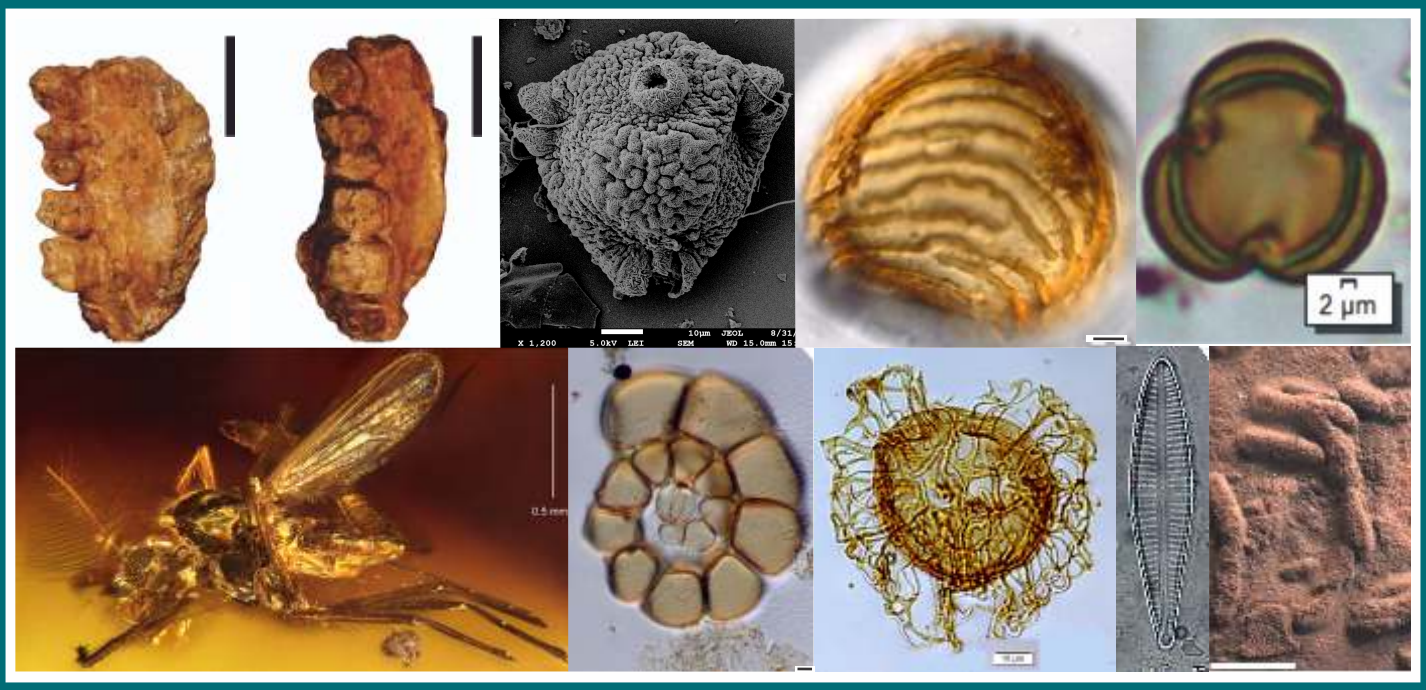
Annual Report

2018-2019



Birbal Sahni Institute of Palaeosciences, Lucknow

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

BSIP at a *Glance*

Professor Birbal Sahni, FRS, established the Institute in the year 1946 to explore and develop palaeobotany as a science in itself, visualizing its potential in solving issues of origin and evolution of plant life, other geological issues including exploration of fossil fuels. Originally plant fossil and related studies based, the mandate of the BSIP was recently expanded to combine it with other areas of palaeosciences, and creating modern facilities to achieve this end. The newly widened mandate aims to look at

- 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 to exploration programmes of oil and coal industry

BSIP is striving to attain excellence in R&D through a dedicated scientific team together with integrated innovative ideas in basic and applied research. In its broadest sense, the BSIP seeks to interpret plant life evolution and geological processes involved, and environmental evolution through time.

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

The palaeofloristic scenarios of the bygone eras help us to figure out the past climatic and environmental changes. However, it is important to tag these climate change events to a time scale, of which study of tree-rings to deduce palaeomonsoon/climate is an important aspect. Dating and study of samples of archaeobotanical as well as studies on ancient DNA are critical to understand the (co-) evolution of culture and civilization. Work on organic petrology to evaluate the quality of lignites/coals for their economic utilization, besides depositional conditions is well under way. Samples for all studies towards fulfilling the BSIP mandate are collected from far and wide, including the polar (Arctic/ Antarctic) regions.

The Museum of the Institute offers a rich repository of fossils collected from India and received from around the globe. A special attraction is the Foundation stone itself, put up in 1949, with 77 fossils inlaid. The Institute posseses a rich collection of literature on palaeosciences. It also houses a herbarium to aid comparing the past and the present vegetation. The radiocarbon dating laboratory of the Institute, is the only such national facility in the country. With the newly widened research mandate, the Institute has acquired the TL/OSL system useful for precise dating of archaeological artefacts and Quaternary sediments. The IRMS, ICP-MS, GC-MS, XRF systems have recently been added for geochemical analyses, besides the establishment of the palaeomagnetic, and ancient DNA laboratories, FE-SEM, Confocal Laser and Raman Spectroscopy. The Institute hosts national/international scientific meets from time to time, and also publishes catalogues, atlases, etc. on special occasions, besides publishing an International journal The Palaeobotanist.

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

Annual Report

2018-2019

Birbal Sahni Institute of Palaeosciences, Lucknow

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

Published by
The Director
Birbal Sahni Institute of Palaeosciences (BSIP)
53, University Road,
Lucknow 226 007, Uttar Pradesh
INDIA

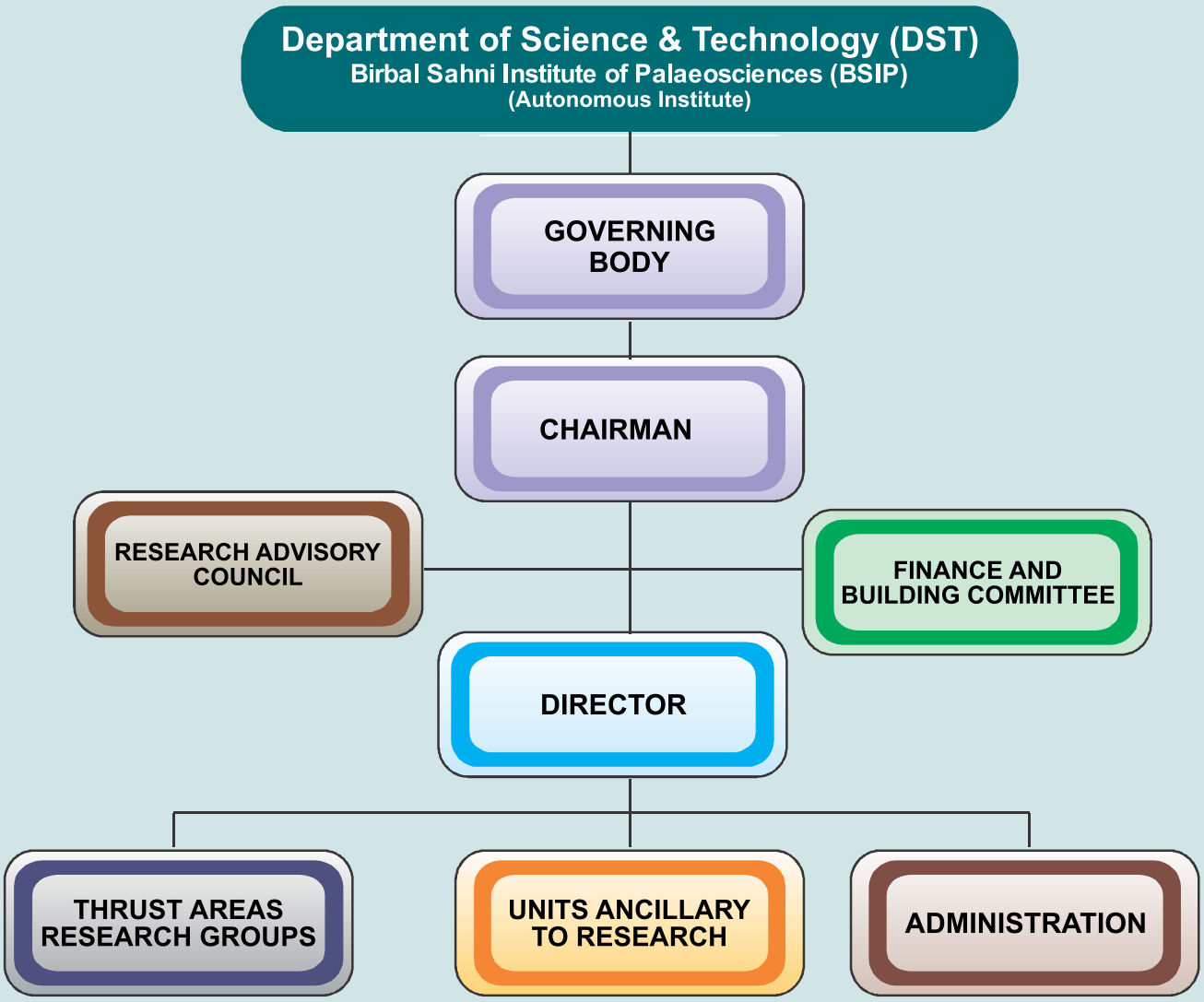
Phone	:	+91-522-2740470/2740413/ 2740011/ 2740865
Fax	:	+91-522-2740485/ 2740098
E-mail	:	director@bsip.res.in rdcc@bsip.res.in
Website	:	http://www.bsip.res.in
ISSN No	:	0972 - 2726
Compiled & Edited by	:	Dr. Anupam Sharma & Dr. Amit K. Ghosh
Support	:	Mr. Madhukar Arvind, Mr. Rattan Lal Mehra, Dr. Biswajeet Thakur, Dr. Santosh K. Shah, Dr. (Mrs) Poonam Verma, Dr. Gaurav Srivastava, Mr. D.S. Bisht & Administration
Visuals	:	Scientists & Photography Unit
Cover photo	:	Micro & Macro photographs of plant/animal elements: Top Row (L/R) : *Sivapithecus* Homonid, *Ludwigia peruviana, Ceratopteris, Artemisia* Bottom Row (L/R) : *Tanytarsus ramus, Microforaminiferal linings, Glaphyrocysta, Gomphonema* sp., *Treptichnus pedum*

Produced by : Research Development and Coordination Cell (RDCC) & Publication Division

September 2019

Contents

Organization Structure



- Precambrian Palaeobiology Group
- Gondwana Ecosystems Group
- Cretaceous-Cenozoic Ecosystems Group
- Coal Petrology and Organic Geochemistry Group
- Quaternary Palaeoclimate Group
- Geochronology, Archaeobiology and Palaeogenomics Group
- Inorganic Geochemistry Group

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

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

Vigilance Officer
Dr. Anjum Farooqui, Scientist-F

Women's Forum
Dr. Vandana Prasad, Scientist-F

Central Public Information Officer
Dr. Ratan Kar, Scientist-E

Foreword

Established in 1946, the Birbal Sahni Institute of Palaeobotany was renamed as the Birbal Sahni Institute of Palaeosciences, in 2017. BSIP carries out research on both fundamental and applied aspects of palaeosciences, and allied earth system sciences with an integrated, multi-disciplinary approach. The research activities focus on past life forms, past climates and ecosystems including the origin and evolution of life, vegetation dynamics through time, palaeoclimate, and exploration of fossil fuels.

The BSIP researches are grouped into the following six main thrust areas: (i) Early life and environment: Evidence from Indian Precambrian Basins, (ii) Phanerozoic Terrestrial and Coastal Ecosystems: Biostratigraphical, Palaeoenvironmental, Palaeo-ecological and Palaeobiogeographical aspects, (iii) Organic petrology: Characterization of solid fossil fuel for depositional and utilizational aspects, (iv) Quaternary palaeoclimate reconstructions, vegetation dynamics and relative sea level changes, (v) Domestication of plants, early farming and ecosystem dynamics during Holocene/Anthropocene, (vi) Geochemical Parameters for correlation, palaeoclimatic, tectonic and provenance studies.

The expertise of the BSIP is utilized by public sector undertakings/organizations such as Oil India Ltd., Coal India Ltd, Archaeological Survey of India, various universities and research organizations on a regular basis.

In recent years, the Institute has widened its scope of research significantly by setting up of new analytical facilities in 2018 - Ancient DNA Lab and Vertebrate Paleontology Lab. The fair number of women scientists (more than one-third) on the rolls of the BSIP is to be made a special mention of. Several young scientists have selected for prestigious post-doctoral fellowships abroad. The Institute has substantially improved its performance during the past few years on various quantifiable parameters, including the quality of its research output as reflected in the total impact factor and citations, organization of international and national conferences, collaborations, consultancy, student training, awards and international fellowships etc. BSIP also participated in the IISF (India International Science Festival) and organized the *Face to Face: New Frontiers in Science programme* for school and college students. Several outreach activities and programmes were also organized in 2018 to familiarize students in schools and colleges with Palaeosciences.

We present this report as a substantive document of our activities from 1.04.18 to 31.03.19, with the resolve to attain higher levels in the years to come.

Vandana Prasad.

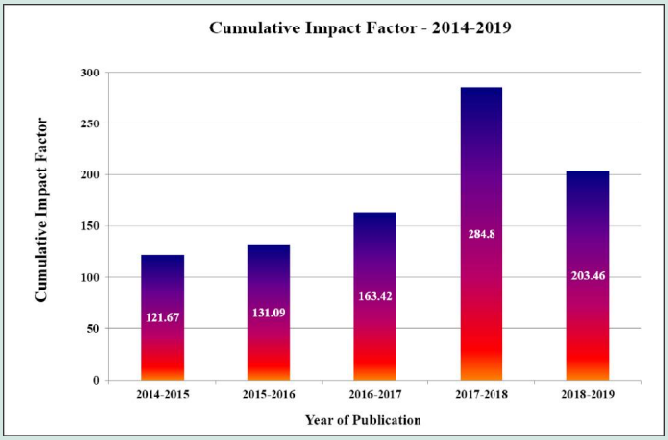
(Vandana Prasad)
Director

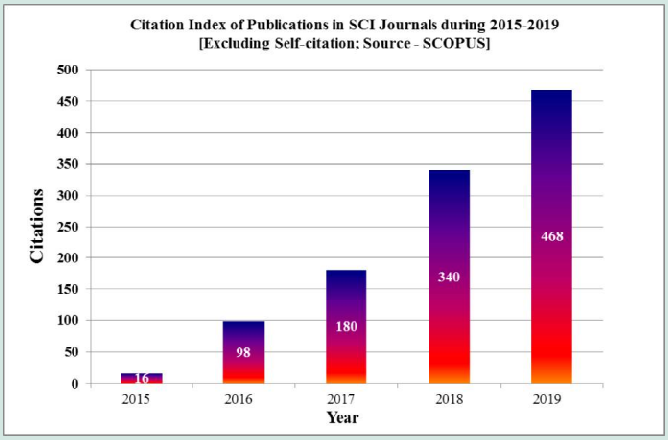

BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES
1946
OUR EXPERTISE
Evolution
Morphology & Taxonomy
High Resolution Biostratigraphy
Palaeobiogeography
Palaeoclimate, Palaeoecology & Palaeoenvironment
Palaeomagnetism & Environmental Magnetism
Palaeontology
Vertebrate
Invertebrate
Geochronology
Radiocarbon
TL/OSL Dating
Elemental, Inorganic & Stable Isotope Geochemistry
Organic Geochemistry & Petrology
Archaeobotany
Dendrochronology
Industrial Palynology
Ancient DNA
Consultancy Services
Contract Training Services
Industrial Palynology & Coal Petrology
Palaeomagnetism & Environmental Magnetism
Scanning Electron Microscopy with EDX & Confocal Laser Scanning Microscopy with Raman Spectroscopy
Geochemistry
XRD
XRF
ICP-MS
IRMS
GC-MS
LPSA
Nutrient Analyzer
DNA Fingerprinting
14C and Luminescence Dating

Research Highlights

- Black shale unit of the Suket Shale exposed in the Chambal Valley yielded Ediacaran Complex Acanthomorphic Palynoflora (ECAP) as well as characteristic Cambrian elements.
- Carbonaceous fossil of benthic multicellular algae have been recorded from the early Mesoproterozoic (~1500 Ma) sediments of the Chhattisgarh Supergroup, comparable to the Family Scytosiphonaceae and belonging to Class Phaeophyceae.
- On the global perspective Mo (*Molybdenum*) /TOC studies from Bijaigarh Shale supports the proposed Earth's atmospheric oxygenation around 1.2 Ga and large scale Mo drawdown in epicratonic basins that resulted into reduced Mo supply to the contemporary open ocean.
- REE and Trace Element data of the Lower Bhander Sandstone and overlying Sirbu Shale from the Neoproterozoic (~1000 Ma) Bhander Group, Vindhyan Supergroup show evidence of oxic hydrosphere during the time of deposition.
- Spectral signature from the lower cloud layer of Venus (~ 50 km above from Venus's surface) suggests that the lower cloud layer host favourable environment for the Earth based bacteria.
- Age of the basal most Talchir sediments, Rajmahal Basin have been assessed by global correlations of the palynoassemblage and is designated as late Pennsylvanian (~304 Ma) which earlier was considered as early Permian (~298 Ma).
- Large and broad fossil leaves from Singrauli Coalfield (Barakar Formation, ~ 280 Ma) suggest existence of a low light or shady condition.
- For the first time, Bennettitalean fructification *Fredlindia* has been reported from the South Rewa Basin (~120-100 Ma).
- The late Cretaceous *Corsinipollenites* from central India and its nearest living fossil pollen *Ludwigia* from Pleistocene Karewa sediments in Kashmir shows pollen morphometrical affinities with living *Ludwigia* species from India.
- Deccan-volcano sedimentary sequences of Jabalpur and Sagar localities showed both reversal and normal polarities compatible with Deccan magnetostratigraphy of 29R-29N magnetochrons.
- A comparative analysis of the maceral composition of Paleocene Palana lignites (~61 Ma) from the Barsingsar Mine with the Matasukh lignites suggests constant rheotrophic or waterlogged conditions during the formation of Barsingsar Lignite while intermittent wet and dry conditions during the formation of Matasukh lignites.
- The oldest fossils (~57 million years) of *Ipomoea* (Convolvulaceae) have been discovered from northeast India which indicates that the ancestors of sweet potatoes were originated in India and not in North America.
- The oldest fossil record (~55-52 Ma) of the genus *Sindora*/*Copaifera* of subfamily Detarioideae belonging to Family Fabaceae (*Hopeoxylon* i.e. *H. umarsarensis* sp. nov.) from Cambay Basin, Gujarat contributes towards the understanding of the origin and palaeo-dispersal pathways of this early-diverging subfamily within the basal Fabaceae.
- Fossil records provide strong evidence of a humid tropical evergreen forest with signature of rainfall seasonality in NW Rajasthan during the early Eocene (~55 Ma).
- Biostratigraphic study based on dinoflagellate cyst provided Danian-Thanetian age to the Giral Lignite Mine succession contrary to the late Paleocene-early Eocene age proposed by the earlier workers.
- Isotopic signature (Carbon Isotope Excursion) of Jerrain-Dauki succession of Paleocene-Eocene age from Jaintia Hills, South Shillong Plateau of NE Himalaya, showed two major negative and for two minor shifts of CIE signifying multiple events of extreme global warm climate during early Paleogene from India.

- Based on palynostratigraphy, age of the top lignite seam and overlying post-lignite succession of Akri Lignite Mine succession, Kutch has been dated as middle Ypersian-early Lutetian (~52-47 Ma).
- Process based sedimentology of Paleogene succession of Jaisalmer Basin indicates a gradual transition in environmental setting from continental aeolian to marginal marine to shallow marine conditions which further suggests a late Paleocene sea level rise and associated transgressive event in pericratonic Jaisalmer Basin.
- Earliest fossils of bamboo from the late Oligocene sediments (~25 Ma) of Assam infer that in Asia the ancient bamboos were evolved in a warm and humid climate.
- Palm megafossil from the Lunpola Basin of the central Tibet of the late Oligocene (~25 Ma) infers that during the deposition a deep valley was present whose height was not more than 2.3 km a.s.l. in central Tibet.
- First record of a hominoid from the Neogene of the Kutch Basin represents a significant southern range extension of Miocene hominoids in the Indian peninsula.
- A much younger age for Dagshai Formation, Himachal Pradesh has been calculated and the palaeolatitude falls at 29ºN, a non-agreement to 22-23ºN given by earlier workers.
- Developed new Li isotope as weathering proxy; Siwalik sections show variable degree of chemical weathering during different time intervals i.e. strong chemical weathering during early Miocene that got slowdown in Middle Miocene and again got pace during the late Miocene time and continue till the mid-Pliocene.
- Palaeo-seasonality of Indian Summer Monsoon during the later Miocene /Burdigalian Age (~20 Ma) was reconstructed using fossilized bivalve *Pitar (Hyphantosoma) simonnei* from Quilon.
- Quantitative data of sea-surface temperature, sea-ice presence, and productivity changes of the Indian sector of the Southern Ocean were obtained using diatom assemblages which helped understand the climate variability at glacial-interglacial time scales.
- Older Dryas stadial between ca.14,100 and 11,700 cal yr BP and Holocene Climate Optimum (HCO) or Holocene Thermal Maximum (HTM) since ca. 8500 cal yr BP to the Present have been identified through pollen evidences from Mahasamund District of Chhattisgarh State. A prolonged warming was observed in the region since the last 11,700 cal yr BP.
- An abrupt weakening in ISM during the Younger Dryas (~12.8-11.5 ka) while a gradual strengthening in ISM during the middle-early Holocene has been identified in the northern Gangetic Plain.
- The occurrence of *Halodinium* sp. (ciliate cysts) in the late Quaternary sediments of Svalbard has provided important evidence of glacial meltwater influence during the deposition of the sediments.
- Signatures of the relative sea level changes (Holocene?) are inferred based on marine microfossils and gastropod shells in the Great Rann of Kachchh Basin which provided evidences of high sea level stand plausibly during mid-late Holocene time.

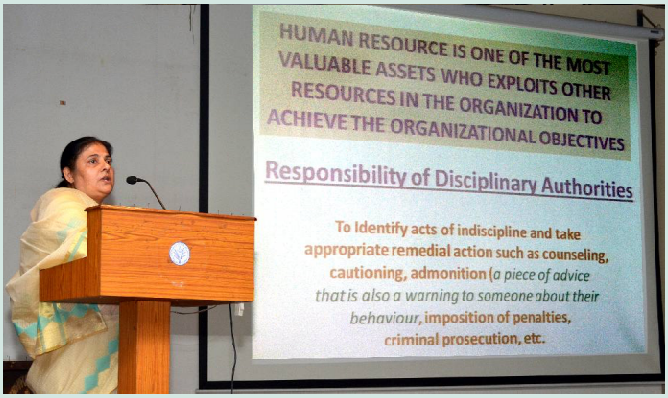


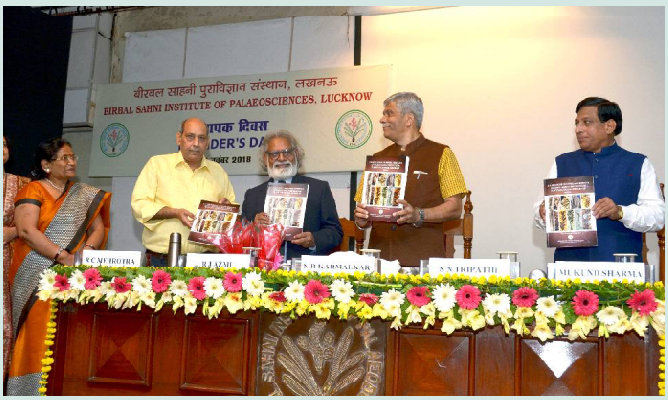


- To answer longstanding questions about the origin of farming and the source of Indo-European languages in South Asia, the largest-ever study of ancient human DNA in South Asia has been conducted and sequenced the first genome of an individual from the ancient Indus Valley Civilization which reveals detail of the shifting ancestry of Central and South Asian populations over time.
- The first ancient human genome from mature Indus valley civilization has revealed no evidence of ancestry from Central Asia, Steppe and Early Iranian farmers and disproves the hypothesis that Agricultural practices in Indus valley Civilization was expanded from Neolithic Iran.
- Abrupt dry spells over short time scales have been observed in the later part of the Holocene (~3.5 ka to Present) from the Pensi-la, Zanskar Valley.
- A ~2400 years climatic history of the Darjeeling area, eastern Himalaya has revealed that centennial scale variations in frequencies of "active dominated" and "break-dominated" periods govern the internal dynamics of the ISM, and considered to be the key forcing mechanism behind the differential behaviour of the ISM over these regions.
- A multiproxy study combining major and trace elements, TOC, pollen, dinoflagellate cysts, diatoms and grain size data has identified Indian Summer Monsoon variability and anthropogenic responses for the last 2000 years in the SW Coast of Kerala.
- The crop remains recovered from the Sarethi archaeological site in the Saryu region of Ganga Plain elucidate that the region was under warm and humid climatic conditions during 200 BCE to 300 CE, however, the climate deteriorated in response to a gradual decrease in SW monsoon from 300-700 CE.
- A 2000 years multiproxy record from the coast of NW Bay of Bengal shows some abrupt changes in association with high/low terrestrial input due to variations in SW monsoon intensity.
- The acceleration in human settlement in Lower Brahmaputra Valley of Assam has been noticed since 710 cal. BP as suggested by the presence of cereal pollen along with increment of *Ziziphus, Mimosa, Clerodendrum* and Arecaceae implying forest clearance.
- Recorded marked warming trend in the beginning of late twentieth century till 2012 in tree-ring of *Pinus wallichiana* based winter temperature reconstruction (time span: 1840-2012 C.E.) for the Lidder Valley, Kashmir, Northwest Himalaya.
- Annual precipitation over six centuries (time span: AD 1383-2017) was reconstructed from semi-arid Kishtwar, Jammu and Kashmir, north-western Himalaya based on tree-ring data.
- Pollen data from the western Himalaya reveals subalpine tree-line species are sensitive to the katabatic winds blowing through glaciers and could show lag in their growing period due to late melting of snow and low air/soil temperature at subalpine zones compared to lower zones.

Outreach Activities

Internal Activities





India International Science Festival

The fourth India International Science Festival 2018 (IISF 2018) was held in Indira Gandhi Pratishthan, Lucknow, Uttar Pradesh from October 5 to 8, 2018. More than 8,000 delegates, across the country, took part in the mega science expo of our country. The festival was inaugurated by our Honourable President Shri Ram Nath Kovind. In his Inaugural Address, the president emphasized the importance of science in our life and in the nation building "From the green revolution to the space program to a thriving biotech industry, science has been among the biggest drivers of India's post-1947 modernisation".

Out of the several activities during the science festival like the Young Scientists Conference and forum; Women and Science; discussion on the role NRI scientists in shaping science in India; NGO's participation; School children's visits; and several others covering all possible aspects including biotechnology, DNA sequencing and rocket science were deliberated in the meet.

One very important part was the Earth science 'Face to Face' with Frontiers of Science. This provided an opportunity to higher secondary, graduation and post graduation research students to attend the sessions of excellence. There were four parallel sessions. There was on Evolution of Life and climate on Earth, which encompassed broad disciplines of physical, biological, meteorological/climatological, palaeontological, evolutionary and environmental sciences. As the theme was focussed on the origin of life on planet Earth, physical and geochemical properties of Earth, evolution of life and climate of past, prediction of the future and ecosystem dynamics, a lot of scientists from our Institute participated in these sessions. There were talks from Prof. Ashok Sahni, Emeritus Professor, Former VC , Panjab University; Prof A.K. Singhvi, Raja Ramnna Fellow, PRL, Ahmedabad; Dr. M Rajeevan Secretary MoES; Prof. Sunil Bajpai, IIT Roorkee; Dr. G.B. Pant, Former Director IITM and Dr. Anil Bharadwaj, Director PRL followed by an interaction on various topics. The other parallel sessions of Face to Face with New frontiers of science, which BSIP was taking care of were-Genomics as a driver of National development; A date with Data: the inside story; and an Career Interactive Session.

The fourth Science festival organised at IGP, Lucknow was a big success.

Secretary DST taking interest in BSIP Stall at IISF, Lucknow

Children taking interest in BSIP Stall at IISF, Lucknow

Foundation Day

The Foundation Day Function was celebrated on the September 10, 2018 and a lecture was delivered by eminent speaker Prof. Nitin R. Karmalkar, Chairman, Governing Body of the BSIP and Vice Chancellor of Savitribai Phule Pune University, Pune. He was also the Chief Guest of the function. In his Welcome Address, he eulogized the technological advancement of the BSIP in the form of newly implemented analytical facilities and stressed upon the integrated and multidisciplinary approach for the cumulative growth of the Institute.

Prof. Vishwas S. Kale, Retired Professor of Geography, Savitribai Phule Pune University, Pune delivered a lecture on the topic 'Late Quaternary fluvial records in the Deccan Traps'. The programme of function was precided over by Prof. Nitin R. Karmalkar. The closing remark was made by Dr. B.D. Singh, Scientist, BSIP.

Founder's Day

The Founder's Day Function was celebrated on the November 14, 2018 and this day two lectures were delivered by the eminent speakers. Prof. Nitin R. Karmalkar, Chairman, Governing Body of the BSIP and Vice Chancellor of Savitribai Phule Pune University, Pune was the Chief Guest of the function. He also presided over the function.

63rd Sir Albert Charles Seward Memorial Lecture

Prof. S.N. Tripathi, IIT Kanpur delivered the 63rd Sir A.C. Seward Memorial Lecture on *Urban and Aerosol induced short to long term changes in rainfall in Indian Summer Monsoon Region and associated implications to climate.*

48th Birbal Sahni Memorial Lecture

Dr. Rafat Jamal Azmi, Ex Scientist, Wadia Institute of Himalayan Geology, Dehradun delivered the 48th Birbal Sahni Memorial Lecture on the topic *How old is the vindhan Basin?*.

B.S. Venkatachala Memorial Lecture


Prof. Sunil Kumar Singh, Director, National Institute of Oceanography, Dona Paula, Goa delivered the 6th B.S. Venkatachala Memorial Lecture on *Role of Ocean Biogeochemistry of Trace Metals in Evolution of Life and Climate* on 4th January, 2019.

K.R. Surange Memorial Lecture


Prof. Ashok Sahni, Professor Emeritus, Panjab University, Chandigarh delivered the 5th Dr. K.R. Surange Memorial Lecture on *Dynamics and Evolution of South Asian Biota : Enigmatic Relationships* on 7th February, 2019.

M.N. Bose Memorial Lecture


Dr. Kalachand Sain, Director, Wadia Institute of Himalayan Geology, Dehradun delivered 5th Dr. M.N. Bose Memorial Lecture on *Imaging Sub-volcanic Mesozoic Sediments and Assessment of Gas-hydratyes towards the Energy Security of India* on March 11, 2019.

Research

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

Precambrian Palaeobiology Group (PPG)

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

PREAMBLE: Antiquity and evolution of early life are important questions for scientists. Their answers could be found in the sediments of Precambrian Eon which spans over more than 3450 Ma and found profusely on the Indian Subcontinent. Each new discovery of life forms answers a few questions but at the same time newer and more important questions stares the scientific community. In the recent past, stromatolites reported from the Greenland took the antiquity of formation of organo-sedimentary structures to more than 3700 million years, but soon these Archaean (4000-2500 Ma before present) stromatolites were also challenged? Incidentally, hunt for newer biogenic records in Archaean did not stop there, instead vigorous search started in different parts of the world. Palaeoarchaean (3600-3200 Ma) rocks were therefore, targeted to record the evidence of life to prove their biogenic origin. Detailed studies were performed on the stromatolites and microbial mat structures from the Singhbhum and Dharwar Cratons to establish their biogenecity. Laminar arrangements of alternate dolomite crystals, fine grained silica and subordinate pyrite grain indicate biogenic origin of these organo-sedimentary structures.

Following Archaean, ~ 2000 Ma history of the Earth is investigated in Proterozoic successions to record the advent of newer and complex biotic forms and their diversity in different depositional realms. For these studies, the Vindhyan and the Chhattisgarh Supergroup sediments in central India were investigated. Palaeobiological studies performed on the rocks of the Chhattisgarh Supergroup have yielded extensively well-preserved lower Mesoproterozoic (~1500 Ma) micro-fossils (acritarchs) and macro-alga comparable to modern algae Phaeophyta. Submicron level morpho-analysis indicates eukaryotic affinity for this macroalga. Similarly, studies on the 1600 Ma old upper part of the Suket Shale of the Vindhyan Supergroup yielded extensive microbial remains which are akin to 635-541 Ma old Ediacaran Complex Acanthomorphic Palynoflora (ECAP) as well as a few Cambrian elements found in several parts of the world. This inconsistency in age and status of the litho-unit of the Suket Shale is still far from resolved. Rocks of the Neoproterozoic Bhander Group of the Vindhyan Supergroup have yielded well preserved long ranging as well as a few Neoproterozoic acritarchs. This assemblage has Neoproterozoic age connotation for the Bhander Group of the Vindhyan Supergroup.

Geochemical studies using trace elements (Mo, Ni) organic carbon isotope and Total Organic Carbon in

sediments of ~ 1200 Ma old Bijaigarh Shale help to understand the heterogeneous water column oxygenation and their spatial impact on continental to open ocean ecosystem. Based on the Mo/TOC values in modern basins, the evaluated deep water renewal time is found to be on centennial scale. On the global perspective, this study supports the proposed Earth's atmospheric oxygenation ~ 1200 Ma before present and large scale Mo drawdown in epicratonic basins resulting into reduced Mo supply to the contemporary open ocean (nutrient depleted conditions). Therefore, the epicratonic basins during mid-late Mesoproterozoic might have acted as a suitable environment for evolution and diversification of eukaryotic clad.

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

Investigators: Mukund Sharma, Veeru Kant Singh & Santosh K. Pandey

Highlights:

- Outcrop samples of black shale unit of the Suket Shale exposed in the Chambal Valley yielded Ediacaran Complex Acanthomorphic Palynoflora (ECAP) as well as Cambrian elements.

Work done:

Deep bore core studies of the lower part of the Suket Shale conducted by ONGC revealed extensive well preserved Ediacaran Complex Acanthomorphic Acritarchs but the assemblage also pose a serious dichotomy in age and status of the litho-unit when compared with the microfossil assemblage of the Suket Shale exposed in the Chambal Valley of central India and equivalent Rohtasgarh Limestone of the Son Valley exposed in Chitrakut area. To understand the biostratigraphic status of the Early Mesoproterozoic (~1600 Ma) Suket Shale in the Proterozoic biosphere, carbonaceous black shale from the Rampur locality of the Neemuch District, Madhya Pradesh were processed by slow maceration techniques to recover the Organic-Walled Microfossils (acritarchs). Outcrop samples, however, belong to the upper part of the Suket Shale. Lithostratigraphic position, geochronological status and biostratigraphic assemblage of the Suket Shale appears skewed. Recovered assemblage is dominated by large sphaeromorphs, viz. *Leiosphaeridia, Satka, Symplassosphaeridium, Pterospermopsimorpha* and a few acanthomorphs, viz. *Germinosphaera*, *Cristallinium*, *Dictyotidium, Lophosphaeridium, Cavaspina* belonging to Sphaeromorphitae, Pteromorphitae and Acanthomorphitae subgroups of acritarchs. Typical Ediacaran cyanobacterial element *Obruchevella* is also noted. In the global record, *Leiosphaeridia* is the common constituent in the Proterozoic microfossil assemblage. However, *Germinosphaera* and *Pterospermopsimorpha* are widely accepted as eukaryotic fossils, which range in age from Latest Mesoproterozoic – Tonian (Fig. 1). Acritarch assemblage recovered from the outcrop samples of the Suket Shale has also yielded characteristic Ediacaran Complex Acanthomorphic Palynoflora (ECAP) as well as Cambrian elements in the black shale unit of the Suket Shale. Occurrence of such biotic elements is a great conundrum and still far from resolved.

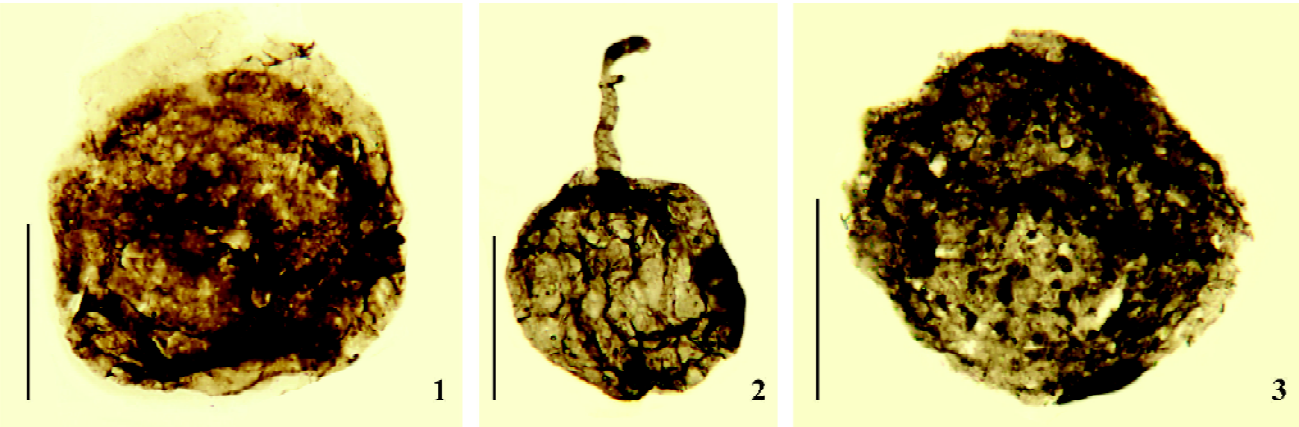


Fig. 1 - Ediacaran acritarchs from the ~1600 Ma Suket Shale: 1. *Pterospermopsimorpha saccata* Yin; 2. *Germinosphaera unispinosa* Jankauskas; 3. *Sinosphaera rupina* Zhang.

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

Investigators: Veeru Kant Singh & Mukund Sharma

Highlights:

- Recorded carbonaceous fossil of benthic multicellular algae from the early Mesoproterozoic (~1500 Ma old) sediments of the Chhattisgarh Supergroup, comparable to the remains of Scytosiphonaceae family belonging to Class Phaeophyceae.

Work done:

Sedimentary successions of the Singhora Group were investigated to record the eukaryotic life forms. Systematically collected carbonaceous shales from the mud dominated sequences of the lower Mesoproterozoic Saraipalli Formation (~1500 Ma) of the Singhora Group (exposed in Surangi River section) divulged a new macroscopic carbonaceous fossil *Palaeoscytosiphon* gen. nov. and its type species *Palaeoscytosiphon shuklaii* sp. nov. (Fig. 2). The carbonaceous fossil is morphologically unbranched, compressed, thallus comprised of long multiple tubular stalks with a rhizoidal/ discoidal holdfast at the base. Holdfast consists of a globose tuberous rhizome and numerous filamentous rhizoids. Stalks are hollow and sharply taper on the tip. Morphological characteristics of described carbonaceous fossils is closely comparable to modern brown alga *Scytosiphon lomentaria* - an irregularly arranged weed of tubular, hollow, unbranched thallus growing on the disk like holdfast. Preservation behaviours, chemical characterization ascertained using Laser Raman Spectroscopy (LRS), as well as, comparisons with living organisms suggest that these remains are remnants of benthic multicellular algae probably comparable to remains of Scytosiphonaceae family belonging to Class Phaeophyceae.

Chemically treated fossiliferous shale of the same horizon has yielded well-preserved specimens of taxonomically distinctive Proterozoic eukaryotic fossil *Tappania plana* Yin for the first time. In the global context, among the various species of this genus *Tappania plana* is widely distributed in the Latest Palaeoproterozoic (Statherian) to the early Mesoproterozoic (Calymmian) organic-walled microfossils assemblages. For cellular anatomy of *Tappania*, Confocal Laser Scanning Microscopy (CLSM) and Laser Raman Spectroscopy (LRS) have been targeted over the Transmitted Light Microscopy (TLM). Over the light microscopy, CLSM and Raman investigation of microfossils provide the high-resolution optical morphology and chemical composition of carbonaceous matter. Collectively, the occurrence of remarkable eukaryotic fossils *Tappania* and carbonaceous fossil *Palaeoscytosiphon* in the Saraipalli Formation of rocks demonstrate the Calymmian age for the lower sediments of the Chhattisgarh Supergroup.

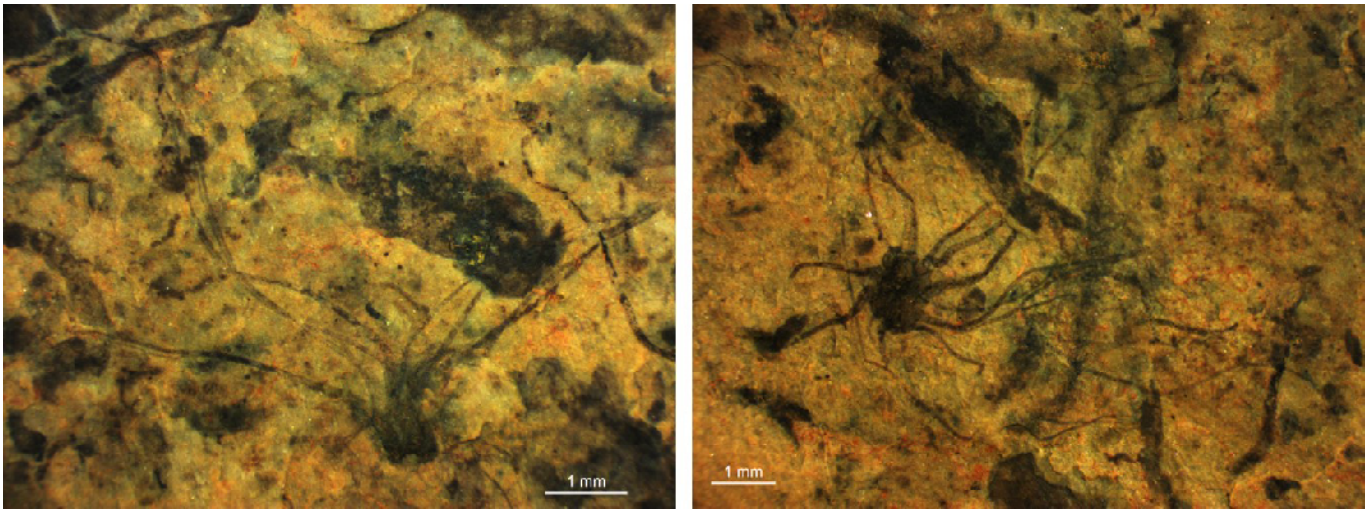


Fig. 2 - Carbonaceous macroalga *Palaeoscitosiphon shuklaii* - a possible phaeophyte, from the ~1500 Ma Saraipali Shale of the Chhattisgarh Supergroup.

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

Investigators: Santosh K. Pandey & Mukund Sharma

Highlights:

- Acritarchs are reported from the black to dark coloured shale/siltstone unit of the Lower Bhander Sandstone.
- REE and Trace Element data of the Lower Bhander Sandstone and overlying Sirbu Shale from the Neoproterozoic Bhander Group, Vindhyan Supergroup shows oxic hydrosphere during the time of deposition.

Work done:

A rich assemblage of acritarchs is reported from the black to grey shale/siltstone unit of the Lower Bhander Sandstone, Bhander Group exposed in Dudhiya and Karari Nala sections, Maihar area, Madhya Pradesh, India. From the same locality, 48 samples of the Lower Bhander Sandstone and overlying Sirbu Shale have been collected systematically on 20 cm interval and detailed litholog have been prepared. Assemblage contains *Leiosphaeridia jacutica*, *Leiosphaeridia crassa, Leiosphaeridia minutissima, Leiosphaeridia tenuissima* and *Ostiana microcystis* (Fig. 3). *Leiosphaeridia* is a long ranging acritarch, whereas *Ostiana* represents Neoproterozoic age for fossil bearing horizon. Preliminary REE, Trace Elements and C and O organic isotope data suggest oxic hydrosphere during the time of deposition of Upper Bhander Sandstone and the Sirbu Shale which validates earlier studies by other workers. Total 364 samples from the Bhander Limestone, Sirbu Shale (Son Valley Section) and Lakheri Limestone, Balwan Limestone (Chambal Valley Section) were analyzed for C and O isotopes.

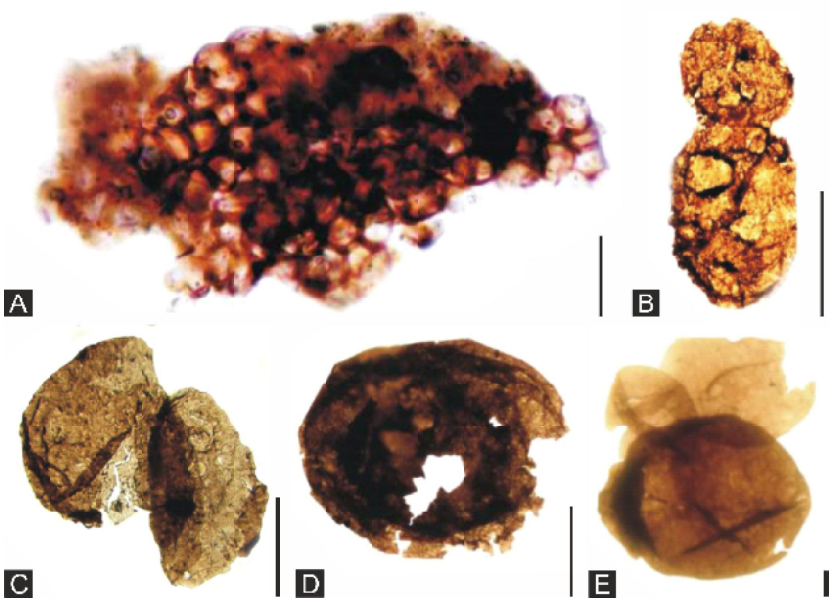


Fig. 3 - Organic-walled microfossils from the Lower Bhander Sandstone (Bhander Group). (A) *Ostiana microcystis*; (B) *Leiosphaeridia crassa*; (C) *Leiosphaeridia tennuissima*; (D) *Leiosphaeridia jacutica*; (E) *Leiosphaeridia minutissima*. Scale Bar: A, E = 10 µm; C = 50 µm; B, D = 100 µm.

Project 1.4: Palaeoredox reconstruction of a Mesoproterozoic Eon: Evidence from Indian Mesoproterozoic basins

Investigators: A.H. Ansari & R.P. Mathew

Highlights:

- The comparative Mo/TOC studies from roughly coeval shallower and deeper part of 1.2 Ga Bijaigarh Shale demonstrate, water column stratification between less saline upper oxic and more saline bottom euxinic water column. This stratification was most likely due to restricted nature of the basin where deep water renewal time was > 100 years (based on the Mo/TOC similarities with Framvaren Fjord, Norway).
- On the global perspective this study support the proposed Earth's atmospheric oxygenation ~ 1.2 Ga and large scale Mo drawdown in epicratonic basins resulting into reduced Mo supply to the

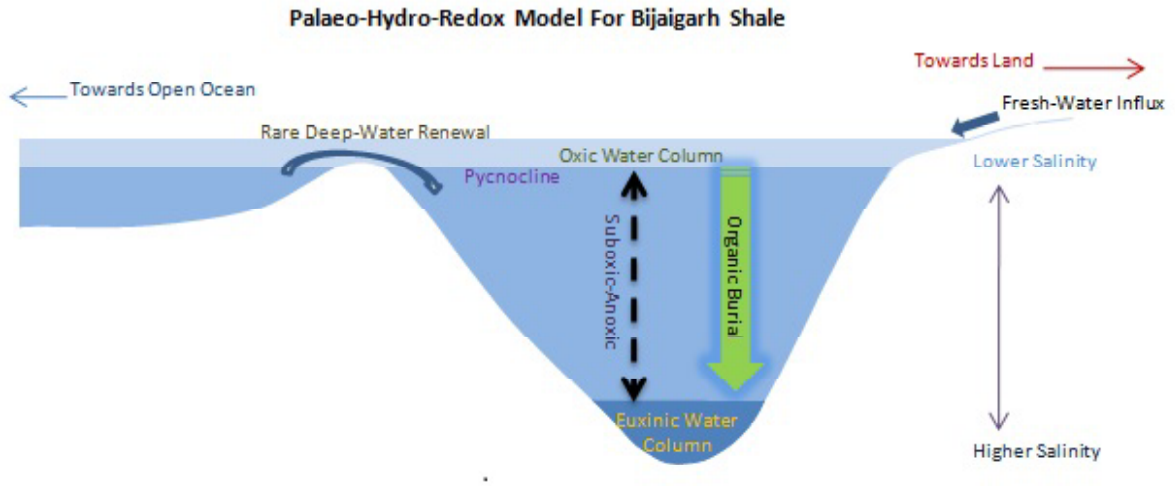


Fig. 4 - Schematic diagram of Palaeo-Hydro-Redox Model for Bijaigarh Shale.

contemporary open ocean. Therefore, shallow oxic and nutrient rich system of the epicratonic basins during mid-late Mesoproterozoic might have acted as a suitable environment for evolution and diversification of eukaryotic clad.

