP-608* held at Novosibirsk, Siberia, Russia during August 15-20, 2016.

Sunil Bajpai, Mukund Sharma & Shilpa Pandey participated in the *35th International Geological Congress (IGC)* held at Cape Town, South Africa during August 27-September 04, 2016.

Neerja Jha & Neha Aggarwal participated in the *World Multidisciplinary Earth Science Symposium (WMESS-2016)* held at Prague, Czech Republic during September 05-09, 2016.

A.K. Pokharia participated in the *5th International Conference of Palaeoethnobotany of China* held at Xian, Shaanxi, China during September 10-14, 2016.

B.D. Singh participated in the *Joint Annual Meeting of TSOP (33rd The Society for Organic Petrology)-AASP (49th American Association of Stratigraphic Palynologists– The Palynological Society)-ICCP (68th International Committee for Coal and Organic Petrology) & Conference* held at Houston (Texas), USA during September 18-23, 2016.

Pauline S. Kavali participated in the *XIV IPC (International Palynological Congress)* and *X (IOPC) International Organization of Palaeobotany Conference* held at Salvador, Bahia State, Brazil during October 23-28, 2016.

M.F. Quamar participated in the *Symposium on Centenary (1916-2016) of Pollen Analysis and the Legacy of Lennart von Post* held at Stockholm, Sweden during November 24-25, 2016.

Jyotsana Rai participated in the *2016 BGC Carbonate Workshop: Subis Complex- An Ancient Great Barrier Reef* (to part of Field Workshop at Miri & Niah Caves of Sarawak, as a joint programme between Shell-PETRONAS-SEACaRL) held at Perak, Malaysia during December 02-04, 2016.

Binita Phartiyal participated in the *American Geophysical Union (AGU) Fall Meeting* held at Mascone, San Francisco, USA during December 12-16, 2016.

Shilpa Pandey participated in the *International Workshop on Aquatic Transitions: South East Asia-Oceania* held at Kuala Lumpur, Malaysia during February 14-17, 2017.

Shilpa Pandey participated in the *International Landcover 6K Workshop* and *Training Course* held at Shijiazhuang, China during March 06-11, 2017.

Anjali Trivedi participated in the *International Botanical Conference* held in Melu Park, Beijing, China on March 12, 2017.

Gaurav Srivastava participated in the *ATBC Asia Pacific Chapter Meeting* held at Xishuangbanna Tropical Botanical Garden, CAS, China during March 25-28, 2017.

Shilpa Pandey participated in the *International Workshop on Measuring Components of Resilience in Long Term Ecological Datasets- EcoR3* held at Finse, Norway during March 27-31, 2017.

In India

P.S. Ranhotra participated in the *Workshop on NMSHE Timberline Project Programme* held at Naukutchiya Tal, Nainital during April 14-15, 2016.

Rajesh Agnihotri, P.S. Ranhotra, S.N. Ali & Ipsita Roy participated in the *Accelerator Mass Spectrometry Workshop* held at Inter University Accelerator Centre (IUAC), New Delhi during April 21-22, 2016.

U.K. Pandey & Syed Azharuddin participated in the *Conference on Quaternary Cliamte: Recent Findings and Future Challenges* held at NIO, Goa during April 28-30, 2016.

S.N. Ali & Mayank Sekhar participated in the *National Workshop on Himalayan Glaciology* held at JNU, New Delhi during May 17-18, 2016.

Rajesh Agnihotri participated in the *Indo-USA Workshop for Combating Air Pollution in North India* held at Hotel Vivanta-Taj, Lucknow during May 25-26, 2016.

Anupam Sharma participated in the *Agilent Workshop on UMA or FTIR Mic/Imaging System* held at COE, Manesar, Gurgaon during June 09-10, 2016.

Rajesh Agnihotri participated in *the National Conference on Recent Trends in Isotope Geochemistry* held at PRL, Ahmadabad during June 16-17, 2016.

Jyotsana Rai & Biswajeet Thakur participated in the *9th NABS (National Academy of Biological Sciences) National Conference on New Biological Researches: Opportunities and Challenges for Sustainable Development* held at Madurai Kamraj University, Chennai during August 11-12, 2016.

Shalini Sharma participated in the *National Seminar on Emergence of Language, Culture and Technologies* held at Sahitya Sansthan, Janardhan Rai Nagar Rajasthan Vidyapeth, Udaipur during November 07-09, 2016.

Jyotsana Rai & Manoj M.C. participated in the *National Conference & 33rd Convention of Indian Association of Sedimentologists with Emphasis on Energy Resources and Climate Change* held at Department of Geology, BHU, Varanasi during November 12-14, 2016.

V.V. Kapur participated in the *5th Forum on X-Ray Digital Imaging and Computed Tomography Workshop* held at General Electric Technical Solution Centre, Pune during November 17-18, 2016.

Rajni Tewari, Srikanta Murthy, Anju Saxena, S.S.K. Pillai & Deepa Agnihotri participated in the *Annual Convention of the International Association for Gondwana Research (IAGR) and 13th International Conference on Gondwana to Asia* held at University of Kerala, Tiruvananthapuram, Kerala during November 19-20, 2016.

Mukund Sharma, V.K. Singh & Shamim Ahmad participated in the *National Conference and Field Workshop on Precambrians of India* held at Bundelkhand University, Jhansi during November 22-24, 2016.

M.F. Quamar & P. Morthekai participated in the *TWAS-ROCASA Young Scientists' Conclave on Frontiers on Earth and Climate Sciences* held at Indian Institute of Sciences, Bengaluru during December 05-07, 2016.

Mahesh Prasad, Ruby Ghosh & S.K. Singh participated in the *International Conference on The Green Planet: Past, Present and Future* held at University of Calcutta, Kolkata during December 21-23, 2016.

O.S. Sarate participated in the Silver Jubilee *National Conference on Plant Diversity: Past and Present* held at Sant Gadge Baba Amravati University, Amravati during December 30-31, 2016.

Rajni Tewai, Anju Saxena & S.K. Pandey participated in the *104th Indian Science Congress* held at Sri Venkateswara University, Tirupati during January 03-07, 2017.

Mayank Shekhar & Ipsita Roy participated in the *National Conference on Himalayan Cryosphere and Hydrology* organized by SERB (DST) and Divecha Centre for Climate Change, and held at IISc, Bengaluru during January 23-24, 2017.

Mukund Sharma, V.K. Singh, A.H. Ansari & Shamim Ahmad participated in the *International Conference on Emergence and Evolution of Biological Complexity* held at National Centre for Biological Sciences, Bengaluru during February 04-06, 2017.

B.D. Singh participated in the *International Conference on NexGen Technologies for Mining and Fuel Industries* organized by CSIR-Central Institute of Mining and Fuel Research (Dhanbad) and held at Vigyan Bhawan, New Delhi during February 15-17, 2017.

Sunil Baipai, Anupam Sharma, Anjum Farooqui, Rajesh Agnihotri, Binita Phartiyal, Ratan Kar, A.K. Pokharia, Pawan Govil, S.K. Basumatary, Biswajeet Thakur, S.K. Shah, Abhijit Mazumder, K.G. Misra, Anju Saxena, P.S. Ranhotra, Ruby Ghosh, Swati Tripathi, Shilpa Pandey, Kamlesh Kumar, Shailesh

Agrawal, S.N. Ali, M.F. Quamar, Jyoti Srivastava, P. Morthekai, S.K. Shukla, Manoj M.C. & all the Sponsored Project Personnel working on Quaternary Palaeoclimate aspects participated in the *International Brainstorming Session/Workshop on Quaternary Environments and Climates: Focus on Holocene and Anthropocene* held at BSIP, Lucknow during February 21-23, 2017.

Syed Azharuddin participated in the *National Seminar on Recent Advances and Challenges in Geochemistry, Environmental and Sedimentary Geology* held at AMU, Aligarh on February 27, 2017.

Swati Tripathi & Neelam participated in the *Workshop on Hindi me Vaigyanic Lekhan Kaise Kare* held at NRLC, Jankipuram, Lucknow on March 01, 2017.

A.K. Pokharia participated in the *Seminar on Antiquity, Continuity and Development of Civilization and Culture in Bharat (India) up to 1st millennium BC* held at ICHR, New Delhi during March 27-29, 2017.

A.K. Ghosh participated in the *Colloquium Frontiers in Biotechnology* (DBT sponsored) held at University of Burdwan, Burdwan during March 29-30, 2017.



A group photo of the participants of International Brainstorming Session on Quaternary Environments and Climates: Focus on Holocene and Anthropocene

Training/Study Visits

Abroad

Manoj M.C. visited and worked on organic geochemistry of Southern Ocean sediment cores to study the paleoclimatic variation during the Quaternary at the Center for Advanced Marine Core Research (CMCR), Kochi University, Kochi Core Centre, Japan under Scientific Committee for Antarctic Research (SCAR) Fellowship Programme during February-May, 2016.

Ruby Ghosh visited Germany and worked with Dr. Angela A. Bruch under the INSA-DFG Bilateral Exchange Programme on 'quantifying openness of paleovegetation via pollen-vegetation-climate relationships: comparing Southern Caucasus and Eastern Himalayas' at the Senckenberg Research Institute, Frankfurt during April 11 to July 09, 2016.

S.K. Pandey visited China and worked with Prof. Xunlai Yuan and associates under the CAS-Presidential International Fellowship Initiative (PIFI, Category B) programme at the Nanjing Institute of Geology and Palaeontology (NIGPAS), Nanjing during May 27 to November 29, 2016. Also attended the Workshop on new techniques in Palaeobiology conducted by the NIGPAS during November 16-18, 2016.

Anjali Trivedi visiting China since June, 2016 (for one year) to work at the Institute of Botany, Chinese Academy of Sciences, Beijing under the CAS-Presidential International Fellowship Initiative (PIFI, Category B) programme.

Vertika Singh joined the Indian Scientific Expedition to the Arctic during July 18 to August 25, 2016 to carry out field work in Ny-Alesund, Svalbard (Norway) area. Samples from the surface sediment, sediments cores (from the lakes) and exposed Quaternary sections have been collected. Grab sampler was used to collect sediments from the fjord.

P.S. Ranhotra, Jyoti Srivastava & M.F. Quamar attended the CNRS Summer School on Pollen data and Quantification of past vegetation cover (POLQUANT): Theory of pollen analysis and its application for vegetation reconstruction held at Moulis, Toulouse, France during August 28-September 02, 2016.

B.D. Singh visited the well-equipped Core Laboratories (Houston, USA) engaged in petroleum/gas reservoir optimization in Texas region, after attending the ICCP General Assembly on September 23, 2016. Had discussions with workers and acquainted with digital colour measurements of organic matters. Also visited the Departments of Earth and Environmental Sciences (Columbia University, New York) and Geosciences (Princeton University, New Jersey), and offices of USGS (at New York & Washington) during September 26 to October 04, 2016. In addition, visited Smithsonian National Air and Space Museum (at Washington), National Science and Space Museum (at Houston), and Science and Natural History Museum (at New York) for the sake of scientific gain.

Rajni Tewari & Deepa Agnihotri visited the Palaeontology Institute and Museum of Zurich University, Zurich (Germany), and the Department of Botany and Palaeobotany and the Natural History Museum (Botany & Palaeobotany Section) of Centro Universitário UNIVATES, Lajeado, Rio Grando do Sul (Brazil) during March 20-31, 2017 in connection with the DST sponsored Indo-Brazilian project.

Arindam Chakraborty visited the Department of Earth Sciences, University College London (during July-September, 2016) and worked as Newton-Bhabha Fellow under Newton-Bhabha Ph.D. placement programme sponsored by DST (India) and British Council (UK).

Suman Sarkar attended the Flugel Course (International Course on Carbonate Microfacies) at the Erlangen University, Erlangen, Germany during March 06-10, 2017.

In India

Neerja Jha attended the 5th Meeting of the Subject Expert Committee (SEC) on Earth and Atmospheric Sciences held at Ahmedabad on April 18, 2016.

S. Nawaz Ali attended the User Interaction Workshop on Accelerator Mass Spectrometry Dating held at IUAC, New Delhi during April 21-23, 2016 and on July 23, 2016.

Mukund Sharma, Binita Phartiyal, V.K. Singh, A.H. Ansari & Shamim Ahmad attended the NASA Spaceward Bound India Programme in Ladakh during August 09-21, 2016.

A.K. Ghosh & Manoj M.C. attended the IODP Review Committee Meeting on Indian IODP Participation held at NCAOR, Goa during September 15-16, 2016.

S.K. Shah attended the GIAN Short Course on 'Reconstruction of the Asian Monsoon System: New Approaches and Techniques' held at IIT, Kanpur during October 17-30, 2016.

Rajni Tewari, Srikanta Murthy, Anju Saxena, S.S.K. Pillai & Deepa Agnihotri attended the Author Workshop on 'how to get published in an international high impact journal' jointly organized by Elsevier, International Association of Gondwana Researches and University of Kerala, and held at Tiruvananthapuram, Kerala on November 18, 2016.

B.D. Singh attended the Meeting of Central Public Information Officers/ First Appalate Authorities of the Autonomous Institutions conducted by the DoPT Ministry regarding the use of RTI-MIS web-Portal, and held at DST, New Delhi on November 18, 2016.

V.K. Singh, S.S.K. Pillai, Shilpa Pandey & M.F. Quamar attended the 2nd India International Science Festival (IISF-2016) organized at National Physical Laboratory, New Delhi during December 08-11, 2016.

K.G. Misra & Amlava Bhattacharyya attended the 3rd GMW and 4th Projects Assessment Committee Meeting of DST (Earth & Atmospheric Sciences) Sponsored Project organized at CUSAT, Kochi during December 14-16, 2016.

