ANNUAL REPORT 2017-2018





BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES, LUCKNOW

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



Professor Birbal Sahni, FRS established the Institute in the year 1946 for the development of 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). Mandate of BSIP has been expanded recently to widen the scope of palaeobotanical researches by combining it with other areas of Palaeosciences, and creating modern facilities to achieve this. With the newly widened mandate the aims and objectives are:

- Understanding origin and evolution of life through time
- > Understanding climate change in recent and deep geological times
- Understanding past civilization and human history
- > Application of palaeosciences in exploration programmes of oil and coal industry

BSIP's main mission is to achieve excellence in R & D work through a dedicated scientific team and continuous development of palaeosciences 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 and ecosystem 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 as well as studies on ancient DNA are 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 Museum of the Institute has 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 Professor Sahni, which was laid by Pt. Jawaharlal Nehru in 1949. The Institute has the richest collection of literature on the palaeosciences. 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. With the newly widened research mandate, the Institute now has the TL/OSL system useful for precise dating of archaeological artefacts and Quaternary sediments beyond the carbon radiometric dating technique. The IRMS, ICP-MS, GC-MS, XRF systems have recently been added for geochemical analyses, besides the establishment of Palaeomagnetic, Ancient DNA laboratories, FE-SEM., CHNS analyzer, Confocal Laser and Raman Spectroscopy and XRD. The Institute holds national/international scientific meets from time to time, and publishes catalogues, atlases, etc. on special occasions, besides publishing 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.

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September 2018



CONTENTS

Foreword	(i)	
Research Highlights	(iii)	
Outreach Activities	(vi)	
Foundation Day	1	
Founder's Day	2	
Research	3	
Project Work	3	
Work Other than Institute's Projects	49	
Collaborative Projects	51	
Sponsored Projects	60	
Research Papers Published	84	
Papers presented at Conferences/Seminars/Workshops	91	
Deputation to Conferences/Seminars/Workshops	96	
Lectures Delivered	100	
Consultancy/Technical Support Rendered	103	
Recognition	107	
Representation in Committees/Boards	110	
Ph.D. Programmes	111	
Units	113	
Publication	113	
Knowledge Resource Centre	114	
Museum	115	
Electronic Data Processing	116	
TL/OSL and Geochemistry Facility	117	
Radiocarbon Laboratory	119	
Scanning Electron Microscopy	120	
Distinguished Visitors	121	
Activities in Official Language		
Governing Body		
Research Advisory Council	125	
Finance and Building Committee	126	
Staff	127	
Appointments	130	
Promotions	131	
Retirement1		
Obituary		
Reservations and Concessions		
Auditor's Report	133	

Organization Structure



• Photography

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





The Birbal Sahni Institute of Palaeosciences, Lucknow, a premier research centre under Department of Science and Technology, Government of India plays a pivotal role to carry out basic research on plant fossils and other associated life forms of the geological past. The prime objectives of the research are focused on the reconstruction of past vegetation, past climate, biostratigraphy, palaeobiogeography and to unravel the history and culture of past civilization. The organization also caters a prime role to inculcate and disseminate the knowledge of this specific aspect of natural science at a global level.

Technological developments in the recent past have opened new vision for the reorientation of scientific research to emulate with the international standard of research in different disciplines of science. The institute has adopted an integrated and multi disciplinary approach to fulfil its aims and objectives as per the mandate. A number of analytical facilities specifically on geochemistry, geochronology, palaeomagnetism and Confocal Laser Scanning Microscopy (CLSM) have been introduced in the institute and cumulative inputs from all these analyses, along with biotic proxies have been made to understand the evolution of organisms, climate, ecosystems and various other aspects more precisely.

This document includes the overall achievements and activities targeted for the year 2017-2018. Contributions during this period in terms of research have been reflected in the form of research papers which have been published in the journals of national and international repute. Significant achievements in various researches, administrative, outreach activities and welfare measures have also been incorporated in this document.

I express my sincere thanks to the Department of Science & Technology (DST), Government of India and the Governing Body of the Institute for constant patronization.

I am highly indebted to the Research Development and Coordination Cell (RDCC) of the institute for its support in preparing this document. Thanks are also due to all the scientific, technical and administrative staff members of the institute for their overall achievement during the tenure. I am hopeful that with their constant efforts the institute's progress in all facets will continue in future.

R.C. Mehrotra

(**R. C. Mehrotra**) Scientist G with Additional Charge of Director



Research Highlights

- For the first time putative megascopic three dimensionally preserved 'seaweed' was reported from the Ediacaran succession of the Sonia Sandstone, Jodhpur Group, Marwar Supergroup, India, which may represent important source of nutrient for big body plan of Ediacaran biota .
- Evidence for high amplitude carbon isotopic negative excursion has been reported on the basis of robust carbon and oxygen isotope stratigraphy of the Ediacaran Bilara carbonate of the Marwar Supergroup, India, which played a pivotal role in the Ediacaran ecosystem.
- Optical studies of planet Venus suggest that particles in Venus lower clouds contain sufficient mass balance to harbor microorganisms, water and solutes, which indicate life in extreme environment under the domain of Astrobiology.
- The Permian palaeobiodiversity and geology of the Ib-River Basin, eastern coastal area, India have been appraised.
- Evidence of repeated fire events in Early Permian 'peat forming' vegetation of India has been detected.
- *Reduviasporonites* has been recorded for the first time from the Permian-Triassic continental sediments in India, adding another significant data point for its presence at the Permian-Triassic boundary (PTB).
- Macroscopic charcoal remains have been reported from late Permian Gondwana sediments of India indicating an evidence of wildfire.
- Patterns of change across Permian Triassic transition Boundary in Chintalapudi area, Godavari Graben, South India and its palaeoenvironmental implications have been interpreted.
- Geochemistry of the Permian-Triassic sequences of the Guryul Ravine section, Jammu and Kashmir, India reveals implications for oceanic redox conditions.
- Palynological assemblage from the Deccan Volcanic Province, central India provides insights into early history of angiosperms and the terminal Cretaceous palaeogeography of Peninsular India.
- Evidences were found for altered cropping pattern (from barely-wheat to millet) in Indus area in response to aridity prevailed at 4.2 ka BP.
- Evidences were found for a widespread reorganization of monsoonal climate since mid-Holocene (~5.5 ka BP) from northwestern Himalayas (Kedarnath area).
- Carbonate distribution in paleosol profiles suggests presence of monsoonal circulation of modern strength in Himalayan foreland at 20 My ago.
- Evidence was found for traces of distinct river source (Vedic Saraswati River) in the Great Rann of Kachchh.
- Proposed a model for evolution of Holocene Ayeyawady mega delta and its geomorphic development. Data reveals the delta remained stable during Holocene.
- Recent past Himalayan glaciers mass balance has been assessed based on Tree ring studies.
- Ancient DNA reveals Late Pleistocene existence of ostriches in Indian Sub-continent.
- Reconstructed genetic history of the Parsi population.
- Determination of Indus River water isotopic composition in the Ladakh region showing contribution of moisture from Mediterranean westerlies (~26%) and the Indian Summer Monsoon (~74%).
- Depositional history and hydrocarbon generation potential of Surkha lignite mine have been extensively studied.
- Fossil data from Deccan Infratrappean sediments suggests existence of marine Seaway in Central India during 65 Ma.

- Fossil leaf forms from Eocene-earliest Miocene of southern Asia reveal a strong monsoonal climate typical of those experienced today as a result of annual migrations of the ITCZ
- CLAMP analysis of fossil leaves from Paleocene-Miocene from India and Southern Tibet revealed an increase in precipitation seasonality vis-à-vis Himalayan Orogeny.
- Carbon isotopic and palynological study provided identification of a deep time globally warm event, second Eocene Thermal Maximum (ETM₂₎ in Panandhro lignite mine succession, Kutch.
- Palynological data from lignitic succession of Panandhro lignite mine, Kutch revealed tropical wet climate in the region during globally warm second Eocene Thermal Maximum (ETM₂, flimatic event.
- Presence of brackish marine mangrove pollen and peridinioid dinoflagellate cysts in the infratrappean at Yeotmal suggested presence of well-developed marine embayment along the Godavari rift zone during the Late Cretaceous.
- The presence of fossil pollen of *Dipterocarpuspollenites cretacea* in the Upper Cretaceous succession provided the earliest record of Dipterocarpaceae in the peninsular India. Their dispersal to SE Asia after the initiation of India-Asia collision strongly supports the 'Out of India" Hypothesis.
- First high resolution Paleocene-Eocene Thermal Maxima (PETM) event recorded from Jathang, Meghalaya.
- The plant standing diversity was inferred from the pollen assemblages from Paleocene Eocene succession at Jathang, Meghalaya. This study indicates globally warm climate during the PETM and in the early Eocene promoted the diversity of tropical plants in the palaeo-equatorial region.
- The Chemical Index of Alteration (CIA) values (> 85%) during PETM event at Jathang suggests that adequate water supply for flushing, which facilitated extreme weathering in the catchment.
- A multi-proxy approach suggested Monsoon-influenced variations in productivity and lithogenic flux along offshore Saurashtra, NE Arabian Sea during the Holocene and Younger Dryas.
- Past crops yield dynamics was reconstructed from tree-ring chronologies in the forest-steppe zone based on lowand high-frequency components.
- Implications for global correlation and floristic evolution were discussed on the basis of detailed palynology and detrital zircon geochronology of the Carboniferous Fenestella Shale Formation of the Tethyan realm in Kashmir Himalaya.
- Implications for palaeovegetation reconstruction have been assessed on the basis of characteristic of modern biotic data and their relationship to vegetation of the Alpine zone of Chopta valley, North Sikkim, India.
- Remarkable preservation of terpenoids and record of volatile signaling in plant-animal interactions have been investigated from Miocene amber.
- Rainfall seasonality on the Indian subcontinent during the Cretaceous Greenhouse has been assessed on the basis of $\ddot{a}^{18}O$ and CO_2 clumped isotope \ddot{A}_{47} of the seasonal growth bands in carbonate shells of mollusc *Villorita cyprinoides* (Black Clam).
- A modern pollen climate dataset from the Darjeeling area, eastern Himalaya shows potential for past climate reconstruction.
- A new insectivorous mammal (Mammalia: Adapisoriculidae) *Bharatlestes kalam*i (named in honor of late Dr. APJ Abdul Kalam) provides first evidence for continued survival of a Gondwanan mammal lineage following the Deccan volcanic activity (Cretaceous–Paleogene transition) within the Indian Subcontinent.
- An assemblage of diverse non-marine ostracods confirms the Late Cretaceous (Maastrichtian) age for the intertrappean deposits near Manawar, which are deposited in a freshwater palustrine/lacustrine system.
- *Rhizopalmoxylon nypoides* a new palm root was discovered from the Deccan Intertrappean beds of Sagar, Madhya Pradesh, India.
- Cambay amber was formed at a time of expanding modern diversity, at the beginning of the Early Eocene climatic optimum (EECO) and just after the Late Palaeocene Thermal Maximum (LPTM).

- Cambay amber shows deposition under near-shore environment having fluctuating conditions. It also reveals a highly diverse fauna of eusocial insects indicating that these groups diversified before the formation of the amber, probably during the PETM.
- Western India lignite mines were studied using multiple techniques to decipher palaeoenvironment and their economic potential.
- Winter (November-March) drought reconstruction of past 250 years using the Standardized Precipitation Evapotranspiration Index (SPEI) based on the tree-ring studies from western Himalaya will help in winter crop management.



Cumulative Impact Factor:

Outreach Activities





Foundation Day

The Foundation Day programme was celebrated on September 10, 2017 and two lectures were delivered by eminent speakers.

Prof. Ajit Chaturvedi, Director of IIT-Roorkee was the Chief Guest and he delivered the Foundation Day Lecture entitled, "How our scientific institutions can scale greater heights?". On this occasion inaugural lecture on Hindi Pakhwara was also delivered by Dr Arvind Chaturvedi, Additional Superintendent of Police, STF, U.P. His lecture on "Digital India: Avsar aur Chunautiyan". The Foundation Day programme was presided over by Professor S.P. Singh, Vice-Chancellor, University of Lucknow.





Founder's Day





The Founder's Day programme was celebrated on November 14, 2017 and two lectures were delivered by eminent speakers.

62nd Albert Charles Seward Memorial Lecture:

The 62nd Albert Charles Seward Memorial Lecture entitled, 'Land vegetation in the Mid-Palaeozoic and its impact on climate" was delivered by Professor Dianne Edwards, FRS of School of Earth and Oceanic Sciences, Cardiff University, UK. Her lecture



started with a summary of recent advances in understanding the nature of land vegetation from Mid-Ordovician through Devonian times. She explained how the evolution of plants took place from the early Devonian through late Devonian, Ordovician and Silurian. She also elaborated how from a green-house world to an ice-house one was transformed through time with the rise of land plants. She concluded that levels of atmospheric carbon





dioxide in the latest Devonian and Carboniferous were much as today resulting in a global climate with major glaciations on Gondwana.

47th Birbal Sahni Memorial Lecture:

Professor P. Balaram of Molecular Biophysics Unit, Indian Institute of Science, Bangalore delivered the 47th Birbal Sahni Memorial Lecture entitled, "Chemical Communication in Biology". He explained in depth that how chemical communication is mediate by a very large library of molecules produced by biochemical synthesis (natural



products) and the process requires orchestration of sequential of chemical reactions catalyzed by enzymes produced by gene coded protein synthesis. He presented an introduction to the complexity of chemical processes that are the key drivers of biology.



Research

Thrust Areas and Projects

ThrustArea 1:

EARLY LIFE AND ENVIRONMENT: EVIDENCE FROM INDIAN PRECAMBRIAN BASINS

Precambrian Palaeobiology Group (PPG)

Group Coordinator: Mukund Sharma Co-Coordinator: K.J. Singh

PREAMBLE: New evidence of early life forms found in the Precambrian (4600-541 Ma) successions is always considered a significant discovery and draws attention of the global scientific community. India with its vast Precambrian rocks is looked upon to enrich our knowledge of the early life. Each new finding from the older rocks bridges the gap in our knowledge about the early development of life, atmosphere and lithosphere on the Earth. Recently, the Archaean (4000-2500 Ma) Singhbhum Craton has yielded one of the oldest zircons on the earth indicating the availability of crustal rocks (hard outer surface of the earth). Therefore the Singhbhum Craton was targeted to record the stromatolites (oldest organo-sedimentary structures) and the microfossils which might have built them during the Archaean Eon. Our study of Meso-Archaean (3200-2800 Ma) rocks exposed in the Kasia Mines has yielded different morpho-types of primitive stromatolites.

The rock of Chhattisgarh Supergroup is considered as the Mesoproterozoic (1600-1000 Ma) age. Recovered fossil evidence is dominated by large size eukaryotic fossils belonging to Sphaeromorphitae and Acanthomorphitae subgroups of acritarchs. They considered to thrive in Mesoproterozoic to Neoproterozoic (1600-541 Ma) age of rocks, whereas the Carbon and Oxygen stable isotope curves indicate Tonian age (1000-720 Ma) for the same Saradih Limestone of the Raipur Group of the Chhattisgarh Supergroup. A sharp decreasing δ^{18} O values suggest onset of the gradual cooling phase of still older age - the Cryogenian (720-635 Ma) Period. Such inconsistency in fossils, chemostratigraphy and geochronological data need suitable explanation will be addressed in this thrust area programme.

Similarly, the inconsistency of Neoproterozoic (1000-541 Ma) fossil contents occurring in Palaeo-Mesoproterozoic succession of the Suket Shales demands a suitable explanation. To resolve this age inconsistency and stratigraphic status, area has been revisited for a fresh collection and study of the succession. New tools are being applied to study the Neoproterozoic Bhander Group of the Vindhyan Supergroup for biomarker studies and to determine the palaeoenvironment and possible age implication through carbon and oxygen isotopic study respectively. Well preserved carbonaceous discs like fossils occurring in the Lower Bhander Limestone and three distinct limestone levels in the Bhander Group, *i.e.* the Bhander Limestone, the Lakheri Limestone and the Balwan Limestone are being geochemically analyzed to understand the evolutionary status of microbial world. A multi-proxy geochemical characterization of the ~1210 Ma old Bijaigarh Shale of the Vindhyan Basin in the Chambal Valley is being attempted to reconstruct the palaeoredox (ancient environment) conditions of a shallow water marine ~1600 Ma old basin. Organic geochemical study was also performed which shows the presence of normal alkene compounds ranging from n-C13 to n-C30 representing bacterial to algal productivity.



Project 1.1: Palaeobiological remains of the Lower Vindhyans and their significance in understanding the Meso-Neoproterozoic biosphere evolution

PI: Mukund Sharma, Co-PIs: Veeru Kant Singh & Santosh K. Pandey

Reports of the characteristic Neoproterozoic acritarchs (organic microfossil) in the Early Mesoproterozoic (~1600 Ma) black Suket Shale challenged the understanding of the evolutionary status of the Proterozoic (2500-541 Ma) biosphere. Restudy of the type area in the Rampur locality of the Neemuch District, Madhya Pradesh was taken up to ascertain the acritarchs in the black shale units of the Suket Shale, which is a benchmark step in the evolutionary history of acritarch. Re-OS dating of these samples are being carried out. Transition from the Semri Group to Kaimur Group was noticed to be angular whereas in the Rampura locality, it shows continuous deposition or no break between the two groups.

fossil contents, stratigraphic position and radiometric age of the black shales. Ten to thirty meter deep dug wells were sampled for black shales to recover microfossils, microbial mats and for radiometric dating. Results confirmed the presence of large acanthomorphic



Fig. – A section of field exposure of finely stratified brown to buff coloured Suket Shale near Junnod, Neemuch District, M.P. which yielded acanthomorphic acritarchs and Microbially Induced Sedimentary structures.

Project 1.2: Early evolution and diversification of Proterozoic eukaryotes: palaeontological and biomarker investigations from the Chhattisgarh Supergroup

PI: Veeru Kant Singh & Co-PI: Mukund Sharma

To understand early evolution of eukaryotes in Proterozoic biosphere, palaeobiological studies was carried out on the different stratigraphic units of the Chhattisgarh Supergroup, viz. the Chandarpur and the Raipur groups exposed in Raigarh District (Chhattisgarh) and Bargarh District (Odisha). Sedimentary successions of these two groups were investigated. Systematically collected carbonaceous black shale from the mud dominated sequences of the Chaporadih Formation of the Chandarpur Group was processed and recovered assemblage was dominated by large size sphaeromorphs and a few acanthomorphs belonging to Sphaeromorphitae and Acanthomorphitae subgroups of acritarchs. Exceptionally well-preserved Organic Walled Microfossils (OWMs) of eukaryotic affinity dominated the assemblage with lesser amount of unicellular cyanoprokaryotes, viz. Polytrichoides – Siphonophycus – Myxococcoides. Well preserved population of Tappania included vesicles (60-120 μ m) bearing multiple branching processes, compound branching processes, and a bi-layered wall structure in which the inner and outer walls exhibit the independent differentiation. However, *Germinosphaera* included spherical vesicle (50–100 μ m) having numerous cylindrical processes on the vesicle. In the global records, the *Tappania* and *Germinosphaera* have been widely accepted as eukaryotic fossils, which range in age from Mesoproterozoic–Neoproterozoic and recorded from the multiple successions in Australia, India, North China, Siberia, and North America.

Carbonate of the Sarangarh and the Saradih formations of Raipur Group were processed for Carbon (δ^{13} C) and Oxygen (δ^{18} O) stable isotopes signatures. Correlation of generated isotope data with standard global Carbon and Oxygen stable isotope curve indicated Tonian age (800–720 Ma) for the Saradih Limestone of the Raipur Group. A sharp decreasing δ^{18} O values suggested onset of the gradual cooling phase of the Cryogenian Period.



Project 1.3: Early metazoan and metaphytes: Testimony from the Neoproterozoic Bhander Group, central and western India

PI: Santosh K. Pandey & Co-PI: Mukund Sharma

In spite of more than a century of study on the carbonaceous discs, known as Chuaria, their origin and affinity are far from conclusive. Besides the Chuar Group specimens, discs from India have contributed significantly towards understanding the nature and taphonomy of the Chuaria. For better resolution, newer tools were applied to analyze these specimens. An extensive fresh collection has been made from the Bhander Limestone of the Bhander Group exposed in the Dulni river section of the Maihar area, M.P. Well preserved carbonaceous discs remains were targeted for biomarker studies through GC-MS analysis. A comparative biomarker study on the extant Nostoc was also conducted to find out the biomarker signature (molecular data) of its true affinity (either cyanobacterial or algal). Black and grey coloured organic rich layers of shale and siltstone units of the Sirbu Shale were processed to record the palaeoredox conditions of deposition of these units.

Carbonate samples were systematically collected from measured section of three distinct levels, i.e. the



Fig. – Well preserved blooms of circular discs *Chuaria* sp. in Bhander Limestone, Dulni River bed, Dulni Village, Maihar, Satna District, MP.

Bhander Limestone, the Lakheri Limestone and the Balwan Limestone of the Bhander Group. Robust carbon and oxygen isotopic study were targeted to determine the palaeoenvironment and possible age connotation.

Project 1.4: Palaeoredox reconstruction of a Mesoproterozoic Eon: Evidence from Indian basins PI: A.H. Ansari & Co-PI: R.P. Mathews

A multi-proxy geochemical characterization of the ~1210 Ma old Bijaigarh Shale of the Vindhyan Basin in the Son Valley has been attempted to reconstruct the palaeoredox conditions of a shallow water Mesoproterozoic basin. The study showed the presence



Fig. – Organic geochemical study on the Bijaigarh Shale, Kaimur Group of the Vindhyan progress to determine the trace metal supergroup in the Son Valley shows the presence of normal alkene compounds ranging from n-C13 to n-C30 dominated by short chain even numbered alkenes (C_{max} at n-C18) indicate microbial source of the organic matter.

of normal alkene compounds ranging from n-C13 to n-C30. The alkene distribution was dominated by short chain even numbered alkenes (C_{max} at n-C18) indicating microbial source of the organic matter. However, in the terpenoid distribution, hopanes were absent. The

isoprenoids pristane (Pr) and phytane (Ph) are identified with a relatively higher abundance of phytane in all the samples. The Pr/Ph ratio calculated for the studied samples ranged from 0.50 to 0.92. Although the values indicated anoxic conditions of the basin, slight increase of the values in the two samples (>0.8) may be an indication of variations in the redox conditions. Further ICPMS analyses are in progress to determine the trace metal concentration and REE on the same set of samples to infer palaeoredox conditions during their deposition.



Project 1.5:Signatures of early life: Evidence from Archaean sediments of IndiaPI: Yogmaya Shukla & Co-PI: Mukund Sharma

Discoveries of oldest zircons and stromatolites from all over the world recently triggered the studies of the Archaean rocks and biosphere evolution. Among the four distinct cratons of the India, the Singhbhum Craton in the eastern part of the country is well known for iron and manganese economic deposits and suitable for understanding the lithosphere evolution. Although majorly Singhbhum Craton is metamorphosed that makes it unsuitable for palaeobiological Finding suitable studies. unmetamorphosed chemically precipitated Archaean age rocks is paramount for palaeobiological studies. In Jharkhand and Keonjhar District of Odisha, a few unmetamorphosed chert, limestone



Fig. – A section of the Archaean domal stromatolite from Iron Ore Formation, Kasia Mine, Barbil, Odisha. The lowermost layers represent stratiform stromatolite followed by pseudocolumnar stromatolitic layers. The pseudo-columns are linked with contiguous spacing.

and dolomite units in iron and dolomite mines of Kasia were investigated. Small domal, laminated stromatolites possibly formed in geyserites settings were sampled for

detailed investigation and microfossil studies. Four main morpho-types were recorded. Multi-proxy studies on these sediments are being carried out.

ThrustArea 2:PHANEROZOIC TERRESTRIAL AND COASTAL ECOSYSTEMS:
BIOSTRATIGRAPHICAL, PALAEOENVIRONMENTAL, PALAEO-
ECOLOGICAL AND PALAEOBIOGEOGRAPHICAL ASPECTS

Gondwana Ecosystems Group (GEG)

Group Coordinator: K.J. Singh Co-Coordinator: Neeru Prakash

PREAMBLE: Since inception the institute has been significantly contributing on the studies of Gondwana palaeobiodiversity. Reconstruction of the vegetation through time involves observation and understanding of the distribution of plant remains belonging to various plant groups in different sedimentary facies of different formations. In this regard, diverse and multidisciplinary studies are being carried out from the Palaeozoic sequences of peninsular basins as well as the Himalayan sequences of the Kashmir and Spiti basins. To draw a comprehensive scenario of the vegetation dynamics and

its palaeoenvironmental implications through Palaeozoic, rigorous analyses of newly collected data and material utilizing the state of the art facilities as well as contemporary approaches along with the synthesis of the gathered and published data from the various basins/subbasins/coalfields need to be put together and observed in the broader perspective. From the extra peninsular regions, studies on the Ordovician to Carboniferous sequences of the Spiti Basin, Himachal Pradesh are indicative of some breakthrough evidences on the early terrestrialization and advent of early land plants from the Indian subcontinent.



Similarly, palynological analysis of the Fenestella Shale Formation from the Carboniferous sequence of Jammu and Kashmir State has provided new insights into the floristic evolution of Gondwana during the Late Palaeozoic. To deduce and reconstruct the biostratigraphy and palaeoclimate, studies are being carried out and emphasis is being given to determine the presence of the Permian-Triassic boundary (PTB) from the continental Permian Triassic sequence of Tatapani-Ramkola Coalfiled, on the basis of the first record of Reduviasporonites in the palynoassemblage. Organic geochemistry has also been done to decipher palaeoclimatic and palaeoenviroment of Rajmahal Gondwana sediments. From the Mesozoic successions of the South Rewa Basin, pteridophytes, pteridosperms bennettitales and conifers were recorded. The genus *Zamites* of the order Bennettitales is quite abundant and diversified. This genus has previously been reported mostly from the Northern Hemisphere, and is reported for the first time from the Indian Gondwana Basin.

Project 2.1: Composition and dynamics of the Palaeozoic floras of India: Synthesis, review and re-assessment

PI: K.J. Singh & Co-PI: Anju Saxena

Permian biodiversity and geology of the Ib River Basin, Odisha, has been reviewed to infer and reconstruct the palaeovegetation, biostratigraphy and palaeoclimate of this basin. It has the second highest plant diversity (91 taxa) among the known Permian Gondwana basins/subbasins of India (the highest is in Talcher Basin, 120 plant taxa). The most diversified macroflora (82 taxa) and the highest species diversity in the genus Glossopteris (53 species) of Indian Gondwana and has been recorded from the Barakar Formation of this basin. Three Australian taxa (Glossopteris waginanus, G. gregoryi and Macrotaeniopteris wianamattae) were also recorded for the first time from Indian Gondwana. The occurrence of In-situ preserved Vertebraria axes in this basin demonstrates the possibility of autochthonous preservation of the vegetation and formation of coal, and these beds might be the palaeosoils. A temperate to warm climate



Fig. (A) – Distribution of various plant groups depicting the diversity trends in Barakar and Kamthi formations of Ib-River Basin.

with ample humidity and sufficient light intensity is inferred for the entire Barakar Formation in Ib River on the basis of flora. The huge amount of coal (22516 million tonnes) accumulated in the Barakar seams along with a large and diverse plant assemblages of the Glossopteris flora recovered from this formation indicates the existence of huge dense forests growing in swamps or low lying river valleys. The comprehensive data involving palaeontology and sedimentology indicate the existence of two interconnected ecosystems in the Ib River Basin during Barakar and Lower Kamthi times, viz. terrestrial and marshy systems.

The Glossopteris flora from Tatapani-Ramkola Coalfield, Son Basin have been reviewed and analysed taking into account all the available data concerning macrofloras, palynology and the petrology to infer the









Fig. – Vegetational reconstruction of Ib-River Basin during late Early Permian (during the deposition of Barakar Formation) depicting the following plants: 1. *Cyclodendron 2. Schizoneura*3. Bengalia 4. Raniganjia 5. Trizygia 6. Neomariopteris 7. Usual fern plants 8. Noeggerathiopsis 9. Euryphyllum 10. Buriadia 11. Ginkgoites 12. Glossopteris 13. Palaeovittaria 14. Gangamopteris 15. Tree trunk of Glossopteris plant.

diversity trends through the Barakar, Raniganj and Panchet formations, and its transformation at the Raniganj-Panchet boundary in this coalfield. The complete flora includes 24 genera and 73 species. Three floristic assemblages were identified on the basis of the macrofloras are the Barakar Aassemblage with 31 taxa, the Raniganj Assemblage with 38 taxa, and the Panchet Assemblage having 33 taxa. The Barakar Formation has a moderate diversity of Glossopteris (18 species), which increases in Raniganj Formation (26 species) and decline in the Panchet Formation (16 species).

The advent of the Triassic witnessed the extinction of some of the Permian elements, such as *Trizygia*, *Dichotomopteris*, *Neomariopteris*, *Gangamopteris*, Glossopteris stenoneura and G. stricta and a decline in the Permian flora, but still 15 Permian taxa (11 species of Vertebraria. Glossopteris, Dizeugotheca, Paracalamites and Schizoneura) continued to the Early Triassic Panchet Formation. However, their representation was reduced, and simultaneously, Dicroidium and other related groups appeared. The species Glossopteris angustifolia, G. barakarensis, G. browniana, G. communis, G. indica, G. pandurata, G. retifera, G. tortuosa and G. tenuifolia which continued in the Early Triassic were relatively smaller in size as compared to their Late Permian counterparts retaining the specific characteristics.

The Raniganj-Panchet boundary has been tentatively delineated in Iria Rivulet section in this coalfield based on the litho characters and the palaeontology. At this boundary, the Glossopteris species typical of the Raniganj Formation (i.e. G. stenoneura and G. stricta) disappear. Some of the Glossopterid taxa, continuing into the Panchet Formation show relatively little discernable change from those found in the Raniganj Formation. The Panchet Formation exhibits a dominance of Dicroidium and also marks the appearance of ?Autunia. Lepidopteris, Heidiphyllum, Linguifolium and Rissikia. Complete

absence of fertile structures of Glossopterids in the Panchet Assemblage indicates the prevalence of unfavourable warm and arid conditions during early Triassic that probably did not allow the Glossopterids to blossom and ultimately they perished for want of reproduction process.

The genus *?Autunia* reported herein is the first record of this taxon from Indian Gondwana and the genera *Rissikia* and *Linguifolium* have also been recorded for the first time from Lower Triassic beds in India. It is envisaged that the plant life was only transformed and evolved near the vicinity of the Permian-Triassic boundary (PTB) in the Tatapani-Ramkola Basin and did not become completely extinct.



Project 2.2: Precursors of Indian Gondwana flora, their subsequent evolution and proliferation through Palaeozoic from Spiti and Son-Mahanadi basins and their palaeo-environmental perspective

PI: Anju Saxena & Co-PI: K.J. Singh

An analysis pertaining to the occurrence, distribution and diversity of the genus *Gangamopteris* in various collieries of Singrauli Coalfield has been carried out. In all, 5 species has been recorded from the Bina, Block-B and Nigahi collieries namely, *Gangamopteris angustifolia*, *G. cyclopteroides*, *G. karharbariensis*, *G. major* and *Gangamopteris* sp. The study from other collieries of this coalfield is under progress. A manuscript pertaining to the palaeobiodiversity of the Glossopteris flora of the Barakar formations of the Nigahi and Block-B colliery has also been finalized.

In addition, a field excursion to Spiti area of Himachal Pradesh was also carried out. Samples for the megafossil, palynological and petrological analyses were collected from the different formations of Ordovician (Thango Formation), Silurian (Takche Formation) and Carboniferous (Po Formation) ages from Tabo and Lalung localities. The samples were subjected to maceration and have yielded dark brown to black coloured palynomorphs along with chitinozoa, melanosclerites, scolecodonts, acritarchs and palynodebries. However, the yield of palynomorphs is relatively poor. SEM study of some of the specimens has also been done. The specimens from Thango Formation are also being prepared for the petrological and isotopic studies. The study is under progress.



Fig. – Palaeobiology of Thango Formation (Ordovician) near Losar Village, Spiti, Himachal Pradesh (Scale bar -10 µm for each SEM image) 1. Chitinozoa, 2. Melanosclerite, 3. Scolecodont, 4. Scolecodont, 5. Acritarch.

Project 2.3: Floristic evolution during the late Palaeozoic of Kashmir region and South Rewa Gondwana Basin: Implications for global correlation, biostratigraphy and palaeoecology

PI: Deepa Agnihotri & Co-PI: Suresh S.K. Pillai

Palynological studies, supplemented by detrital zircon U–Pb ages, from the Fenestella Shale Formation (Carboniferous) near the Gund Village in the Banihal area of Jammu and Kashmir State, India have been carried out for the first time. The study provides new insights into the floristic evolution of Gondwana during the Late Palaeozoic, especially in India, from where the Carboniferous - Permian macro and microfloral records are impoverished. Palynological correlation of the Carboniferous-Permian palynoassemblages described





Fig. - Microfossils recorded from Fenestella Shale Formation near Gund Village.

- A. Microbaculispora tentula
- B. Callumispora adensa
- C. Plicatipollenites indicus
- D. Parasaccites korbaensis
- E. Parasaccites bilateralis
- F. Parasaccites obscurus Parasaccites korbaensis G.
- H. Parasaccites perfectus Parasaccites perfectus I
- J. Crucisaccites indicus
- K. Potonieisporites monosaccoides

- L. Virkkipollenites mehtae
- M. Crucisaccites latisulcatus
- N. Plicatipollenites maculatus
- O. Potonieisporites mutabilis
- P. Rhizomaspora indica Q. Striatopodocarpites diffusus
- U. Striatites solitus

T. Vesicaspora indica

- R. Striatopodocarpites sp. S. Striatopodocarpites sp.

from the various Gondwana countries have also been made for the first time. The palynomorphs from the Fenestella Shale Formation are fairly well preserved and diversified and include 11 genera and 18 species. While the trilete spores and striate bisaccate pollen grains are scarce, monosaccate pollen taxa mainly - Parasaccites, Plicatipollenites and Potonieisporites are dominant. The assemblage is most similar to the Parasaccites korbaensis palynozone of the Lower Gondwana basins of the Indian peninsula and the Stage 2 palynozone of the late Carboniferous of east Australia. Besides, it is comparable with the known Carboniferous assemblages of Pakistan, Yemen and South America; Carboniferousearly Permian assemblages of South Africa and Permian assemblages of Antarctica. The sediment source of the siliciclastic shelf and delta deposits intercalated in the Fenestella Shale Formation is a hinterland in which Precambrian rocks dominantly were exposed and the Th-Uratios of detrital zircons suggest that most rocks exposed on the erosion level in the hinterland had a felsic composition. The youngest U-Pb zircon age of the investigated fossiliferous strata is 329 ± 16 Ma (late Visean to early Serpukhovian), providing a maximum age of deposition of the studied succession. Based on the affinities of the palynofloral assemblage and earlier palaeontological records, a warm, temperate and arid climate has been inferred for the Fenestella Shale Formation.

Project 2.4: Cuticular morphotaxonomy, biostratigraphy, organic geochemistry, and palaeoecology of Lower Gondwana flora from Rajmahal and Damodar basins, India

PI: Suresh S.K. Pillai & Co-PI: R.P. Mathews

Well preserved plant fossil assemblage has been recorded from Rajmahal Basin whose Gondwana sediments extend over large areas of Jharkhand and West Bengal states. The block is located between latitudes 25°1'12" and 25°3'15" N and longitude 87°21'0" and 87°24'0" E. The plant megafossils and cuticles were retrieved from the shale band between seams L-III and L-II. A number of Glossopteris, Gangamopteris and Noeggerathiopsis leaves along with Vertebraria have been tentatively identified. There are 4 genera 14 species of megafossils in the collection, which include ten species of Glossopteris, two species of Gangamopteris and one species of Noeggerathiopsis and Vertebraria each.

Maceration of rock samples has yielded a variety of palynomorphs, dispersed cuticles along with tracheids. The palynocomposition recovered is well correlated with the (zone VI) Faunipollenites varius palynoassemblage of upper Barakar Formation by having dominance of striate bisaccate pollen Faunipollenites and sub-dominance of non-striate bisaccate pollen Scheuringipollenites. The other palynotaxa of the assemblage are Parasaccites, Caheniasaccites, Tiwarisporis, Verticipollenites, Rhizomaspora, Primuspolleintes, Striasulcites and Striatopodocarpites. This assemblage suggests late early Permian age (Tiwari & Tripathi 1992). The floral assemblage is broadly comparable with those described



previously from the Barakar Formation of Damodar, Mahanadi, Wardha, Godavari and Satpura Gondwana basins of India.

Cuticles retrieved from the compressed Glossopteris leaves and from palynological samples show features like shape, nature and arrangement of epidermal cells, type of stomata and guard cells, trichomes as well as trichome bases. Biomarker composition investigation has been performed on coal samples from the same locality. Hydrocarbon fractions are all dominated by a homologous series of C15 to C32 n-alkanes. The acyclic C19 and C20 isoprenoid hydrocarbons, pristane (Pr) and phytane (Ph) are identified in these samples with a dominance of phytane indicating anoxic condition. Most of the terpenoid compounds identified are pentacyclic triterpanes with substantial amounts of hopanes in all the samples. Various biomarker ratios have been calculated including Carbon Preference Index (CPI), Pr/Ph ratio, Terrigenous Aquatic Ratio (TAR) suggesting that these deposits were formed in an oxic terrestrial setting initially which gradually shifted to anoxic aquatic dominant setting. Towards the top of the studied sequence more oxic conditions prevailed again in the depositional area. The hopane distribution indicates the inputs from bacterial source and diterpanes indicates the presence of Gymnosperms in the source vegetation. Interpretation part is going on further. This will be the first study to decipher palaeoclimatic and palaeoenvironmental of Rajmahal Gondwana sediments based on organic geochemistry.



Fig. 1. – 1.*Gangamopteris major* Feistmantel 1879, 2. *Vertebraria indica* (Unger) Feistmantel 1877, 3.*Noeggerathiopsis hislopii* (Bunbury) Feistmantel 1879, 4. *G. arberii* Srivastava 1956, 5.SEM photographs of cuticles showing stomata, 6. SEM photographs stomata with subsidiary cells, 7. SEM photographs of trichomes, 8. Stomata with subsidiary cells, 9. Trichome 10 Non-papilate trichome bases 11. Trichome bases arranged around the stomatal pore, 12. Distribution of various biomarkers in coal samples from Lalmatia coalmine of Rajmahal Basin .(Megafossils scale bar = 1cm).

Project 2.5: Investigations of Permian-Triassic Transition in Peninsular India PI: Amit Kumar Ghosh & Co-PI: Ratan Kar

Palynological study has been carried out from an outcrop succession within the Gondwana Supergroup in India, spanning the end-Permian event. The sampled succession is located within the Tatapani-Ramkola Coalfield, in the Balrampur District of Chhattisgarh State, India. Diverse and well preserved palynological assemblages representing non-marine successions were identified and four assemblage zones



- Fig. –
- A) Panoramic view of the outcrop;
- B) Close-up of the outcrop showing the lithological features of the upper Permian–Lower Triassic transition (the grey shales in the lower part represent upper Permian and the khaki shales above represent Lower Triassic; hammer = 30 cm long);
- C) Basal part of the outcrop showing the typical lithological features of upper Permian black shale and coal; hammer = 30 cm long);
- D) Lithostratigraphic log showing the positions of samples, palynological assemblage zones and the samples yielding *Reduviasporonites*.



Fig.:

A-C. Cylindrical to barrel-shaped individual cells of *Reduviasporonites chalastus* (Foster) Elsik showing the darker clumps in the central part of the cells; D. Typically unbranched filaments of cylindrical to barrelshaped cells (two cells) joined to each other by thickened constrictions.

were distinguished: the upper Permian Zone I: Striatopodocarpites-Densipollenites, and Zone II: Striatopodocarpites-Crescentipollenites; the lower Triassic Zone III: Falcisporites-Klausipollenites and Zone IV: Densipollenites-Lunatisporites. Importantly, the fossil genus Reduviasporonites Wilson is recorded across the Permian-Triassic transition in this study. Although the affinity of Reduviasporonites has been disputed (both fungal and algal affinities have been proposed), the genus is an important constituent of the palynological assemblages from the Upper Permian and Lower Triassic deposits in different parts of the world. The present contribution is the first record of *Reduviasporonites* from the Permian-Triassic continental sediments in India, adding another significant data point for their presence at the Permian-Triassic boundary (PTB). Affinity and palaeoecological perspectives of the taxon have been interpreted.

Project 2.6: Palaeofloristics from Upper Gondwana sediments of South Rewa Basin: Phytogeographical and palaeoecological implications

PI: Neeru Prakash & Co-PI: Neelam Das

The South Rewa Gondwana Basin occupies heart of the Indian peninsula and represents discontinuous graben along the northern part of Son Mahanadi geofracture, which transect the Indian shield in the middle of the peninsula. This gondwanic basin is filled with fluviatile and lacustrine sediments from surface to its extension in subsurface which were developed in response to the tectonic evolution of the basins. Plant fossils are preserved in carbonaceous shale, buff coloured clay and lenticular bedded mudstone belonging to pteridophytes, pteridosperms bennettitales and conifers. The well diversified megafloral assemblage comprising a number of species of pteridophytes, e.g. *Todites* and *Phlebopteris* and branched or unbranched twigs of *Gleichenia* are commonly found in Taken and Jhala area.

The conifers are reported by a number of species of *Elatocladus*, *Allocladus*, *Brachyphyllum*, *Pagiophyllum*, *Araucarites* and *Podozamites*. The flora is dominated by conifers and pteridophytes and is coeval to palaeofloral assemblages of Bhuj, Dhrangadra and Himmatnagar formations where too flora is dominated by conifers and pteridophytes.

Palaeofloral assemblage shows close affinity with Floristic assemblage zone-10 Sukh-Dev (1987), which is characterized by occurrence of *Weichselia, Onychiopsis*, proliferation of *Gleichenia, Araucaria, Allocladus, Brachyphyllum* and *Pagiophyllum* and lack of cycadophytes and pteridosperms. Recently a phylogenetically and phytogeographically significant microsporophyll genus *Caytonanthus* Thomas of family Caytoniaceae has been reported by Prakash & Das (2017). Within the assemblage, the genus *Zamites* of the order Bennettitales is quite abundant and diversified. This genus has previously been reported mostly from the Northern Hemisphere, and is reported for the first time from the Indian Gondwana Basin.



Project 2.7: Palynostratigraphy, palaeoclimate, palaeo-wildfire, depositional environments and patterns of evolution in palynoflora in Rajmahal and Damodar basins (Early Permian to Early Cretaceous)

PI: Srikanta Murthy & Co-PIs: Anju Saxena & Pauline K. Sabina

Macro and Miofloral analyses of coal-bearing sequences of the Jarangdih Coal Mine, Damodar Basin were carried out to infer the floral diversity, age assessment and the palaeoenvironment Barakar sediments. The Barakar strata of this colliery have yielded a diverse macroflora consisting of the groups Glossopteridales (Glossopteris, Vertebraria, Gangamopteris, fructifications and stem casts) and Equisetales (Phyllotheca indica, Schizoneura gondwanensis and Paracalamites sp.). The genus Glossopteris dominates the assemblage with 16 species, viz. G. arberi, G. communis, G. churiensis, G. giridihensis, G. indica, G. intermedia, G. intermittens, G. linearis, G. leptoneura, G. mohudaensis, G. recurva, G. searsolensis, G. stenoneura, G. taenensis, G. tenuinervis and G. tenuifolia. The groups Lycopodiales, Coniferales, Sphenophyllales and Filicales are not represented as macrofloral remains; however, their presence is recorded in the palynoassemblage. The palynological analysis has revealed only one palynoassemblage which is characterized by the dominance of striate bisaccate palynomorphs mainly Faunipollenites and non-striate bisaccate pollen grain Scheuringipollenites. The other stratigraphically significant palynotaxa are Striatopodocarpites, Verticipollenites, Crescentipollenites, Striatites and Arcuatipollenites. The recovered palyno- and megafloral assemblages suggest the late Early Permian (Kungurian)

age to the Barakar strata of Jarangdih Coal Mine and prevalence of moderately warm climate during their deposition.