Work done:

Trace elements (V, Cr, Ni, Sr, Mo, Ba, Th, U) studies of thermally mature shallower section of 1.2 Ga Bijaigarh Shale demonstrate no significant enrichment or depletion in their bulk composition compared to Post Archaean American Shale (PAAS) (Fig. 4). This warrants the use of these trace elements as palaeoredox proxies. Intra-basinal comparison shows that Mo concentration in the bulk shale and pyrite crystals vary from ~ 1 to 56 ppm and ~ 15 to 284 ppm respectively. The heterogeneous distribution of Mo infers a temporal mixing between the water layers under oxygenated atmosphere that is reflected from higher end concentration of Mo. Furthermore, lower Sr/Ba ratio in the shallower section, relative to the deeper section of Bijaigarh Shale, suggests that salinity in the water column increased with depth which created stratification. Due to the water column stratification O_2 in lower layers exhausted by microbial consumption while degradation of organic matter consistently supplied from photic zone primary production. However, terrestrial aerobic oxidation also supplied high load of SO_4 along with redox sensitive trace elements. This SO_4 in O_2 exhausted bottom layer acted as an oxidant for oxidising organic matter thereupon led to sulphide rich condition (euxinic) which is evident from high Mo enrichment. The Mo/TOC ratios from deeper section of the Bijaigarh Shale represent a restricted narrow basin with rare bottom water rejuvenation. Therefore, the hydrographic control on Mo deposition (i.e., its enrichment in the sediment) was relatively higher than redox.

This study strengthens the early evidences of Earth's atmospheric oxygenation during mid-late Mesoproterozoic time. As published record based on molecular phylogeny indicates eukaryotic diversification started around 1.2 Ga, the role of atmospheric oxygenation become more relevant. Additionally, available record shows significant Mo enrichment mostly in the intracratonic/cratonic basins and advocates for eukaryotic diversification in terrestrial basins.

Project 1.5: Signatures of early life: Evidence from Archaean sediments of India

Investigators: Yogmaya Shukla & Mukund Sharma

Highlights:

- Stromatolites have been recorded from the 3,500 Ma old Older Iron Ore Group of Singhbhum Craton, Odisha.
- Microbial mat structures have been recorded from thin sections of chert of Dharwar Craton, south India.

Work done:

The Singhbhum Craton in the eastern part of the country is well known for iron and manganese economic

deposits. It was targeted for the studies of the signatures of early life. Recent discovery of Earth's second oldest rock from Singhbhum Craton increased our interest manifolds on the studies of ancient life and ecosystem, and the biosphere evolution. In a comprehensive field work carried out in the western district of Jharkhand and Keonjhar District of Odisha, a few unmetamorphosed chert, limestone and dolomite units in iron and dolomite mines of Kasia have been recorded. The small extent of the areas, which escaped metamorphism, were examined, measured and sampled for investigation. Small domal, laminated stromatolites possibly formed in geyserites settings have been sampled for detailed investigation and microfossil studies. Microfabric and microstructure studies of these stromatolites have been carried out. These stromatolites are present in carbonate bands as small, low relief mounds. Petrographic thin section observations reveal typical stromatolitic precipitation and accretionary features. The clotted fabric was possibly formed by coccoidal algal or bacterial colonies. Light coloured portions demonstrate diagenetically altered vuggs. Microstructure of stromatolite divisible into fine mineral precipitated layer, and microbial layering with aligned fenestral fabric. Enlarged view of microstructure demonstrates alternation of fine grained carbonate mineral precipitation, fine laminated layers and characteristic Archaean Zebra precipitate pattern. Geochemical and geochronological studies are also targeted on these samples. The non-mature Palaeo-Mesoarchaean Singhbhum Craton stromatolite shows distinctive spatio-temporal changes in the δ^{13}C-org from -39.4 to -28.0‰ which conspicuously suggest the presence of mixotrophic microbial life. Microbial mat structures have been recorded from thin sections of chert of the Dharwar Craton, south India. The presence of wavy-crinkly microbial laminae indicates the biogenic origin of such structures.

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

Gondwana Ecosystems Group (GEG)

Group Coordinator: K.J. Singh (Till July, 2018)
Neeru Prakash (from August, 2018)
Co-Coordinator: Neeru Prakash (Till July, 2019)
Amit K. Ghosh (Since August, 2019)

PREAMBLE: The Gondwana deposits mark the recommencement of sedimentation commenced from Permo-Carboniferous after a long hiatus since the Proterozoic. They were formed during a span of about 200 million years from late Carboniferous to early Cretaceous. The term Gondwana became conventional to encompass a wide array of parameters that include litho-stratigraphy, biostratigraphy, palaeogeography and chrono-stratigraphy. The Gondwana sediments in Peninsular India is basically a non-marine sequence, however, lately, marine signatures

also have been recorded. Both lithological and biological characters have been utilized to determine the temporal limits of the Gondwana sequence. The Gondwana sediments in Peninsular India were deposited in several isolated outcrops distributed in various intracratonic basins, viz. Pranhita-Godavari, Koel-Damodar, Satpura, Narmada, Rajmahal and Son-Mahanadi basins. These sediments are rich in plant fossils belonging to Pteridophytes, Pteridosperms, Pentoxylales, Caytoniales, Bennettitales, Coniferales, Cycadales, Ginkgoales and Angiosperms.

The thrust area includes nine projects contributing significantly towards palaeodiversity, palaeovegetation, palaeoclimate, palaeogeograpy and biostratigraphical correlation from different Gondwana basins of India.

Mega- and microfloral diversity of the Permian sequence of Barakar and Raniganj formations show diverse assemblage of *Glossopteris*, *Gangamopteris*, *Vertebraria* and equisetalean axis. Large and broad leaved *Glossopteris* suggests existence of low light intensity or shady condition. Taxonomic analysis of large number of *Glossopteris* species has been carried out to resolve speciation of the taxon.

An integrated study on the macrofloral, miofloral and megaspore assemblages from the Raniganj (late Permian) and Panchet (early Triassic) formations of Tatapani – Ramkola Coalfield, Chhattisgarh has been carried out in detail to determine the transition of flora after the End Permian Mass Extinction Event.

Palaeofloristic studies of early Cretaceous beds of South Rewa Gondwana Basin shows dominance of Pteridophytes and Conifers followed by Cycadophytes. The floral assemblage indicates warm humid subtropical to tropical palaeoclimatic condition.

Palynological studies have been carried out in Jaisalmer and Wardha basins to demarcate the palynological assemblage zones. Correlation has been made with other Gondwana countries.

Three distinct palynological zones, viz. early Artinskian, late Artinskian and Guadalupian-Lopingian have been identified from the Gondwana succession of Somavaram area of Godavari Graben.

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

Investigators: K.J. Singh (superannuated on 31.07.2018) & Anju Saxena

Highlights:

- Re-examined and re-evaluated the status of various Indian *Glossopteris* species and proposed possible merger of the certain species to avoid ambiguity in the identification.
- The existing 130 species of *Glossopteris* have been put into 27 species complex. Each species complex includes several *Glossopteris* species, which have a distinct and comparable venation pattern.

Work done:

The genus *Glossopteris* is the dominantly occurring plant of the Glossopteris flora that occurred during the Permian. In India, plethora of studies has been carried out on the genus *Glossopteris* which have culminated into exceptionally large number of species (~130). Around 50 species of this genus were created on minor variations (cuticles, etc.), though their morphological features were exactly similar to the already existed and well-established species. This has resulted into a great confusion while identifying the closely resembling forms and many a times leading to wrong identification. The current practice of speciation used for the *Glossopteris* does not reflect natural diversity and seems irrational.

Thus, it warrants an urgent need for a methodical study of already reported *Glossopteris* species from India for precise understanding of their form and speciation. Main purpose of the present investigation is to explore the natural diversity of the *Glossopteris*, not from a splitting or lumping perspective, but in the pursuit of the natural species as far as they can reasonably be established. Working from this perspective and avoiding current trends of establishing new species particularly in India, it is proposed that the number of Indian *Glossopteris* species may be substantially reduced. Therefore, the speciation of *Glossopteris* has been re-examined and some suggestions offered towards clarification. The morphological parameters, (angles of emergence, divergence of veins, openness/closeness of secondary veins and shape of meshes) form reasonable

basis for merging the closely related species. The size and shape of the leaves have been given secondary importance.

The existing 130 species of *Glossopteris* have been put into 27 species complex. Each species complex includes several *Glossopteris* species, which have a distinct and comparable venation pattern. It has been reviewed and analysed that such comparable/closely related forms should be merged into one species or be grouped to form one species complex.

Project 2.2: Precursors of Indian Gondwana flora, their subsequent evolution and proliferation through Palaeozoic from the Son-Mahanadi Basin

Investigators: Anju Saxena & K.J. Singh (superannuated on 31.07.2018)

Highlights:

- Palaeofloristic study of coal bearing sequences of the Barakar Formation of the Block-B and Nigahi collieries, Singrauli Coalfield, has yielded rich and diversified Glossopterid assemblage comprising species of *Glossopteris*, *Gangamopteris*, *Vertebraria* and *Euryphyllum*. The procured fossil leaves are fairly large and broad suggesting the existence of low light or the shady conditions in and around the vegetated area.
- The occurrence of *Gangamopteris-Glossopteris* assemblage, dominance of palynomorph *Scheuringipollenites barakarensis* and sub dominance of striate bisaccate pollen *Faunipollenites* suggest a late early Permian (Artinskian) age to the studied coal bearing sequence of Barakar Formation of Singrauli Coalfield.

Work done:

Mega and miofloral diversity of the coal bearing sequence of the Barakar Formation of the Block-B and Nigahi collieries, Singrauli Coalfield has been studied in detail to infer the palaeofloristics, age assessment and palaeoenvironment. A diverse Glossopterid assemblage has been recorded from a sequence of Block B Colliery, whereas from the Nigahi Colliery no megafossil is reported (Figs 1-3). The assemblage comprises of *Gangamopteris*, *Glossopteris* and equisetalean axis. The genus *Glossopteris* dominates the assemblage and is represented by ten species, namely *G. arberi, G. communis, G. gigas, G. indica, G. longicaulis, G. mohudaensis, G. nautiyalii, G. ranigan-jensis, G. spatulata* and *Glossopteris* sp. The genus *Gangamopteris* is represented by five species, namely *G. angustifolia, G. cyclop-teroides, G. karharbariensis, G. major* and *Gangamopteris* sp. Interestingly, the procured fossil leaves of *Glossopteris* and *Gangamopteris* are fairly large and broad as evidenced by the abundance of *Glossopteris*

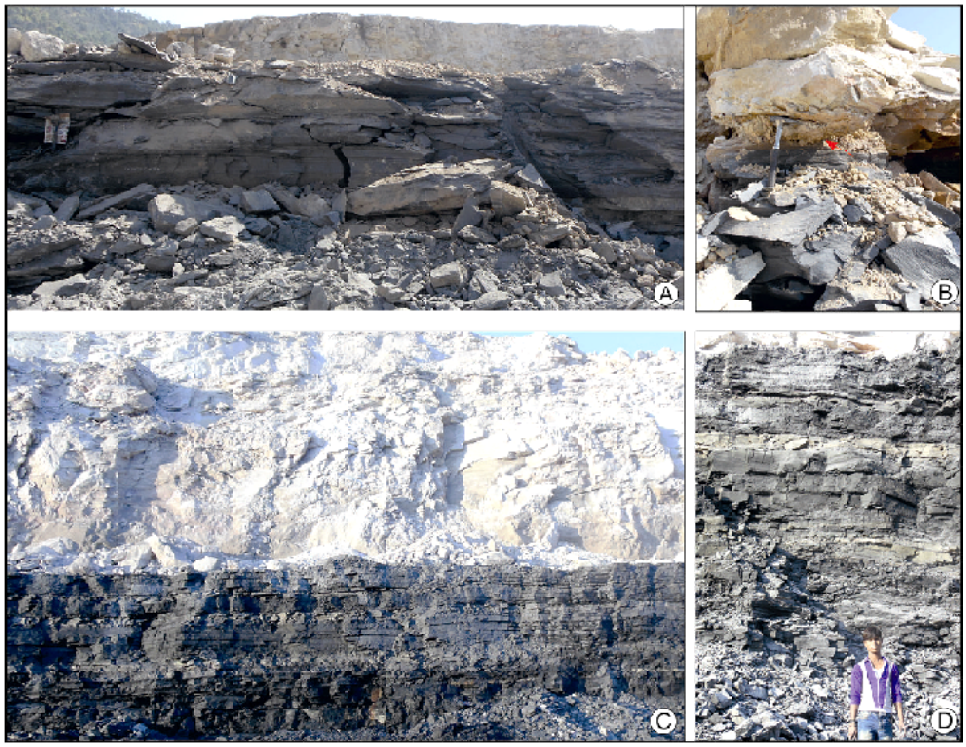


Fig. 1(A). An overview of a part of Turra Seam of Block B Colliery, showing the grey shale, mudstone and sandstone successions. (B). Close view of the Fig. A, showing mudstone and shale contact of the section. (C). An overview of a part of Purewa Top Seam of Nigahi Colliery showing the grey shale, mudstone and sandstone successions. (D). Close view of the section shown in Fig. C.

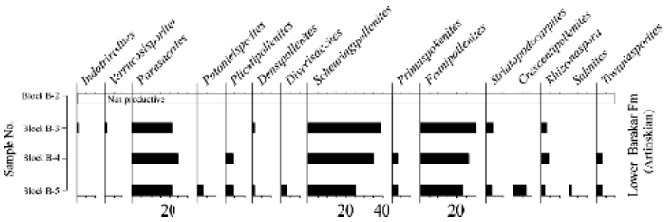


Fig. 2. Distribution of palynomorphs recovered from the Turra Seam of Block B section, Singrauli-Coalfield.

gigas and *Gangamopteris cyclopteroides* in the assemblage suggesting the existence of low light or the shady conditions in and around the vegetated area.

The palynological study has revealed two palynoassemblages; Palynoassemblage I and Palynoassemblage II from the Barakar sediments of Block B and Nigahi collieries respectively. Both the assemblages reveal the dominance of non-striate bisaccate pollen *Scheuringipollenites* and sub dominance of striate bisaccate pollen *Faunipollenites* followed by *Parasaccites*, *Plicatipollenites*, *Potonieisporites*, *Densipollenites*, *Divarisaccites*, striate bisaccates, viz. *Striatopodocarpites*, *Crescentipollenites* and spore *Rhizomaspora*.

The dominance of palynomorph *Scheuringipollenites barakarensis* suggests a late early Permian (Artinskian) age to the studied coal bearing sequences of Block-B and Nigahi collieries which is also substantiated by the diverse occurrence of *Gangamopteris* in the mega plant assemblage.

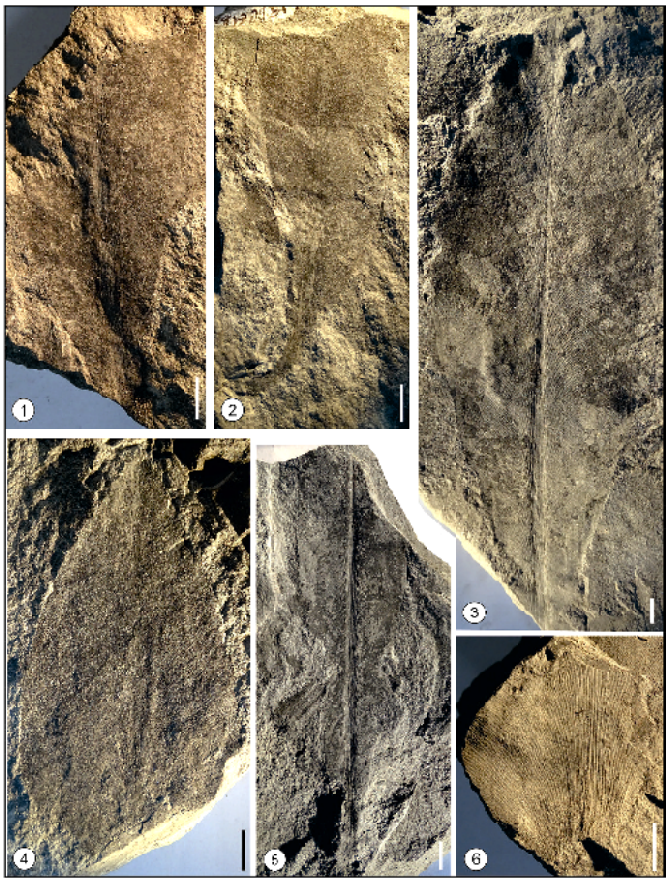


Fig. 3. Some of the megafloral elements recovered from the Block-B Colliery. 1. *Glossopteris arberi* Srivastava 2. *Glossopteris longicaulis* Feistmantel 3. *Glossopteris communis* Feistmantel 4. *Glossopteris nautiyalii* Pant and Singh 5. *Glossopteris indica* Schimper 6. *Euryphyllum* sp.

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

Investigators: Deepa Agnihotri & S. Suresh Kumar Pillai

Highlights:

- Palynomorphs including micro and megaspores have been reported for the first time from the Barakar Formation of Dhanpuri Open Cast Mine, Sohagpur Coalfield, Shahdol District, Madhya Pradesh.
- Plant megafossils and palynofloral assemblage were systematically analyzed for the first time from the middle member of the Pali Formation, near Pali Village, Johilla Coalfield, Umaria District, South Rewa Gondwana Basin, Madhya Pradesh, which indicates the late Permian age for the middle member.

Work done:

Well preserved palynomorphs from the Barakar Formation of Dhanpuri Open Cast Mine, Sohagpur Coalfield, Madhya Pradesh have been reported for the first time (Fig. 4). Dispersed megaspores are represented by 6 genera and 13 species comprising *Banksisporites indicus*, *B. utkalensis*, *Banksisporites* sp., *Barakarella shuklae*, *Barakarella* sp., *Biharisporites* sp., *Bokarosporites rotundus*, *Bokarosporites* sp., *Jhariatriletes baculosus*, *Jhariatriletes* sp., *Talchirella flavata*, *T. trivedii* and *Talchirella* sp. The microspore assemblage shows dominance of monosaccate pollen

grains namely *Parasaccites obscures, P. korbaensis* and *Plicatipollenites indicus,* along with sub–dominance of non–striate bisaccate taxa *Scheuringipollenites barakarensis* and *S. maximus*. Other palynomorphs include trilete *Callumispora barakarensis*, striate bisaccate pollen grains *Faunipollenites* sp. and *Striatopodocarpites multistriatus*, non striate bisaccate genera *Ibisporites diplosaccus* and *Platysaccus ovatus,* along with *Tiwariasporis gondwanensis* and *Vitreisporites* sp.

Well preserved plant fossil assemblage including the orders Filicales and Glossopteridales have been systematically analyzed for the first time from the Pali Formation, near the Pali Village, Johilla Coalfield, Madhya Pradesh. The assemblage comprises genera *Neomariopteris, Glossopteris*, *Vertebraria*, scale leaf and dispersed seeds. The palynoassemblage is characterized by dominance of striate bisaccate pollen grains indicating a late Permian age. The megafloral assemblage of the Pali Formation is comparable with the Kamthi and Bijori formations of Mahanadi and Satpura Gondwana basins, respectively, and to some extent with Pachhwara Formation of the Rajmahal Basin. Moreover, the flora is comparable to that of the Raniganj Formation of the Damodar Basin. The palynoflora of the Pali Formation can be correlated with the late Permian palynofloras of other lower Gondwana basins of India, Antarctica, South Africa, South America and Australia.

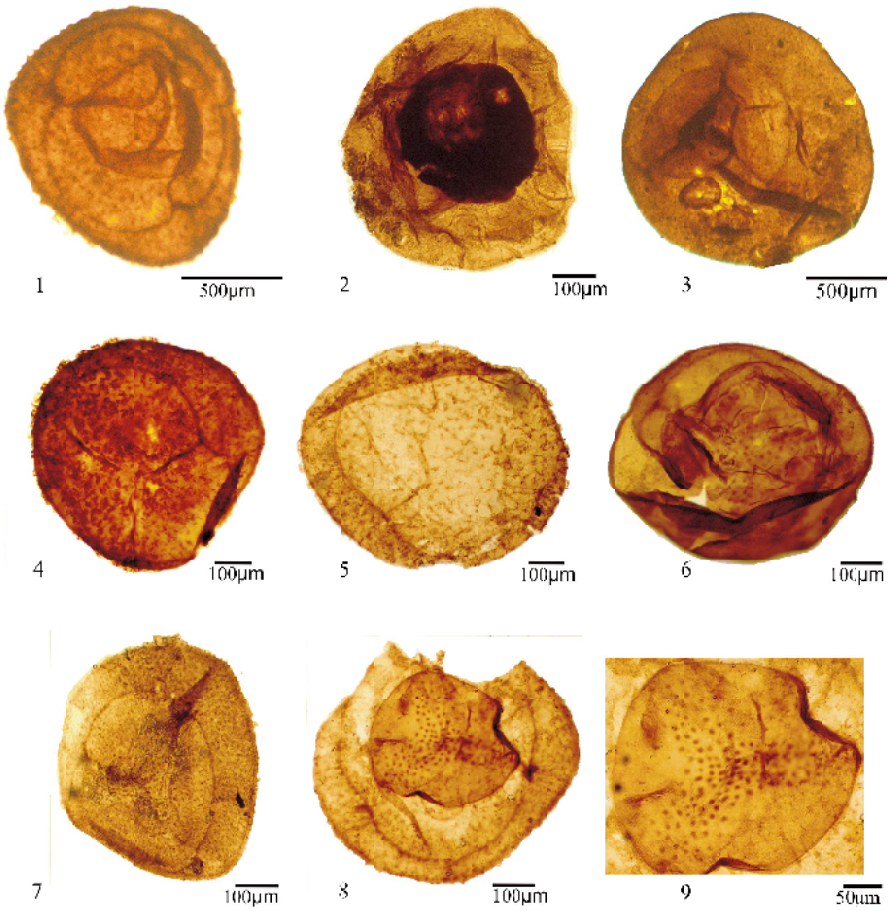


Fig. 4 - Megaspores recovered from the Barakar Formation of Dhanpuri OCM, Sohagpur Coalfield, Madhya Pradesh. 1. *Barakarella shuklae,* 2. *Banksisporites indicus,* 3. *Bokarosporites rotundus,* 4. *Jhariatriletes baculosus,* 5. *Jhariatriletes* sp., *6. Talchirella flavata,* 7. *Talchirella trivedii,* 8. *Talchirella trivedii,* 9. Enlargement of *Talchirella trivedii*

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

Investigators: S. Suresh Kumar Pillai & Runcie Paul Mathews

Highlights:

- Palaeoclimatic analysis based on geochemical and isotopic records on Lalmatia Coal Mine of Rajmahal Basin, Goddar District, Jharkhand, India has been carried out for the first time from Indian Gondwana sequence. The studied Barakar Formation shows drastic intermittent variation of climate in the bottom part and a relatively uniform climate towards the top part of sediments.
- The mega and microfossils studies for the late Permian sediments of Sonepur-Bazari, Eastern Coalfield Limited in the eastern part of Raniganj Coalfield, Burdwan District, West Bengal, (Damodar Basin) shows diverse megafloral assemblage that includes *Phyllotheca, Gangamopteris, Vertebraria*, Scale leaves and equisetalean axis. The palynological assemblage indicates Raniganj Formation. The leaves possess broad meshes that

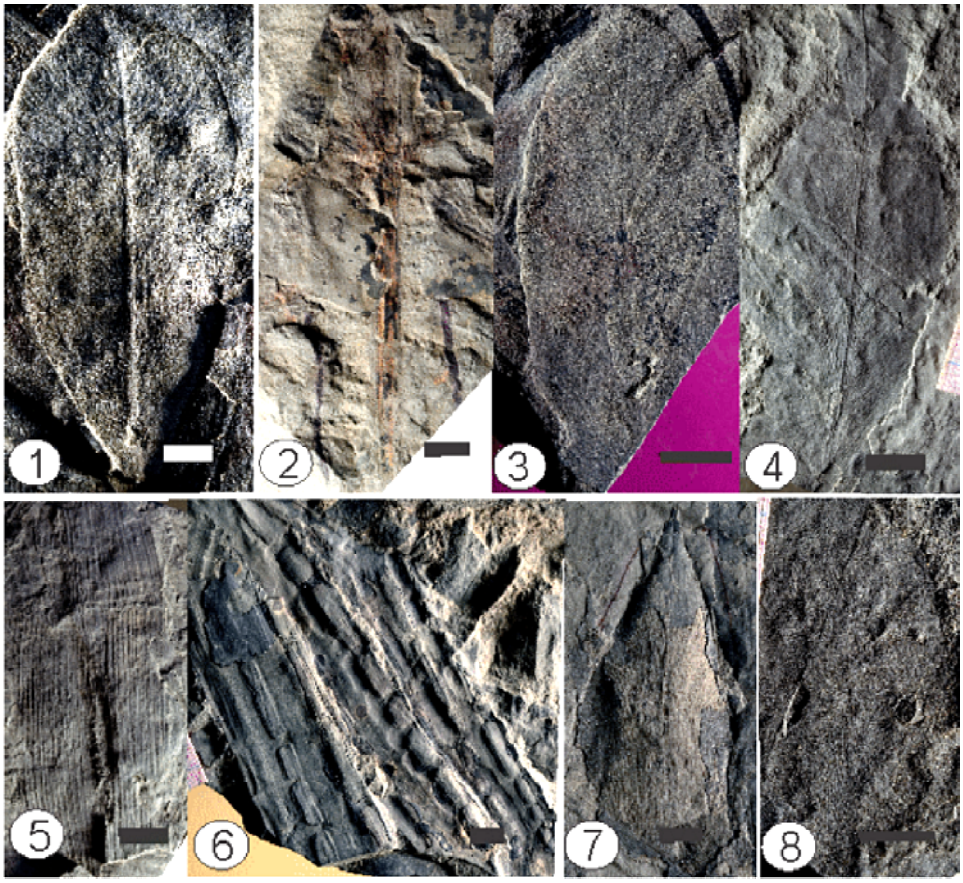


Fig. 5 - Megafloral assemblage from Late Permian sediments of Sonepur-Bazari, Eastern Coalfield Limited in the eastern part of Raniganj coalfield, Burdwan District of West Bengal.

Phyllotheca, Gangamopteris, Verteb-raria, Scale leaves and equisetalean axis. The presence of broad meshes indicate the warm and humid climate during the deposition and variety of megaflora assemblage indicate luxuriant vegetation which contributed towards the formation of coal. The qualitative and quantitative analyses confirms one palynoassemblage characterized by dominance of striate bisaccate pollen *Striato-podocarpites* spp. and sub-dominance of *Crescenti-pollenites* spp. along with *Faunipollenites* and *Densi-pollenites* which comparable to the *Densipollenites magni-corpus* Assemblage zone of Tiwari and Tripathi (1992) and *Striatopodocarpites-Crescentipollenites* Zone – D of Tiwari and Tripathi (1988) that is equivalent to the Raniganj Formation.

indicate the warm and humid climate during the deposition of sediments of Raniganj Formation.

Work done:

The mega and microfossil studies have been carried out from late Permian sediments of Sonepur-Bazari, Eastern Coalfield Limited in the eastern part of Raniganj Coalfield, Burdwan District of West Bengal (latitudes 23°040' 003 N and 23°043' 063 N, longitude 87°011' 143 E and 87°017' 423 E) (Figs. 5-6). The megafloral assem-blage is diverse and represented by dominance of *Glossopteris* leaves (12 species) that represents Upper Permian along with

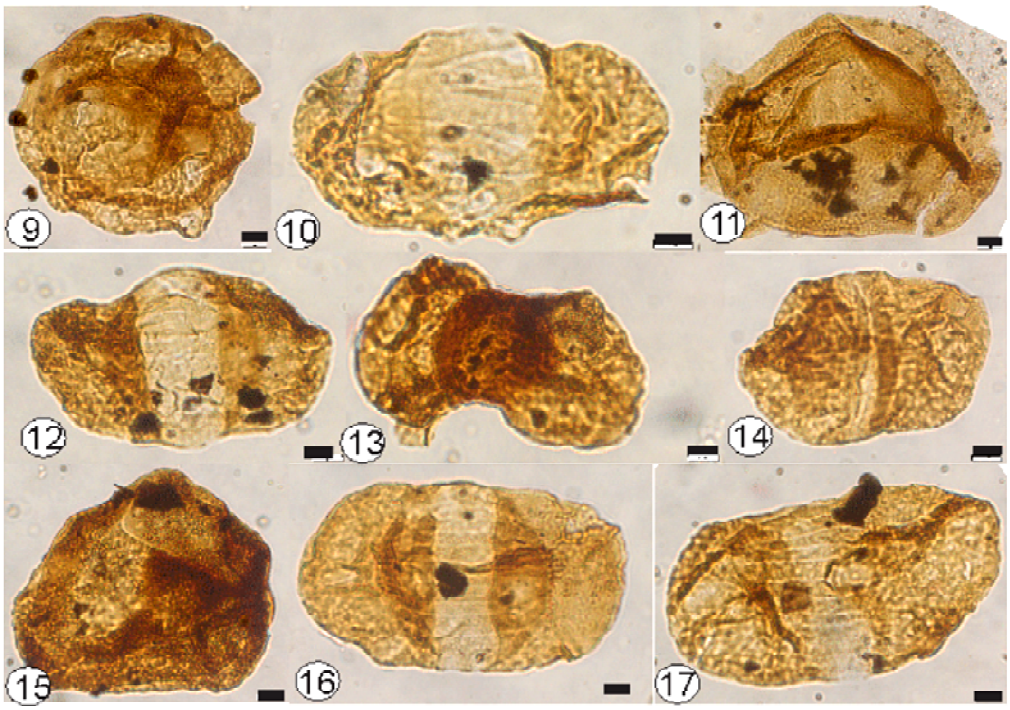


Fig. 6 - Palynoassemblage from Late Permian sediments of Sonepur-Bazari, Eastern Coalfield Limited in the eastern part of Raniganj Coalfield, Burdwan District of West Bengal.

The study of palaeoclimatic based on biomarker and radioisotope study was carried out from the Permian coal bearing sequences of Lalmatia Coalfield, Rajmahal Basin, Goddar District, Jharkhand, India belong to the Barakar Formation (Fig. 7). The *n*-alkane distribution shows higher plant and algal dominant sources, although variations are present in the relative input. The presence of compounds with pimarane, phyllocladane and abietane skeleton suggests copious inputs from conifer and also from the *Glossopteris* flora. The $\delta^{13}C$ value of organic matter corroborates directly with the typical $\delta^{13}C$ values of the Permian sequences. Drastic variation in the palaeoclimate are deciphered in the bottom and top part of the section while it is relatively consistent in the middle part. The biomarker and carbon isotopic ratios unequivocally suggest alternating climatic condition at the bottom part. The Pr/Ph ratio varied from 0.43 to 4.26.

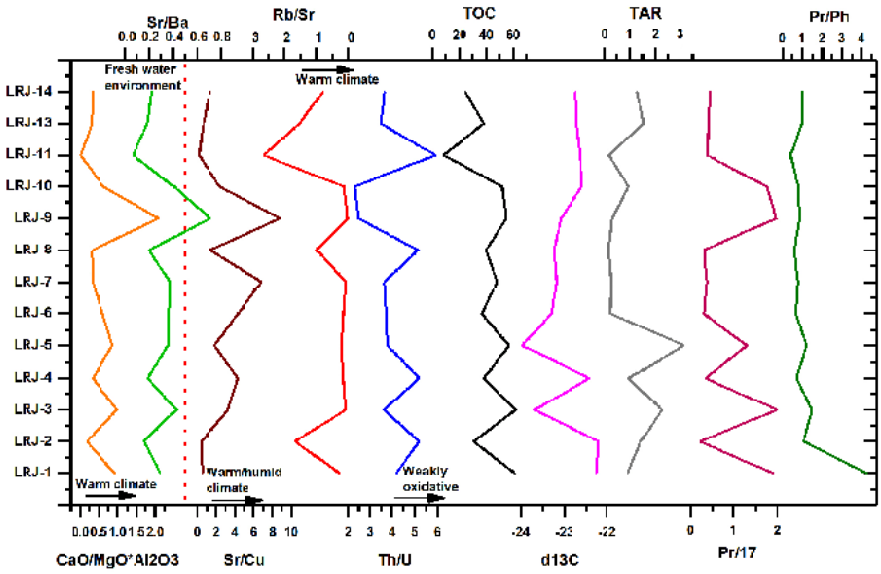


Fig. 7 - Variation of different geochemicaland isotopic parameters along the studied Barakar section of Lalmatia Coalfield, Rajmahal Basin, Goddar District, Jharkhand, India.

Project 2.5: Investigations of Permian-Triassic Transition in Peninsular India

Investigators: Amit KumarGhosh, Ratan Kar & Subhankar Pramanik (BSRS)

Highlights:

- Integrated study of the macrofloral, miofloral and megaspore assemblages from the Raniganj (late Permian) and Panchet (early Triassic) formations of Tatapani – Ramkola Coalfield, Chhattisgarh reveals that the macrofloral assemblage of the Panchet Formation is dominated by two species of *Dicroidium,* i.e. *Dicroidium hughesii* and *D. zuberi.*
- Four palynological (miofloral) assemblage zones have been recognised in the same section, out of which the lower two belongs to late Permian and the upper two belongs to early Triassic along with characteristic megaspore taxa of early Triassic known from other Gondwana basins of Peninsular India and other parts of the world.

Work done:

An integrated study of the macrofloral, miofloral and megaspore assemblages from the Raniganj (late Permian) and Panchet (early Triassic) formations of Tatapani – Ramkola Coalfield, Chhattisgarh have been done in detail. The macrofloral assemblage of the Panchet Formation is dominated by two species of *Dicroidium,* i.e. *Dicroidium hughesii* and *D. zuberi.* The assemblage bears a striking resemblance to the early Triassic macrofloral assemblages known from other Gondwanan countries. Late Permian holdovers, namely *Glossopteris* spp., *Schizoneura* sp. and *Paracalamites* (Equisetaceous stems) continued up to the early Triassic. Four palynological (miofloral) assemblage zones have been recognised in the same section represented by two Upper Permian (Zone I: *Striatopodocarpites-Densipollenites*, and Zone II: *Striatopodocarpites-Crescentipollenites*) and two Lower Triassic (Zone III: *Falcisporites-Klausipollenites* and Zone IV: *Densipollenites-Lunatisporites*) zones. The early Triassic megaspore assemblage is dominated by the characteristic megaspore taxa, viz. *Banksisporites pinguis, Biharisporites sparsus, Hughesisporites variabilis, Nathorstisporites hopliticus, N. reticulatus* and *Noniasporites harrisii* known from the late Permian to Triassic Gondwana sediments of Peninsular India and other parts of the world.

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

Investigators: Neeru Prakash & Neelam Das

Highlights:

- Bennettitalean fructification *Fredlindia* Anderson and Anderson, 2003 is reported for the first time from Indian Subcontinent.

Work done:

The Upper Gondwana sequence of intracratonic South Rewa Gondwana Basin occupies the northern part of Son Mahanadi rift Basin. The basin is filled with fluviatile and lacustrine deposits. Based on lithostratigraphy the basin consists of various formations, viz. Pali (late Permian to early Triassic), Bansa Formation (early Cretaceous) that is overlain by Lameta Formation of Maastrichtian age.

Plant fossils collected from Barambaba and around Chandia area are preserved as impressions in carbonaceous shale, whitish grey shale and clay. The well diversified megafloral assemblage comprising number of species of pteridophytes, e.g. *Todites, Phlebopteris* and branched or unbranched twigs of *Gleichenia* are commonly found in Chandia and Barambaba area.

For the first time in India, number of bennettitalean frond genus *Zamites* has been recovered. Earlier only one frond of this genus was reported from the Upper Gondwana of Kachchh Basin, India. This genus has previously been reported mostly from Northern Hemisphere and efforts have been made to trace the geographic distribution of the genus.

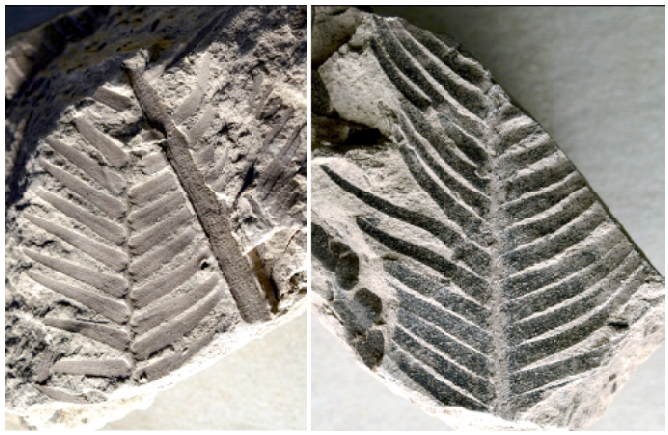


Fig. 8 - *Zamites* and *Ptilophyllum* from early Cretaceous of South Rewa Gondwana Basin, India.

The palaeofloral studies suggest existence of warm, humid subtropical palaeoclimatic condition that might have represented by a forest composed of an over storey of seasonally deciduous conifers (Araucariaceae & Podocarpaceae) admixed with an under storey of cycadophytes (*Taeniopteris, Ptilophyllum*), fern (*Cladophlebis, Gleichenites, Onychiopsis*) and *Sphenophytes* (*Equisetites*).

Well preserved and highly diversified plant fossils indicate less transportation which were later buried under low energy fluvio-lacustrine settings (Fig. 8).

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)

Investigators: Srikanta Murthy, Anju Saxena & Pauline Sabina

Highlights:

- For the first time a palynological assemblage from the Rajmahal Basin has been recovered that can be assigned as youngest late Pennsylvanian, which earlier considered as early Permian.
- The recovered palyno- and megafloral assemblages suggest an early Permian (Kungurian) age to the Barakar strata of Jarangdih Coal Mine and prevalence of moderately warm climate during their deposition of sediments.

Work done:

A palynological assemblage from the Rajmahal Basin has been recovered for the first time and a probable youngest late Pennsylvanian age has been derived which was hitherto considered as early Permian. The palynoassemblage consists of 39 species (5 spores, 25

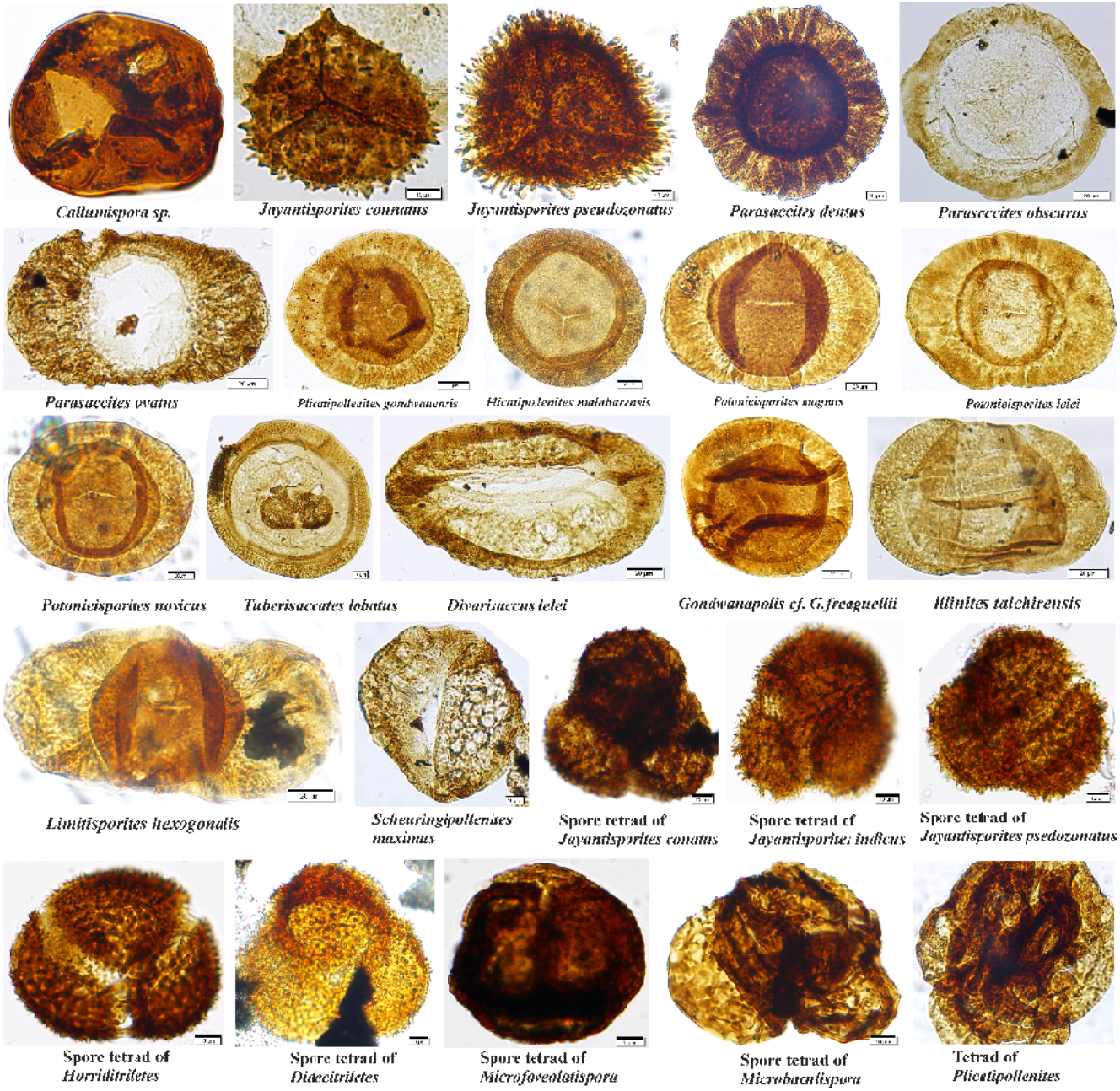


Fig. 9 - Palyno and megafloral assemblage from Jarangdih Coal Mine, Rajmahal Basin.

monosaccate, 5 bisaccate- 3 non striate and 2 striate grains, scarce *Navifusa* sp., scolecodont, algae and fungal hyphae).

Two assemblages have been identified based on the first appearance of taxa, Assemblage I (608.90–599.00 m) dominated by monosaccates and absence of bisaccates and spores. Assemblage II (592.0–590.80 m) also dominated by monosaccates but with the inception of spores, bisaccates and marine palynomorphs. The Assemblage I is correlated to the oldest *Potonieisporites neglectus* Assemblage Zone of Tiwari and Tripathi based on their similarities and the absence of species recorded in the Assemblage II which is correlated to their overlying *Plicatipollenites gondwanensis* Assemblage Zone. Palynoassemblages similar to the Assemblage I, radiometrically constrained to the late Pennsylvanian across Gondwana, along with the lack of diagnostic Permian pollen grains as well as marine Eurydesma fauna and terrestrial glossopterids. All these evidences tentatively support an older age at least for the lower interval of the Talchir Formation. The latter fossils associated to Assemblage II confirm an early Permian age (Fig. 9).

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

Investigators: Pauline Sabina K. & Srikanta Murthy

Highlights:

- A late Pennsylvanian age proposed to the hitherto considered early Permian oldest palynozone from the Indian Gondwana basins-*Potonieisporites neglectus* by correlation with similar assemblages radiometrically constrained to the late Pennsylvanian across Gondwana.
- Affirmed the taxonomic status of *Faunipollenites* as a junior synonym of *Protohaploxypinus* by morphologic comparisons of the specimens attributed to both genera under optical light microscope at each stage of acid treatment to assess their effect, and their observations under CLSM and SEM.

Work done:

Attempted to rectify the hitherto practiced conventional concept of confining palynozones to lithological formations and reinforce the significance of considering the ranges of species by correlating the oldest palynoassemblage from the Penganga area of Wardha Basin with similar assemblages radiometrically constrained to the late Pennsylvanian across Gondwana. This facilitated in the proposal of a late Carboniferous age to the oldest palynozone from the Indian Gondwana basins-*Potonieisporites neglectus* which was hitherto assigned an early Permian age.

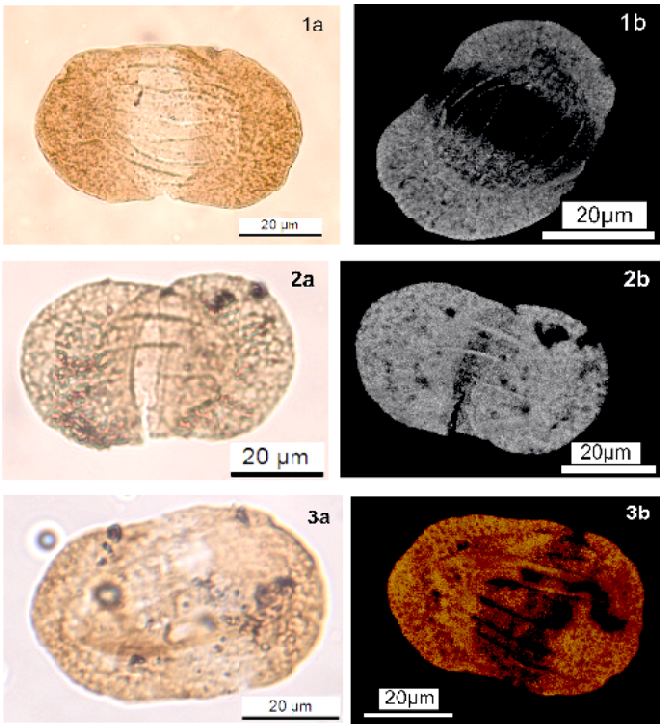


Fig. 10 - 1a (OM) and 1b (CLSM) - *Protohaploxypinus latissimus* (Luber) Samoilovich 1953. 2a (OM) and 2b (CLSM) - *Protohaploxypinus hartii* Foster 1979. 3a (OM) and 3b (CLSM) - *P. perfectus* (Naumova) Samoilovich 1953.

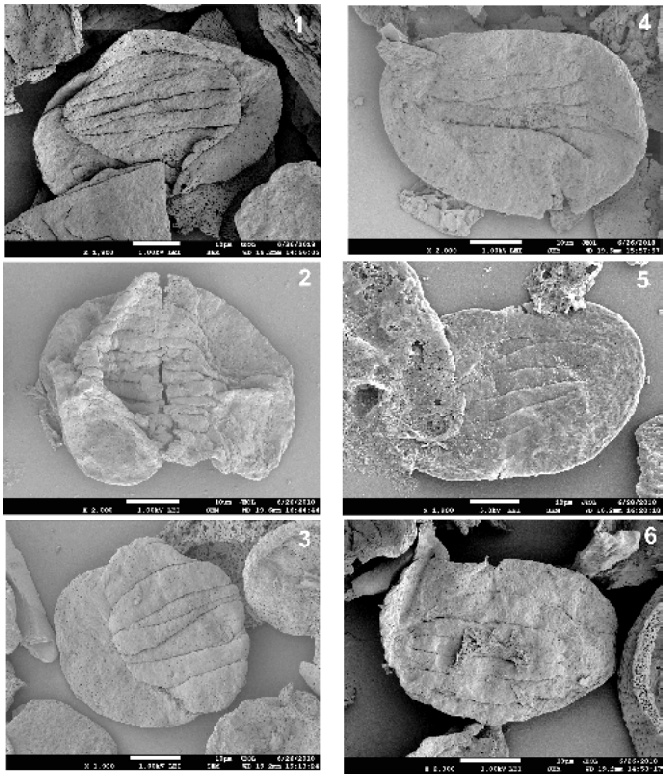


Fig. 11 - SEM images of *Protohaploxypinus* species with distinct central body (1-3) and indistinct central body (4-6). 1. *Protohaploxypinus perfectus* (Naumova) Samoilovich 1953, 2. *Protohaploxypinus microcorpus* (Schaarschimdt) Clarke 1965, 3. *Protohaploxypinus samoilovichii* (Jansonius) Hart 1964, 4-5. *Protohaploxypinus latissimus* (Luber) Samoilovich 1953, 6. *Protohaploxypinus limipdus?* (Balme and Hennelly) Balme and Playford 1967.