Vandana Prasad attended the PAMC Meeting and presented the progress of MoES Project organized at NGRI, Hyderabad during January 26-28, 2017.

Sandhya Misra visited the Earth Science Department of IIT Bombay, Mumbai for biomarkers study during July 21 to August 02, 2016.

U.K. Pandey attended the Field Training Course in Glaciology held at GSI (Northern Region), Lucknow during August 08-September 09, 2016.

Arindam Chakraborty attended the Newton-Bhabha Fellows Meet held at the British Council, New Delhi on November 08, 2016.

Sandhya Misra visited the IIT, Gandhinagar during November 17-23, 2016 to discuss the findings of archaeobotanical investigations from Ropar, Punjab.

Sandhya Misra attended the 61th Accelerator User Workshop at IUAC, New Delhi during December 16-18, 2016 and given a presentation for getting a slot for AMS dating of samples during 16-18 December, 2016.

N.B. Tewari attended the Meeting of Finance/Accounts Officers/Registrars of all DST Autonomous Bodies held at DST, New Delhi during June 29-30, 2016 for uploading FUCs on the PFMS Portal.



Rajni Tewari in Brazil



Deepa Agnihotri in Brazil



Anjali Trivedi in China



S.K. Pandey in China



Manoj M.C. in Japan



Arindam Chakraborty in UK

Lectures Delivered

Palaeontology: An Interface between Earth and Life Sciences (Invited Lecture) at Invertis University, Barelly (on April 23, 2016) – delivered by Sunil Bajpai

Northward Drifting Indian Plate: The Cradle of Biotic Evolution (Foundation Day Lecture) at Indian Institute of Science Education and Research, Pune (on September 20, 2016) – delivered by Sunil Bajpai

Northward Drifting Indian Plate: The Cradle of Biological Evolution (M.R. Sahni Memorial Lecture) at Centre of Advanced Study in Geology, Panjab University, Chandigarh (on March 06, 2017) – delivered by Sunil Bajpai

Astropalaeobiology: Exploring Early Life on Earth and Beyond in NASA Spaceward Bound 2016, Valedictory Session at Amity University, Noida (on August 20, 2016) – delivered by Mukund Sharma

Plant Life through Earth's History with Special Reference to Glossopteris Flora of India (Invited talk as a part of Late Dr. V.N. Bedekar Colloquium Lecture Series on his Birth Centenary) at the Vidya Prasarak Mandals' B.N. Bandodkar College of Science, Thane, Mumbai (on December 05, 2016) – delivered by Rajni Tewari

Aao Jane Kyon ate hain Bhukamp (Radio talk) from Prasar Bharti, All India Radio, Lucknow (on May 01, 2016) – delivered by Jyotsana Rai

Carbon, Nitrogen and Sulfur Isotopic Measurements of Ambient Aerosols of India: Implications to source-apportionment and secondary transformations (Invited talk) in the National Conference on Recent Trends in Isotope Geochemistry at PRL, Ahmadabad (on June 17, 2016) – delivered by Rajesh Agnihotri

Radiocarbon Age of Biological Remains: Fundamentals, Advances and Challenges (Inaugural talk) in the National Seminar (sponsored by DBT Ministry of S&T) at Dayanand Girls P.G. College, Kanpur, UP (on September 20, 2016) – delivered by Rajesh Agnihotri

High-resolution Radiocarbon Dating: Fundamentals, Advances and Challenges (Invited talk) in a Course Work (organized by Ministry of HRD) for understanding Asian monsoon from Speleothems at IIT, Kanpur (on October 19, 2016) – delivered by Rajesh Agnihotri

IODP Expedition 342: Paleogene Newfoundland Sediment Drifts in the IODP Review Committee Meeting at NCAOR, Goa (on September 16, 2016) – delivered by A.K Ghosh

Ancient DNA in the Colloquium on Frontiers in Biotechnology at the Department of Biotechnology, University of Burdwan (on March 30, 2017) – delivered by A.K Ghosh

Briefing on Field Geology and Sedimentology in NASA Spaceward Bound 2016, Introductory Session at the Lemon Tree Premier Hotel, Aero City, New Delhi (on August 08, 2016) – delivered by Binita Phartiyal

Review of the NASA SBI 2016 Field on Sedimentological Aspects in NASA Spaceward Bound 2016, Valedictory Session at the Amity University, New Delhi (on August 21, 2016) – delivered by Binita Phartiyal

Antarctica the Frozen Continent: Scientific Scope, Challenges and Opportunities at the Rotary Club of Greater Lucknow, Lucknow (on October 22, 2016) – delivered by Binita Phartiyal

Agriculture and Agricultural Systems in Prehistory of northern India: An Archaeobotanical Approach (Invited talk) at the Seminar on Antiquity, Continuity and Development of Civilization and Culture in Bharat (India), New Delhi (on March 28, 2017) – delivered by A.K. Pokharia

Past Climate Reconstruction in Himalayan Region using Tree-rings at IIT, Kanpur during GIAN Short Course (on October 22, 2016) – delivered by S.K. Shah

An Introduction to Indian Gondwana and its Correlation with South America: A Palynological Perspective (Invited talk) at the XXVI Semana de Estudos Geológicos of the Universidade Federal Rural do Rio de Janeiro, Brazil (on September 15, 2016) – delivered by Pauline S. Kavali

Quaternary Palynology at the Institute of Botany, CAS, Beijing (on October 18, 2016) – delivered by Anjali Trivedi

Phytoliths: What they Say and Why it Matters? at the Botany Department of the Scottish Church College, Kolkata (on February 10, 2017) – delivered by Ruby Ghosh

Micro-Computed Tomography (CT): An Opportunity in the Field of Palaeontology (Indian Context) (Invited lecture) at the X-Ray Digital Imaging & Computed Tomography Workshop, Pune (November 18, 2016) – delivered by V.V. Kapur

Palaeoecology of the Indian Subcontinent Through the Cenozoic in CNRS Summer School on Pollen analysis and its applications for vegetation reconstruction at Moulis, France (on August 29, 2016) – delivered by Jyoti Srivastava

Algal Biomass in Panamic and Puga Hotspring in NASA Spaceward Bound 2016, Valedictory Session at Amity University, Noida (on August 20, 2016) – delivered by A.H. Ansari

Glimpse of Proterozoic Basins of India at Nanjing Institute of Geology and Palaeontology, Nanjing, PR China (on September 09, 2016) – delivered by S.K. Pandey

OSL Dating (Invited talk) in a short course entitled 'Reconstruction of Asian monsoon systems: New approaches and techniques' held at IIT, Kanpur (on October 19, 2016) – delivered by P. Morthekai

An Overview of early Miocene to late Pliocene Palaeoclimate: Evidence from Andaman and Nicobar Basin based on Siliceous and Calcareous Microfossils at the London Micropalaeontology Group meeting, UCL, U.K. (on September 27, 2016) – delivered by Arindam Chakraborty

Calcareous Nannofossils from Neogene Sediments of the Andaman and Nicobar Islands at the Newton-Bhabha Fellows Meet, British Council, New Delhi (on November 08, 2016) – delivered by Arindam Chakraborty

Innovation and Incubation at the Kamla Nehru Institute of Technology, Sultanpur (on August 02, 2016) – delivered by Y.P. Singh

Lectures by Visiting Scientists



Evidence for Neoarchaean Glaciation Event from the Dharwar Craton, India – delivered by Dr. R. Srinivasan, FNA, Indian Institute of Sciences, Bengaluru and Chief Editor, journal Current Science (on April 22, 2016).



Getting to know Species before too Late – delivered by Prof. Deepthi Yakandawala, University of Peradeniya, Peradeniya, Sri Lanka (on May 25, 2016).



Palaeobotanical and Sedimentological studies on Indian and Sri Lankan Basins: Palaeoenvironmental and Palaeogeographical Implications – delivered by Mr. Panchala Weerakoon, University of Peradeniya, Sri Lanka (on May 25, 2016).



The Jurassic Stable Isotope Record of India and Beyond: Palaeoclimatic, Palaeogeographic and Palaeoecologic Implications – delivered by Dr. Matthias Alberti, Institute of Geosciences, University of Kiel, Germany (on June 13, 2016).



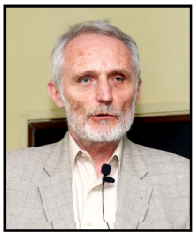
Molecular Approaches to Geomicrobiological Studies in Soil Ecosystem – delivered by Prof. G. Archana, Head, Department of Microbiology, The MS University of Baroda, Vadodara (on September 23, 2016).

A Journey to the Discovery of First UNESCO recognized Geo-Heritage Site at Mistaken Point in Canada (International Fossil Day Lecture) – delivered by Prof. S.B. Misra, formerly Department of Geology, Kumaun University, Nainital (on October 14, 2016).

Isotopic Disequilibrium in Globigerina bulloides and Applications of Clumped Isotope Thermometry – delivered by Dr. Prasanna Kannan Naidu, Centre for Earth Sciences, Indian Institute of Science (IISC), Bangalore (on October 28, 2016)



Qarun Lake Sdiments in Egypt: A Record of the Holocene Climate Events – delivered by Prof. Leszek Marks, Geology Department, University of Warsaw, Poland (on November 08, 2016)

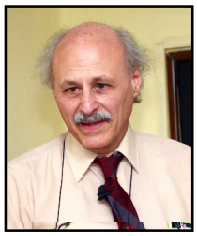


Development of the Holocene Nile Delta in Context of Rise and Decline of the Pharaonic Civilization – delivered by Dr. Fabian Welc, Institute of Archaeology, University of Warsaw, Poland (on November 09, 2016).



Long Pollen Sequences from the Middle Pleistocene Lake Sediments in Poland and their Stratigraphic Significance – delivered by Prof. Leszek Marks, Geology Department, University of Warsaw, Poland (on November 10, 2016)

Sirenians and Seagrasses: An Ecomorphological Perspective– delivered by Prof. Daryl P. Domning, Department of Anatomy, Howard University, Washington DC, USA (on February 03, 2017).



Minerals and Microbes: Their Relationship in the Past and Present – delivered by Dr. V. Purnachandra Rao, Member GB, BSIP and Emeritus Scientist, Civil Vignan's University, Vijaywada (on March 29, 2017).







Satya Nishtha Desh ki Pragati ki Mahati Awashyakta (Vigilance Awareness Week Lecture) – delivered by Sri A.P. Rai, Director, Technical Consultancy Services & Law Department, Geological Survey of India, Lucknow (on November 04, 2016).







The Proterozoic Earth: A Geochemical Insight from Rocks of India (6th Dr. B.S. Venkatachala Memorial Lecture) – delivered by Prof. Jyotiranjan S. Ray, Geoscience Division, Physical Research Laboratory, Ahmedabad (on January 02, 2017).





Insights into the Late Palaeozoic Gondwana Phytogeography (3rd Dr. K.R. Surange Memorial Lecture) – delivered by Dr. Rajni Tewari, Birbal Sahni Institute of Palaeosciences, Lucknow (on February 03, 2017).





Extinctions and Radiations in the History of Life (3rd Dr. M.N. Bose Memorial Lecture) – delivered by Prof. Jere H. Lipps, University of California, Berkeley, USA (on March 03, 2017).



Scientific briefing to college students on the occasion of National Science Day (February 28, 2017)

Consultancy/Technical Support Rendered

The C-14 laboratory serves as a national facility for various organizations and researchers across the country. Major dateable materials are sediments, charcoal, shells, wood pieces, etc. Major personnel utilized our radiocarbon dating facility this year were:

Dr. Sujeet Nayan, Asstt. Superintending Archaeologist, Survey of India Ministry of Culture (Govt. of India), New Delhi

Dr. K.C. Srivastava, Superintending Archaeologist (I/C), Archaeological Survey of India, Excavation Branch-III, Patna

Sri Bulton Dutta, Dy. Director of Research (Arch.), Directrate of Research Govt. of Arunachal Pradesh, Itanagar

Dr. I.A. Khan, Guide of Head, Dept. of Geology and Petroleum Technology, Nowrojee Wadia College, Pune

Dr. Virag Sonake, Asstt. Director, Dept. of Archaeology, M.S., Nagpur

Dr. Milan Kumar Chauby, Archaeological Survey of India, Guwahati

Ms. Manjshree Mandal, SRF, Dept. of Botany, University of Kalyani, West Bengal

The electron microscopes equipped in SEM unit are being used as a central facility. The facility has also been provided to other institutions in spare times. The unit has provided consultancy in investigating the ultra structural morphology and micro-analysis of samples (about 112) received from researchers of following organizations/ universities:

Dept. of Physics, University of Lucknow, Lucknow (UP) – *(Ceramics, Powder materials, Nano films, Metal oxides, Metal alloy)*

Shri Ram Murty Smarak College of Engineering & Technology, Bareilly (UP) – *(Pharmaceuticals samples)*

Dept. of Botany, University of Lucknow, Lucknow – *(Leaf, Seeds)*

Dept. of Applied Physics, B.R. Ambedkar University, Lucknow – *(Nano films, Powder materials)*

CSIR-Central Drug Research Institute, Lucknow – *(Bacteria samples)*

Dept of Geology, Kurukshetra University, Kurukshetra (Haryana) – *(Sediments samples)*

Dept. of Zoology, University of Lucknow, Lucknow – *(Silver Nano material)*

Dept. of Geology, University of Lucknow, Lucknow – *(Coralline Algae samples)*

Saraswati Medical & Dental College, Lucknow – *(Teeth, Tooth filing materials)*

D J College of Dental Science & Research, Niwari Ropad, Modinagar – *(Teeth, Tooth materials)*

Dept. of Applied Chemistry, B.R. Ambedkar University, Lucknow – *(Natural adsorbents materials, crystals structures)*