Palynological analysis have been done for the borehole BRS-7 intersected through Rajmahal Formation (lower Cretaceous), the thinly Dubrajpur Formation (Jurassic-late Triassic) and its basal part coal measures Barakar Formation (lower Permian). The coal bearing sediments palynologically reveal one palynoassemblage Densipollenites magnicorpus Assemblage zone which correlates with the palynoflora of the Raniganj Formation from the Damodar Basin and it indicates late Permian (Lopingian) age. The late Permian palynoflora recorded here is from the lithologically designated Barakar Formation. The overlying Dubrajpur Formation yielded very poor palynoassemblage containing reworking of Permian elements. The palynocomposition shows the presence of Callialasporites, Densipollenites, Striatopodocarpites, Fungal hype, fungal spores and cuticle and absence of precise age marker taxa. The qualitative diversity in the palynoflora from the Rajmahal Formation comprises age marker taxa, viz. Callialasporites spp., Podocarpidites spp., Januasporites spinulosus, Contignisporites spp. and Podosporites tripakshi. The palynoassemblage from the Rajmahal Formation denotes Early Cretaceous (Barriasian) age. Thus the palynodating indicates late Permian and early Cretaceous age.

Project 2.8: Palynostratigraphy, palaeogeography and palaeoecology of the Mesozoic (Jaisalmer Basin) and Palaeozoic (Wardha Basin) successions

PI: Pauline K. Sabina & Co-PI: Srikanta Murthy

I was in Brazil for about 3 years for my Post Doctoral studies at the Instituto de Geociencias, Universidade de Sao Paulo, Sao Paulo, Brazil. I returned to BSIP on the 1st of December 2017 and started the current project. I

need to carry out Field works in the Jaisalmer Basin and Wardha Basin in the coming months. Currently I am working on the Rajmahal Basin as a Co-PI of project No. 2.7. Inferences need to be drawn.



Project 2.9: Palynology, palynofacies and sedimentological aspects of Gondwana sediments from Godavari Basin

PI: Neha Aggarwal & Co-PI: Anju Saxena

Palynological analysis of samples from five bore cores 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. On the basis of palynofloral composition Palynozone-I (*Parasaccites* spp., + *Plicatipollenites* spp.), Palynozone-II (*Scheuringipollenites* spp. + *Ibisporites* spp.) and Palynozone-III (*Striates* + *Crescentipollenites* spp.) have been assigned to Sakmarian, Artinskian and Lopingian age respectively.

Palynological and palynofacies studies carried out in 306 m deep borecore MSM-25 (101 samples) from Somavaram area, East Godavari, south India revealed the presence of five distinct floral assemblages and nine distinct palynofacies assemblages. Palynoassemblages belong to Upper Karharbari, Barakar and Raniganj horizons. On the basis of recovered palynoflora and dispersed organic matter studies Permian deposits have been inferred as fluvio lacustrine with extensive peat forming conditions.

Palynofacies studies carried out in borecore VEM-1 from Vemanpalli area of Chinnur Coalfield of Godavari sub-basin, south India indicate that the sediments are rich in amorphous organic matter and charcoal. On the basis of the quantitative composition of the sedimentary organic matter four distinct palynofacies associations (A-D) have been identified. Palynofacies A-D reflects 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.

In a review work of Chintalapudi sub-basin of Godavari Graben, total eleven palynoassemblages and four distinct palynofloral turnover have been documented. On the basis of recovered palynoflora a succession of Permian-Triassic palynoflora (Talchir-Panchet) has been recovered.



Fig. - Biostratigraphy and Palaeovegetational succession in the Chintalapudi Sub-basin of the Godavari Garben.



Cretaceous-Cenozoic Ecosystems Group (CCEG)

Group Coordinator: R.C. Mehrotra Co-Coordinator: Vandana Prasad

PREAMBLE: This thrust area looks at climate, palaeoenvironment, evolution and biogeographic history of the biota of Late Cretaceous-Cenozoic (65-2.5 Ma) time span, through utilization of plant and animal megafossils, fossil insects, fossil pollen and spores, nannofossils, dinoflagellate cysts, inorganic and organic geochemistry and magnetostratigraphy proxies. The (65-2.5 Ma) time span consists of northward movement of Indian Plate from southern high latitude to subtropical Northern Hemisphere, its collision with the Eurasian Plate and uplift of Himalayas. During its northward journey, the Indian Subcontinent underwent major volcanic activity while passing over the Reunion Hotspot that resulted in the deposition of thick volcano-sedimentary successions in central India (Deccan Traps). The cause of major extinction event at Cretaceous Tertiary boundary is a major issue of debate and the study of Deccan Volcanic Province (DVP) is important to decipher the timing, duration and relationship of the Deccan Volcanic activity to the K-T boundary event. Besides this, the rich vegetation history

from DVP can provide biogeographic clues for tropical angiosperm evolution. Early Palaeogene time span (55.5-52 Ma) consists of a series of extreme global warm events in the geological archives that can provide analogues for recent and future global warming. The lignite bearing early Palaeogene sediments from Kutch, Rajasthan and Cambay (western India) and coal bearing sequences of Garo, Khasi and Jaintia hills (Shillong Plateau, Meghalaya) can serve as analogues for the effect of extreme global warm climate on biota and environment in a tropical setting. Abundant fossils from these sediments can help in building the evolutionary and biogeographic history of tropical plants and animals. Late Eocene-Miocene period is well represented in the western Himalayas and can provide information of different stages of vegetation turnover and the early stages of establishment of monsoonal climate due to Himalayan uplift. Besides, the study of palaeoenvironment, sea level fluctuation, history and dating of Cretaceous-Cenozoic sediment successions are important issues proposed in this thrust area programme.

Project 2.10: Integrative palynological, magnetostratigraphic and sedimentological studies of selected Deccan volcano-sedimentary sections of peninsular India: implications for age, palaeoclimate, palaeobiogeography and evolutionary history of infra-and intertrappean biotas

PI: Mohammad Arif & Co-PIs: Vandana Prasad & Arvind K. Singh

Different stratigraphic successions of Infra- and Inter-trappeans strata of Jabalpur and adjoining region (Lametaghat, Seonighat, Chui Hill Infra-trappeans and Gaumukh and Mehadbani Intertrappeans sections) were investigated for micro and mega floral-faunal remains, associated sedimentary facies and depositional environmental conditions. The detailed field study of Chui Hill and Lametaghat sections revealed standardized lithofacies association namely (a) Green Sandstone facies (b) Lower Limestone facies (c) Mottled nodular marl/ limestone facies (d) Sandy to pebbly limestone facies. The Chui Hill section revealed almost entire succession of Lameta Formation that has Infra-trappean field relation with the overlying Deccan basalt. The detailed facies analysis of Lametaghat Formation revealed the deposition

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of fine to medium grained, moderate-well sorted, large scale chevron cross stratified sandstone with tabular bed geometry (Fig. 1a) in shoreface setting. The succession is further overlain by various limestone facies (lower limestone, mottled nodular marl and pebbly limestone) in erosional to gradational contact with presence of jasper, vein quartz, quartzite fragments revealing their origin probably from Precambrian basement. The several trace fossils (*Thalassinoides, Arnicolites, etc.*) in the form of burrows (Fig. 1b) were also recovered from these facies revealing their deposition in shallow marine setting. Gaumukh (Fig. 1c) and Mehadbani Inter-trappean beds (Fig. 1d) revealed a variegated lithology of carbonaceous mud, fissile black shale, limy mud, and chertified limestone with quartz clast, pyrite, Physa and Bivalvia bioclast. The





Fig. -(a) Chevron cross stratified sandstone observed within green sandstone facies. Note the bimodal direction of foreset lamina, (b) Ichnogenus *Thalassinoides* showing Y-shaped branching within sandy to pebbly limestone facies, (c) Exposure showing Gaumukh Intertrappean bed with carbonaceous mud and black fissile shale, (d) Mehadbani Intertrappean bed showing Chertified limestone at northern bank of Narmada river.

carbonaceous mud yielded a large number of tricolporate pollen that showed affinity with the pollen belonging to subfamily Durionaceae. Presence of *Durio* type fossil pollen in the Late Cretaceous sediments of India suggested that the evolution of Durionaceae in the Gondwana continents and their dispersal to SE Asia took place after the initiation of India-Asia collision, thus supporting *Out of India* dispersal hypothesis.

Project 2.11: Cenozoic plant mega remains of northeastern and western India: Palaeoclimatic and phytogeographic significance

PI: R.C. Mehrotra & Co-PIs: Gaurav Srivastava & Anumeha Shukla

A number of plant mega remains were investigated from the Cenozoic sediments of northeast and western India to build up the palaeofloristics and to reconstruct the palaeoenvironment, both qualitatively and quantitatively. For the first time in India, we reported the occurrence of volatile plant metabolites in the amber collected from the early Miocene sediments (~17 Myr) of Mizoram. These volatile plant metabolites served as pollinator attractants and herbivore and pathogen repellents. The preservation potential of volatile plant metabolites in the fossil record is very poor due to their



Fig. – Fossil leaves of *Cynometra* from the Laisong Formation of Phek District, Nagaland.

low boiling points. The occurrence of these volatiles in the early Miocene amber suggests that the plants had evolved metabolic pathways to synthesize these organic molecules to play an active role in forest ecology, especially in plantanimal interactions.



Fig. - Chisochetonoxylon vastanensis from the early Eocene Vastan Lignite Mine of Surat District, Gujarat.



Fig. – *Lagerstroemioxylon deomaliensis* Lakhanpal*et al.* from the Karit Formation (late Miocene) of the Kargil District, J & K.

A quantification of rainfall during the late Miocene–early Pliocene sediments of Mizoram, northeast India using co-existence approach was carried out. The reconstruction indicates that in northeast India both monsoon and pre-monsoon rainfall were present during the late Miocene– early Pliocene, albeit to a lesser extent than at present.

The Vastan lignite mine of the early Eocene age situated near Surat District (Gujarat) is one of the well-dated and fossiliferous lignite mines in western India. A fossil wood, retrieved from this mine, was systematically described that showed a strong resemblance to the modern genus Chisocheton of the family Meliaceae. Plant fossils are the best source to reconstruct the palaeoenvironment of any region, and here a luxurious, highly diverse tropical evergreen forest was interpreted in and around the fossil locality in contrast to the tropical thorn forest of the present day. This early Eocene highly diverse equatorial forest, once covered a significant portion of the Indian Subcontinent, is now restricted in Western Ghats in south India attesting to changes in climate.



Project 2.12: Palynological investigations of Palaeogene and Miocene sedimentary rocks of West and East Jaintia Hills districts, Meghalaya: implications for palaeoclimate and environments of deposition

PI: GK. Trivedi & Co-PI: P.S. Ranhotra

Palynological assemblage recorded from the Jenam Formation (mid Oligocene) was represented by fungi, pteridophytes, gymnosperms, angiosperms and reworked Gondwana palynofossils. The assemblage recovered was dominated by pteridophytes and fungi with two pteridophytic genera, viz. Pteridacidites and Hammenisporis being most dominant ones while Phragmothyrites was the most common fungal genus. The present study records the occurrence of Permian (Indotriradites sparsus, Cuneatisporites radialis) and Early Cretaceous palynomorphs (*Callialasporites* dampieri, C. trilobatus). The reworking of palynotaxa can be related to the second upheaval of the Himalayas that took place at the end of Eocene and the movements associated with this upheaval continued upto earlymiddle Oligocene. The Gondwana sediments would also have been uplifted and exposed, subjecting it to various episodes of erosion, and subsequently to deposit again with the Tertiary sediments. Presently, a small patch of lower Gondwana deposit occurs at Singrimari, West Garo Hills District of Meghalaya forming the possible source area of Permian palynomorphs. The present study also records Early Cretaceous palynomorphs viz. (Callialasporites segmentatus, C. trilobatus.) which might have been totally eroded and redeposited

or may be present in the subsurface. The dominant occurrence of fungi and pteridophytes in palynomorph assemblage indicates moist, warm, humid, and tropical to subtropical climate with fresh water ponding conditions nearby. Presence of pollen of families Arecaeae (*Palmidites, Monocolpopollenites*), Pellicieriaceae (*Pellicieroipollis*) together with reworked Gondwana palynofossils suggest that the deposition may have



occurred in coastal environment. The presence of bisaccate pollen of gymnospermous families like Pinaceae (*Pinuspollenites*) and Podocarpaceae (*Podocarpus*) suggests that topographically elevated areas were present in the north, not far away from the basin of sedimentation and these pollen seem to have derived from these upland areas.



Project 2.13: Analysis of Amber biota from early Palaeogene sedimentary sequences of Gujarat and Rajasthan basins: palaeoclimatic and palaeoecological perspectives

PI: Hukam Singh & Co-PI: R.P. Mathews

Rich and diversified palynofloral assemblages were recovered from the amber succession of Vastan lignite mine (Figs 1, 2). The floral data were analysed for its interpretation in terms of past vegetation and climate of the resin. Recorded assemblage showed that highly dense, mixed evergreen forest existed in this area during early Eocene period. Vegetative entities clearly indicate humid tropical rain forest environment. The documented floral evidences showed low land angiosperm dominated forest ecosystem with sub-dominated pteridophytic vegetational environment during sediment deposition. In the fossil assemblage, dominance of the major constituents of the recovered pollen was arecaceous pollen flora which suggests proximity of the near shore environment. Rich preservation of fungal fruiting bodies supporting tropicalsubtropical humid climatic conditions at the time of deposition evidenced by the presence of rich variable funginites in the amber embedded lignitic petrological studies.



Fig. 1 – a. Lygodiumsporites eocenicus Dutta and Sah, 1970, b. Lygodiumsporites lakiensis Sah and Kar, c. Todiosporites plicatus Sah and Kar, 1969, d. Cyathidites minor Couper, e-f. Anacolosidites trilobatus, g-h. Inapertusporites kedvesii Elisk, i-j. Spinizonocolpites echinatus Muller, k. Detail of Spinizonocolpites echinatus, l. Spinizonocolpites sp., o. Palmipollenites nadhamunii, p. Palmipollenites sp., q. Psilatricolporites sagitatus, s. Pilatricolporites eocenicus, t. Striacolporites.

Fig. 2 – a. Dipterocarpuspollenites retipilatus Kar 1992, b. Symplocoipollenites constrictus Sah and Kar 1970, c. Matanomadhiasulcites maximus Kar, d. Retibrevicolporites matanomadhensis, e. Proteacidites, f. Ctenolophonodites, g. Dermatobrevicolporites, h. Monosuccate pollen, i-z. Varied fungal fruiting bodies.



Project 2.14: Early Palaeogene climatic records and biostratigraphy: Integrative multiproxy approach from South Shillong Plateau (Meghalaya) and lignite-bearing sequences of Rajasthan

PI: Vandana Prasad & Co-PIs: Anupam Sharma & Jyoti Srivastava

The rich assemblage of dinoflagellate cyst, from Giral lignite mine Barmer Basin, helped in the development of early Palaeogene dinocyst biostratigraphy from low latitude. This assemblage was compared with the global dinoflagellate zonation schemes, and a Danian-Thanetian age is proposed to the succession. Within a precise biostratigraphic control, two marine flooding surfaces were identified that can be correlated with the MFS of 60.7 Ma and 57.9 Ma of Eustatic curve. The present study also provided evidence of the earliest occurrence of wetzeliellioid dinoflagellate cyst (Apectodinium) that showed rapid radiation across the globe during the extreme global warming at Palaeocene-Eocene transition. The present A. hyperacanthum dinoflagellate record of the Giral Mine was an approximately 4 My earlier record from that of El Kef, NW Tunisia thus, reinforcing that the Apectodinium dinoflagellate taxon was a tropical plankton that evolved during the early Palaeocene at low latitude and radiated and migrated to mid and high

PI: Poonam Verma & Co-PI: Abha Singh

latitudinal regions across the globe during periods of extreme global warming at Palaeocene-Eocene boundary.

Six palynological cycles were identified in late Palaeocene/early Eocene sequence of East Khasi Hills, Meghalaya that were linked with global eustatic cycles. Pollen diversity values showed their maximum at the cycle boundaries and their minimum in the middle of the cycles. This pattern may be associated with different palynomorph sources during the extreme sea-level positions. When sea level was low, the rivers were having more transport capacity and gather palynomorphs from the ecosystems of the catchment area. In contrast, during the high sea-level phases, pollen and spores were mainly derived from the adjacent coastal ecosystems, usually dominated by mangrove species. In the Palaeocene/ Eocene transition, diversity showed a constant ascending trend which does not link with the cyclicity due to the superimposition of global climatic warming during the transition.

Project 2.15: Biostratigraphy and palaeoclimatic reconstruction of the Tertiary sequences of Gujarat based on palynomorphs and nannofossils

Palynological study from Lumpy Clay Member, Kutch Basin, Gujarat was investigated for biostratigraphy and precise dating. On the basis of integrated record of dinoflagellate cysts and calcareous nannofossils, the succession was dated early Rupelian (~33-31 Ma). The inferred date corresponded to NP 22 to lower part of NP 23 Nannofossils Zone and Upper most part of D13 to D14 (na) Dinocysts zones (Fig.). The palynological assemblage implied that the deposition may have taken place in environments ranging from shallow lagoonal setup, marine to occasionally reworked by oceanic waves.



Fig. – Composite representation of calcareous nannofossils and dinoflagellate cysts ranges and their correlation with standard calcareous nannofossils and dinoflagellate cysts zones, Lumpy Clay Member, Kutch, Gujarat.

Mesozoic Oceanic Anoxic events based on calcareous nannofossils from the Kachchh Project 2.16: **Basin and the Spiti Valley**

PI: Abha Singh & Co-PI: Shailesh Agrawal

Sediment samples were collected especially from the Mesozoic sequences, containing black shales from Kutch and Spiti areas. A total of seventeen samples, from Lidang-Domal road section of spiti area, were prepared and analysed for nannofossils. However, only one sample was found productive and the assemblage was found dominated by the Watznaueria britannica.

Fig. - Exposure of Spiti, Giumal and Chikkim formations near Domal Top.

Project 2.17: Tertiary vertebrate fauna from wetern India: Origin, evolution and palaeobiogeographic aspects

PI: Vivesh Vir Kapur & Co-PI: Prasanna K.

A new insectivore mammal was identified from the early Eocene Cambay shale sediments of western India. This new mammal has been named Bharatlestes kalami after Dr. A.P.J. Abdul Kalam, Former Indian President, for his iconic contributions as an inspirational role model in Science and Technology in India. Bharatlestes belongs to the family Adapisoriculidae and has been the first record of adapisorculids from the Palaeogene of the Indian Subcontinent. Phylogenetic analysis conducted in order to infer relationships of Bharatlestes with known adapsoriculids from across the globe suggested that Bharatlestes was derived relative to the stratigraphically older taxa Deccanolestes and Afrodon and primitive in comparison to European taxa Bustylus and Adapisoriculus. Bharatilestes has been the first record of a Gondwanan mammal in the Cambay shale mammal fauna and it provided evidence for continued survival of a Gondwanan mammal lineage following the Deccan volcanic activity which straddled the Cretaceous-Palaeogene transition in the Indian Subcontinent.

The mammalian record from infra- and intertrappean sedimentary sequences was restricted to the

Fig. - Bharatlestes kalami (holotype, right dentary with in situ p4, m2-m3): (A1) occlusal view; (A2) close-up view inocclusal aspect showing alveoli in front of p4; (B) labial view; (C) lingual view. (refer Kapur et al. 2017a, 2017b).











Fig. – *Bharatlestes kalami*. (A) m3, occlusal view; (B) m3, lingual view; (C) m3, labial view; (D) m2, occlusalview; (E) m2, lingual view; (F) m2, labial view; (G) p4, occlusal view; (H) p4, lingual view; (I) p4, labial view. Scale bar equals 300 μm for all. (refer Kapur et al. 2017a, 2017b).

Maastrichtian successions, and no mammals have been recorded from the Palaeocene inter-trappean sections or any other Palaeocene deposits in India. The fossil data is currently scarce from the Malwa region of west central India in comparison to other parts of Deccan volcanic province. The microfossils (ostracods, charophytes including fish remains) were recorded from intertrappean section near Manawar, Madhya Pradesh which was investigated for biostratigraphic, palaeoecologic and palaeobiogeographic significance. This investigation suggested deposition in a freshwater (palustrine/lacustrine) system connected to a low-energy stream/river and possible Maastrichtian (Late Cretaceous) age for the Manawar section. Palaeobiogeographically, the endemic nature of ostracods recovered from Manawar supports an Indian origin and an Out-of-India migration.



Fig. - Charophyte gyrogonites identified. (A-D) Platychara cf P. perlata Peck and Reker 1947; (A) lateral view (specimen No. MAN/VVK1015), (B) basal view (specimen No. MAN/VVK1016), (C) basal view (specimen No. MAN/VVK1017), (D) apical view (specimen No. MAN/VVK1018); Molluscs identified in this study. (E-G) Viviparus (=Paludina) cf. V. deccanensis Sowerby 1840; (E) abapertural view (specimen No. MAN/VVK1019), (F) abapertural view (specimen No. MAN/VVK1020), (G) abapertural view specimen No. MAN/ VVK1021), (H) Viviparus (=Paludina) cf. V. subcylindracea Hislop 1860 (specimen No. MAN/VVK1022), (I-J) Lymnaea sp.: (I) abapetural view (specimen No. MAN/VVK1023), (J) abapertural view, (specimen No. MAN/VVK1024); (K-M) Valvata minima Hislop 1860; (K) apical view (specimen No. MAN/VVK1025), (L) apical view (specimen No. MAN/VVK1026), (M) apical view (specimen No. MAN/VVK1027); (N) Valvata cf. V. unicarinifera Hislop 1860; abapertural view (specimen No. MAN/VVK1028); (O) Viviparus (=Paludina) cf. V. soluta Hislop 1860; abpertural view (specimen No. MAN/VVK1029); (P) Viviparus (=Paludina) cf. V. wapsharei Hislop 1860, abapertural view (specimen No. MAN/VVK1030); Fishes identified in this study. (Q) Phareodus sp. scale, (specimen No. MAN/ VVK1031); (R-S) Teleost gen et. sp. indet, scale fragments (specimen No. MAN/VVK1032 and specimen No. MAN/VVK1033). Note: Scale bar equals 90 im for A, B, C, G; 60 im for D; 300 im for E, F, H, I, J, K, L, M, O, Q, R, S; 900 im for N; 350 im for P. (refer Kapur et al. 2018).





Fig. - Ostracod species identified. (A-C) Eucypris intervolcanus Whatley and Bajpai 2000a; (A) carapace (specimen No. MAN/ VVK1001) left lateral view; (B) carapace (specimen No. MAN/ VVK1003) right lateral view, (C) carapace (specimen No. MAN/ VVK1002) dorsal view, (D-E) Cypridopsis hyperectyphos Whatley and Bajpai 2000a; (D) carapace (specimen No. MAN/VVK1005) left lateral view; (E) carapace (specimen No. MAN/VVK1004) dorsal view, (F-G) Gomphocythere strangulata Jones 1860; (F) carapace (specimen No. MAN/VVK1006) left lateral view; (G) carapace (specimen No. MAN/VVK1006) dorsal view, (H-J) Gomphocythere paucisulcatus Whatley et al. 2002b; (H) carapace (specimen No. MAN/VVK1007) right lateral view; (I) carapace (specimen No. MAN/VVK1007) left lateral view; (J) close up SEM photo of the surface ornamentation (specimen No. MAN/VVK1007), (K-M) Frambocythere tumeinsis anjarensis Bhandari and Colin 1999; (K) female carapace (specimen No. MAN/VVK1010) right lateral view; (L) female carapace (specimen No. MAN/VVK1010) dorsal view, (M) male carapace (specimen No. MAN/VVK1013) left lateral view, (N-O) Zonocypris gujaratensis Bhandari and Colin 1999: (N) carapace (specimen No. MAN/VVK1014) lateral view; (O) close up SEM photo of the surface ornamentation (specimen No. MAN/VVK1014).

Note: Scale barequals 100 μ m for A, K, M, N; 60 μ m for B, C, L; 90 μ m for D, G, H; 200 μ m for E, F, I; and 30 μ m for J, O. (Refer Kapur *et al.* 2018).

Project 2.18: Miocene terrestrial biota from NW Himalaya: biostratigraphical, palaeoclimatic and palaeobiogeographic aspects

PI: Ansuya Bhandari & Co-PI: Poonam Verma

A reconnaissance field work was carried out in NW Himalaya near Dogadda and Nilkanth (Fig. 1) for palaeontological studies and to locate co-eval horizons in Garhwal Himalaya equivalent to Dagshai-Kasauli. Samples collected from Dogadda, Nilkanth in Garhwal Himalaya, Dagshai-Kasauli in Shimla Hills and Siwalik in Mohand area along the Saharanpur-Dehradun Road were processed for fossils study. So far more than 200 kg samples from Dagshai-Kasauli and Mohand area have been macerated in lab for microfossils (Fig. 2). Further work is in progress.



Fig. - Field photographs of exposures (A&B) near Doggada in Garhwal Himalaya.



Project 2.19: Sedimentology and geochemistry of Tertiary successions of Rajasthan, India: Implications on palaeoenvironment and palaeoclimate

PI: Arvind KumarSingh & Co-PIs: GP. Gurumurthy & Mohammad Arif

The different stratigraphic units namely, Sanu and Khuiala formations were investigated for process based facies analysis and depositional environment. The field investigation of Sanu Formation revealed a total of three lithofacies that were defined as (a) current cross stratified sandstone facies (Cc) (b) thinly bedded ferruginous sandstone facies (Tf) and (c) intensely burrowed sandstone facies (Ib). The presence of wave or current ripple was not observed at any stratigraphic level of facies delineation which suggested that sedimentation may have taken place in conditions devoid of wave or current process. The occurrence of burrows in topmost facies (facies Ib) has close resemblance to Ichnogenus: Thalassinoides. Based on crossbedded sedimentary structure and sediment texture, the lower part of the Sanu Formation has been described as continental aeolian sedimentary deposits whereas thin laminated to horizontal bedding structure with intense burrowing activity in the upper section is interpreted as marginal marine/ lacustrine depositional environment.

The Khuiala Formation was composed of shale, marl, fossiliferous (Bivalve & Gastropods) limestone, foram rich limestone and thick tabular limestone bed in ascending order. The fossiliferous (Bivalve & Gastropods) and foram rich limestone beds were occurring alternately in northwest of Sanu Village whereas in the Ter-takker Village, it was composed of non-

fossiliferous shale and foram rich limestone bed, suggesting its deposition in shallow marine environment. The gradational contact between the Sanu and Khuiala Formation has been identified at Serwa Village section. The samples collected from Sanu and Khuiala formations in Jaisalmer Basin, and Fatehgarh and Akli formations in Barmer Basin, Rajasthan are being subjected to various



Fig. – Standardized litholog of Sanu Formation showing various lithofacies (Facies Cc, Facies Tf, & Facies Ib) delineated based on the sedimentological observation.

geochemical parameters such as organic carbon and nitrogen (through CHNS analyser), δ^{13} C and δ^{15} N (through IRMS), major oxides (through XRF), clay minerals (XRD) and trace elements (ICP-MS). The sample processing is ongoing and data will be generated in the coming months.


Project 2.20: Oligo-Miocene and associated sedimentary sequences of NW Himalaya: Studies on magnetostratigraphy and monsoon intensification and its variability

PI: Binita Phartiyal & Co-PIs: Sajid Ali & Mohammad Arif

Himalayan orogeny still remains an area of vigorous debate and active research and has been an important aspect in national and international palaeoscience studies. This mountain barrier affected the atmospheric circulation over the Asian Continent including the Indian landmass. The model predictions of the future monsoon vary dramatically. There is scarcity of continental geochemical well dated records that explain such monsoon variability in details. We are investigating the monsoon



Fig. – Oriented sample collection from the Subathu, Dagshai and Kasauli formations in H.P. and Palaeosols for magnetostratigraphy and geochemical analysis respectively.

intensification and its variability associated with climate change and Himalayan uplift. A thorough literature survey and a field survey helped us to identify the gaps in areas and do a preliminary sampling and the analysis of which is under progress. More than 150 samples, from Palaeocene–mid Eocene Subathu Formation and Oligocene–Miocene Dagshai & Kasauli formations of the Himachal Pradesh and the Uttarakhand area, were collected and are being studied for magnetostratigraphy, sedimentology and isotope geochemistry. The samples were also collected from Siwalik exposure (Miocene) of

Tanakpur (Kumaun Himalaya) which are presently being investigated for mineral magnetism. These samples are being subjected to grain size, clay mineral, major element, trace element & isotopic analysis. The sedimentological and geochemical processing of these samples will provide the early evolution of the Himalayas and subsequent changes in the region due to climate change and tectonics. Hence, these formations possibly record the history of monsoon initiation and its variation throughout the period of Himalayan orogeny.

Project 2.21: Reconstruction of Indian summer monsoon seasonality during Mid-Miocene PI: Prasanna K. & Co-PI: Vivesh Vir Kapur

Palaeo-seasonality in the southern coastal peninsular India was reconstructed using bivalve fossil *Pitar* (*Hyphantosoma*) simonnei specimens sampled at Pozhikkara. The δ^{18} O in the growth bands was used to reconstruct the palaeo-seawater δ^{18} O using empirical equilibrium temperature δ^{18} O relationships. Applying the two components mixing model, the contribution of freshwater and seawater contribution at the time of Bivalve growth was estimated. This model yielded a distinct wet and dry season in the Indian Subcontinent during the late Miocene /Burdigalian age.



ThrustArea 3:

CHARACTERIZATION OF SOLID FOSSIL FUEL FOR DEPOSITIONAL AND UTILIZATIONAL ASPECTS

Coal Petrology and Organic Geochemistry Group (CPOGG)

Group Coordinator: B.D. Singh

PREAMBLE: The characterization of organic-rich deposits based on multidisciplinary aspects is wellestablished globally both in academic and applied pursuits. Standard methods for the evaluation of deposits for hydrocarbon potential include organic petrological, geochemical and palaeopalynological techniques. These studies demonstrated the importance of categorizing organic matter in sedimentary sequences for its suitability as fossil fuels (solid, liquid & gas) for industrial purpose. The type, amount, association of organic microconstituents, and level of carbonification (rank/ maturation), physical, chemical properties, and the macromolecular composition provide essential information for the evaluation of organic-rich deposits. In addition to these role of climate, environment (marine influence, hydrological changes, fire events, etc.) and depositional conditions (pH/Eh and bacterial activity), during the formation of these deposits can be determined.

An integrated approach (visual kerogen/OM & geochemical) based research is being undertaken on the lignite seams of western India to understand the source of the organic matter and palaeodepositional conditions, which is unique in Indian context. Further, this data has been utilized to assess the potential of these OM-rich sequences as a source of hydrocarbons. Subsequently, comprehensive data on various sequences of Saurashtra, Cambay and Kachchh basins of Gujarat, and Nagaur Basin of Rajasthan have already been generated in recent years. During this year, investigation on the lignite deposits of Gurha (Bikaner Basin) and Sonari (Barmer Basin) mines of Rajasthan has been compiled in relation to their depositional history and hydrocarbons generation potential.

Project 3.1: Understanding the evolution and optimal utilization aspects of western Indian lignite deposits: Organic petrographical and geochemical perspectives

PI: B.D. Singh & Co-PI: R.P. Mathews & Rimpy Chetia (BSRS, w.e.f. 07.02.2018)

The petrographical results (macerals & rank) of the Gurha lignite deposits (Bikaner District, Rajasthan) have been integrated with palaeopalynological (palynomorphs & particulate OM) and organic geochemical (Rock-eval pyrolysis & biomarkers) data. The organic facies, as derived from petrographic indices (GI-TPI, GWI-VI), OM types and biomarkers data indicate that the precursors of woody peat were deposited in dysoxic-suboxic conditions in a proximal setting under limnotelmatic to telmatic regime with mesotrophic to rheotrophic hydrological conditions, with the shift to an anoxic condition in distal setting towards the termination of sedimentation. The *n*-alkane distributions, maximizing at $n-C_{17}$ and $n-C_{297}$, showed inputs from the algal communities along with the higher plant derived OM. Interestingly,



Fig. – Macerals: ulminite (a), detrohuminite (b), sporinite (c), resinite (d-e), cutinite (f), funginite (g) and fusinite (h-i) in Sonari lignite





Fig. – The selected ion chromatogram (m/z 123) showing the sesquiterpenoid (a) and diterpenoid (d) compounds detected in the Gurha lignite samples.

the presence of Araucariaceae and Podocarpaceae pollen grains, along with the tetracyclic diterpane biomarker (derived from conifers), indicates the existence of gymnosperms in otherwise angiosperms dominated source vegetation. The huminite reflectance values (av. 0.29% $R_{\rm r}$) showed good correlation with average $T_{\rm max}$ value (414 °C), indicating immature nature of these deposits. The TOC content ranges from 13-59 wt.%, and HI values vary between 101 and 546 mg HC/g TOC in the samples. Overall, the lignite-bearing sequence is characterized by having types II–III admixed kerogen/OM, and has potential to generate hydrocarbons upon maturation.

The lignites and associated shales, representing 6 seams, from Sonari Mine (Barmer District, Rajasthan) have been subjected to petrographical, palaeopalynological and bulk geochemical studies. The organic compositional studies revealed the dominance of huminite macerals (av. 55 vol.%) and phytoclasts OM (av. 78%), indicating the occurrence of forested vegetation in the vicinity of deposition site. The mineral matter content in lignites ranges from 4-26% (av. 13 vol.%), and mainly represented by clay minerals and pyrite. The palynomorph assembleges mainly represent dominance of pollen grains referable to tropical families. The most abundant angiospermic pollen is mainly referable to palm family Arecaceae. A high CPI (5.03-9.44), TAR (5.09-20.01) and liptinite macerals (mainly sporinite, cutinite and resinite; av. 11 vol.%) values suggest the dominant vegetal



Fig. – GI vs. TPI plot for Sonari lignites indicating the depositional conditions.

inputs of terrestrial higher plants. The tetracyclic compound de-A-fernene has been identified indicating the presence of pteridophytes in the peat-forming vegetation. The petrographic indices and OM types indicate that the precursors of peat were accumulated in marginal dysoxic-anoxic basin conditions under backbarrier control limno-telmatic regime with rheotrophic hydrological conditions, mostly with high tissue-destruction and brackish water influence. Consequently, the moderate content of amorphous OM (av. 18%) and high amount of non-biostructure phytoclast OM along with the constant occurrence of foraminiferal linings and dinoflagellate cysts in the samples reflect a regular marine incursions and the inter-mixing of terrestrial influx in the proximal settings. The deposits have relatively higher abundance of C_{27} and C_{20} *n*-alkane hydrocarbons. Fuel ratio is between 0.77 and 1.32. The gross calorific values (av. 4601 k cal./g) and the T_{max} (av. 412°C) show that the lignites are of immature nature. Overall, the type of kerogen/OM (type III) along with sufficient TOC contents (1.17-54.84 wt.%, av. 24.78 wt.%) and HI values (32-361 mg HC/g rock) indicates the ability of studied lignite-bearing sequences to generate gaseous hydrocarbons. In addition, a field work has been performed (by RPM & RC) in the Barsingsar (Bikaner-Nagaur Basin) and Jalipa (Barmer Basin) lignite mines of Rajasthan. The lignites and associated clay/shale samples have been collected from the exposed mine sections for their integrated evaluation.



ThrustArea4:

QUATERNARY PALAEOCLIMATE RECONSTRUCTION, VEGETATION DYNAMICS AND RELATIVE SEA-LEVEL CHANGES

Quaternary Palaeoclimate Group (QPG)

Group Coordinator: Anjum Farooqui Co-Coordinator: Ratan Kar

PREAMBLE: There are 15 Projects, which encompass almost all the phytogeographic regions of the country; besides, work has also been undertaken from the southeastern Atlantic and Southern oceans, and the Polar regions. From the coastal regions of India, projects are from the southeastern Ghats and southeast coast, from the eastern coast (Sundarbans and Mahanadi deltas) and from the southwest coast (Kanara region and Kerela Coast). The above projects are addressing the Late Quaternary past climatic changes, monsoonal variations and sea-level fluctuations, based on multi-proxy evidences like microbiota (algae, fungi, testate amoeba), pollenspores, sedimentology and geochemistry. From within the Core Monsoon Zone in central India, vegetation and climatic changes during the Late Quaternary are being studied. The Meghalaya Plateau and south Assam plains are the study areas in the Northeast; where past vegetation, climate variability and anthropogenic impact are the focus of studies. Pollen records are being used for reconstructing the Late Quaternary vegetation and climatic changes from Himachal Pradesh and other areas in western Himalaya. Holocene climate variability is being analysed from the eastern Himalaya (Darjeeling), using modern-vegetation-climate relationship with respect to MAT, MAP and other environmental variables. From the Trans-Himalayan region of Lahaul Valley, pollen assemblages are being analysed for the Holocene climatic history and anthropogenic impact on the high-altitude vegetation. Spatio-temporal reconstructions of Holocene climate records are being done through dendrochronology in eastern and western Himalaya. Diatom productivity is being used to deduce Late Quaternary climatic changes from the southeastern Atlantic and Indian oceans; and from Svalbard, the Late Pliestocene-Holocene climate is being deciphered by desmids and spheroidal carbonaceous particles.

Project 4.1: Monsoonal variation during Late Quaternary in South-western Ghats and South-east coast: a Multi-proxy study

PI: Anjum Farooqui & Co-PI: Anjali Trivedi

The data of microbiota (comprised of algae, fungi, testate amoebae) and pollen/spores from surface sediments is scarce from the Western Ghat region and the present study provides detailed account of these indicating the response of microbiota in different substrates with regard to change in atmospheric moisture content. This analogue will be useful in inferring the past ecology, precipitation and the magnitude of monsoonal fluctuations in the region.

The palynological study of honey samples was

compared with the historical records of melittopalynology to infer change in behaviour of honey bees and opting new plants for foraging in the absence or local extinction of the earlier preferred primary plant species.

A two meter sedimentary soil profile collected during the ongoing project from southern part of Cauvery delta (Gaddilam estuary) has been studied. Radiocarbon dates obtained from BSIP Lab. and palynological studies will provide a high resolution relative sea level changes and climatic fluctuations in the area since Middle Holocene to present (Figs 1-2).





Fig. 1 – Testate amoebae from moist substrate in Western Ghats, Coorg District, Karnataka.

1. Centropyxis aculeata 2. C. aerophila 'aerophila' 3. C. aerophila'sylvatica' 4. C aerophila 'sphaginicola' 5. C. ecornis 6. Cyclopyxis kahli 7. Trigonopyxis arcula 8. Heleopera sphaginicola 9-11. H. petricola 12. H. petricola var. amythistea 13. Padaungiella lageniformis 14. Trinema lineare 15. Euglypha 16. Assulina.



Fig. 2 – Diverse pollen assemblage in honey samples from Western Ghats, Karnataka.

 Calophyllum 2. Caesalpinia 3. Diospyros 4. Cardiospermum
 Jasminum simplicifolum 6. Drypetes 7. Fahrenheitia zeylanica
 Grewia 9. Hydnocarpus pentandra 10. Sauropus androgynous
 Lantana camara 12. Maytenus emarginata 13. Radermachera xylocarpa 14. Pseudobombax 15. Bombax ceiba 16. Acacia (wattle)
 Coffea arabica 18. Syzygium subcrenatum 19. Eugenia
 Strobilanthes 21. Camelia 22. Cocos nucifera 23. Mimosa pudica
 Memecylon angustatum 25. Ocimum filamentosum.

Project 4.2: Quaternary palaeovegetation and palaeoclimate reconstruction in relation to monsoonal activity in Meghalaya utilizing a multiproxy record

PI: S.K. Basumatary & Co-PI: Swati Tripathi

Polliniferous materials (25) collected from Meghalaya were analysed and studied for preparing modern analogue to be used for proper identification of pollen recovered from sedimentary soil profiles. A manuscript was prepared on the modern bat guano and subsurface

samples





bat guano and subsurface Fig. - A view of Pinus khasiana forest in Jaintia hills

Pipulbari and Pine Cave of Garo Hills. The palynodata reflected mainly the tropical deciduous forest admixture

from

Fig. - Nepenthes khasiana plant in Jaintia hills

of evergreen and riparian taxa consisting of *Salmalia*, *Terminalia*, *Duabanga*, *Mesua* and *Syzygium* which exactly display the surrounding vegetation.

soil



Pinus pollen



Poaceae pollen

Three climatic phases have been recognized based on the pollen taxa in south-western Garo Hills, Meghalaya, northeast India. In the first phase, around 4000 years BP, the tropical mixed deciduous forest was flourished composing of *Shorea robusta*, *Schima*, *Duabanga* and Salmalia under warm and humid climatic condition in the region. Second phase was observed as similar as the first phase with comparatively low values of arboreal taxa under relatively less warm and humid climatic condition. Lastly, the third phase, around 500 years BP to present, the forest was deteriorated as evidenced by the low value of arboreal taxa. Absence of *Mesua* and *Nepenthes* pollen was also observed in this phase indicating deterioration of forest in the region. A 1.6 meter Brahmaputra River cut section from the Kamalabari Ghat of Majuli Island has been palynologically analysed. The palynodata reflects the three palaeovegetation and climatic changes in the region. (AMS date to be done).

Project 4.3: Late Pleistocene and Holocene climate variability, vegetation response and anthropogenic impacts in southern Assam, northeast India: a multiproxy approach

PI: Swati Tripathi & Co-PI: Sadhan K. Basumatary

Two sedimentary cores of 100 cm deep were procured from northern and southern banks of Hajong Lake situated in Dima Hasao District of Assam. It is the only natural tortoise habitat in the world. The region is occupied by the tropical semi-evergreen forest consisting of Mesua ferrea, Schima wallichii, Syzygium cumini, Barringtonia, Careya, Musa, Anacardiaceae, Aquifoliaceae, Moraceae, Dipterocarpaceae, Sapotaceae and Meliaceae. The study of multi-proxy biotic assemblage such as- pollen/ spore, phytolith and diatom is under progress.

The palynological investigations of surface soil samples collected from Chatla wetland of Cachar District, Assam showed that

Barringtonia acutangula (local name hazel) has dominance over the other tree taxa, further interpretations are in progress. The attempts to trace the signature of major climate anomalies (Medieval Warm Period and Little Ice Age) in Southeast Asia are still sparse, despite the fact that this region contains numerous lakes and wetlands that may hold potential sedimentary archives. Thus, the pollen analyses of soil samples from a 90 cm deep sedimentary core from Chatla floodplain of southern



Fig. - A tortoise lake surrounded by semi-evergreen forest in Dima Hasao district, Assam.

Assam has provided insight into the changing vegetation, climate and anthropogenic influence in the region during the Late Holocene.

Another MS entitled 'Floristic and climatic reconstruction in Indo–Burma region since Late Pleistocene: a palynological interpretation from endangered wetlands of Assam, northeast India'has been communicated to Quaternary Research.



Project 4.4: Vegetation dynamics and climate change from the central Indian Core Monsoon Zone (CMZ) during the late Quaternary: a multi-proxy approach

PI: M.F. Quamar & Co-PI: S. Nawaz Ali

Pollen analysis of the surface samples (30) from the open areas of Raipur-Bilaspur districts of Chhattisgarh, central India has revealed the complete dominance of non-arboreals over the arboreal taxa. Among the arboreals, tree taxa such as *Acacia* sp., Sapotaceae, *Holoptelea* sp., *Symplocos* sp., *Lannea coromandelica* and *Madhuca indica* as well as Acanthaceae, Fabaceae, as shrubby taxa were found in low frequencies. In the assemblage members of Poaceae, among the herbaceous taxa, was higher in frequency, followed by Tubuliflorae, Malvaceae, *Evolvulus* sp., *Cerealia* and other cultural plant pollen taxa such as Amaranthaceae, Caryophyllaceae, *Artemisia*, *Alternanthera*, Brassicaceae and *Cannabia sativa*. The study indicated the cereal-based agricultural practice in and around the area of investigation.