Affirmed the taxonomic status of *Faunipollenites* as a junior synonym of *Protohaploxypinus* by morphologic comparisons of specimens attributed to both genera under optical light microscope at each stage of acid treatment to assess their effect, and their observations under CLSM and SEM. Observations revealed that pollen grains recovered from samples treated with HCL and HF and Nitric acid for 2 hours displayed a central body with a distinct outline. While, grains from the other set of residues subjected to a longer Nitric acid treatment (24-

48 hours and beyond) and KOH showed an indistinct central body outline. The CLSM and SEM analysis of specimens from both sets of residues revealed a distinct central body outline. On the other hand, certain forms displayed an indistinct central body outline without folds irrespective of the nature of treatment. These analysis confirm that there are features of generic importance such as the general amb of grain and corpus (haploxylonoid to slightly diploxylonoid) and cappa with more than 4/5 striae. The other features are of specific importance (e.g. lateral ridges, cappula shape and size, presence/absence of folds, corpus thickness, type and shape and number of striae/ taenia). Therefore, we affirm the taxonomic status of *Faunipollenites* as junior synonym of *Protohaploxypinus* and refute its current usage (Figs 10-11).

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

Investigators: Neha Aggarwal & Anju Saxena

Highlights:

- Palynofacies studies in Mamakannu and Gundala area of Godavari Graben is based on the hypothesis that huge coal bearing lacustrine deposits developed during the Gondwana time-span and these coal formations need to be fully understood in terms of the palynofacies to provide insight into the physical and biological processes.
- The palynofloral assemblages in 306 m deep succession of Somavaram area of Godavari Graben are characterized by three distinct palynofloral turnovers, phase-1 (early Artinskian palynoflora) dominated with the triletes (filicopsids, lycopsids) and Cordaites, phase-2 (late Artinskian palynoflora) distinguished by the predominance of Glossopterids, and phase-3 (Guadalupian-Lopingian palynoflora) illustrated by the prevalence of Glossopterids alongwith Coniferales.

Fig. 12 - Recovered palynofacies assemblages in the borehole MSM-25.

Work done:

The palynological investigation of 101 samples (306 m deep borehole MSM-25) from the Somavaram area of the Godavari Valley Coalfield has revealed five distinct palynoassemblages (Fig. 12). The Artinskian (Palynoassemblage-I and II), Guadalupian (Palynoassemblage-III and IV), and Lopingian (Palynoassemblage-V) ages have been assigned to the palynoassemblages based on the palynofloral evidence. Artinskian age is characterized by relatively higher $\delta^{13}C$ values, whereas lower $\delta^{13}C$ values are observed at the Lopingian age. Based on the existing SOM, three distinct palynofacies units have been identified. The palynomorphs and structured terrestrial phytoclasts dominate the Palynofacies-A, the dominance of degraded OM and amorphous OM characterize the Palynofacies-B, and predominance of the opaque phytoclasts distinguishes the Palynofacies-C. In addition, the absence of marine elements (foraminiferal linings, acritarchs, etc.) reflects the low energy swamp/peat dominated continental settings.

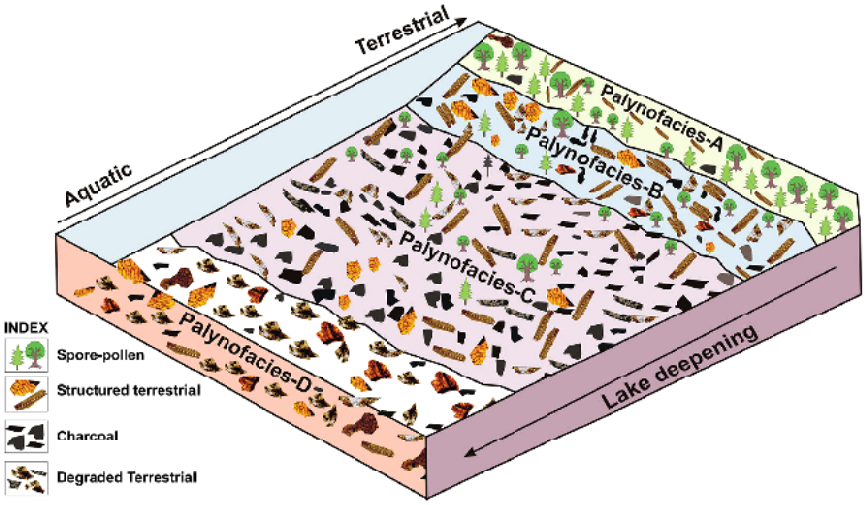


Fig. 13 - Conceptual depositional model from the Gundala and Mamakannu sections of the Godavari Graben based on palynofacies.

The palynofacies analysis was conducted on the Lower Gondwana successions of the Godavari Graben. Palynofacies were analyzed quantitatively, and cluster analysis was performed on different percentages of SOM to obtain zones for the depositional pattern in the lake deposit. The work is based on the hypothesis that huge coal bearing lacustrine deposits developed during the Gondwana time-span and these coal formations need to be fully understood in terms of the palynofacies to provide insight into the physical and biological processes. Based on the existing Sedimentary Organic Matter, four (A–D), distinct palynofacies units were identified, representing the differential environmental setting in the lake. The Palynofacies A-D has been attributed to the freshwater peat environment in a low energy setting; oxidizing environment under shortly transported large terrestrial influx; redeposition of organic matter from fluvio-deltaic settings (oxic) and low energy freshwater swamps (dysoxic-anoxic) respectively. The data demonstrate the combination of lacustrine and fluvio- deltaic depositional environments (Fig. 13).

Cretaceous-Cenozoic Ecosystems Group (CCEG)

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

PREAMBLE: The present thrust area deals with the evolution and palaeobiogeographic history of the biota and climate during the Late Cretaceous to Cenozoic Period (65–2.5 Ma). The reconstruction is based on the plant and animal megafossils, insect fossils, pollen and spores, nannofossils, dinoflagellate cysts, inorganic and organic geochemistry, process based sedimentology and stratigraphic studies including sequence- and magneto-stratigraphic proxies. This time-frame includes the northward voyage of Indian Plate from the Southern Hemisphere, its collision with the Eurasian Plate and subsequent uplift of the mighty Himalayas. During the northward journey, Indian sedimentary basins, especially at plate margins, experienced rise and fall of sea level, leading to deposition of vast amount of terrestrial as well as marine sedimentary archives during the Paleogene. A vast volcanic activity also occurred when the Indian Plate passed over the reunion hotspot resulting into the deposition of thick volcano-sedimentary successions in central India and adjoining areas (i.e. Deccan Traps). The study of these sedimentary archives including Deccan volcano-sedimentary successions (DVSS) is vital in

revealing the operative processes, their timing, duration, and interrelation of the Deccan volcanism to the K-Pg boundary mass extinction, depositional environment and palaeogeography. The magnetostratigraphy data helps in constraining the age and duration of the volcanism and the rich fossiliferous flora from the DVSS can provide clues for tropical angiosperm evolution and phytogeography. The geological archives of the globally warm period during the early Paleogene (55.5–52 Ma) provide analogs for recent and future global warming. The Paleogene sediments from western India (Kutch and Rajasthan), northwest Himalayas and northeast India (Meghalaya) provide an analog of extreme globally warm climate on biota and environment in the tropics. The floral and faunal fossils from these sediments can help in revealing the evolutionary and biogeography of the tropical lineages. In western Himalaya, late Eocene-Miocene sediments are exposed which provide information of different stages of monsoon establishment and Himalaya uplift. Many other issues of global and regional significance such as sea level fluctuations, palaeoclimate, palaeogeography, evolutionary history of biota and dating of Cretaceous-Cenozoic sediment successions were also proposed in this thrust area.

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

Investigators: Mohammad Arif, Vandana Prasad & Arvind K Singh

Highlights:

- Deccan-volcano sedimentary sequences of Jabalpur and Sagar localities showed both reversal and normal polarities compatible with Deccan magneto-stratigraphy of 29R-29N magnetochrons

Work done:

The Deccan traps have been extensively studied during the last few decades for coinciding with K-Pg boundary and has attracted the attention of volcanologists, petrologists, geochemists and stratigraphers from various parts of the world. The magnetic polarity stratigraphy provides a useful, broad correlation tool, and significantly, corroborates the structures identified by the chemostratigraphical data. Oriented basaltic block and sedimentary samples were collected from the Deccan-volcano sedimentary successions (DVSS) of Jabalpur and Sagar (Madhya Pradesh, central India). Here we report the magnetostratigraphy of lava flows encountered from different stratigraphic successions of Infra- and Intertrappean strata of Jabalpur and adjoining region (Seonighat, Chui Hill & Gaumukh Infratrappeans; Mehadbani and Kohani Intertrappeans). The Seonighat infratrappean comprises of limestone with burrows, mottled nodular and pebbly to granular limestone in ascending order overlain by lava flows of normal magnetic polarity with a mean ChRM of D=346°, I=-25°, a_{95}=2.9° which corresponds to C30n chron. The Chui Hill

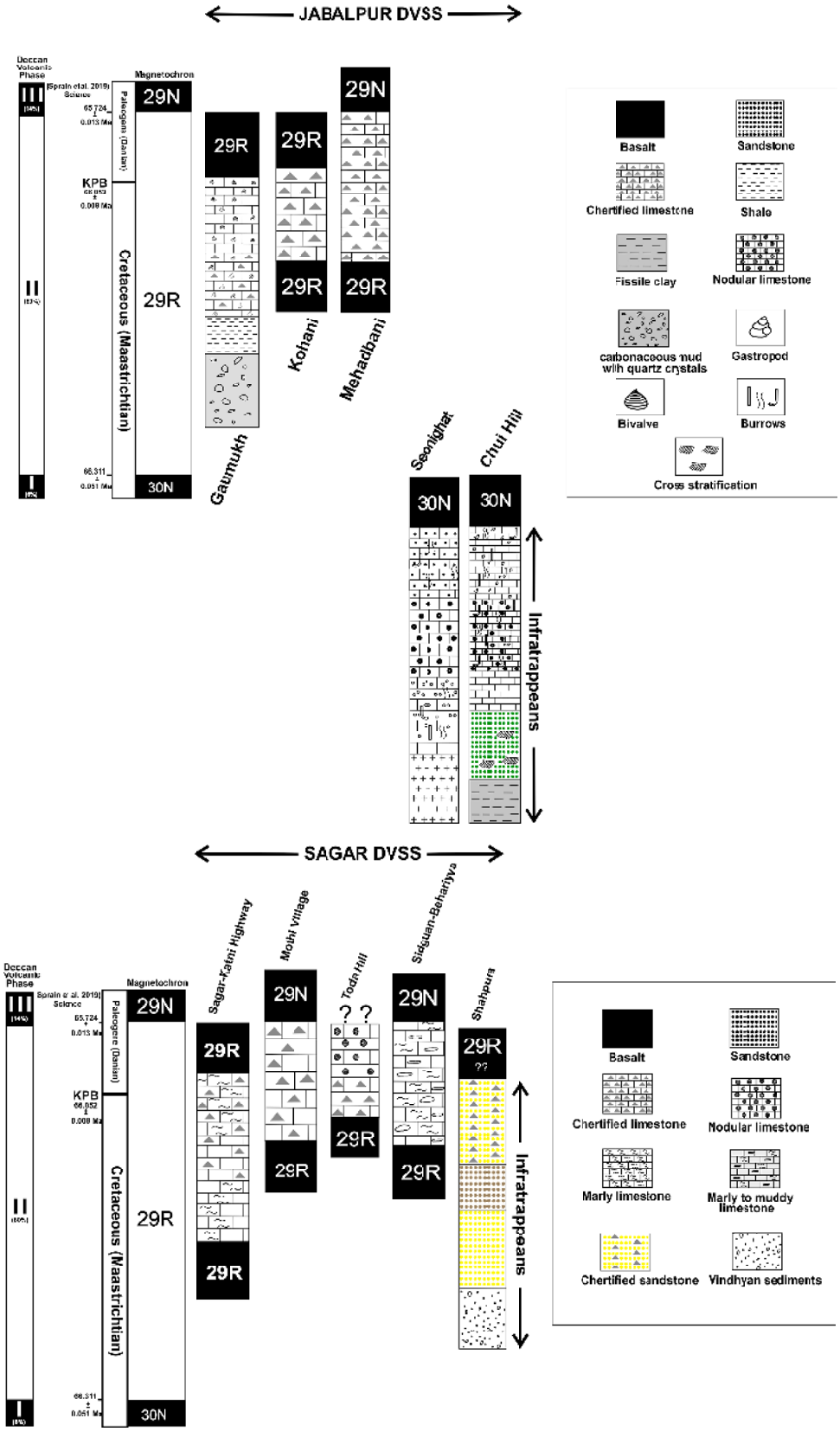


Fig. 14 a and b - Illustrating the magnetostratigraphy data of Jabalpur and Sagar DVSS (MP).

infratrappean comprises of pinkish-white to violet kaolinitic clay layer usually fissile and splintery in character, fine to medium grained sandstone, mottled nodular limestone with burrows and granular to pebbly limestone in ascending order overlain by basalts of normal magnetic polarity with a mean ChRM of D=339.2°, I=-19.8°, a_{95}=5.5° (C30n). The Gaumukh infratrap (Jabalpur) consists of carbonaceous mud, fissile black shale and bioclastic limestone in ascending order overlain by basaltic flows of reverse magnetic polarity with a mean ChRM of D=168.3°, I=28.9°, a_{95}=7.7°, corresponding to C29r. The Mehadbani section exposes a ~3 m intertrappean sediments mostly comprising chertified limestone. The palaeomagnetic data show reversal and normal polarities for the lower (D=167.7°, I=54.9°, a_{95}=5.0°) and upper (D=348.4°, I=-37.7°, a_{95}=2.1°) lava flows respectively, which corresponds to both C29r and C29n chrons. The Kohani section contains ~0.5 m intertrappean sediments (comprising chertified limestone) sandwiched between lower and upper lava flows and the palaeomagnetic data revealed a reversal polarity for both of the flows with a mean ChRM corresponding to D=193.9°, I=64.3°, a_{95}=8.8° (C29r). In summary, the magnetostratigraphic data of lava flows from the Jabalpur DVSS encompasses lower traps with magnetochron C29r (Deccan phase-2: ~80%; Mehadbani succession, late Maastrichtian) and upper traps with C29n (main Deccan phase-3: ~14%, Danian) straddling the K-Pg boundary and coinciding with the Bushe-Poladpur transition (Fig. 14a). The DVSS of Sagar region correspond to magnetochrons C29R and C29N respectively (Fig. 14b).

Project 2.11: Cenozoic plant megaremains of Northeastern and Western India: Palaeoclimatic and phytogeographic significance

Investigators: R.C. Mehrotra, Gaurav Srivastava & Anumeha Shukla

Highlights:

- Fossil records provide strong evidence of humid tropical evergreen forest with rainfall seasonality in NW Rajasthan.
- Earliest fossils of *Ipomoea* (Convolvulaceae) from northeast India are suggestive of Indian ancestry to sweet potatoes.

Work done:

We have reported the earliest fossils of bamboo from late Oligocene sediments of India and inferred that in Asia the ancient bamboos were evolved in a warm and humid climate.

Sweet potatoes are considered as world's second most important root crop. We have discovered the earliest fossils (~57 million years) of *Ipomoea* (Convolvulaceae) from northeast India and inferred that ancestors of sweet potatoes were originated in India and not in North America. The aforesaid inference is also supported by molecular phylogenetic analysis.

We have described a fossil leaf belonging to the monocot genus *Dioscorea* from the early Eocene of Bikaner, Rajasthan. The present fossil from the Indian Subcontinent, along with earlier recorded fossils of the family Dioscoreaceae provides new opportunities to trace the presence of *Dioscorea* (yams) in Gondwana since the Cretaceous.

Four fossil leaves were collected from the Gurha Lignite Mine of Bikaner showing affinities with modern genera *Holigarna grahamii* (Anacardiaceae), *Pterygota alata* (Malvaceae), *Syzygium* (*S. fruticosum* and *S. cumini*; Myrtaceae), and *Gardenia* (*G. lucida* and *G. gummiefra*; Rubiaceae). Fossil records provide strong evidence of humid tropical evergreen forest with rainfall seasonality existing in and around the study area during the depositional period contrary to the present-day dry and desertic conditions.

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

Investigator: G.K. Trivedi

Work done:

Palynological assemblage recorded from the Renji Formation (Upper Oligocene) exposed along Jowai-Badarpur Road Section (N.H.44), East Jaintia Hills District is quite rich. The assemblage is represented by fungi, pteridophytes and angiosperms. The palynofloral assemblage recorded is as follows - *Inapertisporites kedvesii, Phragmothyrites eocenica, Trichothyrites setiferus, Pluricellaesporites* sp., *Lacrimasporonites longus, Cleistosphaeridium heteracanthum, Cordosphaeridium* sp., *Granatriletes* sp., *Pilatriletes* sp., *Polypodiisporonites splendidus, P. turbinatus, P. oligocenicus, Foveomonoletes* sp., *Foveosporites spectabilis, Punctatisporites sarangwarensis, Hammenisporis sussanae, H. assamensis, H. indicus, H. punctatus, Todisporites major, Lygodiumsporites eocenicus, L. pachyexinus, Laevigatosporites indicus, L. intrapunctatus, L. ovatus, L. levis, Polypodiisporonites mawkmaensis, Spinizonocolpites echinatus, Monocolpopollenites eocenicus, Palmidites maximus, Palmidites* sp., *Dicolpopollis fragilis, Polyadopollenites sahii, Monoporites gramineoides, Proxapertites microreticulatus*.

The overall vegetational composition of the palynofossils suggests that the deposition of these sediments took place under coastal with brackish conditions and with sufficient fresh water influx.

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

Investigators: Hukam Singh

Highlights:

- Significantly rich and diversified palynofloral assemblages and hundreds of amber inclusions were investigated from Tarkeshwar Lignite Mine which are excellent indicators for palaeoecological and environmental studies.

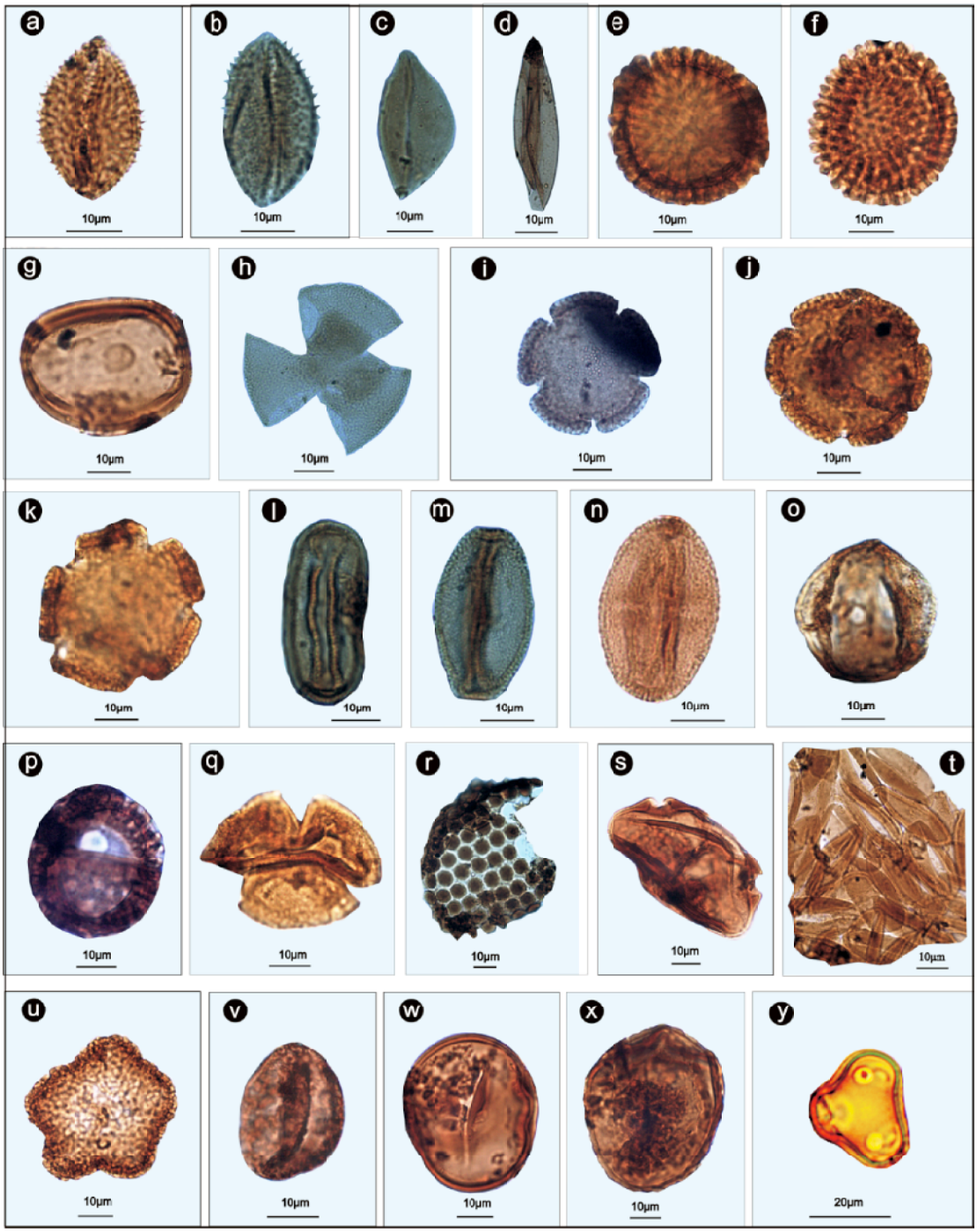


Fig. 15 - Palynofloral assemblage of amber collected from Lignite mines, Gujarat.

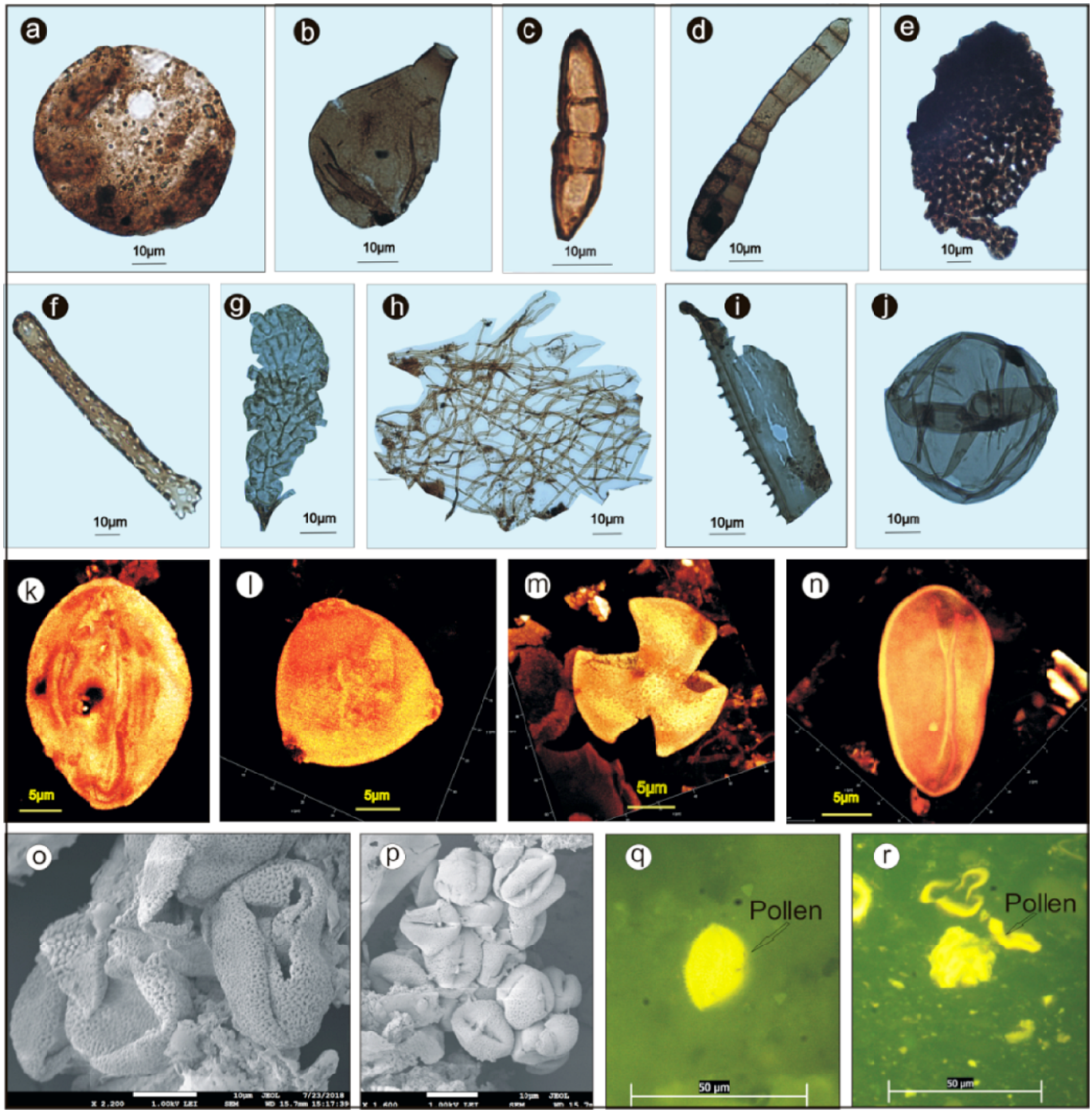


Fig. 16 - Palynofloral assemblage of amber from Cambay & Kutch Basin, Gujarat.

- Amber biota recorded from Valia Lignite Mine, Cambay Basin, and Umarsar Lignite Mine, Kutch Basin, Gujarat are highly productive for new floral and faunal records. The fossil biota is important for zoogeographic, palaeo-ecologic and climatic studies and also in tracing their antiquity.

Work done:

Floral assemblages recovered from amber are rich in diverse angiosperm pollen dominated by *Liliacidites* sp., *Palmidites elongatus, Palmidites pollenites, Proxapertites cursus, Albertipollenites crassireticulatus, Polybrevicolporites cephalatus* and *Dipterocarpuspollenites retipilatus*, as well as by

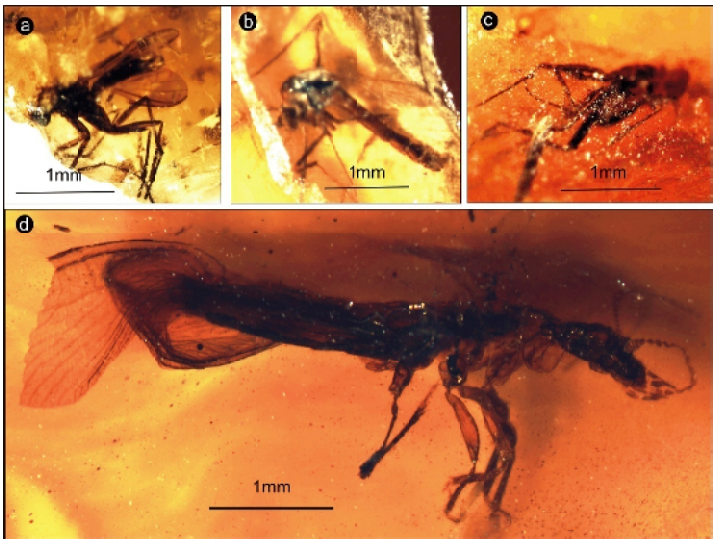


Fig. 17 - Insect inclusion in amber.

pteridophytic spores (*Todisporites major, Dictyophyllidites dulcis, Cyathidites minor* and *Dandotiaspora dilata*) and a variety of fungal, algal bodies (*Botryococcus*); and bryophytes (*Anacolosidites trilobatus*) (Fig. 15-17). It has been observed that pollen grains are better preserved in amber (fossil) in contrast to clay and carbonaceous shales and shows a better representative of the entire pollen spectra. Amber-producing trees are able to catch pollen from the upper and lower canopies including the trunk and at the base in soil and wet areas surrounding the roots leading to a taphonomic bias in comparison to sediment-derived palynological assemblages. Floral and faunal assemblages recorded from Umarsar Lignite Mine, Bhuj District (Kutch), Gujarat.

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

Investigators: Vandana Prasad, Anupam Sharma & Jyoti Srivastava

Highlights:

- Dinoflagellate cysts biostratigraphic study provided Danian-Thanetian age to the Giral Lignite Mine succession contrary to the late Paleocene-early Eocene age proposed by the earlier workers.
- Isotopic signature (Carbon Isotope Excursion) of Jerrain-Dauki succession of Paleocene-Eocene age from Jaintia Hills, South Shillong Plateau of NE Himalaya, showed two major negative ~6.5‰ and for two minor ~3-4‰ shift of CIE signifying multiple events of extreme global warm climate during early Paleogene from India.

Work done:

The geological record of excessive global warm climate, viz. Paleocene-Eocene Thermal Maxima (PETM) event of early Paleogene are dominantly known from the temperate regions of the globe, while similar data from tropical regions are meagre. Interestingly, the coal bearing sequences of late Paleocene-early Eocene age from Jaintia Hills, Meghalaya showed a very good signatures of excessive warming. Isotopic signature (Carbon Isotope Excursion) of extreme warming events is observed in the representative samples of the *Jerrain-Dauki* Paleogene sequence of East Khasi Hills, South Shillong Plateau of NE Himalaya, India. The negative shift of CIE for the two major events is ~6.5‰ and for two minor events is ~3-4‰ respectively shows two major and two minor warming phases.

Organic walled dinoflagellate cysts were documented from 80 m lignite bearing succession of Sonari Lignite Mine, Barmer Basin, Rajasthan. Several age diagnostic forms of Danian age were recovered from the lower part of the section. The study also provided evidence of the earliest occurrence of wetzeliellioid dinoflagellate cyst *Apectodinium* that show rapid radiation across the globe during the extreme global warming at Paleocene-Eocene transition. The present *Apectodinium hyperacanthum* dinoflagellate cyst recorded from the Danian (64 Ma) of Sonari Lignite Mine is an approximately 4 Ma earlier from that of El Kef, NW Tunisia. The present fossil evidence further reinforces that the *Apectodinium* dinoflagellate taxon was a warm water tropical plankton that evolved during the early Paleocene at low latitude and radiated and migrated to mid and high latitudinal regions across the globe during periods of extreme global warming (PETM) at Paleocene-Eocene boundary. Carbon isotope ($\delta^{13}C$) signatures were determined to infer the palaeo-environmental conditions. $\delta^{13}C$ values show variation of ~7.0‰ with maximum excursion (-29.00 ‰) in the upper part of the section that coincided with the *Apectodinium* acme and hence characterized as probable PETM event.

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

Investigators: Poonam Verma & Abha Singh

Highlights:

- Palynostratigraphy based on spore-pollen and dinoflagellate cysts have been done in Akri Lignite Mine succession, Kutch provided middle Ypersian-early Lutetian age for top lignite seam and overlying post-lignite succession.
- The palynological assemblage indicate fluctuating coastal lagoonal to inner neritic marginal marine setting for deposition of succession under warm and humid of early Eocene time.

Work Done:

The study of palynofloral diversity and palaeoenvironments of Early Eocene Akri Lignite succession, Kutch Basin, western India was completed and communicated for publication. A rich and diverse palynological assemblage consisting of algal and fungal remains, dinoflagellate cysts, pteridophytic spores, angiosperm pollen belonging to 30 extant families was recorded. The palynoassemblage from lower part of the succession was dominated by coastal palm pollen of Arecaceae family and marine dinoflagellate cysts whereas the upper part of the succession dominated by terrestrial palynomorphs of megathermal families such as Bombacaceae, Ctenolophonaceae, Dipterocarpaceae, Meliaceae along with mangrove and back-mangrove taxa of Arecaceae and Rhizophoraceae families. Overall, the palynological assemblage indicated a warm and humid climate in a coastal zone, with a dense tropical rain forest in the vicinity of the site of deposition. The deposition took place in mangrove dominated, fluctuating coastal lagoonal to inner neritic marginal marine environment. The assemblage of dinoflagellate cysts and pollen-spores from the section indicated a middle Ypresian-early Lutetian age for the topmost part of the lignite seam and the overlying post-lignitic succession. The recovered assemblages supports the viewpoint that widespread lignite-bearing successions in the western region of the Indian Subcontinent are in part coeval and belong to Early Eocene (Ypresian) age (Fig. 18).

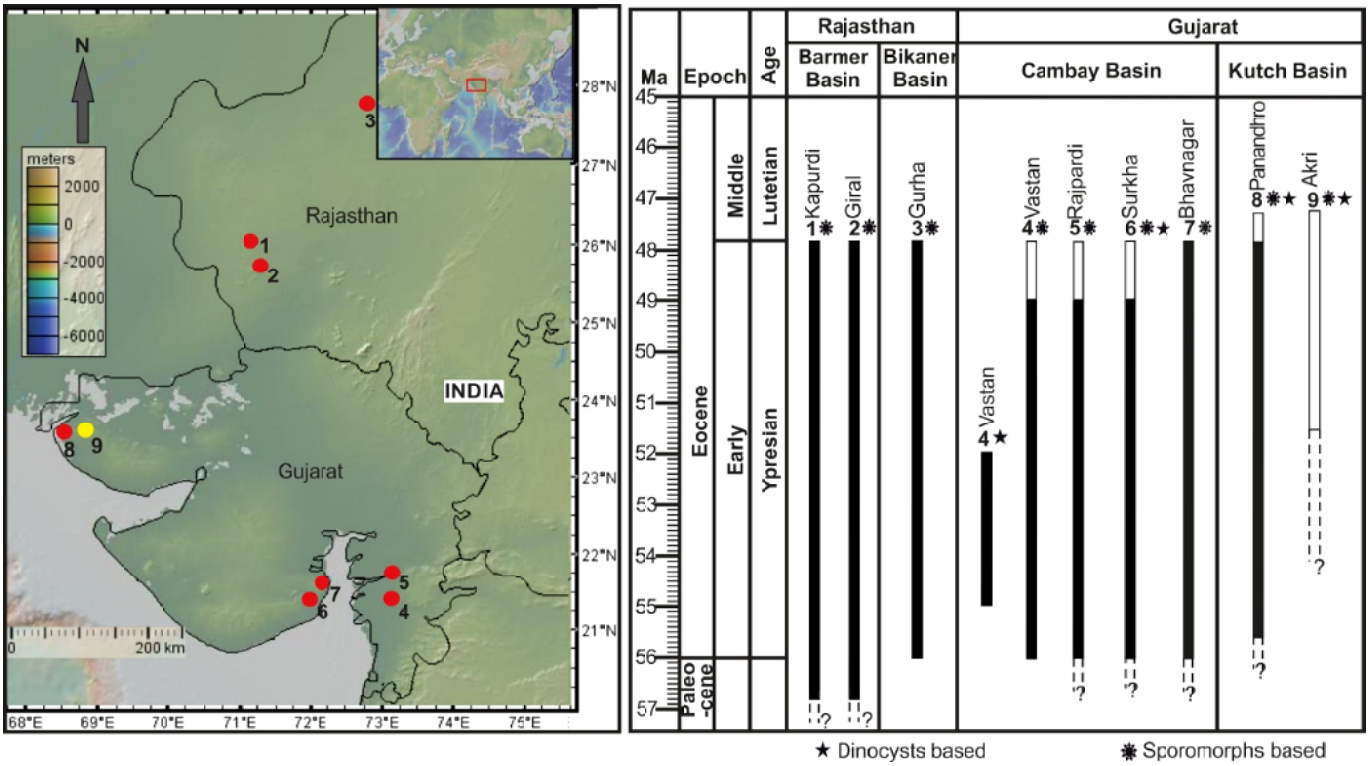


Fig. 18 - Diagram showing location and temporal ranges of various lignite deposits of western India.

Project 2.16: Mesozoic Oceanic Anoxic Events (OAE) based on calcareous nannofossils from the Kachchh Basin and the Spiti Valley

Investigators: Abha Singh & Shailesh Agrawal

Work Done:

During the Mesozoic times, particularly in Toarcian, Early Aptian and latest Cenomanian, OAEs were truly global in nature. These events have been globally recorded by the presence of organic rich sediments (black shales). These events were short-spanned episodes of unusual deposition of high organic carbon rich sediments at depth varying from deep to shallow marine and epicontinental seas. Mostly, during the periods of anoxic condition very warm climatic condition prevailed. In the lithological columns the OAEs are represented by dark grey to black to dark green, laminated organic rich shales. Such types of litho-units have been sampled and studied for nannofossils from the Kachchh Basin and the Spiti Valley to record the possible OAE events.

For the characterization of calcareous nannofloras during OAE intervals, quantitative studies of calcareous nannofossils has been carried out. Late Jurassic-Early Cretaceous age nannofossils were recorded from the black shales of Spiti Formation exposed in Nala section near Langza Village, Spiti Valley and Nirona Dam section, Kachchh Basin (Fig. 19). The nannofossil assemblage in both the areas is dominated by the genus *Watznaueria* which is the most common and resistant form of Jurassic-Cretaceous time and indicates oligotrophic nutrient condition. The isotopic analysis studies from Nirona Dam section, Kachchh Basin is in progress.

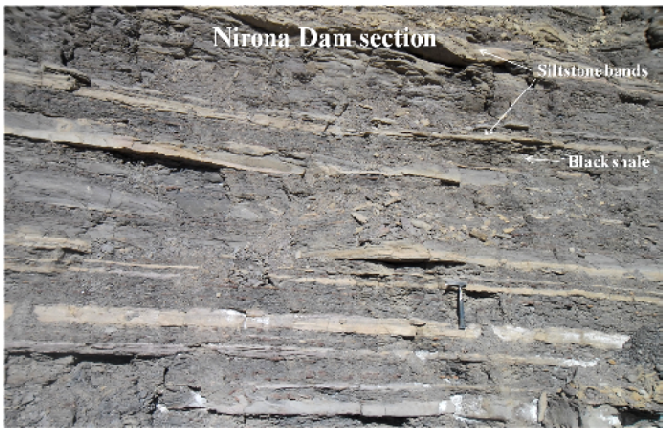


Fig. 19 - Exposure of black shales intermittent with siltstone bands at Nirona Dam section, Kachchh Basin.

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

Investigators: Vivesh Vir Kapur & Prasanna K.

Highlights:

- First detailed assessment of the biotic record (with an emphasis on vertebrates) known from 22 profiles of the Deccan-volcano sedimentary sequences (infra- and intertrappean deposits) allowed to provide inferences on biostratigraphic, palaeoecologic and palaeobiogeographic aspects across the Cretaceous-Paleogene (K-Pg) transition in India.

Work done:

Constraining the age of the Deccan-volcano sedimentary sequences (infra- and inter-trappean deposits) has a direct bearing on the studies that discuss the origin, evolution of the biota in a palaeobiogeographic framework, and also in the context of changes in the palaeoenvironment and palaeoecology. Thus, it becomes important to reinforce the age, environment and the origin/affinity of the faunal elements recovered from these sedimentary deposits. In this context, a reappraisal of the biotic (with an emphasis on the fauna) component in a biostratigraphic, palaeoecologic, and palaeobiogeographic aspect was undertaken while accounting for the data known from 22 profiles from the Deccan Volcanic Province (DVP). The detailed work enabled to conclude that

(1) The bulk of the infratrappean and intertrappean sedimentary exposures are Maastrichtian in age, while a few intertrappean sedimentary successions [e.g., at Jhilmili, Mandla sub-province; at Dudukuru, Balaji, Government and Church quarries, Krishna-Godavari (K-G) Basin, south-east India] are exclusively Danian in age. In addition, the infratrappean succession at Papro (Malwa sub-province) and the intertrappean successions within

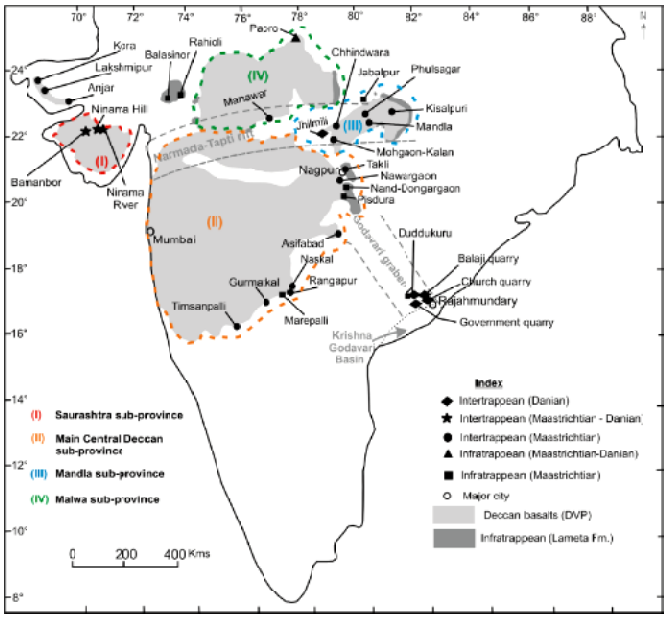


Fig. 20 - Map showing Deccan Volcanic Province (DVP) with palaeontologically significant Maastrichtian–Danian infratrappean and intertrappean localities. (after Kapur *et al.*, 2018). Note the division of the DVP into four sub-provinces: Saurashtra, Main Central Deccan, Mandla and Malwa sub-provinces.

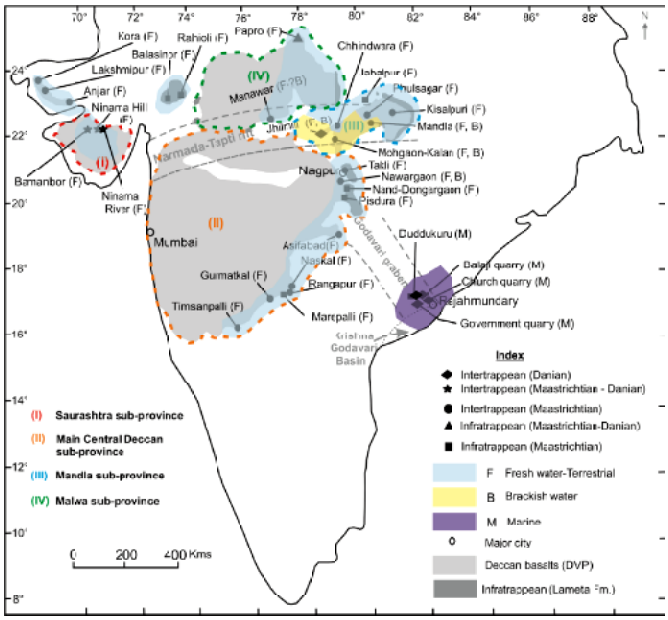


Fig. 21 - Map of the Deccan Volcanic Province (DVP) depicting Maastrichtian–Danian infratrappean and intertrappean localities along with their palaeoenvironments. Note the division of the DVP into three distinct, i.e. fresh-water/terrestrial, brackish water and marine palaeoenvironments.

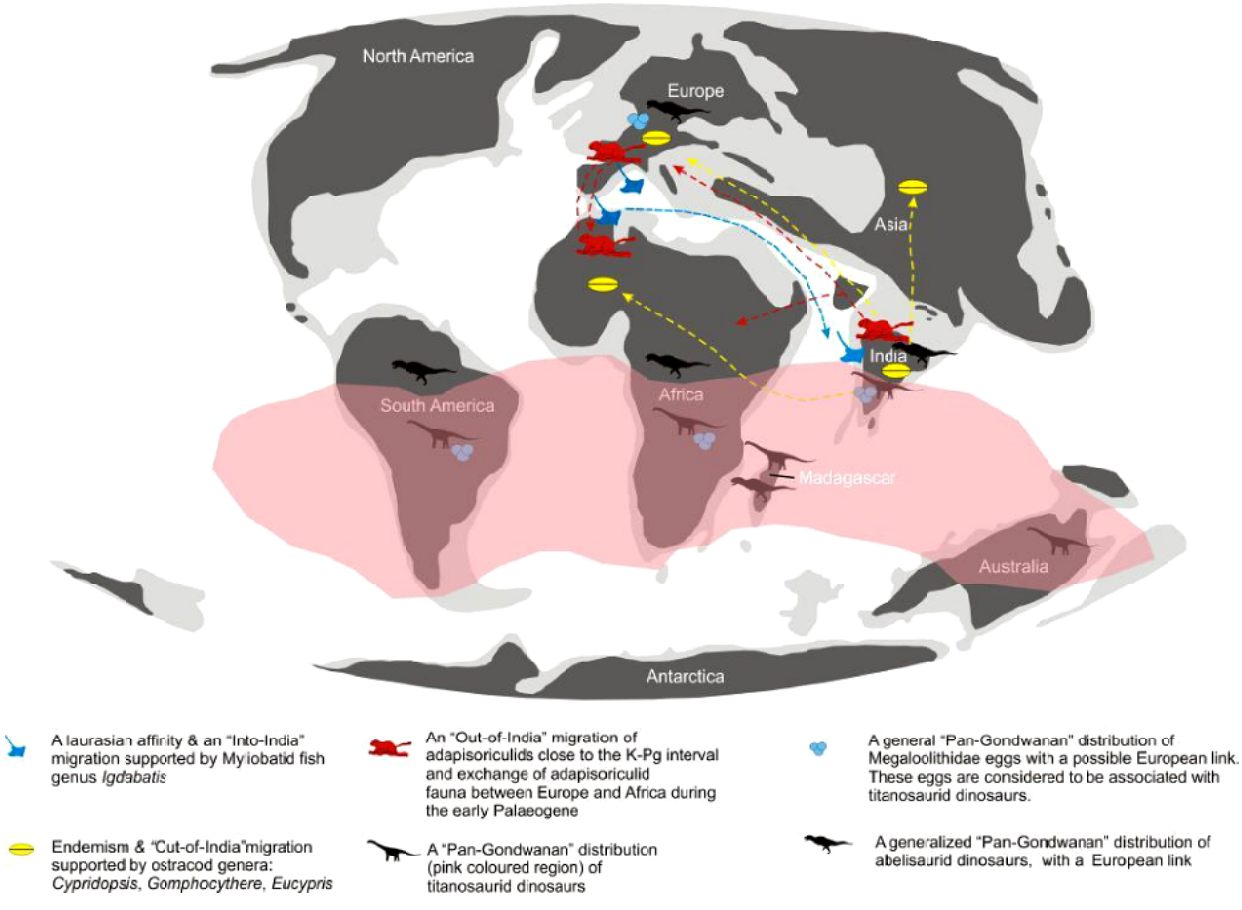


Fig. 22 - Palaeobiogeography close to the K–Pg interval emphasizing on the mixed affinity of the faunal elements (after Scotese, 2001).

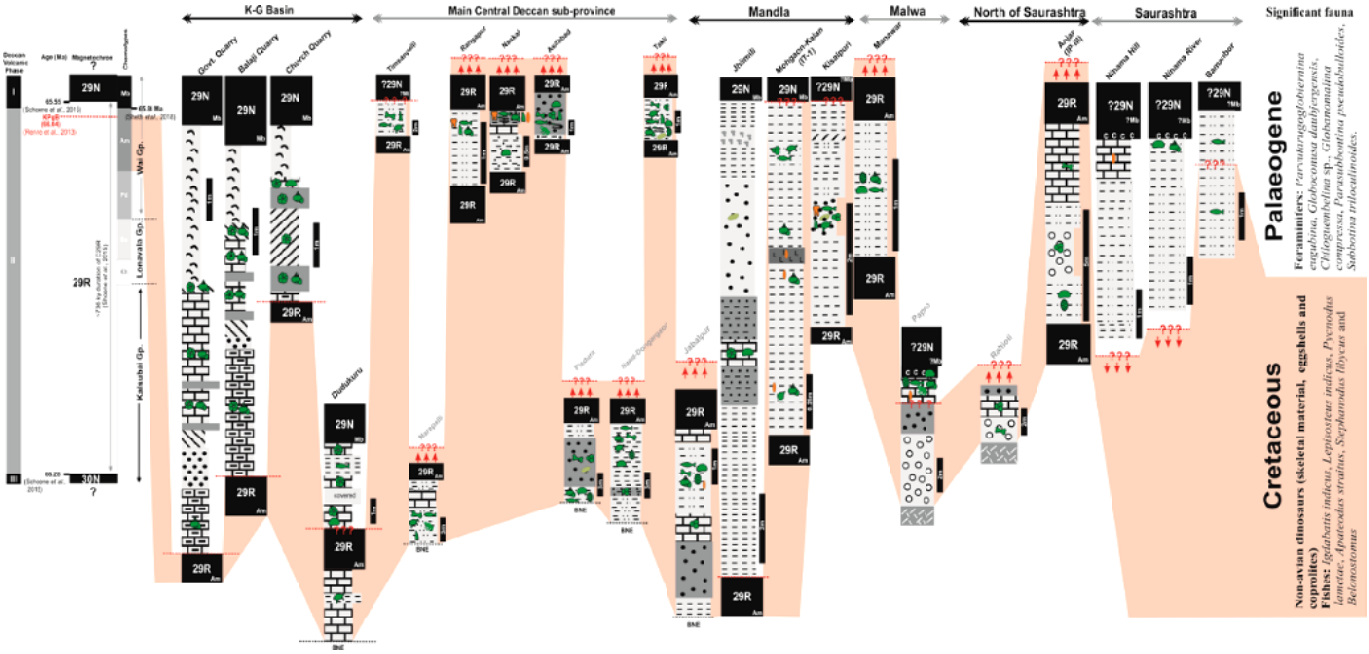


Fig. 23 - A generalized correlation chart for the Cretaceous–Paleogene Deccan volcano-sedimentary sequences of the DVP.

the Saurashtra sub-province (e.g., Bamanbor) plausibly encompass the Maastrichtian–Danian interval (Figs 20, 23).