King George's Medical Univerity, Lucknow – *(Tooth materials, Bon Grafts samples)*

Amity Institute of Biotechnology, Amity University, Lucknow – *(Seed extracts samples)*

Provided consultancy services to Oil India Limited, Mizoram on *Biostratigraphical studies on sub-surface samples of well #AIBAWK-1 in Mizoram (NELP-VA Block: MZ-ONN-2004/1)* (under OIL-BSIP contract no. 6206428). 129 well cutting samples (encountered between 2730 & 4125.30 m intervals) of the sedimentary successions were made available for the study of palynological constituents in the samples to interpret the age and palaeoenvironment, besides demarcation of unconformities/ hiatuses. The final report incorporated the results of the palynological studies (including dinoflagellate cysts, spores-pollen grains, acritarchs, organic matter, calcareous nanofossils & ascidian spicules) has been submitted to OIL. – by Sunil Bajpai, Rahul Garg, Mukund Sharma, Madhav Kumar, Jyotsana Rai, Vandana Prasad & V.K. Singh

Rendered consultancy to Mansarovar Mining Private Limited for geochemical analysis of 10 rock samples. – by Anupam Sharma

In addition, summer training and assistance were imparted to a number of students from the various institutions as detailed below:

Imparted training on Surface Palynology of a coastal wetland from India and its potential palaeoecological applications to Ms. Priyanka Seth, M.Sc. student of Environmental Sciences, University of Lucknow for dissertation work (in April, 2016). – by Jyoti Srivastava

Provided scientific assistance in measurements of vitrinite reflectance and observation under fluorescent light on the Lower Gondwana coal samples to Mrs. Alka D. Kamble and Ms. Mollika Bannerjee, Ph.D. students of the CSIR-Central Institute of Mining and Fuel Research, Dhanbad (in May, 2016). – by B.D. Singh

Imparted training on Quaternary Palynology to Ms. Pavni Misra, Ph.D. student of the Indian Institute of Technology, Kanpur (in May, 2016). – by Anjum Farooqui

Imparted training on the topic Integrated calcareous nannofossil-ammonite biostratigraphy of Patcham and Katrol Formations (Keera Dome), Kachchh to Mr. Chaitanya Mulye and Mr. Suraj Bhosale, M.Sc. (Final) students of the Department of Earth and Environment Science, Krantiguru Shyamji Krishna Verma Kachchh University, Bhuj (during May-June, 2016). – by Jyotsana Rai

Imparted training on the topic Permian palaeofloristics: a case study from Singrauli Coalfield, Son-Mahanadi Basin to Mr. Ashwin George, B.Tech. student of the University of Petroleum & Energy Studies, Dehradun (during May-June 2016). – by Anju Saxena

Imparted Palynological training on the living and surface samples of Rani reserve forest, Kamrup district, Assam to Ms. Seema Singh, M.Sc. Geology student of Krantiguru Shyamji Krishna Verma Kachchh University, Bhuj (during May-June, 2016). by Swati Tripathi

Imparted training on Lower Gondwana Palynology to Ms. Chanchal Lakra and Ms. Sneha Sinha, Ph.D. students of the Department of Geology, Ranchi University, Ranchi (during May-June, 2016). – by Neha Aggarwal & Neerja Jha

Imparted training on Late Permian Palynomorphs and their palaeoclimate from East Bokaro Coalfield, Damodar Basin, India to Ms. Priyanshu Lohani, B.Tech. student of the University of Petroleum & Energy Studies, Dehradun (during June-July, 2016). – by Srikanta Murthy

Imparted training on Early Permian Biodiversity of Dhanpuri Open Cast Mine, Shahdol district (MP) to Mr. Aryman Bhattacharya, B.Tech. student of the University of Petroleum & Energy Studies, Dehradun (during June-July 2016). – by S.S.K. Pillai

Imparted training on Diatoms from surface sediments and its relation to water chemistry from Harshad estuary, Gujarat to Ms. Neelam Dixit, M.Sc. III Semester (Environmental Sciences) student of the Institute of Biosciences & Biotechnology, Chhatrapati Shahu Ji Maharaj University, Kanpur (during June-August 2016). – by Biswajeet Thakur

Imparted training on Diatoms based phytoplankton and their spatial distribution in Harshad estuary, Gujarat to Ms. Deepmalika Tripathi, M.Sc. III Semester (Environmental Sciences) student of the Institute of Biosciences & Biotechnology, Chhatrapati Shahu Ji Maharaj University, Kanpur (during June-August 2016). – by Biswajeet Thakur

Provided scientific and technical inputs to the District Forest Officials of Sahibganj district, Jharkhand State for the development of National Fossil Park in Rajmahal Hills (during November 10-13, 2016). – by A.K. Ghosh, Srikanta Murthy & S.S.K. Pillai

Co-supervised the M. Phil thesis entitled 'Calcareous nannofossils as Late Paleocene to Early Miocene archives of paleoenvironment and paleoclimate in Mannar Basin, Sri Lanka' of Mrs. P.A.S.R.D. Perera, Post Graduate Institute of Science, University of Peradeniya, Sri Lanka. – by Abha Singh

Guided the Master's thesis on 'Dendrochronology with emphasis on the dendrogeomorphology' of Ms. CH. Bency David, Department of Environmental Science, Pondicherry University, Pondicherry (during January-March, 2017). – by P.S. Ranhotra

Guided the Master's thesis on 'Applications of palynology with specialized study on the modern pollen dispersal and vegetation relationship from glaciated valley' of Mr. Guru Vignesh, Department of Environmental Science, Pondicherry University, Pondicherry (during January-March, 2017). – by P.S. Ranhotra

Recognition

R.C. Mehrotra

Awarded "Scientific Output Medal–2016" of BSIP for the best piece of research work done amongst Scientists- E, F and G during the preceding two years (2014 & 2015).



Mukund Sharma

Awarded "External Budgetary Resource Medal–2016" for obtaining external budgetary resources for the Institute (through consultancy services) during the preceding two years (2014 & 2015).



Rajni Tewari

Key Note Speaker and Chairperson of Scientific Session-Life and Environment, *2016 Convention of IAGR and 13th International Conference on Gondwana to Asia*, University of Kerala, Tiruvananthapuram (November 2016).

Chief Guest, Late Dr. V.N. Bedekar Colloquium Lecture Series at the Vidya Prasarak Mandals' B.N. Bandodkar College of Science, Thane (December 05, 2016).

O.S. Sarate

Chairperson, Session I: Theme I— *Palaeofloristics Diversity* of the Silver Jubilee National Conference on Plant Diversity: Past and Present held at the Department of Botany, Sant Gadge Baba Amravati University, Amravati (December 2016).

S.K. Basumatary

Awarded "Shri Chandra Dutt Pant Medal-2016" for the best piece of research work done during the last three years, preceding the year of award, in the category of Scientist-C.



S.K. Shah

Awarded "Diamond Jubilee Medal–2016" of BSIP for publishing the papers in high quality refereed journals during the preceding two years (2014 & 2015).



Deepa Agnihotri

Awarded "Team Medal–2016" for excelling to inculcate team spirit and collaborative integrated work within the Institute or in collaboration with other institution during the preceding two years (2014 & 2015).



Shilpa Pandey

Nominated Co-convener of the special scientific session– Understanding Tropical Climate Change from Geological Perspective to Multidimensional Approach, 35th International Geological Congress, Cape Town, South Africa (August-September, 2016).

Swati Tripathi & M.F. Quamar

Awarded "Dr. Chunnilal Khatiyal Medal–2016" for the best piece of research work done during the last three years, preceding the year of award, in the category of Scientist-B.



P. Morthekai

Awarded "Indo-Australian Early to Mid-Career Researcher Fellowship" to work during July, 2017-January, 2018.

Suman Sarkar

Awarded "Dr. B.S. Venkatachala Memorial Medal–2016" for the outstanding piece of research work in



Palaeobotany under research students' category of BSIP, Lucknow.

Reeta Banerjee

Awarded "BSIP Employee Medal–2016" for working diligently and efficiently with extra efforts in discharging the duties of Technical staff (Group I & II).



Avanish Kumar

Awarded "BSIP Employee Medal–2016" for working diligently and efficiently with extra efforts in discharging the duties (Administration).



Representation in Committees/Boards

Sunil Bajpai

- President, The Palaeobotanical Society, Lucknow.
- Chief Editor, *The Palaeobotanist*.
- Member, Editorial Board, *Journal of the Geological Society of India* (for Fast Track Articles).
- Member, Editorial Board, *Current Science*.
- Member, Indian Journal of Geosciences.
- Council Member, Indian Academy of Sciences, Bengaluru.
- Member, Indian National Committee for IUGS-INQUA.
- Co-Leader, International Geoscience Programe Project (IGCP-608) on Cretaceous
- Convener, International Brainstorming Session/ Workshop on Quaternary Environments and Climates: Focus on Holocene and Anthropocene (BSIP, February 2017).

Neerja Jha

- Transparency Officer, BSIP (under RTI Act-2005) (till 30.09.2016).
- Member, Subject Expert Committee, Women Scientist Scheme of DST (Earth & Atmospheric Sciences).

R.S. Singh

- Secretary, The Palaeobotanical Society, Lucknow.

Rupendra Babu

- Treasurer, The Palaeobotanical Society, Lucknow.

Neeru Prakash

- Joint Secretary, The Palaeobotanical Society, Lucknow.
- Assistant Transparency Officer, BSIP.

Jyotsana Rai

- Member, Editorial Board, The Palaeontological Society of India, Lucknow.
- Evaluator, an International Project of Malaysia under UTP Research Proposals for YUTP-FRG 2017.
- Examiner, B.Sc. (Hons.) Semester VI Examination 2015-16, Geology Practical, BHU, Varanasi.
- Member, Gender Sensitization Committee Sexual Harassment, BSIP.

A. Rajanikanth

- Vice-President, The Palaeobotanical Society, Lucknow.

Mukund Sharma

- President, The Society of Earth Scientists, Lucknow.
- Voting Member, ICS, Sub-Commission on Cryogenian Stratigraphy (2012-17)
- Corresponding Member, ICS, Sub-Commission on Ediacaran (2012-17)
- Organizing Secretary & Co-ordinator, NASA Spaceward Bound India-2016 Meeting.
- Member, Research Development and Coordination Cell, BSIP.
- Joint Secretary, Executive Council, The Palaeontological Society of India, Lucknow (2016-17).
- Member Board of Studies, Curriculum Development, Baba Saheb Bhimrao Ambedkar University, Lucknow.

B.D. Singh

- Associate Member, International Committee for Coal and Organic Petrology (ICCP).
- Principal Member, Solid Mineral Fuel Sectional Committee– PCD-7.4: Methods of Analysis Subcommittee, Bureau of Indian Standards, New Delhi.
- Member, Executive Council, Coal Petrological Society of India.
- Member, Research Development and Coordination Cell, BSIP.
- Principal Member, Solid Mineral Fuel Sectional Committee– PCD-7.5: Methods for the Petrographic Analysis of Coal, Coke and Lignite, Bureau of Indian Standards, New Delhi.

Rashmi Srivastava

- Councilor, International Society of Plant Morphologists.

Rajni Tewari

- Editor, *The Palaeobotanist*.
- Member, Executive Council, The Palaeontological Society of India, Lucknow.
- Member, National Working Group, IGCP Project-597.

Rajesh Agnihotri

- Organizing Secretary, International Brainstorming Session/Workshop on Quaternary Environments and Climates: Focus on Holocene and Anthropocene (BSIP, February 2017).

Anjum Farooqui

- Member, International Geological Correlation Programme (IGCP-495).
- Member, International Council for Biodeterioration of Cultural Properties, Lucknow.
- Organizing Secretary, International Brainstorming Session/Workshop on Quaternary Environments and Climates: Focus on Holocene and Anthropocene (BSIP, February 2017).

A.K. Ghosh

- Chief Editor, *Geophytology,* The Palaeobotanical Society, Lucknow.
- Member, Editorial Board, Journal of Environmental Biology.
- Associate Editor, for a special volume (37) of Journal of Environmental Biology.

Vandana Prasad

- Member, PAC- Climate Change Programme, Ministry of Earth Science.
- Councillor, The Palaeobotanical Society, Lucknow.
- Member, Executive Council, Palaeontological Society of India.
- Member, Research Development and Coordination Cell, BSIP.

Anupam Sharma

- Evaluator, Doctoral Theses, JNU, New Delhi & Pondicherry University, Pondicherry.
- Expert, Ph.D. Viva-Voce, JNU, New Delhi & Pondicherry University, Pondicherry.
- Expert, B.Sc. Geology (Hons) Practical Examination, AMU, Aligarh.
- **Mentor, for** 3 Post Doctoral Fellows under SERB N-PDF Scheme, DST, New Delhi.
- **Member,** Supervisor Panel, Joint Science Academies' Summer Research Fellowship Program, supported by all three Science Academies of India.

S.K. Basumatary

- Member, Editorial Board, Bio-Science Letters (an e-journal of Bodoland Univ., Assam)

Ratan Kar

- Member, Terrestrial Working Group, International Arctic Science Committee.

Binita Phartiyal

- Assistant Editor, *The Palaeobotanist*.
- Member, Subject Expert Committee for Women Scientific Scheme-A of DST, New Delhi (2016-2019).
- Councillor, The Palaeobotanical Society, Lucknow.
- Logistic Coordinator & Member, Spaceward Bound India NASA-2016 Programme for Field Workshop in Ladakh.

A.K. Pokharia

- Executive Member, Indian Society for Prehistoric and Quaternary Studies, Pune.
- Councillor, The Palaeobotanical Society, Lucknow.