The preliminary investigation of a 1.1 m deep sedimentary profile samples from the Mahasamund District has demonstrated that open vegetation occurred in the region under a cool and dry climate, probably indicating reduced monsoon precipitation. The detailed palaeovegetation and palaeoclimate reconstruction in response to monsoonal variations will, however, be made with the availability of ¹⁴C dates, which are awaited.

Project 4.5: Holocene reconstruction of vegetation, relative sea-level and climate changes through multiproxy analysis: Comparative assessment of Sundarbans and Mahanadi delta, East Coast of India

PI: Shilpa Pandey & Co-PI: Kamlesh Kumar

An extensive field work was carried out to collect surface and sub-surface sediment samples from the different islands located on the Odisha coastline. Surface and sub-surface samples of 1.7 m profile were analysed for pollen/spores to prepare modern analogue and reconstruct vegetational and climate dynamics of the Sundarbans, Ganges-Brahmaputra delta, India. Results of modern pollen rain studies indicated the majority of pollen were from mangrove vegetation that reflected the existing local and nearby vegetation. Pollen of *Rhizophora mucronata*, *Sonneratia*, *Aegiceras corniculatum*, *Excoecaria agallocha* and *Avicennia marina* were represented in abundance, compared to grasses and terrestrial herbs were present in moderate numbers. The palynological results of profile show marked changes in the pollen assemblages, three pollen zones (JH-I –JH-III) were recognized. Zone JH-I was represented by large abundances of different mangrove pollen taxa. Nonmangrove pollen and aquatic pollen were rare. Monolete fern spores were also present in high numbers along with the mangrove fern spore *Acrostichum aureum*. Zone JH-II was characterized by low mangrove pollen taxa; especially core mangroves were recorded in sporadic values and marine elements was also noticed. Zone JH-III indicated a high diversity of mangrove pollen, whereas, herbs were represented by pollen of Poaceae and Chenopodiaceae members. Geochemical analysis of subsurface sediment samples from the Lothian Island, Sundarbans was also completed and interpretation of the results is under progress.

Project 4.6: Reconstruction of Quaternary vegetation, climate change and human impact in Himachal Pradesh by pollen proxy records

PI: Anjali Trivedi & Co-PI: Anjum Farooqui

Surface samples and sedimentary soil profiles were collected from the low altitude areas of Himachal Pradesh (Chandigarh (Punjab), Sirmaur, Shimla (H.P.) and adjoining areas).

About 40 surface samples were collected from different ecological niches (moss cushions, forest soil samples, underwater surface soil samples, etc. from Sirmaur District. Modern pollen analogue and other biotic



forms have been recorded in order to use it for assessing the palaeoclimate and palaeoecological changes. The pollen assemblage shows dominance of arboreals (trees & shrubs) and relatively low frequencies of non-arboreals (herbs) indicating the dominance of tree cover in the region. In the reserved forest area, *Shorea robusta* was dominant species followed by consistent occurrence of *Terminalia* spp., *Dalbergia sissoo, Mangifera indica, Syzygium cumini, Juglans regia* in moderate frequencies. Pollen of Acanthaceae, Fabaceae, *Murraya koenigi, Lantana camara, Saxifraga* sp. represented shrubby vegetation. The study showed that the herbaceous ground flora of the forest floor was less-diversified and largely constituted by grasses (Poaceae) followed by intermittent presence of Asteraceae, Ranunculaceae, etc. However, the sporadic presence of *Artemisia* and members of Chenopodiaceae and Brassicaceae depict the region was influenced by human activities. The appreciable number of taxa such as *Pinus roxburghii*, *Cedrus deodara*, *Picea*, *Abies pindraw*, *Quercus*, *Rhododendron*, *Alnus* and *Betula* in the assemblage suggested their transportation from higher altitudinal region in the area of deposition through wind.

Project 4.7: Reconstructing late Quaternary flora and climate through palaeobiological and molecular data from the Kanara region, SW Coast of India

PI: Jyoti Srivastava & Co-PI: Manoj M.C.

Palynological study was carried out on sediment core retrieved from the continental slope region, 40 km off the SW Coast of India in the south-eastern Arabian Sea. The data was compiled to generate high resolution palynological and chronological record for reconstructing past vegetation during the Pleistocene interglacial/glacial cycles, to correlate the terrigenous input with the sea level changes along the Southwest Coast of India and further compare with other regional as well as global records to understand the teleconnection mechanisms. A higher representation of pollen from tropical rainforest during the Last Glacial Maximum (LGM) indicates that this forest type moved down along elevation, probably due to the

lowered temperature. During the last deglaciation and the early Holocene intervals between 13.5 and 7kyr BP, mangroves were more expanded and tropical rainforests were restricted, suggesting a rising sea level and temperature increase. Mangrove development is controlled by conditions at the river mouth influenced by river discharge. Pteridophytic spores were also abundant in wet conditions which are mainly transported by rivers. During the middle Holocene reduction in mangrove pollen and pteridophyte spore appears to be a result of climate change leading to a decrease in the river discharge. This may have been affected by the decreasing intensity of the southwest monsoon.

Project 4.8: Spatio-temporal reconstruction of temperature and hydroclimatic variability in eastern and western Himalaya based on tree-rings

PI: Santosh Kumar Shah & Co-PI: Ratan Kar

A revised 180 years long (1824–2003 C.E.) treering width chronology toon (*Toona ciliata*) from the eastern Himalaya, showed that mean minimum temperature of winter season (October–February) is the most significant climatic factor for the growth of this tree. Based on the calibration model developed for temperature predictand, this study establishes the dendroclimatic potential of toon to carry out future tree–ring based long– term climate reconstruction in the sub-tropical Himalaya (Fig. 1). Based on the 80 tree core samples of Merkus pine (*Pinus merkusii*) from Lohit District of Arunachal Pradesh, northeast India, a tree-ring chronology was developed. The chronology was correlated with river flow data of Lohit River. River flow for the month of May was reconstructed since 1846 C.E. The reconstruction showed close coherence with homogenous precipitation record of northeast India. For the spatial climate reconstruction (i) the existing tree-ring data of various conifer taxa from western Himalaya was standardized using new technique of signal free standardization, and (ii) various gridded climate data and district wise rainfall data were extracted and formatted and homogenized for the western Himalayan region to establish correlation with tree-ring chronologies.



Fig. – 1. (a) Sampling site of *Toona ciliata*, (b) Tree-ring chronology of *Toona ciliata* extending from 1824 to 2003 C.E. (c) Correlation between chronology of *Toona ciliata* and minimum temperature and (d) Linear regression model for winter temperature along with calibration verification statistics.

Project 4.9: Holocene climate records and ecological response of trees from western Himalaya PI: K.G. Misra & Co-PI: Rajesh Agnihotri

The tree-ring samples of Cedrus deodara and Pinus wallichiana from eleven localities in Lahul-Spiti, Himachal Pradesh were analyzed together and found sensitive to precipitation. Using annually resolved well replicated tree-ring data, 11-month Standardized Precipitation Index of July (SPI11-July) extending back to A.D. 1437 (580 years) was developed. The most peculiar feature of this reconstruction was long drought phase during Little Ice Age (LIA) and 1626 being the driest year followed by 1554, 1705, 1971, 2008 and 1785. In the reconstruction pluvial conditions were noticed in the later part of the 20th Century. Droughts and wet



Fig. - Tree-ring sampling site of Betula utilis in Lahul-Spiti, Himachal Pradesh.

years in the reconstructed series were comparable with other hydrological reconstructions from the cold semi-

arid western Himalayan regions influenced by western disturbances. The long-term drought reconstruction from



the Lahul-Spiti region was very valuable in terms of quantifying the effects of droughts on agrarian economy over the region.

The tree-ring samples of *Betula utilis* and *Juniperus polycorpus* from several high altitude climate sensitive sites from Lahul-Spiti, Himachal Pradesh were processed

and ring-width chronologies developed. The tree-ring chronologies of *Betula utilis* were sensitive to temperature while millennium long *Juniperus polycarpus* chronology had climatic signal of precipitation. The work is in progress. Cross-dating of the tree-ring samples is being going on.

Project 4.10: Holocene climatic history of the Lahaul Valley with special reference to anthropogenic impact on high-altitude vegetation: Evidence from an alpine arid region

PI: Ratan Kar & Co-PI: M.F. Quamar

Extensive traverses along the Chandra Valley, Lahaul, from Battal (near the source of Chandra River) to Tandi (at the confluence of Chandra and Bhaga rivers) were undertaken for surface sampling and identification of potential sampling sites for trenching. Pollen-rain studies were initiated to infer the pollen-vegetation relation with reference to the representation of local and extralocal taxa, and also to decipher the magnitude to anthropogenic activities (farming and grazing) in the area.

Surface pollen assemblages, studied so far, reflect an overall dominance of arboreals over the non-arboreals with a predominance of conifers. The arboreals are recorded in high values and comprise *Pinus*, *Picea*, *Abies*, *Corylus*, *Alnus*, *Betula* and *Ulmus*. Amongst conifers, *Pinus* was predominant and present in high frequencies (47-67%) in all the samples. *Picea* and *Abies* were fairly represented. The temperate broad-leaved taxa were observed in variable frequencies of which Alnus was best represented, followed by Ulmus and Corylus, whereas the occurrence of Betula was low. Non-arboreals were well represented by the taxa growing in the area. Amongst the non-arboreals, Tubuliflorae and Apiaceae were the dominant elements. Other than these, Lamiaceae, Chenopodiaceae, Artemisia, Liguliflorae and Convolvulaceae were present in good amounts. Presence of Caryophyllaceae, Ranunculaceae and Solanaceae were in low values, whereas the occurrence of Poaceae and Rosaceae was rare and sporadic. Ferns, along with fungal and algal spores, maintained consistently low values. The study showed that pollen-rain was not compatible to the vegetation as the extra-local elements, especially *Pinus*, was highly over-represented in all the samples.

Project 4.11: Late Quaternary vegetation and climate reconstructions with reference to glacial history of the western Himalayan region

PI: Parminder Singh Ranhotra & Co-PI: Ruby Ghosh

Modern pollen-vegetation relationship has been developed based on analysis of surface samples (moss and sediments) from the Nachiketa and Mahidanda area (~2000 to 2500 m amsl altitudes) near Uttarkashi, Garhwal Himalaya. The study qualitatively correlates the present pollen and vegetation distribution at this altitude. The studies revealed that Pine pollen were highly represented at both the sites due to its profuse pollen production and long distance transport by valley winds. However, in the oak forest, there was a good representation of pollen from diverse broadleaved taxa like, Alnus, Quercus and Rhododendron. It has been noted that the proportion of oak pollen in surface samples was lower than that of earlier analysis from the same site. This might indicate the decline of oak and increase of fire resistant Pine over time. The presence of pollen

of taxa belonging to timberline and subalpine forests, viz. *Abies, Picea, Cedrus* and *Betula* in both sites might indicate the role of valley wind in transporting pollen from far off areas. The work has been accepted for its publication in the journal Tropical Ecology.

Study has been carried out on vegetation and climate reconstruction covering later part of Pleistocene to Holocene (16,600 to 3,660 cal yrs BP) from Rukti, Sangla Valley, Kinnaur, Himachal Himalaya based on pollen and magnetic susceptibility data, exhibited high and low monsoon phases. Climate was warm-moist during 16,600 to 13,300 cal yrs BP that reverted to cool-dry ~11,466 yrs BP, followed by increasing SWM during early Holocene time ~10,772 cal yrs BP. A dry phase with low monsoon was evident during the 8.5 to 7.8 ka which has correlation with global 8.2 ka cool-dry event.



Along with the pollen studies around 90 tree ring core samples collected from 45 trees of Cedrus deodara growing at Sangla Valley, Kinnaur, Himachal Pradesh was processed and measured for the chronology development in order to understand the climate of past few hundred years of the area on annual resolution basis.

The initial analysis showed that the chronology could cover past 300 years and points towards climate reconstruction. Also the 40 surface samples (moss cushions) collected for developing the modern pollen dispersal scenario of the Sangla area and the sediment samples for the past climate reconstruction and dating are under process.

Project 4.12: Exploring the Holocene climate variability using modern vegetation-climate relationships: Evidence from the eastern Himalayas, India

PI: Ruby Ghosh & Co-PI: Shailesh Agrawal

Potential of a modern pollen-climate dataset from the Darjeeling area, eastern Himalaya, for the past climate reconstructions was assessed. The tested dataset includes 73 surface samples from 25 sites collected from a c. 130-3600 m a.s.l. elevation gradient and 124 terrestrial pollen taxa, which were analysed with respect to various climatic and environmental variables such as mean annual temperature (MAT), mean annual precipitation (MAP), mean temperature of coldest quarter (MTCQ), mean temperature of warmest quarter (MTWQ), mean precipitation of driest quarter (MPDQ), mean precipitation of wettest quarter (MPWQ), AET (actual evapo-transpiration) and MI (moisture index). To check the reliability of the modern pollenclimate relationships different ordination methods were employed and subsequently tested with Huisman-Olff-Fresco (HOF) models. A series of pollen-climate parameter transfer functions using weighted-averaging regression and calibration partial least squares (WA-PLS) models were developed to reconstruct past climate changes from modern pollen data, and were cross-validated. Results indicated that three of the environmental variables, i.e. MTCQ, MPDQ and MI showed strong potential for past climate reconstruction based on the available surface pollen dataset. The potential of the regional quantitative palaeoclimate

Quaternary fossil pollen profile from the Darjeeling foothill region with previously reconstructed and quantified climate. The good agreement with existing data allows for new insights in the hydroclimatic conditions during the Last glacial maxima (LGM) and suggested that

reconstruction was further tested on a Late



present modern pollen-climate relationship for Fig. - Plots showing examples of some significant models for species response to climatic variables like MTCQ (°C), MPDQ (mm) and MI using eHOF response analysis. The horizontal axis represents the climate variable and the vertical axis represents the proportion of the pollen taxa.

the (winter) temperature was the dominant controlling factor for glacial changes during the LGM in the eastern Himalaya.



Project 4.13: Late Quaternary palaeomonsoon and palaeoclimatic reconstruction from the southwest coast of India

PI: Biswajeet Thakur& Co-PIs: Manoj M.C. & Abhijit Mazumder

The sediment core samples from Cherai, Vaduthala and Thavanakkadavu localities of Vembanad wetland were studied for palaeoclimatic and palaeomonsoonal inferences. The multi-proxy study included diatoms, palynofacies, elemental records, dinoflagellate cysts and grain size. The present study based on multi-proxy interactions from late Quaternary backwaters, estuaries and marine sediments from Kerala Coast and Arabian Sea regions was used with profound objective to investigate palaeoenvironmental (palaeomonsoon) changes along the Southwest Coast of India. Also, the evolution of the backwater with respect to sea level and palaeoclimatic changes is still in meagre stage and needs to be established with high resolution inferences based on biological, sedimentological and geochemical aspects in a precise geochronologic framework. The study provided insight to variable climatic fluctuations and anthropogenic responses during the last 2000 yrs as evidenced from Cherai core.



Fig. – Centennial-scale climate fluctuations and warm/cool events during the last 2000 cal yr AD and its relation with the SST record from Southern Okinawa Trough (Wu *et al.*, 2012) *G. Bulloides* % record from Arabian Sea (Anderson *et al.*, 2002) Northern Hemisheric (Arctic) temperature record (Mckay & Kaufman, 2014). Warm periods (RWP, STWP, MWP and CWP) and cool periods (DACP and LIA) are also shown.



Project 4.14: Diatom productivity changes from the upwelling-dominated areas of low to high latitude oceanic regimes over the Late Quaternary: Implications for past climatic changes

PI: Sunil K. Shukla & Co-PI: Prasanna K.

A sediment core from the Benguela Upwelling System (BUS), southeastern Atlantic (25°28' S, 13°05' E) was studied for the size variation of the Southern Ocean diatom Fragilariopsis kerguelensis which was preserved during the glacial period (68-30 ka). This study presented the first record of diatom morphology variations of F. kerguelensis from a mid-latitude core and tested the previous hypotheses proposed for the Southern Ocean. The study demonstrated that the size of *F. kerguelensis* was almost half of the mean size of specimens compared to the Southern Ocean downcore records. Moreover, F. kerguelensis valves were smaller and more abundant during early Marine Isotope Stage (MIS) 3 and conversely larger and less abundant during MIS4 and late MIS3. These observations were however not supported by the linear regression analyses and suggested that iron availability could have mediated the size changes of F. kerguelensis rather than the species productivity during 68-30 ka (Fig. 1).

A 10 m sediment core from the Indian sector of the Southern Ocean was studied for the diatom assemblage to reconstruct the quantitative sea-surface temperature, sea-ice variability and productivity changes over the Late Quaternary. A total of one-hundred and ten samples have been completed for the counting of diatoms and quantitative SST as well as sea-ice presence data has been generated. Rests of the samples are in progress to complete the entire sediment core of 10 m.



Fig. 1 – Size variation of diatom *Fragilariopsis kerguelensis* from the Benguela Upwelling System sediment core during 68-30 ka (A) compared with other proxy records (B-G).

Project 4.15: Late Pleistocene - Holocene climatic changes in the Polar Regions (Arctic & East Antarctica)

PI: Vartika Singh

The study of terrestrial biota can help to understand the impact of climatic changes on the ecosystem and their response to various environmental stresses during Pleistocene - Holocene in the Polar regions. An attempt was made to study the surface sediment of the small water body which is more prone to stresses like freezing and desiccation. The desmids, belonging to the conjugating green algae class Zygnematophyceae have been recovered in abundance from the surface sediment of the small water body in the form of empty semicells. The surface sediment samples from High Arctic region of Kongsfjorden, Svalbard were analyzed for the Spheroidal carbonaceous particles (SCP) in an attempt to document the SCP in the environment other than previously studied inland lakes and snow and also to understand the probable source of industrial atmospheric pollution. The SCP were recovered from the Kongsfjorden surface sediments collected along a transect covering the outer, middle and inner part of the fjord. The SCP were counted and grouped based on their size as small (5-10 μ m) and large



 $(20-50 \ \mu\text{m})$. The large proportion of the recovered SCP was of small size with total count of 223 particles as compared to large sized 113 particles. The observed location wise variation in the recovered SCP was due to the hydrodynamic processes of the Kongsfjorden. The deposition of sediments in the outer part of the fjord was affected by the exchange of water between the shelf and fjord leading to low SCP counts in this part. The inner

fjord region was affected by glacial melt water flow active during the summer season. The middle fjord was relatively less turbulent and thus contains higher number of SCP as compared to both outer and inner fjord. The recovery of SCP in the surface sediments of Kongsfjorden in significant numbers suggests that the region is being affected by atmospherically deposited pollutants originating in far-off industrialized regions.

ThrustArea 5:DOMESTICATION OF PLANTS, EARLY FARMING AND ECOSYSTEM
DYNAMICS DURING HOLOCENE/ ANTHROPOCENE

Geochronology, Archaeobiology and Palaeogenomics Group (GAPG)

Group Coordinator: Rajesh Agnihotri Co-Coordinator: Anil K. Pokharia

PREAMBLE: The Indian subcontinent, today, is one of the most densely populated landmass, diverselinguistically, culturally and genetically. Recent researches coming out of this part of the world are tentatively challenging existing theoretical understanding about divergence of Human populations from the continent of Africa (Kumar & Pappu et al. 2018, Nature). The observed human diversity on the sub-continent could be attributed to amicable and adequate shelters with conducive climatic / environmental conditions that offered life to variety of human populations migrating from place to place right from the Late Pleistocene to prehistoric and historical time periods. Unarguably food is the basic requirement for sustenance of human life, thereby; the first project led by Anil Pokharia is engaged in tracing out past food resources, their temporal variability and antiquity of certain species from archaeological sites of India using statistical analyses of macro-botanical remains (seeds/ grains of various crops). Second project led by Rajesh Agnihotri focuses on retrieving past environmental

(monsoonal) / (vegetational change/ shift in cropping practices) using stable isotopes of carbon and nitrogen. This group also conducts multi-proxy geochemical and stable isotopic analysis of various artefacts/ special objects (e.g. metal jewellery pieces found in the vicinity of archaeological sites to unravel past human prowess and expertise. The third project led by Niraj Rai is engaged in establishing both modern and ancient DNA laboratories at BSIP to trace out ancient movements of human populations within India, shifting economic centres, spread of agriculture and pastoral activities in certain parts of India using 'state of the art' ancient DNA approach. Fourth group led by P. Morthekai is engaged in refining and extending capabilities to provide geo-chronological constraints using optically stimulated luminescence (OSL) dating with minimal uncertainties. Hence, in this thrust area, scientists are working across the disciplines to glean a synergized picture about past human and climate history varying at different temporal scales. Four aforesaid institutional projects are listed below.

Project 5.1: Archaeobotanical analysis of diverse plant food resources and palaeovegetation during 3000 BC-300 AD in the Ganga Plain

PI: Anil K. Pokharia & Co-PI: Anjali Trivedi

The group is involved in analysis of macrobotanical remains of Indian archaeological sites. We analysed macrobotanical samples from Indor-khera (1200 BC-AD 200), Saunphari (600-400 BC; lat long) and Biland-khera (300 BC - 300 AD, lat long) to understand past agricultural pattern operative from 1200 BC to 3rd Century AD and its quantitative evolution in order to compare it with

contemporary cultures. Agricultural economy during this time bracket based on both winter and summer season crops were the mainstay of the plant based subsistence economy. Crop-rotation practice was pursued, enabling the land to yield reasonable quantities of food-grains. Areas studied hardly received any manures or fertilizers and pulses constituted a group of crops of the legume



family which, with the help of bacteria in their root nodules, fix atmospheric nitrogen and improve the soil fertility. A greater variety of plants (crops, weeds and wild taxa) were found during 600 BC- 300 AD at all the above mentioned sites.

Furthermore, ten sediment samples from occupational phases of Biland-khera site (lat long) were analysed to investigate human-plant interaction, vegetation and palaeoecology during the settlement time period. Preliminary palynological investigations revealed dominance of non-arboreal in comparison to arboreal taxa. The cultural pollen, viz. Cerealia (>60 µm), Chenopodiaceae, and Caryophyllaceae with heathland taxa such as Artemisia, Tubuliflorae, Liguliflorae, etc. represent that the region was under extensive agricultural practices. The principal woodland taxa recovered were Acacia sp., Bombax, Syzygium and Aegle. A comprehensive account of palynofacies of surface samples around archaeological site along with lake margins is currently underway (Fig. 1).



Fig. 1–1. Syzygium sp., 2. Aegle mormelos, 3. Bombax ceiba, 4. Acacia sp.,
5. Holoptelea integrifolia, 6. Prosopis sp., 7. Aspidopteris sp., 8. Poaceae.
9. Cerealia 10. Xanthium sp., 11. Brassicaceae, 12. Liguliflorae, 13. Chenopodiaceae, 14. Caryophyllaceae, 15. Ranunculus sp. 16. Fern monolete,
17. Cyperaceae, 18. Nigrospora, 19. Tetraploa.

Project 5.2: Investigating Human culture-climate (monsoon) interactions from Holocene to Anthropocene from the vicinity of archeological sites of north India using multi-isotopic and geochemical tracer approach





Fig. – An evidence of human ritual practice found in the archaeological site at 4MSR Village (Anupgraph District, Rajasthan) in form of five spherical shape lumps.

The group is involved in recovering unwritten history of probably first of the settled life-style of human being, i.e. Indus Valley Civilization and other contemporary human civilizations from the archaeological sites of India and available natural sedimentary archives present in the vicinity using a comprehensive multi-isotopic, geochemical and micro-biotic proxies. Towards this several archaeological sites belonging to Indus era are being studied. For instance, archaeological site Khirsara (Gujarat) was studied using stable C isotopes (δ^{13} C) in tandem with abundance pattern of macro-botanical remains. Chief outcome of the study was to find significant change in crop-type (from barley based cropping system to millet based crops) leading to a significant change in sedimentary δ^{13} C just at the 4.10.1 ka BP globally recognized dry phase of India monsoon (published in Pokharia et al. 2017, Plos One). Recently we found an evidence of human ritual practice found in the archaeological site at 4MSR village (Anupgraph District, Rajasthan) in form of





Fig. – Morphologically, starch grains recorded here could be of Sago palm (*Metroxylon* spp.).

five spherical shape lumps (see Fig. 1). At prima facie, it appeared that some sort of food offering. To the best of our knowledge, no ritual practice of offering food items to God(s) have not been reported yet. In the vicinity of lumps, a bent hand-tool was also found. From chronostratigraphic point of view approximate age of this human activity is the mature phase (2172 to 2555 BCE) Indus era. All five lumps were carefully sub-sampled and analyzed for various tracer analyses involving geochemical, stable isotopic, and organic bio-markers. A portion of lump material was also macerated for investigating micro-biotic proxies (if any) under microscope. EDS based non-destructive chemical composition of lumps revealed a significant excess of Mg and Si. The fossilized lump material was showing signatures of glueyness. Microscopic investigations revealed the remnants of starch material. Morphologically, starch grains recorded here could be of Sago palm (Metroxylon spp.) (see Fig. 2). This plant indicates swampy (wet) conditions along the water body either lentic or lotic. Fine cut marks in uni-direction observed in microscopic plant tissue suggested anthropogenic retrieval of starch through rasping process using the adze (human made tool found near the lumps). We carried out preliminary organic biomarker analysis of the lump material by treating it with methanol (MeOH) and found dominance of starch related compounds corroborating presence of starch material in these lumps. Ancient DNA analyses of clay-lumps are also underway. This study indicates that starch rasping probably was in practice in Indus zone as well, has been found in localities of east-Indies nations (Papua New Guinea, Malaysia, Singapore, Philippines and Cambodia) and tropical Latin American countries, like Venezuela.

(200AD-1200AD). Our aim was to understand the crop

domestication pattern and a direct correlation of climatic

environment with selection of rice varieties over 1000

vears of time interval. We also aim to understand the

domestication, selection and hybridisation of the rice which had led to significant changes in the appearance of plants,

morphology, genetic architecture and their nutritional

Project 5.3: Reconstructing the population history of India using Palaeogenomics

PI: Niraj Rai & Co-PIs: Anil K. Pokharia & Vandana Prasad

The group is establishing an ancient DNA laboratory (along with a modern DNA lab) at BSIP Lucknow. Till the works starts at BSIP, DNA of archaeological remnants are being carried out at CCMB, Hyderabad. Some of its interesting endeavours are shown below.

Successful extraction and sequencing of rice genome from prehistoric Vidnagar Archaeological

Site, Gujarat, India – Vadnagar Town, which has existed for more than 2,000 years now, was built around Sharmishtha Lake and remains of this ancient city found in first phase of excavation indicated that the town extended much beyond what was presumed till date. We had received charred rice grains from ASI, Vadodara Circle which consisted samples from different time scales









Fig. 2. – PCA coordinates of individuals from Roopkund reveals two distinct clusters, one resembling populations along the Indian cline and the other related to modern Europeans and especially people from Greece (used with permission from EadaoinHarney)

value. In order to obtain these differences, an understanding of both past and present cultivation dynamics is required. In this project, we are using cutting edge scientific methods, *e.g.* Genomics, and morphological measurements to reconstruct the cultivation history of a rice in North West of India especially Vadnagar. We have isolated authentic ancient DNA from rice grains (Fig. 1)

Ancient DNA analysis of Roopkund skeletal remains – We are trying to understand the genetics of individuals from Roopkund Pass, in Uttarakhand, where hundreds of skeletons were found at the edge of a lake at an altitude of 5,000 meters. We have sequenced extracted authentic ancient DNA from over 40 individuals from that site and have analyzed the samples genetically. We show the results of this unpublished work here in Fig. 2, showing that all the individuals fall into two distinct clusters. The first group called Roopkund2, are European while the second group, Roopkund1 are part of the Indian cline. We then carbon dated both of these sets of samples to around 1200CE.

Project 5.4: Quantification of errors in dose rate towards accurate and precise age-depth information by combining other chronologies within Bayesian Framework



Any palaeoscientific investigations heavily rely on accurate and precise chronology. Although accuracy is the important aspect, high resolution studies based on many proxy studies demand high precision in the chronology as well. Whenever more than one chronology is available, it becomes very important to know how to combine these chronologies to infer the effective reliable chronology for that particular strata/section. Next challenge is to ascertain each depth with particular age based on the combined chronology.

This project deals with (1) obtaining high precise luminescence age estimates by focusing on the dose rate, (2) synthesize other chronologies with the estimated luminescence age estimates for that strata, and (3) obtain age-depth model for a particular section. Specifically, all the error



Fig. – GEANT4 - a Monte Carlo toolkit will be used to simulate the dose rate from the long lived radioactive nuclides such as U, Th and K in the sediment matrix of different geometries such as potteries, bricks, terra-cota, boulders that are embedded in sediment matrix. GEANT4 will also be used to simulate cosmic ray dose rate. A work station is on its way to implement this work.



analyses and treatments will be done within Bayesian Framework. The schematic diagram below has all the above project objectives are in blue color. As it is mentioned in the schematic diagram (in blue colour), the uncertainties (a) in the measured radioactive nuclides (U, Th and K), (b) in the estimated cosmic ray dose rate, (c) due to the deviation from the infinite matrix assumption (grand average dose rate), (d) because of the fluctuation in water content during burial time, and e) due to disequilibrium in radioactive nuclides in the sediment will be dealt in Bayesian way. A field work in the central Himalaya (near Kunti Banar river upstream) has been proposed. This site is expected that the U and Th radioactive series are in disequilibrium, and a variation in water content because of the lithology difference from the earlier preliminary investigation by the co-PI's sponsored project. One BSRS has been assigned to work in this project and the project is going-on.

ThrustArea 6:GEOCHEMICALPARAMETERSFORCORRELATION,PALAEOCLIMATIC, TECTONIC AND PROVENANCE STUDIES

Inorganic Geochemistry Group (IGG)

Group Coordinator: Anupam Sharma Co-Coordinator: Binita Phartiyal

PREAMBLE: Geochemical and isotopic fingerprinting of various geological and geobiological archives has proven to be an important tool to study the earth surface processes, climate-tectonic interaction and evolving earth's climate through time on orbital and/or tectonic timescales. The abundance variation observed in elemental and isotopic composition of geological and geobiological archives provide vital information on the environmental conditions of sediment genesis, secondary processes that alter the source signatures and the depositional environmental conditions. For instance, sediments form and distribute through different agencies such as glaciers, wind and water and therefore preserves variety of geochemical and isotopic signatures experienced during its transformation under the earth surface conditions. Interestingly, the sediments depositing under various depositional environments also preserve signatures of life systems and modifications brought by them in the sediment characteristics. Hence, the sedimentary archives are widely used to study the earth surface processes, evolving climatic and oceanographic processes, climate-tectonic forcing mechanisms, etc. through time.

In order to retrieve information locked in the geological archives, geochemical parameters including major, trace, rare earth element compositions, stable isotopes and biomarkers need to be measured through state-of-the-art analytical instruments, and interpreted to derive meaningful information pertaining to the processes involved as well as the product produced. The information gathered is clubbed with sediment texture, mineralogy and supported by magnetic and chronological dataset helps to evolve a complete and comprehensive picture of the subject and could be utilized by modelers for prediction, policy formulation and management of resources.

The state-of-the-art geochemical facility (Q-ICP-MS, XRF, GC-MS, IRMS, XRD, LPSA, SEM and Raman spectroscopy) developed at BSIP is successfully catering the needs of the host institute, other national institutes and universities. The institute further operates 'Palaeomagnetism and TL/OSL chronology Laboratories' providing dating services to researchers, academia and industry for credible support. This variety of analytical services unusually rare under one roof.

Project 6.1: Late Quaternary glaciation in Lahaul and Ladakh Himalaya with special emphasis on Zanskar Valley

PI: S. NawazAli & Co-PIs: Anupam Sharma & Binita Phartiyal

The glacial stages are not only asynchronous in the Himalaya, but also show inter-regional variability on centennial to multi-millennial timescales. OSL Samples from Suru and Zanskar valleys were collected for OSL dating to delineate the glacial stages. The OSL ages of latero-frontal moraines suggested that the glaciers





Fig.1 - Representative field photographs from the northwestern Himalaya. Field Photograph a & c showing typical permafrost areas, and (b & d) synoptic view of permafrost slope. The green patches in the photograph represent permafrost thawing.

measurement to understand the link between the Tibet and Indian Himalaya over the last century.

Our careful observations suggest that prominent areas of permafrost exist in the northwestern Himalaya and are under stress conditions (thawing) due to increasing temperature (Figs 1, 2). The continued permafrost degradation/thawing will have a deleterious effect on the water resources that possibly will lead to the lowering of water table, vegetation degradation and desertification. Therefore, this is the high time wherein efforts must be made to locate the permafrost areas with field evidences, generate data covering wider geographical and ecological

responded actively to the cold last glacial maximum (MIS 2). The data analysis of a ~ 1.5 m sediment core from the highest pass of the valley, i.e. Penzi la suggested progressive increase in precipitation during the last ~4 ka in Zanskar Valley.

Further, a kame terrace a dry lake bed located in the north of the Tethyan Himalayan and Central Himalayan section was sampled to study the interregional late quaternary glaciations of Ladakh Himalayan region.

We have also collected pottery, bones, coprolites, materials, which will throw light



figurines and several other Fig. 2 - Field photographs (a-d) taken from Changla (Ladakh) showing permafrost table ~110 cm below the surface.

on the human climate interactions over the last century in Ladakh. The samples are being processed for geochemical, isotopic abundances and human genome

domains of the Indian Himalaya and use multiple parameters that directly or indirectly influence the permafrost.



Project 6.2: Compilation and quantification of climate proxy datasets of Indian subcontinent during Holocene

PI: Trina Bose & Co-PI: Binita Phartiyal

Holocene climate proxy dataset for the Indian subcontinent is being compiled through published literature and from various national/international palaeoclimate research databases. The palaeoclimate data from various geological and geobiological archives (Fig. 1) will be included in the database. The quaternary database is being compiled and programmed as a MySQL project. The web input form is being coded in a PHP-Apache web server. A R-programming based graphic output on website is being designed for implementation. For the first time, a geographical information system (GIS) based space-time integration of palaeoclimate information is being programmed for implementation.



Fig. 1 – A graphical representation of the paleo-archives to be included in the database.

Project 6.3: Process-based palaeoclimatic reconstructions from tree ring cellulose isotope data PI: Trina Bose & Co-PI: K.G. Mishra

The project was formulated in coordination with IRMS and Dendrochronology research groups of the institute. Various improvements to analytical and reconstruction methods were proposed. A laboratory for biomolecular studies was designed with a proposal to include accessory instruments to separate tree rings and other layered samples to extract various biomarker molecules like cellulose, etc. for geochemical and isotopic analysis. A process based biochemical reconstruction model was tested successfully on R programming platform through various modifications to the formulation and interpretations (Fig. 1).



Fig. 1–A normalised temperature reconstructed from ä¹¹⁸O data from *Picea smithiana*, from Kothi, Himachal Pradesh compared with Climate Research Unit data for the region (gray-solid).



Project 6.4: Late Holocene environments and provenance of the western Great Rann of Kachchh sediments, western India

PI: Nitesh K. Khonde & Co-PI: G.P. Gurumurthy

Six manually raised sedimentary cores from western GRK Basin were studied. The sediment cores were subjected to ultra-high resolution XRF scanning, and radiogenic isotope dating (210Pb & 137Cs) for all the cores. However, the chronologic control could not be established due to weak signals and insufficient cores depth to obtain the age of deposition (Fig. 1).

A field trip was conducted to check the feasibility of drilling activity in the western Great Rann of Kachchh

Basin. The field survey has yielded good indirect evidences of the past high sea level stand. The older lithological platform containing large gastropod and bivalve shells was studied to ascertain the age of high sea level. The western GRK along the Lakhpat-Koteshwar road has preserved aeolian accumulation in the form of stabilized and semi-active dunes. One of the large dunes was trenched and sampled for the chronologic and depositional studies from this region.



Fig. 1 – Map showing location of series of sediment cores (yellow pins) collected from western Great Rann of Kachchh. Graphs showing Pb-210 and Cs-137 activity along the depths of each core section.



Project 6.5: Holocene climate and vegetation change from Mahi River Basin mainland Gujarat, India: using multiproxy studies

PI: Kamlesh Kumar & Co-PI: Shilpa Pandey

The geological field campaign has been carried out in mainland Gujarat and adjoining areas in the month of February 2018. Samples were collected from the Lake/Pond from the study area to study the Holocene vegetation and climate change. A 1.3 m deep trench was made near the Muval pond which



Fig. 1– Surface sample collection from peripheral part of the pond and trench sample collection from Muval pond.

was \sim 31 km SW from Vadodara District, Gujarat (22^o 10.483'N; 72^o 57.668' E; Fig. 1). In addition, two sediment cores were also recovered from Kavi estuary and Auranga River. Modern vegetation samples including

grasses, tree leaves and shrubs were also collected during the field trip for stable isotopic measurement at different isohyets to discuss the climate changed induced vegetation shift as a modern analogue to discuss the Holocene climate change effect on vegetation.

Project 6.6: Quantification of human-environment interaction with special reference to Anthropocene epoch



The concept of the 'Anthropocene' is now more than a century old but exists under various guises. Humans are considered solely responsible for the anthropogenic activity and driving forces behind Anthropocene climate change. For the last three hundred years, the percentage of ice-free land area that was wild (50%) and intensively used by humans (5%) became 25% and 55% respectively. A new set of elements of hydrocarbon origin (for e.g., Pb, N, P, Cd, Ni, Hg, Zn) could be used for anthropogenic activity fingerprinting. In general, these elements take airborne transport pathway and their signatures could



Fig. 1 – Field photographs showing sediment sampling in and around Varanasi (a-c), and the down core variation in elemental abundances.

be found in 12% of earth's surface including permanent ice-covered areas. Also, fossil fuel combustion has contributed a lot of black carbon; in-organic ash spheres (IASs) and spherical carbonaceous particles (SCPs) directly into the atmosphere. Distinct changes in both radioactive and stable isotopic signatures can be found in



anthropogenic archives such as sediment deposits from the lakes and oceans.

In Indian context, the studies are meagre and therefore the said multidisciplinary project was proposed in the Central Ganga Plain, because it is most populated and fertile land on the earth having >8000 years human record. To achieve the objectives mainly the characterization of anthropogenic signatures based on geochemical, palynological, isotopic studies and artifacts, a field work was conducted in and around Varanasi City, known as the oldest living city of the world. Sediment cores and exposed sections (three each) were collected. The variety of data (Fig. 1), so far generated on one core and one exposed section is showing significant variation and further work is in progress.

Project 6.7: Investigations of Indian monsoonal variability and abrupt climatic events during the late Quaternary: implications for climate forcing on C3-C4 vegetation



PI: Shailesh Agrawal & Co-PIs: S. Nawaz Ali & M.F. Quamar

High resolution proxy records of precipitation with greater temporal and geographic coverage are essential. For this reason, the proposed research work aims at establishing quantitative reconstruction of ISM and understanding the modern ISR-vegetation relationship through carbon isotope signature. Overall, we plan to make multiproxy (carbon and nitrogen isotope, sedimentology, LOI, magnetic susceptibility) high resolution palaeoclimatic reconstructions with a strong chronology control (luminescence and radiocarbon dating). Towards this, we had located a site for collecting samples for palaeoclimatic

Fig. 1 – Map showing the location of study area and a synoptic view with field photographs of the sampling site.

reconstructions. The study site is a wetland/lake body (Rajaura, Gola Gorakhnath, UP; Fig. 1) with excellent potential for understanding the monsoonal variability and understanding the palaeoclimate of the region.

A pit of ~ 150 cm was excavated and samples were collected at an interval of 1 cm. Further down from 150 cm depth, a core of around ~ 250 cm was raised. The OSL ages have been obtained which range from ~ 10 to 13 ka. Magnetic susceptibility analysis of ~350 samples was carried out and the samples are being processed for stable carbon and nitrogen isotopic measurement. Preliminary result showed that this study will provide new insights on the patterns of climate variability, particularly rainfall and water availability, sources of organic matter and effect of monsoonal precipitation on the ambient vegetation, that are not available in the short as well as long term time scale from the Ganga plain.



Project 6.8: Late Quaternary high resolution palaeoceanography study on north-western Bay of Bengal fan sediment based on foraminifera and their geochemical signature

PI: Pawan Govil & Co-PI: Abhijit Majumder

Monsoon has been reconstructed by using Mg/Ca ratio and δ^{18} O values in selected planktonic foraminifer species from the Equatorial Indian Ocean (Saraswat et al., 2005), Andaman Sea (Rashid et al., 2007), and western Bay of Bengal (Govil et al., 2011). All these studies inferred that SW monsoon was weaker during the last glacial maxima (LGM) time compared to Holocene. The present research work seeks to understand the past sea surface salinity and past sea surface temperature (by using Mg/ Ca ratio from planktonic foraminifera) variations from NW Bay of Bengal (BOB) to evaluate the relationship between monsoon and high latitude climate change. In addition, the past productivity changes of NW BOB and compare these changes with the past productivity records of the northern Indian Ocean.

To achieve the objectives, one marine sediment Core SK-336/3 (Lat: 17°19.332' N 83° 35.934' E; Water Depth: 599 mts; Core Length: 4 mts) recovered from western Bay of Bengal (Fig. 9) was obtained from NCAOR core



Fig. 9 – The location map of marine sediment core No. SK-336/3 from NW Bay of Bengal.

repository in July, 2017. Total ~250 samples at 1-2 cm interval were processed to extract the foraminifera. The main focus of this project was to understand the high-resolution variability of monsoon from NW BOB sediments by using foraminifera and their isotopic (δ^{18} O and δ^{13} C) signatures.





Work other than Institute's Projects

Micropalaeontology of the Early Permian sediments from the Nand–Besur Block, Bandar Coalfield, Wardha Basin, Maharashtra.

The sub-surface samples of bore core NP-75 drilled near Nand Village, a part of Nand-Besur Block of Bandar Coalfield, Wardha Basin, Maharashtra have yielded palynomorphs which include spores/pollen grains and megaspores. The pollen assemblage shows the dominance of the genus Scheuringipollenites and sub-dominance of Faunipollenites (=Protohaploxypinus) along with Caheniasaccites, Plicatipollenites, Potonieisporites, Barakarites, Arcuatipollenites, Striatopodocarpites, etc. Megaspores are represented by three genera and nine species comprising Bokarosporites rotundus, Bokarosporites sp., Jhariatriletes filiformis, Singhisporites baculatus, S. indica, S. nautiyalii, S. radialis, S. surangei and Singhisporites sp. The palynomorph assemblage indicates an early Permian age equivalent to the lower Barakar Formation.

S. Murthy, O.S. Sarate, S.S.K. Pillai & R. Tewari

Micropalaeontological studies of the infratrappean sedimentary deposit (Lameta Formation) from a borehole AL-19 located in the Ashtona Village, Yeotmal District, Maharashtra.

Studied infratrappean sedimentary deposit (Lameta Formation) from a borehole AL-19 located in the Ashtona Village, Yeotmal District, Maharashtra yielded a rich assemblage of pollen, spores and dinoflagellate cysts. The presence of several species of Aquilapollenites, Azolla cretacea, Gabonisporis and marine dinoflagellate *Pierceites* suggests a Maastrichtian age for the Infratrappean deposit. A abundance and diversity of tropical angiosperms in the Upper Cretaceous is possibly linked to the latitudinal shifting of the Indian subcontinent from mid to low latitudes and the prevalence of humid climatic conditions. The numerical abundance of Spinizonocolpites (Nypa), coastal palms, and a large number of peridinioid dinoflagellate cysts in the Infratrappeans suggest a brackish marine depositional setting close to the low-lying coastal rain forest in central India during the Late Cretaceous.