(2) The majority of the infratrappean and intertrappean sequences show a prevalence of a terrestrial-freshwater (palustrine/lacustrine) ecosystem (Fig. 21). However, the marine ecosystem was mainly restricted within the K-G Basin (Fig. 21). The brackish-water ecosystem was prevalent during the Danian in the south-west Mandla sub-province (e.g., Jhilmili); however, it was undoubtedly short-lived to prevent the development of benthic communities (Fig. 21).

(3) The three distinct ecological niches of the DVP quite perplexingly sustained a mixed (laurasian and gondwanan) affinity biota along with endemic elements (Fig. 22).

(4) To record the biotic changes across the Cretaceous-Paleogene (K–Pg) Transition (within the Indian subcontinent) regarding diversity, environment, ecology and related aspects, a combination of both qualitative and quantitative approaches should be considered in future investigations.

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

Investigators: Ansuya Bhandari & Poonam Verma

Highlights:

- Recorded freshwater fish remains, gastropods and ostracods of Miocene age from Mohand area of Siwalik Basin.
- Around 400 kg samples from Daghai-Kasauli (Pre-Siwalik) and Mohand areas (Siwalik) have been macerated for microfossils and the work is in progress.

Work done:

A reconnaissance field work has been carried out in NW Himalaya (Dagshai-Kasauli) for palaeontological investigations. About 135 Kg samples was from the Dagshai & Kasauli in Shimla Hills and about 370 kg of samples was collected from Mohand area in Siwalik (Fig. 24).

Fig. 24 - Field photograph of Mohand area of Siwalik Group.

So far approximately 400 kg of sample collected from the NW Himalaya has been macerated for recovery of microfossils. Few fresh water fish remains, gastropods and ostracods from Mohand area of Siwalik have been recovered and further study is under progress.

Mudstone samples (D1, D2 and D3) from Dagshai Formation and siltstone (K1, K2 and K3) from Kasauli Formation have been macerated for palynological studies and the work is under process.

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

Investigators: Arvind Kumar Singh, G.P. Gurumurthy & Md. Arif

Highlights:

- Process based sedimentology of Paleogene succession of Jaisalmer Basin indicate a gradual transition from continental aeolian to marginal marine to shallow marine environment suggesting a late Paleocene sea level rise and associated transgressive event in pericratonic Jaisalmer Basin.
- The elemental and isotopic ratio analysis of Sanu and Khuiala Formation reveal a multiple source with little to moderate radiogenic $^{87}Sr/^{86}Sr$ concentration.

Work done:

The process based sedimentology of Sanu Formation revealed a total of three lithofacies that are defined as (a) current cross stratified sandstone facies (Cc) (b) thinly bedded ferruginous sandstone facies (Tf) and (c) intensely burrowed sandstone facies (Ib). The study of these lithofacies suggest its depositional setting ranging from continental aeolian to marginal

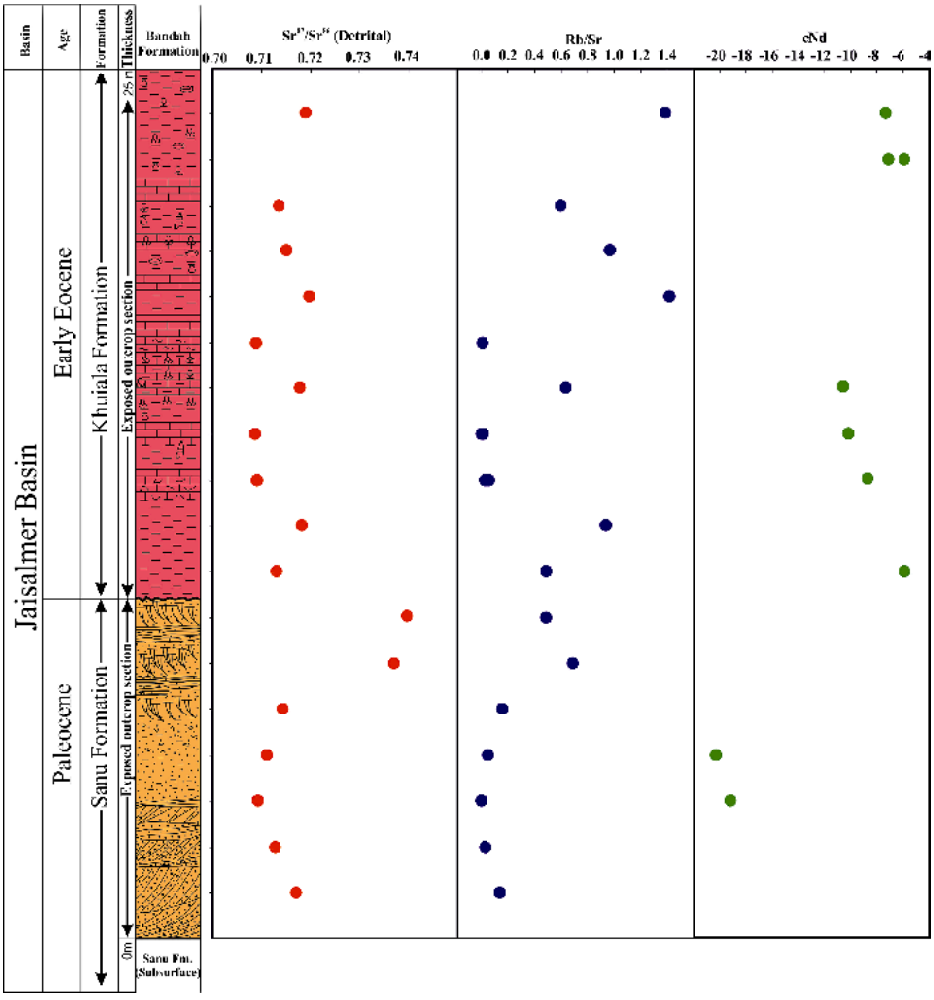


Fig. 25 - Sr^{87}/Sr^{86}, Rb/Sr and âNd concentration of detrital and bulk fraction from exposed sediments of Sanu and Khuiala formations.

marine/lacustrine setup. The Khuiala Formation shows lithofacies association of ocherous shale, marl, fossiliferous limestone, foram rich limestone, and thick tabular limestone bed along with invertebrate (bivalve & gastropods) and foraminifera fossils which suggest its deposition in inner to mid shelf. Unlike Khuiala, Bandah Formation is the dominantly characterized by foraminiferal limestone in association with rich planktic assemblage, occasional thin streaks of marl and yellow fissile shale all indicative of marine shelf environment ranging inner to mid shelf.

The $^{87}Sr/^{86}Sr$, Rb/Sr and εNd ratios measured in the detrital fraction shows distinct origin of clastic sediments during the Sanu and Khuiala sediment deposition (Fig. 25). Their distribution (Sr and Nd isotopic ratios) is largely caused by differences in the sediment source rather than intensity of weathering processes. Within the Sanu Formation, the sediments collected from the Lila-Pariwar (eolian to shallow marine) and Mohammed Ki Dhani localities (eolian) appear to be sourced from different lithologies with less radiogenic $^{87}Sr/^{86}Sr$ in the Lila-Parivar unit, and radiogenic $^{87}Sr/^{86}Sr$ composition with low strontium concentration in Mohammed Ki Dhani, which later transgresses to Khuiala Formation of shallow marine origin. Khuiala sediments appear to be originated from a common source with slightly non-radiogenic strontium. The ongoing measurements of grain size and neodymium isotope will help in pinpointing the sediment source.

Therefore, the gradual transition from continental aeolian to marginal marine to shallow marine environment (inner to mid shelf) indicated by change in lithology, Sr isotope ratio, sedimentary structures, trace fossils (*Skolithos*) and foraminiferal assemblages (benthic & planktic) reveal a late Paleocene sea level rise and associated transgressive event in pericratonic Jaisalmer Basin.

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

Investigators: Binita Phartiyal, Sajid Ali & Md. Arif

Highlights:

- A much younger age for Dagshai Formation is calculated and the palaeolatitude falls at 29°N, a non-agreement to 22-23°N given earlier workers.
- Developed new Li isotope as weathering proxy; Siwalik sections show variable degree of chemical weathering during different time intervals and hence monsoonal precipitation associated with global climate change.

Work done:

There is scarcity of continental geochemical well dated records that explain such monsoon variability in details from the Himalayan mountain barrier which affects the atmospheric circulation over the Asian Continent. We are investigating the monsoon intensification and its variability associated with climate change and Himalayan uplift. More than 150 samples for sedimentological and geochemical interpretation along with oriented samples for palaeomagnetism were collected Subathu, Dagshai and Kasauli formations exposed along road cuts in Himachal Pradesh. Subathu and Dagshai sections yielded ChRM directions whereas Kasauli section shows in coherent results. Earlier studies state that Dagshai palaeolatitude was at 22-23°N, but our preliminary studies point at much younger age for Dagshai as the palaeolatitude falls at 29°N (Fig. 26).

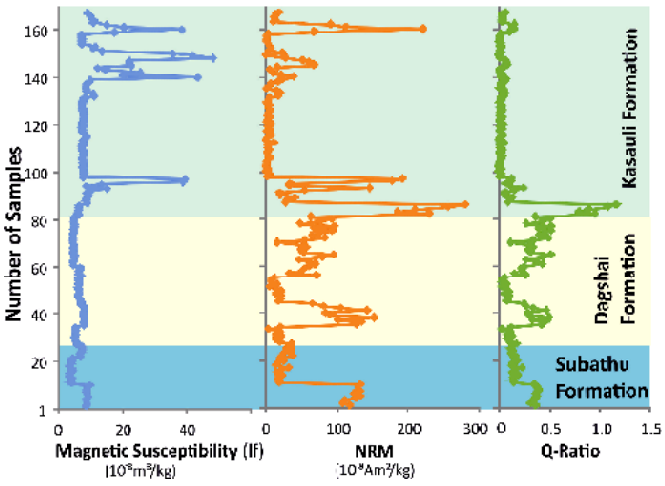


Fig. 26 - Illustrating the variations in the magnetic parameters of the Subathu, Dagshai and Kasauli formations.

Dagshai and Kasauli sections show intense degree of chemical weathering and hence more monsoonal precipitation coinciding with relatively warmer Early Oligocene and Late Oligocene. Clay mineral records also suggest these periods as more humid periods coinciding

with relatively warmer Early Oligocene and Late Oligocene.

Developed new Li isotope as weathering proxy because of the fact that it has various advantages as a weathering proxy, (1) its two isotopes have a large relative mass difference, (2) Li is not critical in biological or atmospheric cycles like other tracers such as oxygen, carbon or calcium isotopes, (3) Li is relatively uniformly distributed in the Earth's crust. Li is highly enriched in silicates and depleted in carbonate, which makes it an excellent proxy for silicate weathering. It is also independence of source rock composition and provide excellent secular proxy of silicate weathering. Primary results suggest strong chemical weathering during Early Miocene that got slowdown in Middle Miocene and again got pace during the Late Miocene time period and continue till the mid-Pliocene.

Project 2.21: Reconstruction of Indian Summer Monsoon seasonality during Mid-Miocene

Investigators: Prasanna K & Vivesh Vir Kapur

Highlights:

- Palaeo-seasonality of Indian Summer Monsoon was reconstructed using fossilized bivalve *Pitar (Hyphantosoma) simonnei* from Quilon.
- Palaeo-ecology and habitat was reconstructed using fossilized otoliths of *Ambasidarum* sp. from Quilon

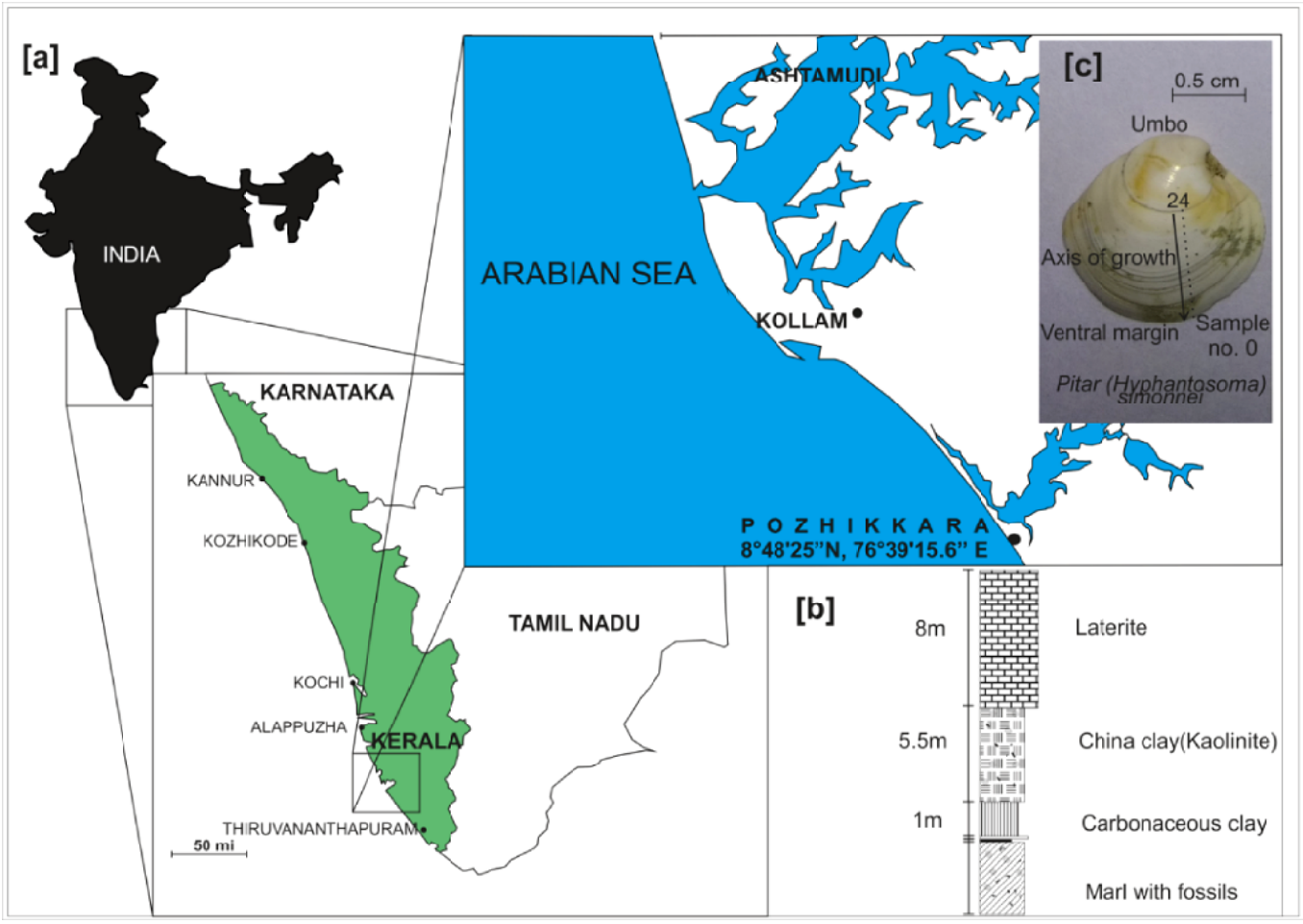


Fig. 27 - Geographic locations of Pozikkara. (A) – Southern state of Kerala is shown as inset in India and actual location of sample collection is shown in as inset in Kerala, (B) – Litho stratigraphy of the location, (C) – Fossil *Pitar (Hyphantosoma) simonnei* specimens sampled at Pozhikkara is shown along with the Growth increments were micro-sampled with a resolution of ~2 lines per mm.

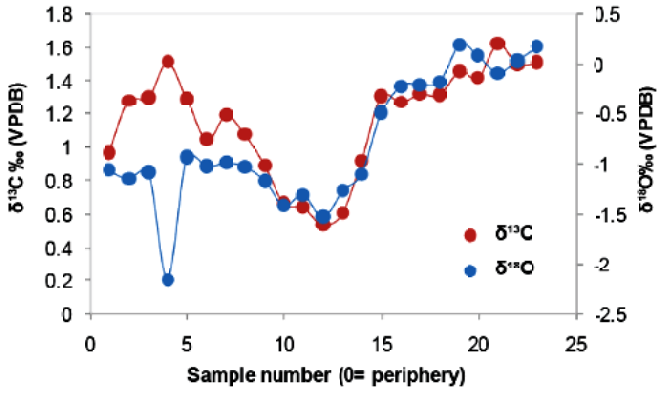


Fig. 28 - Seasonal $\delta^{18}O$ and $\delta^{13}C$ data from the shell of a fossil bivalve *Pitar (Hyphantosoma) simonnei* collected from Pozhikkara, Kerala, India. This bivalve provides an insight into annual climate cycles during the Burdigalian.

Work done:

Palaeo-seasonality in the southern coastal peninsular India was reconstructed using bivalve fossil *Pitar (Hyphantosoma) simonnei* specimens sampled at Pozhikkara shown in Fig. 27. The $\delta^{18}O$ in the growth bands was used to reconstruct the palaeo-seawater $\delta^{18}O$ using empirical equilibrium temperature $\delta^{18}O$ relationships shown in Fig. 28. 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 distinct wet and dry season in the Indian Subcontinent during the later Miocene /Burdigalian age.

Thrust Area 3 ORGANIC PETROLOGY: CHARACTERIZATION OF SOLID FOSSIL FUEL FOR DEPOSITIONAL AND UTILIZATIONAL ASPECTS

Coal Petrology and Organic Geochemistry Group (CPOGG)

Group Coordinator: B.D. Singh

PREAMBLE: The organic matter characterization based on multidisciplinary aspects is well-established globally both in academic and applied pursuits. The type, amount, association of micro-constituents, 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 environmental (climate and ecology) and depositional conditions (pH/Eh conditions, bacterial activity, hydrological conditions, marine influence, fire events, etc.) prevailed during the formation of these deposits. The present study relates with the nature and origin of the economically exploitable lignite deposits of western India (Gujarat & Rajasthan) mainly on the basis of petrographic, bulk and organic geochemical aspects in addition to the available evidences from other investigations (palaeofloral, sedimentological, etc.). Although the lignite-bearing sequences are known for a very long time, limited studies are available on the characterization of the organic matters. The characteristics of organic matter in Rajasthan Basin are still not addressed. To get a comprehensive data on the evolution of the seams, the source characteristics and factors controlled during the formation of the organic matter, systematic organic petrographical and geochemical analyses are required. Implications of the palaeogeography and the palaeoclimate are to be addressed. The utilization potential of the lignites should be studied to address the energy requirement of the present scenario.

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

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

Highlights:

- The maceral composition of Paleocene Palana lignites have been studied from the samples collected from the Barsingsar Mine and a comparative analysis with the Matasukh lignites, suggests constant rheotrophic or waterlogged conditions during the formation of Barsingsar Lignite while intermittent wet and dry conditions prevailed during the formation of Matasukh lingites.
- The macromolecular characterization of Barsingsar lignites suggested significant variation in the overall biomarker composition from that of other lignites in western Rajasthan pointing to the noticeable variation in the source organic matter composition which is further supported by the petrographic studies.

Work done:

The petrographical study of Barsingsar Lignite of Bikaner-Nagaur Basin of Rajasthan has been done. The study shows that the huminite is the most abundant maceral group (av. 75 vol. %) and consists mainly of detrohuminite followed by telohuminite. Detrohuminite is represented by densinite (av. 68 vol. %) and attrinite (av.

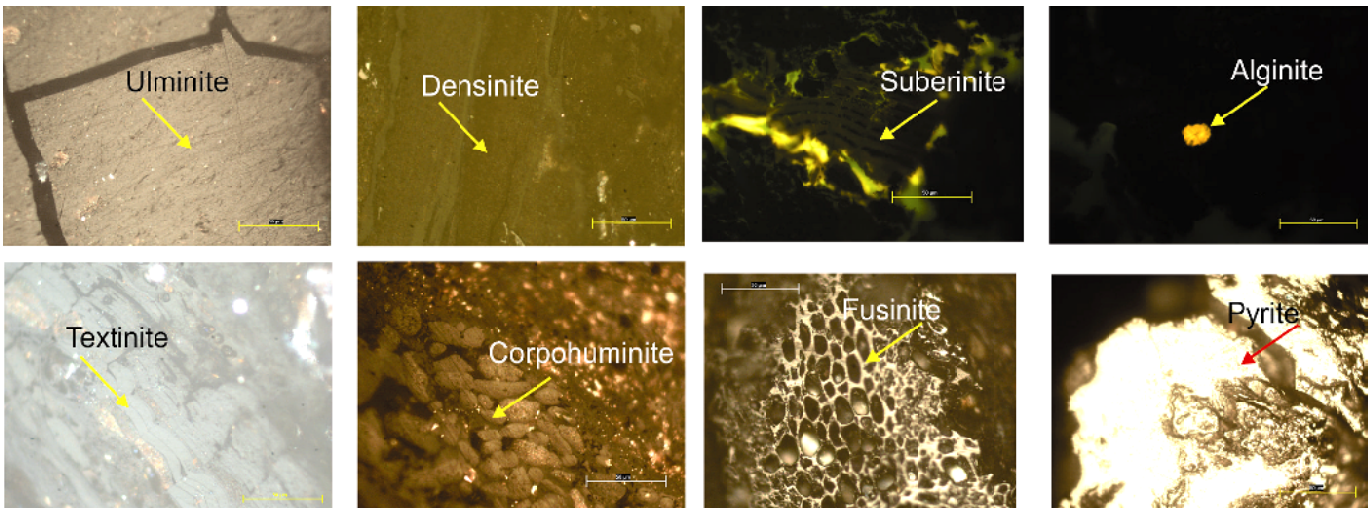


Fig. 1 - Representative macerals identified in the Barsingsar Lignite samples.

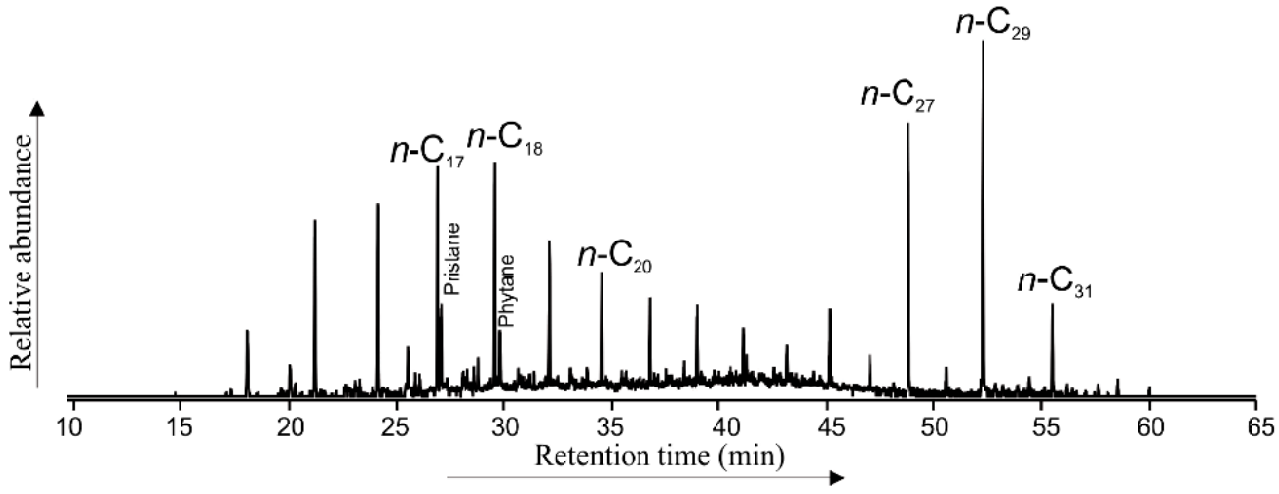


Fig. 2 - Representative sample showing *n*-alkane distribution of the Barsingsar lignite extracts.

4 vol. %), while telohuminite is mainly contributed by ulminite (av. 4 vol. %). Textinite was almost absent. Gelohuminite mainly composed of corpohuminite (av. 0.3 vol. %) and gelinite was also absent. Inertinite has a relatively low percentage (av. 9 vol %) and liptinite shows low content (av. 10 vol. %) in these lignites. The mineral matter shows an average of 6 vol. %. A high GI (avg. 6.65) and low TPI (avg. 0.16) values in the lignite of Barsingsar Mine are indicative of continuous wet conditions in the basin with a slow rate of subsidence during the decay of organic matter. This is well corroborated with higher proportions of huminite over inertinite macerals. An estimate of GWI (avg. 14.11) and VI (avg. 0.17) values in the lignite of Barsingsar Mine is found. The average GWI value is more than one that is indicates the rheotrophic condition.

The study of normal alkane distribution in the samples shows that the distribution ranges from *n*-C_{13} to *n*-C_{33}. In most of the samples, bimodal distribution pattern is observed. The C_{max} varies from sample to sample indicating variation in the input of organic matter. The Pr/Ph ratio is greater than 1 in most of the samples suggesting oxic condition (Figs 1-2).

Thrust Area 4 QUATERNARY PALAEOCLIMATE RECONSTRUCTIONS, VEGETATION DYNAMICS AND RELATIVE SEA LEVEL CHANGES

Quaternary Palaeoclimate Group (QPG)

Group Coordinator: Anjum Farooqui
Co-Coordinator: Ratan Kar

PREAMBLE: The 15 projects encompass almost all the phytogeographic regions of the country; besides, work has also been undertaken from the southeastern Atlantic, Southern oceans and the Polar regions. From the coastal regions of India, projects are from the Southeastern Ghats and Southeast Coast, Eastern Coast (Sunderban and Mahanadi deltas) and Southwest Coast (Kanara region and Kerela Coast). The above projects are addressed towards the late Quaternary climatic changes, monsoonal variations and sea-level fluctuations based on multi-proxy evidences like microbiota (spore-pollen, algae, fungi, testate amoeba), sedimentology and geochemistry. From within the Core Monsoon Zone in central India, vegetation and climatic changes during the late Quaternary have been 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 have been used for reconstructing the late Quaternary vegetation and climatic changes from Himachal Pradesh and other areas in Western Himalaya. Holocene climate variability has been 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 have been 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 have been used to deduce late Quaternary climatic changes from the southeastern Atlantic and Indian oceans; and from Svalbard, the late Pleistocene-Holocene climate have been 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

Investigators: Anjum Farooqui & Anjali Trivedi

Highlights:

- Middle Holocene (7.6ky) palaeoshoreline recorded in Edathua, Kerala
- Palynological study in surface soil samples reveal a decreasing moisture availability variation between 9 to 11° latitude in the south western Ghats.
- Anthropogenic pressure on present day vegetation and soil microenvironment was assessed through multi-proxy analysis.

Work done:

Sedimentary profiles and surface soil samples (including moss cushions and agricultural land) between latitude 9.571705 to 10.90362 and longitude 76.519165 to 77.241713 were collected from Kottayyam to Coimbatore regions in the southwestern Ghats, Kerala and Tamil Nadu. A sedimentary profile near Edathua, Kerala shows a peat layer below ~6 m sandy sediment. The Radiocarbon date of the peat is ~7.5 ka and the palynological results reveal brackish to fresh water diatom assemblage along with the evidences of cuticle fragments of mangroves showing salt glands. It has been inferred that during Middle-Holocene transgression the Vembanad Estuary extended south-eastwards to about 15 km near Edathua area from the present day south-eastern flank of Vembanad Lake. The palynological study of surface soil samples in varied microenvironments from south to north as mentioned above reveals a marked difference in moisture content analysed by diatoms and testate amoebae assemblage. The pollen/spores in these samples also delineate the natural climate change from south to north and clearly reflects the anthropogenic pressure and deforestation due to rubber plantation, tea plantation, fodder grass projects and economically important sandalwood forestation.

Project 4.2: Quaternary palaeovegetation and palaeoclimate reconstruction in relation to monsoonal activity in Meghalaya

Investigators: S.K. Basumatary & Swati Tripathi

Highlights:

- Marker pollen taxa have been identified and characterised in relation to the different vegetation types and climate from the Jaintia Hills, Meghalaya.
- Three palaeovegetation and climatic succession have been characterised in Jaintia Hills based on the pollen assemblage through the analysis of the sedimentary profile road exposure section from the Jaintia Hills.

Fig. 1 - *Schima wallichii* Forest in Jaintia Hills.

Fig. 2 - Samples collection from the grassland areas of Jaintia Hills.

Work done:

Studied 50 surface soil and moss cushion samples collected it from different vegetation types (Pine, evergreen, deciduous forest and grassland) of Jaintia Hills, Meghalaya. The recorded palynodata display a good agreement with the extant vegetation. Some important

Fig. 3 - Road cutting section in Jaintia Hills, Meghalaya.

arboreal pollen taxa have been identified as marker pollen in relation to the different vegetation types. These recorded marker taxa have been precisely utilized in interpreting the palaeovegetation and past climate in the region.

A palynological study of 2.5 meter sedimentary road cutting section from Jaintia Hills reflected three palaeovegetation and past climatic phases in the region. Radiocarbon dating of the samples is in progress. In the first phase, the tropical evergreen forest was flourished that comprises *Schima, Elaeocarpus*, *Duabanga* and *Mesua* which thrived under warm and humid climatic condition. The evergreen taxa, especially *Mesua*, *Elaeocarpus* and *Syzygium* along with *Nepenthes* and *Impatiens* pollen strongly indicate high rainfall activity in the region. The second phase was observed as similar as the previous phase with comparatively low values of arboreal pollen taxa under relatively less warm and humid climatic condition. In the third phase, the forest was deteriorated as evidenced by the high value of non-cereal pollen taxa. The presence of cereal and *Brassica* pollen and decrease value of arboreal pollen taxa in the palynoassemblage is suggestive of the forest deterioration in relation to the anthropogenic activity in the region (Figs 1-3).

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

Investigators: Swati Tripathi & S.K. Basumatary

Highlights:

- Modern pollen precipitation coupled with phytolith assemblage provides a solid data-base for the palaeovegetation and past climate interpretation in Barak Valley of Assam.
- The acceleration in human settlement since 710 cal. BP is evidenced by the presence of cereal pollen along with increment of *Ziziphus, Mimosa, Clerodendrum* and Arecaceae implying forest clearance in Lower Brahmaputra Valley of Assam.

Work done:

In contrary to Brahmaputra Valley, the palynological studies on surface samples of Karimganj District, Barak Valley display a factual composition of present vegetation in the form of good assemblage of arboreals (*Syzygium, Terminalia, Duabanga*, Moraceae, Sapotaceae,

Fig. 4 - A view of Son wetland, Assam.

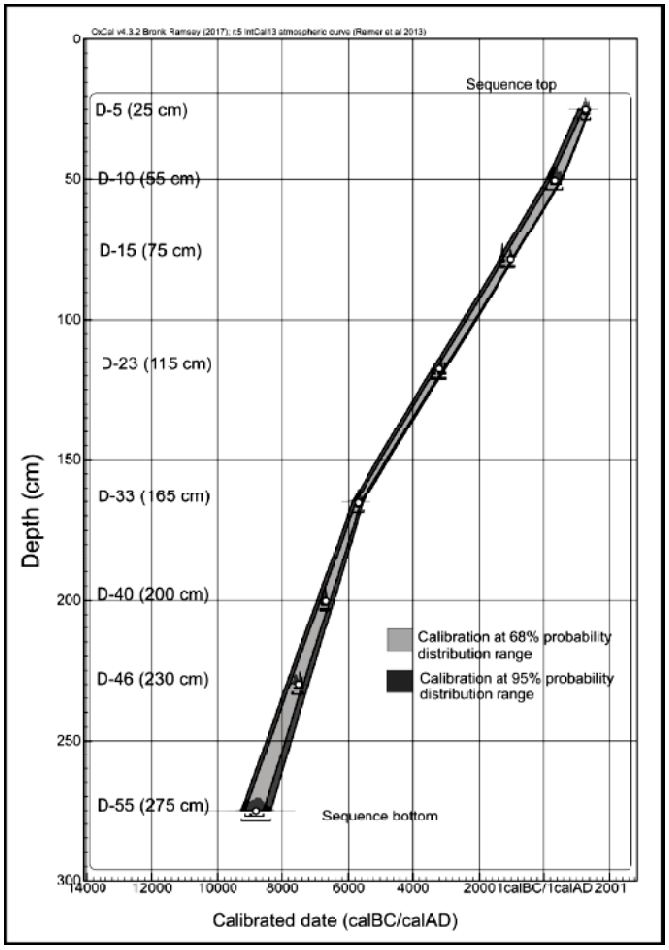


Fig. 5 - Bayesian age-depth model of the Deepor wetland sequence. Calibrated age distributions of the four radiocarbon ^{14}C dates and four interpolated dates are plotted with their calibrated medians shown in open circles.

Meliaceae, etc.) and non-arboreals (Poaceae, *Xanthium*, Tubuliflorae, Brassicaceae, Amaranthaceae and Cyperaceae).

Maceration of forty surface soil samples collected from Son wetland of Karimganj District, Assam has been completed for pollen analysis (Fig. 4). The major pollen types include Cereal, Asteraceae and Polygonaceae which clearly indicates immense pastoral practices along with luxuriant growth of marshy taxa.

Palaeovegetation vis à vis past climatic alterations for the last 13,000 cal. BP were deciphered based on the detail palynological data from 2.8 and 1.5 m deep sedimentary sequences from endangered wetlands of Kamrup and Goalpara districts, Assam. The inception of *Shorea* and *Lagerstroemia* begins around 8,390 cal. BP, which indicates that in Deepor Forest, the strengthening of the SW monsoon occurred during the same time frame. Similar observation of proliferation of *Shorea* and *Lagerstroemia* occurred at around 11,000 cal. BP in Chayagaon swamp of Kamrup District, Assam implying strengthening of the monsoon. Thus, it is clear from the present investigation that SW monsoon became active at the termination of the Younger Dryas with further weakening during 4,071 to 2,655 cal. BP displaying an evidence of weak monsoon due to low frequencies of major arboreals, marshy and aquatic taxa (Figs 5-6).

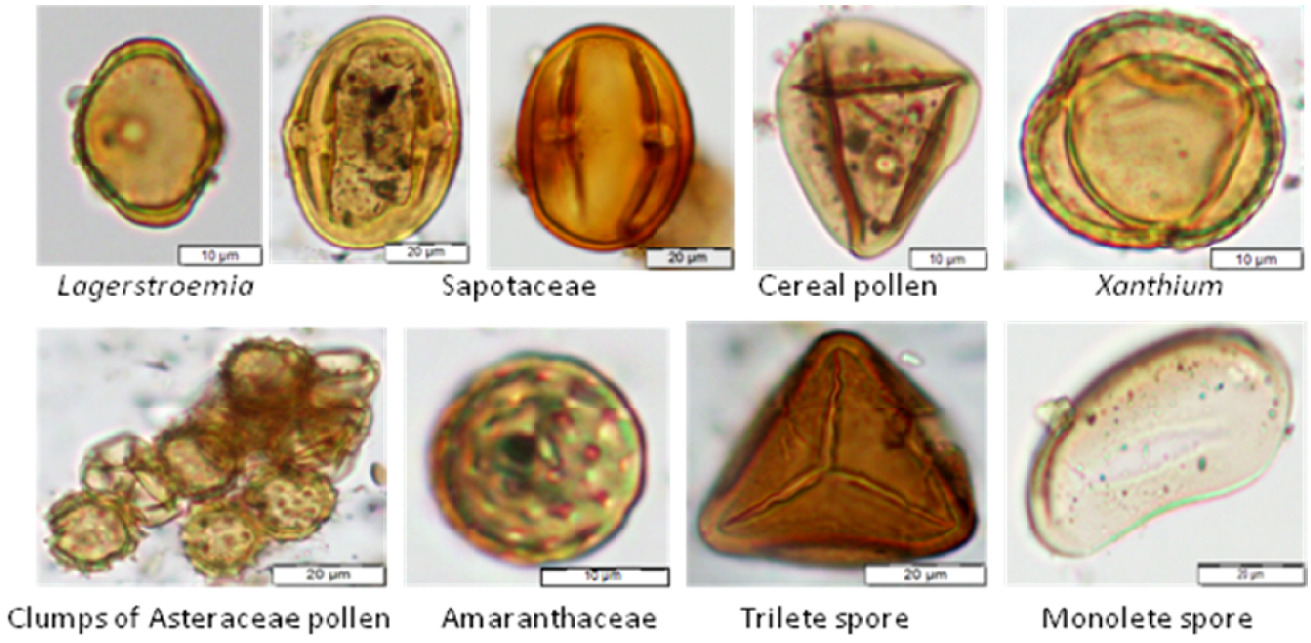


Fig. 6 - Palynoassemblage retrieved from surface soil of Son wetland, Assam.

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

Investigators: M.F. Quamar & S.N. Ali

Highlights:

- Pollen evidence from Mahasamund District of Chhattisgarh State indicated Older Dryas stadial between ca.14,100 and 11,700 cal yr BP and Holocene Climate Optimum (HCO) or Holocene Thermal Maximum (HTM) since ca. 8500 cal yr BP to the Present. A prolonged warming was observed in the region since the last 11,700 cal yr BP.
- The ecological indicative values of the modern NPPs from the said region have also been specified, which could further be utilized in palaeoecology and palaeoclimatic reconstruction.

Work done:

Palaeopalynological records of 1.1 m deep lacustrine sediment profile from the Mahasamund District, Chhattisgarh (central India) suggest that between ca. 11,700 and 8500 cal yr BP, a mixed tropical deciduous forest occurred in the region under a regime of warm and humid climate with good monsoon precipitation. The forest expanded into a dense mixed tropical deciduous forest since ca. 8500 cal yr BP to the Present under warm and relatively more humid climatic conditions with further increase in monsoon precipitation, correlatable partly with the Holocene Climate Optimum (HCO) or Holocene Thermal Maximum (HTM). Prior to the initiation of the long warm period, an open vegetation occurred in the region between ca.14,100 and 11,700 cal yr BP under a cool and dry climate, probably indicating reduced monsoon precipitation, and partially correlated with the Older Dryas stadial.

The study of surface samples from Raipur-Bilaspur districts of Chhattisgarh State revealed that pollen assemblages represent regional vegetation characteristics rather partially, as most of the forest elements, especially trees and shrubs are either under-represented or remain palynologically silent. The low pollen productivity of most of the tropical deciduous taxa is responsible for the irregularity in their representation in pollen spectra, attributable to entomophilous mode of pollination. Increasing human population and anthropogenic activities could also be affecting the modern pollen-rain/vegetation relationships. Besides, the recovered NPPs (algal remains, fungal spores, other plant remains and animal remains) could be indicating warmer climate (zygospores of *Zygnema* and *Spirogyra* and *Botryococcus*), colder–warmer climates (alternation of *Pediastrum*–*Botryococcus*), as well as oscillations in atmospheric precipitation (*Botryococcus* and *Pediastrum*) and freshwater marshy condition (*Pseudoschizaea*); soil erosion (*Glomus* spp.), local grazing and human pressure (*Sporormiella* sp., *Sordaria* sp., *Podosora* sp., *Coniochaeta* cf. *ligniaria*, *Delitschia* and *Cercophora*).

Pollen analysis of a 1.4 m deep sedimentary profile from Panguiha Lake (PL), Dhamtari District (Chhattisgarh State), central India, comprising 70 profile samples, has been initiated.

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

Investigators: Shilpa Pandey & Kamlesh Kumar

Highlights:

- Mid –Late Holocene climate and sea-level changes influenced vegetational succession.
- Impact of anthropogenic activities observed on mangrove ecosystem

Work Done:

Forty surface samples along with three sedimentary profiles collected from various coastal sites of Odisha have been analysed to establish the modern pollen-vegetation relationship and palaeoclimatic reconstruction.

Pollen analysis of 25 surface samples collected from Bhitarkanika and adjoining areas, Odisha has been carried out.

Pollen analysis of a 2.15 m deep sediment profile collected from the Nimaniya Lodi Village, near Kaikhali, South 24 Parganas Division, Sundarbans has been done. A total of 43 samples were collected at an interval of 5 cm each. Lithologically, it represents silt and clay. Mangroves, represented by *Avicennia* and *Suaeda* are dominated in the area along with *Sonneratia* and *Porterasia coarctata*. About 15 surface samples have also been chemically processed for pollen studies to prepare modern analogue.

Manuscript on the Lothian Island, Sundarbans based on multiproxy data is under preparation.

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

Investigators: Anjali Trivedi & Anjum Farooqui

Work done:

Pollen analysis of about forty six sediment samples from the forest area near the Renuka Lake, Sirmaur District, Himachal Pradesh has been done (Fig. 7). The analysis reveals a good assemblage of arboreals (trees & shrubs) comprising *Shorea robusta, Dodonea viscose, Bombax ceiba, salix* sp., *Syzygium* sp., *Terminalia* sp., *Holoptelea integrifolia*, *Acacia inlotica*, *Syzygium cumini,* etc. in order to their relative abundance. The non-arboreals pollen is dominated by grasses (Poaceae) pollen grain together with members of the families Tubuliflorae, Liguliflorae, *Cannabis* and *Carissa,* etc. Presence of cultural taxa, viz. *Cerealia*, *Artemisia* and pollen grains of the families Chenopodiaceae/ Amaranthaceae, etc. reflect anthropogenic activities in the region. The constant occurrence of the marshy taxa, such as Cyperaceae and sporadic representation of *Polygonum plebeium*, *P. serrulatum* and Liliaceae suggest the existence of intermittent wetlands and the proximity of the lake. The extra regional taxa as *Pinus roxburghii*, *Cedrus* and *Abies* are also preserved in good quantity.

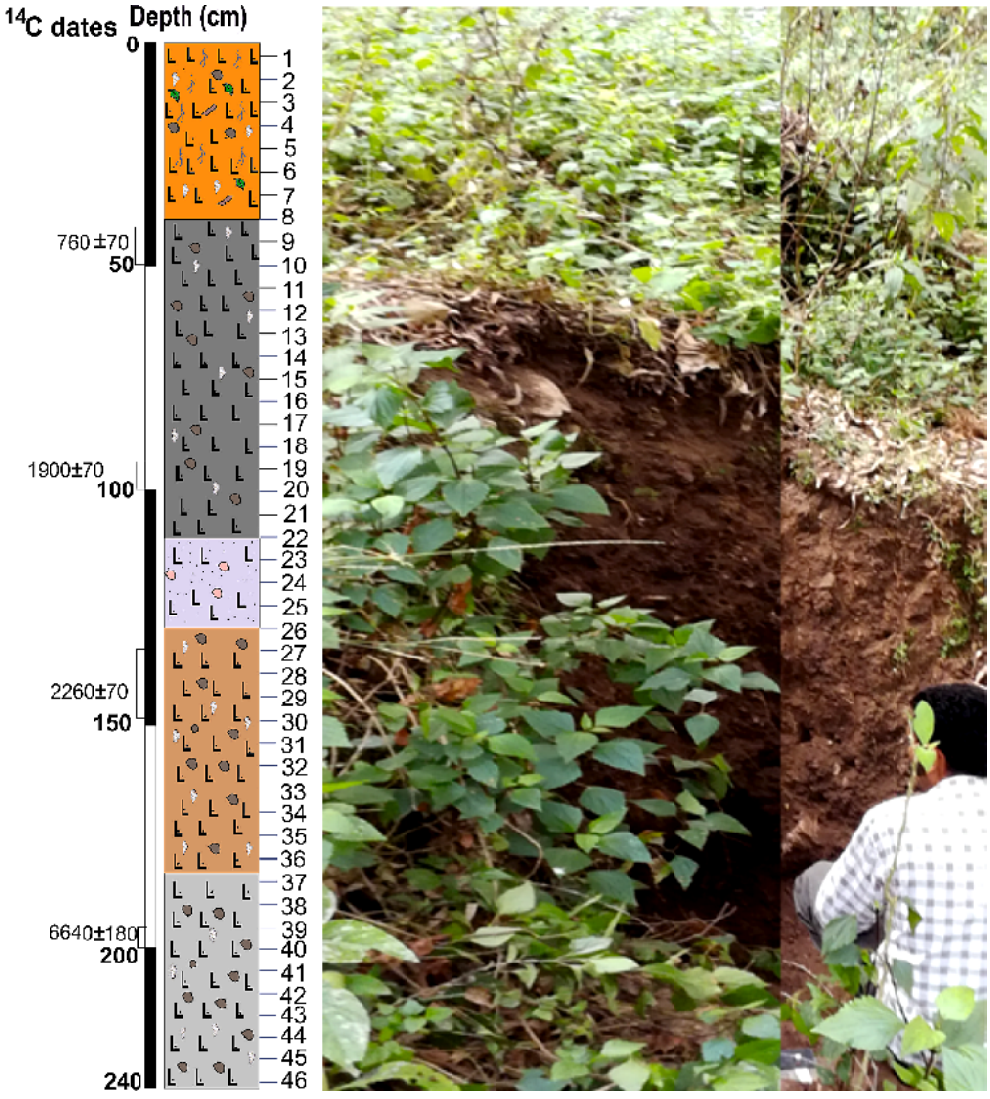


Fig. 7 - Litholog of sediments collected near Renuka Lake, Sirmaur District, Himachal Pradesh.

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

Investigators: Jyoti Srivastava & Manoj M.C.

Work done:

A 4.2 m sediment core collected from the southeastern part of the Arabian Sea at the water depth of 460 m was collected that extends up to the late Glacial Period (13.5 kyr BP). The core has five age control points which reveal different sedimentation rates, i.e. late Holocene 15.4 cm/kyr, early Holocene 24.8 cm/kyr and late Glacial Period records 31.6 cm/kyr. Palynological data of the presently studied core recorded late Glacial to early Holocene reduced terrestrial vegetation along with a gradual increasing trend of mangroves such as *Rhizophora apiculata, Avicennia* sp. and *Excoecaria agallocha* after ~9.3 kyr BP which reaches maximum ~6.3 kyr BP. Increased pollen abundance proved that during this period large amount of fresh water was injected to the south-eastern Arabian Sea due to high intensity of the monsoon. After 3.5 kyr BP decline in mangroves and terrestrial pollen taxa suggests decrease in river discharge due to lower intensity of monsoon during this period (Fig. 8).

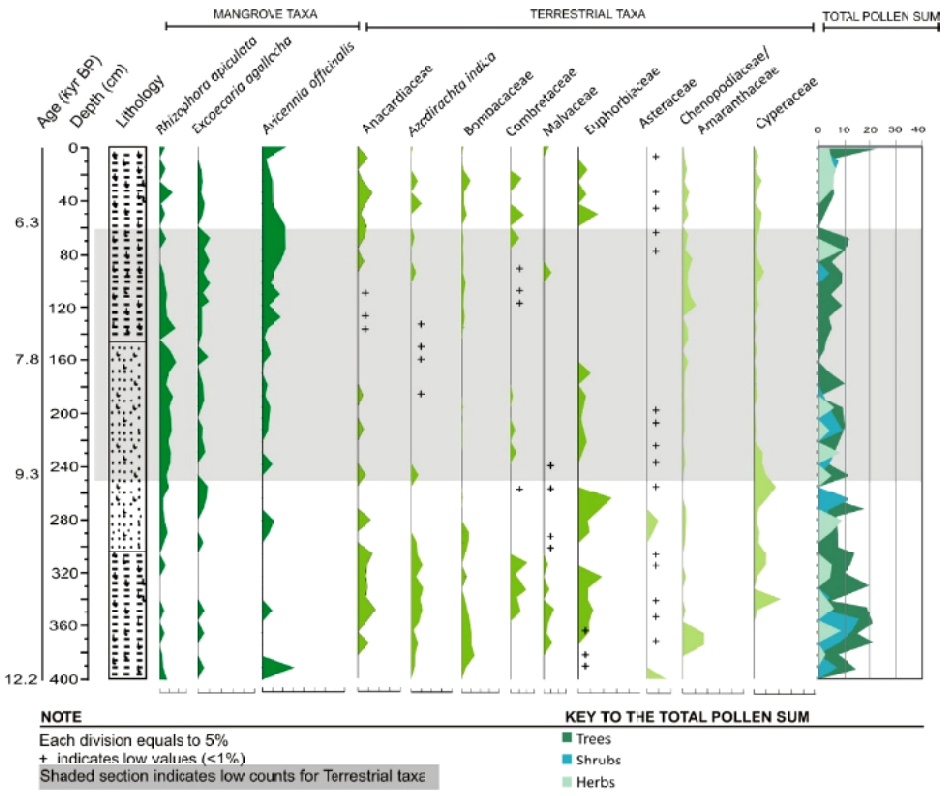


Fig. 8 - Palynological diagram of a sediment core from southeastern Arabian Sea.