S.K. Shah

- Examiner, Viva-voce examination of Ph.D. (candidate Mr. N.P. Gaire), Central Dept. of Environmental Science, Tribhuvan University, Kathmandu, Nepal.
- Examiner, Viva-voce examination of Ph.D. (candidate Mr. D.K. Kharal, Institute of Foretry, Tribhuvan University, Pokhara, Nepal.

Biswajeet Thakur

- Co-editor, Earth Science India Website (an Open Access Journal).

V.V. Kapur

- Editor, Journal *Geophytology*.

Shilpa Pandey

- Councillor, The Palaeobotanical Society, Lucknow.

Anju Saxena

- Co-Editor, Editorial Board of an open access journal *Earth Science India.*
- Member, Research Development and Coordination Cell, BSIP.

Vartika Singh

- Scientific Reviewer, International Climate Literacy and Energy Awareness Network (CLEAN), funded by the National Science Foundation & National Oceanic & Atmospheric Administration, USA.

Jyoti Srivastava

- Editor, Journal *Geophytology*.

Swati Tripathi

Member, Editorial Board, Journal of Plant Science and Research.

Ph.D. Programmes

Name of Ph.D. Scholar	Subject	Date of Award/ Registration	University	Supervisor(s)	Title of Ph.D. Thesis
Sandeep Kumar	Geology	May 2016 Awarded	Kurukshetra University, Kurukshetra	Dr. Alpana Singh (BSIP) Prof. NN Dogra	Palynostratigraphy and petrology of Panandhro lignites, Kutch Basin, Gujarat, India
Arun Joshi	Botany	May 2016 Awarded	Garhwal University, Srinagar	Dr. Rajni Tewari (BSIP) Dr. RK Jain	The *Glossopteris* flora of Manuguru area, Godavari graben: Palaeoecological implications, evolutionary perspectives and basinal correlation
Reshmi Chatterjee	Botany	July 2016 Awarded	Andhra University, Visakhapatnam	Dr. AK Ghosh (BSIP) Prof. GM Narasimha Rao	Floral diversity, biostratigraphy and palaeoecology of the Triassic sequences from the South Rewa and Satpura Gondwana basins
Sudhir Shukla	Geology	August 2016 Awarded	Indian Institute of Technology, Roorkee	Prof. Sunil Bajpai (BSIP)	Paleogene larger foraminiferal biostratigraphy of parts of Western Indian Shelf
Harinam Joshi	Botany	March 2016 Submitted	Kumaun University, Nainital	Dr. Neerja Jha (BSIP) Dr. Yogesh Joshi	Palynology of subsurface Gondwana sediments in Chintalapudi sub-basin, south India, its stratigraphical and palaeoenvironmental implication
Shreya Mishra	Botany	March 2016 Submitted	Kumaun University, Nainital	Dr. Neerja Jha (BSIP) Prof. SS Gahlain	Permian and Triassic palynology, correlation of Gondwana sediments in Ayyanapalli-Sattupalli-Chintalapudi coal belt and its palaeoenvironmental implications
Priyanka Monga	Botany	March 2016 Submitted	Kumaun University, Nainital	Dr. Madhav Kumar (BSIP) Dr. Yogesh Joshi	Palynostratigraphy, palynofacies and depositional environment of Early Tertiary sediments of Cambay Basin, Gujarat
Ranjana	Botany	March 2016 Submitted	Kumaun University, Nainital	Dr. Anjum Farooqui (BSIP) Dr. Yogesh Joshi	Climate induced relative sea level changes and coastal vegetation in Krishna delta, south east coast of India
Premraj Uddandam	Botany	April 2016 Submitted	Kumaun University, Nainital	Dr. Vandana Prasad (BSIP) Prof. Hema Joshi	High resolution palaeoclimatic studies from the western Bay of Bengal
Nivedita Mehrotra	Geology	February 2017 Submitted	University of Lucknow, Lucknow	Dr. Amalava Bhattacharyya Prof. Munendra Singh	Analysis of Quaternary climate change in north-east India based on multi-proxy data
Arindam Chakraborty	Botany	March 2017 Submitted	University of Burdwan, Burdwan	Dr. AK Ghosh (BSIP) Prof. PK Pal	Diversity and palaeoecology of the benthic and planktonic assemblages from the Neogene sequence of Andaman & Nicobar Islands
Meenakshi Hira	Environ-mental Sciences	July 2012 Continuing	Central Univ. of Himachal Pradesh, Dharamshala & JNU, New Delhi	Dr. Anupam Sharma (BSIP) Dr. Anurag Linda & Dr. Sudesh Yadav	Metal characterization of computers and mobile phone e-waste and its impact on different soil types
Vikram Partap Singh	Geology	September 2012 Continuing	Banaras Hindu University, Varanasi	Dr. BD Singh (BSIP) Prof. MP Singh	Petrology and geochemical characterization of lignite deposits of Saurashtra Basin (Gujarat), India: Implications to economic potential and depositional setting

Bandana Dimri	Geology	March 2013 Continuing	Banaras Hindu University, Varanasi	Dr. Mukund Sharma (BSIP) Prof. RK Srivastava	Genesis of Mesoproterozoic chert: A case study from the Salkhan Limestone of the Semri Group, Vindhyan Supergroup and its implication on life in extreme conditions
Debarati Nag	Geology	March 2013 Continuing	Banaras Hindu University, Varanasi	Dr. Binita Phartiyal (BSIP) Prof. Mallickarjun Joshi	Geomorphology, palaeoclimate and neotectonics during Quaternary Period of the Indus Valley between Leh and Batalik, Ladakh Himalaya
Randheer Singh	Geology	March 2013 Continuing	Banaras Hindu University, Varanasi	Dr. Binita Phartiyal (BSIP) Dr. Bindhyachal Pandey	Geomorphology, tectonics and climate during Quaternary Period of the Tangtse Valley Ladakh, NW Himalaya
Ruchika Bajpai	Geology	March 2013 Continuing	Banaras Hindu University, Varanasi	Dr. Ratan Kar (BSIP) Prof. AD Singh	Investigation of the Holocene climate variability from the glacial sites in Lahaul Valley, Western Himalaya, India
Surabhi Garg	Geology	September 2013 Continuing	Banaras Hindu University, Varanasi	Dr. Jyotsana Rai (BSIP) Prof. AK Jaitely	Integrated nannofossil-ammonite biostratigraphy of Wagad, Kachchh: Palaeoenvironmental and palaeobiogeographic implications
Kriti Misra	Geology	September 2013 Continuing	University of Lucknow, Lucknow	Dr. Ratan Kar (BSIP) Prof. Munendra Singh	Holocene climatic variability around Chora-Bari Glacier (Kedarnath), Western Himalaya, India
Veeru Kant Singh	Geology	September 2013 Continuing	Banaras Hindu University, Varanasi	Dr. Mukund Sharma (BSIP) Prof. RK Srivastava	Biostratigraphy of the Mesoproterozoic Chhattisgarh Basin exposed in the Bargarh District, Odisha, India
Tarasha Chitkara	Geology	July 2014 Continuing	Kurukshetra University, Kurukshetra	Dr. Anupam Sharma (BSIP) Dr. Om Prakash Thakur	Quaternary palaeoclimatic studies using multi-proxy approach around Kurukshetra, Haryana, India,
Syed Azharuddin	Geology	September 2014 Continuing	Banaras Hindu University, Varanasi	Dr. Pawan Govil (BSIP) Prof. AD Singh	Oceanographic and climatic reconstructions based on foraminifera and their isotopic signatures from the eastern Arabian Sea
Ipsita Roy	Botany	October 2014 Continuing	University of Lucknow, Lucknow	Dr. PS Ranhotra (BSIP) Prof. YK Sharma	Climate and glacial history during Late Quaternary from the Dokriani Bamak Glacier, Western Himalaya
Utsa Singh	Geology	October 2014 Continuing	University of Lucknow, Lucknow	Dr. PS Ranhotra (BSIP) Prof. R Bali	Palaeoclimatic reconstruction of Chopta Tungnath region, using multiproxy data
Uttam Pandey	Geology	November 2014 Continuing	University of Lucknow, Lucknow	Dr. SK Shah (BSIP) Prof. Munendra Singh	Dendroclimatology of Liddar Valley and adjoining areas in Kashmir Himalaya
Tanka Dhar Behra	Geology	February 2015 Continuing	Indian School of Mines, Dhanbad	Dr. Jyotsana Rai (BSIP) Dr. AK Bhaumik	Climatic variation and biostratigraphy of sediments deposited in Krishna-Godavari Basin, Bay of Bengal, India
Ashish Kumar Pal	Geology	September 2015 Continuing	Banaras Hindu University, Varanasi	Dr. PS Ranhotra (BSIP) Prof. B Pandey	Dating of geohazard on the basis of Dendrochronology at Gangotri Glacier Valley, Uttarkashi, Uttarakhand

Anand Prakash	Geology	January 2016 Continuing	Banaras Hindu University, Varanasi	Dr. Anju Saxena (BSIP) Prof. PK Singh	Palaeobiodiversity of coal forming flora of western part of Son-Mahanadi Basin: Depositional, petrological and palaeoecological implications
Priyanka Joshi	Geology	March 2016 Continuing	Banaras Hindu University, Varanasi	Dr. Binita Phartiyal (BSIP) Prof. Mallikarjun Joshi	Geomorphological evolution and climatic variations in the Changla Basin, Ladakh Range, Trans Himalaya, India in the Late Quaternary
Vikram Singh	Geology	March 2016 Continuing	Banaras Hindu University, Varanasi	Dr. KG Misra (BSIP) Prof. AD Singh	Tree-ring based climate variability in Jammu and Kashmir since Little Ice Age
Ashish Kumar Mishra	Geology	May 2016 Continuing	Banaras Hindu University, Varanasi	Dr. Vandana Prasad (BSIP) Prof. AD Singh	Late Cretaceous-Early Palaeogene climatic events: A case study from Krishna-Godavari Basin
Jyotsana Dubey	Geology	September, 2016 Continuing	Banaras Hindu University, Varanasi	Dr. S Nawaz Ali (BSIP) Prof. Vaibhav Srivastava	Chronology of glaciation, palaeoclimatic reconstruction and their climatic implications in the Thangu Valley, Sikkim Himalaya, India
Salman Khan	Geology	September 2016 Continuing	Banaras Hindu University, Varanasi	Dr. Anjum Farooqui (BSIP) Prof. UK Shukla	Pliocene-Pleistocene changes in vegetation, climate and sedimentation in middle and high latitudes
Raj Kumar	Geology	September 2016 Continuing	Banaras Hindu University, Varanasi	Dr. Neelam (BSIP) Prof. B Pandey	Mesozoic sediments of Jaisalmer Basin, Rajasthan: Palaeoclimatic, palynostratigraphic and palaeobiogeographic implications based on fossil records
Amulya Saxena	Geology	September 2016 Continuing	University of Lucknow, Lucknow	Dr. Abhijit Mazumder (BSIP) Prof. DS Singh	Depositional history of pollen diversity through the late Holocene with the special reference of the degradation of endangered wetlands of Assam
Yogesh Kumar	Geology	January 2017 Continuing	Sambalpur University, Sambalpur, Orissa	Dr. Mukund Sharma (BSIP) Prof. Shreerup Goswami	Palaeobiology and chemostratigraphy of the Kurnool Group, India
Husain Shabbar	Geology	January 2017 Continuing	Sambalpur University, Sambalpur, Odisha	Dr. Anju Saxena (BSIP) Prof. Shreerup Goswami	Biodiversity of Ordovician-Silurian Periods of Spiti area, Himachal Pradesh, India: Palaeoclimatic and palaeoecological implications

Units

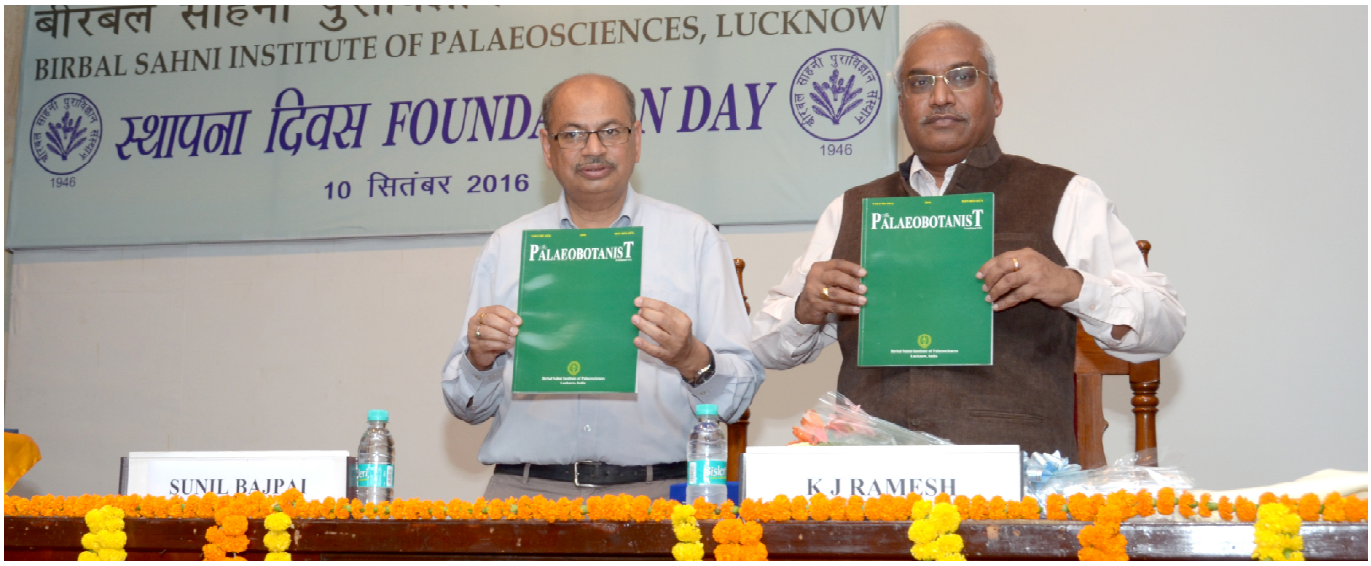
Publication

Journal— *The Palaeobotanist*

This year two issues of BSIP's flagship journal *The Palaeobotanist* were published. The first 65(1) was Special Issue on Gondwana and incorporated 15 research papers. The second 65(2) contained 8 research papers.