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

Palynofacies, isotopic and biomarker analysis to establish palaeodepositional settings of Permian samples (borehole MGK-6) from the Kachinapalli Block of Godavari sub-basin, south India.

Collaborative work has been done with Dr. Shailesh Agrawal and Runcie Paul Mathews for palynofacies, isotopic and biomarker analysis to establish palaeodepositional settings on samples of Permian age (borehole MGK-6) from the Kachinapalli Block of Godavari sub-basin, south India. Overall, the palynofacies data suggest that the oxidizing environments are replicated by the predominance of gymnospermous pollen, structured terrestrial and charcoal. On the other hand, anoxic conditions are indicated by a high percentage of degraded and amorphous organic matter. Biomarker study shows the presence of *n*-alkane homologous $(C_{15} \text{ to } C_{31})$ with unimodal and bimodal distribution patterns. Biomarker composition reveals that the vascular plants input, as well as the microbially altered organic matter, are the major source in the studied Permian sequence. It is also supported by the carbon preference index (CPI: 0.46 to 2.25).

Neha Aggarwal, Shailesh Agrawal & Runcie Paul Mathews

Palaeoenvironmental reconstruction (based on palynofacies) of freshwater sequences in Lingala-Koyagudem Coalbelt of Godavari Graben.

Palaeoenvironmental reconstruction (based on palynofacies) of freshwater sequences in Lingala-



Fig. – Distribution of the recovered palynofacies from Gundala and Mamakannu sections of Godavari graben in the terrestrial and aquatic ecosystems.



Koyagudem Coalbelt of Godavari Graben reflects the combination of lacustrine and fluviodeltaic depositional environments. The stratigraphic distribution of the four distinct palynofacies assemblages (A-D) indicates their deposition from terrestrial to aquatic ecosystem.

Neha Aggarwal & Biswajeet Thakur

Significant terminal Maastrichtian calcareous nannofossil assemblage was recorded from the road side section near Syndai Village, Meghalaya. The presence of *Micula prinsii* in the productive samples along with the other latest Maastrichtian nanno taxa suggests that the assemblage belongs to Micula prinsii Zone and well correlates with the CC26b Zone of Perch Nielsen and UC 20d^{TP} Zone of Burnett. *Micula prinsii* is the most evolved form of the genus *Micula* and got extinct just



Fig. - Correlation of Latest Maastrichtian nannofossil Zone and changes in bulk ?18O along with studied section.

before K-Pg boundary. Cluster analysis envisaged that in the lower part of the section, high stress conditions prevailed with low surface water productivity. While, in the upper part surface water productivity increased in relatively marginal depositional environment.

Abha Singh & Poonam Verma

Twenty two (22) plant species preserved as Herbarium specimens in Botanical Survey of India, Allahabad were studied under Light Microscope and Scanning Electron Microscope in BSIP, Lucknow. Stomatal index in 8 species of *Bauhinia* leaf was analyzed. Stable Carbon Isotope in these leaf samples has been done. Results indicate the response of plants to progressively increased CO₂ and other environmental changes within a span of last 50-60 yrs. The study is aimed to provide indicative plant species in response to climate change (Global Warming).

Anjum Farooqui, Swati Tripathi & Shailesh Agrawal

CNS studies of lake samples (Nawabganj, Unnao) have been completed to infer the climate fluctuations.

Anjum Farooqui [& Rajesh Agnihotri]

Under the project 2.14, field work has been carried out in the early Palaeogene sedimentary successions of Rajasthan area. During the field excursion Open Cast Lignite mines in Bikaner, Barmer and outcrop sections in Jaisalmer area were visited to undertake detailed study and sampling for palynological and geochemical investigations.

The sediment samples collected from Varanasi are grounded and processed for the biomarker analysis to evaluate the changes in vegetation composition and palaeohydrology during pre and post warming using biomarkers like abundances of *n*-alkanes and *n*-alkane δD .

Manoj M.C. [& Vandana Prasad & others]

Palaeo-seasonality in the southern coastal peninsular India was reconstructed using bivalve Fossil *Pitar* (*Hyphantosoma*) simonnei specimens sampled at Pozhikkara. The δ^{18} O in the growth bands was used to reconstruct the paleo-seawater δ^{18} O using empirical equilibrium temperature δ^{18} O relationships. Applying the two component mixing model the contribution of freshwater and seawater contribution at the time of bivalve growth was estimated. This model yielded a distict wet and dry season in the Indian Subcontinent during the later Miocene /Burdigalian age.

Prassana K.



Collaborative Projects

High spatial resolution morphological and geochemical studies of microfossils from the Chitrakut Formation, Vindhyan Supergroup, central India.

FIB-TEM, FIB-SEM and Nano SIMS investigations of Chitrakoot sample representing base of the Vindhyan Basin have been completed at Bristol University. Over all investigations indicate preservation of true nucleus in the fossil.

> Veeru Kant Singh and Mukund Sharma [& David Wacey (University of Bristol, Bristol, UK)]

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

Major, trace and rare earth element (REE) geochemistry has been carried out to characterize sourcerock weathering and climatic variability of the late Permian Weller Formation and the late Triassic Lashly Formation of Gondwana sequences which have yielded rich record of plant mega- and micro fossils associated with coal beds in post-glacial conditions in Allan Hills of South Victoria



Fig. – Chondrite-normalized REE patterns for Carbonaceous shale (ATP 020) of Wellar Formation and Green shale (ATP238) of Lashly Formation) showing composite T3 & T4 tetrad effect.

Land, Antarctica. The geochemistry suggests dominantly a felsic provenance with a volcanogenic input and role of weathering and hydrothermal alteration. The palaeoclimatic interpretation derived from geochemical analysis indicates warm, temperate and humid conditions during the late Permian, and warm and humid conditions during the late Triassic.

Rajni Tewari, Deepa Agnihotri [& Sankar Chatterjee (Texas Tech University); Sundeep Pandita (Jammu University); N.S. Siddiah (Jawahar Lal Nehru University)].

Palaeobotanical and sedimentological studies on Indian and Sri Lankan basins with special reference to Gondwana flora, their palaeoenvironmental and palaeogeographic implications.

The palynological study on Tabbowa sediments from Sri Lanka reveals predominant Jurassic gymnospermous pollen assemblage (Araucariacites australis, A. cooksonii, A. fissus and Callialasporites dampieri) characteristic of the Callovian-Kimmeridgian age. The collective palynoflora can be correlated with Classopollis-Araucariacites-Shanbeipollenites Assemblage Zone of Africa and Murospora florida Zone of Indian peninsula and Australia, which shows a close phytogeographic relationships during Middle to Late Jurassic periods. Palynofacies studies have been carried out in Tabbowa beds, Srilanka to understand the palaeodepositional environments. Palynofacies-I has been distinguished by the dominance of terrestrial phytoclast (TP) along with sub dominance 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 phytoclast which indicates slow and steady low energy settings such as a marsh or a swamp. Palynofacies-III was distinguished by the dominance of opaque phytoclast (OP) 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 Amorphous Organic Matter (AOM) followed by terrestrial and opaque phytoclasts which represent a reducing (dysoxic to anoxic) environment. Palynofacies and sedimentological studies inferred oxic-dysoxic conditions prevailed when the sediments and phytoclasts laid under shallow brackish water conditions and in a fluvio-deltaic environment.

Neha Aggarwal [& H.A.H. Jayasena et. al.]



Conifers from the Early Cretaceous of the Rajmahal Basin.

Two new conifer taxa assigned to the families Cupressaceae and Podocarpaceae have been described from the intertrappean sediments of the Rajmahal Formation in Jharkhand State. The remains are silicified, composed of sterile and fertile shoots, detached leaves and dispersed seeds. The specimens have been placed under the family Cupressaceae, are described as Hirandubia cupressoides gen. et sp. nov., which shows close affinity with the extant cupressaceous genera Platycladus Spach and Chamaecyparis Spach, and provides the first comprehensive record of Cupressaceae from the early Cretaceous of India. *Elatocladus*-type shoots and detached leaves have also been recovered. In association with the shoot fragments and detached leaves, a new kind of podocarpaceous dispersed seed designated as Podocarpospermum podocarpoides sp. nov., occurs together with a microsporangiate cone Podostrobus rajmahalensis (Rao) Rao and Bose, having in situ bisaccate pollen grains. These remains are all attributed to the family Podocarpaceae and have some similarities to extant Podocarpus L'Herit ex Pers. Based on the occurrence of a diverse range of conifers and Bennettitales in the early Cretaceous flora of Rajmahal Formation interpretation palaeoecology and palaeogeography has been done.

> Amit K. Ghosh, R. Kar, R. Chatterjee, A. Chakraborty [& J. Banerji]

Amending *Welwitschiophyllum brasiliense* Dilcher, Bernardes-de-Oliveira & Et Lott 2005.

Based on optical and SEM studies *Welwitschiophyllum brasiliense* Dilcher, Bernardes-de-Oliveira & Et Lott 2005 has been emended on the following features identified and observed:

The anatomical characteristics are important amendments to the species *Welwitschiophyllum brasiliense* diagnosis. This analysis verified in *W. brasiliense* the presence of new features not previously observed such as sunken stomata on both leaf surfaces; the mesophyll presenting its cells organized into columns (palisade parenchyma) on both sides of the leaf; vascular bundles accompanied laterally by interruptions filled by idiomorphous of calcium oxalate (?) crystals.

The epidermal cells with sinuous anticlinal walls, the sunken stomata, the fibres in the mesophyll, the likely palisade parenchyma and aquifer hypodermis (flattened by the weight of the pressure exerted by sediments deposited on the sheet) are adaptative characters related to low water availability, typical of the palaeoenvironment in which *W. brasiliense* thrived.

A comparison of the anatomical features observed in W. brasiliense, with those of Welwitschiaceae, Bromeliaceae and Agavaceae suggests a near similarity with Welwitschiaceae-based on parallel vascular bundles not convergent in the apex (enabling the longitudinal tearing of the leaf from the apex to the base); the thick hypodermis involving suprastomatal chambers; palisade parenchyma symmetrically present in both sides of the leaf; sunken stomata on both sides of foliar lamina; presence of suprastomatic and substomatic chambers; vascular bundles present in only one row; calcium oxalate crystals (idiomorphs in *Welwitschiophyllum*); tracheary elements with uni or bi seriate circular bordered pits; and with possible gyres of secondary wall helix. The similarities of Welwitschiophyllum brasiliense with Bromeliaceae and Agavaceae are probably foliar convergent evolution adaptative features among these groups.

> Pauline Sabina Kavali [& Bernardes-de-Oliveira & Isabel Cortez de Souza]

Palynological investigations of Serra Alta and Rio do Rasto formations (Passa Dois Group), Serra do Rio do Rastro (White's Column) and Urubici regions in Santa Catarina State, Brazil.

They support the correlation to the middle Artinskian-Wordian Lueckisporites virkkiae Zone in Paraná Basin of Brazil, the Striatoabieites anaverrucosus-Staurosaccites cordubensis Zone of Uruguay and the Lueckisporites–Weylandites Zone of western Argentina. Diagnostic species with a shorter Guadalupian-Lopingian range such as Lophotriletes parryensis, Staurosaccites quadrifidus, Weylandites cincinnatus, Cladaitina veteadensis, Guttulapollenites hannonicus, Protohaploxypinus microcorpus, allowed the



Fig. - Location map of the Serra do Rio do Rastro and Urubici, Paraná Basin, Brazil



Fig. - Vertical distribution of the main taxa in the Serra Alta Formation at Serra do Rio do Rastro.

assignment of the Serra Alta Formation to the Kungurian-?Roadian and the Rio do Rasto Formation to the Capitanian (?Lopingian). These species could be used in future biostratigraphic schemes of the Late Permian if their stratigraphic ranges are assessed in the Paraná Basin and other basins in South America. *Dictyotriletes cousmineri* and *Cladaitina veteadensis* are recorded for the first time from the Brazilian Paraná Basin.

Diverse plant deposits composed of hygromesophylous plant taxa (lycophytes, sphenophytes, ferns, cordaitalean, some pteridosperms), and meso-xerophytic taxa (conifer, some pteridosperms, ginkgoaleans) are recorded in our palynoassemblages of the Serra Alta and Rio do Rasto formations in different frequencies, and also they are present in other palynoassemblages in subsurface samples from Passa Dois Group. They represent in a broad sense, the deciduous forests of the *Glossopteris* Realm in Gondwana developed under cool temperate conditions. In the Paraná Basin, the first *Glossopteris* – *Brasilodendron* Zone of the Rio Bonito Formation. The preservation of diverse plant groups in several deposits of the Passa Dois Group as well as the presence of spores of hygro-mesophyle affinities and pyrite in the exine of palynomorphs in most of the levels of our assemblages in the Serra Alta and Rio do Rasto formations, would reflect seasonally warmer and humid climates favoured by a lower palaeolatitude position and the development of a marine environment extended in the southern region of Brazil in agreement with palaeogeographic reconstructions during the Guadalupian.

Pauline Sabina Kavali [& Mercedes di Pasquo, Paulo A. Souza & Cristina Felix]

Worked with Dr. Paudayal on the plant fossils from the Lower and Middle Siwalik sediments of Surai Khola Section, Nepal. Qualitative as well as quantitative analysis has been done on the floristic assemblage. Qualitative analysis indicates that wet evergreen forest taxa were dominant during the Lower Siwalik, while significant amount of deciduous taxa were present during the Middle Siwalik indicating an increase in the seasonality of rainfall. Quantitative analysis of the floristic assemblage by Coexistence Approach (CA) indicates an increase in



aridity in the dry season (winter season) during the Middle Siwalik in comparison to that in the Lower Siwalik. On the basis of our quantitative analysis we have inferred that the expansion of C4 plants during the Middle Siwalik was most probably due to the weakening of winter rainfall and increase in cold month temperature that increased the possibility of forest fire and promoted the expansion of C4 plants.

Gaurav Srivastava [& Khum N. Paudayal, Department of Geology, Tribhuvan University, Kathmandu, Nepal]

Dr. Tripathi collected some fossil woods and leaves from the Miocene sediments of the Trans-Himalayan region. Of them, one fossil wood was identified as *Lagerstroemia* L. The nearest living relative of the fossil wood is *Lagerstroemia parviflora* Roxb. which indicates that the climate was warm and humid during the deposition of sediments in the fossil locality.

Gaurav Srivastava [& S.C. Tripathi, Geological Survey of India, Southern Region, India]

Recovered and identified macro and micro floral assemblages from the early Eocene sedimentary sequences of Tarkeshwar Lignite Mine (Cambay Basin) Gujarat (Lat 21°22'35" N and Long 73°07'35" E) Surat District, western, India. Plant macro fossils from this area comprise fossil woods, leaves, fruits, seeds, leaf cuticles, etc. The study revealed the occurrence of several phytogeographically significant taxa such as Walsura piscidia (Meliaceae), Ziziphus xylophyrus (Rhamnaceae), Saurauia napaulensis (Actinidiaceae), Calophyllum inophyllum (Clusiaceae), Schleichera oleosa, Drimycarpus racemosus (Sapindaceae), Diospyros pilosula (Ebenaceae), Terminalia tomentosa, T. bellerica, Combretum decandrum (Combretaceae), Lagerstroemia macrocarpa (Lythraceae) and taxa probably belonging to the Cyperaceae, while the palynofloral assemblage comprising mainly angiosperm pollen including Proxapertites microreticulatus, Acanthotricolpites *Proxapertites* cursus, bulbospinosus, Spinizonocolpites prominatus, Longapertites sp., Matanomadhiasulcites maximus, Matanomadhiasulcites kutchensis, Tricolporopollis matanomadhensis, Barringtoniapollenites retipilatus, Lakiapollis ovatus, and Ctenolophonidites costatus. The pteridophytes are represented by *Cyathidites minor*, Todiosporites kutchensis, Dandotiaspora telonata, Lygodiumsporites lakiensis, Lycopodiumsporites palaeocenicus, Dictyophillidites granulates and Laevigatosporites lakiensis. Besides, a few fungal



Fig. - 1. Cyathidites minor, 2. Todiosporites kutchensis,
3. Dandotispora telonata, 4. Lakiapollis ovatus, 5. Lakiapollis ovatus,
6. Lakiapollis ovatus, 7. Proxapertites microreticulatus, 8. Proxapertites cursus,
9. Acanthotricolpites bulbospinosus,
10. Spinizonocolpites prominatus,
11. Longapertites sp.,
12. Matanomadhiasulcites maximus,
14. Tricolporopollis matanomadhensis,
15. Barringtoniapollenites retipilatus,
16. Ctenolophonidites retipilatus,
17. Ctenolophonidites costatus,
18. Callimothallus assamicus,
19. Callimothallus sp. 1,
20. Phragmothyrites eocenica.

remains including *Callimothallus assamicus*, *Callimothallus* sp., *Phragmothyrites eocenica* and *Notothyrites setiferus*, are also present in the assemblage. 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. Dinoflagellate cysts have also been recovered. 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 dinoflagellate cysts along with foraminiferal linings clearly indicate a marine environment, whereas the pollen assemblage of the family Arecaceae is indicative of a near-shore environment (Figs 1, 2).





Fig. 2 – 1-2. *Polyspharedium subtile*, 3-4. cf. *Polyspharedium*, 5. *Lejeunecysta* sp. ind, 6. *Apectodinium* sp., 7. *Apectodinium* sp., 8-9. *Selenopemphix armata*, 10-12. Foraminiferal linings.

Hukam Singh [& Mahesh Prasad retired scientist, BSIP]



fragment of Micromphalites From а (Clydomphalites) clydocromphalus Arkell [M] collected from A4 bed of Jumara, a moderately to poorly preserved nannofossils assemblage was recorded containing Axopodorhabdus cylindratus, Biscutum constans, Braarudosphaera bigelowii, Carinolithus magharensis, Carinolithus sp., Conusphaera sp., Ethmorhabdus gallicus, Lotharingius hauffii, Lotharingius sp., Pseudoconus enigma. Tetrapodorhabdus shawensis, Uniplanarius sp., Watznaueria barnesiae, Watznaueria britannica and Zeugrhabdothus erectus. The assemblage is dominated by the Watznaueria spp. The presence of Biscutum constans (FO 168.28 Ma), Watznaueria barnesiae (FO 168.2 Ma) and Carinolithus magharensis (LO 167.2 Ma) restricts the lower age of the A4 bed within Early Bathonian (168.28 Ma) and the upper age into early Middle Bathonian (167.2 Ma).

The nannofossil assemblage (twenty two taxa) recorded from the Zeilleria Bed (bed C4) shows relatively good preservation and productivity. The assemblage contains Axopodorhabdus sp., Biscutum dorsetensis, Biscutum ellipticum, Crepidolithus crassus, Crepidolithus granulatus, Cyclagelosphaera margerelii, Discorhabdus criotus, Discorhabdus hannibalis, Ethmorhabdus gallicus, Faviconus sp., Lotharingius barozii, Lotharingius contractus, Lotharingius crucicentralis, Lotharingius hauffii, Retecapsa surirella, Stephanolithion bigotii bigotii, Stephanolithion hexum, Watznaueria barnesiae,

> Watznaueria britannica, Watznaueria ovata, Watznaueria sp. and Zeugrhabdothus erectus. The presence of Lotharingius contractus (LO 165.5 Ma), L. hauffii (LO 165.5 Ma) and Stephanolithion bigotii bigotii (FO 164.8 Ma) restricts the age of the Zeilleria Bed (bed C4) between 164.8-165.5 Ma, within latest Early Callovian (NJ12b subzone).

Abha Singh [& Sreepat Jain, Department of Geology, Adama Science and Technology University, Adama, Oromia, Ethiopia]





A study using carbonate distribution within the palaeosol profiles has helped to infer appearance of monsoonal circulation of modern strength in the Himachal Pradesh segment of the Himalayan foreland by at least 20 My ago, cued to the High Himalayan deformation and ongoing Tibetan Plateau uplift and retreat of the Paratethys Sea. The Palaeosol records also demonstrate a decline in chemical weathering with the Himalayan and Tibetan uplift, which was a force for global warming, rather than cooling, over the past 20 My (Retallack *et al.*, 2018).

Vivesh Vir Kapur [& Gregory Retllack, University of Auregon]

The simultaneous oxygen isotope study on modern and Roopkund tooth provides first-hand knowledge about the identity of Roopkund victims. Average diet and water intake of the human buried during the Roopkund catastrophe was identified.

In another study stable isotope ratios water vapour, rainwater and seawater samples from the tropical Indian Ocean and the Southern Ocean sector was used for understanding its dependency on ocean atmospheric parameters. We estimated the fraction of recycled moisture at each location using our observation. The fraction varies from 0 to 33.0% with an average value of $13.4\pm7.7\%$ (Refer: Prasanna *et al.*, 2018; Rahul *et al.*, 2018).

The well-preserved Phygraea (Phygraea) vesicularis shell recovered from Late Cretaceous sediments of the Cauvery Basin was used to determine the past rainfall seasonality pattern on the Indian Coast when the subcontinent was positioned at latitude ~30°S. The observed variations in Cretaceous seawater temperature was 21–37°C and translates to a range in reconstructed water δ¹⁸O from -0.5 to 1.7‰VSMOW. Based on this two end-member mixing model, the seasonal change in freshwater contribution to the Cretaceous estuary ranged from 3 to 31% between summer and winter. Our finding suggests that large-scale atmospheric circulation and seasonal hydroclimate patterns at mid-latitudes during the Cretaceous global warming interval were not substantially different from the present-day (Refer: Ghosh *et al.*, 2018).

Prassana K. [& Anilkumar, Kerala University & Prosenjit Ghosh, IISc]

The geochemical and petrophysical characteristics of shale beds/samples from the Permian Lower Gondwana sequences (Barakar, Barren Measures & Raniganj



Fig. – Relationship between total pore volumes (TPV) normalized to TOC contents and thermal maturity (VR₃%) of studied shale samples.

formations) of Raniganj Basin have been evaluated. The significances of palaeodepositional conditions, thermal maturity, organic-inorganic contents, pore formation, associated pore structures, and resulting porosity / permeability are assessed in respect to the potential shale gas reservoir. The pore dynamics and connectivity between the diverse pore have been modeled through image processing of SEM photographs. The permeability has shown a moderate positive correlation with inorganic content, signifying the clays and minerals host substantial connectivity between micro- to mesopores in the shale beds. The Barren Measures shales have shown larger pore connectivity as compared to the Barakar and Raniganj shales.

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

The petrographical and geochemical features of Barakar Formation (early Permian) coal and associated shale samples from the Auranga Coalfield (Damodar Basin) have been investigated. All the samples have been found in the range of fair to excellent hydrocarbon generation in respect of TOC contents and S2 values (under Rock-eval pyrolysis) with the required thermal maturity (Tmax: coals- 420-426 °C, shales- 409-468 °C). It is observed that the linear relationship of total maceral content with TOC may help in their determination empirically. The regression analysis of macerals indicates the dominant role of alginite, other liptinites (resinite, suberinite, sporinite, liptodetrinite), and vitrinite (perhydrous) in hydrocarbon generation. However, the inertinites may also play considerable positive role. In addition, A-factor (aliphatic/aromatic peak intensity) and C-factor (carbonyl/aromatic peak intensity) under FTIR spectra suggest dominance of kerogen (OM) type III, IV and II/III. The geochemical indices (CIA, CIW & ICV) indicate strong to intermediate weathering, under passive continental margin depositional setting supporting luxurious



vegetation and organic matter preservation in a stable environment.

B.D. Singh [& A.K. Varma & Associates (IIT-ISM, Dhanbad)]

Under Research Training Fellowship of Developing Countries (RTF-DCS) scheme of NAM S&T Centrewoody origin of the OM. A high bacterial activity is evidenced by the abundance of hopanoids in the extractable OM as well as by the amorphous OM. The high measured TOC contents exceeding 20 wt.% in some samples may give an economic value of the organic layers of Saouef Formation, having potential to generate gas upon maturation.



Fig. – Section profile including the variations in TOC, TS, HI and T_{max} values, palynofacies and petrographic compositions, measured reflectance, and the petrographical indices.

DST— The lignite and associated carbonaceous shale samples from the Miocene sequence (Saouef Section in central NE Tunisia) of Tunisia have been evaluated, using petrographic, palynofacies, bulk geochemical, biomarkers and carbon isotope parameters. The depositional condition fluctuated between terrestrial environments with a low water table to the limnic environment. The organic matter (type III-IV kerogens) is derived from higher land plants (e.g. wood, root, bark) from mixed vegetation including conifers and angiosperms, and emerged macrophytes. The dominance of huminite over the liptinite and inertinite maceral groups, along with the phytoclasts, confirms the

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

A study on the relationships between petro-chemical framework, biomarkers and ancient peat-forming ecosystems on samples from the Barka Sayal area of South Karanpura Coalfield (Damodar Basin) has been performed. The n-alkane distribution suggests the formation of the coal deposits in waterlogged conditions. High contribution of submerged or floating aquatic macrophytes along with the higher plants into the peat biomass is inferred. The gymnosperm source as well as the bacterial contribution of organic matter is also



identified. The deposition of the organic matter took place in a relatively oxic basin conditions in a terrestrial setting.

B.D. Singh & R.P. Mathews [& A.K. Singh & Associates (RGIPT, Rae Bareli)]

High resolution palynological study has been carried to infer a millennium to century scale climate fluctuations in the Ganga plain.

Anjum Farooqui [&Pavni Misra, JRF, IIT Kanpur]

Intra Institute collaboration for palynological study in the older sediments (Maastrichtian) and its morphometrical lineage to Quaternary pollen has been published.

Anjum Farooqui [& K. Murthy, O.S. Sarate & Vandana Prasad]

Palynological investigation of two sediment profiles collected from the mouth of the Kharod river along the Gulf of Kachchh has been carried out to reconstruct the mid-Holocene sea-level changes along the Gulf of Kachchh. The study indicates that after the Last Glacial Maximum (LGM), fluvial system became active. The oldest exposed fluvial deposit is optically dated between >15 ka and 9 ka implying that during this period, sea-level was significantly lower (Manuscript is under review).

Shilpa Pandey [& Navin Juyal, Physical Research Laboratory, Ahmedabad]

Investigated the variability of yield of the three main crop cultures, viz. spring wheat, spring barley and oats in the three zones of Khakassia Republic, Russia. It was observed that the dominant pattern in the crops yield is caused by water stress during periods of high temperatures and low moisture supply with heat stress as additional reason. Multifactor linear regression model was developed to estimate climate- and autocorrelationinduced variability of the crops yield. In addition, correlation of the yield variability of the main crops (wheat, barley & oats) with hydrothermal regime and growth of conifer trees (*Pinus sylvestris* and *Larix sibirica*) in forest-steppes were investigated in Khakassia, South Siberia. Based on these results, two-research article were published in *International Journal of Biometeorology*.

S.K. Shah [Elena Babushkina, Khakass Technical Institute, Siberian Federal University, Abakan, Russia]

A 405 years (1611–2015 C.E.) long tree-ring chronology of Blue pine (*Pinus wallichiana*) from Dolpo

area of trans–Himalayan region, western Nepal was developed. Based on linear regression model, February– August drought (scPDSI) was reconstructed for 319 years (1697–2015 C.E.). This reconstruction accounts for 39.4% of the total variance of the actual scPDSI in calibration period. Manuscript submitted.

S.K. Shah [& Dinesh Bhuju & Narayan P. Gaire, Tree-ring Society of Nepal, Ze-Xin Fan, XTBG, CAS, P.R. China]

Twenty-six samples from a 1.3 m core from Chandra Tal, Lahaul-Spiti were palynologically analysed. In general, the qualitative and quantitative representation of sporepollen taxa is not that good, as it is an arid region with sparse vegetation. Nonetheless, pollen-spores are present in the sediments that bring out the changing vegetation in response to climatic fluctuations. Throughout the sequence, an overall dominance of arboreal pollen is observed over the non-arboreal pollen. However, changes in the AP/NAP ratio can be observed across the profile, and four pollen zones have been demarcated in the pollen assemblage from bottom to top. Fifteen surface sediment samples, collected from the periphery of the lake, are further being studied to develop the modern analogues for comparison with the fossil pollen assemblages of the core.

Ratan Kar & Ruchika Bajpai [& A.L. Ramanathan & Monica Sharma (JNU, New Delhi)]

Developed the climate and tree growth relationship using the tree ring chronology of *Pinus roxburgii* and reconstructed relative humidity (RH) for the Pithoragarh region, Kumaon, western Himalaya, in collaboration with the GBPNIHESD, Almora, under DST (NMHSE) program. A consistent and significant positive relationship with precipitation but negative with temperature has been recorded over this region. Reconstructed RH for past 300 years indicates around 57 high and 50 low humidity years. A continuous decline in the relative humidity has been observed during last 35 years which can provide an understanding on the global warming trend over the Himalayan region.

P.S. Ranhotra et al. [& GBPNIHESD, Almora]

Tectonic-climatic-geomorphic-palaeoclimatic model of Kota Kinabalu Valley, Borneo.

The study suggests a tephra layer interbedded within very thick coal beds near Mukah, Sarawak & Borneo. This tephra layer can be considered as regional stratigraphic marker with precise chronostratigraphic control. Systematic sedimentological, mineralogical,





Fig. - Shows occurrence of ash layer interbedded between thick coal seams. (a) depicts the excellent preservation of tephra layer interbedded between very thick sub-bituminous coal deposits, as exposed in a quarry section. The depositional and facies associations (litholog in (a)) are akin to the present day coastal plains. (b) depicts the macroscopic view of a core sample recovered from the region. The absence of any internal sedimentary structure, monotonously uniform color, texture, and contact relationships of the tephra layer can be observed from these photographs. The occurrence of sharp contact between the underlying coal seam and tephra layer ((e) shows few of the glass shards recovered from the quarry section and core samples) suggests a major erosional boundary, enforced by flooding of lowenergy swamps during and/or immediately after the volcanic event. This information, together with the radiometric dating results of the present study implies a sea level rise and the cessation of offshore bypassing of terrestrial sediments as a result of or during the aftermath of the catastrophic volcanic event, which resulted into major changes in climate, tectono-magmatic and depositional-erosional events of the region.

geochemical and zircon U-Pb geochronological studies have revealed a major effusive volcanic event during the latest Middle Miocene, presumably contemporaneous and/ or related to a magmatic event of an earlier phase of the Mt. Kinabalu pluton or magmatism in West Sarawak or East Sabah. The volcanic event had promoted catastrophic flooding of coastal swamps and fall-out from the ash clouds that formed a regionally monotonous tephra layer across the Serravallian- Tortonian boundary. The tephra layer was deposited in a coastal plain-swamp, seasonal, shallow, high-moderate energy, fluvial channel-lacustrine environmental setting, wherein atmospheric fallout and eroded material from regoliths formed over older basement and volcanic rocks of the hinterland which were mixed to produce the tephra layer. Our findings provide robust evidence for the prevalence of intensive chemical weathering under a wet-humid climate, and relative tectonic quiescence before the major effusive event, and the existence of vast, monotonously gently-sloping coastal plains and luxuriant vegetation akin to the present.

Anupam Sharma & V. Prasad

[& Mu. Ramkumar, M. Santosh, R. Nagarajane, S.S. Li, M. Mathew, D. Menier, N. Siddiquig, J. Rai, A. Sharmah, S. Farooqui, M.C. Poppelreiter & J. Lai, (University of South Brittany, France & Periyar University, Salem]

Holocene monsoon evolution in SE Asia (Myanmar) as reflected by the provenance and weathering of Ayeyawady River sediments.

This project deals with the Ayeyawady delta sediments recovered by drill-coring in the delta region. The project aims to track the sediment sources of the delta sediments and its change through the Holocene and reconstruct the sedimentary evolution of the Ayeyawady delta. Another aspect is to reconstruct the Holocene monsoon variability through the Holocene to recent. Various geochemical studies based on major, trace elemental and radiogenic isotope measurements will be employed on the core sediments. Measurement part will be carried out at Tongji under the sanctioned project at Tongji University, Shanghai, China

Nitesh K. Khonde [& Liviu Giosan & Shouye Yang (Tongji University, China)]



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Sponsored Projects

1. Project: "Changes in the biosphere across the transition of Mesoproterozoic-Neoproterozoic succession of Buxa Formation, Sikkim Lesser Himalaya and its correlation with coeval succession" (SR/FTP/ES-151/2014).

PI: Shamim Ahmad

The Buxa Formation, the only remnant of Proterozoic rocks in the Rangit Tectonic Window of Lesser Himalaya (Sikkim region), is considered as Meso-Neoproterozoic succession. There is no direct radiometric date available for this sedimentary succession. To ascertain its age, a high resolution palaeobiological and geochemical investigations of Buxa Formation are being carried out. Trace metal and REE investigation have been carried on bulk rock samples of Buxa Formation. The total REE



Fig. – Chondrite normalised HREE diagram of Buxa Dolomite (Buxa Formation), Sikkim Himalaya, reflecting Europium (Eu) anomaly.

concentration in majority of samples are quite low (<30 ppb), however, a few samples have >250 ppb concentration. The chondrite normalised diagram of REE of the samples of Buxa Formation suggests towards its granitic characteristics with the pattern of enriched in light rare earth elements (LREE) and relatively depleted in heavy rare earth elements (HREE) along with negative 'Eu' anomaly. All the samples are enriched in LREE [(La/Sm) N = 2.88–5.16] and relatively depleted in HREE [(Gd/Yb) N = 1.04–2.80]. The result indicates that analyzed samples belong to the Terminal Proterozoic. C-isotopic evolution also corroborated by oscillations of REE during

the Meso-Neoproterozoic time period in the Lesser Himalaya in Eastern Gondwana.

2. Project: "High-Resolution stable isotopic and geochemical studies of the late Neoproterozoic-early Cambrian Bilara Group, Marwar, Rajasthan to understand the contemporary carbon cycle and the Shuram enigma" (SR/FTP/ES-107/2014).

PI: Arif Hussain Ansari

Four hundred fifty seven samples from seven different open cast mines were analyzed for carbon and oxygen isotope. The carbon oxygen isotope data were compared with Shuram excursion of Oman and Doushantuo Formation of south China. It is found that the carbon isotope curves of Doushantuo Formation and Bilara Group are very close. In Oman's Shuram Formation, carbon isotope suddenly plunges to a value below -10‰ and for a gradually decrease to a long depth before reaching to a value close to 0‰. Whereas carbon isotope curves in the Doushantuo and Bilara have negative excursion alternated with positive excursion. However, in the Doushantuo Formation and the Bilara Group the carbon isotope values also reach up to very low -10‰. Extreme negative excursions noted in the Bilara carbonates may be the part of globally seen extreme negative excursion between Cryogenian and Pc-C boundary. The exact reason of this negative excursion is not clear but our study support the model presented by Rothman et al. (2003) that talked about the buildup of organic matter at the ocean bottom during the anoxic Mesoproterozoic Period and or the period during which oxygen was limited to the surface water. After the Cryogenian Period when oxygen first time reached to the lower reaches of the ocean, it led to oxidation of organic matter and produced carbonate enriched with ¹²C and these processes mostly happened at continental margin situated near atmospheric convergence zone.

Trace metal analysis of the Gotan Limestone and the Pondlo Dolomite samples of Barna II Mine indicate different palaeoenvironmental stages of their deposition (oxic to anoxic). The Sr data are also suggestive of the similar outcome. The Sr⁸⁶/Sr⁸⁷ from the Gotan Limestone suggests an age of this litho unit to be around 570 Ma.


3. Project: "Palaeofloristics of Lower Gondwana sediments of India and Brazil with special reference to palaeowildfire, palaeoecological, palaeoclimatological and biostratigraphical significance" (w.e.f. 1.04.14).

PI: Rajni Tewari & Deepa Agnihotri (Co-PI)

A review work on Lower Gondwana seeds has been carried out to make some inferences about seed size contributions to the ecological comprehension of past floras and to elucidate some questions about seed size evolution. The analyzed data have been derived from Permian sediments of different Indian basins (Talchir, Karharbari/ Barakar and Raniganj formations). Forty six seed types were studied using the volume and area as unit of analysis. The results indicate the increase in the seed size from Talchir Formation to Karharbari/Barakar Formation (Sakmarian/Artinskian). The appearance of large-seeded species in Karharbari/Barakar Formation agrees with changes in vegetational structure proposed by studies based on other plant remains (leaves, roots and woods). The differences between the total seed size and nucellus size were also increased (Study is in progress).

4. Project: DST Inspire Fellowship entitled "Diversity and palaeoecology of the benthic and planktic biotic assemblages from the Neogene sequence of Andaman and Nicobar Islands" (Grant- IF 120842/ 2013-14, from 1st April, 2017 to 29th October, 2017).

PI: Arindam Chakraborty -DST-INSPIRE Fellow & A.K. Ghosh -Project Supervisor

A comprehensive review of siliceous microfossils from Andaman and Nicobar Basin was carried out. The siliceous microfossils of Andaman and Nicobar are represented by diatoms, radiolarians, silicoflagellates, sponge spicules, etc. The siliceous microfossils from the early to middle Miocene outcrops on Havelock Island are poorly preserved and most of them are broken and dissolute. The diatom assemblage is represented by the marker diatom taxon, viz. Cestodiscus peplum that indicates the geological age as late early to early middle Miocene. The age has also been reconfirmed more precisely by marker radiolarians from the RN 4 Zone. Together, the microfossils indicate an age range of 16.4 to ~ 15.0 Ma for the section that are co-relatable with the event of Miocene Climate Optimum (MCO). Abundance and diversity of well preserved siliceous microfossils remarkably increased in the late Miocene sediments as observed in the outcrop samples of Neil Island. The diatom assemblage is represented by Actinocyclus ellipticus,



Fig. - Diatoms (A-R) A. Paralia sulcata (Cave Point Section, Neil Island) B. Stictodiscus nankoorensis (Cave Point Section, Neil Island) C. Azpeitia nodulifera (East Coast Section, Neil Island) D. Actinoptychus senarius (Cave Point Section, Neil Island) E. Grammatophora stricta (South Point Section, Havelock Island) F. Nitzschia reinholdii (East Coast Section, Neil Island) G. Thalassionema nitzschioides (Cave Point Section, Neil Island) H. Diploneis crabro I. Hemidiscus cuneiformis (Cave Point Section, Neil Island) J. Actinoptychus ellipticus (Cave Point Section, Neil Island) K. Actinoptychus ellipticus var. javanica (Cave Point Section, Neil Island) L. Cocconeis pellucida (Cave Point Section, Neil Island) M. Arachnoidiscus ornatus (Cave Point Section, Neil Island) N. Biddulphia tridens (CavePoint Section, Neil Island) O. Triceratium favus (Mus Jetty Section, Car Nicobar Island) P. Grammatophora serpentina (South Point Section, Havelock Island) Q. Grammatophora longissima (South Point Section, Havelock Island) R. Gephvria media var. ornata (South Point Section, Havelock Island) Silicoflagellate (S) S. D. fibula ausonia (Mus Jetty Section, Car Nicobar Island) Sponge spicule (T) T. Orthodichotriaenes (Mus Jetty Section, Car Nicobar Island) Radiolarians (U-Z) U. Solenosphaera polymorpha (Mus Jetty Section, Car Nicobar Island) V. Acrobotrys disolenia (East Coast Section, Neil Island) W. Stichocorys delmontensis (Cave Point Section, Neil Island) X. Didyomocyrtis penultima (EastCoast Section, Neil Island) Y. Calocycletta costata (Kalapathar Section, Havelock Island) Z. Artophormis sp. (Mus Jetty Section, Car Nicobar Island).

A. ellipticus var. javanica, Actinoptychus senarius, Paralia sulcata and Thalassionema nitzschioides indicate a late Miocene age though Actinoptychus senarius, Paralia sulcata and Thalassionema



nitzschioides are still extant. During microscopic observation we also have identified the marker radiolarians of RN 8 and RN 9 zones. In Car Nicobar Island during early Pliocene, the diversity of diatoms is fair with poor to moderate preservation; however, their abundance is reduced in comparison to the radiolarians. The abundance and diversity of diatoms along with other siliceous microfossils from the Zanclean (early Pliocene) sequence is remarkably less in comparison to the Tortonian (late Miocene) sequence exposed in Neil Island of Andaman and Nicobar Islands. The reduced abundance and diversity of siliceous microfossils in the Zanclean may be due to the nutrient deficit condition owing to the closure of Indonesian Throughflow (ITF) and poor sediment influx from the terrigenous sources. This evidence of less silicified organisms in the study area demarcates the event of early Pliocene biogenic silica crash.

The Ph.D. thesis entitled 'Diversity and palaeoecology of the benthic and planktic biotic assemblages from the Neogene sequence of Andaman and Nicobar Islands' submitted in March, 2017 has been awarded by The University of Burdwan in October, 2017.

 Project: National Post Doctoral Fellowship entitled "Investigations on the Mio-Pliocene climate in the Northern Indian Ocean: An integrated micropalaeontological and geochemical approach" (Grant-NPDF/2017/ 000690, from 30th October, 2017 to 31st March, 2018).

PI: Arindam Chakraborty

Analyses on multiple microfossils (diatoms, calcareous nannofossils and radiolarians) have been undertaken on the samples collected from the outcrop exposed in Vijaynagar Village near Kalapathar Beach, Havelock Island of Northern Indian Ocean. The diatom assemblage is represented by the marker diatom taxon, viz. Cestodiscus peplum that indicates the geological age as late early to early middle Miocene. The calcareous nannofossil assemblage also indicates a latest early Miocene to earliest middle Miocene (Burdigalian-Langhian) age based on the presence of characteristic forms of NN 4 Zone. The age has also been reconfirmed more precisely by marker radiolarians from the RN 4 Zone. Together, the microfossils indicate an age range of 16.4 to ~15.0 Ma for the section. Most of the recovered microfossils are indicative of warm water. The age of the outcrop derived from multiple microfossils, *i.e.* calcareous nannofossils, radiolarians and diatoms are corelatable with the event of Miocene Climate Optimum (MCO).



Fig. 1 - (A-T). Commonly occurring calcareous nannofossils from Sawai Bay 'A' Section, Car Nicobar Island, A. Umbilicosphaera foliosa (BSIP Sample no. 7874/01), B. Umbilicosphaera rotula (BSIP Sample no. 7874/01), C. Reticulofenesrta sp. (5-7µm, BSIP Sample no. 7874/ 01), D. Sphenolithus heteromorphus (BSIP Sample no. 7874/01) E. Discoaster pentaradiatus (BSIP Sample no. 7874/11), F. Ceratolithus armatus (BSIP Sample no. 7874/08), G. Calcidiscus leptoporous (BSIP Sample no. 7874/07), H. Pontosphaera multipora (BSIP Sample no. 7874/08), I. Coccolithus pelagicus (BSIP Sample no. 7874/10), J. Helicosphaera carteri (BSIP Sample no. 7874/09), K. Helicosphaera sellii (BSIP Sample no. 7874/02), L. Helicosphaera wallichii (BSIP Sample no. 7874/06), M. Sphenolithus abies (BSIP Sample no. 7874/ 07), N. Scyphosphaera globulata (BSIP Sample no. 7874/05), O. Discoaster surculus (BSIP Sample no. 7874/10), P. Reticulofenesrta sp. (<3µm, BSIP Sample no. 7874/05), O. Cvclicargolithus floridanus (BSIP Sample no. 7874/04), R. Discoaster brouweri (BSIP Sample no. 7874/01), S. Rhabdosphaera clavigera (BSIP Sample no. 7874/ 11), T. Cryptococcolithus mediaperforatus (BSIP Sample no. 7874/ 05).