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

Investigators: Santosh Kumar Shah & Ratan Kar

Highlights:

- Reconstructed 154-year (1846-1999 C.E.) long May month river flow of the Lohit River Basin, North-east India based on tree–rings of *Pinus merkusii*
- Recorded marked warming trend in the beginning of late twentieth century till 2012 in tree-ring of *Pinus wallichiana* based winter temperature reconstruction (time span: 1840-2012 C.E.) for the Lidder Valley, Kashmir, Northwest Himalaya

Work done:

From the Eastern Himalaya region, (1) based on 80 tree cores of *Pinus merkusii*, a 170 year (1830-1999 C.E.) long regional tree-ring width chronology (Fig. 9) was prepared and correlated with Lohit's river discharge data. Based on the analysis, river flow for the May month was reconstructed for the past 154 years (1846 to 1999 C.E.) for the Lohit River Basin, Arunachal Pradesh. The longest extreme low flow periods recorded in the reconstruction are 1889–1895 C.E. and 1873–1877 C.E.

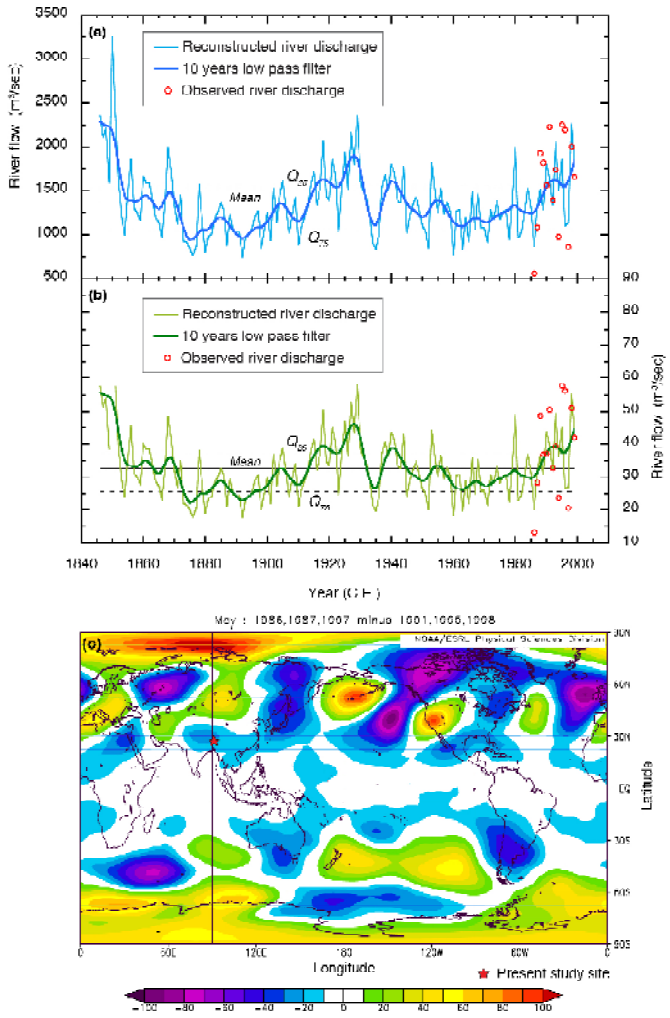


Fig. 9 - (a) The reconstructed May river flow, spanning 1846-1999 C.E. along with 10-year low-pass filtered smooth and actual May river flow, spanning 1986-1999 C.E. for Demwe Lower gauge station and (b) Gimliang gauge station. (c) Composite map of difference in May 500 mb height anomalies in dry minus wet years.

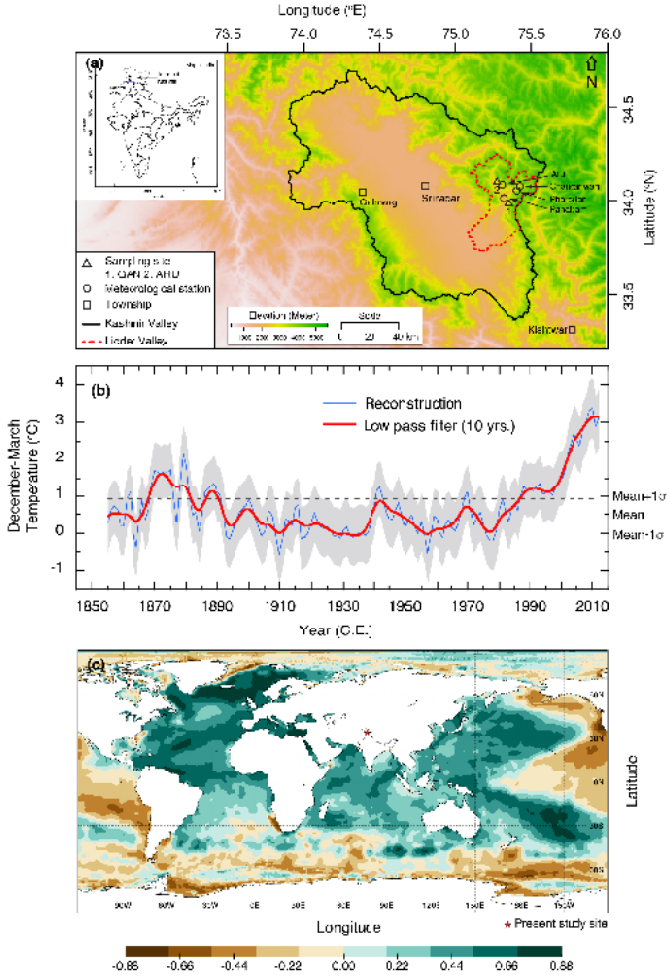


Fig. 10 - (a) Map showing the locations of tree-ring sites and meteorological stations. (b) Reconstructed winter (December-March) temperature for the Lidder Valley, spanning 1855-2012 C.E. and (c) Spatial field correlation between reconstructed temperature with global sea surface temperature (SST) records of HadISST for 1979-2012 C.E.

The atmospheric anomaly of 500 mb geo-potential heights in dry and wet years (dry minus wet) in May revealed, the circulation patterns in the region that was influenced by the Siberian high and the El Niño Southern Oscillations (ENSO) patterns originating in the Pacific Ocean (Fig. 9), (2) Processed 12 scrub tree samples of *Juniperus squamata* from Thangu valley, North Sikkim and cross-dated total 58 radii, which shows possibility of building 198 year long tree-ring chronology of this species and (3) Prepared 141 year (1878-2018) long regional chronology of *Pinus kesiya* from Khasi Hills, Meghalaya.

From Western Himalaya region a winter (December-March) temperature back to 1855 C.E. was reconstructed from the Lidder Valley of Kashmir using a regional tree–ring width chronology of *Pinus wallichiana*. The most noticeable feature of the reconstruction is marked by warming trend at beginning in the late twentieth century and persisting through the present (Fig. 10). The periodicities observed in the reconstructed temperature are likely associated with the Atlantic Multidecadal Oscillation and El Niño–Southern Oscillation (Fig. 10).

Project 4.9: Holocene climate records and ecological response of trees from western Himalaya

Investigators: Krishna Gopal Misra & Rajesh Agnihotri

Highlights:

- Millennium long ring-width chronology of Himalayan pencil cedar developed from more than 4000 masl altitude of western Himalaya.
- Developed annual precipitation reconstruction over six centuries from semi-arid Kishtwar, Jammu and Kashmir, northwestern Himalaya.

Work done:

Tree-ring samples from treeline site of Yoche, Himachal Pradesh were studied and treeline limit over the altitude of 4000 masl in the Himalayan region has been recorded. In this study, millennium-long tree-ring chronology of Himalayan pencil cedar (extending back to AD 789; 1226 years) developed for the first time from the western Himalaya at an altitude of about 4000 masl. The study indicates dendroclimatic potential of such high altitude treeline species which are growing at climatic threshold limit in very harsh condition.

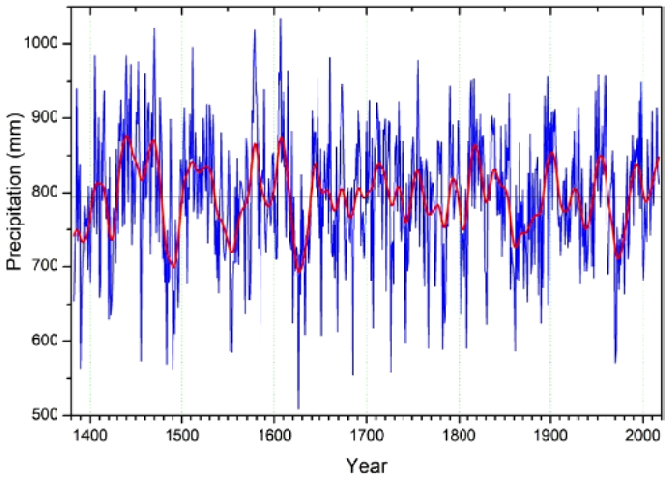


Fig. 11 - Six century long annual precipitation reconstruction from Kishtwar, Jammu and Kashmir.

Used Himalayan pine (*Pinus wallichiana*) ring-width chronology, goes back to the AD 1578 from cold semi-arid Lahaul-Spiti, Himachal Pradesh to reconstruct precipitation over the region (Fig. 11). Using Himalayan pine chronology and precipitation from previous year December to current year July (DJ), precipitation reconstruction has been developed back to AD 1730 over the Lahaul-Spiti region. The reconstructed precipitation revealed strong year-to-year and decadal scale variability. Decadal variation in the form of low and high precipitation episodes were analysed and it has been found that the 1780-1789, 2000-2009 are the decades associated with low precipitation and 1950-1959, 1770-1779 are associated with high precipitation. Most of the individual extreme years were accumulated in the 18th Century.

Cedrus deodara and *Pinus gerardiana* tree-ring samples from localities around Kishtwar, Jammu and Kashmir were analyzed and reconstructed annual precipitation over six centuries using composite chronology of both species. Reconstructed precipitation shows annual to decadal scale variation and 20th Century precipitation is more turbulent as compared to previous centuries with increasing trend since 1970s to the present.

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

Investigators: Ratan Kar & Md. F. Quamar

Highlights:

- The pollen-vegetation relationship in the Lahaul Valley is not compatible to the extant vegetation due to over-representation (especially *Pinus*) of extra-local elements.
- Evidences of anthropogenic activities (agriculture and grazing) are discernible in the pollen records of the surface sediments.

Work done:

Palynological studies of 35 surface samples, in two transects - from the eastern extremity of the Lahaul Valley (Battal-Chhatru), to the central part (Chhatru-Gramphu), were completed to generate modern pollen-vegetation relationship and to understand the human-environment interactions.

Samples from Battal to Chhatru show that arboreals are well-represented by conifers (*Pinus, Abies, Picea* and *Cedrus*) and broad-leaved elements (*Alnus, Corylus, Betula, Ulmus* and *Rhododendron*). Amongst the conifers, *Pinus* represents the highest frequency (55-81%), followed by *Abies* (3-10%) and *Picea* (1-8%). The temperate broad-leaved taxa are observed in variable frequencies, of which *Alnus* (3-5%) and *Ulmus* (2-3%) are common; whereas, *Corylus*, *Betula* and *Rhododendron* are rare. Most frequently occurring non-arboreals are members of Lamiaceae (1-6%) and Rosaceae (1-6%). Papaveraceae (0.5-1.6%), Convolvulaceae (0.8-1.2%) and Poaceae (0.2-1.2%) are commonly present, while the representation of members of Polygonaceae, Apiaceae, Brassicaceae and Euphorbiaceae are sporadic. Amongst the steppe elements, *Artemisia* (2.6-3.7%), Amaranthaceae (0.8-2%), Tubuliflorae (0.4-1.4%) and Liguliflorae (0.8-1.7%) are well represented, whereas, *Ephedra* has been recorded in extremely low values.

Palynological studies were further undertaken from Chhatru to Gramphu for observing the changes, if any, in the pollen rain across the transect. There is a subtle reduction in the conifers - *Pinus* (47-67%), *Picea* (0.7-4%) and *Abies* (2-3%). Amongst the broad-leaved taxa, *Alnus* (2-4%) and *Ulmus* (1-3%), maintain their frequencies; whereas, *Corylus* (0.8-4%) and *Betula* (0.5-0.7%) show a marginal increase. Non-arboreals are better represented than the preceding zone. Ferns are represented in lesser amounts, along with algal and fungal spores in both the transects. Palynological work, further down the valley, from Gramphu to Tandi is in progress, especially to decipher the anthropogenic input of pollen, as this region is under agricultural activities. Palynological studies from a trench section is also under progress on palaeoclimatic aspects.

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

Investigators: P. S. Ranhotra & Ruby Ghosh

Highlights:

- Arboreal pollen more readily transported from low altitude temperate vegetation zones to high altitude subalpine and alpine zones with distinct change in the frequencies of predominant pine and oak pollen ~2500-2600 m amsl, taken as pollen transition zone in the western Himalaya.
- Subalpine tree-line species recorded sensitive to the katabatic winds blowing through glaciers and could show lag in their growing period due to late melting of snow and low air/soil temperature at subalpine zones compared to lower zones.

Work done:

Established the modern pollen dispersal scenario along the altitudinal gradient covering temperate to alpine vegetation zones in Uttarkashi and Dokriani areas, western Himalaya. A distinct transition noticed in the pollen frequencies of predominant *Pinus* and *Quercus* between ~2500-2600 m amsl. Statistical analyses signify the role of wind in pollen dispersal. Arboreal pollen from temperate zones are more readily transported to higher altitude subalpine and alpine zones, suggesting strong role of day time up-valley winds. Database holds significance in assessing temporal tree-line shifts and glacial dynamics on fossil pollen records.

Moss posters analyzed from the Sangla Valley, Kinnaur, Himachal Pradesh show dominance of arboreal taxa representing the vegetation of area. Good amount of conifer pollen is compatible with the dominant growth and distribution of conifers in the valley, viz. *Cedrus deodara* growing till the elevation ~3000 m amsl and *Pinus wallichiana* till ~3600 m amsl. *Abies* and *Picea* are very sparse in the valley. *Betula utilis,* a tree line forming broad-leaved taxa grows till ~3800 m amsl. Dominance of pine pollen in the high altitude (>3000 m asl) samples as compared to lower altitude well relate with present pine vegetation at the higher elevations.

Developed the 280 years old tree ring chronology of *Cedrus deodara* for the Sangla region, Kinnaur (HP) and the relationship established between climate (mean temperature) and tree growth was found positive for the winter months and negative for the summer months. To understand the growth uniformity and age stand structure for the deodar trees the established relationship between the girth and age of the trees (n=34) by linear regression has been found positive and significant ($r = 0.65$, $P < 0.05$) with 44% variability explained by girth. This shows near uniformity in the growth of deodar.

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

Investigators: Ruby Ghosh & Shailesh Agrawal

Highlights:

- A ~2400 years climatic history of the Darjeeling area, eastern Himalaya has been reconstructed combining pollen, phytoliths, non-pollen palynomorphs (NPPs), $\delta^{13}C$ signatures, sediment texture and total organic carbon (TOC) records from a lacustrine deposit to explore ecosystem response to climate change and to understand the possible forcing mechanisms behind it.

Work done:

Indian Summer Monsoon (ISM) dominated eastern Himalayan vegetation is sensitive to even a minor change in climate parameters, and thus suitable for studying climate-plant interactions. A ~2400 years climatic history of the Darjeeling area, eastern Himalaya has been reconstructed combining pollen, phytoliths, non-pollen palynomorphs (NPPs), $\delta^{13}C$ signatures, sediment texture and total organic carbon (TOC) records from a lacustrine deposit to explore ecosystem response to climate change and to understand the possible forcing mechanisms behind it. This study is focused on two northern hemispheric late Holocene climatic events namely Medieval Warm Period (MWP) and Little Ice Age (LIA). Although considerable variations exist globally for these warm (moist) and cool (dry) periods with respect to their timing, duration, and hydroclimatic dynamics, this study identifies a humid climatic phase at the beginning of the last millennium, a pre-MWP less humid phase, while MWP was wetter than the former phase and a wet LIA in the Darjeeling Himalaya. Result of this study indicates that this climatic variability also induced changes in the regional vegetation. During 364 BC to AD 131, the region was humid harbouring a dense broad-leaved evergreen forest; a comparatively drier condition prevailed between AD 131 and 624 might be owing to the thinning of the forest cover. A wet phase has been observed during AD 1118.

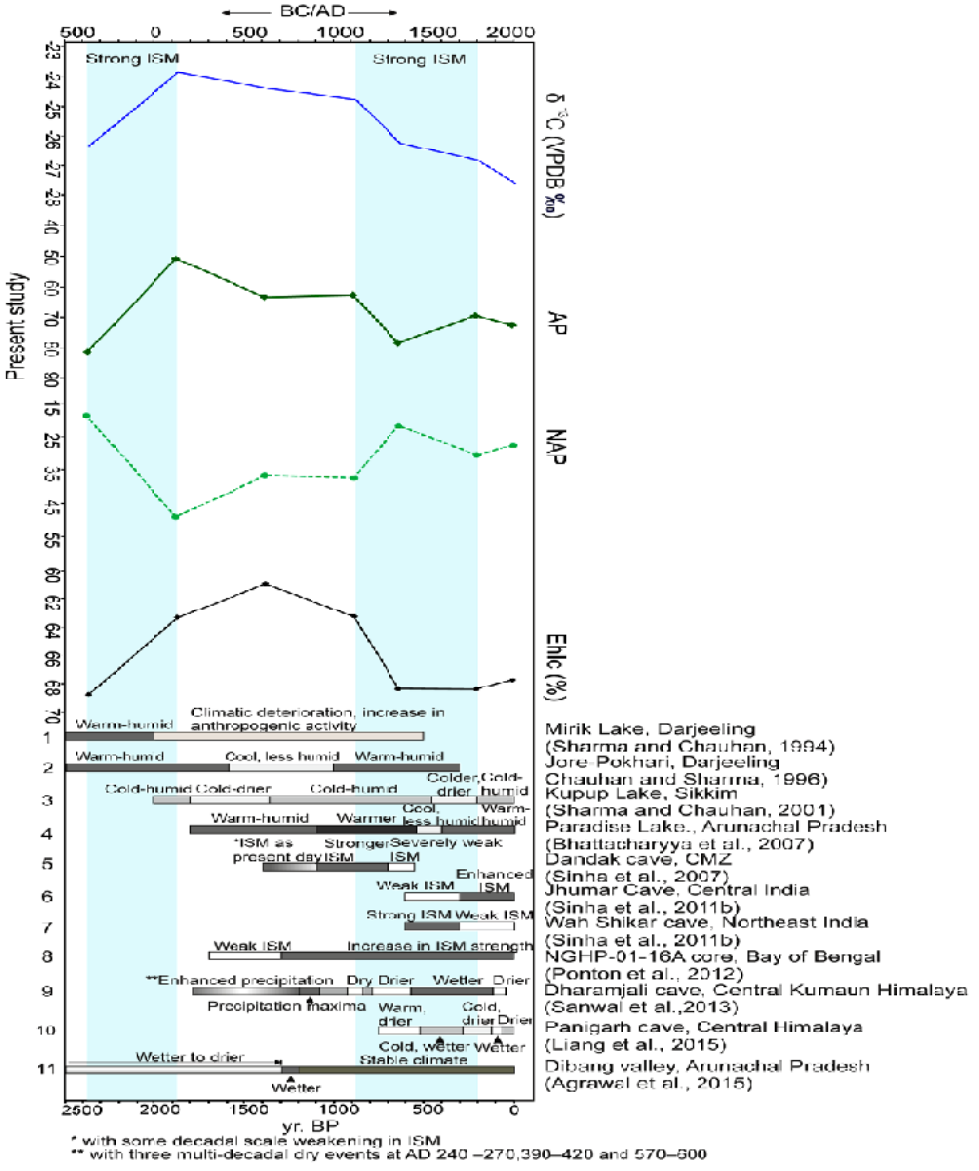


Fig. 12 - Comparison of stable carbon isotopic data, AP, NAP percentages and the eastern Himalayan Ic (EhIc) data of SMP with proxy records for the ISM variations during the past ~2500 years.

A further increase in monsoonal strength is apparent between AD 1367 and 1802. Considering the available records (Fig. 12) from the eastern Himalaya and peninsular India it is inferred that centennial scale variations in frequencies of "active dominated" and "break-dominated" periods govern the internal dynamics of the ISM, and considered to be the key forcing mechanism behind the differential behaviour of the ISM over these regions.

Project 4.13: Late Quaternary palaeomonsoon and palaeoclimatic reconstruction from the Southwest Coast of India

Investigators: Biswajeet Thakur, Manoj M.C. & Abhijit Mazumder

Highlights:

- 2000 years Indian Summer Monsoon (ISM) variability and anthropogenic responses from SW Coast of Kerala have been recorded.

Work done:

The study of sediment cores from Vaduthala (VD) and Thavanakkadavu (THK) from Vembanad wetland, Kerala were investigated using multi-proxy study incorporating diatoms, geo-chemical parameters and textural analysis for palaeoclimatic and palaeomonsoonal inferences. The study of the Vaduthala core shows varying degree of limnological, ecological and primary productivity in the region. The diatom diversity indicates differential level of primary productivity in the region owing to various natural and anthropogenic responses. The various freshwater, brackish and marine diatoms suggest that the limnological pattern from present to past varied in the depositional setting. The centric/pennate ratio shows various levels of wetland fluctuations indicating variability in monsoonal intensification. The diversity of diatoms allows inferring sea-level changes in the wetland. The occurrence of stress diatoms points towards increasing eutrophication in the wetland due to high anthropogenic activities.

The geochemical data (REE and Trace elements) along with diatom diversity in the Thavanakkadavu core also indicate ISM variability and primary productivity signals due to natural and anthropogenic selection. The abundance and diversification of the diatoms shows differential environmental setting in this part of Vembanad. The diatom diversity shows high centric freshwater and marine taxa over benthic ones. The centric/pinnate ratio shows differential hydrodynamic fluctuations indicating varying intensification in monsoonal behaviour. The diatoms study suggests enhanced runoff, nutrient availability, and better photosynthesis during the deposition time. The co-occurrence of stress diatoms like *Melosira*, *Navicula*, *Synedra*, *Achnanthidium*, *Gomphonema*, *Amphora*, *Pinnularia* indicates anthropogenic activity and pollution in the wetland vicinity and causing eutrophication in the wetland.

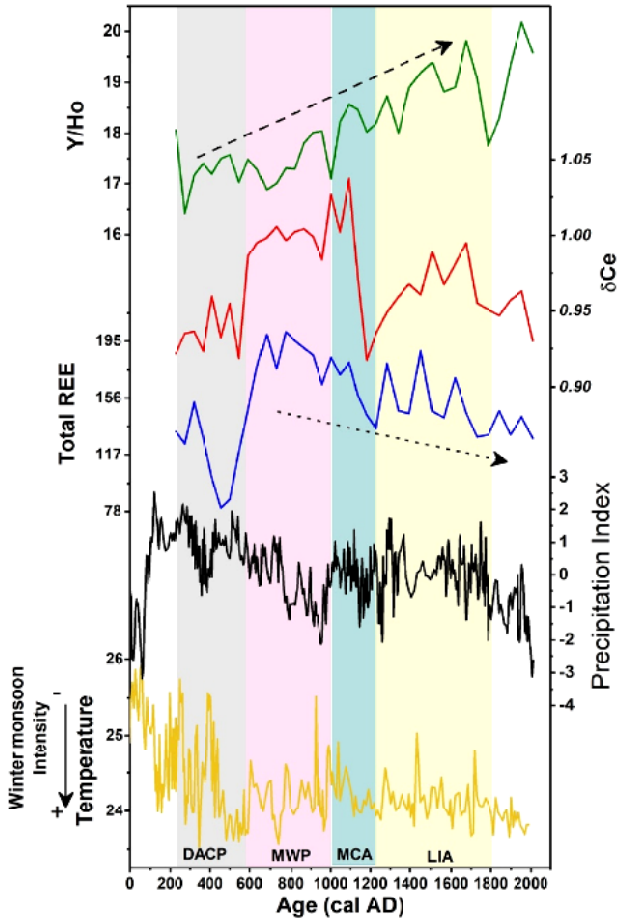


Fig. 13 - Centennial-scale events from the REE record during the last 2000 cal yr AD and its relation with the monsoon precipitation index records from China (after Tan *et al.*, 2018) and winter sea surface temperatures from the Arabian Sea (after Munz *et al.*, 2015).

The rare earth elemental record of the Cherai sediment core was studied to trace the provenance and depositional environment of the Vembanad wetland for the last 2000 cal yr AD. The REE records are synchronous with the episodes of centennial-scale warm/cool events and essentially follow the northern hemispheric climate cycles (Fig. 13).

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

Investigators: Sunil Kumar Shukla & Prasanna K.

Highlights:

- Quantitative data of sea-surface temperature, sea-ice presence, and productivity changes of the Indian sector of the Southern Ocean were obtained using diatom assemblage.

Work done:

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 (SST), sea-ice presence, and productivity changes over the late Quaternary. A total of four-hundred samples were analyzed for the counting of diatoms, and quantitative SST, as well as sea-ice presence data, was generated. The data obtained will help to understand palaeoceanographic changes of the Indian sector of the Southern Ocean in a quantitative and process-oriented way.

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

Investigator: Vartika Singh

Work done:

The organic walled forms of *Halodinium* have been recovered from the Quaternary sedimentary deposits of High Arctic Svalbard. The occurrence of *Halodinium* sp. in the late Quaternary sediments of Svalbard has provided important evidence of glacial meltwater influence during the deposition of the sediments. *Halodinium* is said to be of algal origin found in marine to estuarine environments providing a signal of increased glacial meltwater influence. The early records of *Halodinium* are from the Pliocene sediments of the Bering Sea and uppermost Pliocene of southwestern England to recent sediments of Canada. The occurrence data of *Halodinium* sp. suggests it thrives in coastal estuarine environments with brackish marine salinities. These have also been recorded in the fjord surface sediments of Baffin Bay and show significant increase towards the glacier meltwater plumes.

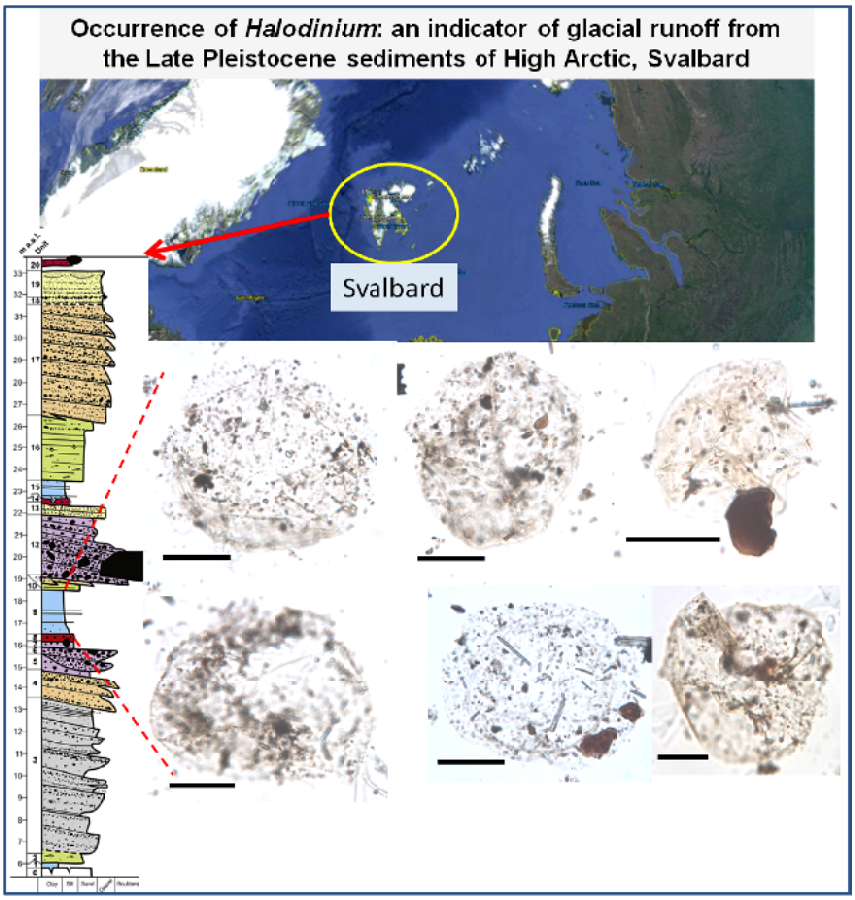


Fig. 14 - Photomicrographs of *Halodinium* sp. (Scale bar - 20 µm).

Recently, the genus *Halodinium* had been placed within Ciliates based on phylogenetic data. The affinity with the ciliates provides a better understanding of their ecological significance as an indicator for coastal conditions and freshwater influence. In the light of phylogeny *Halodinium* is grouped in a clade with mainly marine species, except for *Urotricha* sp., that is most closely related to *Halodinium verrucatum* and was sequenced

from lacustrine plankton. This large genus includes mostly freshwater forms but also marine species. The regular flange rim and the monospecific clusters of specimens of *Halodinium verrucatum* are somewhat like the morphology described by Matsuoka and Head (1992) for *Cyclopsiella*, suggesting an attached / encrusting habitat.

The study of recovered freshwater diatoms from the same lithounit as *Halodinium* also provides a significant signal of freshwater input during the deposition of the late Quaternary sediments of Svalbard (Fig. 14).

The study of biota of shallow terrestrial water body of the High Arctic region is being done. It can help to understand the impact of rapidly changing Arctic climate on the ecosystem and their response to various environmental stresses.

Thrust Area 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: Agriculture has remained a major pillar for human sustenance since beginning of organized human life. The group is involved in investigating past agricultural and other socio-economic activities conducted by ancient settlers belonging to Indus Valley civilization. We attempt and apply a variety of multiple tracers (isotopic, geochemical, environmental magnetic and micro-biotic proxies) in archaeological remains available from various excavations. The combination of aforementioned multiple proxies allow us to understand past agriculture, crop types, water status, manure practices, firing history of artisans so on and so forth and thus overall subsistence of ancient dwellers along with their changing socio-economic and environmental conditions.

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

Investigators: Anil K. Pokharia & Anjali Trivedi

Highlights:

- Both winter and summer season crops were the mainstay of the plant based subsistence economy.
- The relative proportion of crops elucidate that this region was under warm and humid climatic conditions during 200 BCE to 300 CE, however, the climate deteriorated in response to a gradual decrease in SW monsoon from 300-700 CE.

Work done:

Analyzed archaeobotanical samples from Sarethi archaeological site in the Saryu region of Ganga Plain datable to 200 BCE-700 CE.

Plant remains from Sunga-Kushana (200 BCE-300 CE) Period

About 358 charred remains representing 26 plant taxa were recorded. The most abundant cereal was *Oryza*

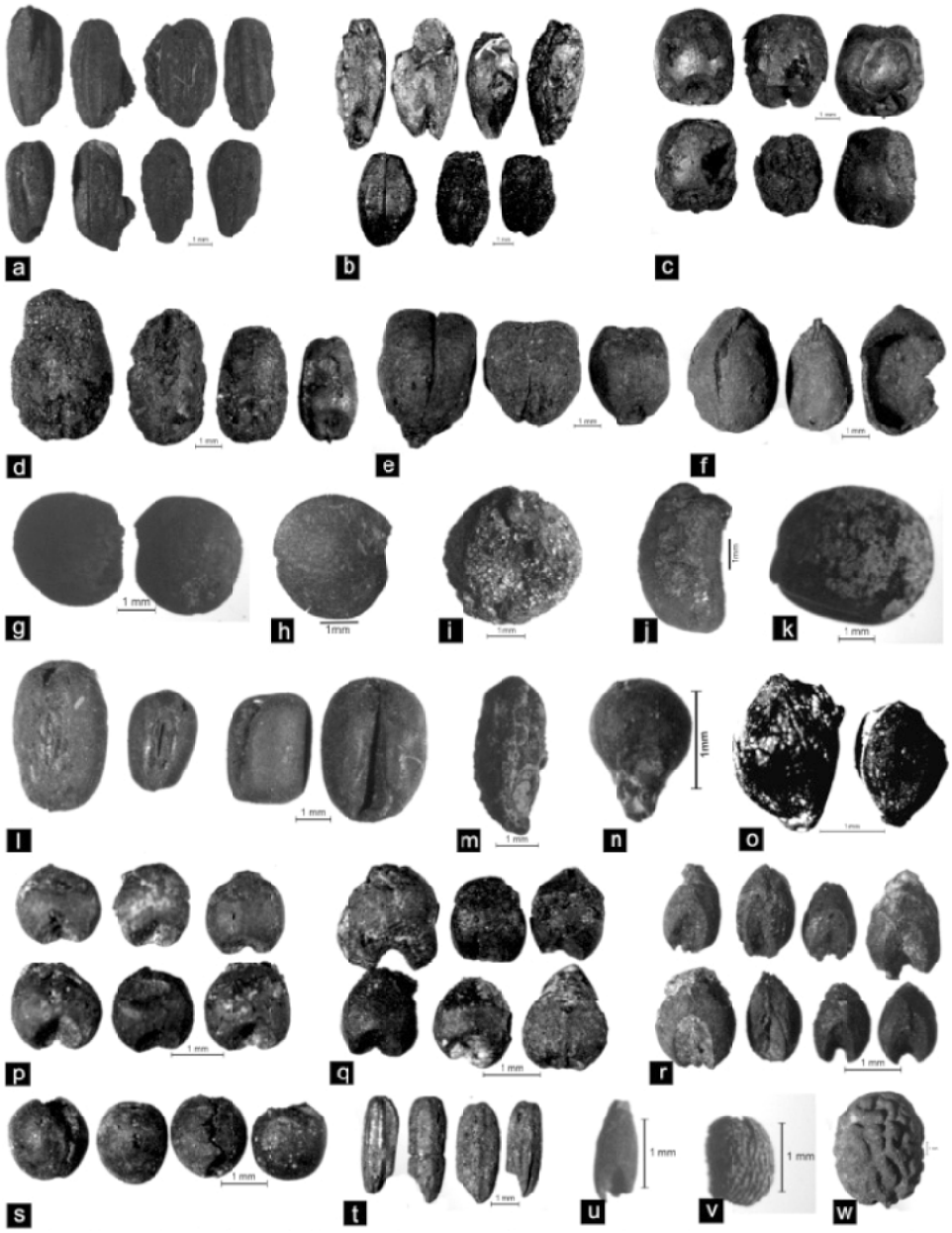


Fig. 1 - a, *Oryza sativa*; b, *Hordeum vulgare*; c, *Triticum sphaerococcum*; d, *Triticum aestivum*; e, *Cicer arietinum*; f, *Gossypium arboreum/herbaceum*; g & h, *Lens culinaris*; i, *Pisum arvense*; j, *Macrotyloma uniflorum*; k, *Cajanus cajan*; l, *Vigna* sp.; m, *Linum usitatissimum*; n, *Pennisetum glaucum*; o & p, *Paspalum scrobiculatum*; q, *Panicum miliaceum*; r, *Setaria* sp.; s, *Vicia sativa*; t, *Oryza rufipogon*; u, *Andropogon* sp.; v, *Trianthema triquetra*; w, *Ziziphus nummularia*.

sativa (21%), followed by *Hordeum vulgare* (15%), *Triticum aestivum* (5%), *T. sphaerococcum* (2%), *Panicum miliaceum* and *Paspalum scrobiculatum* (4% each), and *Pennisetum glaucum* (<1%). Pulses are represented by *Vigna radiata/mungo (*21%), *Cicer arietinum* (12%), *Pisum arvense* and *Lens culinaris* (3% each), and *Lathyrus sativus*, *Macrotyloma uniflorum* and *Cajanus cajan* (<1% each). The oil and fibre yielding plants are represented by *Linum usitatissimum* and *Gossypium arboreum/herbaceum* (1% each).

Plant remains from Gupta and post Gupta (300-700 CE) Period

The analysed samples yielded 151 charred remains belonging to 16 taxa. The cultivated crops during this phase show continuity from the preceding phase. The most abundant among the crops was *Oryza sativa* (33%), followed by *Vigna radiata/mungo* (17%), *Hordeum vulgare* (11%), *Triticum aestivum* (7%), *Cicer arietinum* (6%), *Lens culinaris* (4%), and *Triticum sphaerococcum*, *Lathyrus sativus* and *Gossypium* sp. (1% each). The rain-fed minor cereals are represented by *Paspalum scrobiculatum* (8%), *Panicum miliaceum* (6%) and *Setaria* sp. (7%) (Fig. 1).

Implications for palaeodiet, palaeoecology and palaeovegetation 200 BCE to 700 CE

From the point of view of agricultural economy, there is enough justification to surmise that the practice of rotation of crops was pursued by the settlers. The overall trend of agricultural produce represent 58% summer and 41% winter crops during 200 BCE-300 CE, suggesting significant winter precipitation as well as relatively high summer rainfall. Whereas, during 300-700 CE the summer crops accounts for 72% and the winter crops accounts for 28% suggesting settlers during this phase were more dependent on rain-fed crops (Fig. 2).

Thus, the archaeobotanical findings from Sarethi have elucidated that this region was under warm and humid climatic conditions during 200 BCE to 300 CE, however, the climate deteriorated in response to a gradual decrease in SW monsoon from 300-700 CE. Despite

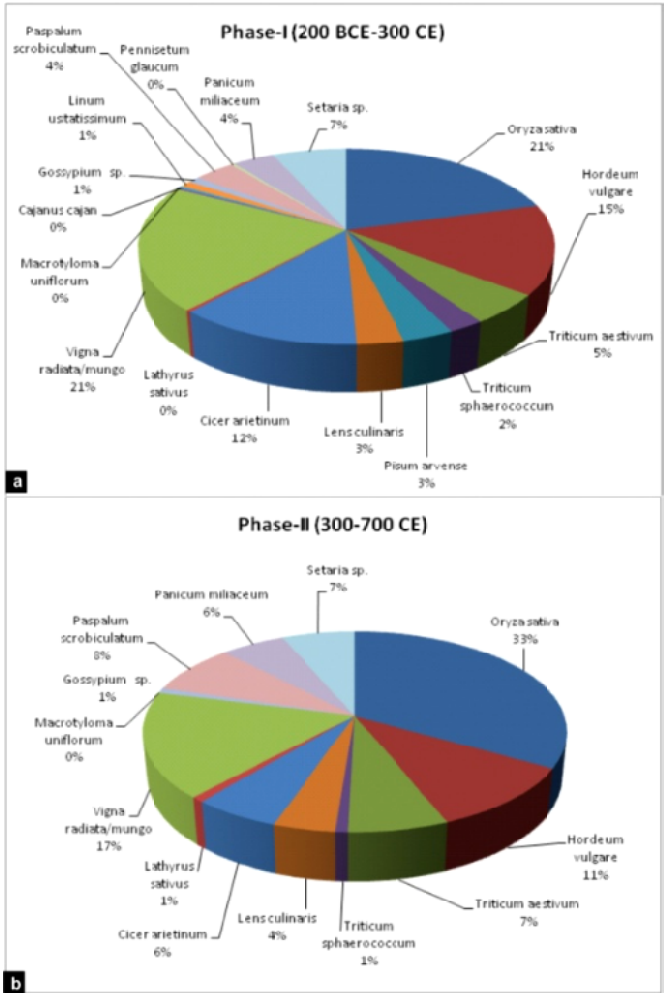


Fig. 2 - Relative proportion of field crops: a. Sunga-Kushana period (200 BCE-300 CE); b. Gupta and post Gupta period (300-700 CE).

evidence of drier climate the cultivation of summer crops might have been preferred due to availability of adequate subterranean as well as surface water in ponds and lakes

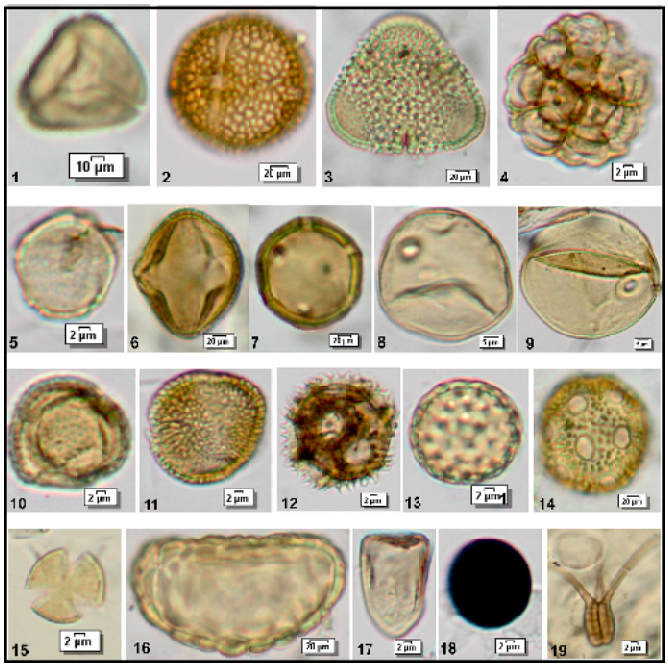


Fig. 3 - 1. *Syzygium* sp., 2. *Aegle marmelos,* 3. *Bombax ceiba,* 4. *Acacia* sp., 5. *Holoptelea integrifolia,* 6. *Prosopis* sp., 7. *Aspidopteris* sp., 8. Poaceae. 9. Cerealia 10. *Xanthium* sp., 11. Brassicaceae, 12. Liguliflorae, 13. Chenopodiaceae, 14. Caryophyllaceae, 15. *Ranunculus* sp. 16.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

for irrigation to support the expanding population (Fig. 3).

The dominance of cultural pollen taxa in the sediment samples from the Ganga Plain during 200 BCE-300 CE suggest that the region was under extensive agricultural practices. Further, photo-documentation of pollen taxa identified was carried out.

Field excursion to three archaeological sites in the Ganga Plain region was also carried out.

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

Investigators: Rajesh Agnihotri, Anjum Farooqui, Niraj Rai & Niteshkumar Khonde

Highlights:

- Enhanced environmental magnetic activity was measured in soil-sediment and hearths belonging to the mature (industrial) phase of Indus civilization era (~2600e1800 BCE).
- Stable C and N isotopic data of major Indus crops were measured and compared with stable isotopic values of their modern counter-parts in order to assess past crop-water status and manuring practices.
- Cultural layers of Vadnagar archaeological excavations revealing artifacts of early historic period (300 BCE to ~800 AD) were dated using both radiocarbon and OSL dating.

Work done:

Archaeo-magnetic vis-à-vis geochemical imprints of an Indus industrial archaeological site from western Rajasthan

Indus Valley Civilization (IVC) is believed to span between ~3300 to ~1800 BCE in the north-western part of the Indian subcontinent along the Indus and eloped Saraswati River (dry channel of Ghaggar-Hakra River). This ancient human settlement is famous for its highly developed agriculture, pastoral, architectural, industrial, town management and trade activities. The Indus archaeological site 4MSR (29°12'87.2"N, 73°9' 421"E) is situated along the dry bed of Ghaggar-Hakra (erstwhile Saraswati) river channel. ^{14}C ages of cultural layers indicate the site spanned from the pre/early Harappan phase till the termination of mature phase (4306±79 to 1836±154 BCE). The site recovered a series of industrial hearths, furnaces, kilns, jewelry (Copper, Gold and Silver), anvil, fishhook, arrowhead, spearhead, moulds, slag etc.

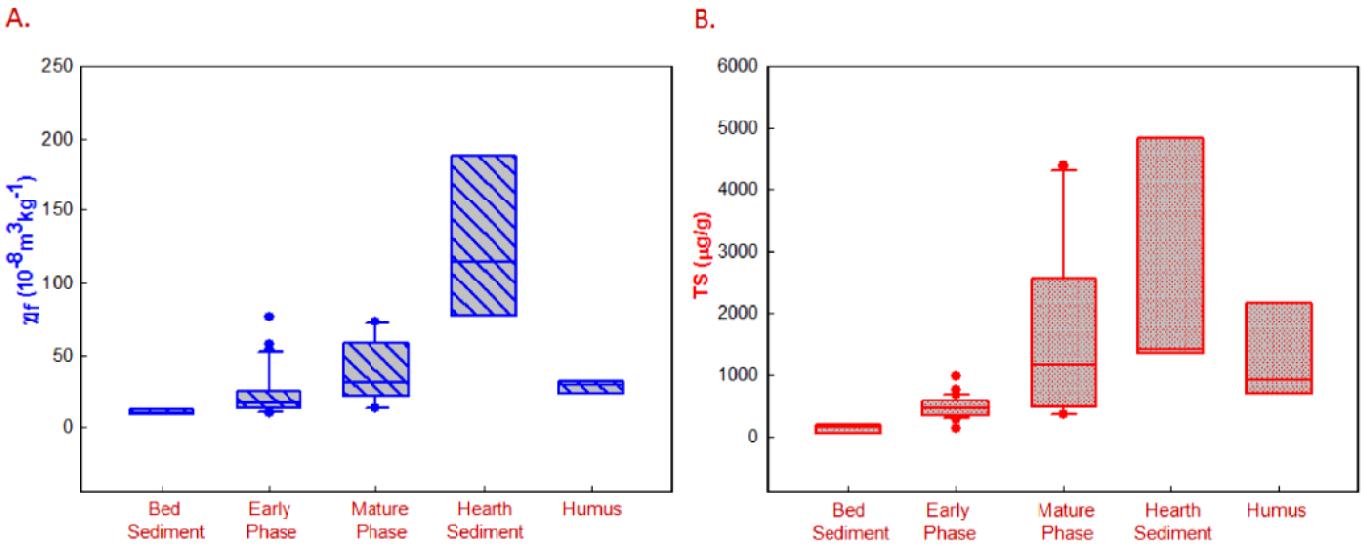


Fig. 4 - Box-whisker plots showing magnetic susceptibility (d_{lf}) and total S concentration (TS) in the soil-sediments of early phase, mature phase and hearth. Their contents in the natural bed sediment and modern humus are also shown.

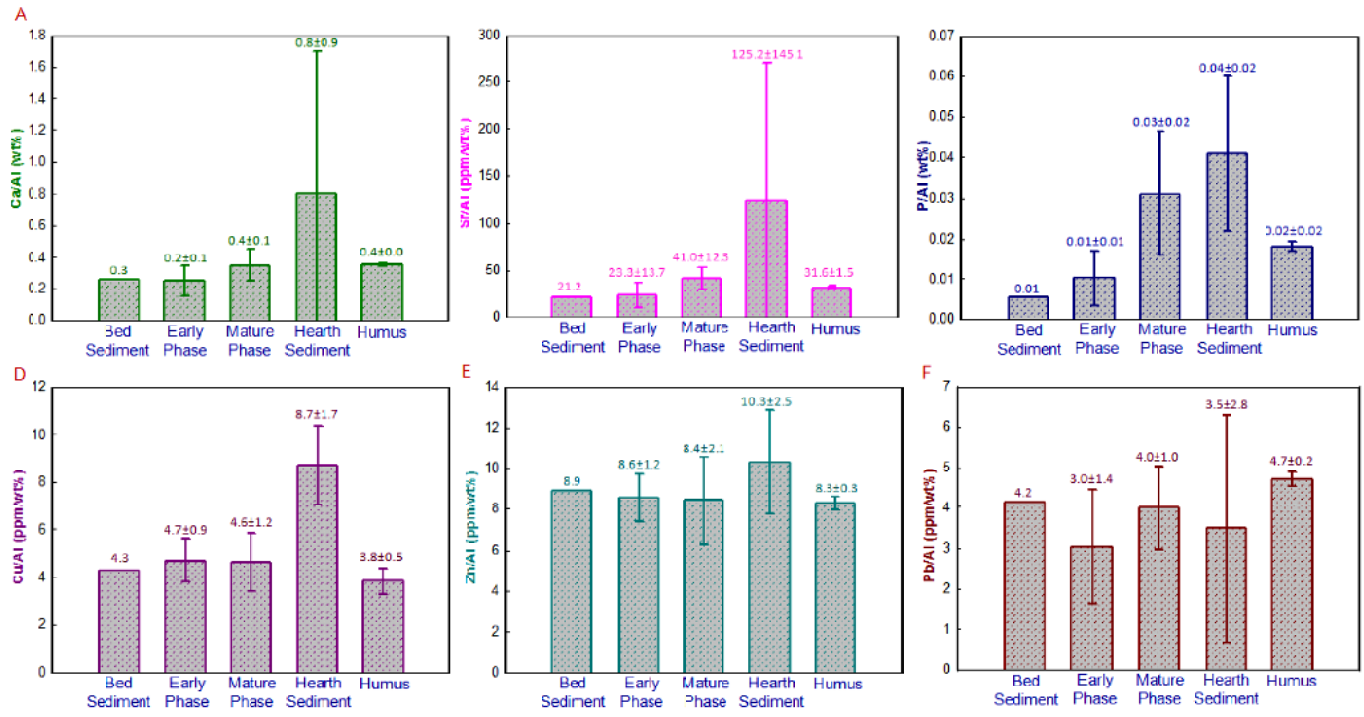


Fig. 5 - Comparative account of elemental ratios in the Early and Mature phase of Harappan culture and hearth sediments with respect to modern humus and natural bed sediment. Major and minor elements shown here were measured using XRF technique.