Annual Report

Bilingual Annual Report of the Institute was published in English and Hindi containing pertinent information related to research work carried out under different projects during the period April 01, 2015 to March 31, 2016. Besides, research papers published, conference participation, training/deputation, awards/honours, Foundation/Founders' Day celebrations, reports of different units, annual accounts and related aspects with relevant photographs and graphics were included.

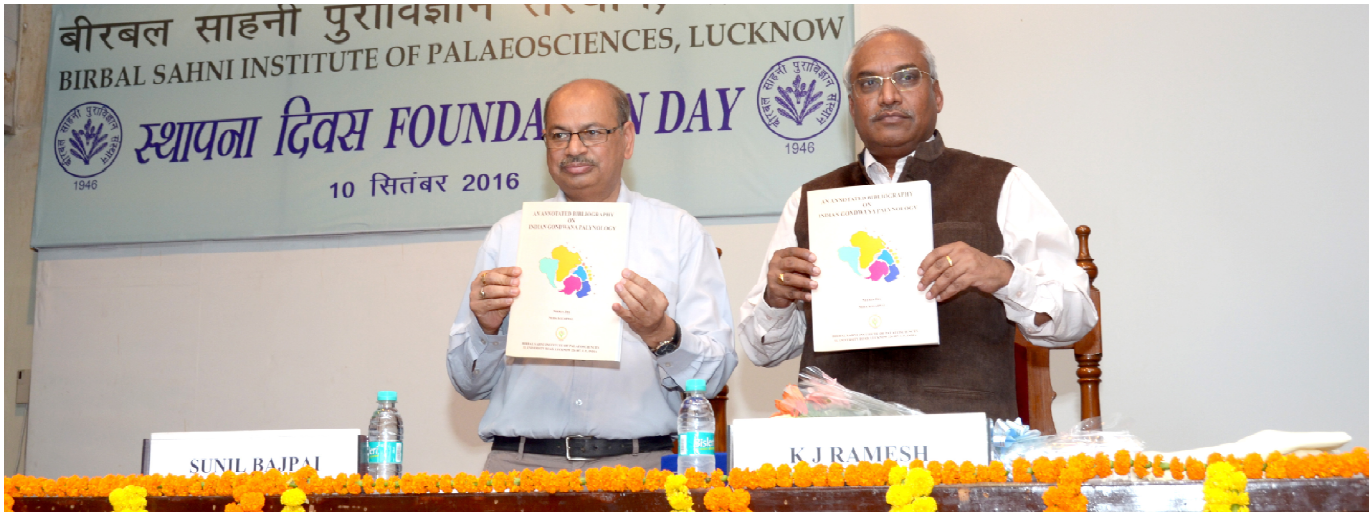


Catalogue

A Catalogue entitled 'An Annotated Bibliography on Indian Gondwana Palynology' by Neerja Jha and Neha Aggarwal was published.

Miscellaneous

Invitation cards for Foundation Day, Founders' Day, and other programmes organised from time to time were printed, besides biographical profiles and abstracts of lectures delivered by eminent speakers.



Knowledge Resource Centre

KRC (Knowledge Resource Centre) is committed to providing best information services and support to its users in this era of information sharing, and to fulfillment of its mission to disseminate the knowledge generated. Besides holding an excellent collection of literature on Palaeobotany and allied subjects, KRC also provides immediate access to articles by subscribing online databases, e-journals and through National Knowledge Resource Consortium (NKRC) of CSIR-DST. Weekly services of 'New Arrivals' having content pages of journals/ books acquired by KRC and 'News Clippings' having scientific contents from Newspapers and magazines purchased are being regularly communicated to users. Libsys software supports all in-house operations like cataloguing, circulation, serial control and binding management. The holdings are accessible by OPAC (Online Public Access Catalogue). OPAC is searchable by author, title, accession number, subject and several other fields. The procured new literature is continuously added to the database.

The current holdings of library are as under:

Particulars	Additions during 2016-17	Total
Books (in English)	9	6,311
Journals (bound volumes)	160	17,336
Reprints	-	40,100
Reference Books	-	351
Books in Hindi	83	695
Ph.D. Thesis	-	103
Reports	-	46
Maps & Atlases	-	61
Microfilm/ Fisches	-	294
Compact Disk	-	74

(Working hours 09:30–18.00 Monday-Friday)

Currently, the library is receiving 169 journals (115 through subscription & 54 through exchange). There are 167 registered card holders using the library facilities.

e-Journals

Web based access of the journals is available over the Institutes' LAN from the following publishers– Elsevier (Science Direct: http://www.sciencedirect.com/), John Wiley (http://onlinelibrary.wiley.com/), Nature Publishing Group: (Nature: http://www.nature.com/nature/index.htmal), Oxford University Press (http://www.oxfordjournals.org/), Springer (http://link.springer.com/), and Taylor and Francis (http://www.tandf.co.uk/journals/).

Databases

Scopus (http://www.scopus.com/), Web of Science (http://apps.webofknowledge.com/), and JGate@NKRC (www.jgateplus.com) database.

KRC Facilities

KRC resource sharing activities— The library shares its resources with all important academic/ research institutions in India. As a member of National Knowledge Resource Consortium (NKRC), the library keeps close contacts with libraries under DST and CSIR.

Library is for leisure— Library has a separate section for Hindi and English fictions, classic literature, novels, books on general interest and six daily news papers, etc.

Institutional repository— Library has an institutional digital repository available over the web (http://14.139.63.228:8080/pbrep/) and the Institute in-house journal *The Palaeobotanist*, Annual Reports, and Institute Special Publications are accessible over it.

Reprographic activity— KRC has a lamination machine to preserve the old and fragile scientific literature.

Exchange Facility

1. Institutions on exchange panel with our in house journal *The Palaeobotanist* 37
2. Journals received from different institutes on exchange basis 51

Training

KRC provides 12 months' training to two Apprentice Trainees for library working.

The following Institutions/ Organizations availed the Library facilities:

Departments of Botany and Geology, University of Lucknow, Lucknow

Jawaharlal Nehru University, New Delhi

Department of Ocean Studies & Marine Biology, Pondicherry University (Port Blair Campus), Port Blair, Andamans

History Department, Harvard University, Cambridge (USA)

Museum

Museum plays a vital role in popularizing and disseminating the knowledge of palaeosciences amongst students, scholars and teachers/scientists within the country and abroad. During 2016-2017, two exhibitions were set up in New Delhi (December, 2016) and Tirupati (January 2017). National Science Day (28th February) was also celebrated in a befitting manner. It was observed as an Open House, and around 200 students from various colleges visited the Institute's museum and laboratories.

Research materials (megafossils, palynological samples) were collected from 150 localities in different parts of the country by scientists working on the various Institute's projects as well as on various sponsored projects. Type materials of 26 research papers were also submitted to the repository during the period. Four sets of plant fossils were gifted to various colleges/universities within the country, and fossil specimens were also given to the distinguished guests as gifts during lectures/ conference held in the Institute from time to time.

Museum Holdings

Particulars	Addition during 2016-2017	Total
Type and Figured specimens	129	8,724
Type and figured slides	324	15,330
CDs	22	142

Specimens/samples collected during the field work under various projects:

Project	Megafossil Specimens	Palynological Samples
Project– 1	-	650
Project– 2	150	-
Project– 3	-	47
Project– 4	394	198
Project– 5	-	172
Project– 6	-	40
Project– 8	-	884
Project– 9	-	147
Project– 11	-	164
Project– 12	-	24

Samples deposited under Sponsored/ Collaborative Projects:

DST Project No.: YSS/2015/001195	:	287
DST Project No.: SR/FTP/ES-23	:	345
DST Project No.: SR/FTP/ES-127/2014	:	670
DST Project No.: SR/WOS-A/ EA-1018/2015	:	212
DST Project No.: SR/FTP/ES-84/2014	:	766
DST Project No.: SR/DGH-50/2013	:	197
DST Project No.: SB/DGH-89/2014	:	190
DST Project No.: SB/DGH-76/2013	:	223
DST Project No.: SERB/F/1960/2016-17	:	68
DST Project No.: SB/EMQ- 244/2014	:	51
DST Project No.: SB/EMEQ-161/2014	:	153
DST Project No.: EMR/ 2015/000881	:	63
NMHS (MoEF &-CC/CHEA) 1886/X11-86/2016	:	280
MoES Project No.: PO (GeoSci)/36/2014	:	124
Samples from Oil India Limited	:	129
BSIP-GSI Collaborative Project	:	15 (+18 specimens)

Specimens / Slides gifted to:

Prof. V.C. Tewari, Geology Department, Sikkim Central University, Gangtok (Sikkim)

Dr. Panzy Singh, Head, Department of Botany, I.T. College, Lucknow (UP)

Dr. Ashok K. Das, Head, Department of Botany, Bethune College, Bidhan Sarni, Kolkata (WB)

Dr. R.K. Dwivedi, Govt. P.G. College, Lansdowne, Jaiharikhal, Pani (Uttarakhand)

Institutional Visitors:

Sagar Public School, Rohit Nagar, Bhopal (MP)

Govt. Post Graduate College, Rajaji Puram, Lucknow (UP)

Forest Training Institute, Kanpur (UP)

MP Council of Science & Technology, Nehru Nagar, Bhopal (MP)

Maharana Pratap Govt. Post Graduate College, Hardoi (UP)

University of Burdwan, Rajbati, Burdwan (WB)

Syamsunder College, Under Burdwan University (WB)

NRLC, Aliganj, Lucknow (UP)

M.L.K. (Post Graduate) Collge, Balrampur (UP)

Govt. V.Y.T. OG. Autonomous College, Drug (CG)

Remote Sensing Applications Center, Lucknow (UP)

Ghunghunwala P.G. College, Dwarika Puri, Hans, Faizabad (UP)

Electronic Data Processing

National Knowledge Network (NKN) connectivity in the Institute is successfully running and provides 24-hour internet facility to the Institute staff. E-mail accounts of the BSIP staff, Units/Sections have been opened through Google Mail Server on Institute Domain (*bsip.res.in*). An Anti Virus Program Quick Heal Endpoint Security 6.0 Business edition with 150 user license has been installed in the server to protect the system from viruses and worms.

The Computer Section is maintaining and updating the Institute's website regularly. Intranet website has also been launched for Institute users and various utility forms are uploaded in PDF and word format. Notices are regularly updated in Intranet Website. Wireless Internet Connectivity is running within the campus. The Institute Facebook page and Twitter account has been created and regularly updated the information with photographs. This year Institute has procured 10 TFT monitors and 10 Laptops. In addition, Payroll, Form16 and pension packages are also modified as per the requirements of the Account Section. The Computer Section is providing help to scientists in preparing the multimedia presentations, charts, graphs, lithologs and diagrams for their scientific publications and documentation.

Scanning Electron Microscopy

The Scanning Electron Microscopy (SEM) unit of the Institute is dedicated to providing help in research on morphological and structural characterization of the samples in the range of micro/nano scale and non-destructive elemental analysis using EDS. The unit is equipped with Field Emission Scanning Electron Microscope (FESEM - JEOL 7610F), JEOL Auto fine Sputter Coater, JEOL Carbon Coater and Bal-Tec Critical Point Dryer (CPD). EDAX make peltier cooled EDS spectroscopy detector is attached with FESEM for elemental analysis of the samples.

Institute's scientists working in the various disciplines used the SEM facility for analyzing their samples. The investigated samples included both living and fossil materials, carbonate organic, etc. In spite of Institute's own scientific workload, this facility was also provided in a consultancy mode to around 27 researchers from other universities, academic institutions and colleges of India. Consultancy not only provided some amount of income for the Institute but also helped bring publicity to the Institute.



Distinguished Visitors

Dr. Harsh Vardhan, Honorable Minister, Science and Technology, Govt. of India

Dr. R. Srinivasan, Chief Editor, journal Current Science, Bengaluru

Dr. K.J. Ramesh, Director General, Indian Meteorology Department, New Delhi

Prof. Nigel C. Hughes, University of California, Riverside, USA

Dr. (Ms) Nayanjot Lahiri, Professor of History, Ashoka University, Haryana

Prof. A.K. Singhvi, Physical Research Laboratory, Ahmedabad

Sri M. Raju, Director General, Geological Survey of India, Kolkata

Prof. Jere H. Lipps, University of California, Berkeley, USA

Prof. Daryl P. Domning, Howard University, Washington DC, USA

Prof. Deepthi Yakandawala, University of Peradeniya, Peradeniya, Sri Lanka

Prof. John Dearing, University of Southampton, UK

Prof. R.J. Wasson, Institute of Water Policy, National University of Singapore, Singapore

Prof. Somnath Dasgupta, Jamia Millia Islamia University, New Delhi

Prof. R. Ramesh, Physical Research Laboratory, Ahmedabad

Prof. Leszek Marks, University of Warsaw, Poland

Prof. G. Archana, MS University of Baroda, Vadodara

Dr. Jyotiranjan S. Ray, Physical Research Laboratory, Ahemadabad

Dr. Matthias Alberti, University of Kiel, Germany

Dr. Fabian Welc, University of Warsaw, Poland

Prof. Yogesh Praveen, Historian, Lucknow

Prof. Neeraj Chaubey, Kamla Nehru Institute of Technology, Sultanpur



Activities in Official Language

The Institute continues to endeavour to attain the set target for Official Language implementation. During 2016-17, the Institute participated in both half yearly meetings of Nagar Rajbhasha Kaaryaanvayan Samiti (Office -3) held at the Indian Institute of Sugarcane Research, Lucknow. The scientists and technical officers/ employees of the Institute also took active part in science communication in Hindi through the various media. The events included popular science lectures in various institutions/forums, radio talks, interactions during exhibitions and popular science articles.