Analysis of siliceous and calcareous microfossils from the two outcrops of Sawai Bay Formation on Car Nicobar Island, Northern Indian Ocean also has been carried out. Sawai Bay 'A' Section is devoid of siliceous microfossils, however, 23 taxa of well preserved calcareous nannofossils (Fig. 1) belonging to 14 genera have been recovered. Twenty-five taxa of diatoms belonging to 17 genera, 25 radiolarian taxa belonging to 20 genera along with 18 taxa of calcareous nannofossils have been identified from Sawai Bay 'B' Section. The





Fig. 2– A. Planktonic/Benthic ratio of diatoms (Sawai Bay 'B' Section), B. Spumellarian/Nassellarian ratio of radiolarians (Sawai Bay 'B' Section).

diversity of diatoms is fair with poor to moderate preservation; however, their abundance is reduced in comparison to the radiolarians (Fig. 2). The significant diatom taxa are represented by *Azpeitia nodulifera*, *Coscinodiscus radiatus*, *Stictodiscus nankoorensis* and *Triceratium favus*. The significant radiolarian taxa are *Didymocyrtis avita*, *Euchitonia elegans*, *Siphocampe lineata*, *Stichocorys* sp., *Semantis* sp. and *Stylochlamydium* sp. The silicified microfossils are also represented by silicoflagellates and sponge spicules. The diversity of silicoflagellates is less in comparison to the sponge spicules. The sponge spicules are dominated by Astrophorids.

The marker forms of calcareous nannofossils (Fig. 1) clearly suggest a Zanclean age (early Pliocene) for the two outcrops. Occurrence of the marker silicoflagellate Dictyocha fibula ausonia also clearly indicates the age of the sequence as Zanclean. The abundance and diversity of diatoms along with other siliceous microfossils from the Zanclean (early Pliocene) sequence is remarkably less in comparison to the Tortonian (late Miocene) sequence exposed in the Ritchie's Archipelago of Andaman and Nicobar Islands. The reduced abundance and diversity of siliceous microfossils in the Zanclean may be due to the nutrient deficit condition owing to the closure of Indonesian Throughflow (ITF) and poor sediment influx from the terrigenous sources. This evidence of less silicified organisms in the study area demarcates the event of early Pliocene biogenic silica crash.

Samples of the aforementioned work were obtained from the repository of BSIP, Lucknow. Apart from that

offshore samples from the cores of NGHP of Andaman Basin have been procured and chemical processing is in process.

6. Project: "Investigation on phytoplankton diversity and geochemistry of the Miocene – Pliocene sequence from the Andaman and Nicobar Island: its significance in past climate reconstruction" DST-INSPIRE Fellowship (Grant- IF 170181, from 8th November, 2017 to 31st March, 2018).

PI: Stuti Saxena (DST-INSPIRE Fellow, JRF) & A.K. Ghosh (Project Supervisor)

A diatom assemblage represented by the marker diatom taxon, viz. *Cestodiscus peplum* from Havelock Island has been recovered. It indicates the geological age as Burdigalian-Langhian. The calcareous nannofossil assemblage characteristic of NN 4 Zone also indicates the same age.

 Project: "Reconstruction of Miocene to Pleistocene palaeoclimate derived from the studies of silicified and calcified microfossils from Andaman and Nicobar Islands" DST-INSPIRE Fellowship (Grant- IF 170761, from 26th December, 2017 to 31st March, 2018).

PI: Rikee Dey (DST-INSPIRE Fellow, JRF) & A.K. Ghosh (Project Supervisor)

Well preserved radiolarians have been documented from an outcrop of Havelock Island of Ritchie's Archipelago where *Calocycletta costata* is most significant. Based on the occurrence of marker radiolarian taxon *Calocycletta costata* the outcrop is assignable to the RN 4 Zone of Sanfilippo and Nigrini (1998).

8. Project: "Mesozoic fluvial and coastal deposits of Jaisalmer Basin, Rajasthan: palaeoclimatic, palynostratigraphic and palaeobiogeographic implications based on fossil floras" (Grant-SB/ EMEQ-161/2014).

PI: Neelam Das & Raj Kumar

Jaisalmer Basin is the largest basin and is situated in the north-western part of Rajasthan State. Fossiliferous Mesozoic rocks are displayed as isolated outcrops and are represented as Lathi, Jaisalmer, Baisakhi, Bhadesar, Pariwar and Habur formations in ascending order.

Plant fossils are reported for the first time from the new locality of Pariwar Formation – Serawa Village which is about 2 km east of Sanu Village. About 1.5 m thick



sequence of Pariwar Formation is exposed which is comprises mainly of very coarse to gritty sandstone. The lower bed is whitish yellow in color but sometimes variegated in nature medium to coarse grained, micaceous, friable sandstone and sometimes as ironstone. The upper beds are similar to lower ones except the top one which is very hard and siliceous in nature. All the beds are either horizontal or show a very low dip up to 20. A number of plant megafossils of *Ptiliophyllum* are collected from both upper and lower bed. The flora is monospecific type and none of the other plant fossil is found. This section has also yielded nannofossils, viz. Ceratolithoides sp., Cyclagelosphaera margerelii (Noel, 1965), Calculites sp., Diazomatolithus galicinus (Gorka, 1957), Discorahbdus ignotus (Gorkha, 1957), Faviconous multicolumnatus (Bralower, 1989 in Bralower et al., 1989), Laguncula pitcherensis (Rai, 2006), Rhabdophidites sp., Watznaueria biporta (Bukry), W. fossacincta (Black, 1959), W. barnesae (Black, 1959), W. britannica (Stradner) and Prediscoshaera columnata (Stover, 1966) has also been identified which is a cosmopolitan marker, whose FAD marks the base of lower Albian (base of CC8a). Occurrence of nannofossils along with a huge number of plant megafossil indicates small episodes of marine influence near the sea shore.

9. Project: "Palyno-biozonation and palaeoclimatic reconstruction of Permo-Mesozoic sediments, West Bokaro Coalfield, Damodar Basin" (Sponsored by DST, New Delhi, No. No.SB/EMEQ-139/2014).

PI: Srikanta Murthy

Macro and Miofloral analyses of coal-bearing sequences of the Jarangdih Coal Mine, Damodar Basin were carried out to infer the floral diversity, age assessment and the palaeoenvironment during the deposition of Barakar sediments in this area. The Barakar strata of this colliery have yielded a diverse macroflora consisting of the groups Glossopteridales (*Glossopteris, Vertebraria, Gangamopteris,* fructifications and stem casts) and Equisetales (*Phyllotheca indica, Schizoneura gondwanensis* and *Paracalamites* sp.). The genus *Glossopteris* dominates the assemblage with 16 species, viz. *G. arberi, G. communis, G. churiensis, G. giridihensis, G. indica, G. intermedia, G. intermittens, G. linearis, G. leptoneura, G. mohudaensis, G. recurva, G. searsolensis, G.*



Fig. – Palynomorphs recovered from the Barakar Sediments of Jarangdih colliery, east Bokaro Coalfield. (Scale bar for all figures-10µm)

- a. Microfoveolatispora raniganjensis
- b. Microbaculispora barakarensis
- c. Microfoveolatispora media
- d. Barakarites indicus
- e. Scheuringipollenites barakarensis
- f. Scheuringipollenites maximus
- g. Dicappipollenites crussus
- h. Dicappipollenites sp.
- i. Faunipollenites varius.

- j. Striatopodocarpites fusus
- k. Distriatites sp
- 1. Rhizomaspora indica
- m. Alisporites sp.
- n. Corisaccites alutas
- o. Arcuatipollenites ovatus
- p. Lueckisporites virkkiae
- q. Verticipollenites gibbosus
- r. Distriamonocolpites ovalis

stenoneura, *G. taenensis*, *G. tenuinervis* and *G. tenuifolia*. The groups Lycopodiales, Coniferales, Sphenophyllales and Filicales are not represented as macrofloral remains; however, their presence is recorded in the palynoassemblage.

The palynological analysis has revealed only one palynoassemblage which is characterized by the dominance of striate bisaccate palynomorphs mainly *Faunipollenites* and non-striate bisaccate pollen grain *Scheuringipollenites*. The other stratigraphically significant palynotaxa are *Striatopodocarpites*, *Verticipollenites*, *Crescentipollenites*, *Striatites* and *Arcuatipollenites*. The recovered palyno- and megafloral assemblages suggest the late Early Permian (Kungurian) age to the Barakar strata of Jarangdih Coal Mine and prevalence of moderately warm climate during their deposition.



10. Project: "Quantitative reconstruction of the paleogene climate of palaeo-equatorial region based on Indian Palynological records" (MoES/ P.O.(GeoSci.)/36/2014).

PI: Vandana Prasad, Co-PI: Madhav Kumar, Ashish K. Misra (JRF) & Mahi Bansal (JRF)

To underscore the comparative study of 10 Ebenaceae type fossil pollen retrieved from Vastan Lignite Mine, Gujarat and phylogenetic analyses (Maximum likelihood and Bayesian analysis) were carried out based on different statistical models. Pollen morphological data of the 10 fossil pollen and 69 extant species of family Ebenaceae as well as their DNA sequence data. Family Sapotaceae was taken as outgroup. Divergence history was estimated by using the age of the fossils as tip dates to calibrate the Fossil Birth Death (FBD) Model in the BEAST software. The output of the analyses confirms the affinity of recovered fossil pollen to extant Ebenaceae pollen and indicates the origin of the family to be in early Cretaceous ~121 Ma. The reconstruction of pollen character evolution using Ape and Geiger package in R reveals that major pollen characters of the family are synapomorphic and have been evolving conservatively. The study carried out so far opens a broad way to reconstruct palaeobiogeographic history of the plant family Ebenaceae on a global scale.

Besides this, we tried to reconstruct the disputed biostratigraphy of early Cretaceous sediments of Krishna Godavari Basin which is currently positioned at the east coast of Indian peninsula. The basin was once connected with western margin of Australia until it started rifting away from it during early Cretaceous. To define age model for the early rifting history of India and Australia, we analyzed a 54 m thick well cutting sedimentary succession from Dengaru well-1, Krishna Godavari Basin (Provided by Oil India Ltd.) for organic walled foraminifera indicates the depositional conditions to be fairly open marine. The study suggests first transgressive event to occur during early Aptian in KG Basin.

11. Project: "Pliocene Arctic Climate Teleconnection (PACT) Component I (Dinoflagellate and palynofacies study" (MoES/ Indo-Nor/PS-8/2015, 28.06.2016).

PI: Vandana Prasad & Pranav Tyagi (JRF)

In this project sediment core from ODP, Leg-151, 910-C, from Yermak Plateau, North West of Svalbard Archipelago was studied for dinoflagellate cyst. Eighty six samples have been analyzed. Already available biostratigraphy data of calcareous nannofossils and planktonic foraminifers provide information related to the age of the sediments. The diversity and abundance of dinoflagellate cysts are generally low with a relatively high abundance of reworked dinoflagellate cysts. The presence of in-situ peridiniod dinoflagellate cysts and Operculodinium centrocarpum and Operculodinium israelianum indicates temperate warming events during mid Pliocene period. The presence of large number and good preservation of reworked dinoflagellate cysts suggests massive reworking of Cenozoic and Mesozoic marine sediments in the region.

12. Project: "Analysis of the Early Eocene Amber from Cambay and Kutch basins, Gujarat, western India: Palaeoecological, environmental and climatic significance" (Project No. EEQ/2016/000112).

PI: Hukam Singh (Frauke Stebner, Jes Rust, David Grimaldi. Collaborators Bonn University, Germany and American Museum of Natural History NY, USA)

A good amount of insect remains have been recovered from early Eocene Cambay amber from Surat District, Gujarat. These insect remains are analyzed and

dinoflagellate cyst and foraminifera study. A total of two genera and nine species of foraminifera and 14 species of dinoflagellate cysts belonging to 12 genera were identified. Based on last appearance datum (LAD) of foraminifera and dinoflagellate cyst, we concluded that the sedimentary succession corresponds to an early Aptian age. The presence of large number of



ce of large Fig. 1 – Photographs of Palaeognoriste orientale n. sp., holotype male: a) Thorax and head, B). Male planktonic terminalia. C. Habitus, lateral view.





Fig. 2 – Photographs of Lygistorrhina indica n. sp. A) Lygistorrhina indica n. sp., paratype habitus, lateral view. B). Lygistorrhina indica n. sp. paratype.

identified (Figs. 1, 2). One new genus and three new species of Lygistorrhinidae have been reported. Members of the Lygistorrhinidae can be found in tropical to temperate warm forest 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 ecology and distribution of the species remains largely unknown.

13. Project: "Palaeogene vertebrate fauna from the lignite associated sedimentary sequences of western India: Investigations of evolutionary and biogeographic aspects" [DST/SERB Fast Track Young Scientist Project (SR/FTP/ES-49/ 2012)].

PI: Vivesh Vir Kapur

A new insectivorous mammal has been identified from the early Eocene Cambay Shale sediments of western India. This new mammal has been named Bharatlestes kalami after Dr. A P J Abdul Kalam, Former Indian President, for his iconic contributions as an inspirational role model in Science and Technology in India. Bharatlestes belongs to family Adapisoriculidae and is the first record of adapisorculids from the Palaeogene of the Indian Subcontinent. Phylogenetic relationships of Bharatlestes with known adapsoriculids from across the globe suggest that Bharatlestes is derived than older Deccanolestes and Afrodon and primitive compared to European Bustylus and Adapisoriculus. Bharatilestes is also the first record of a Gondwanan mammal within the Cambay Shale mammalian assemblage. Overall, the new data from the early Eocene provide evidence for continued survival of a Gondwanan mammal lineage following the Deccan volcanic activity (Cretaceous-Palaeogene transition) in the Indian Subcontinent.

14. Project: "Geological significance of early Miocene nonmarine fossils from NW Himalaya vis- à-vis their record from eastern Kutch, India" (DST NO : SR/FTP/ES-91/2013 SERB DST Project).

PI: Ansuya Bhandari

The two main fossil localities from which the fossils were collected are Pasuda and Tapar in the Bachau Taluka of central Kutch. In this area, the Khari Nadi Formation overlies the Deccan Traps and is overlain by the Sandhan Formation of Pliocene age. By macerating more than 200 kg samples in lab I enlarged microfossil sample size comprising cyprinid fish teeth, rodent molars, ostracods, gastropods etc from Kutch.

15. Project: "Characterization of glacial lake deposits of the Ladakh range, NW Trans Himalaya: implication to landscape evolution and palaeoclimate" (SR/DGH69/13).

PI: Binita Phartiyal & Co –PI: Anjum Farooqui

About 40 surface sediment samples (pools, streams/ lakes) and one 90 cm sedimentary profile from dug out pit were studied for micro-biotic forms. These include pollen/spores, algae/ diatoms, microscopic fragmentary parts of insects and testate amoebae. Palynological results show similarity in assemblage between 3.4-3.0 ka in the past and present day. The work highlights the progressive aridity since 3.0 ka as the sediments above this is barren indicating absence of micro-biotic deposition either due to shrinking of lake or lack of suitable environment favouring primary productivity. The impact of Global Warming since the last 100 yrs is indicated by rich assemblage of palynomorphs and heterotrophs such as testate amoeba accounting to more than 40%. As these are primary destructors of cellulose, enhanced productivity leading to oligotrophic conditions in the cold arid region of Ladakh is inferred. A manuscript entitled "Microbiota of high altitude glacial lake in Ladakh Range, NW Indian Himalaya: Implications to climate fluctuation during Late Holocene" by Priyanka Joshi, Anjum Farooqui and Binita Phartiyal has been submitted.

16. Project: "Vegetation succession and climate oscillation since late Quaternary from northern Assam, northeast India: a multiproxy analysis" [DST No: SB/EMEQ-225/2014 (w.e.f. 24-07-2014)].

PI - Sadhan Basumatary

The pollen grains have been analysed from a 1.6 m deep Brahmaputra River section of the Kamalabari Ghat



Fig. - Greater One Horn Rhino and Deer in natural habitat in Orang Wildlife Sanctuary, Assam.

in Majuli island. The palynodata reflected the three palaeovegetation and climatic changes in the region. In the first phase, a tropical deciduous forest composed of Salmalia, Albizia, Syzygium and Terminalia was observed under warm and humid conditions in the region. The presence of highland taxa Rhododendron along with evergreen taxa Mesua, Castanopsis and Areca in the palynoassemblage was indicative of the flood activity in the region. The second phase was established with comparatively low value of arboreal taxa such as Syzygium, Dillenia and Salmalia than the first phase. The comparatively high value of *Rhododendron* and evergreen taxa was observed which indicative high flood activity than the preceding phase. The cerealia along with Brassica, Lamiaceae and Coriandrum are suggestive of the human activity in the region. Lastly, in the third phase the deterioration of forest was observed as evidence of the low arboreal taxa. The flood activity was consistent as evidence of the regular presence of Rhododendron pollen in the palynoasssemblage (AMS date to be done).

Studied on pollen and non-pollen palynomoprhs of 25 herbivore (Rhino, elephant, deer and wild buffalo) dung samples collected from the different localities of protected and reserve forest of Assam. The predominance of grass pollen and phytoliths in all dung samples indicates that grasses are the primary diet of these herbivorous animals.



Xanthium

Trilete spore

Lagerstroemia

www.bsip.res.in

The fungal remains especially coprophilous fungal spores namely *Sporormiella*, *Saccobolus* and *Gelasinospora* were observed consistently from the studied dung samples. This modern database might be a strong baseline to interpret the palaeoherbivory analysis in relation to the megafaunal extinction during Quaternary period in the region and to correlate in global level.

17. 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).

PI: Swati Tripathi

Pollen and non pollen palynomorphs analyses of 16 dung samples of two endangered deer species namely Sangai (Rucervus eldii eldii M'clelland) and Hog (Axis procinus Zimmermann) deer was undertaken from Keibul Lamjao National Park of Manipur, northeast India, to examine the preferences in dietary habit in relation to the present vegetation and ecology of the region. The summer and winter dung samples were studied systematically to display their dietary habits in relation to the seasonal variability and phenology of the extant vegetation. The grass is the primary food for both deer species, though, it is obvious, and our generated dataset also supports this, as evidenced by the abundance of grass pollen and phytoliths in the assemblage. The marshy and aquatic taxa are observed and indicative of the important dietary plants for their survival as well as perennial water logged condition in the region. The relative abundance and diversity of arboreals in the summer dung samples coheres with the extant vegetation, where most of the arboreal taxa are in full bloom during summer season.









Fig. - Major pollen and NPPs in deer dung samples.

Besides, a paper entitled 'Vegetation history, monsoonal fluctuations and anthropogenic impact during the last 2330 years from Loktak Lake (Ramsar site), Manipur, northeast India: a pollen based study'has been published in Palynology (Taylor & Francis).

18. 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).

PI: M.F. Quamar

The study carried out on sedimentary profiles from Jammu region has provided significant insights into the vegetation dynamics and associated climate change influenced by the variations in ISM precipitation during the last ~8.5 ky. Mixed conifer/broad-leaved forest generally occupy the region in alternation with the mixed broad-leaved/conifer forest under cool-dry and warm and humid climatic conditions, respectively. Pluvial environments, however, have also been observed on the basis of acute scarcity of pollen grains and simultaneous prevalence of sandy deposits in the respective lithocolumns of the sedimentary pollen profiles in the study areas around 10.6 ka and 3.9 ka. Furthermore, the palaeoclimatic inferences drawn have found signatures of the Holocene Climatic Optimum (HCO) (7000-4000 yr BP) and Medieval Warm Period (MWP) (750-1200 AD).

19. Project: "Mangrove dynamics and relative sea level changes during Late Quaternary in Godavari Delta" (SR/FTP/ES-84/2014).

PI: Jyoti Srivastava

Pollen in the surface sediment collected in a transect from sea to land in the Coringa mangrove wetland was analyzed to determine the spatial and quantitative composition of the pollen record for palaeoecological interpretation. Autochthonous pollen preservation of the existing mangrove species was predominant in the sediments and serves as a potential indicator of coastal wetland. The low quantity of allochthonous and parautochthonous pollen in the sediment reflects the regional plant community. Statistical analysis of the palynological data shows a high association between pollen from Avicennia marina, Clerodendrum inerme and their vegetation. Aegiceras corniculatum, Sonneratia, Ceriops decandra, Xylocarpus mekongenesis, Cocos nucifera, Azadirachta indica, Syzygium, Chenopodiaceae, Poaceae, and Cyperaceae show over representation. Ordination techniques for individual species using fidelity and dispersibility indices and regression analyses suggest four different floristic groups of (1) High dispersibility-moderate fidelity taxa; (2) High dispersibility-low fidelity taxa; (3) Moderate dispersibilitylow fidelity taxa; (4) Low dispersibility-high fidelity taxa. Species with high fidelity and moderate-low dispersibility indices could be used to identify the vegetation types in sedimentary sequences. The presence of discriminatory taxa (Avicennia marina, Sonneratia sp.), even in small quantities help in accurate identification of the local vegetation. Results indicate that while mangrove pollen is transported over short distances, non-mangrove pollen and spores are transported from longer distances. Thus, the status of mangrove and non-mangrove pollen in the sediments provides a clue to the (palaeo) coastal ecology and the (palaeo) climatic conditions.

20. 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).

PI: S.K. Shah & U. Pandey

Finalised development of 24 tree-ring chronologies of various conifer taxa (*Abies pindrow*-17; *Cedrus deodara*-3; *Picea smithiana*-2 and *Pinus wallichiana*-2) from Kashmir Valley, northwest Himalaya using signal free standardized technique. The response of climate (temperature, precipitation and drought) on tree-ring





Fig. – Reconstructed 4-month average (April-July) discharge for the Shingo River, that drains the Upper Indus River Basin for 243 years (1760–2002 C.E.) using composite tree-ring chronology of *Abies pindrow* of Sindh valley. This long-term reconstruction is coherent with the river flow proxies at other sites from the Upper Indus Basin and tree-ring based precipitation records from the Kashmir Valley.

chronologies was established to select suitable predictands for reconstruction.

Reconstructed 3-months total (April-June) precipitation since 1723 C.E. for the Lidder (Liddar) Valley, Kashmir, northwest Himalaya using composite tree-ring chronology of *Cedrus deodara*. The reconstruction shows a prolonged driest period between 1822-1887 C.E. The wettest period occurred during the early nineteenth century and latter part of the twentieth century. The reconstruction was compared with documented extreme flood, famines and drought events in Kashmir Valley occurring in past. The impact of westerlies in the precipitation patterns was evident in analysis of composite 500 mb height-anomaly. Furthermore, the reconstruction was validated through comparison with independent records and spatial correlation with gridded drought and precipitation.

Reconstructed 4-months average (April-July) discharge for the Shingo River, that drains the Upper Indus River Basin for 243 years (1760–2002 C.E.) using composite tree-ring chronology of *Abies pindrow* of Sindh Valley. This long-term reconstruction is coherent with the river flow proxies at other sites from the Upper Indus Basin and tree-ring based precipitation records from the Kashmir Valley.

Final progress report compilation is in progress.

PIs: K.G. Misra, R.R. Yadav & Vikram Singh

The collected tree-ring samples of *Cedrus deodara*, from various climate sensitive steep slope sites to develop high resolution long term snowfall pattern over the Lahul-Spiti region, Himachal Pradesh were analysed. Using well replicated tree-ring samples of *Cedrus deodara* snowfall reconstructed extended back to ~ six centuries. The reconstruction showed annual to decadal scale variability in snow-fall. The reconstruction is very useful for society as snowmelt is prime source of water for socioeconomic needs.

22. Project – "Investigation of high altitude climate variability during Holocene around Hamtah Glacier, Lahaul-Spiti, western Himalaya, India" (DST-Women Scientist Scheme, No. SR/WOS-A/ EA-1018/2015).

PI: Ruchika Bajpai (& Ratan Kar, Mentor)

To understand the pollen-vegetation relationship in the region surface samples were analysed in order to estimate the extent of occurrence of various taxa of the present vegetation prevailing in the pollen rain. Arboreals are well represented by conifers and broad-leaved elements, while the non-arboreals are represented by taxa growing in the vicinity of the study area. The arboreals recorded are Pinus, Abies, Picea, Cedrus, Alnus, Corylus, Betula, Ulmus and Rhododendron. Amongst the conifers, Pinus represents the highest frequency with values ranging from 55-81%. Abies is also well represented in good frequencies (3-10%); Picea ranges from 1-8%; whereas, representation of Cedrus is sporadic. The temperate broad-leaved taxa are observed in variable frequencies of which Alnus (3-5%) and Ulmus (2-3%) are present in good amounts. Corvlus and Betula occur infrequently and the representation of Rhododendron is extremely low. Non-arboreals are represented by members of Lamiaceae, Papaveraceae, Rosaceae, Poaceae, Apiaceae, Ranunculaceae, Convolvulaceae, Polygonaceae, Brassicaceae, Euphorbiaceae along with other steppe elements including Asteraceae, Chenopodiaceae, Artemisia and Ephedraceae. Most frequently occurring non-arboreals are members of Lamiaceae (1-6%) and Rosaceae (1-6%). Ferns are represented in lesser amounts (0.7-2.1%) along with algal and fungal spores. The results show a



strong incompatibility of the pollen assemblages with the present vegetation in the study area.

23. Project – "Tree-line shifts, climate change and anthropogenic impact during the Holocene from Chopta-Tungnath region, Garhwal Himalaya, India" (CSIR-UGC NET Fellowship, UGC Grant No. 19/06/2016(i)EU-V-205247; w.e.f. 05/06/2017)

PI: Amit K. Mishra & Ratan Kar

An altitudinal transect from ~2800 m to ~3670 m was covered from the road-head at Chopta to Chandrashila peak (above Tungnath) for the present study. The vegetation at the lower altitudes is dominated by *Quercus* along with *Rhododendron*. At elevations around ~3000 m, clusters of *Abies* and scattered *Picea* can be seen. At ~3200 m, the other arboreals gradually fade out and stunted thickets of *Rhododendron* mark their appearance, which continue up to ~3670 m and form the tree-line. Thirtyfive surface sediment samples were collected along the transect and the dominant vegetation at each sampling point was noted. Palynological analysis of the samples is underway to develop the modern analogues and to interpret the modern pollen-vegetation relation in the study area.

24. Project: "Study of the Late Pliestocene-Holocene climatic and environmental changes around Ny-Alesund, Svalbard" (CSIR-UGC NET Fellowship, UGC Grant No. 19/06/2016(i)EU-V-205255; w.e.f. 10/11/1017).

PI: Kajal Singh & Ratan Kar

Multi-proxy studies on twenty-eight sediment samples from a 140 cm deep trench from Ny-Alesund have been taken up to decipher the past climatic and environmental changes in the region since the LGM. The trench shows variations in its lithology, with the lower part constituted of pelagic clay having shell fragments, while the middle and upper part has sand-silt intercalations. Initially, the samples have been analysed for quartz grain microtexture studies under SEM. Palynological, mineral magnetic and geochemical studies of the profile would also be undertaken.

A paper entitled – 'Climatic history of Ny-Alesund region, Svalbard, over the last 19,000 yr: insights from quartz grain microtexture and magnetic susceptibility' was finalized and communicated to Polar Science. 25. Project: Palaeoclimate and lake history of Tapovan, Gangotri Glacier area, Western Himalaya (SR/DGH-56/2013).

PI: P.S. Ranhotra & Co-PI: Amalava Bhattacharyya, Ashish K. Pal (JRF till July 2017)

From the Dokriani and Gangotri area around 400 years old tree ring chrononology was developed using the tree rings of Abies spectabilis and Pinus walichiana respectively. The ring width indices were analyzed for climate and glacial mass reconstruction since 1615 AD for the Uttarakhand region. The reconstructions were also made for the Himachal Himalaya and Kashmir region and the results were compared. The climate growth relationship is found positive with the temperature of winter months. The glacial mass balance reconstruction showed significant loss of glacial mass since 1600 AD i.e. during little ice age phase thus indicating that LIA effect was less in the Himalayan region. Though there were also intermittent phases of less negative or even positive mass balance. The study also found the relationship of total solar irradiance as well El Nino with the climate-glacial time series. Since 1970 there has been more loss of mass for ISM dominant Uttarakhand glaciers as compared to Himachal region, whereas the northwest glaciers show negligible loss. The findings have been published in Scientific Reports.

26. Project: "Tree growth response of selected tree species of timber line to climate variability across the Indian Himalayan Region" (MoEF&CC (under NMHS program) project number 1886/XII-86/2016).

PI: P.S. Ranhotra & Co-PI: Amalava Bhattacharyya, Utsa Singh (JPF till Oct 2017), Bency David (JPF since Dec 2017)].

Previously collected tree ring core samples of *Abies spectabilis* (Himalayan fir) from Tungnath area (Uttarakhand) were analyzed for tree line dynamics and climate-growth response of this species in the area. *Abies* forms the timber line limit at ~3355 m amsl along the Chopta-Tungnath temple transect. The sampled trees within the altitudinal transect of ~2780 to 3364 m amsl were dated and calculated for Age, Diameter at breast height (DBH), and correlation models are developed between Age-DBH, DBH-Altitude and Age-Altitude for analyzing the age stand structure and tree line dynamics of Himalayan fir and also calculated the temporal shift rate of this species at the area. Developed mean chronology of ~317 years extends back to 1699 AD. Correlation between tree ring width and climate



(temperature and precipitation) has also been established using the gridded climate data (CRU-TS.422) for the Tungnath region.

Carried out field works in May and September 2017 to Daksum (~2400 m amsl) and Sinthan top (~3800 m amsl), south Kashmir, J & K. Abies spectabilis grow densely on slopes till ~3500 m amsl, followed by Pinus wallichiana. Stunted Juniperus reach above Abies limit. In broadleaved trees Acer form patches till ~3300 m amsl, overtopped by Betula utilis. Rhododendron form dense patches on slopes reaching above ~3600 m amsl. The ground taxa are well covered by the elements of Poaceae, Asteraceae, Ranunculaceae, Polygonaceae, Rosaceae, Saxifragaceae, etc. Collected 426 cores from 213 trees of Abies spectabilis from altitudinal range of 3200-3500 m amsl and ~2400 m amsl; 112 cores from 56 trees of Betula utilis between altitudes 3400 to 3620 m amsl; 50 cores from ~28 trees of Pinus wallichiana between altitudes 3380 to 3600 m amsl. 35 surface (moss) samples are collected from the altitudinal range of 2300 to 3800 m amsl. Core samples have been processed and measured for chronology development for Abies and Pinus.

27. Project: "Late Quaternary biotic-abiotic interactions from the Harshad estuary, Gujarat, India: Implications on palaeo-productivity and climate" (SR/FTP/ES-149/2014 awarded by DST-SERB).

PI: Biswajeet Thakur

An assessment of palynofacies and sedimentological data on a sediment core (125 cm) from Harshad estuary, Saurashtra, Gujarat, India was carried out for the palaeoenvironmental and palaeoclimatic reconstructions and to evaluate their bearing on cultural developments during Indus and subsequent cultures in the peripheral zone of southwest monsoon. In Zone-1 (~5397%5105 cal yrs BP) the palynofacies component in conjugation with grain size showed a high terrestrial influx. Broadly, in Zone-2 (~5097%1756 cal yrs BP), the variation in Botryococcus algae (2%10%) indicates that the freshwater inundation in the estuary started receding during ~4165 calyrs BP (4.2 ka event) and reached to a slight elevated value at ~1756 cal yrs BP. This holds true as the present period points towards scarcity of Indian Summer Monsoon (ISM). The archaeobotanical evidence from studied sites in the region also shows the shift in cropping pattern (millet based) in contrast to earlier phase (urbanization), indicating human adaptation in response to climate change. Zone-3 (~1757%449 cal yrs BP), the Amorphous Organic Matter (AOM) in the lower interval ranging from ~1757 to ~1531 cal yrs BP and there after increase to a great extent from ~1486 to ~1080 cal yrs BP correspond to Medieval Climate Optimum (MCO). However, the fluctuating behaviour of the palynofacies and grain size to a great extent at ~720 to ~449 cal yrs BP can be attributed to time span limiting to the Little Ice Age (LIA).

28. Project: "Late Quaternary Palaeoclimatic/ sea level changes and anthropogenic responses from estuarine complexes of western India: A multi-proxy approach" (SB/EMEQ/244-2014).

PI: Biswajeet Thakur & Priyanka Seth (JRF)

In the present study with fourty five surface samples collected from three estuarine systems (Sabarmati river system -15 samples, Dhadhar river system -20 samples and Mahi river system -10 samples) of Gujarat region of western India. On the basis of the study it was inferred that the diatom diversity and C/N ratio substantiate each other to indicate biotic-abiotic interactions. The changes in the diatom community in different estuarine setting corroborates to the changes in the trophic state which is fed from different watershed characteristics and anthropogenic contributors. The study emphasizes high anthropogenic influence in the Sabarmati estuary based on diatom thanatocoenoses. The mixed proportion of marine and freshwater diatoms in varying capacity; elucidates runoff related changes and tidal influence, giving vital contribution on their distribution in the supratidal and intertidal estuarine setting.

29. Project: "Macro and micro phytodiversity and behavioural pattern of pollen deposition in and around endangered wetlands of Assam: A palaeoecological conservational perspective" (EMR/2014/000233).

PI: Abhijit Mazumder & Co-PI: Samir Kumar Bera & Amulya Saxena (JRF)

The present study is focused on the forest areas within the Kamrup Metropolitan District of Assam, India. The field survey indicates that, in most of the notified forest areas, moist mixed deciduous forest dense and open categories are available. Boko, Motapahar, Mirza, Bonda-Narengi & Chandrapur Reserve Forests are having good quality forest covers.

Pollen morphological study of 40 major core plant species comprising 20 genera under 15 families from reserve forests of Rani Reserve Forests, Assam was made. The pollen morphology along with their respective phenological variations is significantly useful for



characterization of species from tropical reserve forest distributed in Kamrup District, Assam, Northeast India.

115 samples from surface and core from Rani Reserve Forests and Deepor Bil, Kamrup District, Assam had been processed and quadruplicate diatom slides were made to identify and make distribution chart of all major diatom species. Twenty major diatoms were identified, among which pennate forms are dominating.

A comparative study of palynodebris from spider meshes & air catches from Boko Reserve Forest, Assam is made. An evaluation of pollen and spores suspended in the atmosphere is significant as inferred from both substrates. The study is in a good agreement between pollen content in spider webs and extant vegetation in and around study area.

Documented NPPs (Non Pollen Palynomorphs) serving supplementary information to enhance palynological analysis of any study area which offers conventional source of insights pertaining to the past. Well-identified NPP types were categorised as algal remains and fungal spores from Sukurberia area under Jarasal Reserve Forests, Kamrup, Assam. The detailed study on NPPs from the tropical regions in north eastern reserve forests with their potential role in deciphering palaeoecology, palaeoenvironment and palaeoclimate is meagre. Greatly diverse fungal spore assemblage implies warm and humid climatic conditions in the lake and swamp basins in study area.

30. Project: "Provenance and environmental records of lake sediments from Kerala, South India - using a suite of geochemical proxies" (DST-SERB under DST Fast Track Young Scientist Scheme. SR/FTP/ES-153/2014).

PI: Manoj M.C.

The effects of climatic events from the lake sediments from the Kerala regions are poorly understood, and the knowledge on the relationship of such climatic changes with the monsoonal activities are limited. Sampling carried out in Vellayani, Vagamon and Pookodu Lake from the south, middle and north Kerala, which will represent the monsoonal variation from the entire Kerala. A 14.2 long sediment core has been collected during the first year from Vellayani Lake. The top 1.5 m core is showing dark brown muddy sediment and is followed by a very low sedimentary recovery till 5 m. Below that the sediment has poor recovery and collected as 50 cm each. The long gap in the top 5 m is compensated in the second core and same has been sub-sampled into 2 cm resolution



Fig. – Location map of the core locations from the Vellayani, Vagamon and Pookode Lake.

for the further analysis. The top 4.5 m core spanning 10 ka BP shows high rate of sedimentation rate at Vellavani Lake. The bottom part of the sediment, between 550 and 1400 cm, consisted of layers of white sandy silt followed by silty clay with calcareous Mollusk shells. Two sediment cores of 40 cm and 85 cm collected from Vagamon Lake and are sub sampled at 1 cm intervals. The 85 cm core spanning up to last two thousand year showing distinct variation in hydrodynamics which clearly showing the monsoon variation at the study area. Two sediment cores of 50 cm and 2.5 m collected from Pookode Lake and are sampled at 1 cm intervals. The sediment textural variation from these cores shows mainly composed of sand and silt contributing <80% at all the sites, suggests that the indicating that a relatively violent environment prevailed during the deposition of sediments.

31. Project: "Palaeoclimate and palaeoceanography of the lower Bengal Fan from the late Paleogene to present – IODP Expedition 354" (IODP India, NCAOR, Ministry of Earth Sciences. IODP India Project No. NCAOR/IODP/20.15/ 5(IV)2017).

PI: Manoj M.C.

International Ocean Discovery Expedition 354 to 8°N in the Bay of Bengal drilled a seven sites, 320 km long transect across the Bengal Fan. Three deeppenetration and an additional four shallow holes give a spatial overview of the primarily turbiditic depositional system that comprises the Bengal deep-sea fan. This study on the past dynamics and intensity of deep ocean circulation in the Bay of Bengal using high resolution sortable silt records along with the other proxies will enhance the understanding of the influence of ocean water masses in modulating the climate and to elucidate the connection between the productivity, monsoonal





Fig. – Map of the Himalayan erosion system showing the position of Expedition 354 IODP core sites.

intensity and deepwater circulation parameters. Though, it is difficult to produce the bottom current intensity from the Bengal fan sediment, because of the turbidite deposition, the undisturbed pelagic/hemipelagic sections will be analysed for the palaeocurrent and palaeoceanographic studies. Bulk fine-fraction contents are generally high (>80 wt%) in the hemipelagic units and it is very low for the section where the sand turbidite deposit is prominent. One insidious way in which size distributions can be influenced by processes other than bottom currents and record a source-related signature is by the fine tails of turbidity currents. Major turbidity currents with coarse bases and grading, and debris flows, are fairly obvious. Majority of the samples show a mean SS that of medium silt (15.6-30 im) while the whole range varies from 14.64 to 44.38 im. Most of these samples show a unimodal distribution patter and are composed mainly of very coarse, coarse, and fine silt and to a lesser extent with fine sand. The mean varies throughout the succession with a distinct decreasing trend towards the top. Trend line analysis for the SS mean shows a gradual decrease in mean throughout the early Pleistocene which then takes a more rapid slop around mid to late Pleistocene. It appears that the mean of the fine fraction $(<63 \,\mu\text{m})$ is generally decoupled from the coarse fraction. 32. Project: "Palaeoceanographic and biogeochemical response of the northern Indian Ocean to the Himalayan uplift and denudation" (The Indo-Japanese Joint Research project No. DST/INT/JSPS/P-232/2016.)

Co-PI: Manoj M.C.

Climate change research requires collaboration to share experience, expertise and resources. This research will extend the ongoing collaboration to the next level where joint data interpretation, student exchange, mutual visits were carried out. The IODP Expedition 354 drilled seven sites in the Bay of Bengal, providing a unique opportunity to improve our understanding of the link between glacial cycles, tropical oceanographic changes, and monsoon strength. The Bengal Fan sediment cores are characterized by precise age control from late Miocene to early Pleistocene (unpublished data). Under this proposed project, the presence and distribution of lipid biomarkers and stable carbon and nitrogen isotopes of bulk organic matter, and Sr-Nd isotope, major and trace elements in the sediments carried out in Shinshu University & Kochi Core Centre, Japan. The organic and inorganic geochemical data will be used as proxies to reconstruct past biogeochemical, environment and climate conditions. PIs visited and carried out analysis at Shinshu University & Kochi Core Centre, Japan from 26th November, 2017 to 6th December, 2017.

33. Project: "Subsistence pattern, vegetation dynamics and climate change during Harappans (Indus) and subsequent cultures in northwestern India: A palaeoethnobotanical approach" (EMR/2015/000881).

PI: Anil K. Pokharia, Shalini Sharma (JRF), Neelam Mishra (TA)

Analysis of macrobotanical remains from Vadnagar, Kanmer and 4MSR and microbotanical remains from Mandovari Lake (Sirohi, Rajasthan) were carried out. Photo-documentation of Chandravati, a Medieval site in southern Rajasthan has been completed and preparation of manuscript is under preparation. Signatures of agricultural shift and vegetational change linked to climate fluctuations over the past millennium have been recorded from the archaeological sites and lacustrine sediments in the north-western region (Rajasthan and Gujarat) of India.



34. Project: "Linking Vadose zone microbial ecology and geochemistry in sediments core from alluvial Mahi River, western India" (Project Ref. No. SR/S4/ES-565/2011).

PI- Prof. G. Archana & Co-PIs Prof. D.M. Maurya and Anupam Sharma, Ms. Shazi Farooqui (Project Assistant)

Three sediment cores have been retrieved from the lower Mahi river catchment of the mainland Gujarat. The textural studies, mainly the grain size analysis, confirm 35. Project: "Characterization of glacial lake deposits of the Ladakh, NW Trans Himalaya: Implications on landscape evolution and Palaeoclimate" (Project Ref. No.- SR/DGH-69/ 13).

PI: Binita Phartiyal & Co-PI: Anjum Farooqui & Priyanka Joshi (JRF)

The Chang-La and Yaya-Tso-Mahi basins of the NW-SE trending, ~350 km Ladakh range placed between the Indus Suture Zone (ISZ) in the south and the



Fig. 1 - Plot of downcore variation in moisture, organic carbon and inorganic carbon.

that the sediments are largely moderately sorted, bimodal, finely skewed and leptokurtic in nature. The bimodal character suggests that these sediments are contributed from more than one source and transported to the present sites dominantly by deflation processes. The thin section slides of bulk samples studied suggest that the quartz is the most dominant constituent supplemented by lithic fragments and very limited abundance of amphiboles and mica, however, the heavy mineral separates from the bulk samples have maximum abundance of opaque's followed by lithic fragments and amphiboles, pyroxenes and zircon (~ 2 and 0.5% respectively). The appreciable amounts of lithic fragments and amphiboles in the bulk and heavy mineral fraction indicates that the provenance must have abundance of basic igneous rocks, which has experienced more of mechanical rather than the chemical weathering. A complete set of mineralogical and geochemical data of one CRD core is generated (Fig. 1) and as soon as the dates are obtained a manuscript will be finalized.

The project has been prematurely closed (after two years only) as the PI didn't sought the extension on time. The project completion report, however, been submitted to SERB-DST, New Delhi as desired by the sponsoring agency.

the main focus of study. The distribution of the sediments here are a product of the glacial, fluvial and the lacustrine depositional environments and processes. The reconstruction of the glaciers was done on the basis of the lateral and terminal moraines present in different altitudes, which show a

Karakoram Thrust (KT)

in the north basin were

11-12 km retreat during the Late Quaternary period. With the help of Survey of India topographic maps and satellite



Fig. 1– Drainage Map of the Ladakh Range showing the basin selection based on the area and the glacial lakes; Site 1 is a moderate basin, Site 2 the largest basin of Ladakh Range and HorLa-Mahe one of a small basin.



Fig. 2 - (A) Detailed lithology of the Lake 1 with chronological constraints; (B) Permafrost zone at 100 am level); (C) Lithology and chronology of Lake 2; (D) Dry lake lithology and chronology; and (E) Photograph showing the pitting of the Dry lake with ChangLa Pass in the background.

data (Google Earth, ASTER- GDEM) and field check a complete reconstruction of the geomorphology of the area has been attempted from almost last 7000 yrs BP. Multi proxy studies show a peak aridity at ~2600 yr BP. An overall distribution of the biotic proxies shows dominance of heterotrophs such as thecamoebians (48%) followed by primary producers like chlorophytic algae/ diatoms

of two types- ones with rich assemblage of micro-biota and good primary productivity indicative of a perennial and an old lake system and other with no micro-biota indicative of a younger system in a primary stage. Oligotrophic condition in the ecosystem with sufficient dissolved oxygen for thecamoebians and optimum pH favourable for biological forms is observed (Figs. 1-3).