Recovered evidences suggest the metallurgical nature of this Indus site during the mature phase (2742±104 to 1836±154 BCE). To gain insights into the firing history vis-à-vis type of metallurgical activities of this archaeological site, we sought to use environmental magnetic susceptibility in tandem with elemental composition of excavated hearths and host soil-sediments. We observed highly enriched magnetic susceptibility (δlf 114±61.2 $10^{-8}m^3kg^{-1}$) in the industrial hearths indicating high degree of burning activity (Fig. 4). Sulfur (S), Calcium (Ca), Strontium (Sr) and Phosphorous (P) contents were also found to be highly enriched in these hearths. Among transition elements, Copper (Cu), Zinc (Zn) and Lead (Pb) were also showed significant enrichments in these hearths (Figs 4 & 5).

Stable isotopic investigation of past (Indus era) agricultural activity

The site 4MSR is unique in terms of providing a continuous habitation / occupation from early to the end of mature Harappan phase. During the early phase, the site shows signatures of mainly agriculture and pastoralism, whereas the mature phase revealed evidences of industrial activities. To reconstruct the past agricultural practices especially hydrological conditions and manuring during both the occupational phases, we measured Carbon and Nitrogen isotopes ($\delta^{13}C$, $\delta^{15}N$) of recovered macro-botanical grains (charred seeds) and compared them with modern agricultural grains (seeds) of same taxa. To gauge past hydrological conditions, we estimated $\delta^{13}C$ of crop-seeds as well as habitational soil-sediments of both cultural phases.

Developing modern (isotopic) analogues for tracing and quantifying agricultural activities of the past retrievable from geological / (archaeological) repositories.

Collected surface soils from about two dozen types of crop-fields with the help of Indian Agricultural Research Institute. Also collected modern day crops for corresponding type of agricultural fields. Stable isotopic data ($\delta^{13}C$ and $\delta^{15}N$) of these set of samples are being generated in order to understand complex 'soil'-'seed'-'ambient hydrology'-'surface temperature' relationships. Special focus areas are vicinities of archaeological sites of India for reconstructing past environmental conditions especially contemporary hydrological conditions and prevalent manuring practices.

Project 5.3: Reconstructing the population history of India using Palaeogenomics

Investigators: Niraj Rai, Anil K. Pokharia & Vandana Prasad

Highlights:

- Established first ancient DNA data from South Asia.
- Sequenced the genome of prehistoric humans including the Harappans.

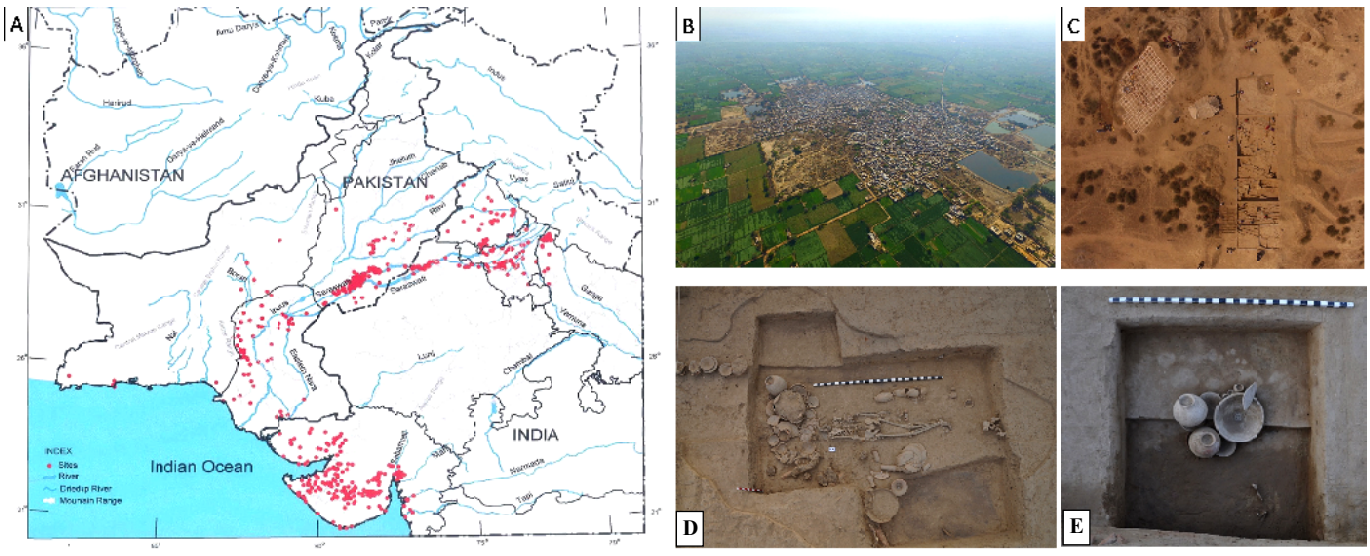


Fig. 6 - Archaeological context. (A) Map of the spread of Mature Harappan sites showing the position of Rakhigarhi. (B) Aerial view of the present-day Rakhigarhi village and archaeological mounds. (C) Excavation in the Harappan urban area during the 2015-16 season. (D) Primary burial including mortuary objects. (E) A secondary burial.

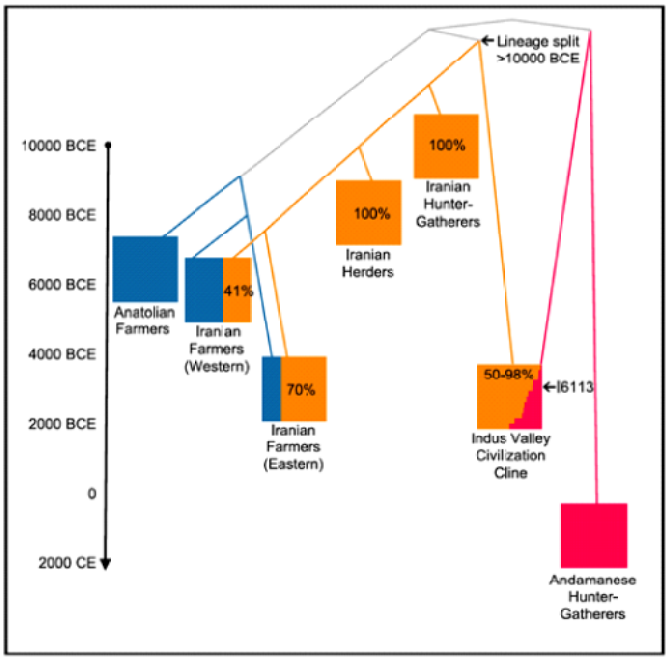


Fig. 7 - Graphical explaination of Harappan ancestry shows no detectable ancestry from Steppe pastoralists or from Anatolian and Iranian farmers, suggesting farming in South Asia arose from local foragers rather than from large-scale migration from the West.

Work done:

Produced first Ancient DNA data from human skeletal remains of Rakhigarhi (Harappan site) which is dating back to 2400 BCE (Fig. 6). We reported for the first time that Ancestry of Harappan Civilization was largely South Asian (Fig. 7) and the farming practices during Harappan Civilization was indigenous.

Whole genomes of 1300 year old human skeletal remains from Roopkund Lake were establihsed. Using Ancient DNA methods and by sequencing Genetic data show genetically two distinct groups—consistent with observed morphological variation (Fig. 8). First Ancestry was found to present-day South Asians while second group is comprised of individuals with eastern Mediterranean-related ancestry, most closely related to present-day Greek populations, with additional affinities to ancient Near Eastern groups.

Coming to the use of Ancient DNA technology in wild life conservation, we attempted first approach ever to solve the mystery of Indian Cheetah. The Indian cheetah was hunted to extinction by the mid-20th century. Recent work using limited genetic data from two historical

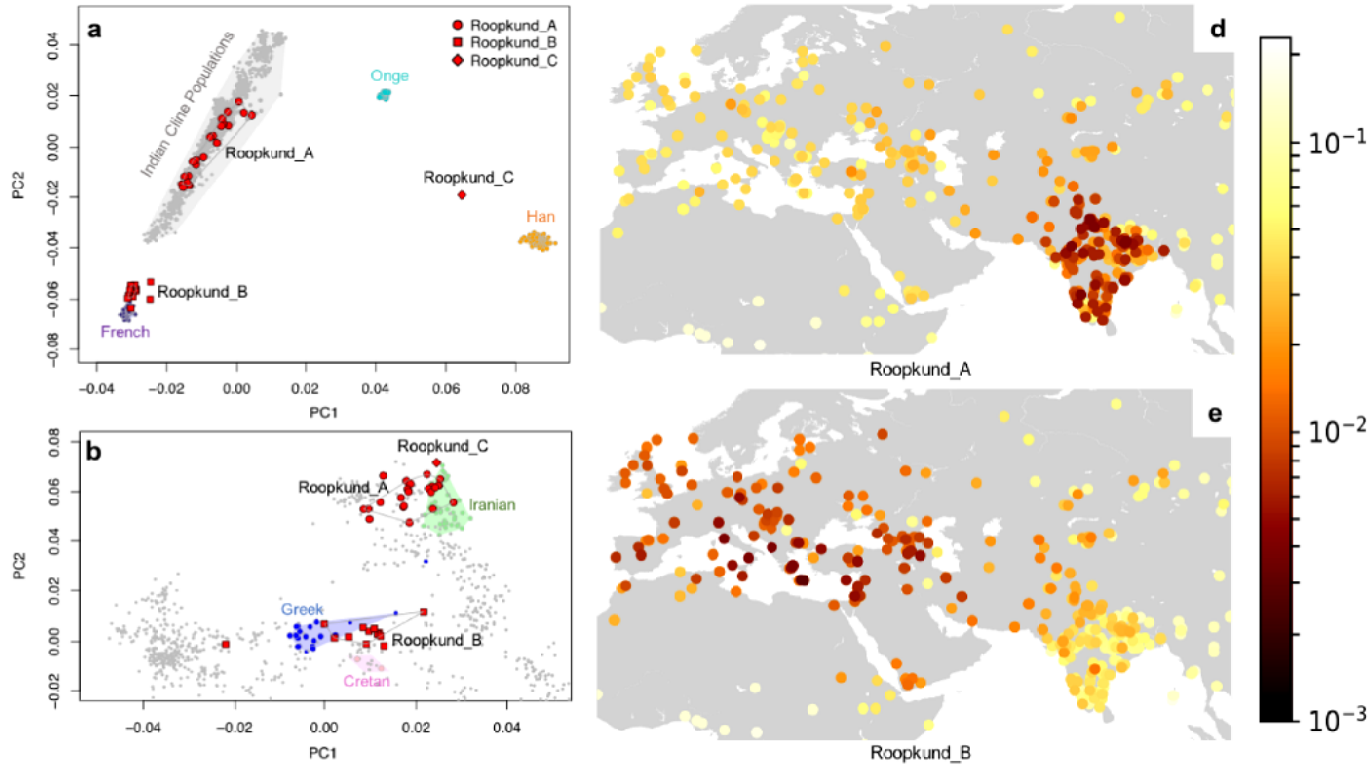


Fig. 8 - Genetic structure of the skeletons of Roopkund Lake. (a) Principal Component Analysis shows two clusters of the ancestry (b) PCA of 988 present day West Eurasians with the Roopkund individuals; Greeks are shown in blue, Cretans in pink, Iranians in green, and all other West Eurasian populations in grey. A grey polygon encloses all the individuals in each Roopkund group with >100,000 SNPs. and longitudes; deeper red coloration shows lower differentiation to the Roopkund genetic cluster being analyzed.

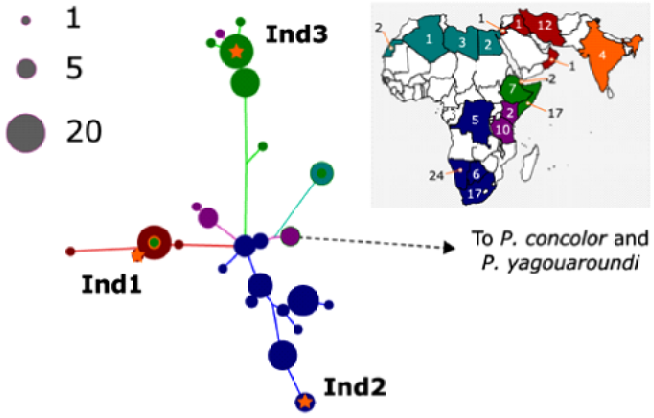


Fig. 9 - Tree schematic situating the Indian cheetah mtDNA within a worldwide sample of 121 modern and historic cheetah, based on a maximum likelihood unrooted tree using a concatenated alignment of up to 1238bp. Colours indicate sampling location, and the numbers of samples from different countries is indicated on the map: green – Northeast African; teal – Northwest African; purple – East African; blue – South African; dark red – southwest Asian; orange - Indian. A small number of samples are customs seizures such that actual origin is ambiguous. The three partial historic mtDNA sequences presented in this.

Indian cheetah samples identified the close genetic relationship between Indian and Iranian cheetah, supporting their classification as a single Asiatic cheetah subspecies (*Acinonyx jubatus venaticus*). Here, we report the recovery of a much larger portion (4116bp) of an Indian cheetah mtDNA mitogenome, along with a historical cheetah mtDNA from Mysore and a modern specimen (Fig. 9). We date the coalescence time of Indian and African cheetah mtDNA to 75ky, indicating that previously proposed dates based on short mtDNA fragments are considerable underestimates. This deep mtDNA coalescence does not necessarily imply a similarly deep population divergence. Surprisingly, the Mysore sample belonged to the South African cheetah subspecies *A. j. jubatus*; African cheetah are known to have been imported from East Africa during the early 20th century, but this is the first indication of an additional South African source. Finally, the modern specimen represents the first reported full Northeast African *A. j. soemmeringii* mtDNA. Together, these animals reflect the recent history of indigenous and imported cheetah in India.

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

Investigators: P. Morthekai & S. Nawaz Ali

Highlights:

- Environmental magnetic analyses rule out the post depositional changes in the concentration of radioactive nuclides.

Work done:

A site was identified in central Himalaya where Th/U ratio was not only lower than typical sediment value but also varying with depth (Fig. 10). Samples were collected at every centimeter interval in a 4 m deep pit for geochemical analyses (major geochemistry and stable isotope geochemistry) and environmental magnetic analyses. Further 12 samples each were collected for ^{14}C (AMS) dating and luminescence dating respectively.

Results from environmental magnetic analyses and AMS ^{14}C (from PRL, Ahmedabad) were obtained. Radiocarbon ages are overestimated (sediments cannot be older than the moraine itself) and at some depths little reversal in ages were observed. Analysis of luminescence ages was withheld because post depositional changes (like radionuclide movement from and to the investigation site) need to be ruled out which is a pre-requisite. Environmental magnetic analyses (low field magnetic susceptibility and magnetic minerals) have suggested that the post depositional reworking is least likely.

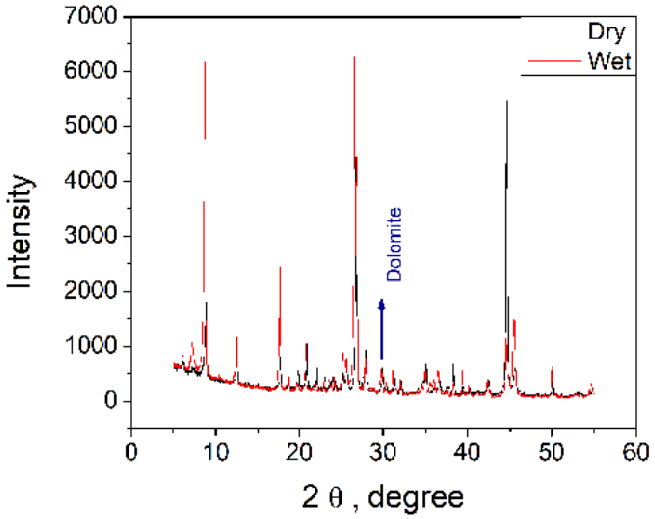


Fig. 10 - X-ray diffractometry data shows the presence of dolomite both in dry sieved and wet sieved samples (< 45 µm).

To understand the over-estimation in radiocarbon ages, reasons were sought whether it is the presence of dead carbon either in organic or inorganic form. Our preliminary investigation using X-ray diffractometer

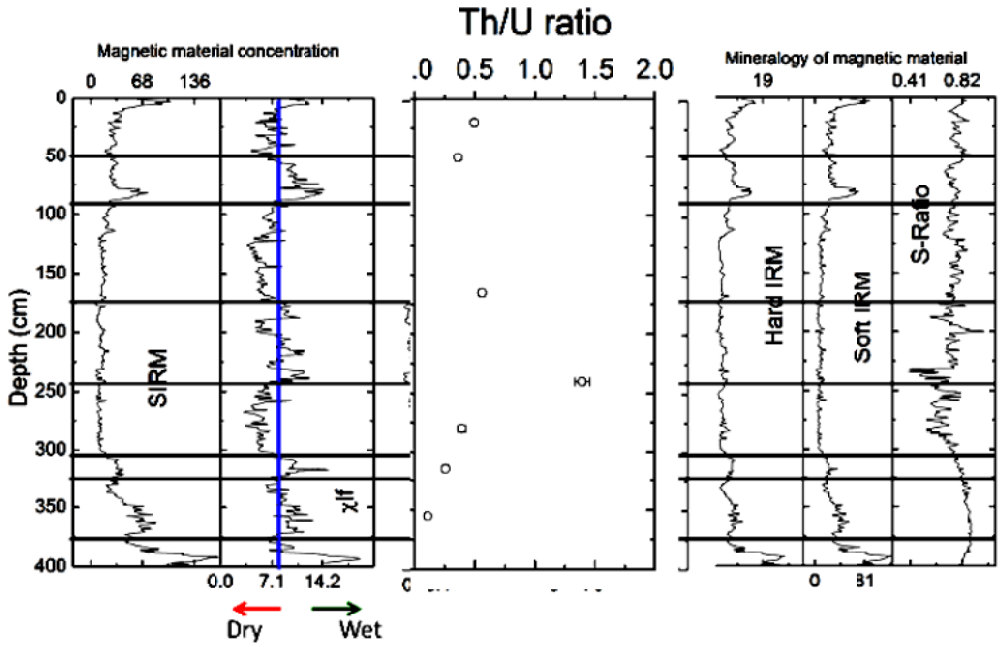


Fig. 11 - Magnetic material concentration (left: using low field magnetic susceptibility and SIRM) and magnetic mineralogy (right: using IRM and S-ratio) are given with depth. Th/U ratio at particular depths are also shown (middle). Blue line is at the median of the data and horizontal grey lines indicate significant zones in which the magnetic proxy indicate about the wet and dry condition.

(XRD) suggests the presence of dead carbon in inorganic form (dolomite) and calcite in the samples (Fig. 11), which might have caused the overestimation in the depositional ages. Black and red lines indicate the samples were either dry sieved or wet sieved (< 45 µm) respectively.

Other measurements (stable isotope geochemistry and major oxides geochemistry) are going on which will help not only to reconstruct a high resolution palaeoclimate in this transition zone (Indian summer monsoon and the Westerlies) but also in interpreting the luminescence and radiocarbon ages.

Thrust Area 6: GEOCHEMICAL PARAMETERS FOR CORRELATION, PALAEOCLIMATIC, TECTONIC AND PROVENANCE STUDIES

Inorganic Geochemistry Group (IGG)

Group Coordinator: Anupam Sharma
Co-Coordinator: Binita Phartiyal

Preamble: Geochemical parameters are the foremost, tested and widely applied in palaeoclimatic, tectonic and provenance studies. The sediments are the most widely studied archive of the geologists, climatologists, evolutionary biologists, archaeologists and so on. Sediments depositing through different agencies such as glaciers, wind and water and therefore preserves variety of signatures experienced during its transformation under the earth surface conditions. The abundances of various chemical elements provide important information on weathering of rocks and sediment production under variety of tectono-climatic setup, however, geochemical characteristics of provenance and signatures of modifications brought in through life systems are also get preserved in the sediment. Therefore, the information locked in the sediments; geochemical parameters such as major and trace elements including

rare earth elements, stable isotopes and biomarkers composition provide credible information on the processes as well as the product. In larger perspectives the information obtained is not only have academic significance but also have infrastructural, industrial, economic and societal implications and could be utilized for project formulation, climate modelling, designing policies and resource management. It is indeed a matter of satisfaction that a variety sophisticated instruments such as ICP-MS, XRF, GC-MS, IRMS, XRD, LPSA, SEM and Raman Spectroscopy have been established and running satisfactorily. The output from the lab is increasing at significant pace. In a relatively short time the Geochemical facility of BSIP, Lucknow has become an important research centre and successfully catering the needs of the host institute and also facilitating at local/ regional and national level to researchers, academia and industry.

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

Investigators: Sheikh Nawaz Ali, Anupam Sharma & Binita Phartiyal

Highlights:

- Glaciers responded to gLGM and reached their maximum extent between ~20-25 ka.
- Abrupt climate surges over short time scales are observed in the later part of the Holocene from a ~1.3 m deep sedimentary profile from the Pensi-la, Zanskar Valley.

Work done:

Investigation of the latero-frontal moraines was undertaken to reconstruct the pattern of glacier advances and associated climate variability in the Suru Valley, western ranges of Zanskar Himalaya, north India. The farthest and most extensive glaciation is manifested by the presence of large latero-frontal moraines that descend down the tributary valleys and terminate in the trunk Suru Valley. Earlier studies (based on ^{10}Be and ^{14}C ages) have assigned these moraines (Tongul glacial stage) to the early part of late glacial period (~16.7–17.4 ka) however this does not accord well with the local and regional evidences. Limited number of ^{14}C ages and a large spread in ^{10}Be ages, the precise chronology of this glaciation has remained elusive. Optically stimulated luminescence (OSL) dating for this glaciation (Tongul glacial stage) and suggest that the Suru Valley glaciers have responded to the global last glacial maximum (gLGM) and reached their maximum extent between ~20-25 ka (Fig. 1). This glaciation was driven by enhanced mid-latitude westerlies and reduced temperature (viz. continental cooling) during MIS 2.

A ~1.3 m deep sedimentary profile from the Pensi-la, Zanskar Valley (Fig. 2) was sampled to understand the Holocene climatic fluctuations in this area. We have recorded relatively higher d^{13}C values complimented by TOC, LOI and grain size parameters during Late–

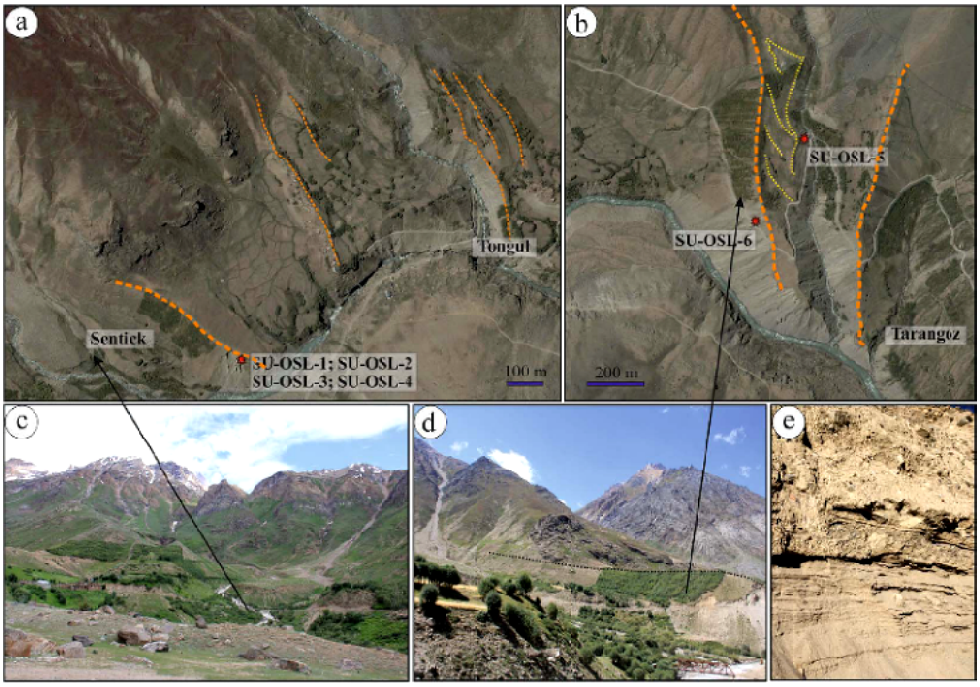


Fig. 1 - (a, b) Synoptic view shown on a Google earthPro image showing (highlighted-orange lines) the lateral moraine and the location of OSL sample collection sites (c, d) Field photographs of the Sentick and Tarangoz valleys, (e) Close up of a sand lens OSL sample.

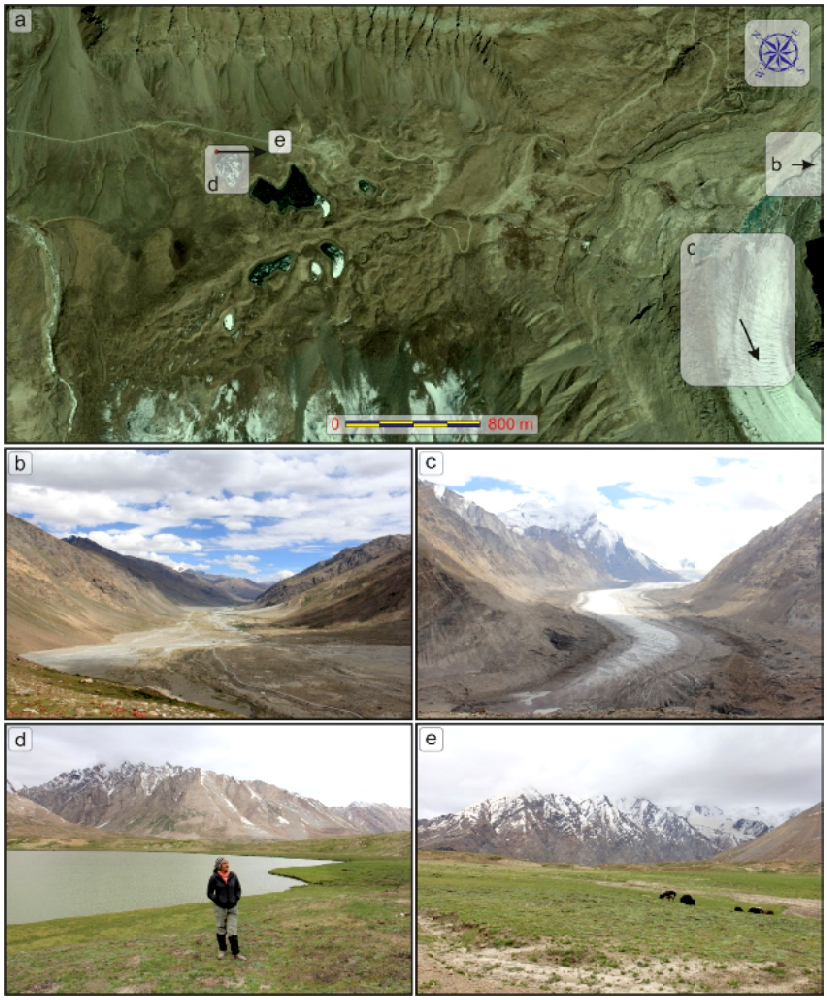


Fig. 2 - (a) Synoptic view of Pensi-la area on Google Earth image showing the location of different field photographs and study site, (b) Downstream view of the Zanskar Valley from Pensi-la, (c) Field photograph showing the Drang Drung Glacier, (d) The kettle-hole lake on Pensi-la (pass), (e) Local herbaceous vegetation growing along the moist places in Zanskar Valley, representation of C3 vegetation.

Northgrippian implying that the area witnessed a dry climate during (~5100-3500 cal yrs BP). A stable climate with moderate precipitation during ~3500-2400 cal yrs BP is observed. Since ~2400 cal yrs BP a gradual strengthening of ISM is recorded. This gradual strengthening of ISM is interrupted by a high amplitude abrupt reversal (decadal scale dry events) with a step wise decreasing intensity at ~2300, 1500, 1000 and 500 cal yrs BP.

A multi-proxy high-resolution palaeolimnology record from North Pulu (Ladakh) shows that between 4585-4294 cal yr BP, an oxic lake condition existed with freeze-thaw action, prominent weathering, more sediment generation and less organic productivity. Between 3974-2064 cal yr BP, climate ameliorated to somewhat moderate warm climate and relatively high lake levels followed by a 260-year period (between 1244-984cal yr BP) of warmer climatic conditions. LIA in the region is experienced between 984-620 cal yr BP. Between 620-360 cal yr BP climatic condition was again warm.

A bird humerus has been recovered from a micro-vertebrate accumulation bearing sand layer (flood deposit) from a fluvial-lacustrine section exposed near the village Shachukul, Tangtse Valley, Ladakh indicative of a sudden burial of the material caused by flood event.

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

Investigators: Trina Bose & Binita Phartiyal

Highlights:

- Review of more than 120 Quaternary palaeodatasets from the Subcontinent
- Plotting of available data from Kachchh Basin to assess multi-proxy interpretation

Work done:

Preliminary plots were made to interpret biological, chemical and physical climate proxies in the Kachchh Basin, western India. Testing of appropriate visual display for multi proxy 3-D data and the programming method to plot such diagrams consistently and autonomously using R, Octave or Python. A paper describing various aspects of Palaeosciences and how spatial and temporal integration of the information is important for improvement of palaeoclimate information extraction is prepared.

Space-time integration of palaeoinformation in a Geographical Information System (GIS) setup is being programmed and implemented for the first time globally.

Project 6.3: Process-based palaeoclimatic reconstructions from tree ring cellulose isotope data

Investigators: Trina Bose & Krishna Gopal Misra

Highlights:

- Collaboration project was started with PSIT College of Engineering to design and fabricate a machine powered wood and soft sediment core sampler. Other instruments were also designed and are ready for fabricated.
- Various methods of relative humidity extrapolation from tree ring width data were explored for best input for temperature reconstruction using process-based modelling.

Work done:

A collaboration project was started with PSIT College of Engineering to design and fabricate a machine powered wood and soft sediment core sampler suiting our field conditions and budget.

Following were designed for the Tree Ring Isotope laboratory:

1. Teflon micro processing unit to enable higher recovery of cellulose from tree ring wood.
2. High pressure container with gas flow options for isotopic exchange between vapour and solids so that hydrogen isotope of botanical molecules can be analysed in bath mode.

Testing the methods of extrapolation of relative humidity from ring width data for best input for temperature reconstruction using process-based modelling. Process based biochemical reconstruction model was tested through various modifications to the formulation and interpretations.

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

Investigators: Niteshkumar Khonde & G.P. Gurumurthy

Highlights:

- Signatures of the relative sea level changes (Holocene?) are found in the trench section from the Great Rann of Kachchh Basin. Typical marine microfossils and gastropod shells provided evidences of high sea level stand plausibly during mid-late Holocene times.
- Aeolian dune field in the western GRK Basin sampled shows the dominance of the drying climate and lowering of the relative sea level probably within past 10k. The sediment appears to be locally derived and dominated by coarse grained material.

Work done:

Trenching was done at northeastern GRK Basin during the field in 2018. The idea behind this trenching was to encounter the fluvial and marine sediments across the time. It was expected that high sea level stands will bring the marine waters/sediments to the trenching site and yield the marine signatures on biotic and/or geochemical proxies. When the collected sediment samples were investigated for the physical examination of desired fraction under the microscope, it yielded significant amount of marine microfossils, i.e. foraminifera. The foraminiferal assemblage is comprised of mostly benthic foraminifera belonging to genus *Ammonia*, *Quinquiloculina*, *Elphidium*. Interestingly, the size of these foraminifera tests is quite big as compared to the tests recovered from the central basin core raised from Dhordo locality earlier. This information has implications on two aspects, (1) The abundant foraminifera zone marks the high sea level stand in the GRK Basin which was otherwise dominated by fluvial environment, (2) The size of the foraminiferal test is surprisingly large as compared to their central basin counterparts. Preliminary observations suggest that high salinity water input from the south flowing helped to maintain the salinity of the local microenvironment and supplied essential nutrients to the community and as a result of that the size of the foraminiferal tests has increased in this region. However, this hypothesis needs to be tested further before concluding finally.

At least two levels of older lithology platforms (Mesozoic sedimentary rocks, e.g. limestones/sandstones) were found to be dominated by the large shells of

gastropods which typically found in the shallow marine environment. Interestingly the recent sediment cover of these sediments appears to have removed by the strong winds over period of time, whereas these heavy shells are left over to the sites. This clearly suggests the high seal level stand in the recent past in western GRK. The chronological framework will throw more light on these high stand events and their correlatibility and work is in progress.

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

Investigators: Kamlesh Kumar & Shilpa Pandey

Highlights:

- First time ~800 modern vegetation samples were collected from southern Gujarat to the north part of Gujarat to understand $\delta^{13}C$ fractionation in the modern vegetation and its relationship with precipitation.
- A multi-proxy study of 1.3 m deep sediment profile suggests that there was a drought period of ~100 years from 1075-975 cal yr BP in the mainland Gujarat.

Work done:

Based on multi-proxy records (1400 cal yr BP – Present), the entire sediment profile was divided into four zones. The zone-I (1400-1075 cal yr BP) comprises decreasing SiO_2, low Al_2O_3 and Fe_2O_3 and less variation in CaO and Na_2O indicates less warm and humid climatic conditions prevailing in the region. In the zone –II abrupt increase in the SiO_2 and Na_2O and depletion in the Al_2O_3, Fe_2O_3 and MgO indicates a pulse of drought phase of ~ 100 years. In the Zone-III increasing trend in the SiO_2, Al_2O_3 and CaO, whereas the decrease in Fe_2O_3 indicates more sediment water interaction during enhanced SW monsoon from 975-425 years. In the uppermost zone from 425 years to present there is no significant change in the major oxides which indicates more or less modern climatic conditions (Fig. 3).

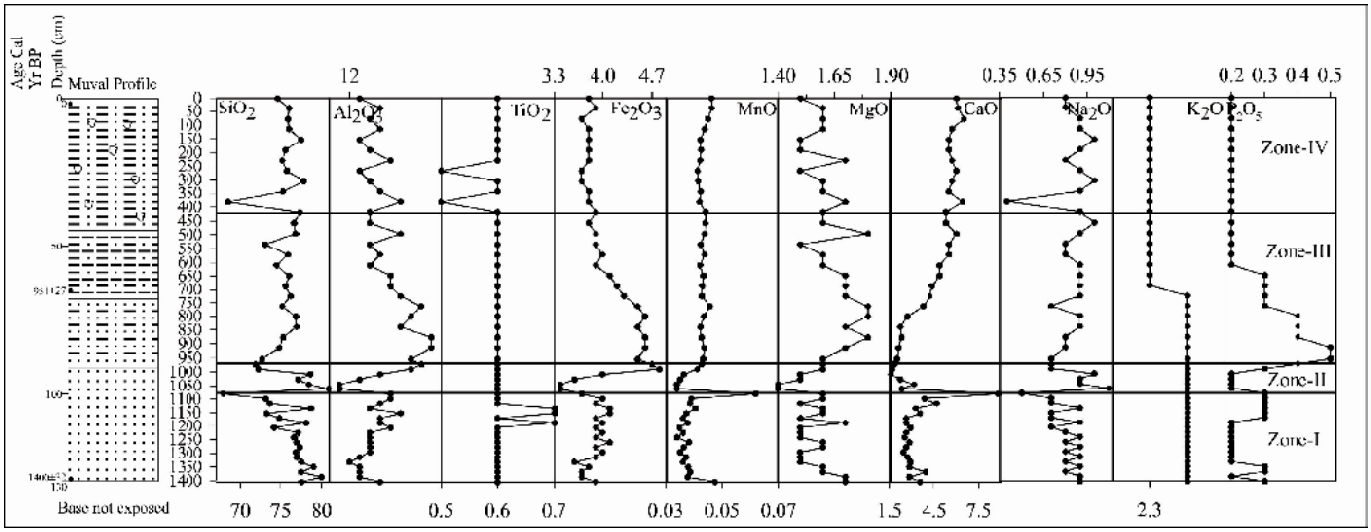


Fig. 3 - Major oxide variations in the Muval core.

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

Investigators: Anupam Sharma, Pawan Govil, Anjali Trivedi & Kamlesh Kumar

Highlights:

- The sediment core collected from the vicinity of Varanasi City provides high resolution geochemical data showing appreciable variation, wherein the abundance of several anthropogenically sensitive elements are registering significant increase in abundance ~750 years before present.

- Anthropocene data is showing good agreement with existing regional palaeoclimate data with additional signatures of other climatic events such as drought/ famine and floods, which need to be addressed.

Work done:

There are a number of studies coming from the western world, however, in Indian context, the studies are meagre and therefore a multidisciplinary project was proposed in the Central Ganga Plain, because it is most populated and fertile land on the earth having >8000 years human records. The major objective of the project was to collect information, and for that a sediment core was raised from the outskirts of the Varanasi City. Approximately two millennium records deduced through ^{14}C AMS chronology show that the lower half of the sediment core shows significantly higher rate of sedimentation compared to the upper half. The mineralogy and major elements chemistry is indicating its Himalayan source dominated by calc-alkaine suite. Most of the elements are showing a sudden increase in abundance ~850 cal yr BP; however, this increase in elements of anthropogenic significance such as As, Cd, Co, Pb is particularly interesting showing that there must be an increase agricultural/industrial activities. The stable carbon isotope based palaeoclimate data is showing good agreement with existing regional palaeoclimate such as Medieval Warm Period (MWP) and Little Ice Age (LIA) with additional signatures of other climatic events such as drought/famine and floods, which need to be confirmed with archaeological records.

Project 6.7: Investigations of Indian monsoonal variability and abrupt climatic events during the late Quaternary: implications for climate forcing on C_3-C_4 vegetation

Investigators: Shailesh Agrawal, S. Nawaz Ali & Md. Firoze Quamar

Highlights:

- Modern vegetation-climate relationship suggests significant effect of moisture content on the $\delta^{13}C$ values of plants.
- Our data shows most prominent abrupt shift in ISM during the Pleistocene whereas, gradual change in ISM is observed during Holocene.

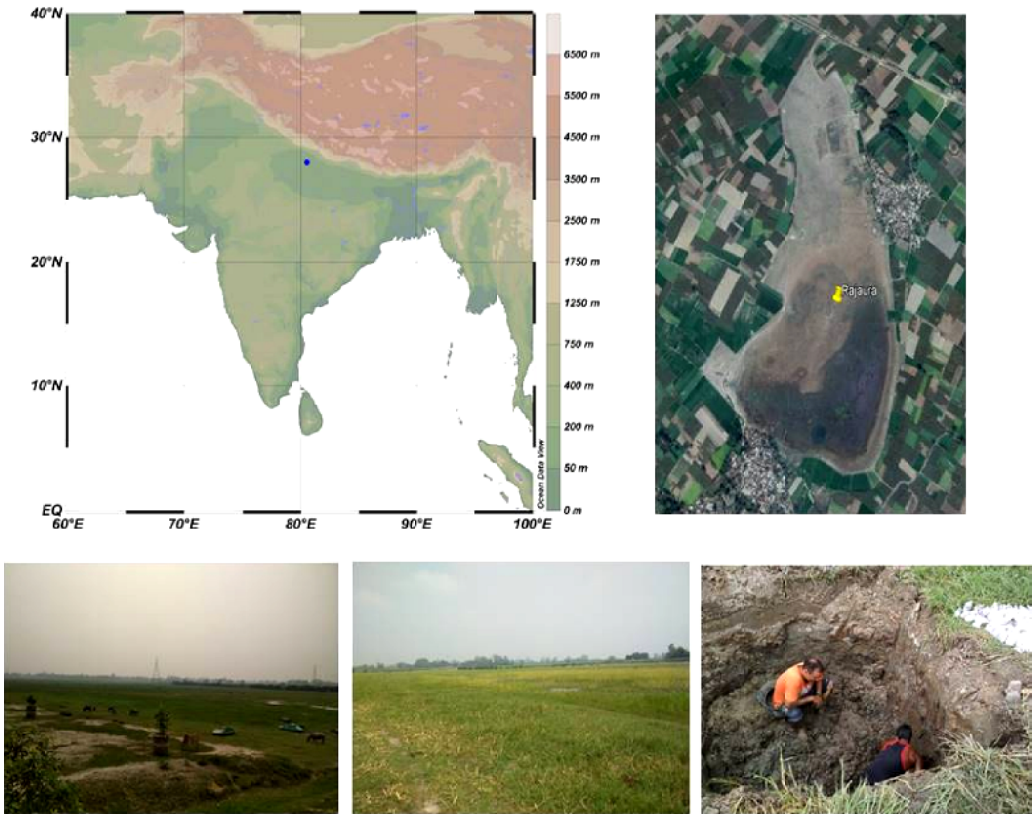


Fig. 4 - Map shows location of study area and field photographs.

Work done:

This project aims at reconstructing high resolution centennial-scale Indian Summer Monsoon (ISM) variability from lake sediments in northern Ganga Plain. We have used stable isotopic ($\delta^{13}C_{org}$) data, Total Organic Carbon (TOC) content, Total Nitrogen (TN) content and TOC/TN ratio of the organic matter associated with sediment and magnetic susceptibility data of bulk sediments. To understand the modern vegetation-climate relationship, a modern isotope based analogue has been developed. Towards this, we have used 108 surface sediment samples that have been collected in a pre-planned gridded pattern. The $\delta^{13}C$ value of the surface samples range between –25.2 and –20.7‰ (n=86), with an average of –23.5‰. The TOC values range from 0.48% to 15.2% (average 3.1%). It has been observed that the lake experienced a heterogeneous water level (annually). Using seasonal remote sensing data, we have observed that the south-eastern sector of lake remains filled with water throughout the year, however the north-western part remains dry except for the monsoon period. This seems to have a significant effect on the $\delta^{13}C$ values and is manifested by lower values of $\delta^{13}C$ (average -23.1‰) in waterlogged sector and relatively higher values (average -22.6‰) towards the drier part (north-west). The frequency curve shows the maximum values falls in the range of -22.5‰ to -21.4‰ suggesting mix source of organic matter (C_4, C_3 and aquatics). The $\delta^{13}C$ values of ~3.5 m core taken from the same lake show significant variation and range -32.7 to -14.4‰, spanning an 18‰ range. The most prominent abrupt shift in ISM is observed during the Pleistocene. On the other hand, gradual changes in ISM were observed during Holocene (Figs 4-5).

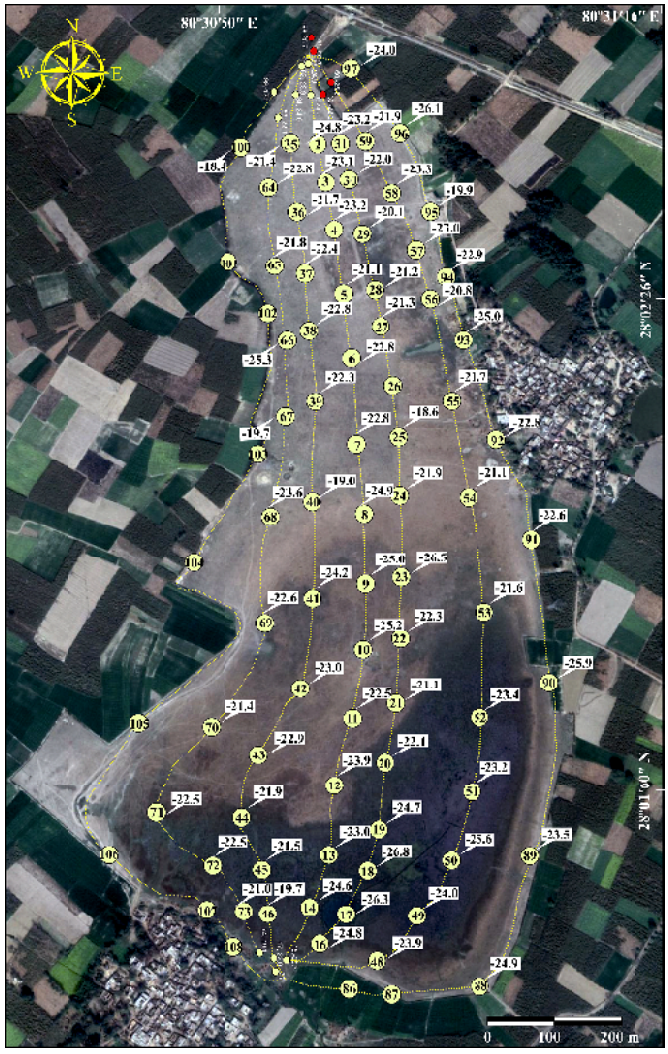


Fig. 5 - Typical $\delta^{13}C$ values of surface sediments collected from the Rajaura Lake, Gola Gokarannath.

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

Investigators: Pawan Govil & Abhijit Mazumder

Highlights:

- Sea level and regional climate fluctuations are possibly the main cause to foraminiferal productivity in the coast of NW Bay of Bengal.
- Recent 2000 year's records from multi-proxy dataset show the high resolution and abrupt changes in association with high/low terrestrial input. It infers the variations in SW monsoon intensity.

Work done:

One marine sediment core SK-336/3 (Lat: 17°19.332' N 083°35.934'E; Water Depth: 599 mts) was obtained from western Bay of Bengal to achieve the high resolution study to understand the palaeoceanography, productivity and surface hydrography variations. The sediment core samples were used for the micropalaeontological (Planktonic and Benthic foraminiferal abundance, planktic/benthic ratio), sedimentological (grain size distribution)

and geochemical analysis ($\delta^{13}C_{org}$, $\delta^{15}N$ and TOC/TN ratio). Hydrography of the western Bay of Bengal is highly governed by the precipitation and run off during the SW monsoon. The initial three meter core length spans a time period of 6 ka BP based on 4 radiocarbon ages and evident the high sedimentation rate. The planktonic/benthic foraminifera abundance counts were performed and calculated the planktonic/benthic foraminifera abundance in one gm sediments which clearly indicate the foraminiferal productivity variations within the 6 ka BP. Simultaneously, planktonic/benthic ratio was also calculated to understand the variation in ocean water depth/sea level. Grain size analysis was performed on samples to understand the sediment deposition environment and terrigenous dilution effect on foraminiferal productivity in the study area and it shows the variation of terrestrial input to the core site on century scale. The $\delta^{13}C_{org}$, $\delta^{15}N$ and TOC/TN ratio data shows the variation in biological productivity and denitrification processes within the study area during recent to 6 ka BP. The $\delta^{13}C_{org}$ and TOC/TN data indicates that the source of organic carbon may influence by the sea level and/or associated with regional climate fluctuations to the core site. Furthermore, organic carbon records suggest the mix signals of C3 and C4 vegetation terrestrial input to the region during 6 ka BP. The $\delta^{15}N$ values show good correlation with $\delta^{13}C_{org}$ on some places especially with in earlier 2000 years records. It clearly evident that the high/low productivity is responsible for the denitrification processes in the core vicinity.

Field Training Programme

A field training programme on "Pollen productivity estimates (PPE) for the reconstruction of past vegetation cover" was organized during January 22-23, 2019 at Nawabganj Bird Sanctuary, Unnao, Uttar Pradesh in collaboration with French Institute of Pondicherry, Puducherry (Dr. Anupama Krishnamurthy, Dr. S. Prasad and Navya Reghu).

Vegetation survey was carried out using standard CRACKLES PPE field protocol. Soil samples were also collected for modern pollen study. Training on software's related to PPE such as Crackles Survey Manager was demonstrated during the lecture session at BSIP, Lucknow.

Work other than Institute's Projects

Four samples of porcellanite and black shales from the Chhattisgarh Supergroup were dated by means of zircon SIMS U-Pb dating using the Cameca IMS 1280 instrument at Institute of Geology and Geophysics, Chinese Academy of Sciences (IGGCAS), Beijing P.R. China. Detrital zircon grains recovered from the porcellanite samples from the Rehatikhol Formation, Singhora Group delineates the age ranging from 2.1-2.4 Ga. Two grains show euhedral morphology with distinct zoning characteristics and give SIMS ages of ca. 1.2 Ga, which suggests a maximum depositional age of the sampling horizon. Porcellanite samples from the Chhuipalli Formation, Singhora Group decipher four zircon ages, two of which are detrital grains giving the age ranging from 2.1-2.3 Ga. The other two euhedral zircon grains provide SIMS ages of ca. 1351 ± 21 Ma (MSWD = 0.43), suggesting a maximum depositional age of the sampling horizon. In conclusion, the age of the Singhora Group has been estimated to be <1.2 Ga.