Hindi Fortnight

Hindi Fortnight was celebrated during September 10-26, 2016. During the Hindi Fortnight, 34 staff members participated in a series of competitions including *Hindi Typing* (Computer), *Noting*, *Debate* and *Antyaaksharee*. The Director, BSIP encouraged the participants to take part in the competitions. A *Kavi Sammelan* was also organized on 21st September. The valedictory function was held on 26th September in which Prof. Yogesh Praveen was the Chief Guest. Hindi books of reputed authors were given away as prizes.

The results of various competitions are given below:

Typing	:	I – Mr. Rahul Gupta, II – Mr. Saheb Lal Yadav, III – Mr. Raj Kumar
		Encouragement: Mr. Ram Ujagar & Ms. Saumyata
Noting	:	I – Dr. Anupam Sharma, II – Mr. Aashish Pal, III – Mr. Yogesh Kumar
Encouragement	:	Dr. Sandhya Misra, Mr. Saheb Lal Yadav & Mr. Raj Kumar
Debate	:	I – Mr. Randheer Singh, II – Ms. Priyanka Seth, III – Mr. Aashish Mishra
		Encouragement: Dr. Sandhya Misra & Mr. Yogesh Kumar





Antyaaksharee : I – Dr. Anju Saxena, Dr. Sandhya Misra, Mr. Uttam Pandey

II – Dr. Neelam, Ms. Kanika, Mr. Aashish Kumar Mishra

III – Dr. Shilpa Pandey, Mr. Hussain Sabbar, Ms. Neelan Mishra

Encouragement : Mr. R.K. Awasthi, Mr. Randheer Singh, Mr. Vikram S. Negi, Mr. Yogesh Kumar, Dr. Poonam Verma, Ms. Utsaa, Ms. Priyanka Joshi, Ms. Jayanti, Mr. Aashish Pal

Hindi Workshop

The quarterly Workshops were organized on the subjects listed below. The Workshops were followed by lively discussions. The topics of the talks were:



Aaie Brahmaand kee gahraai men kho jaaen [by Prof. Neeraj Chaubey, Kamla Nehru Institute of Technology, Sultanpur] on June 27, 2016.



Avadh kee Sanskriti [by Prof. Yogesh Praveen, Lucknow] on September 26, 2016.



Pradooshan tere kitane (ku) Roop [by Mr. Vipul Sen *urph* Vipul Lakhnavee] on November 25, 2016.



Bhaarteeya Vigyan kee Kahaanee [by Mr. Randheer Singh, Research Scholar] on March 15, 2017.

Bhasha Utsav

On March 26, 2017, a programme "Bhasha Utsav" was organized jointly with Bhartiya Bhasha Pratishthapan Rashtriya Parishad, Uttar Pradesh Branch, Lucknow. A number of persons from various cities of the country presented papers in the symposium. Several Hindi experts presented their views. Among those who spoke were Prof. K. Vanaja, Cochin University of Science and Technology, Kochi; Shri Mahesh Chandra Dwivedi, IPS; Prof. Usha Sinha; Dr. M.L. Agarwal; Director BSIP Prof. Sunil Bajpai and others. The Souvenir-cum-abstract book was also released on this occasion.



Miscellaneous

Meetings of the Official Language Implementation Committee of the Institute were organised in each quarter. The computers in the Institute with net facility have access to multi-lingual software. The process of making forms bilingual is near completion and efforts are also on to have a Hindi version of the Institute's website. The Annual Report 2015-16 of the Institute was also published in Hindi. Abstracts of all research papers published in the Institute's journal *'The Palaeobotanist'* were also published in Hindi. In adherence to the section 3(3) of the Official Language Act 1963, efforts are being continued to increase the Hindi correspondence.

Governing Body

(w.e.f. 11.03.2014)

Chairman
Prof. Deepak Pental
Former VC, University of Delhi
Director (R&A)
Centre for Genetic Manipulation of Crop Plants
University of Delhi, South Campus, Benito Juarez Road
Dhaula Kuan, New Delhi-110 021

Members

Secretary
(or his nominee)
Department of Science and Technology
Technology Bhavan, New Mehrauli Road
New Delhi-110 016

Finance Adviser
(or his/her nominee)
Department of Science and Technology
Technology Bhavan, New Mehrauli Road
New Delhi-110 016

Prof. Talat Ahmad
Vice Chancellor
Jamia Millia Islamia Central University
Jamia Nagar, New Delhi-110 025

Prof. G.V.R. Prasad
Head, Department of Geology
University of Delhi
Delhi-110 007

Dr. V. Purnachandra Rao
Ex-Scientist, NIO, Goa & Emeritus Scientist
Department of Civil Engineering
Vignan's University, Vadlamudi-522 213

Prof. L.S. Chamyal
Department of Geology
M.S. University of Baroda
Fatehganj, Vadodara-390 002

Dr. K.J. Ramesh
Director General
Indian Meteorological Department, MoES
Prithvi Bhavan, IMD Campus, Lodhi Road
New Delhi-110 003

Director General
(Ex-Officio Member)
Geological Survey of India
27, Jawaharlal Nehru Road
Kolkata-700 016

Prof. Sunil Bajpai
Director
Birbal Sahni Institute of Palaeobotany
Lucknow-226 007

Director
(Ex-Officio Member)
Botanical Survey of India
CGO Complex, 3rd MSO Building, Block F,
DF Block, Sector I, Salt Lake City, Kolkata-700 064

Member Secretary
Registrar
Birbal Sahni Institute of Palaeosciences, Lucknow-226 007

Research Advisory Council

(w.e.f. 23.06.2014)

Chairman

Prof. S.K. Tandon
Adjunct Professor
Department of Earth and Environmental Sciences
Indian Institute of Science Education and Research
Bhopal Bypass Road, Bhauri, Bhopal-462 066

Member-Convener (Ex-officio)
Director
Birbal Sahni Institute of Palaeosciences, Lucknow

Members

Prof. R. Geeta
Department of Botany
University of Delhi
Delhi-110 007

Prof. N.N. Dogra
Department of Earth Sciences
Kurukshetra University
Kurukshetra-136 119

Prof. G.V.R. Prasad
Department of Geology
University of Delhi
Delhi-110 007

Dr. V. Ravikant
Department of Geology & Geophysics
Indian Institute of Technology
Kharagpur-721 302

Dr. V.P. Misra
Ex-Dy. Director General, GSI
4/490, Vivek Khand
Gomti Nagar, Lucknow-226 010

Dr. Suryendu Dutta
Department of Earth Sciences
Indian Institute of Technology Bombay
Powai, Mumbai-400 076

Prof. S.D. Biju
Department of Environmental Studies
University of Delhi
Delhi-110 007

Shri S.K. Srivastava
Former CMD, Oil India Limited
Flat 001, Tower 2, Gardenia Glory
Sector 46, Noida-201 301

Shri S.N. Choudhuri
Ex-Director (Geology)
Geological Survey of India
Natural Energy Resources, Mission IIB
Bhu-Bijnan Bhavan, DK-6 Salt Lake
Sector II, Kolkata-700 091

Sr. Deputy Director General
(Ex-officio Member)
HOD Northern Region
Geological Survey of India
Vasundhara, Sector-E, Aliganj
Lucknow-226 020

Finance and Building Committee

(w.e.f. 23.06.2014)

Chairman (Ex-officio)

Prof. Deepak Pental
Chairman, Governing Body
Birbal Sahni Institute of Palaeosciences, Lucknow

Members

Finance Adviser, DST, New Delhi

Shri B.K. Mishra
Finance and Accounts Officer
Indian Institute of Toxicology Research
M.G. Marg, Lucknow-226 001

Shri V.B. Singh
Ex-Chief Engineer (Civil), UPPCL
4/125, Vishal Khand
Gomti Nagar, Lucknow-226 010

Director
Birbal Sahni Institute of Palaeosciences, Lucknow

Non-Member Secretary

Registrar
Birbal Sahni Institute of Palaeosciences, Lucknow



Independence Day (August 15, 2016)

Republic Day (January 26, 2017)

Staff

Director

Prof. Sunil Bajpai

Scientists

Scientist 'G'

Dr. (Mrs) Neerja Jha (retired w.e.f. 30.11.2016 AN)
Dr. R.S. Singh

Scientist 'F'

Dr. Rupendra Babu
Dr. Madhav Kumar
Dr. B.D. Mandaokar (retired w.e.f. 31.01.2017 AN)
Dr. R.C. Mehrotra
Dr. C.M. Nautiyal (retired w.e.f. 31.07.2016 AN)
Dr. (Mrs) Neeru Prakash
Dr. Mahesh Prasad
Dr. (Mrs) Jyotsana Rai
Dr. Annamraju Rajanikanth
Dr. O.S. Sarate
Dr. Mukund Sharma
Dr. B.D. Singh
Dr. K.J. Singh
Dr. (Mrs) Chanchala Srivastava (retired w.e.f. 30.09.2016 AN)
Dr. (Mrs) Rashmi Srivastava
Dr. (Mrs) Rajni Tewari

Scientist 'E'

Dr. Rajesh Agnihotri
Dr. (Mrs) Anjum Farooqui
Dr. A.K. Ghosh
Dr. K.L. Meena (retired w.e.f. 30.04.2016 AN)
Dr. (Mrs) Vandana Prasad
Dr. Anupam Sharma
Dr. G.K. Trivedi

Scientist 'D'

Dr. S.K. Basumatary (w.e.f. 01.01.2017)
Dr. Pawan Govil (w.e.f. 01.01.2017)
Dr. Ratan Kar
Dr. Srikanta Murthy (w.e.f. 01.01.2017)
Dr. (Mrs) Binita Phartiyal
Dr. A.K. Pokharia
Dr. S.K. Shah (w.e.f. 01.01.2017)
Dr. Hukam Singh (w.e.f. 01.01.2017)
Mr. V.K. Singh (w.e.f. 01.01.2017)
Dr. Biswajeet Thakur (w.e.f. 01.01.2017)

Scientist 'C'

Dr. (Mrs) Neha Aggarwal (w.e.f. 01.01.2017)
Dr. (Mrs) Deepa Agnihotri
Dr. Shailesh Agrawal (w.e.f. 01.01.2017)
Dr. S. Nawaz Ali (w.e.f. 01.01.2017)
Dr. (Ms) Ruby Ghosh
Dr. V.V. Kapur (w.e.f. 01.01.2017)
Dr. (Mrs) Pauline S. Kavali
Dr. Kamlesh Kumar
Dr. Abhijit Mazumder
Dr. K.G. Misra
Dr. (Mrs) Neelam Das (w.e.f. 01.01.2017)
Dr. (Mrs) Shilpa Pandey
Dr. S.S.K. Pillai
Dr. M.F. Quamar (w.e.f. 01.01.2017)
Dr. P.S. Ranhotra
Dr. (Mrs) Anju Saxena
Dr. (Mrs) Anumeha Shukla
Dr. (Mrs) Abha Singh (w.e.f. 01.07.2016)
Dr. (Ms) Vartika Singh
Dr. Gaurav Srivastava
Dr. (Mrs) Jyoti Srivastava (w.e.f. 01.01.2017)
Dr. (Mrs) Swati Tripathi
Dr. (Mrs) Anjali Trivedi
Dr. (Mrs) Poonam Verma

Scientist 'B'

Dr. A.H. Ansari
Dr. Manoj M.C.
Dr. R.P. Mathews
Dr. P. Morthekai
Dr. S.K. Pandey
Dr. S.K. Shukla

Technical Personnel

Technical Officer 'D'

Mr. Madhukar Arvind (w.e.f. 27.04.2016)
Mrs. Reeta Banerjee
Mr. P.S. Katiyar
Mrs. Sunita Khanna
Mrs. Kavita Kumar
Mr. T.K. Mandal
Mr. R.C. Mishra
Mr. Pradeep Mohan
Mr. Chandra Pal

(The names are in alphabetical order according to 'surnames')

Mr. V.K. Singh
Mr. V.P. Singh
Mr. Y.P. Singh
Mr. A.K. Srivastava (retired w.e.f. 31.10.2016 AN)

Technical Officer 'C'
Dr. Subodh Kumar
Mr. R.L. Mehra
Mr. V.K. Nigam

Technical Officer 'B'
Mr. S.R. Ali
Mr. D.S. Bisht
Mr. D.K. Pal
Mr. Dhirendra Sharma
Dr. S.K. Singh

Technical Officer 'A'
Mr. Sumit Bisht (w.e.f. 27.04.2016)

Technical Assistant 'E'
Mr. Chandra Bali
Dr. Nilay Govind
Mr. Avanish Kumar
Mr. M.S. Rana
Ms. Kirti Singh (w.e.f. 26.04.2016)
Mr. S.C. Singh
Mr. Ajay K. Srivastava
Mr. C.L. Verma

Technical Assistant 'D'
Mr. Pawan Kumar

Technical Assistant 'B'
Mr. J. Baskaran
Mr. A.K. Sharma
Ms. Richa Tiwari (w.e.f. 25.04.2016, on lien w.e.f. 06.06.2016 AN)
Mr. Ram Ujagar (w.e.f. 25.04.2016)