(26%) and gymnosperms (8%). The angiospermic herbaceous pollen comprised about 6% along with fungal spores (8%), rest 4% constitutes cysts (both algal and egg cysts). Lakes in the region are



Fig. 3 - Multi-proxy analysis of the Tslotak dry lake section showing the cold and warm phases from 6800- 1500 years BP.



36. Project: "Multiproxy palaeoclimatic studies of Quaternary lake sediments from southern Madhya Pradesh, India" (Project No: SR/FTP/ ES-16/2014).

PI: Kamlesh Kumar

SERB-DST sponsored Project Project Title: Multiproxy Palaeoclimatic studies of Quaternary lake sediments from southern Madhya Pradesh, India (Project No: SR/FTP/ES-16/2014) The results of sediment texture, δ^{13} C values, TOC, TN, TOC/TN and magnetic susceptibility (clf) of a 1.54 m deep trench sediments recovered from the core monsoon zone (CMZ) of central India to understand the paleovegetational history and Indian Summer Monsoon (ISM) variability during the Holocene (Fig. 1). The lower δ^{13} C values, TOC/TN ratio and



Fig. 1– Comparison of (a) Nonia Tal÷lf records and (b) δ^{13} C records with (c) δ^{18} O of *G. Rubber* from sediment of Sindhu (Indus) River mouth (Staubwasser et al., 2003); (d) δ^{18} O record from marine sediments (Saraswat et al., 2016); (e) δ^{18} O record of a stalagmite from Dongge Cave, China (Dykoski et al., 2005); (f) δ^{13} C_{wax} record from Lonar Lake sediments (Sarkar et al., 2015). The yellow band represents the driest phase corresponding to ~2ka BP in CMZ.

magnetic susceptibility (Xlf) from ~11.4 to 9.5 ka BP suggest enhanced ISM intensity which is well correlated with other available ISM records from both terrestrial as well as marine archives. A gradual stepwise expansion of C4 plants during ~8.1 and 6.3 ka BP, ~6.3 to 4.7 ka BP and ~3.0 to 2.0 ka BP) suggests a gradual weakening of ISM. The highest ä 13C values ("18.7‰) recorded at ~2.0 ka BP indicate dominance of C4 plants suggesting weakest phase of ISM in the study area. A sudden increase in ISM intensity from ~2.0 to 1.6 ka BP can be inferred from the expansion of C3 plants. Subsequently, three stages of enhanced ISM are recorded during ~1.6 and 0.93 ka BP, ~0.76 and 0.42 ka BP and ~0.28 ka BP to present. 37. 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" (Project Ref. No. SR/DGH-89/2014).

PI: Sheikh Nawaz Ali & Co-PIs: Anupam Sharma & P. Morthekai & Jyotsana Dubey (JRF)

This project deals with the geomorphological evolution and palaeoclimatic reconstruction in the Thangu Valley, north Sikkim. The glacial-geomorphological disposition of different provides significant insights about the evolution of pro- and periglacial landscapes. Using geomophological and stratigraphical methods, field surveys, SRTM DEM, Landsat ETM+ and Google Earth data, four major events of glaciation have been



Fig. 1 – Map compilation showing (a) location of Sikkim in South Asia with different topography and weather systems, (b) shuttle radar topographic mission (SRTM) digital elevation model (DEM) of the study area, (c) Digital elevation model showing the major drainage and the location of sampling sites; Field photograph showing (d) sub humid vegetation towards south of sampling sites and (e) Dry steppe vegetation towards the north of the sampling sites. Please note that the location of the photographs are shown in Figure 15c. (The maps are created using ArcGIS Version 10.2).





Fig. 2: The bottom blue line of the graph represents the d¹³C value (‰ VBDB), The red line shows total organic carbon (%), the olive-green line indicates the low field magnetic susceptibility and the top most green line represents the reconstructed average rainfall (mm).

established. The presence of pro-glacial lakes in the region indicates that the glaciers are melting and radically responding to global warming and are potentially vulnerable for generating GLOFs. Besides this, modern analogues have been prepared using modern pollen palynomorphs (PP), non-pollen palynomorphs (NPP) and stable carbon isotopic data of soil organic matter (SOM) for the Chopta Valley. The average value of δ^{13} C is "26.6‰, which clearly indicates dominance of C3 vegetation in this valley which is also corroborated by the palynological data.

In order to quantify the Indian summer monsoon (ISM) variability for a monsoon dominated agrarian based



Fig. 3 – Variations of Annual precipitation climatology (mm) (a, b, c and d) and JJAS precipitation climatology (mm/month) (e, f, g and h) over Indian region (67-98 °E; 7-38 °N) during (a, e) Historical (1850-2005), (b, f) Last Millennium (850-1849), (c, g) Mid-Holocene (~ 6kya before present (B.P.)) and (d, h) Last Glacial Maximum (LGM; ~21kya B.P.) over Indian region from IPSL-CM5A-LR for (a, e), CSIRO-Mk3L for (b, f) and (c, g) and COSMOS-ASO for (d, h) gbbal climate models respectively. For Mid-Holocene and Last glacial maximum variations are shown over a period of 500 and 600 years respectively.

Indian socio-economy, we used combined high resolution δ^{13} C, total organic carbon (TOC), sediment texture and environmental magnetic data of the samples from a ~3m deep glacial outwash sedimentary profile from the Sikkim Himalaya. Our decadal to centennial scale records identified five positive and three negative excursions of the ISM since last ~13 ka.

The most prominent abrupt negative ISM shift was observed during the termination of the Younger Dryas (YD) between ~11.7 and 11.4 ka (Fig. 1, 2). While, ISM was stable between ~11 and 6 ka, and declined prominently between 6 and 3 ka. Surprisingly, during both the Medieval Warm Period (MWP) and Little Ice age (LIA) spans, ISM was strong in this part of the Himalaya.

These regional changes in ISM were coupled to southward shifting in mean position of the Atlantic Intertropical Convergence Zone (ITCZ) and variations in East Asian monsoon (EAM). Our rainfall reconstructions are broadly in agreement with local, regional reconstructions and PMIP3, CSIRO-MK3L model simulations (Fig. 3).

38. Project: "Chronology and climatic implications of Late Quaternary glaciations in the upper Dhauliganga and Alaknanda valleys, Central Himalaya, India" (Project Ref. No. SRF/FTP/ES-23/2013).

PI: Sheikh Nawaz Ali

The project provides stratigraphically constrained optical and radiocarbon dating on the Moraines (ice contact sediments), out-wash gravel terraces and stratified scree deposits in the the upper Dhauliganga Valley, (Trans Himalaya), Uttrakhand, India. This work provides new insight into the role of climate variability in driving the late Quaternary glaciation and the evolution of paraglacial landforms in the Trans Himalayan region (upper Dhauliganga Valley) of Central Himalaya. Besides this, it is for the first time that Radio carbon ages of peat layers present between the stratified scree fan deposits have been obtained and used to understand the landform evolution and phases of deglaciation in the area.

The samples were collected from a proglacial sedimentary profile (~3.5 m) in Kunti Banar valley, upper Dhauliganga basin situated in the transitional zone between the dry trans-Himalaya towards north and sub-humid Himalayas towards the south. A multiproxy study viz. carbon isotope (δ^{13} C), total organic carbon (TOC), magnetic susceptibility (XIf), loss on ignition (LOI), pollen analysis aided with optically stimulated luminescence



Fig. 1 – Line graph of the multiproxy data used in this study. The bottom purple line (a) of the graph represents the TOC (%) values; (b) the black line represents the δ^{13} C value (‰; VPDB); (c) the turquoise line represents the reconstructed precipitation; (d) the pink line shows the moisture (%) content; (e) organic carbon (%) is represented by blue line; (f) the green line represents the carbonate (%) values and (g) the red line represents low field magnetic susceptibility.

(OSL) dating were used for establishing the ISM variability and its quantification during the last ~15 kyr (Fig. 1). Our reconstruction has demonstrated that the area witnessed three major phases of high and almost same number of moderate to low ISM since ~15 kyr. Significant weakening of the ISM is observed during the Younger Dryas (YD) between ~12.2 and 10.5 ka and during ~8.5 2.0 ka. An increase in ISM is observed during ~10.5 8.5 ka and after 2.0 ka. Surprisingly our data suggest that the mid-Holocene ISM weakening was more severe than that of the YD in this region and is attributed to the contribution of mid-latitude westerlies during YD.

These observations are broadly in accordance with other studies in the central Himalayas and give some important insights on mid-latitude westerlies and their contribution as a moisture source.

This project has been completed and the final completion report has been submitted to the DST, New Delhi.

39. SERB-DST Fast Track sponsored Project Project Title: High Resolution paleoclimatic and paleoceanographic study on the eastern Arabian Sea off Saurashtra-based on foraminifera and their geochemical signature (SR/FTP/ ES-53/2013).

PI: Pawan Govil

The present multi-proxy study over offshore-Saurashtra NE Arabian sea using two marine sediment cores from the shelf area to record high resolution monsoonal, sea level and productivity variations during last 12.5 Ka. For the first time, both Oxygen minimum zone (OMZ) and non-OMZ regimes have been recorded from the same area during the Holocene which helped in understanding the changes in biogeochemical signatures associated with the OMZ (Fig. 1). The reported abrupt events matching with previous Arabian Sea and global records include three cold events, i.e. Younger Dryas (YD), 8.2 Ka and 4 Ka events which correspond to SWM weakening and a warm event, i.e. pre-boreal (PB) which correspond to strengthened SWM. Moreover, we have also reported a new cold event centering around 10.1 Ka (abrupt event or AE) which is observed for the first time from the Arabian Sea palaeoceanographic record.

The recorded cold events also marked the productivity collapse in the area. Lower sea level has been recorded during early Holocene. Further, sea level increased during 8-5 ka marking Holocene sea-level high stand (HSLH) at ~5.5 Ka. Thereafter, it dropped marginally during late Holocene till it attained the present conditions. Spectral analysis of the high-resolution δ^{18} O Gruber from both the cores record the cyclicity of ~256 years in the SWM which corresponds to Holocene deVries solar cycle.





Fig. 1 – Details of the work published from the SERB-DST project (SR/FTP/ES-53/2013). 1. The map showing location of the studied core SK-240/485; 2. Chronological framework of the core SK-240/485 since 12.5 ka; 3. Down core variation in the productivity of the area since 12.5 ka; 4. Temporal variation in 180 (‰ VPDB) showing the variation in southwest monsoon intensity since 12.5 ka; 5. Down core variation in the lithogenic flux since 12.5 ka; 6. Variation in Planktonic and Benthic foraminifera percentage showing bathymetric variation in the area since 12.5 ka.

40. Project: "Post LGM sedimentation pattern and environmental changes in the Great Rann of Kachchh Basin, western India"*.

PI: Nitesh Konde

The projects aims to investigate the post-LGM sedimentation pattern in the central Great Rann of Kachchh Basin based on the earlier drilling done in the basin. There are three major components in this project (1) determination of high-resolution sedimentary pattern (2) characterisation of spatial & temporal reconstruction of overall sedimentary evolution of the Great Rann of Kachchh Basin and (3) detailed provenance characterization. The cores raised by prof. D.M. Maurya, M.S. University of Baroda will be used to study in this project.



Fig. 1a Stabilized dune in the western GRK basin from the large dunefield along the Koteshwar-Lakhpat road. b) Trench section of the dune from sampled during field in 2018.

* Currently the project is getting transferred from M.S. University of Baroda to BSIP, Lucknow. The project was in abeyance from Jan 2017 to Jan 2018.



41. Project: Analysis of plants and human relationship since Late Pleistocene from Dzuko Valley- Nagaland, northeast India {SERB- DST sponsored Fast Track Project; Reference No: YSS/2015/001193).

PI: Sandhya Misra

Multiproxy data has been generated and under progress from Dzukou Valley (4 trenches) and Shilloi Lake (10 cores were raised) towards the achievement of the objectives- First to understand the changing landscape dynamics of Dzuku Valley and adjoining region under this connection multiproxy data has been generated from various laboratories of country.

Fourteen AMS dates from Direct AMS, USA and IUAC, New Delhi puts a time bracket from early Holocene to present. Multi-proxy data generated in the project shows that Dzukou is predominantly under the influence of C3 vegetation indicating towards the cool and dry climatic conditions prevailing at the study site with decrease in the rainfall during past 10000 years. Charcoal analysis from the study site gives a signal of both wild and human generated fire episodes in the area.



Field photograph and sample collection in Dzukou Valley



Field photograph of Shilloi Lake and Sediment Cores raised

varied natural and human induced conditions. Second to understand the evolution of Shilloi Lake at spatial and temporal scale. In this regard during June 2017 Shilloi Lake and adjoining regions bordering the state of Manipur and Nagaland were explored for the collection of modern and potential samples for the palaeo-climatic studies. In



42. Project: "Reconstruction of climate and dating of geo-hazard related to hydro-geomorphic evidences from Sikkim Himalaya based on tree-ring proxy" [DST Young scientist project (No.SR/FTP/ES-127/2014, w. e. f. 27-08-2015)].

PI: Mayank Shekhar

A tree ring based chronology extending from 1758 -



Fig. – Examples of scars in the increment cores and cross sections of trunk from trees at Sainj Valley showing dated flood scar mark 1980, 2003, 2005, 2006, 2008, 2009 and 2010.

2016 CE of natural hazards derived from the dendrogeomorphic analysis of 184 disturbed fir trees growing on the event sites of debri flow in and around Lachung Valley, Sikkim has been prepared. We are able to reconstruct 26 hazard events between 1758 and 2016 CE. This tree ring based analysis of natural hazard provides quantitative data and the frequency of past events. In addition exploratory analysis of tree-ring records from the three landslide affective sites reveals multiple periods of mass movement during the 20th century in the Sikkim Himalaya.

43. 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).

PI: Amalava Bhattacharyya & Co-PI: Mayank Shekhar, Markus Stoffel, Juan Antonio Ballesteros Cánovas & Daniel Trappmann

Several tree species and sites where recent and past process of natural hazards activity reconstructed, namely flash floods in the Beas and Sainj rivers as well as snow avalanches in Solang Valley. Through this exploratory analysis, we ascertain that tree-ring techniques have wide applicability in the analysis of natural hazards, not only in the Kullu region but also in other geographical contexts of the Himalayas.

Fig. Examples of scars in the increment cores and cross sections of trunk from trees at Sainj Valley showing dated flood scar mark 1980, 2003, 2005, 2006, 2008, 2009 and 2010.

44. Project: "Analysis of Holocene climate change in Tripura and Mizoram based on pollen, environmental geomagnetism and isotope data" (SR/WOS-A-ER-18/2014).

PI: Nivedita Mehrotra-Woman Scientist (DST-WOS-A Scheme)

Field work was carried out and four sub surface sediment profiles were collected from various parts of Mizoram. About twenty moss cushion samples were also collected from various sites in Mizoram for modern vegetation studies based on modern pollen data. Historical documents were surveyed from various archival resources in Aizwal, Mizoram to understand the routes of human migration into Mizoram and vegetation changes due to anthropogenic activities in Mizoram through time. Existing Archaeological records were surveyed to identify impacts of human settlements in Mizoram during the Holocene and changes in the population distribution and impacts on vegetation and land cover. Twenty-six sub-surface samples from Hmuntha, Twai, and twenty surface samples from Mizoram were processed for palynological analysis. Lithology of all four sediment profiles from Mizoram was diagrammatically represented.

Surface sediment samples collected from Mizoram were studied for modern pollen analysis. Presently this data is being analyzed for further understanding of the modern vegetation of Mizoram.

Antoher sub-surface sediment profile from Khwanglung Village, Champai, Mizoram, was macerated and 20 samples will be further studied for palynological analysis. Sub samples from one sediment profile collected from Hmuntha Village, Twai was also send for carbon dating to Direct AMS U.S.A. for procurement of radiocarbon dates.



The palynological data from surface sediment samples from Tripura was analyzed to understand the modern vegetation and climate in Tripura and a manuscript was submitted and was accepted for publication. Palynological data and environmental geomagnetism data of two sub surface sediment profiles from Chari Lam and Srinagar Tripura were analyzed. A manuscript was prepared based on the study of these sub surface sediment profiles from Tripura. A manuscript was prepared on a study based on "the Late Quaternary sediments from Tripura, North-east India: perspective on the constraints of their radiocarbon dating" and was published.

45. Project: "Facies dynamics of Palaeocene-Eocene carbonates from Meghalaya, N-E India: palaeoenvironmental implications" [SERB-sponsored project (SR/FTP/ES-143/2014)].

PI: Suman Sarkar

Thin sections from various quarry and road sections of the Jowai-Badarpur Road (Jaintia Hills) and Shillong-Cherrapunjee Road (Khasi Hills) have been analyzed for assessment of microfacies and associated palaeoenvironmental implications of Late Palaeocene-Middle Eocene carbonates, with further work in progress. The Thanetian-Ilerdian microfacies of the Lakadong Limestone comprise abundant larger benthic foraminifera, calcareous red and green algae, and secondary bryozoans, gastropods, echinoderms, bivalves with very rare solitary/ branched corals. In case of Ypresian Umlatdoh Limestone, calcareous green algae increase significantly and a shallowing tendency is observed in comparison to the Lakadong Limestone depositional environments. Orthophragminids dominate in both the Lakadong and Umlatdoh Limestone units with species of Orbitoclypeus and Lakadongia showing very high abundance in the former, being gradually replaced by *Discocyclina* spp. The widely distributed but poorly known coralline alga Distichoplax has been studied extensively and novel aspects of its morphology and ecology have been evaluated highlighting its possible causes of extinction across the geologically critical Palaeocene-Eocene transition. Several new species of LBF Miscellanea, Ranikothalia, Operculina, Assilina, Nummulites, Rotalia and Alveolina have been recorded in the present study that are being examined in detail to make a



Fig. – Biotic components of the Lakadong Limestone in association with *Distichoplax* (a) Geniculate *Corallina* and smaller miliolid; (b) *Corallina*, *Discocyclina*, non-geniculate algae and rotaliids; (c) *Discocyclina* and geniculate coralline algae; (d) *Discocyclina*, echinoderm and algal debris; (e) encrusting *Sporolithon*; (f) warty *Sporolithon*; (g) *Miscellanea* spp.; (h) *Quinqueloculina* and geniculate coralline algae. Scale bars: 300 µm.

generalized assessment of the LBF gradients in the Eastern Tethys during the Palaeocene-Eocene transition. New species of coralline *Sporolithon* and melobesioid genera *Mesophyllum* and *Lithothamnion* have also been recorded. Palaeocommunity structure has been evaluated in the carbonates of the Lakadong Limestone successions from the Jaintia Hills in order to understand the role of coralline algae and other benthic biotic components like larger benthic foraminifera in the food web dynamics of the relic ecosystem.



46. Development Of Multi-Century High-Resolution Climate Records From Alpine Bushes In The Western Himalaya, India [SERB-sponsored project (PDF/2016/000129 w.e.f. 16 Nov. 2016)]

PI- Akhilesh Kumar Yadava & Mentor- Dr. K G Misra

The Increment core samples of Himalayan cedar (*Cedrus deodara*) were collected from different sites in Chakrata region of

chronology of Himalayan cedar has been used to develop drought index {Standardized Precipitation Evapotranspiration Index (SPEI)} back to AD 1773. The reconstruction has revealed decadal scale variations in drought over the region. The detailed analysis of the SPEI reconstruction is in progress.

Ring-width chronology of Himalayan cedar (*Cedrus deodara*) AD 1608-2016. The number of cores used in the preparation of chronology is also indicated.

Chakrata region of Dehradun district, Uttarakhand during April-May 2017. The r i n g - w i d t h sequences in samples were precisely dated to calendar year of their formation and ringwidths measured to prepare ring-width chronology. The



Fig. – Ring-width chronology of Himalayan cedar (*Cedrus deodara*) AD 1608-2016. The number of cores used in the preparation of chronology is also indicated.



Police Meet





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- Joshi Priyanka & Phartiyal Binita 2017. Geomorphological evolution of the ChangLa Basin, Ladakh, NW Trans Himalaya, India during Late Quaternary. ICG 2017, New Delhi 6-11th November 2017.
- Khan Salman & Farooqui Anjum 2018. Gradational climate cooling from low to high latitudes during Pliocene/ Pleistocene: a palynological record. *National Conference on Climate Change and Natural Resources*, 20-21 Feb, 2018. Lucknow University, Lucknow, Page 5.
- Md. Arif 2017. Rock magnetic characterization of impact shocked products from Lonar Crater: National Seminar on Deccan Volcanism and Biotic Events across the K/T Boundary, held October 26–28, 2017, Dept. of Applied Geology, Dr. Harisingh Gour University, Sagar, Madhya Pradesh (Oral Presentation).
- Mehrotra RC 2017. Cenozoic woods of India: an overview. Ninth Pacific Regional Wood Anatomy Conference (PRWAC) & the International Academy of Wood Science (IAWS) Meeting held during 26-29 Sept., 2017 in Bali, Indonesia.



- Mehrotra RC & Tiwari RP 2017. Some interesting elements of the Deccan Intertrappean flora of India. National Seminar on Deccan Volcanism and Biotic Events across the K/T Boundary held during 26-28 Oct., 2017 in Sagar.
- Murthy Srikanta 2017. Palynomorphs and fossil charcoal from early Permian (Artinskian), Auranga Coalfield, Koel River Valley, India. *XXVI Indian Colloquium on Micropalaeontlogy and Stratigraphy* held at Department of Geology, University of Madaras, Guindy Campur, Chennai. August, 2017 (Abstract 144).
- Phartiyal Binita, Joshi Priyanka, Nag Debarati & Singh Randheer 2017. Late Holocene Climatic scenario of the Ladakh Range, Trans Himalaya, India. Third Pole Science Summit-TPE-CSTP-HKT Joint Conference, Kunming, China, 10-12 July 2017. (No. SII-5) pp 76-77.
- Phartiyal Binita, Nag Debarati, Singh Randheer & Joshi Priyanka 2017. Geomorphological implications due to climate-tectonic impacts in the fragile cold arid desert of Ladakh, Trans-Himalaya, India during the Late Quaternary. ICG 2017, New Delhi 6-11th November 2017
- Prasad Vandana 2017. New fossil evidence from late Cretaceous Infratrappean sediments, Yeotmal suggests marine transgression in to central India from the east coast. In the National Seminar on Deccan Volcanism and Biotic Events across the K/T Boundary, held October 26–28, 2017, Dept. of Applied Geology, Dr. Harisingh Gour University, Sagar, Madhya Pradesh (Oral Presentation).
- Prasad Vandana, Sharma Anupam, Srivastava Jyoti & Manoj MC 2017. Study of extreme global warming events during deep time: An analogue for future climate change". Outreach program on the foundation day at Birbal Sahni Institute of Palaeosciences, 10th September 2017.
- Saxena A & Singh KJ 2017. Development of the *Glossopteris* flora and its end Permian demise in the Tatapani-Ramkola Coalfield, Son-Mahanadi Basin, India. XXVI Indian Colloquium on Micropalaeontology and Stratigraphy-2017, Madras University, Chennai, pp.126.
- Seth Priyanka, Thakur Biswajeet, Sharma Anupam & Farooqui Shazi 2017. Diatoms and C/N variability in intertidal and supratidal estuarine settings from Gujarat, western India. XXVI Indian Colloquium

on Micropaleontology and Startigraphy (ICMS-2017) organized by Department of Geology, University of Madras, Guindy Campus, Chennai from August 17-19, 2017. pp. 51-52.

- Seth Priyanka, Thakur Biswajeet, Sharma Anupam & Farooqui Shazi 2018. Value of multiproxy analysis to reconstruct the surface processes in Sabarmati estuary, Mainland Gujarat" at National Conference on Climate Change and Natural Resources: Impact and Sustainable Development in Indian Perspective, 20-21 February, 2018. pp. 77.
- Sharma Shalini, Mishra Neelam, Pokharia AK & Pande PC 2018. Introduction of African millets in India: A repercussion of maritime contacts. *International Conference on Maritime Archaeology With Special Reference to Indian Ocean Countries*, University of Kerala, Thiruvananthapuram, India, February 06-09, 2018, p. 48.
- Singh AK, Chakraborty PP & Sarkar S 2017. Provenance, redox structure, and hydrocarbon propensity of shale intervals from Proterozoic Vindhyan Basin: clues from geochemistry (major, trace and REE), TOC and stable isotope (δ^{13} C) chemistry. 34th convention, Indian Association of Sedimentologists (IAS), Sant Gadge Baba Amravati University, Amravati; 19-21, December, 2017; *Extended Abstracts' Volume*.
- Singh Randheer & Phartiyal Binita 2017. Climatic variability on the rain shadow zone of Trans Himalaya since the late Quaternary based on a multi-proxy approach from Tangtse Valley, Ladakh NW India. Third Pole Science Summit-TPE-CSTP-HKT Joint Conference, Kunming, China, 10-12 July 2017. (No. SII-5) pp 141-142.
- Singh V, Misra KG, Yadava AK & Yadav RR 2018. Treering inferred drought reconstruction from Kishtwar, Jammu & Kashmir, India. National Conference on Climate change and natural resources; Impact and sustainable developments in Indian prospective" held at Geology Department, Lucknow University, Lucknow from 20-21 February, 2018 (pp. 55-56).
- Singh VK & Sharma Mukund 2017. Advantage of Confocal Laser Scanning Microscopy (CLSM) and Laser Raman Spectroscopy (LRS) over Transmission Light Microscopy based investigations of Proterozoic Microscopic fossils. XXVI Indian Colloquium on Micropalaeontology and Stratigraphy (ICMS - 2017), August 17-19, 2017.



- Srivastava Gaurav & Mehrotra RC 2017. Neogene vegetation and climate change in northeast India. National Symposium on Current Trends in Research in Biotic Systems held in Shillong during 29-30 June, 2017.
- Srivastava Gaurav & Tiwari RP 2017. Evolution of palms (Arecaceae) in India. National Seminar on Deccan Volcanism and Biotic Events across the K/T boundary held in Sagar during 26-28 Oct., 2017.
- Srivastava Jyoti, Farooqui Anjum & Seth Priyanka 2017. Quantitative relationship between pollen, vegetation and climate in a coastal wetland from India and its palaeoecological application" for the 5th National Conference for the Ocean Society of India 2017.
- Srivastava Jyoti, Farooqui Anjum, Thakur Biswajeet & Seth Priyanka 2018. "Environmental impact on Coringa mangrove wetland as a tool for palaeoecological reconstruction" at National Conference on climate change and natural resources: Impact and sustainable development in Indian perspective, 20-21 February, 2018. pp. 11.
- Tewari R 2017. Palaeoecological manifestation through fossil plant cuticle, in abstract volume of National Symposium on "Current trends in research in biotic systems" held at North Eastern Hill University, Shillong during June 28–30, 2017, pp. 16.

Thakur Biswajeet, Manoj MC, Srivastava Jyoti, Seth

Priyanka, Premraj U, Prasad Vandana, Sharma Anupam & Farooqui Shazi 2017. Responses of biotic and abiotic proxies to environmental changes – Case studies from west coast of India. Outreach program on the foundation day at Birbal Sahni Institute of Palaeosciences, 10th September 2017.

- Thakur Biswajeet, Seth Priyanka, Sharma Anupam & Farooqui Shazi 2017. Biotic-abiotic responses at Harshad Estuary, Saurashtra, western India. XXVI Indian Colloquium on Micropaleontology and Stratigraphy (ICMS-2017) organized by Department of Geology, University of Madras, Guindy Campus, Chennai from August 17-19, 2017. pp. 41-42.
- Tripathi S 2018. Floristic and climatic reconstruction in Indo-Burma region since Late Pleistocene: a palynological interpretation from endangered wetlands of Assam, northeast India. Nat. Conf. Clim. Change Nat. Resources; Impact Sustain. Develop. Ind. Perspec., Lucknow, Februrary, 2018 (Abstract 7).
- Tripathi S, Singh S & Roy RK 2017. Contribution to taxonomic characterization, evolution and preservation in *Bougainvillea* Comm. Ex Juss. (a popular ornamental plant) through pollen morphometric analysis. *XXVI Ind. Colloq. Micropaleontol. Stratigr.*, Chennai, August, 2017 (Abstract 131-132).





Deputation to Conferences/Seminars/Workshops

Abroad

- Anjum Farooqui participated in CCA 2017- Sixth International Conference on Climate Change Adaptation held at Toronto, Canada during 16-17 September, 2017.
- Abha Singh attended the 14th Annual Meeting of the Asia Oceania Geosciences Society (AOGS) held at Singapore during August 06-11, 2017.
- Abha Singh participated in the 16th International Nannoplankton Association Meeting (INA 16) held at National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Athens, Greece during September 24-28, 2017.
- Amit Kumar Ghosh & Arindam Chakraborty attended International Nannoplankton Association Meeting INA 16, held at Athens, Greece during 24-28 September, 2017.
- Deepa Agnihotri visited Department of Botany and Palaeobotany, Centro Universitário UNIVATES, Lajeado, Rio Grando do Sul, Brazil in connection with the DST Sponsored Project entitled "Palaeofloristics of Lower Gondwana sediments of India and Brazil with special reference to palaeowild fire and its palaeoecological, palaeoclimatological and biostratigraphical significance" (w.e.f. 1.04.14) during March 20-April 27, 2017
- Kamal Jeet Singh participated in Indian National Science Academy, New Delhi and Chinese Academy of Sciences, China bilateral exchange programme 2017. Also visited Department of Palaeobotany and Palynology, Nanjing Institute of Geology and Palaeontology, Nanjing, China to work with Prof. Jun Wang, Director of this department during May 26 – June 26, 2017.
- M.C. Manoj & Supriyo Das visited the Shinshu University
 & Kochi Core Centre, Japan under Indo-Japanese
 Joint Research Project No.-IV-BSIP/SP/2017-18/
 L-752, November 26 December 6, 2017.
- Mahi Bansal participated in the International Biogeography Society meeting held at Bangalore, India and gave poster presentation on Biogeography

of the tropical plant family Ebenaceae: fossil evidences from the Indian Subcontinent during September 26-29, 2017.

- Mukund Sharma participated in India International Science, Festival-2017, held at Chennai during October, 2017.
- P. Morthekai deputed to Griffith University, Brisbane, Queensland, Australia to avail Indo-Australia Early to Mid Career Researchers Fellowship, EMCRF during 11.07.2017 to 10.02.2018 (7 months).
- Poonam Verma deputed to 14th Annual Meeting Asia Oceania Geosciences Society, Singapore during 6th to 11th August, 2017 held at Suntech Convention and Exhibition Centre, Singapore.
- R.C. Mehrotra attended Ninth Pacific Regional Wood Anatomy Conference (PRWAC) & the International Academy of Wood Science (IAWS) Meeting held at Bali, Indonesia during September 26-29, 2017.
- Shilpa Pandey attended an International Workshop "14th Annual Meeting Asia Oceania Geosciences Society Conference" (AOGS) held in Singapore during March 27-31, 2017.
- Shilpa Pandey participated in an International Conference "3rd Young Science Meeting and 5th Open Science Meeting held at Zaragoza, Spain during May 07-13th, 2017.
- Srikanta Murthy participated in Kazan Golovinsky Stratigraphic Meeting held at Kazan Federal University, Kazan, Russia during September 19-23, 2017.
- Vandana Prasad presented "Fossil evidence for decline of Gondwanan vegetation due to early Paleogene hyperthermal events: A case study from the Indian Subcontinent" (oral presentation) in 14th Annual Meeting Asia Oceania Geosciences Society, Singapore, August, 2017.
- Vandana Prasad presented "Paleobiogeographic history of plant family Dipterocarpaceae based on the earliest Eocene fossil pollen records from Indian Subcontinent" (oral presentation) in 14th Annual Meeting Asia Oceania Geosciences Society, Singapore, August, 2017.


Vartika Singh attended Annual Meeting of Geological Society of America held at Seattle, USA during October 22-25, 2017.

In India

- Anju Saxena attended XXVI Indian Colloquium on Micropalaeontology and Stratigraphy-2017 held at Madras University, Chennai from 17.08 to 19.08.2017.
- Anju Saxena participated in National: 37th Trade Fair held at Pragati Maidan New Delhi for Museum Expo under the DST pavilion.
- Anjum Farooqui & Anjali Trivedi attended National Conference on Climate Change and Natural Resources, 20-21 Feb, 2018. Lucknow University, Lucknow
- Ansuya Bhandari deputed as Women Scientist to attend International Indian Science festival (IISF) and also participated in special session "A Women Scientist & Entrepreneur's conclave" held at Tag Auditorium, Chennai dirong October 13-16, 2017.
- Ansuya Bhandari deputed to attend the 37th India International Trade fair, 2017(IITF) at Pragati Maidan during 14-18 November, 2017. I have participated in the IISF for display our fossils during Trade Fair, 14-17 Nov, 2017 in Delhi.
- Ansuya Bhandari & BN Tiwari attended XXVI Indian Colloquium on Micropaleontology and Stratigraphy (ICMS-2017) scheduled for Aug 17-19, 2017 in Department of Geology, University of Madras, Chennai.
- Ansuya Bhandari & BN Tiwari attended National Workshop on Indian Siwalik :Recent Advances and Future Research held at Geological Survey of India (GSI), Northern Region (NR), Lucknow during June 21-22, 2017.
- Anupam Sharma attended Meeting of Scientists of BSIP and Senior UP Police Officers to discuss the possibilities, modalities, constraints of usage and demonstration of new sophisticated analytical facilities to help the state administration, organized by Birbal Sahni Institute of Palaeosciences, Lucknow on July 17, 2017.
- Anupam Sharma conducted outreach program on the occasion of the Foundation Day "Study of extreme

global warming events during deep time: An analogue for future climate change" held at Birbal Sahni Institute of Palaeosciences, Lucknow on September 10, 2017.

- Anupam Sharma participated in Meeting of National Committee for finalizing the specification and configuration of the ICP-MS (high resolution) with Laser Ablation system held at Wadia Institute of Himalayan Geology, Dehradun on December 28, 2017.
- Anupam Sharma attended Technical Committee Meeting for the purchase of Low Background Gamma Ray Spectrometer for the 'Climate Change Research Centre' of Madhya Pradesh Council of Science & Technology held at Madhya Pradesh Council of Science & Technology, Bhopal, M.P. during May 18, 2017.
- Biswajeet Thakur, Suresh Pillai & Ram Dheeraj participated in Gujarat Scientific Literacy Festival organized by DST, New Delhi held at Valsad, Gujarat during October 26-28, 2017.
- Deepa Agnihotri participated in 37th India International Trade Fair held at Pragati Maidan, New Delhi during November 20-25, 2017.
- Gaurav Srivastava attended National Symposium on Current Trends in Research in Biotic Systems held in Shillong during 29-30 June, 2017.
- Jyoti Srivastava attended 5th National Conference for the Ocean Society of India 2017, from 28-30 August 2017 at ESSO-National Centre for Earth Science Studies, Thiruvananthapuram.
- Jyoti Srivastava, Mahi Bansal, Ashish K. Misra & S. Jeyakumar attended XXVI Indian Colloquium on Micropaleontology and Stratigraphy (ICMS - 2017) 17–19 August, 2017 at Department of Geology, University of Madras, Chennai.
- Prasanna K. attended the 3rd Edition of IISF 2017 held in Chennai during October 13-16, 2017.
- M.C. Manoj. attended "3rd Indian International Science Festival (IISF) 2017" held at Anna University, Chennai, India during October 13-16, 2017.
- M.C. Manoj, Anupam Sharma, Pawan Govil & Runcie Paul Mathews attended Agilent Workshop on FTIR Microscopy and Chemical Imaging- Resolution for Every Application" held at Manesar, Haryana, India, June, 2017.



- M.C. Manoj attended Review Meeting on DST-SERB research project No. SR/FTP/ES-153/2014" held at University of Kerala, Trivandrum, India, during April, 2017.
- Neelam Das attended "National Seminar on Reaching the Unreached through Science and Technology, Allahabad chapter Indian Science Congress Association" held at University of Allahabad, Allahabad, during February 24-25, 2018.
- Neha Aggarwal participated in India International Science Festival, 2017 (IISF, 2017) held at IIT Madras and CSIR-CLRI during October 13-16, 2017.
- Neha Aggarwal participated in Indian Geological Congress 20th Convention held at Nagpur during 3-5th October, 2017.
- PS Ranhotra attended a National Seminar on the Himalayan Biodiversity: Characterization and Bioprospection for sustainable utilization held at the Department of Botany, Kashmir University, Srinagar, J & K on September 18-19, 2017. Also Co-chaired one session on the forest ecosystem and response to climate.
- Anjum Farooqui, PS Ranhotra & Ipshita Roy attended INQUA HaBCom training workshop: Methods and challenges for quantitative palynology and paleoecology in south Asia, from 29th January to 4th February 2018 at the French Institute of Pondicherry, Pudducherry.
- Quamar M. Firoze participated in the INQUA-HABCoM Workshop-cum-Training Programme on quantification of pollen at French Institute of Pondicherry (IFP), Puducherry during January 27-February 5, 2018.
- R.C. Mehrotra & Gaurav Srivastava attended National Seminar on Deccan Volcanism and Biotic Events across the K/T Boundary held during 26-28 Oct., 2017 in Sagar.
- Gaurav Srivastava attended National symposium on Current trends in research in biotic systems held at Shillong during June 29-30, 2017.
- R.P. Mathews participated in the FTIR Microscopy and Chemical Imaging Workshop held at Agilent Technologies Manesar Facility, Haryana on June 23, 2017.
- Rajkumar attended National Conference "XXVI Indian Colloquium on Micropaleontology and Stratigraphy"

held at University of Madras, Guindy Campus, Chennai, during August 17-19, 2017.

- Rajni Tewari & Deepa Agnihotri participated in National Symposium on "*Current trends in research in biotic systems*" held at North Eastern Hill University, Shillong during June 28–30, 2017.
- S.K. Pandey participated in 37th India International Trade Fair, 2017 (IITF) held at Pragati Maidan, New Delhi during November 14-18, 2017.
- Shalini Sharma & Neelam Mishra participated in the International Conference on Maritime Archaeology with special reference to Indian Ocean Countries, held at University of Kerala, Thiruvananthapuram, during February 2018 (Abstract: 48).
- Shilpa Pandey attended National Conference on "Silver Jubliee Mangrove ecosystem" held at National Institute of Oceanography (NIO), Dona Paula, Goa during July 26-27, 2017.
- Srikanta Murthy participated in XXVI Indian Colloquium on Micropalaeontlogy and Stratigraphy held at Department of Geology, University of Madaras, Guindy Campur, Chennai during 17-19, August, 2017.
- Suresh S Kumar Pillai attended Indian International Science Festival 2017(IISF) at Chennai from October 12-17, 2017.
- Suresh S Kumar Pillai attended 37th Indian International Trade Fair 2017 at Pragati Maidan, New Delhi from November 21-25, 2017.
- Suresh S Kumar Pillai attended exhibition "Gujarat literary function" held at Valsad from October 26-28, 2017.
- Swati Tripathi participated in the National Conference on Climate Change and Natural Resources; Impact and Sustainable Development in Indian Perspective held at University of Lucknow, Lucknow during February 20-21, 2018.
- Swati Tripathi participated in the XXVI Indian Colloquium on Micropaleontology and Stratigraphy held at University of Madras, Chennai during August 17-19, 2017.
- Vandana Prasad & Mohd Arif attended National Seminar on "Deccan Volcanism and Biotic Events across the K/T Boundary" conducted by Geological Society of India held at Dept of Applied Geology, Dr. Hari Singh Gour University, Sagar, Madhya Pradesh during October 26-28, 2017.



- Vandana Prasad attended "Women Scientist & Entrepreneur Conclave" in Indian International Science Festival -2017 during13th -16th October, 2017 held at Anna University, Chennai.
- Jyoti Srivastava attended 5th National Conference for the Ocean Society of India 2017, held at ESSO-

National Centre For Earth Science Studies, Thiruvananthapuram during 28-30 August 2017.

Jyoti Srivastava attended XXVI Indian Colloquium on Micropaleontology and Stratigraphy (ICMS - 2017) held at Department of Geology, University of Madras, Chennai during August 17–19, 2017.

Swachhta Abhiyan





Lectures Delivered

- Past climate reconstruction in Himalaya region using tree-rings (Invited talk) at Tree Ring and Environmental Change Group, Xishuangbanna Tropical Botanical Garden (XTBG), Chinese Academy of Sciences, P.R. China. (on January 29, 2018) – delivered by Santosh K. Shah.
- *Tree ring analyses in Matlab and R* (Invited talk) at Tree Ring and Environmental Change Group, Xishuangbanna Tropical Botanical Garden (XTBG), Chinese Academy of Sciences, P.R. China. (on January 29, 2018) – delivered by Santosh K. Shah.
- Palaeobotany and its significance during Science camp under INSPIRE Programme sponsored by DST at the Arunachal University of Studies, Arunachal Pradesh (on February 01-05, 2018) – delivered by Shilpa Pandey.
- Darwin's dilemma and enigma & evidence of Precambrian life In: Emergence and Evolution of biological Complexity (Key Note Lecture) at NCBS, Bangalore (on February 4-6 2017) delivered by Mukund Sharma.
- Palynology and its role in climate change interpretations: case studies from Himalayan glaciers at Vidyasagar University, West Bengal (on February 5, 2018) – delivered by Ratan Kar.
- Stratigraphy and Stratigraphic Principles at Vidyasagar University, West Bengal (on February 6, 2018) – delivered by Ratan Kar.
- Palynological studies of the Gondwana sediments: stratigraphy, Permian-Triassic Boundary and application in coal exploration at Vidyasagar University, West Bengal (on February 7, 2018) – delivered by Ratan Kar.
- An overview of silicified and calcified microfossils: their Significance (Special Lecture) for M.Sc. students at Department of Botany and Forestry, Vidyasagar University, West Bengal (during February 06-08, 2018) – delivered by Amit Kumar Ghosh.
- Origin of life and Co-evolution (Special Lecture) for M.Sc. students at Department of Botany and Forestry, Vidyasagar University, West Bengal (during February 06-08, 2018) – delivered by Amit Kumar Ghosh.

- Palaeomagnetism: Technique, Importance and Applications at CAS Programme of UGC, Department of Geology, Lucknow University (on February 16, 2018) – delivered by Binita Phartiyal.
- Gondwana palaeoflora of India: an overview at Centro Universitário UNIVATES, Lajeado, Rio Grando do Sul, Brazil (on April 20, 2017) – delivered by Deepa Agnihotri.
- Biostratigraphy of Kerala Basin based on palynology and calcareous nannofossils: implications on palaeovegetation and palaeoclimate (project proposal presentation) under Extra Mural Research Programme of SERB, New Delhi in 4th Group Monitoring Workshop (GMW) & 5th Program Advisory Committee - Earth & Atmospheric Sciences (PAC-EAS), DST, New-Delhi held by State Council for Science, Technology & Engineering, Shimla (during April 24-25, 2017) -Delivered by Poonam Verma.
- Magnetostratigraphy and Biostratigraphy for M.Sc. 4th Semester Course; Kumaun University Nainital; (GLG-404(b): Palaeoclimatology Course) (on May 03-04, 2017) - delivered by Binita Phartiyal.
- Development of the Glossopteris flora and its end Permian demise in the Tatapani - Ramkola Coalfield, Son-Mahanadi Basin, India in the Department of Palaeobotany and Palynology, Nanjing Institute of Geology and Palaeontology, Nanjing, China (on June 1, 2017) – delivered by Kamal Jeet Singh.
- Palaeozoic Floras of India A Review in the Department of Palaeobotany and Palynology, Nanjing Institute of Geology and Palaeontology, Nanjing, China (on June 6, 2017) – delivered by Kamal Jeet Singh.
- Palaeoecological manifestation through fossil plant cuticle (Key-note Lecture) in National Symposium on "Current trends in research in biotic systems" held at North Eastern Hill University, Shillong (on June 28, 2017) – delivered by Rajni Tewari.
- Palaeofire evidences in the late Permian sediments of Kashmir: possible cause of end-Permian mass extinction in National Symposium on "Current trends in research in biotic systems" held at North





















Eastern Hill University, Shillong (on June 28, 2017) – delivered by Deepa Agnihotri.