To resolve the inconsistency of biostratigraphy and geochronology in the Vindhyan Supergroup, robust sampling have been done from different stratigraphic horizons in the month of January-February, 2019. Twenty eight sandstone and porcellanite samples are being analyzed in the geochronology laboratory for zircon and xenotime U-Pb dating using Cameca IMS 1280 instrument at IGGCAS at Beijing.

Mukund Sharma, S.K. Pandey, Veeru Kant Singh, A.H. Ansari & Yogmaya Shukla [& Dr. Zhangwu Lan (Institute of Geology and Geophysics, China)]

For the first time fossil biofilms have been reported from the petrographic thin section analysis of the Neoproterozoic phosphorites from India. Five distinct microfabrics in the phosphatic bands of the Neoproterozoic Halkal Shale of the Bhima Basin have been documented. The brown layers of the biofilms are constituted by homogenous phosphate ground mass with organic nature of fossil microbial filaments. The manuscript entitled "Biofilm microfabrics in phosphoritic units of the Halkal Shale, Bhima Basin, South India" is under revision in the Journal *Precambrian Research*.

Yogmaya Shukla & Mukund Sharma [& Nora Noffke, USA and Flavia Callefo, Mexico]

An assemblage of organic walled microfossils (OWM) consisting of 17 taxa belonging to 10 genera has been reported from the Neoproterozoic Owk Shale of the Kurnool Group, South India. The assemblage comprises sphaeromorphs, colonial aggregates, filamentous forms, spiral cylindrical filaments belonging to cyanobacteria, problematic acanthomorphic acritarchs, Netromorphic, Sphaeromorphic and Acanthomorphic groups. The manuscript entitled "Organic walled microfossils from the Neoproterozoic Owk Shale, Kurnool Group, South India" is under revision in the journal "Palaeoworld".

Yogmaya Shukla & Mukund Sharma [& V.N. Sergeev, GINRAS, Moscow]

In continuation of CAS-PIFI-2016 fellowship studies, new findings have been incorporated in a manuscript on the Ediacaran genus *Flabellophyton*, which were previously reported from the Lantian Formation (635–551 Ma) of south China and the Ediacara Member (560–550 Ma) of south Australia. Present report signifies the presence of *Flabellophyton* from the Shibantan Member of the Dengying Formation (551–541 Ma) in south China. *Flabellophyton*, the only genus that occurs in all three taphonomic windows, i.e. shale, sandstone and carbonate rocks. A manuscript on the "Taphonomy and palaeoecology of Ediacaran fossil *Flabellophyton* (Metaphyte) from the Lantian and Ediacara biotas" has been prepared for the journal "Gondwana Research".

S.K. Pandey [& Bin Wan, Zhe Chen, Xunlai Yuan, Ke Pang, Chengguo Guana, Xiaopeng Wang (NIGPAS, Nanjing, China), Shuhai Xiao, Qing Tang (Virginia Tech, USA)]

A detailed investigation on palaeofloristics, palynology and organic geochemistry of fossiliferous horizons in and around Ustali area of Ib River Basin, Odisha, India has been carried out. The macrofloral assemblage comprises equisetaceous stems, *Schizoneura gondwanensis, Trizygia speciosa, Neomariopteris polymorpha, N. talchirensis,* 26 species of *Glossopteris,* 3 species of *Gangamopteris, Vertebraria indica, Plumsteadiostrobus pretiosus,* stem cast and three dispersed seed genera, viz. *Samaropsis, Cordaicarpus, Rotundocarpus.* The floral assemblage of the Lower fossiliferous horizon, i.e. off-white silty shale comprises *Gangamopteris* and narrow and medium mesh form *Glossopteris* species, whereas the assemblage of uppermost grey shale consists of medium and broad mesh form *Glossopteris* species and *Neomariopteris*. It

demonstrates a marked change thereby advocating two different floral zones in the Raniganj Formation exposed in Ustali Village of Ib River Basin. These floral zones demonstrate the evolution of midrib and meshes in different reticulate leaves. The upper floral zone belongs to the late Upper Permian (Changhsingian age), while the lower floral zone belongs to the early Upper Permian (Wuchiapingian age). The palaeobotanical investigation and lithological features have revealed the presence of the Raniganj Formation (Lopingian epoch) exposed in the studied section of the Ib River Basin. The palynoassemblage recovered from the samples of the studied section shows predominance of the genus *Striatopodocarpites* spp. and sub-dominance of *Faunipollenites* spp. along with some stratigrahically significant taxa, viz. *Densipollenites magnicorpus, Crescentipollenites globosus, Chordasporites australiensis, Falcisporites nuthaliensis, Strotersporites perfectus, Lunatisporites pellucidus, Striomonosaccites* spp., *Guttulapollenites hannonicus*, *Weylandites lucifer* and *Kamthisaccites kamthiensis.* The assemblage confirms its resemblance with the late Permian Raniganj palynoflora. The biomarker analysis indicates a high contribution of algal and microbial organic matter during the deposition. However, the overall biomarker composition and distribution suggest an increased thermal maturity of the studied samples.

S. Suresh K. Pillai, Neha Aggarwal, Runcie P. Mathews & Anju Saxena, [& Shreerup Goswami (Univ. of Sambalpur, Odisha)]

Palynofloral study was carried out on the borehole NP-74 of Wardha Basin. Qualitative and quantitative analysis of the palynoassemblage has revealed two distinct palynoassemblages. The abundance of *Scheuringipollenites* sp. (40-51%) and sub dominance of *Parasaccites* sp. (25-30%) characterizes Palynoassemblage-I (277-283 m). The dominance of *Scheuringipollenites* sp. (30-78%) along with *Faunipollenites* sp., *Striatopodocarpites* sp. and taeniates (13-28%) demarcates Palynoassemblage-II (102.5-271 m). Palynoassemblage-I and II show its resemblance to the upper Karharbari and lower Barakar palynoflora of the early Permian age, respectively. On the basis of the recovered palynoflora, Artinskian age may be assigned to the palynoassemblages I and II. Four genera of megaspores have also been recovered at a depth of 202 m. By the palynofacies investigations, five distinct Palynofacies Association (A-E) has been identified. Palynofacies Association A is demarcated by the predominance of the spore-pollen, Palynofacies Association B is characterized by the dominance of structured terrestrial elements, Palynofacies Association C is dominated by charcoal, Palynofacies Association D is distinguished by the dominance of degraded organic matter and Palynofacies Association E is marked by the predominance of amorphous organic matter. Palynofacies Association A-E is deposited in a peat-forming setting; fairly dense vegetation in the proximal settings; oxidizing conditions in exposed areas of flood plains; slight flow/ waterlogged settings and oxygen-deficient conditions in low energy environment.

Neha Aggarwal, Srikanth Murthy & S. Suresh Kumar Pillai

Prepared a Catalogue entitled "A Catalogue of Upper Gondwana (Jurassic–Early Cretaceous) plant megafossil genera of India". The present catalogue is aimed to unify, update and provide generic diagnosis / description of various forms with their photographs, text-figures, systematic classification, geologic and geographic occurrences in Indian sedimentary basins. This catalogue is an addition to the list of Institute's publications. The compilation of palaeofloral data in the form of a catalogue will not only facilitate the young researchers in gaining knowledge of the Mesozoic plant fossils but also it will serve as a handy reference for active researchers in this field.

Neeru Prakash & Neelam Das

The bore core NP–74 drilled near Nand Village, a part of Nand–Besur Block of Bandar Coalfield, Wardha Basin, Maharashtra has 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 nine species belonging to three genera, viz. *Bokarosporites rotundus*, *Bokarosporites* sp., *Jhariatriletes filiformis*, *Singhisporites baculatus, S. indica, S. nautiyalii, S. radialis, S. surangei* and *Singhisporites* sp. The miospore and megaspore assemblages indicates an early Permian age equivalent to the lower Barakar Formation.

Srikanta Murthy, O.S. Sarate & Neha Aggarwal

Analyzed the palaeoflora of the Kota Formation to understand their diversity and palaeoecological significance. We also described a new species

Agathoxylon kotaense belonging to the conifer family Araucariaceae (Fig. 1). Our study shows that the flora was dominated by conifers and that it is comparable to that of the late Jurassic – Lower Cretaceous flora of Gangapur Formation, Pranhita-Godavari Basin and also to that of the Rajmahal Formation of the Rajmahal hills.

The growth ring pattern and leaf fossil assemblage suggest that the growth was seasonal, but mostly stressed.

Chinnappa Chopparapu, A. Rajanikanth & Kavali Pauline Sabina

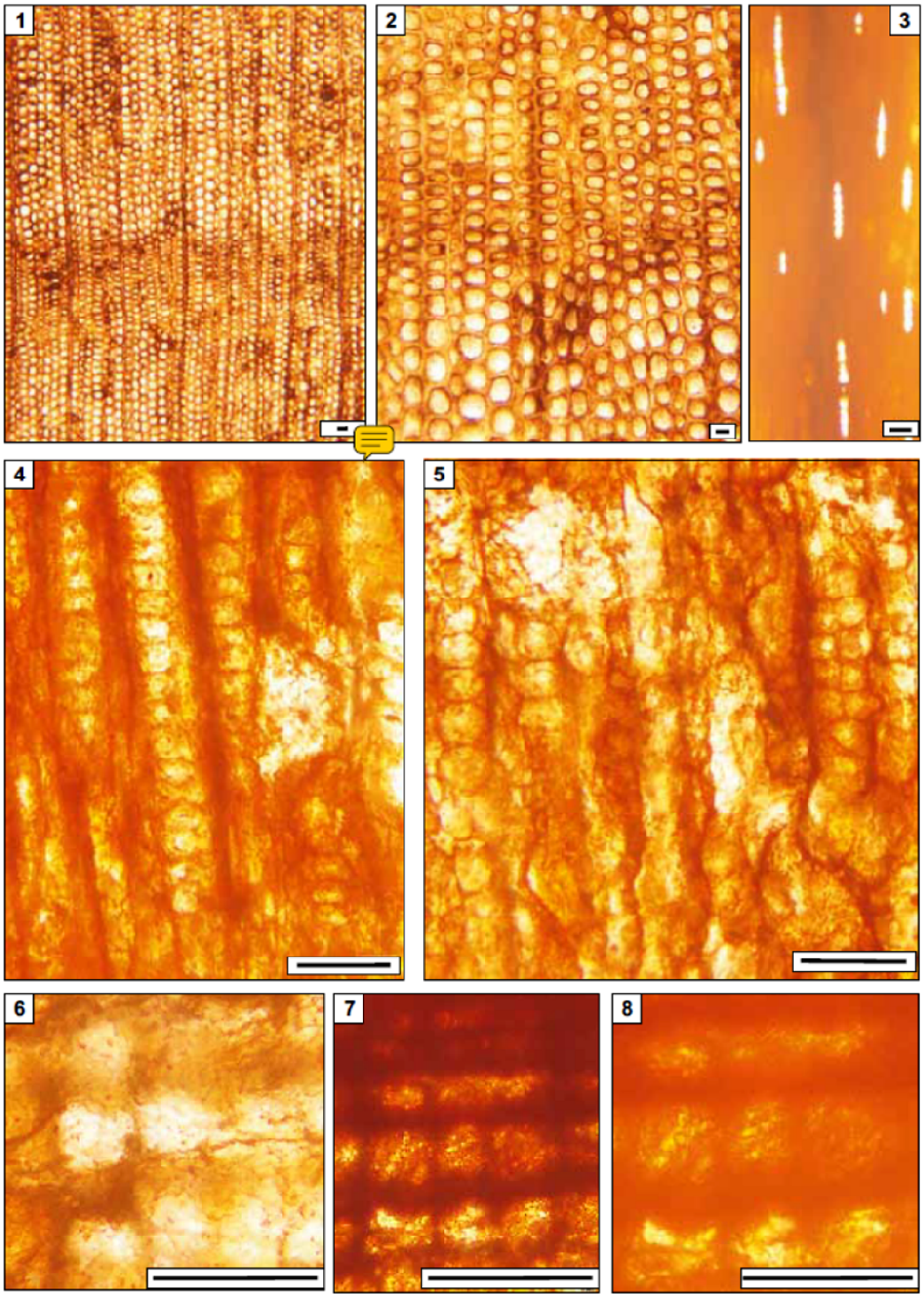


Fig. 1 – *Agathoxylon kotaense* n. sp., BSIP 16274; 1, 2: Transverse section showing indistinct growth ring and tracheid cells, 3: Tandential section showing uniseriate ray cells, 4: Radial section showing uniseriate bordered pits, 5: Radial section showing biseriate bordered pits arranged in sub-oppositely, 6, 8: Crossfield area with group of araucarioid pits.

The xylotomy of the silicified wood from the late Jurassic to Early Cretaceous sequence of Kota Formation of the Pranhita-Godavari Basin has been studied and its systematic affinity has been identified. The wood is characterised by distinct growth rings with mixed pitting on radial tracheid walls and taxodioid cross-field pits.

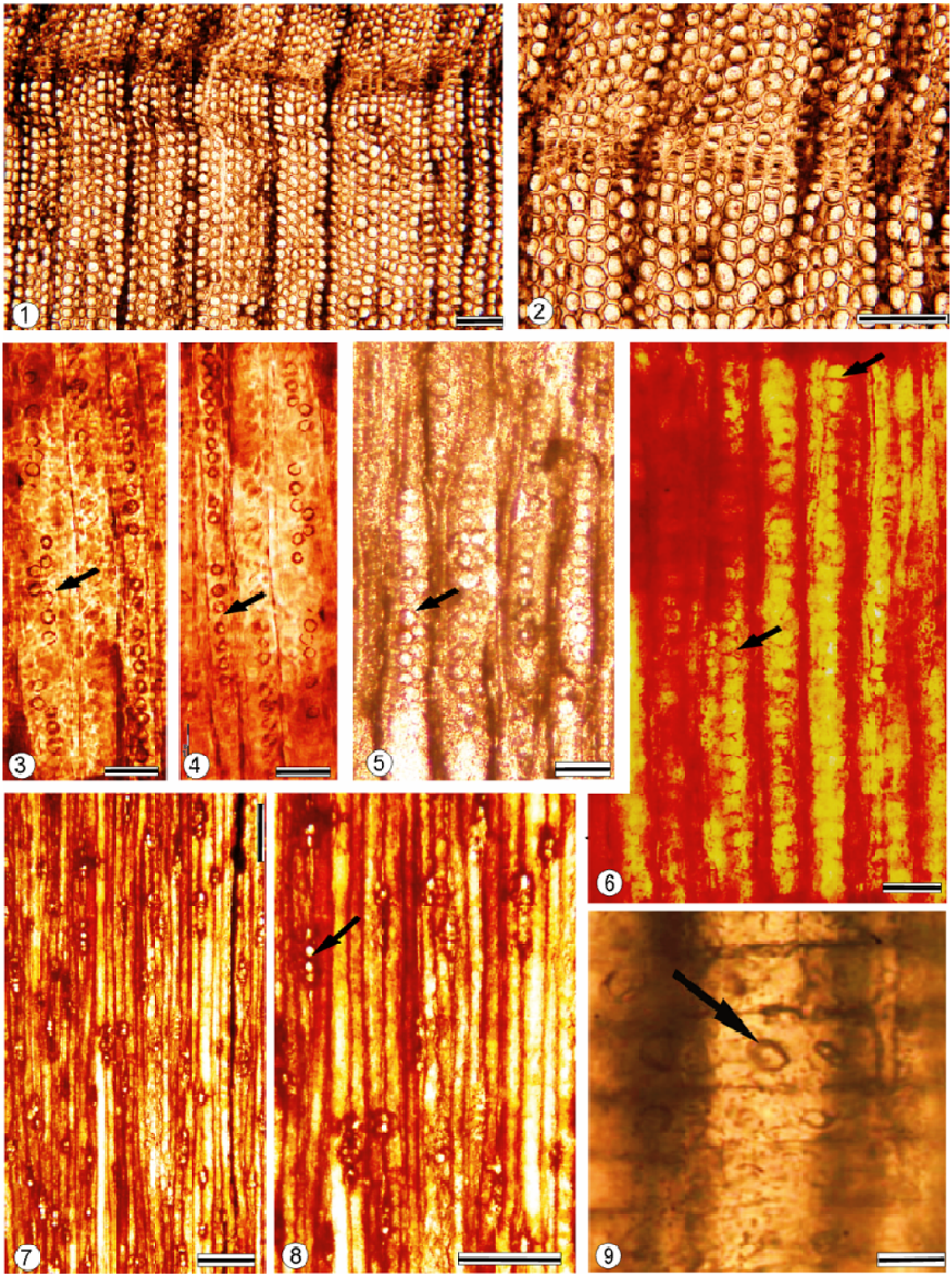


Fig. 2 – (1-9). *Protaxodioxylon sahnii* sp. nov., (1, 2) transverse section showing indistinct growth ring and tracheid cells; (3, 4) radial section showing uniseriate bordered pits arranged separately (see arrow); (5) radial section showing biseriate bordered pits arranged in sub-oppositely; (6) radial section showing contiguous uniseriate bordered pits; (7, 8) tangential section showing uniseriate ray cells; (9) crossfield area with taxodioid pits. Scale bar 50 µm.

The combination of these features observed in the studied wood indicates that it belongs to *Protaxodioxylon* of the taxodiaceous Cupressaceae and a new species *Protaxodioxylon sahnii* sp. nov. has been instituted (Fig. 2). The comparison of wood with the modern representatives of the family suggests its relation with *Taxodium*. The present fossil wood with distinct growth rings characterised by their low percentage of latewood suggests that the growth conditions were favourable. The riparian habitat was inferred for the *Protaxodioxylon sahnii* sp. nov., based on sedimentological features and other associated plant fossils. The vegetation in the study area was possibly favoured by the influence of a subtropical climate with seasonal variation and by high levels of precipitation along the river banks.

Chinnappa Chopparapu, A. Rajanikanth & Kavali Pauline Sabina

The Barakar sequence of Tapin North Open Cast Mine West Bokaro Coalfield, Jharkhand has been investigated for the palynofacies analysis. On the basis of the recovered dispersed organic matter counts, three distinct palynofacies (I-III) have been identified. Palynofacies-I is characterized by the dominance of spore-pollen; Palynofacies-II is demarcated by the abundance of opaque phytoclasts along with high value of the opaque/translucent phytoclast ratio and Palynofacies-III is distinguished by the dominance of opaque phytoclasts with low value of the opaque/translucent phytoclast ratio. Palynofacies analysis of the whole succession indicates swamp-dominated phase along with the intraseam parting of river and lake deposits which directly corroborates with the palynofloral studies.

Neha Aggarwal & Srikanta Murthy

Palynological investigation on the samples of IB River has been carried out. Abundance of striate bisaccates (*Striatopodocarpites* spp. and *Faunipollenites* spp.) along with the presence of stratigraphically significant taxa, viz. *Chordasporites australiensis*, *Falcisporites stabilis, F. nuthaliensis, Strotersporites perfectus, Lunatisporites pellucidus, Striomonosaccites* sp., *Guttulapollenites hannonicus*, *Weylandites lucifer* and *Kamthisaccites kamthiensis* confirms its resemblance with the Raniganj palynoflora of the late Permian affinity.

Neha Aggarwal & S. Suresh K. Pillai

Some ambers containing insect remains have been identified from Surat District, Gujarat (Figs 3, 4). The

Fig. 3 - Amber embedded insects from, Cambay Basin (Tarkeshwar), Gujarat. *Gujaratomyia miripes* Gilka *et* Zakrzewska, 2018, adult male, BSIP Tad-610, early Eocene, 54 Ma, Tadkeshwar Mine, Gujarat, India: (A) inclusion in amber; (B) habitus; (C) apical part of hind leg tibia; (D) head; (E) scutellum with strong setae; (F) hypopygium in dorsal aspect.

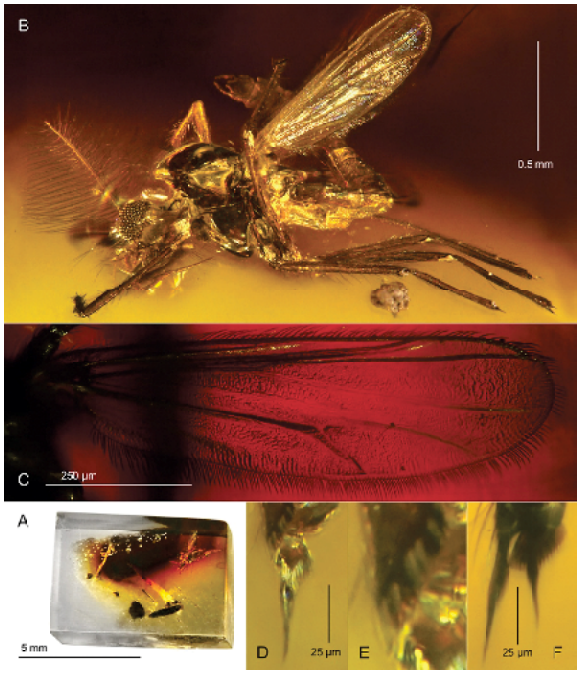


Fig. 4 - *Tanytarsus ramus* sp. nov., adult male, BSIP Tad-521, early Eocene, 54 Ma, Tadkeshwar Mine, Gujarat, India: (A) inclusion in amber; (B) habitus; (C) wing; (D) tibial armature of mid leg; (E) spur-less comb of mid leg magnified *ca.* 3 times relative to (D); (F) tibial combs and spurs of hind leg.

new genus of insect is represented by three new species of Lygistorrhinidae. These insects Lygistorrhinidae are found in present day tropical to temperate warm forest.

Hukam Singh (& Wojciech Gilka & Marta Zakrzewska)

Fossil pollen recovered from Infratrappean sequence (65 Ma) from a borehole succession located in the Ashtona Village, Yavatmal District, Maharashtra, Wardha-Godavari Basin showed affinity with the extant pollen belonging to Linaceae. Two pollen morphotypes inaperturate and tricolpate were recovered from the sediments. Dimorphic characters in the exine ornamentation (thrum type) in the fossil pollen suggested hetrostylous nature of the fossil plant.

Mahi Bansal, Vandana Prasad, Anjum Farooqui & Srikanta Murthy

During the period of the Postdoctoral Fellowship at UCLA, I was involved in 3 projects, Firstly identification and analysis of fossilized Dinosaur egg shells from Portugal. The project aimed at reconstruction of the past ecology by comparing the Dinosaur egg shells and concretions from Casal da Rola, Porto das Barcas (Sp. *Torvosaurus*), Paimogo (Sp. *Lourinhanosaurus*). The initial results for egg shells of *Torvosaurus* and *Lourinhanosaurus* from Porto das Barcas and Paimogo respectively show reasonably high temperature of upto 63 and 75°C respectively whereas egg shells from Casal da Rola shows a moderate temperature of 32°C. The concretions also show a variable results of 55 and 16°C for Porto das Barcas and Paimogo respectively and 48°C for the concretions of Casal da Rola.

My second project was to identify the equilibrium precipitation of deep sea coral from various parts of the globe taken from the Smithsonian Museum collections. Here we report new data to further develop "clumped" isotopes as a palaeothermometer in deep-sea corals as well as to investigate mineral-specific, taxon-specific, and growth-rate-related effects. We analyzed 35 aragonitic scleractinian, high-Mg calcitic gorgonian and red precious deep-sea corals and compared results to published data for other aragonitic scleractinian taxa. Measured Δ_{47} values were compared to *in situ* temperatures, and the relationship between Δ_{47} and temperature was determined for each group to investigate taxon-specific effects. We find that aragonitic scleractinian deep-sea corals exhibit higher values than high-Mg calcitic gorgonian corals and the two groups of coral produce statistically different relationships between Δ_{47}–temperature calibrations. These data are significant in the interpretation of all carbonate clumped isotope calibration data as they show that distinct Δ_{47}–temperature calibrations can be observed in different materials recovered from the same environment and analyzed using the same instrumentation, phosphoric acid composition, digestion temperature and technique, CO_2 gas purification apparatus and data handling. The results show that the abundance of $^{13}C^{18}O^{16}O$ in CO_2 produced by acid digestion of fish otolith aragonite is a function of growth temperature, following the relationship: $\Delta_{47} = (0.103 \pm 0.013 \times 10^6)/T^2 + 0.591 \pm 0.456$ (n = 31) shown in Fig. 5 for Gorgonian and $\Delta_{47} = (0.055 \pm 0.008 \times 10^6)/T^2 - 0.071 \pm 0.096$ (n = 16) shown in Fig. 6 for Sclerentinian corals, in per mil, of $^{13}C^{18}O^{16}O$ in CO_2 relative to Carbon Dioxide Equilibriated Scale (CDES), and T is the temperature in Kelvin.

In the third project we revisited the relationship between growth temperatures of aragonitic fish otoliths and abundances of $^{13}C^{18}O^{16}O$ produced by acid digestion

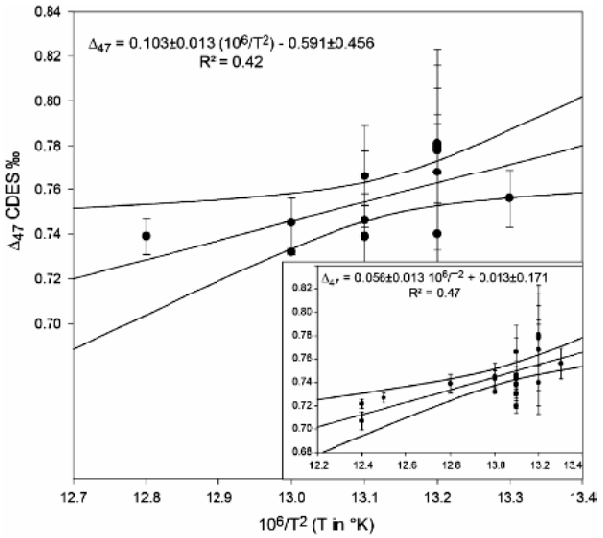


Fig. 5 - Clumped isotope calibration of Gorgonian deep-sea coral compared to results previously published by Kimball *et al.* (2015).

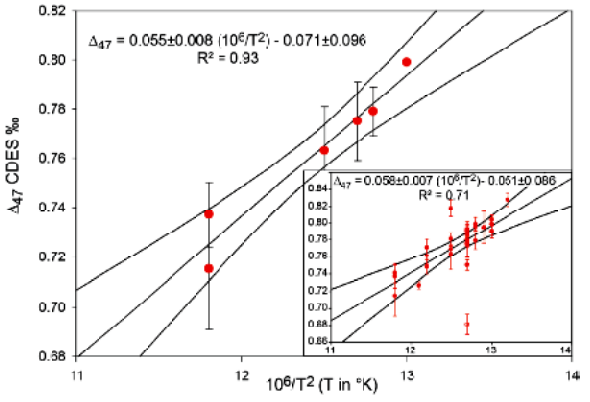


Fig. 6 - Clumped isotope calibration of Scleractinian deep-sea coral compared to results previously published by Kimball *et al.* (2015), Thiagarajan *et al.* (2011) and Ghosh *et al.* (2006).

of those otoliths. Our calibration is based on analyses of otoliths from seven species of modern fish analysed in Ghosh *et al.* (2007). The temperatures at which fish otoliths precipitated were estimated by the mean temperature in the waters, in which they lived, averaged over their estimated lifetimes. Estimated growth temperatures of our samples vary between 2 and 25°C. Our results show that the abundance of $^{13}C^{18}O^{16}O$ in CO_2 produced by acid digestion of fish otolith aragonite is a function of growth temperature, following the relationship: $\Delta 47 = (0.040 \times 10^6) / T^2 + 0.207$ is the enrichment, in per mil, of $^{13}C^{18}O^{16}O$ in CO_2 relative to Carbon Dioxide Equilibriated Scale (CDES), and T is the temperature in Kelvin.

Prasanna K. [& Prof Aradhna Tripathi, UCLA]

Investigation of palynofloral composition from Sonari Lignite bearing sequence has been carried out. The study suggests the presence of angiosperm pollen grains (*Spinizonocolpites, Kapurdipollenites, Retiverrumonosulcites, Acanthotricolpites, Clavadiporopollenites, Palmidites, Longapertites, Palmaepollenites*) are mainly referable to Family Arecaceae, and one of the oldest monocots (*Proxapertites*) Family Araceae from the preliminary study on dinoflagellate cysts assemblage, age-diagnostic taxa recorded at several levels indicates early Eocene (? Ypresian) age.

Bhagwan D. Singh
[& Poonam Verma, BSIP, Lucknow]

The study of the archaeological samples (spheroidal lumps) from the Indus Valley human civilization in north-western India has been done. Comparative study of pulse extracts shows the presence of two FAME compounds, which significantly contribute to ~ 43.5% of the total assemblage. These two compounds also occur in the lump sample extract with 30% contribution, suggesting the common or nearly common source, possibly pulse/s that may have used for the preparation of these lumps.

Runcie Paul Mathews
[& Rajesh Agnihotri, BSIP, Lucknow]

Permian coal bearing sequences of Lalmatia was studied to infer the palaeoclimatic conditions. Drastic variation in the palaeoclimatic conditions have been deciphered in the bottom and top part of the section while relatively consistent conditions prevailed in the middle part.

Runcie Paul Mathews
[& S. Suresh K. Pillai, BSIP, Lucknow]

A molecular analytical approach has been rendered to a dark coloured resinous deposit on the cave roofs of interior Ladakh region, to get more information on its nature and formation. The macromolecular characterization shows the presence of *n*-alkane compounds, aromatics and acid-ester compounds.

Runcie Paul Mathews [& Anupam Sharma, BSIP, Lucknow]

A palynological and other multi-proxy studies were carried out in Pulicat lagoon with the surface sediments collectetd after the floods in Chennai due to high winter season rainfall.

Anjum Farooqui & Anjali Trivedi

A review of the modern pollen dispersal studies, so far undertaken from the phytogeographically and climatically different regions of India, was done. The progress made in the recent years on such studies was highlighted, suggestions for overcoming limitations and recommendations for future studies were discussed.

Another review of the Late Pleistocene-Holocene vegetation and climate change from the Western and Eastern Himalaya based on palynological perspectives has been done and the manuscript on the said aspects is under review.

Ratan Kar & MF Quamar

A high-resolution multiproxy (elemental, textural, diatom, pollen, dinoflagellate cyst) decadal to centennial-scale record from the Cherai Coastal area, Kerala, southwest India was presented. The palynological record of ~ 2000 cal yr AD suggests a complex environmental condition prevailing at the depositional site augmenting the role of natural as well as anthropogenic agents either in the form of transport, human activities or natural agents of denudational processes. Multiple proxy data suggest that a shift towards wetter climatic conditions occurred during 910 to 1228 cal yr AD. The dataset also records a shift towards drier conditions started during the early 13th Century AD with a loss in vegetation diversity. This record of Cherai sediments was also compared with other continental and marine palaeoclimatic records to explore global and/or regional trends of climate variability during the past 2000 years. The present findings are coherent with the different centennial-scale episodes of warm/cool events such as Medieval Warm Period, Medieval Climate Anomaly, Little Ice Age and recent warming and support the hypothesis of marine-terrestrial teleconnection.

Manoj MC, Jyoti Srivastava, Premraj Uddandam, Biswajeet Thakur & Priyanka Seth

A spatial rainfall reconstruction for the districts of Kerala was attempted using point-by-point regression approach, based on a tree-ring chronology developed using living tree cores and left overs stumps of teak (*Tectona grandis*). The tree-ring chronology was correlated with rainfall of each districts and found May rainfall was significantly positive. Based on this relationship, spatial May rainfall was reconstructed for each district for 1745-2000 C.E. Further analysis and manuscript preparation is in progress.

S.K. Shah

Forty tree cores from 20 trees of *Pinus kesiya* were collected from Manipur during January, 2019 by L. Thomte. All cores were processed using standard methods of Dendrochronology and subsequently, a tree-ring chronology of 39 years (1980-2018 C.E.) was developed. The chronology was compared with IMD gridded daily and monthly climate datasets in order to understand the influence of climate on tree growth. Further analysis of data is ongoing and preparation of manuscript is in progress.

L. Thomte & S.K. Shah

A combined high resolution $\delta^{13}C$, total organic carbon (TOC), sediment texture and environmental magnetic analyses of the samples from a ~ 3 m deep glacial outwash sedimentary profile from the Sikkim Himalaya was done to reconstruct monsoonal variability in the Sikkim Himalaya since the last 13.7 ka. These 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. 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 Intertropical Convergence Zone (ITCZ) and variations in East Asian monsoon (EAM).

Ruby Ghosh, Shailesh Agrawal [& Sheikh Nawaz Ali]

Analysed five archaeobotanical samples received from Dr. J. Baskar, Archaeological Officer/Director-Alagankulam Excavation, Department of Archaeology, Govt. of Tamil Nadu, Chennai from Alagankulam archaeological site. Seeds of African origin *Adansonia digitata* which is regarded to have been introduced in

Fig. 6 - A. *Adansonia digitata* (Baobab Tree); B. *Adansonia digitata* (enlarged).

327 BC in Indian Subcontinent along with *Tamarindus indica*, *Citrus* sp. and *Ziziphus* sp. were recorded (Fig. 6).

Anil K. Pokharia

Atmospheric fine particulate matter ($PM_{2.5}$) has emerged as a major environmental threat especially over major cities of Indo-gangetic plains such as New Delhi and Lucknow. This PM2.5 led atmospheric pollution often experienced as severe smoky fog (SMOG)/ haze episodes in the beginning of winter months. Fine $PM_{2.5}$ particles are capable of affecting entire ecosystem, agricultural productivity and severely reduce human life longevity. A severe SMOG (smoke+fog) episode with air-visibility less than 2 km with average $PM_{2.5}$ concentration of ~ 800 µg/m^{-3} occurred in Delhi and the National Capital Territory (NCT) just after the Diwali-festival and spanned from 30th October to 07th November 2016 (Delhi-SMOG-2016). Using daily variations in chemical and isotopic signatures of $PM_{2.5}$ in tandem with meteorological parameters, we deduced primary contributing factors responsible for development of Delhi-SMOG-2016 and investigated transformation pathways of carbon, sulfur and nitrogen compounds using their stable isotopic values. The proposed recipe based on our multi-tracer analyses indicates three major factors contributing to the SMOG event- (i) transport of carbonaceous material from north-western India (mainly Punjab-Haryana) due to open-field agricultural-waste burning that rose from 26 Oct. through 11 Nov. 2016, (ii) weaker northerly winds, shallower boundary layer, cooler air temperatures, and

enhanced humidity enforcing 'atypical' air-stagnation, and (iii) direct emissions from fire-cracker bursting on 30 Oct. 2016 (Diwali night). This study was unique as for the first time it investigated apparent delay in timing of agricultural waste burning in northwestern states of Delhi after 2010; that could possibly be causing a gradual increase in severity of SMOG events in the recent years. Findings of this multi-isotopic study of atmospheric pollution phase were published in the journal *Atmospheric Pollution Research* (Elsevier; https://doi.org/10.1016/j.apr.2018.12.015).

Rajesh Agnihotri, Anjum Farooqui, Niraj Rai & Nitesh Kumar Khonde

Work with Prof. Eske Willerslev and Prof. Maanasa Raghavan (Centre for Geogenetics, Copenhegan) and on UKIERI project entitled "Using sedimentary DNA to unravel the long-term impact of environmental changes on human health and subsistence in India" is aimed at to provide novel, multi-proxy evolutionary perspectives on increasingly growing global concerns, especially plaguing developing nations such as India, surrounding the long-term impact of environmental changes on human health and subsistence. Our focus is to use a unique state-of-the-art multi-disciplinary approach, employing a combination of geo-environmental, genetic and archaeological methodologies, in order to achieve two primary objectives feeding into the overall goal of the project.

Food/water quality and its impact on human health: How do environment (climate) and humans come together over time to impact on the food and water resources in India? We will address this question by investigating the evolutionary trajectory and drug resistance strategies of the bacteria *Vibrio cholera*, the causative agent of cholera, which is transmitted via contaminated food and water and exerts a massive public health burden in India.

Food security/availability and its impact on subsistence: What is the regional domestication and evolutionary history of major crop species, especially rice, in India and how can this information inform present and future agricultural strategies? Ultimately, our project will contribute towards a multitude of fields including public health and epidemiology, vaccine development strategies, evolutionary biology, sanitation, agricultural policies and conservation in India.

Niraj Rai [& Eske Willerslev, Professor at Centre for Geogenetics, Copenhegan and Maanasa Raghavan]

Luminescence dating using feldspar has more potential (date sediments of older than 300 ka) and problems. This approach is a basic research where the involvement of band-tail states in the final luminescence output (luminescence decay curve or shine down curve). Luminescence signals arising from feldspar (infra-red stimulated luminescence; IRSL) has been fitted with Bequerel type function (combination n-exponential functions) and its temperature dependence was shown to follow non-Arrhenius kinetics (super-Arrhenius). All these observations were explained using the presence of band-tail states below the conduction band of feldspar crystal. Further, the thermal quenching has been shown to occur somewhere else rather than recombination centre, as commonly known.

P. Morthekai, Rabiul Biswas & A.K. Singhvi

Palaeosciences - a new word that is coined now-a-days and this research is a philosophical attempt (1) to define what is palaeosciences, (2) whether these sciences can be qualified to be called science in strict sense, (3) where can the palaeosciences be misused and how can these misusages be reduced, (4) what are the philosophical underpinnings for the pluralistic approach that palaeosciences undertake and (5) explanation of all the above points using the color of dinosaurs as a case study.

P. Morthekai

Quartz that has feldspar inclusion pose problems in estimating age of neither quartz nor feldspar. These two cannot be separated physically or chemically as the contamination is not at the surface of quartz but inside it. Attempt was made to see the presence of feldspar inside the quartz by petrological microscope on thin slides having half cut quartz grains. The presence of feldspar of size less than 5 μm was observed. Raman Spectroscopy is expected to give the spectroscopy features of the inclusion which will help to confirm whether it is feldspar or something else.

P. Morthekai, Priyanka Singh, S. Nawaz Ali, Santosh Pandey, Parminder Singh, Ipsita Roy [& Jeyangonda Perumal, WIHG, Dehradun]

The inter-institutional, interdisciplinary team work in scientific research has resulted in significant outcome, in the form of research papers.

There have been total 140 samples measured of luminescence in Risoe TL/OSL Reader - 1 and 2. TL/OSL Reader - 2 has been functioning since 30.05.2018.

These 140 samples include commercial sample and in-house project samples.

Collaboration with BHU (as the External Supervisor of Jyotsna Dubey) continued the collaborative research with Dr. P. Morthekai, Dr. S. Agrawal, Dr. B. Phartiyal, Dr. A. Sharma, Dr. Biswajeet Thakur and Dr. P. Govil (BSIP).

Sheikh Nawaz Ali, Anupam Sharma & Binita Phartiyal

Vertebrate fossils (mammalian) collected from the Gangetic plain (north India) to understand the biodiversity, palaeoecological and palaeoenvironmental changes and its relation with climate change during the Quaternary Period. Preparatory work on vertebrate remains for subsequent morphotaxonomic and related inferences is in process.

Kamlesh Kumar, Anupam Sharma, Mukesh Yadav & Vivesh V. Kapur

Carbon isotope ($\delta^{13}C$) and rare earth element (REE) concentrations in representative samples of the shallow marine Subathu Formation, explored from the Neelkanth and Dogadda sections of Northwestern Himalaya (India) were determined to infer the palaeo-environmental condition during the late Paleocene and middle Subathu Eocene Formation. The depositional setting, biostratigraphical constrained age along with $\delta^{13}C$ values and lower TOC suggested an intense warm period, that might be coeval with the Paleocene-Eocene Thermal Maxima event (PETM).

M.K. Shukla & Anupam Sharma

The study on different parts of mobile phones were studied following the leaching tests and it was found that the waste mobile phones must be considered as hazardous due to the potential adverse impact of toxic metals on human health and environment. However, mobile phones can be an asset as systematic extraction and recycling could reduce the demand of primary metals mining and conserve the natural resources.

Anupam Sharma & P. Morthekai (& Meenakshi Hira, SudeshYadav, Anurag Linda & Sushil Kumar)

Understanding the dynamics of life under extreme climate provides valuable information about the diversity and causative factors that play a governing role in biotic adaptations. The study on diatom diversity have been explored in water samples belonging to Penzi-la lake (6 samples) and Zanskar River (18 samples) and their response to underlying physical parameters at an altitude of ~4500 m asl. These analyses supports our hypothesis that diatoms and physio-chemical parameters bear S. premiere relation and this hold true under the high altitudinal stressed environments.

S. Nawaz Ali, Anupam Sharma, Biswajeet Thakur, P. Morthekai, Shazi Farooqui, Binita Phartiyal & Priyanka Seth

The Trans-Himalayan region of NW India's landscape is fairly understood. Over the years, our understanding in drawing climatic inferences from the sedimentary archives has improved significantly but the discrepancy in chronology, among and within different dating techniques, poses a serious challenge. Similarly, till recently, it was argued that the major source of moisture to the Ladakh region is contributed from the Mediterranean Sea, however, it is emphasized that Indian Summer Monsoon source is also an equally important supplier. The review work highlights that the disturbed chronology and inadequate data support on moisture sources are two grey areas for further research.

Anupam Sharma & Binita Phartiyal

With the help of Isotope Ratio Mass Spectrometer carbon, oxygen and nitrogen isotopic study have been performed on various institute projects. Data interpretation work is going on. The details are given below.

Recent samples

a. Total organic carbon (TOC) and carbon isotopic analysis of Honey samples (Dr. Anjum Farooqui), bulk sediments, Himalayan region (Dr. Ratan Kar), plants samples, Gujarat (Dr. Kamlesh Kumar), and sediments and modern plants samples Ladakh (Dr. S. Nawaz Ali) have been done.

Quaternary

b. TOC and carbon isotopic analysis of lake sediments, Varanasi (Dr. Anupam Sharma), sedimentary profile, central Himalaya (Dr. P.S. Ranhotra & Dr. Ruby Ghosh), lake sediments, Central India (Dr. Kamlesh Kumar) and south India (Dr. Manoj MC) have been done.

c. TOC, total nitrogen (TN), carbon and nitrogen isotopic analysis in the proglacial lake, Ladakh (Dr. Anupam Sharma & Dr. S. Nawaz Ali) have been done.

d. TOC, TN, carbon and nitrogen isotopic analysis and C-O analysis in marine sediments, Bay of Bengal have been performed (Dr. Pawan Govil).

e. Carbon and oxygen isotopic study of carbonate nodules, Mahi Basin, bulk sediments, Ladakh (Dr. Anupam Sharma) and tooth enamel sample (Dr. Neeraj Rai) have been done.

Paleocene-Eocene

f. TOC and carbon isotopic study of Giral Mine samples (Dr. Vandana Prasad), NE Himalayan and Sonari mines samples (Dr. Anupam Sharma), lignite samples (Dr. Poonam Verma) and leaf samples, Gurha Mine (Dr. Anupam Sharma) have been done.

Permian

g. TOC, TN, carbon and nitrogen isotopic analysis in the coal and shale samples, Barakar Formation, Jharkhand (Dr. Suresh Pillai).

Precambrian

h. TOC and carbon isotopic study of Marwar, Cudappa and Vindhyan Supergroup samples have been done (Dr. Arif Ansari & Mr. Yogesh).

i. Carbon and oxygen isotopic analysis in the carbonate samples, Bhander Group have been carried out (Dr. Santosh K. Pandey).

Sediment samples from various terrestrial settings:

- Rare earth elements and trace element analysis have been done for Dr. Anupam Sharma.
- Rare earth elements and trace element analysis have been done for Dr. S. Nawaz Ali.
- Rare earth elements and trace element analysis have been done for Dr. Arif Ansari.
- Rare earth elements and trace element analysis have been done for Dr. Santosh Pandey.
- Rare earth elements and trace element analysis have been done for Dr. Veeru Kant Singh.
- Rare earth elements and trace element analysis have been done for Dr. Gurumurthy.

Chairman, Governing Body BSIP taking interest in Museum in visit

Collaborative Projects

An attempt has been made to understand the possibility of life in the Venus's cloud by interpreting the spectral signature especially from the lower cloud layer (~ 50 km above from Venus's surface). The lower cloud layer host favourable environment, i.e. ~ 1 atmospheric pressure and 60°C temperature for the Earth based bacteria. In addition, the spectral signature suggests that this part of the cloud is mainly composed of Fe-S molecules that can provide the source of energy by electron shuttling between ions and molecules for a microbial life to grow and multiply. The spatio-temporal spectral changes in contrast and albedo between 300 and 500 nm are commonly attributed to micron size sulphur based particles. However, understanding the nature (biogenic and abiogenic) of these particle require lab based experiments to find the possible candidate with similar optical properties.

A.H. Ansari
[S.S. Limaye (University of Wisconsin, USA)]

Performed Confocal Laser Scanning microscopic studies to understand the high resolution sub-micron level morphological characteristic of *Ceiba* Mill. (Bombacoideae, Malvaceae) pollen over Light Microscopy and Scanning Electron Microscopy. The study has been finalized and published in the journal *Palynology*.

Swati Tripathi, Anjum Farooqui & Veeru Kant Singh
[Shilpi Singh & Rup Kumar Roy, CSIR-National Botanical Research, Lucknow]

To demonstrate the evolution of midrib and venation pattern, megafloral assemblage recorded from the Barakar sediments of Dholpahar section along Singda Rivulet near Gopal Prasad Village in Talcher Basin have been studied. The assemblage comprises of equisetaceous stems, *Gangamopteris buriadica*, *Palaeovittaria kurzii* and 19 species of the genus *Glossopteris*. Record of *Gangamopteris, Palaeovittaria* and many narrow mesh forms of *Glossopteris* from two older fossiliferous horizons demonstrates that these fossils were preserved during Lower Barakar sedimentation. The presence of middle and broad mesh forms of *Glossopteris* in the youngest fossiliferous horizons reveals that these fossils were preserved during the deposition of Upper Barakar sediments. The continuation of some of the Karharbari plant fossils in the early phase of Barakar Formation and their disappearance in the flora of Late Barakar suggests a shift in the climatic setup. Palaeoclimate and palaeovegetation of this area are also summarised in this study. Moreover, the fossil assemblages of different fossiliferous beds of Dholpahar section demonstrate the evolution of midrib and meshes in different reticulate leaves.

Anju Saxena & K.J. Singh
[& Shreerup Goswami (Univ. of Sambalpur, Odisha)]

Diatoms were studied from the 2.8 m thick lacustrine profile of Lahuradewa Lake, Ganga Plain to infer human occupation in the form of paddy cultivation since about 10,000 kyrs. The variation in planktic and benthic diatoms forms reflects changes in the water budget of the lake in response to the change in rainfall, viz. more planktic in humid phases and less planktic in dry phases. These changes correspond to the changes identified by other proxies, namely phytoliths. Paddy field diatoms are present in good numbers since ~ 8 ka along with anthropogenic diatoms; their numbers increase during dry phases and decrease in humid phases. This supports the contention that humans were living in this area since early Holocene and agriculture activity started around 8 ka. Presence of paddy field diatoms in lake sediments is rather unique. It is argued that the lake margin was used for paddy cultivation. Intermittently, sediment and organic remains namely paddy field diatoms, rice phytoliths and grass microcharcoal were washed from lake margin agricultural fields into deeper parts of the lake, those were preserved in the lake sediments.

Anju Saxena & Biswajeet Thakur
[& I.B. Singh (INSA Senior Scientist)]

A manuscript entitled "Palynology of the *Cyclolobus walkeri* bed, Gungri Formation (Late Permian), Spiti Valley, Northwest Himalaya, India" was finalized. Diverse assemblage of palynomorphs has been recorded for the first time from the ammonoid *Cyclolobus walkeri* bearing top bed of the Gungri Formation, Lingti Road Section, Spiti Valley. The palynoassemblage reveals the dominance of striate bisaccate pollen grains namely *Faunipollenites perexiguus*, *Striatopodocarpites magnificus*, *Crescentipollenites fuscus*, *Densipollenites magnicorpus* along with some early Triassic palynomorphs, viz. *Lunatisporites pellucidus*, *Playfordiaspora cancellosa*, *Satsangisaccites nidpurensis* and *Chordasporites australiensis*. The

assemblage indicates a late Permian (Changhsingian) age for the Gungri Formation. The palynoflora bears similarity with those of the late Permian of peninsular India, other Gondwanic continents and those found along the west Tethyan margin including Pakistan and Israel.