Administrative Personnel

Accounts Officer: Mr. N.B. Tewari
Private Secretary: Mrs. M. Jagath Janani

Section Officer
Mrs. Ruchita Bose
Mr. Hari Lal
Mrs. Swapna Mazumdar
Mr. K.P. Singh
Mrs. Pennamma Thomas (retired w.e.f. 30.11.2016 AN)

Stenographer: Mr. Murukan Pillai
Hindi Translator: Mr. Ashok Kumar

Assistant
Mr. Mishri Lal
Mr. S.S. Panwar
Mr. Rameshwar Prasad
Mr. Gopal Singh
Mr. Avinash K. Srivastava
Mrs. Renu Srivastava
Mr. Koshy Thomas
Mr. N. Unnikannan

Upper Division Clerk
Ms. Chitra Chatterjee
Mrs. Sudha Kureel
Mr. R.K. Mishra (w.e.f. 07.12.2016)
Ms. Manisha Tharu

Lower Division Clerk
Mr. Rahul Gupta
Ms. Anupam Jain
Mr. Mahesh Nayar
Mr. Manoj Singh

Driver
Mr. Nafis Ahmed ('IV')
Mr. D.K. Misra ('IV')
Mr. M.M. Misra ('IV)
Mr. V.P. Singh ('IV')
Mr. P.K. Misra ('III')

Multi Tasking Staff

MTS: Mr. K.C. Chandola

MTS 'II'
Mr. K.K. Bajpai
Mr. Kesho Ram (retired w.e.f. 30.09.2016 AN)
Mr. D.B. Kunwar
Mr. M.L. Pal
Mr. Ram Dheeraj
Mr. Mohammad Shakil (retired w.e.f. 31.08.2016 AN)
Mr. Bam Singh
Mr. Ram Singh

(The names are in alphabetical order according to 'surnames')

MTS 'I'

Ms. Bhawana (Bajpai) Awasthi
Mr. R.K. Awasthi
Mrs. Beena
Mr. V.S. Gaikwad
Mr. Hari Kishan
Mr. Deepak Kumar
Mr. Inder Kumar
Mr. Raj Kumar
Mr. Ramesh Kumar
Mr. Shailesh Kumar
Mr. Suneet Kumar
Ms. Nandani
Mr. Kailash Nath
Mr. Mathura Prasad
Mr. Ram Chander
Mrs. Ram Kali
Mr. Ravi Shankar
Mr. A.P. Singh
Ms. Sandhya Singh
Mr. Ram Kewal Yadav

Ph.D. Programme Scholars

Mr. Anand Prakash, JRF (supported by CSIR-UGC NET)
Mrs. Richa Gupta, JRF (self supported)
Mr. Yogesh Kumar, JRF (self supported)
Mr. Husain Shabbar, JRF (self supported)

Sponsored Project Personnel

Dr. Suman Sarkar, YS
Dr. Mayank Shekhar, YS
Ms. Ruchika Bajpai, WS
Mrs. Nivedita Mehrotra, WS
Dr. Shamim Ahmed, PI/PDF
Dr. Sandhya Misra, PI
Dr. S. Jeyakumar, RA
Dr. A.K. Yadava, RA (relieved w.e.f. 11.11.2016 AN)
Ms. Kriti Mishra, CSIR-SRF
Mr. Arindam Chakraborty, DST Inspire Fellow
Mr. Syed Azharuddin, JRF
Ms. Jyotsana Dubey, JRF
Ms. Priyanka Joshi, JRF
Mr. Ashish K. Mishra, MOES-JRF
Mr. Ashish K. Pal, JRF
Mr. Uttam Pandey, JRF
Ms. Ipsita Roy, JRF (resigned w.e.f. 14.06.2016 AN)
Ms. Shalini Sharma, JRF
Ms. Shivani, JRF (resigned w.e.f. 02.05.2016 AN)
Mr. Vikram Singh, JRF
Mr. Premraj Uddandam, MOES-JRF
Ms. Neelam Mishra, Technical Assistant
Mr. Sandeep Kr. Kohri, Project Assistant (relieved w.e.f. 18.07.2016 FN)
Mr. Saheb Lal Yadav, Project Assistant
Ms. Shazi Farooqui, Project Assistant
Mr. Raja Ram Verma, Field Assistant (relieved w.e.f. 10.11.2016 AN)

Retired Staff


Dr. Neerja Jha


Dr. C.M. Nautiyal


Dr. Chanchala Srivastava


Dr. B.D. Mandaokar


Dr. K.L. Meena


Mr. A.K. Srivastava


Mrs. Pennamma Thomas


Mr. Kesho Ram


Mr. Mohammad Shakil

Appointments

Mrs. A. Vijaya Venkateswari, Lower Division Clerk w.e.f. 19.09.2016.

Mr. Sanjay Kumar, Registrar w.e.f. 29.12.2016.

Dr. Trina Bose, Scientist 'B' w.e.f. 29.03.2017.

Mr. Sandeep Kumar Kohri, Technical Assistant (temporary for one year) w.e.f. 18.07.2016.

Mr. Ishwar Chandra Shukla, Technical Assistant (temporary for one year) w.e.f. 18.07.2016.

Ms. Saumyata Tripathi, Technical Assistant (temporary for one year) w.e.f. 18.07.2016.

Mr. Jitendra Yadav, Technical Assistant (temporary for one year) w.e.f. 18.07.2016.

Under BSIP Ph.D. Programme

Mr. Mukesh Yadav, Junior Research Fellow (Category I-supported by CSIR-UGC NET) w.e.f. 27.03.2017.

Sponsored Project Personnel

Ms. Priyanka Seth, Junior Research Fellow (DST sponsored) w.e.f. 13.06.2016.

Ms. Ipsita Roy, DST Inspire Fellow w.e.f. 15.06.2016.

Ms. Utsa Singh, Junior Research Fellow (DST sponsored) w.e.f. 14.07.2016.

Ms. Mahi Bansal, Junior Research Fellow (MoES sponsored) w.e.f. 01.08.2016.

Mr. Salman Khan, Junior Research Fellow (MoES sponsored) w.e.f. 30.09.2016.

Mr. Raj Kumar, Junior Research Fellow (DST sponsored) w.e.f. 03.10.2016.

Mr. Pranav Raj Tyagi, Junior Research Fellow (MoES sponsored) w.e.f. 05.10.2016.

Ms. Amulya Saxena, Junior Research Fellow (DST sponsored) w.e.f. 21.10.2016.

Mr. Raja Ram Verma, Project Assistant (DST sponsored) w.e.f. 11.11.2016.

Dr. Akhilesh Kumar Yadava, Post-Doctoral Fellow (DST sponsored) w.e.f. 16.11.2016.

Dr. Matsyendra Kumar Shukla, National Post-Doctoral Fellow w.e.f. 21.11.2016.

Dr. (Ms.) Anju Verma, National Post-Doctoral Fellow w.e.f. 01.02.2017.

Reservations and Concessions

The Institute is following General Reservation Orders of the Government of India as applicable to Autonomous Bodies and amended from time to time for the reservations and concessions of Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Classes (OBC) and Physically Handicapped Persons for the posts meant for direct recruitment in Group 'A', 'B', 'C' and 'D' as per Govt. of India Orders.

Obituary



Mr. J.N. Nigam, Ex-Technical Officer 'A' passed away on 23.08.2016.



Mrs. P.K. Srivastava, Ex-Receptionist passed away on 21.09.2016.



Dr. B.N. Jana, Ex-Scientist 'E' passed away on 12.10.2016.



Dr. H.P. Singh, Ex-Deputy Director passed away on 17.10.2016.



Mr. B.K. Jain, Ex-Section Officer passed away on 01.01.2017.



Mr. Gurcharan Singh, Ex-Registrar passed away on 26.01.2017.

AUDITOR'S REPORT

To the Governing Body of 'The Birbal Sahni Institute of Palaeosciences', 53, University Road, Lucknow

Report on the Financial Statements

1. We have examined the Balance Sheet of **M/s Birbal Sahni Institute of Palaeosciences, 53, University Road, Lucknow** as at 31st March 2017 and also the Income & Expenditure Account and Receipt and Payment Account for the year ended on that date and a summary of significant accounting policies and other explanatory information, attached herewith.

Management's Responsibility for the Financial Statements

2. Management is responsible for the preparation of these financial statements that give a true and fair view of the financial position and financial performance of the society in accordance with the Accounting Standards issued by the Institute of Chartered Accountants of India. This responsibility also includes maintenance of adequate accounting records in accordance with the provisions of the Act for safeguarding of the assets of the Institute and for preventing and detecting frauds and other irregularities; selection and application of appropriate accounting policies; making judgments and estimates that are reasonable and prudent; and design, implementation and maintenance of adequate internal financial controls, that were operating effectively for ensuring the accuracy and completeness of the accounting records, relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

3. Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with Standards on auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with the ethical requirement and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement(s).

4. An audit includes performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Company's preparation and fair presentation of the financial statements in order to design audit procedure that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of entity's internal control. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

5. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

6. **Subject to our comments in Annexure-A to our audit report attached**, in our opinion and to the best of our information and according to explanations given to us, the said accounts, read with notes thereon, if any give a true and fair view in conformity with the accounting principles generally accepted in India:

   i. In the case of the Balance Sheet, of the state of the affairs of the society as at 31st March 2017, and

   ii. In the case of the Income & Expenditure account, of the surplus of the society for the year ended on that date.

iii. In the case of the Receipt & Payment account, of the receipts and payments of the society for the year ended on that date.

Report on Other Legal and Regulatory Requirements

7. As required by Section 12A(b) of Income Tax Act, 1961:

a) We have sought and obtained all the information and explanations, which, to the best of our knowledge and belief, were necessary for the purposes of the audit.

b) In our opinion, proper books of account have been kept by the society so far as appears from our examination of the books.

c) The balance sheet, the Income & Expenditure Account and the Receipt & Payment account are in agreement with the books of account maintained at the head office at Lucknow.

d) In our opinion, there are no observations or comments on the financial transactions, which may have an adverse effect on the functioning of the Society.

For: Singh Agarwal & Associates
Chartered Accountants



Mukesh Kumar Agarwal
FCA, DISA (ICAI)
Partner
Membership No - 073355

Place: Lucknow

Date: 04th September 2017

ANNEXURE - 'A'

(Annexed to and forming part of the Audit Report for the year ended 31st March, 2017)

COMMENTS / AUDIT OBSERVATIONS ON ACCOUNTS OF 'BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES' - LUCKNOW

LOANS & ADVANCES:

1. Advances (capital head) unsettled and pending for recovery / adjustment as on 31.03.2017 under different heads, since long, are to be properly taken care of at the Institute level for early adjustment thereof. Details of which are as under:

PARTICULARS	YEAR	AMOUNT
Advances for Furniture and fixture	2013-14	24000.00
Chempharam Industries, India	Since 2014-15	8220731.00
Alliance Book Suppliers, Delhi	2014-15	200883.89
International Book Distributing Co.	2014-15	12161.00
Useful Book Services, Lucknow	2014-15	78143.00
L C Charges	Several years	365085.30
Lab Line Traders	2014-15	321883.00
Oriental Insurance	Several years	2079.00
Perkin Elmer	2014-15	396435.00
Deputy controller of Accounts	2014-15	3001.00
Skytech Systems (India) Private Limited, Thane	2012-13	40087.00

2. A sum of Rs. 3225313/- is outstanding with "Track Cargo Private Limited, New Delhi" but equipment wise details of the same is required to be identified and the cost to be capitalized along with the cost of equipment. Similarly, a sum of Rs. 694111.93 is outstanding in LC Charges for which details to be identified and appropriate action to be taken.

3. Register of Advance is not updated and reconciled with financial accounts on regular basis. As on 31st March 2017, a sum of Rs. 2086904.59 is outstanding as "Advances for Expenses" which includes the following advances which are outstanding for more than one year and needs to be properly taken care of at the Institute level for early adjustment thereof. Details of which are as under:

NAME OF PERSON/ STAFF	PENDING SINCE	AMOUNT
Dr. Ram Avtar	2013-14	25000.00
Koshy Thomas	More than 2 Years	17800.00
Parminder Singh	More than 2 Years	22200.00
Perkin Elmer (Advance for maintenance of Equipment)	2013-14	33708.00
V. Nirmala	2013-14	8845.00
George Society of India	Before 2012-2013	12000.00

4. In Project accounts, advance given to staff / other parties is not being recorded separately. Instead, the same is directly debited to Project account and no separate controlling record is being maintained for recording advances. The advance given to party / staff should be recorded as advance and the same should be adjusted on settlement to tract the actual outstanding position of advance in project accounts.

5. A sum of Rs. 116499.70 was outstanding in "Pension contribution to be transferred" for last 2-3 years. During the year, a sum of Rs. 116499/- was transferred to "Pension Fund" and balance 0.70 is still outstanding. The same should also be transferred to Pension Fund.

LIBRARY AND PUBLICATION:

6. Physical verification of the stock of the library books has been conducted during the financial year 2016-17 or after that date. Only a certificate has been issued that "Physical Verification has been done as per books and found in order". Mere submission of a certificate will not serve the purpose. Complete verification report is required to be enclosed along with the certificate.

STORES AND WORKS & BUILDING:

7. Maintenance & updation of Fixed Assets register & Stores register needs to be strengthened. The value of fixed assets as per fixed assets register and stores register must match with the value in the fixed assets schedule. Proper reconciliation needs to be done and registers to be updated on regular basis.