- Akinetes from late Palaeoproterozoic Salkhan Limestone (>1600 Ma) of India: A proxy for understanding life in extreme conditions (Invited Lecture) at EON Workshop, 'Cosmic perspective of Earth: a planet permeated and shaped by Life-Implications for Astrobiology' Earth-Life Science Institute, Tokyo Institute of Technology, Japan, (on September 13-15, 2017) delivered by Mukund Sharma.
- Origin and evolution of life through earth's history with special reference to Glossopteris flora of India (Invited Lecture) at Christian College, Lucknow (during September, 2017) – delivered by Rajni Tewari.
- Plate tectonic movement of continent and disjunct distribution of plant species: Studies from Indian plant fossil records (Key-note Lecture) in the International Biogeography Society meeting in Bangalore, India (during September 26-29, 2017) – delivered by Vandana Prasad.
- *Coal forming flora of India* on International fossil day at BSIP, Lucknow (on October 11, 2017) – delivered by Deepa Agnihotri.
- Origin and evolution of ~66 to ~50 million year old warm blooded animals – an Indian context as part of "International Fossil Day" organized by the Institute (BSIP, Lucknow) (on October 11, 2017) delivered by Vivesh V Kapur.
- *Isotopic studies on Cochin estuary* (Invited talk) at Geology Department, Kerala University (on October 21, 2017) – delivered by Prasanna K.
- Hearths, clay-balls, food-grains and soil-sediments of Early to Mature phase of Indus (Harappan) culture: Multi-tracer investigations to understand pre-historic anthropogenic activities in northwest India (invited seminar) at Max Planck Institute for

Social Science and Human history Jena Germany (on November 22 2017) delivered by Rajesh Agnihotri.

- Identification of radiation induced defects participating in IRSL of feldspars in the Institute of Photonics and Advanced Sensing (IPAS), The University of Adelaide, Adelaide, South Australia, Australia (on November 14, 2017) – delivered by S. Nawaz Ali.
- Contributions of BSIP in International Nannofossil Association Meeting (INA-16) held at Athens, Greece (on December 11, 2017) – delivered by Abha Singh.
- Palynofloral diversity changes across the Palaeogene warming event (ETM2, ~53.7 Ma) in the Palaeoequatorial region: evidences from Panandhro Lignite Mine, western India in 14th Annual Meeting Asia Oceania Geosciences Society, Singapore – delivered by Poonam Verma.
- Occurrence of Halodinium: an indicator of glacial runoff from the Late Pleistocene sediments of Svalbard at Geological Society of America, Annual Meeting 2017, Seattle, USA) – delivered by Vartika Singh
- Application of Remote sensing and GIS in social sciences - ICSSR sponsored Workshop on 19th February, 2018 in Geography Department, Lucknow University on Remote Sensing and GIS in Social Science Research delivered by Biswajeet Thakur.
- Glacial geomorphology, Moraine stratigraphy and Dating of Quaternary sediments at Centre of Advanced Study in Geology, Lucknow University, Lucknow – delivered by S Nawaz Ali.
- Glacial geomorphology, modern analogues and high resolution Holocene palaeoclimatic reconstructions from the north Sikkim Himalaya, India at Innsbruck Geo Seminar Series 2017, Austria – delivered by S Nawaz Ali.



Consultancy/Technical Support Rendered

- Veeru Kant Singh provided consultancy for Raman Spectroscopy to Indian Institute of Toxicological Research, Lucknow.
- Palaeomagnetism Laboratory services provided by Binita Phartiyal and Md. Arif:
- Dr. Siddharth P. Prizomwala, ISR, Raisan, Gandhinagar -Analysis of Susceptibility, ARM and IRM's of samples from western India from October 30 – November 11, 2017.
- Dr. Gurumurthy GP, BSIP, Lucknow, IODP sponsored project (Environmental magnetism) from December 7-23, 2017.
- Ms. Deeksha Bohra, Kumaun University, Nainital MSc dissertation on mineral magnetism of samples from Dewar Lake from January 15-22, 2018.

Consultancy/Service provided to institutional scientists:

- 1) Dr. Anjum Farooqui, (Sandi Lake, Hardoi).
- Dr. Firoz Quamar, (Nauga, Samba, Bajalta, R.S. Pura, Jammu & Kashmir, Nakta Taal & Govind Lake, Chhattisgarh.
- 3) Dr. Anjali Trivedi, Seven Taal, Simran Taal & Renuka Lake.
- 4) Dr. Anil Pokharia, Vadnagar, Gujarat.
- Some of the other potential beneficiaries (sister organizations, government/public/private sectors, universities) are:
- Archaeological Survey of India, New Delhi
- Agharkar Research Institute, Pune
- Babasaheb Bhimrao Ambedkar University, Lucknow
- Babu Banarasi Das University, Lucknow
- Banaras Hindu University, Varanasi, U.P.
- Bhakra Beas Management Board (BBMB), Chandigarh
- Botanical Survey of India
- Centre for Water Resources Development and Management, Govt of Kerala, KSCST, Kerala
- Department of science and Technology, India
- Garhwal University, Srinagar
- Geological Survey of India (GSI), Lucknow
- Geological Survey of India, Kolkata

Geology Department, Anna University, Chennai

- IISR, Gandhinagar, Gujarat
- In house scientists (BSIP)
- Indian Institute of Petroleum and Energy, Vangali, Andhra Pradesh.
- Indian Institute of Petroleum, Dehradun
- Indian Institute of Science (IISc), Bangaluru
- Indian Institute of Technology, Kanpur
- Indian Institute of Tropical Meteorology, Pune, India
- Indian Meteorological Department, Pune, India
- Integral University, Lucknow

Jawaharlal Nehru University, New Delhi

- Kumaun University, Nainital
- National Centre for Antarctic and Ocean Research, Goa
- National Centre for Earth Science Studies, Trivandrum
- National Geophysical Research Institute, Hyderabad
- National Institute of Oceanography, Goa
- National Metallurgical Laboratory, Jamshedpur
- Oil and Natural Gas Corporation
- Oil India Limited, Jodhpur
- Other Departments in the Universities and Institutes dealing with palaeoclimatic and oceanographic/ limnological studies
- Petroleum Organisations and Institutes such as
- Physical Research Laboratory, Ahmedabad
- Rajasthan State Archaeology Department
- Rajasthan Vidhyapeeth, Udaipur
- Rajiv Gandhi Institute of Petroleum Technology, Raebareli, Uttar Pradesh
- Singrani Collaries Company Limited (SCCL)
- Snow and Avalanche Study Establishment (SASE), Chandigarh
- Universities and research Institutes such as
- Various departments of State Climate Change, Planning and Policies



Various universities involved in palaeobotanical research

Wadia Institute of Himalayan Geology, Dehradun

- The Radiocarbon dating facility of Birbal Sahni Institute of Palaeosciences continues to serve as a National facility catering variety of users across from India and abroad. A total of 84 samples (excluding blanks and standards) were dated. This includes 29 Institute samples, 17 consultancy samples, and 32 samples carried out based on collaborative research. Major clients of BSIP Radiocarbon laboratory are listed below.
- Dipti Nagar, Institute of Climate studies, Kottayam, Kerala
- Viraj Sontake, State Archaeology, Nagpur
- C.P. Priju, Ground Water Division, Centre for Water Resources Development Management, Kozhikode
- Krishna R. Prasad, CESS, Thiruvananthpuram
- Quenlin Deveris, CNRS, France
- Total money earned through consultancy during the year 2017-18 : INR 2,68,800/- (Two lakhs sixty eight thousand eighthundred only).
- Around 334 specimens of various disciplines were investigated for morphological features using FESEM. Various techniques and operating parameters are used for getting better images to variety of samples (eg living & fossil, tooth, charcoal wood, megaspores, pollen grains, sediments, etc.). The consultancy services has also been rendered besides Institute's scientific work such to researchers of around 29 departments of various universities, academic institutions and colleges of India for studying their samples.
- Dept of Physics, University of Lucknow, Lucknow (Polymers composites, Nano Powder materials, ceramics, Nano films, Metal oxides, Metal alloy)
- Shri Ram Murty Smarak College of Engg. & Tech., Bareilly (*Pharmaceuticals samples*)
- Dept. of Geology, University of Lucknow, Lucknow (quartz garins, river sediments EDAX)
- Dept. of Botany, University of Delhi, Delhi (pollen grains, seeds)
- Dept. of Orthodontics, Saraswati Dental College, Faizabad Road, lucknow (Teeth, Tooth filing materials)
- Dept. of Pharmacy, Prasad Institute of Technology, Jaunpur, UP (Pharmaceuticals samples)

- Dept. of Botany, Lucknow University, Lucknow (leaf, stem)
- Institute of Pharmaceutical Sciences & Research, Sohramau, Unnao, U.P. (Drug spheres)
- DY Patil University School of Dentistry, Navi Mumbai (tooth samples)
- Dept of Chemistry, University of Lucknow, Lucknow (polymer samples)
- Dept of Zoology, University of Lucknow, Lucknow
- The Gas Chromatography-Mass Spectrometry (GC-MS) unit is being used as a central facility. The facility has also been provided to other institutions in spare times. The unit has provided consultancy in analysis and identification of compounds on 18 samples provided by researchers of following organizations:
- Faculty of Pharmacy, Integral University, Lucknow (UP)— (Herbal extracts)
- Rajiv Gandhi Institute of Petroleum Technology, Rae Bareli (UP)— (Coal & lignite extracts)
- Palynological study of 5 samples from palaeocchannels, Periyar river, India. Centre for Water Resources Development and Management, Govt of Kerala, KSCST, Kerala (Rs.15,000/- to Institute). Results show fluctuation in relative sea level changes on the basis of mangrove pollen and other marine /estuarine palynomorphs by Dr. Anjum Farooqui & Dr. Anjali Trivedi.
- Imparted training on palaeoenvironmental reconstruction using mineral magnetism of Dewar lake to Deeksha Bora, M.Sc. student from Department of Geology, Kumaun University, Nainital for Masters dissertation, January, 2018 by Dr. Binita Phartiyal.
- Imparted training on Mineral and Environmental Magnetic Proxies Implication to Quaternary Climate to Rupali Sharma M.Sc. student HNB Garhwal University, SRTC, Tehri Garhwal, Uttarakhand for a dissertation submitted in partial fulfilment of the requirement for the award of the Degree of Master of Science in Geology from February-March 2018 by Dr. Binita Phartiyal.
- Imparted training on melissopalynological investigations in Bongaigaon District of Assam, Northeast India to Ms. Vandana Tiwari, M.Sc., student of the Department of Botany, University of Lucknow (April-May, 2017). – by Dr. Swati Tripathi.
- Imparted training on modern pollen-vegetation relationship from tropical forest of Goalpara District, Assam,



Northeast India to Ms. Akansha Patel, M.Sc., student of the Department of Botany, University of Lucknow (April-May, 2017). – by Dr. Swati Tripathi.

- Imparted summer training on "Diatoms variability in a dynamic coastal ecosystem: A case study from Sabarmati & Mahi river estuary, Gujarat" to Ms Deepali Chaturvedi, M.Sc student of the Department of Environmental Science, Lucknow University, Lucknow (04th April to 22nd May, 2017) – by Dr. Biswajeet Thakur.
- Imparted summer training on "Diatoms as a tool to monitor coastal ecosystem in Dhadhar river estuary, Gujarat" to Ms Vandita Singh, M.Sc student of the Department of Environmental Science, Lucknow University, Lucknow (04th April to 22nd May, 2017) – by Dr. Biswajeet Thakur.
- Imparted training on Quaternary climate and proxy methods to Anjana Mathew M.Sc. student from Department of Geology, University of Kerala, Kerala for Masters dissertation as IASc Summer Research Fellow from April, 11 to June, 07 2017 by Dr. Binita Phartiyal.
- Imparted summer training on Dendrochronology from Lohit District (Arunachal Pradesh), India to Miss. Rohini Singh M.Sc. student of the Department of Geology, Banasthali University, Rajasthan (May 13-June 23, 2017). – by Dr. Santosh K. Shah.
- Imparted training on palynology of Lower Gondwana sediments of Godavari Graben to Mr. Musarrat Beig, integrated M.Sc. applied geology student from Indian Institute of Technology, Kharagpur (May 22 – July 10, 2017) by Dr. Neha Aggarwal.
- Imparted summer training on petrographical characterization of the coal deposits from Kurja and Kapildhara mines of Sohagpur Coalfield (Madhya Pradesh), India to Mr. Reshav Thakur and Mr. Ankit Rana, M.Sc. students of the Department of Applied Geology, Kurukshetra University, Kurukshetra (June 06-29, 2017). – by Dr. R.P. Mathews.
- Imparted summer training on Fundamentals of Stable Isotope Geochemistry and Sample Preparation Technique to Mr. Amit Kumar Gupta, M.Sc. students of the Department of Geology, H.N.B. Garhwal University, Srinagar (Garhwal) Uttarakhand (June 06-August04, 2017) – by Dr. Shailesh Agrawal.
- Imparted summer training on various aspects of vertebrate palaeontology with special emphasis on laboratory techniques for the recovery of microvertebrate

fossils and photo documentation to Mr. Shirish Verma, B.Sc. (H) 3rd year [Integrated B.Sc. (H) -M.Sc. (H) Geology] student from Hansraj College, University of Delhi, Delhi, India (June 06 – July 10, 2017) – by Dr. Vivesh Vir Kapur.

- Imparted summer training to Mr. Rohan Uday Dusane, M.Sc (Geology), Department of Earth and Environmental Sciences, KSKV Kachchh University, Bhuj, Gujarat, India (June 28 – August 16, 2017). – by Dr. Vivesh Vir Kapur.
- Imparted summer training on "To build multi-proxy Paleo database from Quaternary deposits in Rann of Kutch & surrounding areas of Rajasthan using MySQL" to Tandrila Sarkar, M.Tech. Petroleum Exploration student of IIT(ISM)-Dhanbad (11 June 2018 to 12 July 2018). – by Trina Bose.
- Imparted training on "Modern pollen-vegetation relationship from Akhnoor (Jammu and Kashmir), India: Implications for the interpretation of fossil pollen records" to Mr. Tripathi Anuj Kumar, M.Sc. (pursuing), Department of Environmental Science, C.S.M. University, Kanpur, India during June-August, 2017. - by Dr. Md. Firoze Quamar.
- Imparted summer training on Palaeodiet, Palaeoecology and Palaeoenvironment of human settlement sites (1200 BC-200 AD) in Ganga Plain: A Palaeoethnobotanical Approach to Miss Vaishali, M.Sc student of the Department of Environmental Science, C.S.J.M. University, Kanpur (June 5-September 5, 2017)- by Anil K. Pokharia.
- Imparted training on 'Rock magnetic characterization of Ultramafics and Gneisses rocks from Wayanad, Kerala' to Omer M. Ahmed (Native of Sudan) from University of Kerala, Trivandrum for a dissertation submitted in partial fulfilment of the requirement for the award of the Degree of Master of Science in Geology from 21st July to 4th August 2017 by Dr. Binita Phartiyal and Dr. Mohammad Arif.
- Imparted summer training under SHE-INSPIRE program on "Dendrochronological techniques to understand the climatic variability from Jageshwar, Kumaun Himalaya, India" to Mr. Pradeep Kumar, M.Sc. student of the Geology Department, Kumaun University, Nainital (August14-28, 2017). – by Dr. K.G Misra.
- Imparted summer training under SHE-INSPIRE program on "Application of Dendrochronology to understand the climatic variability from Gangolihat, Uttarakhand,



western Himalaya" to Ms. Pooja Chand, M.Sc. student of the Geology Department, Kumaun University, Nainital (August14-28, 2017). – by Dr. K G Misra.

Imparted summer training on High Resolution Optical and Spectroscopic Instrumentation and their applications in Life, Palaeosciences and Material Sciences to Mr. Varunjeet Singh, B. Tech. Student of Dr. A.P.J. Abdul Kalam Technical University, Lucknow, Uttar Pradesh, (September 01 - October, 31, 2017). – by Veeru Kant Singh and Subodh Kumar.

Imparted training on palynological study of sedimentary profile to Ms. Pavni Misra (M.Sc. Geology) of Indian Institute of Technology, Kanpur for her Ph. D prog. on Climate and vegetation during Holocene in the gangetic plain - by Dr. Anjum Farooqui.



Republic Day





Recognition

Kamal Jeet Singh

Awarded INSA-CAS Fellowship 2017: Awarded the mentioned Fellowship under Bilateral International Exchange Programme to work with Prof. Jun Wang, Director, Department of Palaeobotany and Palynology, Nanjing Institute of Geology and Palaeontology, Nanjing, China.

Anju Saxena

- Awarded INSA-CAS Bilateral Exchange Program grant for the year 2018, to carry out work in Nanjing Institute of Geology and Paleontology, CAS, Nanjing, China.
- Awarded a sponsored project entitled as "Quest for the signatures of early land plants, their subsequent evolution and biodiversity of the Early Palaeozoic sequences of Spiti Himalayas: Palaeoenvironmental and paleogeographical implications" by SERBDST. Grant is yet to be released.

Dr Arindam Chakraborty

- Awarded National Post Doctoral Fellowship from SERB, DST, Goverment of India.
- Selected as a Shipboard Scientist in IODP Expedition 378 (South Pacific Paleogene Climate).

Neha Aggarwal

Awarded Professor O.P. Varma Award for the best paper in Indian Geological Congress 20th Convention (3-5th October, 2017) at Nagpur.

Prasanna K.

Awarded Indo-US Postdoctoral Fellowship by IUSSTF for postdoctoral research at University of California at Los Angeles, USA.

Swati Tripathi

Received 'Associateship' of Indian Academy of Sciences, Bangalore from 2017 to 2021.

Shilpa Pandey

Regional Talent Award 2017 under Science Category by Maharaja Jyotiraditya Madhavrao Scindia during Madhav Jyoti Alankaran Event, May, 2017.

Santosh K Shah

Appointed Resource person during "Workshop on Tree ring analysis using Matlab and R" at Tree Ring and Environmental Change Group, Xishuangbanna Tropical Botanical Garden (XTBG), Chinese Academy of Sciences, P.R. China.

Sunil Kumar Shukla

- INSA-DFG Bilateral Exchange Programme 2017 to conduct research at MARUM-Center for Marine Environmental Sciences, University of Bremen, Germany from June 01 to August 29, 2017 (3 months) - (Sunil Kumar Shukla).
- Awarded SERB Overseas Postdoctoral Fellowship 2016-2017 to conduct research at UMR-CNRS, EPOC, Université de Bordeaux, France from December 20, 2017 to December 19, 2018 (12 months) - (Sunil Kumar Shukla).
- Awarded SERB Overseas Postdoctoral Fellowship 2016-2017 to conduct research at University of California, *Los Angeles, U.S.A for a period of 12 months* (Prasanna K.)

Priyanka Seth, Biswajeet Thakur, Anupam Sharma and Shazi Farooqui

Bagged 3rd Best Poster Award in the National Conference on Climate Change and Natural Resources: Impact and Sustainable Development in Indian Perspective, 20-21 February, 2018 for the work presented entitled *"Value of multiproxy analysis to reconstruct the surface processes in Sabarmati estuary, Mainland Gujarat"*.

P. Morthekai

Indo-Australian Early to Mid Career Research Fellowship (EMCRF).

Nitesh K Khonde

- Awarded SERB Indo-US postdoctoral Fellowship was earned prior to joining BSIP.
- Awarded State Key Maritime laboratory Open Fund Visiting Scholarship 2018-2019, Tongji University, China.









































Participants receiving award during the Hindi Pakhwara function

Himani Patel

Awarded Outstanding Poster presentation entitled "Ancient DNA studies: New perspective on old samples" in International Conference INABASDG-2018 held at the Institute of Agricultural Sciences, BHU.

Ashok Kumar

Awarded by State Electoral Commissioner, Uttar Pradesh for his excellent work as Booth Level Officer (Sarojini Nagar, Lucknow constituency) at state level.



Vigilance Week







Representation in Committees/Boards

Amit Kumar Ghosh

- Member, Editorial Board, Journal of Environmental Biology.

Vandana Prasad

- Selected as Theme Coordinator, for *Critical Events*, *Mass Extinctions and Evolution of Biosphere* for 36th IGC International Geological Congress (due to be held from 2-8 March 2020)

Abha Singh

- Supervising M. Phil Thesis of Ms. Siyumini Perera, University of Peradeniya, Sri Lanka on the topic "Calcareous Nannofossils as Late Paleocene to Early Miocene archives of paleoenvironment and paleoclimate in Mannar Basin, Sri Lanka.
- Member, Scientific Programme Committee, 36th International Geological Congress (due to be held from 2-8 March 2020.
- Life Member of The Palaeonotological Society of India.
- Life Member of the Palaeobotanical Society of India.

Rajni Tewari

- Chaired a scientific session "Biodiversity functions and climate change adaptations" in National Symposium on "Current trends in research in biotic systems" held at North Eastern Hill University, Shillong.

Binita Phartiyal

- Expert Member in Women Scientist Scheme (WOS-A), Department of Science and Technology, New Delhi for the year 2016-2019.

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.
- 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.
- Member, Research Development and Coordination Cell, BSIP (till January 28, 2018).
- Evaluator & Examiner, Ph.D. Thesis, Indian Institute of Technology (ISM), Dhanbad.

Shilpa Pandey

- Co-convener of the Special International Scientific Session title-"IG25- Multi-dimensional Aspects of Climate Change Over South Asian Region" in an International Conference Asia Oceania Geosciences Society, Singapore to be held 6-11th August, 2017.
- Invited as Mentor in Science camp under INSPIRE Programme sponsored by DST at the Arunachal University of Studies, Arunachal Pradesh (Feb. 01-05, 2018).
- Invited as Visiting Professor at the Earth and Environmental Sciences Department, Kachchh University, Bhuj, Gujarat (January 07-13, 2018).



Ph.D. Programmes

Name of Ph.D. Scholor	Subject	Date of Award/ Registration	University	Supervisor(s)	Title of Ph.D. Thesis
Arindam Chakraborty	Botany	October 2017 Awarded	University of Burdwan, Burdwan	Dr Amit K. Ghosh Professor P.K. Pal	Diversity and Palaeoecology of the Benthic and Planktonic biotic assemblages from the Neogene Sequence of Andaman and Nicobar Islands
Ms. Ranjana	Botany	May 2018 Awarded	Kumaun University, Nainital	Anjum Farooqui Dr. Yogesh Joshi,	Climate Induced Relative Sea Level Changes and Coastal Vegetation in Krishna Delta South East Coast of India
Vikram Partap Singh	Geology	March 2018 Awarded	Banaras Hindu University, Varanasi	Dr. BD Singh Prof. MP Singh	Petrology and geochemical characterization of lignite deposits of Saurashtra Basin (Gujarat), India: Implications to economic potential and depositional setting
Debarati Nag	Geology	May 2017 Submitted	Banaras Hindu University, Varanasi	Dr. Binita Phartiyal Prof. M. Joshi	Geomorphological architecture and palaeoclimate of the Late Quaternary sequence of Indus catchment (between Gupuk and Batalik), Ladakh
Ruchika Bajpai	Geology	May 2017 Submitted	Banaras Hindu University, Varanasi	Dr Ratan Kar Dr. A.D. Singh	Investigation of the Holocene climate variability from the glacial sites in Lahaul Valley, western Himalaya, India.
Randheer Singh	Geology	March 2013 Ongoing	Banaras Hindu University, Varanasi	Dr. Binita Phartiyal Prof. B. Pandey	Chaturth kalp ke dauran Tangtse Ghati, Ladakh , uttar paschim Himalaya ki bhu- akriti, vivartanik aur jalvayu
Bandana Dimri	Geology	March 2013 Ongoing	BHU, Varanasi	Dr. Mukund Sharma Prof. Rajesh K 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
Veeru Kant Singh	Geology	September 2013 Ongoing	BHU, Varanasi	Dr. Mukund Sharma (BSIP) Prof. Rajesh K Srivastava	Biostratigraphy of the Mesoproterozoic Chhattisgarh Basin exposed in the Bargarh District, Odisha, India
Ms Kriti Mishra	Geology	October 2013 Ongoing	University of Lucknow, Lucknow	Dr. Ratan Kar Dr. M. Singh	Analysis of Holocene climate variability using multi-proxy data around Chorabari Glacier (Kedarnath), western Himalaya, India.
Nandita Tiwari	Geology	January 2014 Ongoing	UPES, Dehradun	Dr. Mukund Sharma Dr. Uday Bhan	Neogene <i>Chara</i> fossils assemblage from India in the context of extant forms, palaeobiological issues and geological inferences
Syed Azharuddin	Geology	September 2014 Ongoing	Banaras Hindu University, Varanasi	Dr. Pawan Govil Prof. A.D. Singh	Late Quaternary oceanographic and climatic reconstructions based on foraminifera and sediment geochemical signatures from the northeastern Arabian Sea.
Uttam Pandey	Geology	November, 2014 Ongoing	University of Lucknow, Lucknow	Dr. Santosh K. Shah Prof. Munendra Singh	Dendroclimatology of Liddar Valley and adjoining area of Kashmir Himalaya
Ms Shazi Farooqui	Geology	November, 2014 Ongoing	University of Lucknow, Lucknow	Dr. Anupam Sharma	Geochemical study of Late Quaternary subsurface sediments of Lower Mahi River, western India



Ashish Kr. Mishra	Geology	July 2015 Ongoing	BHU, Varanasi	Dr. Vandana Prasad Prof. A.D. Singh	Cretaceous-Early Paleogene climatic events: A case study from Krishna- Gadavari Basin
Vikram Singh	Geology	March, 2016 Ongoing	BHU, Varanasi	Dr. K G Misra Dr. R R Yadav Prof. AD Singh	Tree-Ring based Climate variability in Jammu and Kashmir since Little Ice Age
Priyanka Joshi	Geology	March 2016 Ongoing	Banaras Hindu University, Varanasi	Dr. Binita Phartiyal Prof. M. Joshi	Geomorphological evolution and the climatic variations in the ChangLa- Tangste Basin, Ladakh Range, Trans Himalaya.
Anand Prakash	Gondwana Palaeo- biology	2016 Ongoing	BHU, Varanasi,	Dr Anju Saxena Prof. P.K. Singh	Palaeobiodiversity of coal forming flora of western part of Son-Mahanadi Basin: depositional and palaeoecological implications
Ms. PASRD Perera (M.Phil. degree)	Geology	May 2016 Ongoing	University of Peradeniya, Sri Lanka	Dr. Abha Singh Prof. Kapila Dahanayake Dr. Jagath Gunatilake	Calcareous nannofossil biostratigraphy of the Late Cretaceous to Early Paleogene succession at Mannar Basin, Sri Lanka.
Mahi Bansal	Geology	July 2016 Ongoing	Panjab University, Punjab	Dr. Vandana Prasad Dr. Ajay Patnaik	Phylogenetic structure and biogeography of Indian Paleogene vegetation: A study based on pollen fossil records from western Indian lignites.
Husain Shabbar	Gondwana Palaeo- biology	2017 Ongoing	Sambalpur University, Odisha	Dr Anju Saxena Prof. S. Goswami	Ordovician-Silurian Biodiversity of the Tethyan Himalayan strata, Spiti, H.P., India
Ms. Pavni Misra	Geology	2017 Ongoing	IIT Kanpur, Kanpur	Dr. Anjum Farooqui Prof. Rajiv Sinha	Climate and vegetation during Holocene in the gangetic plain
Yogesh Kumar	Geology	January 2017 Ongoing	Sambalpur University, Orissa	Dr. Mukund Sharma Prof. Shreerup Goswami	Palaeobiology and chemostratigraphy of the Kurnool Group, South India
Shalini Sharma	Botany	July 2017 Ongoing	Kumaun University, Nainital	Dr. Anil K. Pokharia Prof. P.C. Pande	Exploring plant-food resources, vegetation and climate of Indus (Harappan) and subsequent cultures in north-western India.
Rikee Dey	Geology	2018 Registered	IIT-ISM, Dhanbad	Dr. Amit K. Ghosh Dr. A.K. Bhoumik	Reconstruction of Miocene to Pleistocene palaeoclimate derived from the studies of silicified and calcified microfossils from Andaman and Nicobar Islands
Stuti Saxena	Botany	Registered 2018	University of Burdwan, Burdwan	Dr. Amit K. Ghosh Professor J.P. Keshri	Investigation on phytoplankton diversity and geochemistry of the Miocene – Pliocene sequence from the Andaman and Nicobar Island: its significance in past climate reconstruction
Subhankar Pramanik	Botany	Registered 2018	University of Burdwan, Burdwan	Dr. Amit K. Ghosh Professor J.P. Keshri	Vegetational scenario and floral transition across Permian-Triassic in Peninsular India





The Palaeobotanist

This year two issues of the journal *The Palaeobotanist* were published. The first 66(1) incorporated 8 research papers. The second 66(2) contained 6 research papers.

Annual Report

Bilingual Annual Report of Institute was published in Hindi and English containing pertinent information related to research work carried out in the Institute under different research projects during the period 1st April 2016 to 31st March 2017. Besides, conference participation, awards, research papers published/accepted, training/ deputation, Foundation/Founders' Day celebration, reports of different units, annual accounts and related aspects with relevant graphics and photographs were included.

Catalogue

A Catalogue entitled "A Catalogue of Calcareous Nannofossil Records from India" by Jyotsana Rai and Abha Singh was published.

Miscellaneous

Invitation cards for Foundation Day, Founder's Day, and other programmes organised from time to time were printed. Biographical profiles and abstracts of lectures given by eminent speakers on various functions were printed.





Knowledge Resource Centre

Knowledge Resource Centre is committed to provide best information services and support to its users in the era of information sharing and fulfill its mission to disseminate the knowledge.

Besides holding an excellent collection of Palaeobotany and its allied subjects, KRC also provides immediate access of 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 regularly being communicated to its 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 literatures are continuously added to the database.

The current holdings of library are as under:

Particulars	Additions during 2017-18	Total
Books in English	24	6,335
Journals (bound volume	es) 188	17,524
Reprints	79	40,179
Reference Books	-	351
Books in Hindi	-	695
Ph.D. Thesis	7	110
Reports	-	46
Maps & Atlas	-	61
Microfilm/ Fisches	-	294
Compact Disk	-	74

(Working hours 9.30-18.00 Mon-Fri)

Currently the library is receiving 166 journals (115 through subscription and 51 through exchange). There are 175 registered card holders using the library facilities.

The following Institutions/ Organizations availed the Library facilities:

- 1. Department of Botany, Lucknow University, Lucknow
- 2. Department of Geology, Lucknow University, Lucknow

3. Department of Ancient Indian History, Banaras Hindu University, Varanasi

e-Journals

Web based access of the journals is available over the Institute' s 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.html), Oxford University Press (http:// www.oxfordjournals.org/), Springer (http:// link.springer.com/), 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).

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 fiction, classic literature, novels, books on general interest, 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, Institute Special publications are accessible over it.

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

Exchange Facility-

- 1. Institutions on exchange panel 34 with our in house journal '*The Palaeobotanist*'
- 2. Journals received from different institutes 51 on exchange basis

Training

KRC is providing 12 months training to two Apprentice trainees for library working.



Museum

Museum plays a vital role to popularize and disseminate the palaeontological knowledge amongst the students and researchers within the country and abroad. During this period, the exhibits from the museum were displayed in the three national exhibitions. One exhibition, i.e. the IISF 2017, Mega Science Technology & Industries Expo, was held at Anna University, Chennai during 13 to 16 October, 2017; the second exhibition was organised by the Gujarat Scientific Literacy Festival that was held at Valsad, Gujarat during 26 to 28 October, 2017. The third one, i.e. the 37th India International Trade Fair held at Pragati Maidan, New Delhi from 14 to 27 November, 2017.

National Science Day 2018 was celebrated on 28th February in a befitting manner. It was observed as an Open House and around 250 students from various colleges visited the Institute's Museum and different Laboratories. On this occasion, popular scientific lectures were delivered by institute's scientists and research scholars.

Research material (megafossils and palynological samples) were collected from 295 localities spreading in different parts of the country by the scientists working on Institute's projects as well as on various sponsored projects. Type materials of 34 research papers were also submitted in the repository during this period.

Two sets of plant megafossils were gifted to various colleges within the country and fossil specimens were also given to the distinguished visitors as gifts during conferences/lectures held in the Institute.

Museum Holdings:

Particulars	Addition during 2017-18	Total
Type and Figured Specimens	343	9,067
Type and Figured Slides	201	15,531
CDs	17	159

Specimens/ Samples collected by the Scientists during the field work under various projects:

Project	Megafossil Specimens	Palynological Samples
Project-1		544
Project-2	592	1179
Project-3		891
Project-4		385
Project-5		1062
Project-6		2239

Samples deposited in the repository under Sponsored/Collaborative Projects:

SB/EMEQ- 225/2014	27 Samples
EMR/2014/000233 (DST Sponsored)	85 Samples
SR/WOS-A/ES-18/14	94 Samples
SR/WOS-A/ES-18/14	21 Samples
SERB-DST (SR/FTP/ES-143/2014)	110 Samples
SERB/F/7133/2016-17	200 Samples
SR/FTP/ES-81/2013/2014	282 Samples
NMHS, Project No. 1886/XII-86/2016	216 Samples
PDF/2016/000129	158 Samples
SR/DGH-69/13	216 Samples
SR/S4/ES-621/2012	12 Samples
SR/S4/ES-621/2012	1,175 Samples
SERB Spon. Project EMEQ-139/2014	143 Samples
NMH Project-1882/XII-86/2016	194 Samples
SB/EMEQ-225/2014	118 Samples
EMR/2014/000233 (DST Sponsored)	65 Samples
SB/EMEQ-244/2014	314 Samples
SR/FTP/ES-149/2014	60 Samples

Specimens / Slides gifted to the Educational Centres:

Department of Earth Sciences, IIT Roorkee, Roorkee-247 667, Uttarakhand, India

Center for Earth Sciences, Indian Institute of Science, Bengaluru- 560012, India





- Fossil Memento Presented to the Distinguished Guests:
- Prof. Ajit K.Chaturvedi, Director IIT, Roorkee.
- Prof. Nachiketa Rai, IIT, Roorkee.
- Prof. S.P. Singh, V.C. Lucknow University, Lucknow.
- Prof. P. Balram, Ex. Director, IISc, Bangaluru.
- Prof. Dianne Edwards, School of Earth and Ocean Sciences, Cardiff University, Cardiff, U.K.
- Dr. Arvind Chaturvedi, SP, STF, Lucknow.
- Dr. G.K. Goswami, DIG, CBI, Lucknow.
- Prof. A.K. Tirpathi, Director CIMAP, Lucknow.

Institutional Visitors:

Sri JNPG, Post Graduate College, Lucknow, U.P.

- Forest Training Institute, Kanpur.
- Lokmanya Tilak Mahavidyalaya, Wani Dist. Yavatmal, Maharashtra.
- Feroze Gandhi College, Rai Bareilly, U.P.
- Ghunghunwala R.J. College, Ghatkopar, M. Mumbai University, Mumbai.

- DST TV Series on Geology & Geography of India, Crew Members:
- Mr. Rajendra Kondapalli- Director.
- Mr. Abhishek Jain: Associate Producer.
- Mr. Shail Chauhan- Cameraman.
- Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot.
- Dattajirao Kadam Arts, Science and Commerce College, Ichalkaranji District Kolhapur, Maharashtra.
- Birla Balika Vidyapeeth, Pilani, Rajasthan.
- Geological Sciences, Jadavpur University, Kolkata, West Bengal.
- Geology Department, Bangalore University, Bengaluru.
- Archaeological Survey of India Lucknow.
- Toshiki Osada, Research Institute, Kyoto, Japan.

Archaeological Survey of India, Vadodara, Gujarat.

- Institute of Archaeological Survey of India, New Delhi.
- University of Gaur Banga Malda, West Bengal.

Electronic Data Processing

NKN (National Knowledge Network) connectivity in the Institute is successfully running and provides 24 hours internet facility to the Institute staff.

E-Mail accounts for 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 to protect the system from viruses and worms.

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. Institute Facebook page and twitter account has been created and regularly updated the information with photographs. This year Institute has procured 10 user license Corel Draw 2017 software.

In addition, Payroll, Form16 and pension packages are also modified as per the requirements of the Account Section. Computer Section is providing help to the scientists in preparing the multimedia presentations, charts, graphs, lithologs and diagrams for their scientific publications and documentation.



TL/OSL and Geochemistry Facility

The TL/OSL and Geochemistry Facility of Birbal Sahni Institute of Palaeosciences, Lucknow is dedicated to serve as a National facility providing data to users throughout the country as well as abroad. The Birbal Sahni Institute of Palaeosciences is a premier centre for plant fossil research and mainly emphasis on different aspects of taxonomy, evolutionary history, and palaeoclimatic study. To give a better shape and clear picture of the past, classical palaeobotany has to be supported with diverse lines of investigations, particularly the geochemical and chronological techniques, which provide additional information. Environmental issues of the geological past help in solving boundary problems using geochemical tools. Similarly, it also registers high resolution climatic fluctuations and can be better reconciled by integrating fossil data with modern lines of research in sedimentology, geochemistry and geochronology. Towards this, the BSIP has a world class state of the art laboratory facility having sophisticated instruments such as ICP-MS, XRD, XRF, IRMS, GC-MS supported with ASE, Particle Size Analyzer, TL/OSL reader, HPGe, Isodynamic magnetic separator, Pellet preparation machine, Micro-drill, disc and ball mill, microwave digestion system, etc.



Risoe Luminescence Reader



Magnetic Separator

A new advanced continuous flow isotope ratio massspectrometer (CF-IRMS, model MAT 253) with three periphiral units i.e. Elemental Analyser (Flash 2000HT), Gas Bench, and GC isolink for measuring stable isotopes of carbon, nitrogen, sulfur, hydrogen and oxygen (C, N, S, H & O) in a variety of natural materials. The Luminescence dating facility (LumDL) equipped with two Risoe automated TL/OSL Reader DA-20, additionally having violet laser stimulation, time-resolved luminescence detection, is used to measure the light output. High pure Ge-solid state gamma ray detector is used to estimate the concentration of U, Th and K that are responsible for annual luminescence input to the natural sample. Magnetic barrier separator (Frantz LB-1 Model) is used to separate magnetic minerals, feldspar and quartz from the sediment extract. Luminescence dating technique provides specific dates (ranging from 10 to 1,00,000 years) of sediment samples. This technique is used by the researchers who work in the palaeosciences to know the age of the sediments. Accelerated solvent extraction (Dionex ASE 350) is a technique for extracting organic compounds from solid and semisolid samples with liquid solvents. Dionex ASE systems use organic and aqueous liquid solvents at elevated temperatures and pressure to increase the efficiency of the extraction process. The Gas Chromatography/Mass Spectrometry (GC/MS) combines the features of gas-chromatography and mass spectrometry to identify different organic compounds presents in the organic matter, which includes Alkanes, Fatty acids, Alkenones, Sterols, etc. GC-MS is becoming the tool of choice for tracking organic compounds derived from variety of plants as well as in their fossil counterpart, which may enable us to understand evolution through time and may also help in palaeoclimate reconstruction. The Agilent 7700 ICP-MS provides unparalleled accuracy in high-matrix samples, redefining cell performance in helium mode with a revolutionary 3rd generation cell design the ORS3. Use of autosampler makes this easier and faster, especially for routine work and large numbers of samples analyses.

The X-ray Diffraction (XRD) of PANalytical (X'PERT³) offers a wide range of material characterization using X-ray for bulk minerals, nano materials and Geological samples. Major oxide quantification is done by a X-Ray Fluorescence (XRF PANalytical make) through a wavelength dispersive (WD-XRF) instrument. It has wide applications, viz.





X-ray diffractrometer



X-ray fluorescence

quantification of elements in hard rocks and sediments / soil of the geological past as well as metals and alloys.

List of Institute's Scientists/scholars using the Facility on routine basis

Drs. Mukund Sharma, B.D. Singh, Vandana Prasad, Anupam Sharma, Anjum Farooqui, Amit K. Ghosh, Rajesh Agnihotri, Binita Phartiyal, Ratan Kar, Anil K. Pokharia, S.K. Basumatary, Pawan Govil, K.G. Mishra, S.S.K. Pillai, P.S. Ranhotra, Anju Saxena, Vartika Singh, Veeru Kant Singh, Biswajeet Thakur, A.H. Ansari,



ICP-MS

GC-MS

Neha Aggarwal, Shailesh Agrawal, Abha Singh, S. Nawaz Ali, Ruby Ghosh, Vivesh V. Kapur, Kamlesh Kumar, Manoj M.C., Runcie P. Mathews, P. Morthekai, Santosh K. Pandey, Neelam Das, Shilpa Pandey, Abhijit Mazumdar, Sunil K. Shukla, Poonam Verma, Anjali Trivedi, Sajid Ali, Gurumurthy T., Prasanna K., Nitesh K. Khonde.

List of other Research institutes/universities who have used the facility during 2017-18

- 1. Integral University, Lucknow
- 2. Patna University, Patna, Bihar
- 3. D-Maps, New Delhi
- 4. Babasahab Bheemrao Ambedkar University, Lucknow
- 5. Lucknow University, Lucknow
- 6. Ranchi University, Jharkhand
- 7. National Institute of Pharmaceutical Education and Research, Raebareli
- 8. IISER, Mohali
- 9. Indian Institute of Toxicological Research (IITR), Lucknow
- 10. Jawaharlal Nehru University, New Delhi
- 11. Central University of Himachal Pradesh
- 12. Allahabad University, Allahabad
- 13. IISER, Kolkata
- 14. Delhi University, Delhi



Radiocarbon Laboratory

The Radiocarbon dating facility of Birbal Sahni Institute of Palaeosciences continues to serve as a National facility catering variety of users across from India and abroad. The traditional radiometric method utilizes conventional beta-counting of benzene prepared by trimerization of CO₂ extracted from organic and inorganic capable of measuring ¹⁴C atoms of ~1mg of solid graphite powder made from dateable carbon. Sample throughput of AMS 14C dating is also relatively much higher compared to conventional beta counting technique.

As a first step, to gain capability of sample preparation for AMS ¹⁴C dating, BSIP's Radiocarbon



dating laboratory is poised to create a dedicated ultra-AMS modern sample preparation lab, which is comprising a complete stable isotopic tracing of various organic and inorganic samples generally subjected to radiocarbon dating. Towards this, we procured and installed a set of coupled instruments which are Elemental Analyzer (EA), Carbonate hydrolysis system (CHS), Automatic graphite preparation system and Isotope ratio massspectrometer (CF-EA-CHS-IRMS-AGE). Establishments of protocols for different

carbon contained in any natural/environmental sample. The set-up is comprised of an offline glass line vacuum extraction system to produce 1-3 ml of liquid benzene $(C_{\alpha}H_{\alpha})$ and an ultra low-level Quantulus Liquid Scintillation counter (Wallac 1220®). An Elemental analyzer (EA1112; Thermo®) is used for pre-selection and quantification of organic and inorganic carbon of samples selected for benzene preparation. Overall, the processing for benzene involves combustion (hydrolysis) of the pre-treated organic (inorganic) samples followed by trimerisation using appropriate catalysts at different stages. Correction for the counting efficiency of the samples is carried out using spectral quench parameter (SQP) and dates are calibrated using the Calib 7.1 programme. Varieties of samples (carbonates, woodcharcoal pieces, organic rich sediments and peat layers etc.) are routinely dated.

The conventional radiometric dating by beta counting is highly labour- intensive, time taking method which requires larger amount of dateable carbon (~10 gm). In contrast, Accelerator Mass Spectrometry directly is stable isotopic measurements and preparation of graphite powder from different matrix of samples are currently underway. A snapshot of coupled set of various instruments are shown below.

Consultancy / Technical Support Rendered -

A total of 84 samples (excluding blanks and standards) were dated. This includes 29 Institute samples, 17 consultancy samples, and 32 samples carried out based on collaborative research. Major clients of BSIP Radiocarbon laboratory are listed below.