8. Physical verification of Non-Consumable assets & Consumable items for the year ended 31.03.2017 was done in April 2017 to June 2017. While verification no summary of Fixed Assets was being prepared. Only a certificate has been issued that "Physical Verification has been done as per books and no discrepancies have been noticed". Mere submission of a certificate will not serve the purpose. Complete verification report is required to be enclosed along with the certificate

For: Singh Agarwal & Associates
Chartered Accountants



Mukesh Kumar Agarwal
FCA, DISA (ICAI)
Partner
Membership No - 073355

Place: Lucknow

Date: 04th September 2017

ANNEXURE - 'A'

(Annexed to and forming part of the Audit Report for the year ended 31.03.2017)
BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES, LUCKNOW

AUDIT OBSERVATIONS - FINANCIAL YEAR - 2016-2017

<table>
<tr>
<td>1.</td>
<td>Advances (capital head) unsettled and pending for recovery / adjustment as on 31.03.2017 under different heads, since long, are to be properly taken care of at the Institute level for early adjustment thereof. Details of which are as under:
<table>
<tr><th>Particulars</th><th>Year</th><th>Amount</th></tr>
<tr><td>Advances for Furniture and fixture</td><td>2013-14</td><td>24000.00</td></tr>
<tr><td>Chempharam Industries, India</td><td>Since 2014-15</td><td>8220731.00</td></tr>
<tr><td>Alliance Book Suppliers, Delhi</td><td>2014-15</td><td>200883.89</td></tr>
<tr><td>International Book Distributing Co.</td><td>2014-15</td><td>12161.00</td></tr>
<tr><td>Useful Book Services, Lucknow</td><td>2014-15</td><td>78143.00</td></tr>
<tr><td>L C Charges</td><td>Several years</td><td>365085.30</td></tr>
<tr><td>Lab Line Traders</td><td>2014-15</td><td>321883.00</td></tr>
<tr><td>Oriental Insurance</td><td>Several years</td><td>2079.00</td></tr>
<tr><td>Perkin Elmer</td><td>2014-15</td><td>396435.00</td></tr>
<tr><td>Deputy controller of Accounts</td><td>2014-15</td><td>3001.00</td></tr>
<tr><td>Skytech Systems (India) Private Limited, Thane</td><td>2012-13</td><td>40087.00</td></tr>
</table>
</td>
<td>Noted for compliance. Above mentioned advance has been settled against some of the firms and efforts are being made to get remaining adjusted. Fully adjusted account will be shown to audit shortly.</td>
</tr>
<tr>
<td>2.</td>
<td>A sum of Rs. 3225313/- is outstanding with "Track Cargo Private Limited, New Delhi" but equipment wise details of the same is required to be identified and the cost to be capitalized along with the cost of equipment. Similarly, a sum of Rs. 694111.93 is outstanding in LC Charges for which details to be identified and appropriate action to be taken.</td>
<td>Out of the above outstanding amount a sum of Rs. 1650259.00 has been settled. Settlement of remaining amount is in process. Fully adjusted account will be shown to audit shortly.</td>
</tr>
<tr>
<td>3.</td>
<td>Register of Advance is not updated and reconciled with financial accounts on regular basis. As on 31st March 2017, a sum of Rs. 2086904.59 is outstanding as "Advances for Expenses" which includes the following advances which are outstanding for more than one year and needs to be properly taken care of at the Institute level for early adjustment thereof. Details of which are as under:
<table>
<tr><th>Name of person/ staff</th><th>Pending since</th><th>Amount</th></tr>
<tr><td>Dr. Ram Avtar</td><td>2013-14</td><td>25000.00</td></tr>
<tr><td>Koshy Thomas</td><td>More than 2 Years</td><td>17800.00</td></tr>
<tr><td>Parminder Singh</td><td>More than 2 Years</td><td>22200.00</td></tr>
<tr><td>Perkin Elmer (Advance for maintenance of Equipment)</td><td>2013-14</td><td>33708.00</td></tr>
<tr><td>V. Nirmala</td><td>2013-14</td><td>8845.00</td></tr>
<tr><td>George Society of India</td><td>Before 2012-2013</td><td>12000.00</td></tr>
</table>
</td>
<td>Advance to the tune of Rs. 12,40,226.59 has been settled. Fully adjusted account will be shown
to audit shortly.</td>
</tr>
</table>

4.	In Project accounts, advance given to staff / other parties is not being recorded separately. Instead, the same is directly debited to Project account and no separate controlling record is being maintained for recording advances. The advance given to party / staff should be recorded as advance and the same should be adjusted on settlement to tract the actual outstanding position of advance in project accounts.	Adjustment of advance is being monitored by maintaining ledger in the system for each sponsored project. Separate advance register has also been maintained for sponsored projects.
5.	A sum of Rs. 116499.70 was outstanding in "Pension contribution to be transferred" for last 2-3 years. During the year, a sum of Rs. 116499/- was transferred to "Pension Fund" and balance 0.70 is still outstanding. The same should also be transferred to Pension Fund.	As pointed out the sum of Re. 0.70 is also transferred to pension fund.
6.	Physical verification of the stock of the library books has been conducted during the financial year 2016-17 or after that date. Only a certificate has been issued that "Physical Verification has been done as per books and found in order". Mere submission of a certificate will not serve the purpose. Complete verification report is required to be enclosed along with the certificate.	Noted for future compliance. Complete verification report will be attached with the certificate.
7.	Maintenance & updation of Fixed Assets register & Stores register needs to be strengthened. The value of fixed assets as per fixed assets register and stores register must match with the value in the fixed assets schedule. Proper reconciliation needs to be done and registers to be updated on regular basis.	Noted for future compliance. Duly reconciled registers will be put up to audit.
8.	Physical verification of Non-Consumable assets & Consumable items for the year ended 31.03.2017 was done in April 2017 to June 2017. While verification no summary of Fixed Assets was being prepared. Only a certificate has been issued that "Physical Verification has been done as per books and no discrepancies have been noticed". Mere submission of a certificate will not serve the purpose. Complete verification report is required to be enclosed along with the certificate	Noted for future compliance. Complete verification report will be attached with the certificate.

(N B Tewari)
Accounts Officer

(Sanjay Kumar)
Registrar

(Sunil Bajpai)
Director

Form of Financial Statements (Non-Profit Organizations)

Birbal Sahni Institute of Palaeosciences, Lucknow

Balance Sheet as at March 31, 2017

(Amount - Rs.)

Particulars	Schedule No.	Current Year 31.3.2017	Previous Year 31.3.2016
CORPUS/CAPITAL FUND AND LIABILITIES			
CORPUS/CAPITAL FUND	1	639,794,596.39	245,614,530.71
RESERVES ANS SURPLUS	2	33,210,903.00	33,210,903.00
EARMARKED/ENDOWMENT FUNDS	3	354,474,685.53	323,698,173.85
SECURED LOANS AND BORROWINGS	4	-	-
UNSECURED LOANS AND BORROWINGS	5	-	-
DEFERRED CREDIT LIABILITIES	6	-	-
CURRENT LIABILITIES AND PROVISIONS	7	21,361,099.00	24,231,758.31
TOTAL		**1,048,841,283.92**	**626,755,365.87**
ASSETS			
FIXED ASSETS	8	192,518,510.85	207,272,159.69
INVESTMENTS-FROM EARMARKED/ENDOWMENT FUNDS	9	354,474,685.53	323,698,173.85
INVESTMENTS-OTHERS	10	38,130,198.00	32,923,041.00
CURRENT ASSETS,LOANS,ADVANCES ETC.	11	463,718,793.54	62,861,991.33
MISCELLANEOUS EXPENDITURE			
(to the extent not written off or adjusted)			
TOTAL		**1,048,842,187.92**	**626,755,365.87**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

For **Singh Agarwal & Associates**
Chartered Accountants

CA. Mukesh Kumar Agarwal
(Partner)

(N B Tewari)
Accounts Officer

(Sanjay Kumar)
Registrar

(Sunil Bajpai)
Director

Form of Financial Statements (Non-Profit Organizations)

Birbal Sahni Institute of Palaeosciences, Lucknow

Income and Expenditure Account for the period / year ending March 31, 2017

Fig. in Rupees

Particulars	Schedule	Current Year 2016-17	Previous Year 2015-16
INCOME			
Income from Sales/Services	**12**	595,888.25	534,400.00
Grants/subsidies (OB, Deposit A/C and Transfer from Cap. Fund)	**13**	682,100,000.00	305,000,000.00
Fees/Subscriptions	**14**	-	-
Income from Investments (Income on Invest. From earmarked/endow.Funds transferred to Funds)	**15**	107,157.00	4,034,330.00
Income from Royalty,Publication etc.	**16**	286,748.00	105,996.00
Interest Earned	**17**	4,797,932.00	1,216,544.00
Other Income/Adjustments	**18**	2,903,652.37	3,807,214.95
Increase/(decrease)in stock of Finished goods and works-in-progress	**19**	-	-
TOTAL(A)		**690,791,377.62**	**314,698,484.95**
EXPENDITURE			
Establishment Expenses	**20**	220,874,859.00	194,209,012.00
Other Administrative Expenses etc.	**21**	44,522,489.68	48,148,538.30
Expenditure on Grants,Subsidies etc.	**22**	-	-
Interest	**23**	-	-
Depreciation (Net Total at the year-end-corresponding to Schedule 8)		31,213,963.26	34,057,488.66
TOTAL (B)		**296,611,311.94**	**276,415,038.96**
Balance being excess of Income over Expenditure**(A-B)**		394,180,065.68	38,283,445.99
Transfer to Special Reserve (Sepecify each)		-	
Transfer to/from General Reserve to Pension Fund		-	
BALANCE BEING SURPLUS/DEFICIT CARRIED TO CORPUS/CAPITAL FUND		**394,180,065.68**	**38,283,445.99**
SIGNIFICANT ACCOUNTING POLICIES	**24**		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	**25**		

For **Singh Agarwal & Associates**
Chartered Accountants

CA. Mukesh Kumar Agarwal
(Partner)

(N B Tewari)
Accounts Officer

(Sanjay Kumar)
Registrar

(Sunil Bajpai)
Director

Form of Financial Statements (Non-Profit Organizations)
Birbal Sahni Institute of Palaeosciences, Lucknow
Receipts and Payments Account for the period / year ended March 31, 2017

Fig. in Rupees

RECEIPT			PAYMENTS		
	Current Year	Previous Year		Current Year	Previous Year
	2016-17	**2015-16**		**2016-17**	**2015-16**
I. Opening Balances			**1) Expenses**		
a) Cash in hand	-	-	a) Establishment Expenses(Corresponding to Schedule 20)	220,874,859.00	194,209,012.00
b) Bank Balances			b) Administrative Expenses(Corresponding to Schedule 21)	44,522,489.68	48,148,538.30
i) In current accounts					
ii) In deposit accounts	22,452,784.89	16,992,424.93	**II) Payments made against funds for various projects**	34,688,955.19	34,664,561.20
iii) Endowment deposits			(Name of the fund or project should be shown along with		
iv) TDS on other grant	88,968.00	62,580.00	the particulars of payments made for each project)		
II. Grants Received			**III. Investments and deposits made**		
a) From Government of India	682,100,000.00	256,145,000.00	a) Out of Earmarked/Endowment funds	2,219,847.00	
b) From State Government			b) Out of Own Funds (Investments-Others)		
c) From other sources(details)			**IV. Expenditure on Fixed Assets & Capital Work-in-Progress**		
(Grant for capital & revenue exp.	-	48,855,000.00	a) Purchase of Fixed Assets	16,460,314.42	147,810,250.81
To be shown separately)			b) Expenditure on Capital Work-in-Progress		
d) Deposit Account			**V. Refund of surplus money/ Loans**	6,956,119.87	829,193.00
III. Income on Investment from			a) To the Government of India		
a) Earmarked/Endow. Funds		-	b) To the State Government		
b) Own Funds (Utilized)			c) To other providers of funds		
IV. Interest Received			**VI. Finance Charges (Interest)**		
a) On Bank deposits	-	4,034,330.00	**VII. Other Payments (Specify)**		
b) Loans, Advances etc.	4,797,932.00	1,216,544.00	i) Advances to Staff	1,338,429.00	1,588,484.00
i) Sale proceeds of Publications	286,748.00	105,996.00	ii) Earnest Money Refunded	-	700,000.00
ii) Miscellaneous Income	2,903,652.37	3,807,214.95	iii) Advances to Parties	71,554,344.20	150,959,339.55
iii) Sale of Services (Consultancy)	596,148.00	534,400.00	iv) Pension Fund	116,499.00	-
iv) Group Insurance			v) Transfer to reserve & surplus	-	52,735,443.00
VI. Amount Borrowed	5,653,350.00	2,165,414.87	**VIII. Closing Balances**		
VII. Any other receipts (give details)			a) Cash in hand	115.00	-
(Pension Contribution)			b) Bank Balances		
Transfer from Reserve Fund	(5,100,000.00)	43,000,000.00	i) In current accounts		
Net Receipt from Project	34,356,174.00	38,296,944.00	ii) In deposit accounts		
TDS Refund	1,841,657.00	1,141,660.00	iii) Saving account	383,471,280.50	22,452,784.89
i) Recovery of Advances	32,520,995.60	237,819,066.00	iv) Endowment deposit account		
ii) Earnest Money Deposit	10,000.00	10,000.00	v) TDS on other grant	305,157.00	88,968.00
iii) FDR Matured					
TOTAL	**782,508,409.86**	**654,186,574.75**		**782,508,409.86**	**654,186,574.75**

For **Singh Agarwal & Associates**
Chartered Accountants

CA. Mukesh Kumar Agarwal
(Partner)

(N B Tewari)
Accounts Officer

(Sanjay Kumar)
Registrar

(Sunil Bajpai)
Director



PALAEOMAGNETISM LABORATORY

Installation of Equipments & Training





Inauguration





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