- 1 Dipti NagarInstitute of Climate studies, Kottayam Kerala
- 2 Dr. Viraj SontakeState Archaeology, Nagpur
- 3 Dr. C.P. PrijuGround Water DivisionCentre for Water Resources Development Management, Kozhikode
- 4 Krishna R. PrasadCESS, Thiruvanantpuram
- 5 Dr. QuenlinDeverisCNRS, France



Scanning Electron Microscopy

The scanning electron microscopy unit (SEM unit) of the institute is dedicated for providing support frontline research in the palaeobotanical, geological, biological and materials science, etc. for the Institute's scientists for observing morphological and structural characterization of the scientist's samples in the range of micro/nano scale and non destructive elemental analysis using EDS. The unit is equipped with Field Emission 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 user samples.

Around 334 specimens of various disciplines were investigated for morphological features using FESEM. Various techniques and operating parameters are used for getting better images to variety of samples (eg living & fossil, tooth, charcoal wood, megaspores, pollen grains, sediments, etc.). The consultancy services has also been rendered besides Institute's scientific work such to researchers of around 29 departments of various universities, academic institutions and colleges of India for studying their samples.

Dept. of Physics, University of lucknow, Lucknow (Polymers composites, Nano Powder materials, ceramics, Nano films, Metal oxides, Metal alloy)

Shri Ram Murty Smarak College of Engg. & Tech., Bareilly (*Pharmaceuticals samples*)

Dept. of Geology, University of Lucknow, Lucknow (quartz garins, river sediments EDAX)

Dept. of Botany, University of Delhi, Delhi (pollen grains, seeds)

Dept. of Orthodontics, Saraswati Dental College, Faizabad Road, lucknow (Teeth, Tooth filing materials)

Dept. of Pharmacy, Prasad Institute of Technology, Jaunpur, UP (*Pharmaceuticals samples*)

Dept. of Botany, Lucknow University, Lucknow (leaf, stem)

Institute of Pharmaceutical Sciences & Research, Sohramau, Unnao, UP (Drug spheres)

DY Patil University School of Dentistry, Navi Mumbai (tooth samples)

Dept. of Chemistry, University of Lucknow, Lucknow (polymer samples)

Dept. of Zoology, University of Lucknow, Lucknow (micro particles, wood extract)

Dept. of Bioengineering, Integral University, Dasauli, Lucknow (leaf, roots)

Dept. of Geology, Amar Singh College, Srinagar (Sediment grains)

Dept. of Applied Physics, Babasaheb Bhimrao Ambedkar University, Raibarelli Road, Lucknow (Nanomaterial, crystals structures)

Dept. of Biotechnology, BNPG College, Udaipur, Rajasthan (Living pollen spores)

School of Engineering, BBD University, Lucknow (Aluminum metal alloy)





Distinguished Visitors

- Prof. Ajit K.Chaturvedi, Director Indian Institute of Technology, Roorkee.
- Prof. Nachiketa Rai, Indian Institute of Technology, Roorkee.
- Prof. S.P. Singh, Vice Chancellor, Lucknow University, Lucknow.
- Prof. P. Balram, Ex. Director, ISC, Bangaluru.
- Prof. Dianne Edwards, School of Earth and Ocean Sciences, Cardiff University, Cardiff, U.K.

- Dr. Arvind Chaturvedi, SP, Special Task Force, Lucknow.
- Dr. GK. Goswami, DIG Central Bureau of Investigation, Lucknow.
- Prof. A.K. Tirpathi, Director, Central Institute of Medicinal and Aromatic Plants, Lucknow.
- Prof. Rajeevan, Secretary, Ministry of Earth Sciences, Govt. of India
- Shri N. Kutumba Rao, Director General, Geological Survey of India

Birbal Sahni Death Anniversary





Activities in Official Language

The Institute continues to make effort to attain the set target for Official Language implementation. The Institute participated in both the Half Yearly meetings of Nagar Raj bhasha Kaaryaanvayan Samiti during the year 2017-18 situated in 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 various media. These included popular Science Lectures in various institutions/ forums; interactions during exhibitions and popular science articles. Mr. Malik, Dy. Director, Regional Implementation Office (Northern Region), Ministry of Home Affairs, Department of Official Language inspected the Institute on 22 June, 2017.

Hindi Fortnight

Hindi Fortnight was celebrated during September 10-25, 2017. During the Hindi Fortnight, Forty two staff members participated in a series of competitions including Hindi Typing (Computer), Noting, Essay, Debate and Antyaaksharee. The Director attended and encouraged the participants during the competitions too. Kavi Sammelan was also organized on September 25, 2017.

Results of various competitions are given below:-

Typing	:	I - Ms. Manisa Tharu
		II - Mr. Ajay Kumar Srivastava
		III - Mr. Saheb Lal Yadav
Encouragement	:	Mr. Raj Kumar, Mr. Mahesh Nair, Mr. Ram Ujagar, Ms. Saumya Tripathi

Essay : I - Dr. Anupam Sharma II - Mr. Yogesh Kumar, Mrs. Sandhya Mishra

III - Mrs. Neelam Das



Encouragement :	Mr. Raj Kumar, Ms. Shalini Sharma, Ms. Neelam Mishra, Ms. Sandhya ² Singh	
Noting :	I - Mr. Rahul Gupta	
	II - Dr. Anupam Sharma	
	III - Ms. Manisa Tharu	
Encouragement :	Mr. Raj Kumar, Mr. Yogesh Kumar, Mr. Rajesh Mishra Mr. Manoj Singh	
Debate :	I- Mr. Yogesh Kumar 3	•
	II -Mr. Y.P. Singh, Mr. Randheer Singh	
	III - Mr. P.K. Mishra	
Encouragement :	Dr. Trina Bose, Mrs. Sandhya Mishra, Dr. A. Rajnikanth, Mr. K.C. Chandola	
Antyaaksharee :	I - Mrs. Sandhya Mishra, Mr. H Amulya	3ł
	II - Mr. Aashish Mishra, Ms. W Priyanka Joshi, Neelam Das, Mr. F Yogesh Kumar n	va ta iu
	III - Ms. Shalini Sharma, Mr. Amit Mishra	iaj he Ka
Encouragement :	Ms. Neelam Mishra, Ms. Jyotsana C Dubey, Dr. Trina Bose, Ms. Shaazi ^A	Ch Ag

Hindi Workshop

The quarterly workshops were organized on the following subjects. The workshops were followed by lively discussions related to the topics

Farooqui

of talks and related terminology:-

 Shodh men Raj Bhasha Hindi kaa Mahatva - Dr. Ajay Kumar Sah, Principal Scientist, Indian Institute of Sugarcane Research, Lucknow (08.6.2017)



2. Digital India: Avasar Aur Chunautiyan - Dr. Arvind Chaturvedi, Additional Superintendant of Police, Special Task Force, U.P. (10.9.2017)



3. *Maanav men Hone waalee Beemaariyan* -Prof. Ajay Kumar Sharma, HOD Zoology, University of Lucknow, Lucknow (22.12.2017)



Bhasha Utsav

On March 18, 2018 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 India presented papers in the symposium. Several Hindi experts presented their views. Among those who spoke were Dr. Nimesh Kapur from Vigyan Prasar, Noida (U.P.), Shri Mahesh Chandra Dwivedi, IPS, Prof. Usha Sinha, Dr. M.L. Agarwal and others. The Souvenir-cum-abstract book was also released at this juncture.

Miscellaneous

Meetings of Official Language Implementation Committee of the Institute were organized in each quarter. The computers of the Institute with net facility have access to multi-lingual software. The process of making forms bilingual is near completion. The Annual Report of the Institute was published in Hindi also. In the international journal of the Institute, *'The Palaeobotanist'*, abstracts of all the research papers in Hindi were also published. In adherence to the section 3(3) of the Official Language Act 1963, efforts are continued to improve correspondence in Hindi.



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

Prof. Talat Ahmad Vice Chancellor Jamia Millia Islamia Central University Jamia Nagar, New Delhi-110 025

Dr. V. Purnachandra Rao

Ex-Scientist, NIO, Goa & Emeritus Scientist Department of Civil Engineering Vignan's University, Vadlamudi-522 213

Dr. K.J. Ramesh

Director General Indian Meteorological Department, MoES Prithvi Bhavan, IMD Campus, Lodhi Road New Delhi-110 003

Prof. Sunil Bajpai

Director Birbal Sahni Institute of Palaeobotany Lucknow-226 007 Finance Adviser

(or his/her nominee) Department of Science and Technology Technology Bhavan, New Mehrauli Road New Delhi-110 016

Prof. G.V.R. Prasad

Head, Department of Geology University of Delhi Delhi-110 007

Prof. L.S. Chamyal

Department of Geology M.S. University of Baroda Fatehganj, Vadodara-390 002

Director General

(Ex-Officio Member) Geological Survey of India 27, Jawaharlal Nehru Road Kolkata-700 016

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

www.bsip.res.in

Annual Report 2017-2018

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. G.V.R. Prasad

Department of Geology University of Delhi Delhi-110 007

Dr. V.P. Misra

Ex-Dy. Director General, GSI 4/490, Vivek Khand Gomti Nagar, Lucknow-226 010

Prof. S.D. Biju

Department of Environmental Studies University of Delhi Delhi-110 007

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 **Prof. N.N. Dogra** Department of Earth Sciences Kurukshetra University Kurukshetra-136 119

Dr. V. Ravikant Department of Geology & Geophysics

Indian Institute of Technology Kharagpur-721 302

Dr. Suryendu Dutta

Department of Earth Sciences Indian Institute of Technology Bombay Powai, Mumbai-400 076

Shri S.K. Srivastava

Former CMD, Oil India Limited Flat 001, Tower 2, Gardenia Glory Sector 46, Noida-201 301

Sr. Deputy Director General

(Ex-officio Member) HOD Northern Region Geological Survey of India Vasundhara, Sector-E, Aliganj Lucknow-226 020

125





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

Women's Day











Staff

Director

Prof. Sunil Bajpai

Scientists

Scientist 'G' Dr. R.S. Singh (retired w.e.f. 31.08.2017 AN)

Scientist 'F'

Dr. Rupendra Babu (retired w.e.f. 31.07.2017 AN)
Dr. Madhav Kumar
Dr. R.C. Mehrotra
Dr. (Mrs) Neeru Prakash
Dr. (Mrs.) Vandana Prasad (w.e.f. 01.01.2018)
Dr. Anupam Sharma (w.e.f. 01.01.2018)
Dr. Mahesh Prasad (retired w.e.f. 31.08.2017 AN)
Dr. (Mrs.) Jyotsana Rai (retired w.e.f. 31.05.2017 AN)
Dr. Annamraju Rajanikanth (retired w.e.f. 28.02.2018 AN)
Dr. O.S. Sarate (retired w.e.f. 31.12.2017 AN)
Dr. Mukund Sharma
Dr. Bhagwan D.Singh
Dr. (Mrs.) Rashmi Srivastava (retired w.e.f. 31.10.2017 AN)
Dr. (Mrs.) Rajni Tewari (retired w.e.f 30.09.2017 AN)

Scientist 'E'

Dr. Rajesh Agnihotri Dr. (Mrs.) Anjum Farooqui Dr. Amit K.Ghosh Dr. Ratan Kar (w.e.f. 01.07.2017) Dr. (Mrs) Binita Phartiyal (w.e.f. 01.07.2017) Dr. Anil Kumar Pokharia (w.e.f. 01.07.2017) Dr. GK.Trivedi

Scientist 'D'

Dr. Sadhan Kumar Basumatary Dr. Pawan Govil Dr. Krishna Gopal Mishra (w.e.f. 01.01.2018) Dr. Srikanta Murthy Dr. S. Suresh K. Pillai (w.e.f. 01.07.2017) Dr. (Ms) K. Pauline Sabina (w.e.f. 01.07.2017) Dr. (Mrs) Anju Saxena (w.e.f. 01.07.2017) Dr. Santosh Kumar Shah Dr. Hukam Singh Shri Veeru Kant Singh Dr. (Miss) Vartika Singh (w.e.f. 01.01.2018) Dr. Biswajeet Thakur

Scientist 'C'

- Dr. (Mrs) Neha Aggarwal
- Dr. Shailesh Agrawal
- Dr. (Mrs) Deepa Agnihotri
- Dr. Sheikh Nawaz Ali
- Dr. Arif Hussain Ansari (w.e.f. 01.01.2018)
- Dr. Manoj M.C. (w.e.f. 01.01.2018)
- Dr. (Ms) Ruby Ghosh
- Dr. Vivesh Vir Kapur
- Dr. Kamlesh Kumar
- Dr. Abhijit Mazumdar
- Dr. P. Morthekai (w.e.f. 01.07.2017)
- Dr. (Ms) Neelam
- Dr. Santosh Kumar Pandey (w.e.f. 01.01.2018)
- Dr. (Mrs) Shilpa Pandey
- Dr. Mohd. Firoze Quamar
- Dr. Parminder Singh Ranhotra
- Dr. (Mrs) Anumeha Shukla
- Dr. Sunil Kumar Shukla (w.e.f. 01.01.2018)
- Dr. (Mrs) Abha Singh
- Dr. (Mrs) Jyoti Srivastava
- Dr. Gaurav Srivastava
- Dr. (Mrs) Swati Tripathi
- Dr. (Mrs) Anjali Trivedi
- Dr. (Mrs) Poonam Verma

Scientist 'B'

- Dr. Trina Bose
- Dr. Runcie Paul Mathews

Technical Personnel

Technical Officer 'D' Sri Madhukar Arvind Mrs Reeta Banerji Sri Pavan Singh Katiyar Mrs Sunita Khanna (retired w.e.f. 30.11.2017 AN) Mrs Kavita Kumar (retired w.e.f. 30.04.2017 AN) Sri Tapan Kumar Mandal Sri Rattan Lal Mehra (w.e.f. 03.04.2017) Sri R.C. Mishra Sri Pradeep Mohan Shri Chandra Pal (retired w.e.f. 28.02.2018 AN)

(The names are in alphabetical order according to 'surnames')



Sri Vinod Kumar Singh Shri Vijay Pratap Singh Shri Yogendra Pratap Singh

Technical Officer 'C' Dr. Subodh Kumar Sri V.K. Nigam

Technical Officer 'B'

Dr. Syed Rashid Ali Sri Digambar Singh Bisht Sri Dhirendra Kumar Pal Sri Dhirendra Sharma Dr. Sanjai Kumar Singh

Technical Officer 'A' Sri Sumit Bisht

Technical Assistant 'E'

Sri Chandra Bali (retired w.e.f. 31.12.2017 AN) Dr. Nilay Govind Sri Avanish Kumar Sri Subhash C. Singh Sri Madan Singh Rana Mrs Kirti Singh Sri Ajay Kumar Srivastava Sri Chhotey Lal Verma (retired w.e.f. 30.09.2017 AN)

Technical Assistant 'D'

Sri Pawan Kumar

Technical Assistant 'B'

Sri J. Baskaran Sri Ashok Kumar Sharma Ms Richa Tiwari (on Lien) Sri Ram Ujagar

Administrative Personnel

Registrar Sri Sanjay Kumar (resigned w.e.f. 25.09.2017 AN) Sri Sandeep Kumar Shivhare (w.e.f. 28.12.2017 AN)

Accounts Officer Sri N.B. Tewari (retired w.e.f. 31.01.2018)

Private Secretary Mrs M. Jagath Janani

Section Officer

Mrs Ruchita Bose Sri Hari Lal Mrs Swapna Mazumdar Sri K.P. Singh

Stenographer Sri Murukan Pillai

Hindi Translator

Sri Ashok Kumar

Assistant

Sri Mishri Lal Sri N. Unnikannan Sri Shailendra Singh Panwar Sri Rameshwar Prasad Sri Gopal Singh Sri Avinash Kumar Srivastava Mrs Renu Srivastava Sri Koshy Thomas

Upper Division Clerk

Miss Chitra Chatterjee Ms Sudha Kureel Sri Rajesh Kumar Mishra Miss Manisha Tharu

Lower Division Clerk

Sri Rahul Gupta Miss Anupam Jain Sri Mahesh Nair Sri Manoj Singh Mrs Vijaya Venkateshwari

Drivers

Sri Nafis Ahmed ('IV') Sri Devendra Kumar Mishra ('IV') Sri Madan Mohan Mishra ('IV') Sri Vijay Pratap Singh ('IV') Sri Pushpendra Kumar Mishra ('IV' w.e.f.22.01.2018 FN)

Multi Tasking Staff

Multi Tasking Staff: Sri K.C. Chandola Multi Tasking Staff 'II' Sri K.K. Bajpai

(The names are in alphabetical order according to 'surnames')



Sri Ram Dheeraj Sri Dhan Bahadur Kunwar Sri Mani Lal Pal Sri Bam Singh Sri Ram Singh

Multi Tasking Staff 'I'

Mrs Bhawana Awasthi Sri R.K. Awasthi Smt. Beena Sri Ram Chander Sri Vishwanath S. Gaikwad Smt. Ram Kali Sri Hari Kishan Sri Deepak Kumar Sri Indra Kumar Sri Raj Kumar Sri Ramesh Kumar Sri Shailesh Kumar Sri Suneet Kumar Km. Nandani Sri Kailash Nath Sri Mathura Prasad Sri Ravi Shankar Sri Ankit Pratap Singh Miss Sandhya Singh Sri Ram Kewal Yadav

Sponsored Project Personnel

Dr. S. Jeyakumar, RA (resigned) Ms Mahi Bansal, JRF Ms Jyotsana Dubey, JRF Miss Priyanka Joshi, JRF Sri Raj Kumar, JRF Sri Ashish Kumar, JRF Sri Ashish Kumar Mishra, JRF Sri Ashish Kumar Pal, JRF (relieved w.e.f. 02.08.2017 AN) Sri Uttam Pandey, JRF Sri U Prem Raj, JRF Ms Amulya Saxena, JRF Ms Priyanka Seth, JRF Ms Shalini Sharma, JRF Sri Vikram Singh, JRF (relieved w.e.f. 31.10.2017 AN) Ms Utsa Singh, JPF (relieved w.e.f. 23.10.2017 AN) Sri Pranav Raj Tyagi, JRF Sri Raja Ram Verma, PA (relieved w.e.f. 21.09.2017 AN) Sri Saheb Lal Yadav, PA (relieved w.e.f. 31.10.2017 AN) Ms Neelam Mishra, TA

DST Inspire Fellow

Sri Arindam Chakraborty (relieved w.e.f. 23.10.2017 AN) Ms Ipsita Roy

Young Scientists

Dr. Mayank Shekhar, YS DST Sponsored Project Dr. Suman Sarkar, YS Dr. (Mrs) Sandhya Misra, YS DST Sponsored Project

JRF Under BSIP Ph.D. Programme Self Supported Category-II

Sri Husain Shabbar, SRF (w.e.f. 19.06.2017) Sri Yogesh Kumar, JRF Mrs Richa Gupta, JRF

JRF Under BSIP Ph.D.Programme Self Supported Category-I Sri Mukesh Kumar Yadav, JRF

JRF Under BSIP Ph.D. Programme Category-I Supported By CSIR-UGC-JRF-Net Fellowship Sri Anand Prakash, JRF (relieved w.e.f. 07.07.2017 AN)

Principal Investigator Dr. Shamim Ahmed, PI

Women Scientist Under Women Scientist Scheme - A Ms Ruchika Bajpai, Women Scientist

Women Scientist Under-DST Women Scientist Scheme A (WOS-A) Mrs Nivedita Mehrotra, Women Scientist

National Post Doctoral Fellow

Dr. Akhilesh Kumar Yadav Dr. Anju Verma (relieved w.e.f. 21.06.2017 AN) Dr. Matsyendra Kumar Shukla



Appointments

- Dr. Arvind Kumar Singh, Scientist 'B' w.e.f. 10.04.2017 (FN)
- Dr. Mohammad Arif, Scientist 'B' w.e.f. 11.04.2017 (FN)
- Dr. Sajid Ali, Scientist 'B' w.e.f. 11.04.2017 (AN)
- Dr. Ansuya Bhandari, Scientist 'B' w.e.f. 12.04.2017 (FN)
- Dr. Niteshkumar Narendra Khonde, Scientist 'B' w.e.f. 20.04.2017 (AN)
- Dr. Prasanna K, Scientist 'B' w.e.f. 21.04.2017 (FN)
- Dr. Gurumurthy G.P., Scientist 'B' w.e.f. 21.04.2017 (FN)
- Dr. Niraj Rai, Scientist 'C' w.e.f. 24.04.2017 (FN)
- Dr. Yogmaya Shukla, Scientist 'B' w.e.f. 26.04.2017 (FN)
- Sri Amit Kumar Mishra, JRF self supported Ph.D. Category-I w.e.f. 05.06.2017
- Ms Rikee Dey, JRF BSIP/ CSIR-UGC w.e.f. 22.06.2017
- Sri Masud Kawsar, JRF w.e.f 08.08.2017 (FN)
- Sri Sanjay Kumar Singh Gahlaud, JRF BSIP/CSIR w.e.f. 25.08.2017
- Sri Sachin Kumar, JRF BSIP/CSIR w.e.f. 28.08.2017
- Ms Shachi Bajpai, JRF BSIP/CSIR w.e.f. 06.09.2017
- Ms Shivalee Srivastava, Technical Assistant 'B' w.e.f. 07.09.2017 (AN)
- Sri Ishwar Chandra Rahi, Technical Officer 'A' w.e.f. 11.09.2017 (FN)
- Sri Mahboob Alam, JRF w.e.f. 14.09.2017 (FN)
- Miss Nandita Tiwari, Technical Officer 'A' w.e.f. 21.09.2017
- Sri Raja Ram Verma, Technical Assistant 'B' w.e.f. 22.09.2017

- Sri Amrit Pal Singh Chaddha, Technical Assistant 'E' w.e.f. 25.09.2017 (FN)
- Dr. Prasanta Kumar Das, Technical Assistant 'E' w.e.f. 29.09.2017
- Ms Sakshi Srivastava, PA w.e.f. 18.10.2017 (FN)
- Dr. Arindam Chakraborty, National Post Doctoral Fellow 30.10.2017 (FN)
- Dr. Chinnappa Chopprapu, National Post Doctoral Fellow 27.11.2017 (FN)
- Ms Bency David Chinthala, Jr. Prj. Fellow w.e.f. 08.12.2017
- Sri Sandeep Kumar Shivhare, Registrar w.e.f. 28.12.2017 (AN)
- Sri Subhankar Pramanik, BSRS w.e.f. 05.01.2018
- Mr. Mohd. Shadman, BSRS w.e.f. 08.01.2018
- Sri Ishwar Chandra Shukla, Technical Assistant 'D' w.e.f. 17.01.2018 (FN)
- Sri Sandeep Kumar Kohri, Technical Assistant 'D' w.e.f. 17.01.2018 (FN)
- Sri Jitendra Yadav, Technical Assistant 'D' w.e.f 17.01.2018 (FN)
- Ms Archana Sonkar, Technical Assistant 'A' w.e.f. 19.01.2018 (FN)
- Ms Himani Patel, BSRS w.e.f. 22.01.2018
- Sri Sumit Singh, Project Assistant w.e.f. 05.02.2018(FN)
- Ms Shubhangi Baranwal, BSRS w.e.f. 06.02.2018
- Ms Rimpy Chetia, BSRS w.e.f. 07.02.2018
- Ms Priyanka Singh, BSRS w.e.f. 13.02.2018

Resignation

- Ms Kriti Mishra, SRF (CSIR-UGC NET FELLOW) w.e.f. 01.04.2017
- Sri Subhankar Paramanik, JRF-under Category 'II' (Self supported) w.e.f. 04.01.2018
- Sri Sanjay Kumar, Registrar w.e.f. 25.09.2017(AN)
- Dr. S. Jeyakumar, RA



Promotions

Scientific Staff

- Sri Husain Shabbar, SRF w.e.f. 19.06.2017
- Dr. Ratan Kar, Scientist 'E' w.e.f. 01.07.2017
- Dr. (Mrs) Binita Phartiyal, Scientist 'E'w.e.f. 01.07.2017
- Dr. Anil Kumar Pokharia, Scientist 'E' w.e.f. 01.07.2017
- Dr. S.Suresh K. Pillai, Scientist 'D' w.e.f. 01.07.2017
- Dr. (Ms) K. Pauline Sabina, Scientist 'D' w.e.f. 01.07.2017
- Dr. (Mrs) Anju Saxena, Scientist 'D' w.e.f. 01.07.2017
- Dr. P. Morthekai, Scientist 'C' w.e.f. 01.07.2017
- Dr. Anupam Sharma, Scientist 'F' w.e.f. 01.01.2018
- Dr. (Mrs) Vandana Prasad, Scientist 'F' w.e.f. 01.01.2018
- Dr. Krishna Gopal Mishra, Scientist 'D'w.e.f. 01.01.2018
- Dr. (Ms) Vartika Singh, Scientist 'D' w.e.f. 01.01.2018
- Dr. Arif Hussain Ansari, Scientist 'C' w.e.f. 01.01.2018
- Dr. Manoj M.C., Scientist 'C' w.e.f. 01.01.2018
- Dr. Santosh Kumar Pandey, Scientist 'C' w.e.f. 01.01.2018
- Dr. Sunil Kumar Shukla, Scientist 'C' w.e.f. 01.01.2018

Technical Staff

Sri Rattan Lal Mehra, Technical Officer 'D' w.e.f. 03.04.2017

Administrative Staff

Sri Pushpendra Kumar Mishra, Driver 'IV' w.e.f. 22.01.2018 (FN)

Relieved

- Dr. Anju Verma, National Post Doctoral Fellow, w.e.f. 21.06.2017 (AN)
- Sri Ashish Kumar Pal, J.R.F. w.e.f. 02.08.2017 (AN)
- Sri Raja Ram Verma, Project Assistant w.e.f. 21.09.2017 (AN)
- Ms Utsa Singh, Junior Project Fellow w.e.f. 23.10.2017 (AN)
- Sri Saheb Lal Yadav, Project Assistant w.e.f. 31.10.2017 (AN)
- Sri Arindam Chakraborty, DST Inspire Fellow w.e.f. 23.10.2017 (AN)
- Sri Jitendra Yadav, Temporary Technical Assistant w.e.f. 17.01.2018 (FN)
- Sri Ishwar Chandra Shukla, Temporary Technical Assistant w.e.f. 17.01.2018 (FN)
- Sri Sandeep Kumar Kohri, Temporary Technical Assistant w.e.f. 17.01.2018 (FN)
- Sri Anand Prakash, JRF/ CSIR-UGC w.e.f. 07.07.2017(AN)
- Sri Vikram Singh, JRF w.e.f. 31.10.2017 (AN)

Retirement

- Mrs Kavita Kumar, Ex-Technical Officer 'D' w.e.f 30.04.2017(AN)
- Dr. (Mrs) Jyotsana Rai, Ex-Scientist 'F'w.e.f. 31.05.2017 (AN)
- Dr. Rupendra Babu, Ex-Scientist 'F' w.e.f. 31.07.2017 (AN)
- Dr. R.S.Singh, Ex-Scientist 'G' w.e.f. 31.08.2017 (AN)
- Dr. Mahesh Prasad, Ex-Scientist 'F' w.e.f. 31.08.2017 (AN)

- Dr. (Mrs) Rajni Tewari, Ex-Scientist 'F' w.e.f. 30.09.2017 (AN)
- Sri Chhotey Lal Verma, Ex-Technical Assistant 'E' w.e.f. 30.09.2017 (AN)
- Dr. (Mrs) Rashmi Srivastava, Ex-Scientist 'F' w.e.f. 31.10.2017 (AN)
- Mrs Sunita Khanna, Ex-Technical Officer 'D' w.e.f. 30.11.2017 (AN)
- Dr. O.S. Sarate, Ex-Scientist 'F' w.e.f. 31.12.2017 (AN)



(AN)

28.02.2018 (AN)

- Sri Chandra Bali, Ex-Technical Assistant 'E' w.e.f. 31.12.2017 (AN)
- Sri N.B. Tewari, Ex-Accounts Officer w.e.f. 31.01.2018 (AN)



Mrs Kavita Kumar





Dr. Rupendra Babu



Dr. A. Rajanikanth, Ex-Scientist 'F' w.e.f. 28.02.2018

Sri Chandra Pal, Ex-Technical Officer 'D' w.e.f.

Dr. R.S.Singh



Dr. Mahesh Prasad



Dr. Rajni Tewari



Sri Chhotey Lal Verma



Sri Chandra Bali



Sri N.B. Tewari



Dr. Rashmi Srivastava



Mrs Sunita Khanna

Dr. A. Rajanikanth



Dr. O.S. Sarate



Sri Chandra Pal



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.


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 2018 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 2018, 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**

Place: Lucknow Date: 31st August, 2018 (Mukesh Kumar Agarwal) FCA, DISA (ICAI) Partner Membership No - 073355



ANNEXURE - 'A'

(Annexed to and forming part of the Audit Report for the year ended 31st March, 2018)

COMMENTS / AUDIT OBSERVATIONS ON ACCOUNTS OF 'BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES' - LUCKNOW

1. The internal control over loans and advances is not adequate. There should be a process of periodic reconciliation of advances. During our verification, it was noticed that adequate record is not being maintained and the advances are not being reconciled periodically.

LOANS & ADVANCES:

2. Advances (capital head) unsettled and pending for recovery / adjustment as on 31.03.2018 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
Chempharam Industries, India	Since 2014-15	8220731.00
Alliance Book Suppliers, Delhi	2014-15	200883.89
M/s E. Schweizerbart'sche	Several years	2657.25
M/s Spem A/c	Several years	88257.00
L C Charges	Several years	689289.42
Oriental Insurance	Several years	2867.00
Perkin Elmer	2014-15	396435.00

- 3. A sum of Rs. 3469629/- is outstanding with "Track Cargo Private Limited, New Delhi". As per list of unsettled advances given by store section, advance with M/s Track Cargo Private Limited is Rs. 3123266/. The difference of Rs. 346363/- to be identified. Equipment wise detail of the same is required to be identified and the cost to be capitalized along with the cost of equipment.
- 4. Register of Staff Advance is not updated and reconciled with financial accounts on regular basis. As on 31st March 2018, a sum of Rs. 2082322.45 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 Awatar	2013-14	25000.00
Dr. Anil Pokharia	13 th May 2016	54700.00
Jitendra Yadav	31 st March 2017	2000.00
Thomos Baker (Chemicals)	Prior to 2013	89150.00
Perkin Elmer (Maintenance of Equipment)	2013-14	33708.00
George Society of India	Before 2012-2013	12000.00

BANK RECONCILIATION STATEMENT:

5. In Bank Reconciliation Statement as on 31st of March 2018, Credit without advice amounting to Rs. 2618156/- which includes Rs. 700000/- for more than 3 months are lying. Similarly, a sum of Rs. 228391.27 is outstanding in debit without advice which includes 2 entries of Rs. 191680.14 relating to year 2016-2017. The details of these entries to be identified and appropriate action to be taken.



6. In Project Accounts, advance given to staff / other parties is not being recorded separately. Instead, the same is directly debited to Project Accounts 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.

LIBRARY AND PUBLICATION:

7. Physical verification of the stock of the library books has been conducted during the financial year 2017-18 or after that date. No unreasonable shortage was noticed during their sample physical verification. However, some books/ journals were found missing on sample verification. Detailed physical verification is required to be done and appropriate action to be taken for shortages.

STORES AND WORKS & BUILDING:

- 8. 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.
- 9. Physical verification of Non-Consumable Assets & Consumable Items for the year ended 31.03.2018 was done in April 2018. 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

Place: Lucknow Date: 31st August, 2018 (Mukesh Kumar Agarwal) FCA, DISA (ICAI) Partner Membership No - 073355



ANNEXURE - 'A'

(Annexed to and forming part of the Audit Report for the year ended 31.03.2018) BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES, LUCKNOW

AUDIT OBSERVATIONS - FINANCIAL YEAR - 2017-2018

Particulars/	Observations	Action Taken								
1. The internal control over lo There should be a proce advances. During our vo adequate record is not being not being reconciled period	bans and advances it ass of periodic re erification, it was g maintained and the lically.	Noted for complains and processed for suitable action in the current F.Y. 2018-19.								
2. Loans And Advances										
Advances (capital head recovery/adjustment as on since long, are to be prop level for early adjustment under:) unsettled and 31.03.18 under c erly taken care of thereof. Details o	We have controlled over loans and advances and it now being maintained.								
Particulars	Year	Amount								
Chempharm Industries India	2014-15	8220731.00	Since the Firm has not handed over the charge, the due notice has been issued for its recovery.							
Alliance Book Supliers, Delhi	2014-15	200883.89	Reminder attached for recovery.							
M/s E.Schweizerbart'sche	Several Years	2657.25	These are online subscriptions as informed by library, hence it is been booked in the expenditure in the current F.Y.							
M/s Spem A/c	Several Years	88257.00	These are online subscriptions as informed by library, hence it is been booked in the expenditure in the current F.Y.							
LC Charges	Several Years	689289.42	Equipment wise breakup has not been provided by Bank. Hence it is required to be booked as expenditure.							
Oriental Insurance	Several Years	2867.00	Already settled.							
Perkin Elmer	2014-15	396435.00	Noted for complains and processed for suitable action.							
3. A sum of Rs. 3469629/- i Limited, New Delhi". As p by store section, advance Limited is Rs. 3123266/ be identified. Equipment w to be identified and the cos cost of equipment.	s outstanding with er list of unsettled with M/s Track The difference of I vise detail of the sa st to be capitalized	The expenditure is being booked in CNR Research and Appratus Equipment.								
4. Register of staff advance is financial accounts on regul of Rs. 2082322.45/- is expenses" which includes outstanding for more than taken care of at the inst thereof. Details of which ar	s not updated and the lar basis as on 31.0 outstanding as the following advation year and needs the level for eas under:	The Advance Register is being maintained. Rs.687676.45 outstanding F.Y. 2018-19.								



Nai	ne of Person/Staff	Pending Since	Amount								
Dr.	Ram Awatar	2013-14	25000	Noted for complains and processed for suitable action.							
Dr.	Anil Pokharia	13th May 2016	54700	Noted for complains and processed for suitable action.							
Jite	ndra Yadav	31st March 2017	2000	Settled in F.Y 2018-19							
The	omas Baker (Chemicals)	Prior to 2013	89150	Settled in F.Y 2018-19							
Per	kin Elmer	2013-14	33708	-							
Geo	orge Society of India	Before 2012-13	12000	Receipt is not traceable, it may be booked expenditure							
5.	In Bank Reconciliation S 2018, Credit without advi- which includes Rs. 70000 lying. Similarly, a sum of debit without advice w Rs.191680.14 relating to t these entries to be identifi- taken.	tatement as on 31st ce amounting of Rs. 0/- for more than 3 Rs. 228391.27 is out which includes 2 he year 2016-17. The ed and appropriate a	Noted for complains and processed for suitable action.								
6.	In Project Accounts, advan not being recorded separate debited to Project Account record is being maintaine advance given to party/staft and the same should be ad actual outstanding position	ce given to staff / othe ely. Instead, the same nt and no separate d for recording adv f should be recorded ljusted on settlement of advance in Project	The Advance Register is being maintained.								
7.	Library and Publication										
	Physical verification of the been conducted during the that date. No unreasonabl their sample physical books/journals was found Detailed physical verificat appropriate action to be tak	e stock of the library financial year 2017- le shortage was noti verification. Howe missing on sample v ion is required to be en for shortages.	The detailed physical verification is being undertaken.								
8.	Stores & Works & Buildi	ng									
	Maintenance and Upgradat stores register needs to be s assets as per Fixed Asset R match with the value in t reconciliation needs to be on regular basis.	ion of Fixed Assets R strengthened . The va egister and Stores Re he fixed asset sched done and registers to	The documentation is being done as per FRSR, GFR 2017 & other relevant rules.								
9.	Physical verification of Consumable Items for the in April 2018. While ver Assets was being prepare issued that "Physical Ver books and no discrepance submission of a certificate	Non-consumable A year ended 31.03.201 ification no summar d. Only a certificato ification has been d ies have been notic will not serve the purp	Points noted for complains and action is being initiated.								

phone

(Ruchita Bose) For Accounts Officer

Spann

(Sandeep Kumar Shivhare) Registrar

R.C. Mehrotra

(R.C. Mehrotra) Director



Form of Financial Statements (Non-Profit Organizations)

Birbal Sahni Institute of Palaeosciences, Lucknow

Balance Sheet as at March 31, 2018

(Amount - Rs.)

SCHEDULE 1 - CORPUS/CAPITAL FUND:	Curren	it Year	Previo	us Year			
	31.3.	2018	31.3.	2017			
Balance as at the beginning of the year	63,97,94,596.39		63,97,94,596.39				
Add : Contributions towards Corpus/Capital	-		-				
Fund							
Add: Donation representing Funds/Assets with	-		-				
BSIP (Transferred from Donation Funds)							
Less Adjustment of Donation Fund	-		-				
Add: Balance of net income/expenditure	2,39,55,700.73	66,37,50,297.13	-	63,97,94,596.39			
transferred from the Income and Expenditure							
Account							
Balance as at The Year - End		66,37,50,297.13		63,97,94,596.39			
SCHEDULE 2 - RESERVES AND SURPLUS:	Curren	ıt Year	Previous Year				
	31.3.	2018	31.3.	2017			
1. Capital Reserve:							
As per last Account	-		-				
Addition during the year	-		-				
Less : Deduction during the year	-	-	-	-			
2. Revaluation Reserve:							
As per last Account	-		-				
Addition during the year	-		-				
Less : Deduction during the year	-	-	-	-			
3. Special Reserves:							
As per last Account	-		-				
Addition during the year	-		-				
Less : Deduction during the year	-	-	-	-			
4. General Reserve:							
As per last Account	3,32,10,903.00		3,32,10,903.00				
Addition during the year							
Less : Deduction during the year		3,32,10,903.00		3,32,10,903.00			
TOTAL		3,32,10,903.00		3,32,10,903.00			

For Singh Agarwal & Associates Chartered Accountants



CA. Mukesh Kumar Agarwal (Partner)

R.C. Mehrotre

(Ruchita Bose) For Accounts Officer

(Sandeep Kumar Shivhare) Registrar

(R.C. Mehrotra) 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, 2018

			rig. in Kupees
Particulars	Schedule	Current Year	Previous Year
		2017-18	2016-17
INCOME			
Income from Sales/Services	12	9,00,052.00	5,95,888.25
Grants/subsidies (OB, Deposit A/C and Transfer from Cap. Fund)	13	33,98,93,000.00	68,21,00,000.00
Fees/Subscriptions	14	-	-
Income from Investments (Income on Invest. From earmarked/endow. Funds transferred to Funds)	15	1,87,041.00	1,07,157.00
Income from Royalty, Publication etc.	16	1,23,306.00	2,86,748.00
Interest Earned	17	1,64,52,893.50	47,97,932.00
Other Income/Adjustments	18	17,42,071.87	29,03,652.37
Increase/(decrease) in stock of Finished goods and works-in-progress	19	-	-
TOTAL(A)		35,92,98,364.37	69,07,91,377.62
EXPENDITURE			
Establishment Expenses	20	25,43,69,607.00	22,08,74,859.00
Other Administrative Expenses etc.	21	4,76,02,052.40	4,45,22,489.68
Expenditure on Grants, Subsidies etc.	22	-	-
Interest	23	-	-
Depreciation (Net Total at the year-end-corresponding to Schedule 8)		3,33,71,004.24	3,12,13,963.26
TOTAL (B)		33,53,42,663.64	29,66,11,311.94
Balance being excess of Income over Expenditure (A-B)		2,39,55,700.73	39,41,80,065.68
Transfer to Special Reserve (Sepecify each)		-	
Transfer to/from General Reserve to Pension Fund		-	-
BALANCE BEING SURPLUS/DEFICIT CARRIED TO CORPUS/CAPITAL FUND		2,39,55,700.73	39,41,80,065.68
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

For Singh Agarwal & Associates

Chartered Accountants



CA. Mukesh Kumar Agarwal (Partner)

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R.C. Mehrotra

(Ruchita Bose) (Sandeep Kumar Shivhare) For Accounts Officer Registrar

(R.C. Mehrotra) Director

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0100 LING TO THE ST Form of Financial Statements (Non-Profit Organizations) Birbal Sahni Institute of Palaeosciences, Lucknow

Fig. in Rupees

	1	Previous Year	2016-17		22,08,74,859.00	4,45,22,489.68		3,46,88,955.19				22,19,847.00			1,64,60,314.42		69,56,119.87						13,38,429.00	1	7,15,54,344.20	1,16,499.00			115.00	1
		Current Year	2017-18		25,43,69,607.00	4,76,02,052.40		3,50,68,965.21	-						4,35,61,001.09								10,78,851.00	98,000.00	6,54,09,665.89				•	1
int for the period / year ended March 31, 2018	PAYMENTS			1) Expenses	a) Establishment Expenses(Corresponding to Schedule 20)	b) Administrative Expenses(Corresponding to Schedule 21)		II) Payments made against funds for various projects	(Name of the fund or project should be shown along with	the particulars of payments made for each project)	III. Investments and deposits made	a) Out of Earmarked/Endowment funds	b) Out of Own Funds (Investments-Others)	IV. Expenditure on Fixed Assets & Capital Work-in-Progress	a) Purchase of Fixed Assets	b) Expenditure on Capital Work-in-Progress	V. Refund of surplus money/ Loans	a) To the Government of India	- b) To the State Government	c) To other providers of funds	VI. Finance Charges (Interest)	VII. Other Payments (Specify)	i) Advances to Staff	ij Earnest Money Refunded	iii) Advances to Parties	iv) Pension Fund	v) Transfer to reserve & surplus	VIII. Closing Balances	a) Cash in hand	b) Bank Balances
yments Accou		Previous Year	2016-17					2,24,52,784.89		88,966.00		68,21,00,000.00										36,96,391.00	11,01,541.00	2,86,748.00	29,03,652.37	5,96,148.00		56,53,350.00		
ecerpus and Fa	1	Current Year	2017-18		115.00			38,34,71,280.50		3,05,157.00		33,98,93,000.00			'							1,53,29,729.50	11,23,164.00	1,23,306.00	17,42,071.87	9,00,052.00		-	13,38,980.25	
X	RECEIPT			I. Opening Balances	a) Cash in hand	b) Bank Balances	i) In current accounts	ii) In deposit accounts	iii) Endowment deposits	iv) TDS on other grant	II. Grants Received	a) From Government of India	b) From State Government	c) From other sources(details)	(Grant for capital & revenue exp.	To be shown separately)	d) Deposit Account	III. Income on Investment from	a) Earmarked/Endow. Funds	b) Own Funds (Utilized)	IV. Interest Received	a) On Bank deposits	b) Loans, Advances etc.	i) Sale proceeds of Publications	ii) Miscellaneous Income	iii) Sale of Services (Consultancy)	iv) Group Insurance	VI. Amount Borrowed	VII. Any other receipts (give details)	(Pension Contribution)

For Singh Agarwal & Associates

ii) Earnest Money Deposit iii) FDR Matured i) Recovery of Advances

TOTAL

Chartered Accountants

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CA. Mukesh Kumar Agarwal (Partner)

phone

For Accounts Officer (Ruchita Bose)

(Sandeep Kumar Shivhare)

Registrar



38,34,71,280.50

37,64,47,435.38

3,05,157.00

3,40,444.00

Endowment deposit account

TDS on other grant Saving account

In deposit accounts In current accounts

<u>.</u>

(51,00,000.00)3,43,56,174.00

(2,50,00,000.00)

Fransfer from Reserve Fund

Net Receipt from Project

TDS Refund

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18,41,657.00 3,25,20,995.60

7,99,46,790.04 2,48,02,375.81

10.000.00

78,25,08,409.86

82,39,76,021.97

78,25,08,409.86

82,39,76,021.97

(R.C. Mehrotra) Director

Annual Report 2017-2018