Deepa Agnihotri, Rajni Tewari, Ram Awatar & Saurabh Gautam [& Shreerup Goswami (Sambhalpur University, Odisha); Michael Brookfield (University of Massachusetts, Boston, USA); Jeremy Williams (Kent State University, Ohio, USA)]

A detailed investigation on palaeofloristics, palynology and organic geochemistry of fossiliferous horizons has been carried out in and around Ustali area of Ib River Basin, Odisha, India. The complete macrofloral assemblage comprises equisetaceous stems, *Schizoneura gondwanensis* (Equisetales); *Trizygia speciosa* (Sphenophyllales); *Neomariopteris polymorpha, N. talchirensis* (Filicales); 26 species of *Glossopteris;* 3 species of *Gangamopteris; Vertebraria indica; Plumsteadiostrobus pretiosus* (scale leaf)*;* stem cast and three dispersed seed genera, viz. *Samaropsis, Cordaicarpus, Rotundocarpus* (Glossopteridales). The floral assemblage of the lower fossiliferous horizon, i.e. off-white silty shale comprises *Gangamopteris* and narrow and medium mesh form *Glossopteris* species; whereas, the assemblage of uppermost grey shale consists of medium and broad mesh form *Glossopteris* species and *Neomariopteris*. It demonstrates a marked change, thereby advocating two different floral zones in the Raniganj rocks of the Ustali Village in Ib River Basin. These floral zones demonstrate the evolution of midrib and meshes in different reticulate leaves. Upper floral zone belongs to the late Upper Permian (Changhsingian age), while the lower floral zone belongs to the early Upper Permian (Wuchiapingian age). The palaeobotanical investigations and lithology of the investigated area of the Ib River Basin have identified the presence of the Raniganj Formation sediments (Lopingian epoch) exposed in the studied section. The palynoassemblage recovered in the section reveals the predominance of the genus *Striatopodocarpites* spp. and sub-dominance of *Faunipollenites* spp. along with some stratigrahically significant taxa, viz. *Densipollenites magnicorpus, Crescentipollenites globosus, Chordasporites australiensis, Falcisporites nuthaliensis, Stroters-porites perfectus, Lunatisporites pellucidus, Striomonosaccites* spp., *Guttulapollenites hannonicus*, *Weylandites lucifer* and *Kamthisaccites kamthiensis*. It confirms its resemblance with the Raniganj palynoflora of the late Permian affinity. The biomarker analysis indicates a high contribution of algal and microbial organic matter during the deposition. However, the overall biomarker composition and distribution suggests an increased thermal maturity of the studied samples.

S. Suresh K. Pillai, Neha Aggarwal, Runcie P. Mathews & Anju Saxena, [& Shreerup Goswami (Univ. of Sambalpur, Odisha)]

Palynological investigation of bore-hole GDH-42, drilled at Barapukuria Basin, Dinajpur District, Bangladesh, has for the first time indicated that the coal belongs to Barakar Formation of Early Permian age. Earlier known occurrences of coal from the same basin had placed the deposits in the Raniganj Formation. The palynological assemblage recorded in the present study in bore-hole GDH-42 from Barapukuria Basin, Bangladesh, shows a close resemblance with the palynoflora described from the Barakar Formation of different Indian Gondwana sequences like Son-Mahanadi, Damodar and Godavari Valley basins. The palynological assemblage shows an overwhelming dominance of *Scheuringipollenites,* followed by striate bisaccate forms, viz. *Faunipollenites* and *Striatopodocarpites*.

Ratan Kar, Subhankar Pramanik & Amit K. Ghosh [& Subrata Saha (Environment Science Discipline, Khulna University, Khulna, Bangladesh) F. Haque (Department of Geology, Dhaka University, Dacca, Bangladesh)]

The Conifer genus *Brachyphyllum* (Brongniart) Lindley & Hutton and its species *Brachyphyllum regularis* Borkar & Chiplonkar is reported for the first time from Hathmati River Section of Himmatnagar Sandstone of Gujarat State (Fig. 1). Its thick leathery leaves are adapted to long period of drought and cold

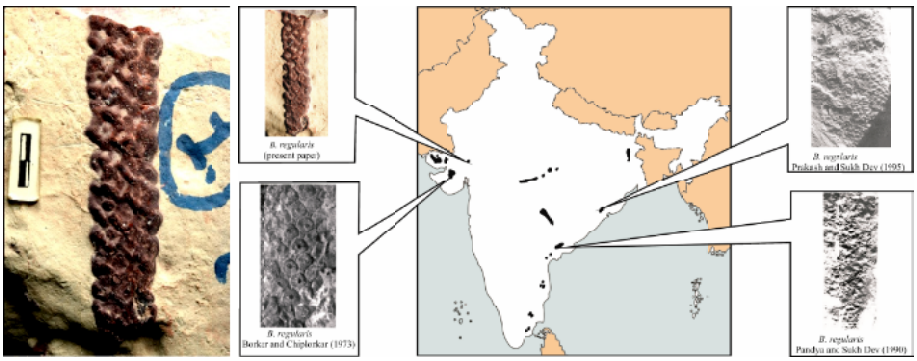


Fig. 1 - (i) *Brachyphyllum regularis* Borkar et Chiplonkar from Himmatnagar, Sandstones, Gujarat, (ii) Geographical distribution in India.

conditions which is evidenced by its cuticular characters, e.g. thick, mostly hypostomatic cuticle, sunken stomata, circularly arranged subsidiary cells with thick walls and presence of stomatal hairs. Xeromorphic adaptations indicate that araucarian trees often grew in forest not far from the coastal area in tropical to subtropical climatic conditions.

Initially it was only reported from Songarh of Kathiawar, later it was also reported from Athgarh and Gollapalle formations of east-coast. Its occurrence in Himmatnagar Sandstones is very significant as it extends its geographic distribution from east to west of Indian Gondwana basins.

Neeru Prakash & Neelam Das
[& Nishith R Bhatt & Paras M Solanki
(M.G Science Institute, Ahmedabad)]

First record of plant fossils from Lanela Member of Baisakhi Formation – The plant fossils were collected from the Bhadasar ridge scarp section which is exposed along road side on the south of Bhadasar Ridge. They are preserved in coarse-grained ferruginous sandstone. The preservation of fossils is very poor. Although some characteristic features are visible to identify the fossils. For the first time plant fossils are recorded from the Lanela Member of Baisakhi Formation. These fossils are *Equisetites* (Pteridophytes), *Williamsonia* (Bennettitales), *Taeniopteris* (Cycadales) and *Brachyphyllum*, *Elatocladus*, *Stachyotaxus* and *Araucarites* (Conifers). The plant megafossil assemblage is dominated by conifers over cycadophytes (Bennettitale and Cycads) however pteridophytes are not preserved. Presence of *Stachyotaxus* Nathorst within the assemblage is quite important as this form genus of megastrobilus has been reported earlier from Rajmahal and Kachchh basins only and was not reported earlier from other Gondwana basins. Florin while discussing its affinity had opined that it belongs to family Podocarpaceae. The assemblage is akin to Floristic Zone 9 of Sukh-Dev where too conifers are dominant over cycadophytes with fewer occurrences of pteridophytes.

Neeru Prakash & Neelam Das
[& Krishna Kumar (GSI, Jaipur)]

Plant fossils (*Ptilophyllum* and *Cladophlebis* fronds) have been recorded for the first time from Katrol Formation (Kimmeridgian) of Kachchh Basin from a horizon about 18.70 m below the top bed of a section exposed along the road (4 km to Jawahar Nagar Village) in the eastern part of the Kachchh mainland. The succession belongs to the middle member (Rudramata shale) of the Jhuran Formation (= Katrol Formation). The plant fossils bearing bed is about 140 cm thick, lithologically characterized by whitish, argillaceous fine sandy siltstone with the top 10 cm represented by ferruginous sandstone with vertical burrows. The occurrence of *Ptilophyllum* and *Cladophlebis* fronds within the Kimmeridgian succession of the Katrol Formation of the Kachchh Basin suggests terrestrial influx. During this time interval, the biomass of the floral assemblage was overwhelmingly dominated by *Ptilophyllum* fronds over other palaeo-floristic components that is coeval to Floristic Zone No. 8 of Sukh-Dev. Long sized pinnate bennettitalean fronds with their morphological and anatomical features suggest xeromorphic adaptability and strategy to minimize water loss in subtropical to tropical climatic conditions. It indicates that probably they were growing in a low land or near coastal regions. Well preserved large sized compound leaves suggests that the leaf litters were not subjected to long distance transportation as these were preserved in low water energy and low rate of sedimentation not far from channel.

Neeru Prakash & Neelam Das
[& Dhirendra Kumar Pandey
(Manipal University, Karnataka)]

Palynological, fossil charcoal and biomarker analysis were carried out to establish the age, to understand the anatomy of fossil wood and type of compounds characteristics of fire events on the sub-surface sediments from borehole DHL #2 drilled at Dhulia Block in Rajmahal Basin. The palynological investigation indicates the presence of only one palynoassemblage (*Scheuring-ipollenites, Faunipollenites*) belonging to lower part of Barakar Formation, early Permian (Artinskian). The study also reveals the dominance of Glossopteridales and subdominance of Cordaitales and Coniferales. The fossil charcoal study is an additional information from the early Permian (Artinskian) wildfire data from peninsula of India. The analysis involves scanning electronic microscopy (SEM) for understanding anatomical features of fossil charcoal (Fig. 2). All the charcoal fragments exhibit homogenised cell wall, uni to biseriate pitting and rays with single cell wall on the tracheids pointing to gymnospermous affinities. Fare preservation, large in size almost without abraded edges suggest their hypoautochonous nature.

The biomarker characterization indicates the presence of *n*-alkanes, isoprenoids, terpenoids and aromatic compounds. Bimodal distribution of *n*-alkanes with a C_{max} at *n*-C_{25} has been observed. Diterpenoids and pentacyclic terpenoids have been identified these indicate

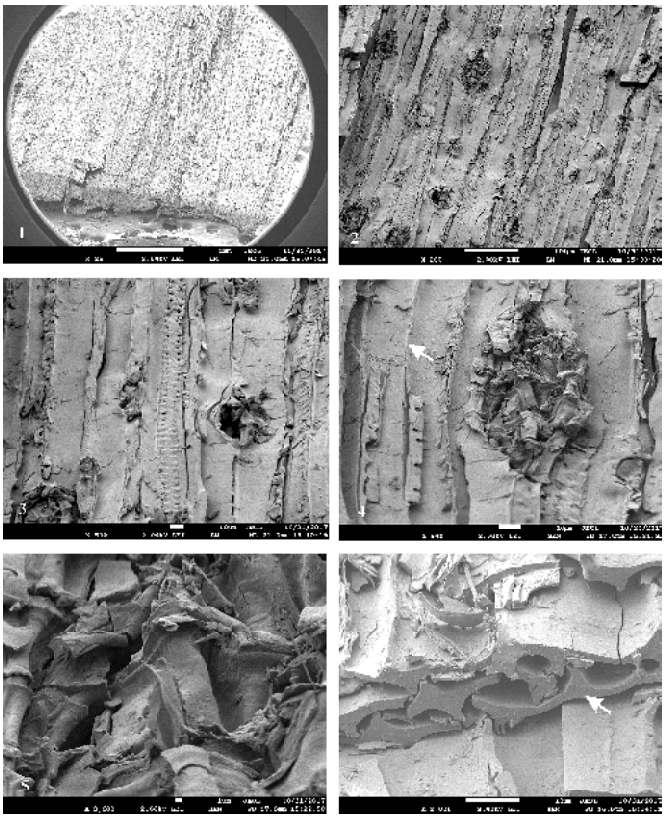


Fig. 2 - Scanning electron microscopic (SEM) photographs of fossil charcoal (depth 88.00 m) from borehole DHL #2, Rajmahal Basin. 1. Overview of charcoal fragments, 2. Tracheids in tangential view showing single celled rays high, 3. Detailed tracheids showing biseriate pits and uniseriate rays high, 4. Detailed tracheids showing cell wall (arrow) and uniseriate rays high, 5. Detailed view of uniseriate rays high, 6. Tracheids in cross section showing homogenized cell wall.

the inputs of conifer vegetation and bacterial activity. Polyaromatic hydrocarbon (PAH) compounds identified in the samples along with the charcoal fragments together clearly suggest that the fire events occurred during the formation of these sediments.

Srikanta Murthy & Runcie Paul Mathews
[V.A. Mendhe (CIMFRS - CSIR LAB, Dhanbad)]

The first palynological investigation of the Andigama Basin (borehole AND01) in Sri Lanka was undertaken to assess the palynological composition, palynofacies, and palaeoenvironment of the sediments. The palynofloral composition suggests an age of the late Jurassic to early Cretaceous (Tithonia-Berriasian).

The palynological assemblage is demarcated by the predominance of coniferous pollen grains of *Araucariacites* spp., *Callialasporites* spp. along with some stratigraphically significant taxa (Fig. 3). Palynofacies (I-III) content shows the dominance of terrestrial phytoclasts, palynomorphs and Amorphous Organic Matter (AOM) respectively. Palynofacies-I defines dysoxic conditions in fluvio-deltaic settings, Palynofacies-II suggests autochthonous and proximal settings in humid conditions at the depositional site and Palynofacies-III indicates dysoxic-anoxic environment at the depositional site.

Neha Aggarwal
[& W.A. Panchala Weerakoon (Sri Lanka)]

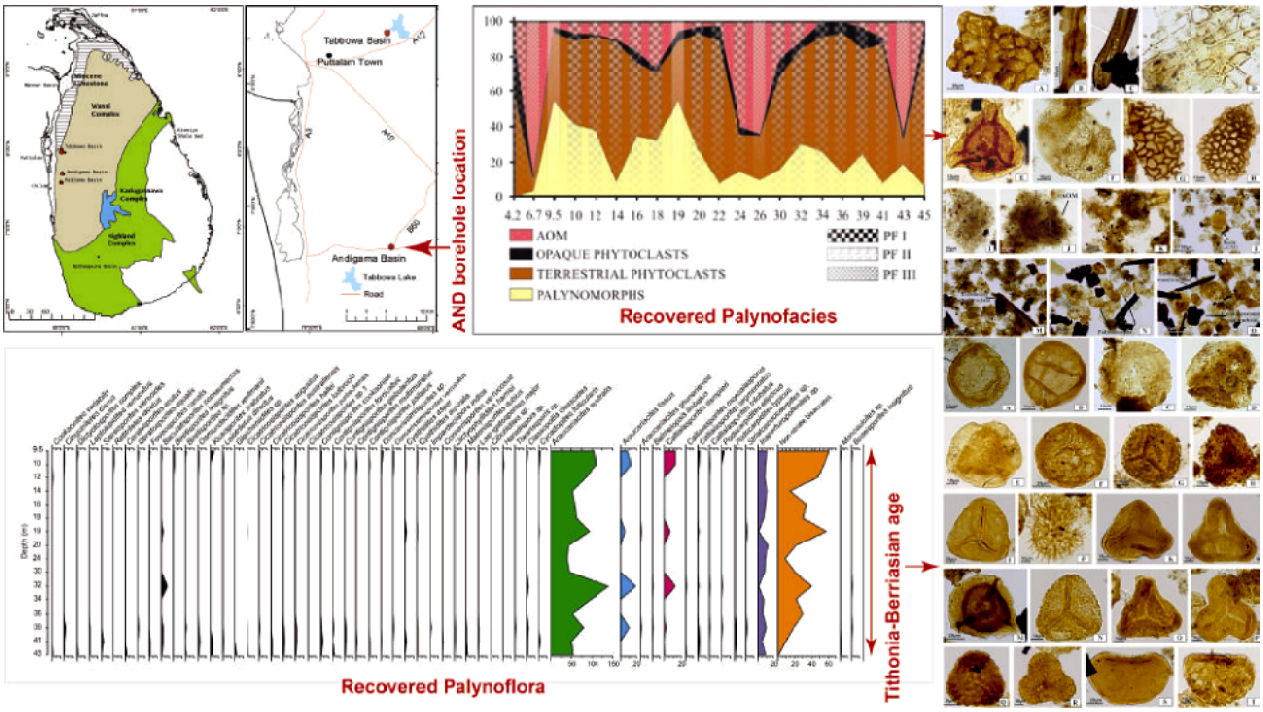


Fig. 3 - Palynological and palynofacial analyses carried out in borehole AND01, Sri Lanka.

Worked on the palm megafossil collected from the Lunpola Basin of the central Tibet. The recovered palm belongs to late Oligocene (~25 Ma) age. On the basis of this palm fossil, we have inferred that during the deposition of the sediments of Lunpola Basin was a deep valley that was not more than 2.3 km a.s.l. in height in central Tibet.

Gaurav Srivastava [& Tao Su, Xishuangbanna Tropical Botanical Garden, Yunnan Province, China].

Worked on the megafossil leaves collected from the Lukundol Formation of the Kathmandu Valley which belongs to late Pleistocene age. Two fossil leaves have been identified as *Albizzia* and *Bauhinia* of the family Fabaceae. Further work on these fossil leaves is in progress.

Gaurav Srivastava [& Prof. Khum N. Paudiyal, Tribhuvan University, Nepal]

A number of fossil woods from the Cuddalore Sandstone of south India were investigated and published.

R.C. Mehrotra & Anumeha Shukla [& Dr. N. Awasthi]

Testate amoeba extracted from Middle Siwalik claystone sediments deposited during Upper Miocene, Darjeeling, West Bengal (Fig. 4). Total 30 species belonging to eight families of the testate amoebae were recorded. Based on the occurrence of variety of Testate amoeba it has been concluded that the conductive humid habitat (mean annual temperature of 23-27°C and precipitation > 200 cm) and the land connections as well as species migration took place during Miocene between the Indian subcontinent and the adjoining Eurasia and perhaps that resulted in the diversification of these protists in the northeastern India.

Hukam Singh [& Anjum Farooqui BSIP]

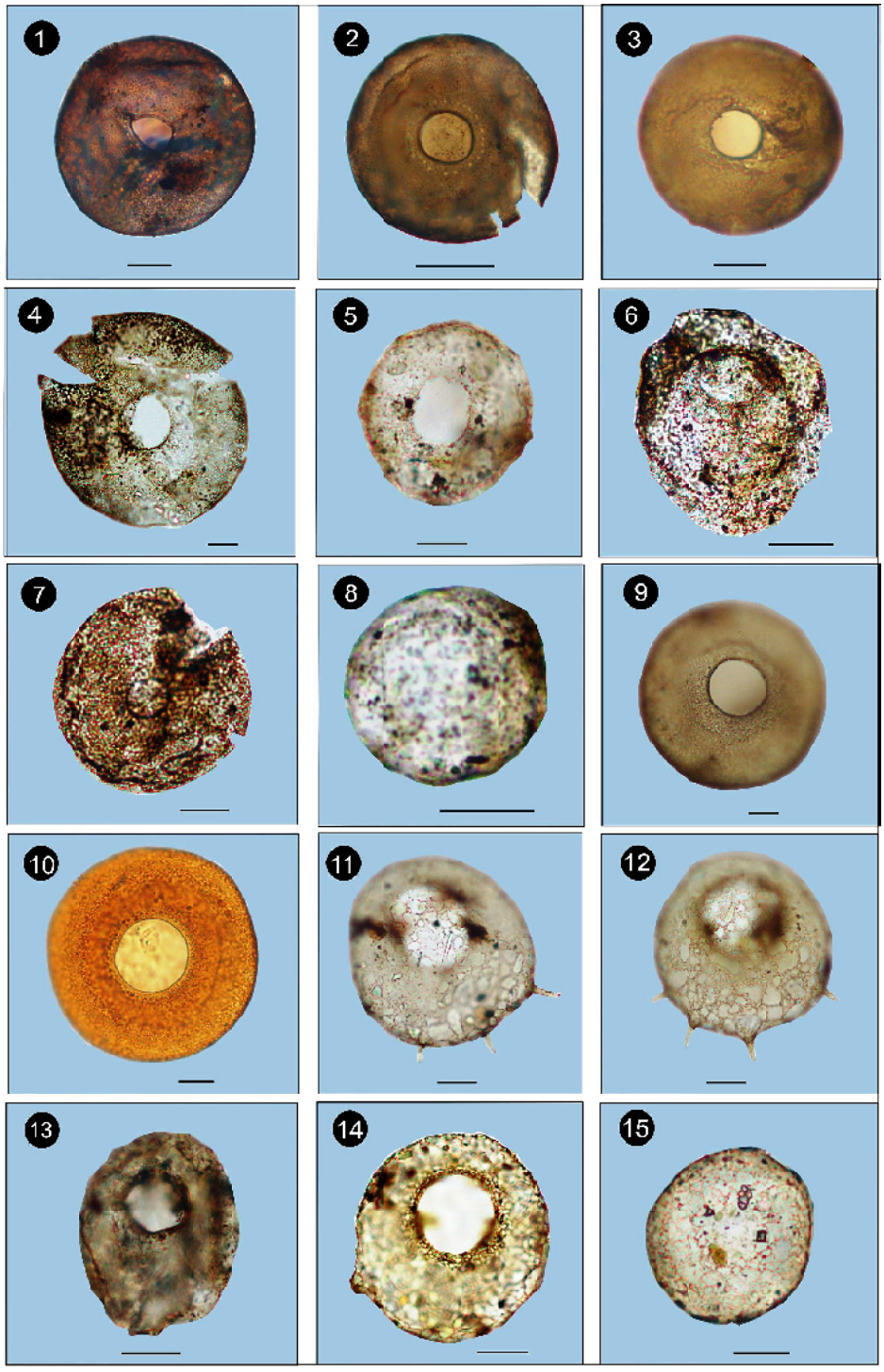


Fig. 4 - Testae amoeba recorded from Upper Miocene age of the Middle Siwalik sediments.

A new fossil wood of *Hopeoxylon,* i.e. *H. umarsarensis* sp. nov. showing close resemblance with modern wood of *Sindora*/*Copaifera* of the subfamily Detarioideae (Family Fabaceae) has been described from the Umarsar Lignite Mine of Kutch Basin, Gujarat (Fig. 5). This is the oldest fossil record of *Sindora*/*Copaifera* which contributes towards the understanding of the origin and palaeo-dispersal pathways of this early-diverging

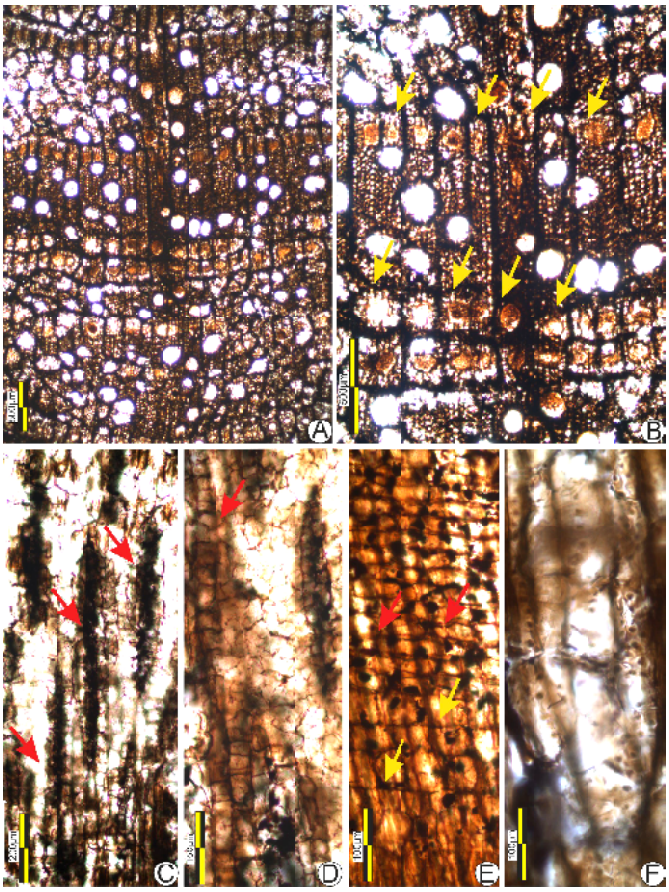


Fig. 5 - *Hopeoxylon umarsarensis* sp. nov. (A) Cross section of the fossil wood showing arrangements of vessels and rows of gum canals at variable distance, (B) High resolution of the cross section of the fossil wood showing rows of gum canals at variable distance (yellow coloured arrows), (C) Tangential longitudinal section of the fossil wood showing 1–2 seriate rays (mostly uniseriate) (red coloured arrows), (D) Tangential longitudinal section of the fossil wood showing chambered parenchyma cells (red coloured arrows), (E) Radial longitudinal section of the fossil wood showing heterocellular rays, upright cells (yellow coloured arrows) and procumbent cells (red coloured arrows), (F) Radial longitudinal section of the fossil wood showing intervessel pits.

subfamily within the basal Fabaceae.

Hukam Singh
[& Anumeha Shukla & Rakesh Chandra Mehrotra]

Fifteen samples were analysed for nannofossils from Upper Limestone Member (Antalo Limestone) exposed at Mugher (Blue Nile Basin) Ethiopia, eastern Africa. Two samples were found productive for nannofossils, one at the base (sample 1965 m) and the other at the top (2043b m) (Fig. 6). Diversity is low in both the samples (recorded 9 nannofossil species from 1965 m sample; 12 nannofossil species from 2043b m sample). Sample 1965 m yielded fairly preserved, moderately productive

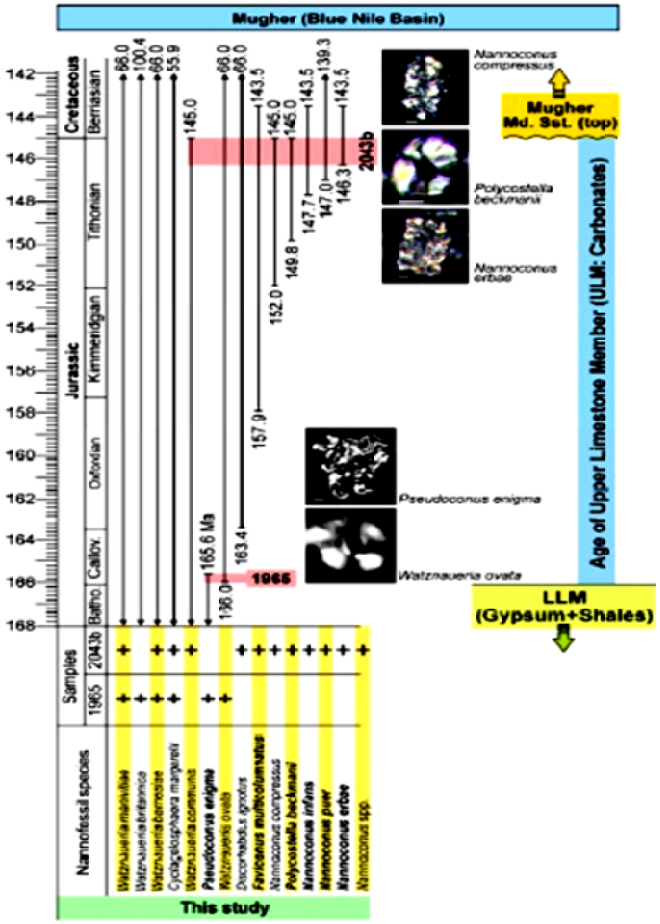


Fig. 6 - Nannofossil record from 1965 and 2043b samples, their stratigraphic range and age assignment of the Upper Limestone Member, Blue Nile Basin, Ethiopia.

nannofossils. The preservation of nannofossils in sample 1965 m is better than in sample, 2043b m, which contains fairly good number of nannofossils but of moderate preservation. In the later sample some forms are showing effect of dissolution and some forms are overgrown due to recrystallization.

The Upper Limestone Member yielded *Watznaueria barnesiae* dominated assemblage with age–diagnostic marker taxa of nannofossils. Sample No. 1965 m, from the base of the ULM yielded characteristic Early Callovian forms of *Pseudoconus enigma* and *Watznaueria ovata*. *P. enigma* spans from the base of the NJ11 zone (Bajocian) to the top of NJ12a subzone whereas *W. ovata* starts only from the base of the Callovian stage (163.47–166.07 Ma). This suggests that the sample no. 1965 m is of earliest Callovian. Sample 2043b has yielded *Nannoconus* (*N. compressus*, *N. erbae*, *N. infans* & *N. puer*) and the presence of marker taxa *Polycostella beckmannii* has been observed. The presence of *Nannoconus* is indicative of the advent of Tithonian. *P.*

beckmannii is a zonal marker for NJT15b and ranges upto the end Tithonian. Based on the nannofossil assemblage, it is safe to assign sample no. 2043b between the lower part of the NJT17a subzone to the end of Tithonian (145 Ma).

Abha Singh
[& Prof. Sreepat Jain (Adama Science & Technology University, Ethiopia)]

To understand the origin, early evolution and historical biogeographic significance of the fossil Sirenian (seacow) from the Tertiary (particularly Eocene, Oligocene and Miocene) sedimentary sequences of Kutch, western India, numerous skeletal remains (skulls and associated post cranial remains) of sirenians were

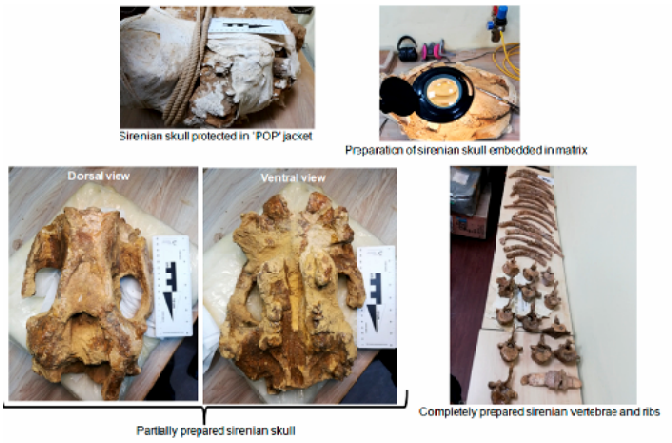


Fig. 7 - Numerous skeletal remains of sirenians were collected from the Tertiary sequences of Kutch, western India.

collected from the Tertiary sequences of Kutch, western India (Fig. 7). Preparation works and morphometric analyses in a phylogenetic framework on the collected Sirenian remains are in progress.

Vivesh V. Kapur
[& Daryl P Domning (Howard University, Washington DC, USA)]

To understand the biodiversity, ecological and historical biogeographic aspects (related to sea level fluctuations during the Neogene) pertaining to the fossil mammals (both terrestrial and marine) and associated vertebrates from the Neogene sedimentary sequences of Kutch, western India, the preparation works and morpho-taxonomic studies on the collected skeletal elements (isolated dentition, mandibles, maxillary fragments and post-cranial remains) are in process.

Vivesh V. Kapur
[& Martin Pickford (Sorbonne Universités, MNHN, CNRS, Paris, France)]

Hominoid remains from Miocene deposits in India and Pakistan have played a pivotal role in understanding the evolution of great apes and humans since they were first described in the 19th Century. A hominoid maxillary fragment preserving the canine and cheek teeth collected in 2011 from the Kutch (= Kachchh) Basin in the Kutch, Gujarat, western India has been described (Fig. 8). A basal Late Miocene age is proposed based on the associated faunal assemblage that includes *Hipparion* and other age-diagnostic mammalian taxa. Miocene Hominoidea are known previously from several areas of the Siwalik Group in the outer western Himalayas of India, Pakistan and Nepal.

This is the first record of a hominoid from the Neogene of the Kutch Basin and represents a significant

Fig. 8 - Field photographs of Miocene fossil-bearing exposures in Gujarat, western India.

southern range extension of Miocene hominoids in the Indian peninsula. The specimen is assigned to the Genus *Sivapithecus*.

Ansuya Bhandari
[& Dr. Richard F. Kay, Dr. Blythe A. Williams, Dr. Sunil Bajpai & Dr. B. N. Tiwari]

Total organic carbon, Mo concentrations and organic carbon isotope analysis of black shales from Vindhyan Basin revealed stratified Vindhyan hydrosphere with anoxic and sulfidic deep water. However, Vindhyan sea developed an euxinic deep water setting during various stages of deposition of Arangi, Rampur and Bijaygarh shale members. The low concentration of Mo and Cr suggest moderate to depleted reservoir respectively.

Arvind K. Singh
[Partha Chakraborty (DU) & Subir Sarkar (JU)]

Micromorphology of the paleosols indicate three phases of humid conditions spanning 90–80 ka, 50–30 ka, and 10 ka with intervening drier conditions. The paleosols formed during the humid phases are defined by extensive illuviation, increased mineral weathering, and strong pedogenic activity. Dominance of pedogenic carbonates and weak pedogenic development suggest drier conditions during 75–60 ka and 30–20 ka. Alluvial cyclicity of the GYI successions based on intensity of pedogenic development and presence of Bt horizons shows differences in the fluvial aggradational cycles (FACs), FAC sets, and the sequence boundaries (Sb) on account of allogenic and autogenic controls. Two major sequence-boundary features at ~ 80 ka and ~ 10 ka are defined by the formation of Alfisols over the entire GYI. These define large-scale degradation, hiatus in sedimentation, and incision across the entire interfluve over the last 100 ka which may be caused by a progressive uplift, incision, and tilting of the interfluve during this period. It has been demonstrated that the mature paleosols in fluvial strata of the alluvial valleys like the Ganga Plains can serve as useful stratigraphic markers to describe the non-marine sequences.

Arvind K. Singh
[Pankaj Srivastava (DU) & Associates]

To understand depositional environment of the Karewa Basin grain size analysis was carried out on Early Pleistocene sediment samples from Kashmir Valley.

Anjum Farooqui, Suresh K. Pillai, Deepa Agnihotri, Rajni Tewari, Sunil K. Shukla, Sajid Ali, Anjali Trivedi, Kamlesh Kumar, Salman Khan
[& S.K. Pandita, G.D. Bhat (Jammu University, India)]

The otolith clumped isotope calibrations have been used to validate the temperature and environmental water composition of Arabian Sea using Tuna (*Thunnus albacares*) and Bay of Bengal using Big eye snapper (*Lutjanus lutjanus*) otoliths. The estimated average oxygen isotope in surface water was 0.82±0.8‰ which is comparable to the average value of -0.3±0.4‰ reported from the coastal water of the region. The applications were further extended to study the bottom water temperature from well preserved otoliths of *Ambasidarum* sp. from the sediments of Quilon Basin of India deposited during the Miocene time. The technique was employed to estimate the average bottom water temperature (38°C), which is similar to the calculated climatic estimates for temperature based on Co-existance Approach Kern *et al*. (2013)

Prasanna K & Vivesh Vir Kapur
[& Prof Prosenjit Ghosh, IISc]

Vitrinite reflectance analysis of lignites of Bikaner-Nagaur Basin has been done. The calculated mean values of huminite reflectance range from 0.23 to 0.30% (av. 0.26% $R_{r\,mean}$), suggesting immature nature.

Runcie Paul Mathews
[& Alok Singh, RGIPT, Rae Bareli]

The palynological study on the proboscis of the moth samples from Arunachal Pradesh was carried out. Out of the 25 samples, 10 samples were found potential. The overall study on the proboscis of moth sample reveals that, these moths perform as the pollinating agent of *Rhododendron* plants as evidenced by the abundance of the *Rhododendron* pollen adhered on their proboscis (Fig. 9, 10). The presence of the other pollen especially

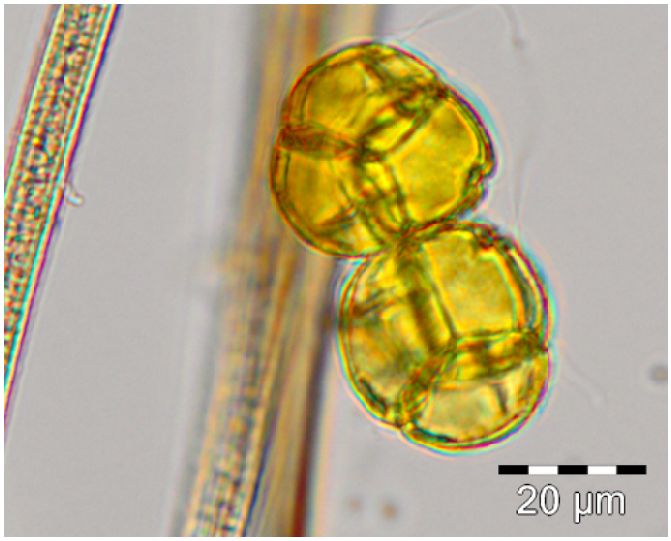


Fig. 9 - *Rhododendron* pollen adhered in the proboscis of the moth

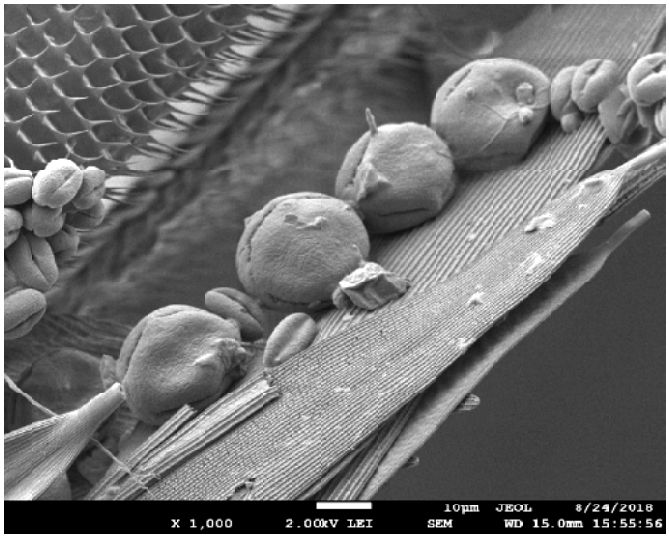


Fig. 10 - SEM of the proboscis of the moth showing the attached *Rhododendron* pollen.

Asteraceae and *Brassica* were also marked in the studied samples. The presence of the *Brassica* pollen is significant and suggestive of the cultural activity in and around the study areas.

Sadhan K. Basumatary & Swati Tripathi
[& Navneet Singh, Zoological Survey of India, Kolkata, India]

Fungal spores preserved on dung of wild Yak (Fig. 11) from the higher Himalayan region of India were studied in order to understand differences in their diversity and abundance in summer and winter. A total of 19 coprophilous and non-coprophilous fungal spore types were recovered from the dung samples. The diversity of the fungal spores in both seasons was almost similar. Multivariate principal component analysis (PCA) applied

Fig. 11 - Wild Yak (*Bos mutus*) in the Indian Himalaya

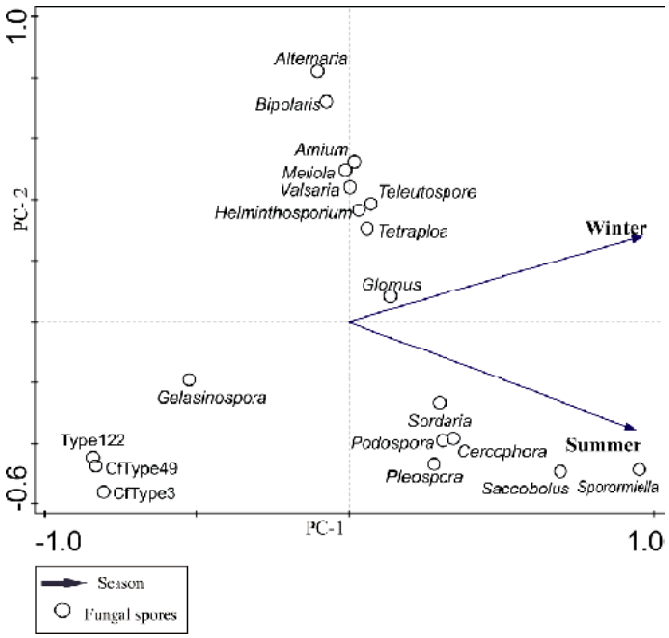


Fig. 12 - The PCA analysis of the fungal spores on summer and winter dung samples of Yak (*Bos mutus*).

to the coprophilous and non-coprophilous fungal frequency data indicated significant variation in summer and winter fungal types (Fig. 12). Such differences in modern dung samples can serve as a baseline for the interpretation of coprolites of megafauna and provide insights into their ecology and extinction. Complementing palaeoherbivory analysis, this baseline data can also be applied to the examination of sedimentary soil profiles to determine the presence and abundance of coprophilous fungi as a reflection of the former presence of megafauna in the region during the Quaternary. Such studies can also provide information on the relationship between the flora and fauna in relation to the development of agro-pastoralism in the region.

Sadhan K. Basumatary, Hukam Singh, Swati Tripathi & Anil K. Pokharia [& Eline N. van Asperen (Durham University, Durham, UK) & H. Gregory McDonald (Bureau of Land Management, Utah State Office, USA)]

Field Emission Scanning Electron Microscopy (FESEM) and Confocal Laser Scanning Microscopy (CLSM) based pollen morphometrical investigations have been performed on different species of *Ceiba* and *Bombax ceiba* (Fig. 13). The pollen morphology of these aforesaid species cannot be interpreted accurately under Light Microscopy (LM).

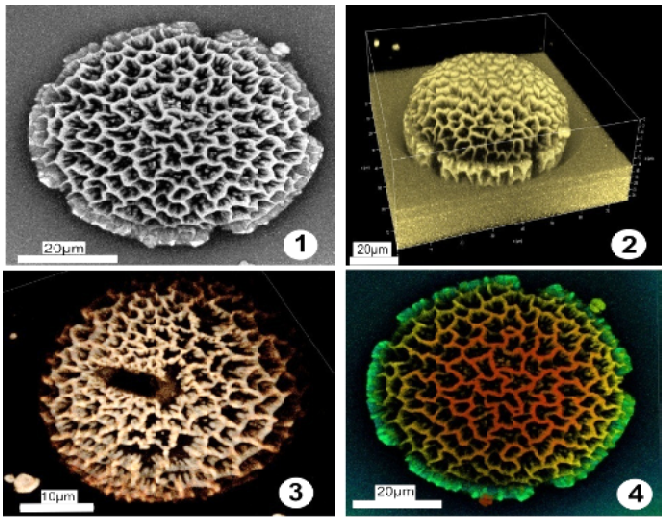


Fig. 13 - CLSM micrographs of acetolyzed pollen grains of hybrid species of *Ceiba*, *C. insignis*. (1). 5-colporate aperture with reticulate pattern in polar view, (2). 3-D image of pollen giving an appearance of igloo house with apertures giving an appearance of doors, (3). Pollen showing reticulate pattern with median short colpi, (4). Mosaic image displaying the uniformly arranged bacula over the muri and reticulate pattern.

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

The generated multiproxy dataset reveals that wild grass is the primary food for endangered deer species (Sangai, *Rucervus eldii eldii* and Hog, *Axis porcinus*) found in Manipur (Fig. 14). High diversity of plants in their diet is necessary for their survival as reflected in summer and winter dung samples.

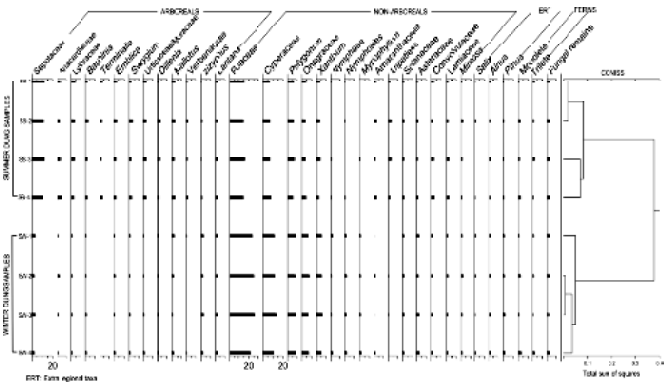


Fig. 14 - Pollen spectra generated from dung of Sangai deer (*Rucervus eldii eldii*)

Swati Tripathi & Sadhan K. Basumatary
[& Yengkhom R. Singh, Dept., of Earth Sciences, Manipur University; H. Gregory McDonald, Bureau of Land Management, Utah State Office, USA; Deepika Tripathi, Dept., of Botany, Allahabad University & L. Joykumar Singh, Central Forest Division, Government of Manipur, Imphal]

The micro- and macrobotanical remains on wild Yak dung from western Himalayas, providing evidence for understanding the diet, habitat, and ecology of extant and extinct mega-herbivores. Grasses are the primary diet of the Yak as indicated by the abundance of grass pollen and phytoliths (Fig. 15).

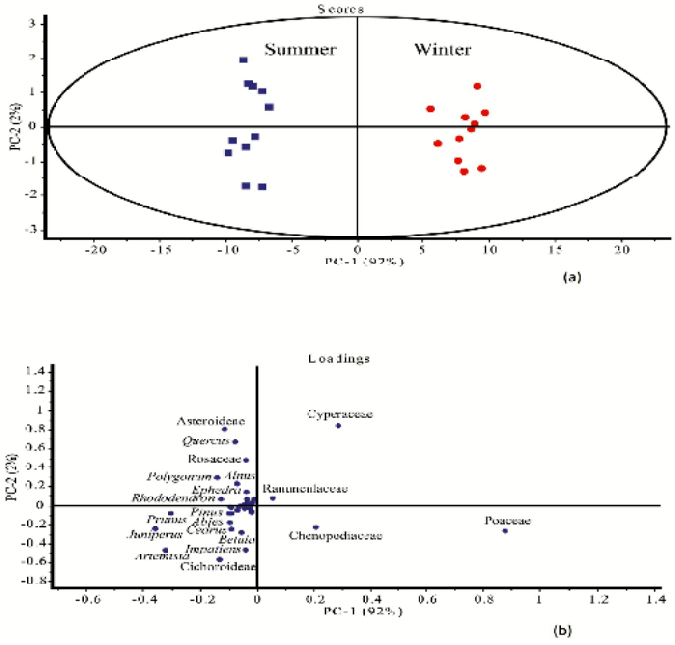


Fig. 15 - The PCA analysis of summer and winter dung samples of Yak (*Bos mutus*).

Sadhan K. Basumatary, Hukam Singh, Swati Tripathi & Anil K. Pokharia
[& H. Gregory McDonald (Bureau of Land Management, Utah State Office, USA)]

The studies conducted through Field Emission Scanning Electron Microscopy (FESEM) and Light Microscopy (LM) draws plausible lineage of extant *Ludwigia* species with that of fossil specimens recovered at two different time frames based on similarities in pollen morphometry.

Anjum Farooqui, Swati Tripathi, Srikanta Murthy & Vandana Prasad
[& Arti Garg, A.N. Shukla & G.P. Sinha (BSI, Allahabad)]

To understand the vegetational response and relative sea-level changes during Holocene, a sediment profile collected from Chirayanam, Godavari Delta has been carried out for palynological studies.

Shilpa Pandey [& Prof. K. Nageswara Rao, Department of Geo-Engineering, Andhra University, Visakhapatnam]

Surface and sub-surface samples collected from the Nonia Tal, Madhya Pradesh have been palynologically analyzed to investigate modern pollen vegetation relationship and Holocene vegetation as well as climatic variations.

Shilpa Pandey & Kamlesh Kumar

Sedimentological, palynological and geochemical study was carried out on a marine sediment core retrieved from the upper continental slope of southeastern Arabian Sea. The multi proxy data provides a detailed regional vegetation and climate history for the southeastern Arabian Sea since the Last Glacial-Holocene transition. Texture, $CaCO_3$ and OC data recorded late Glacial to early Holocene (~13.5- 8 kyr BP) reduced productivity, which may be due to dilution of water column by increased river discharge when the monsoon was intense, that in turn may have altered the physic chemical properties of the water column favouring the growth of the marine organisms. A good representation of pollen from mangroves and tropical moist deciduous forest along with dinocysts suggests a rising sea-level and temperature increase during this period. After this strengthened monsoon period, ~8.1- 6.3 kyr BP shows a gradual weakening of Indian Summer Monsoon due to an abrupt increasing trend in $CaCO_3$% and OC, which shows an

increased productivity and less freshwater discharge from rivers. Mangrove development is also controlled by conditions at the river mouth influenced by river discharge. An increase in salt tolerant mangrove species along with a decline in arboreal taxa was recorded in response to weakened monsoon conditions and stabilized sea level between ~7 and 6.3 kyr BP. After 6.3 kyr BP, mangrove and tree diversity declined, probably reflecting the drier climatic conditions. Between ~4.6 and 2 kyr BP, reduction in $CaCO_3$ and increase in OC indicates high intensity freshwater input resulting in reduced productivity. The mangrove forest also rejuvenated during this period, although reduced in biodiversity and areal extent along with the dominance of herbaceous taxa indicating enhanced monsoonal activity but with decreased intensity. The climatic variations deduced based on this multi proxy data is in agreement with the interpretations based on other studies from the monsoon-dominated areas around the Arabian Sea and Indian subcontinent.

Jyoti Srivastava & Manoj M.C. [& B.R. Manjunath (Department of Marine Geology, Mangalore University)]

A 405- year (1611–2015 C.E.) long tree-ring chronology of *Pinus wallichiana* from the Dolpo area of the trans–Himalayan region in Nepal was developed. The correlation analysis revealed significant positive correlations with February–August, self-calibrated Palmer drought severity index (scPDSI). A 319-year long (1697–2015 C.E.) February–August scPDSI series was

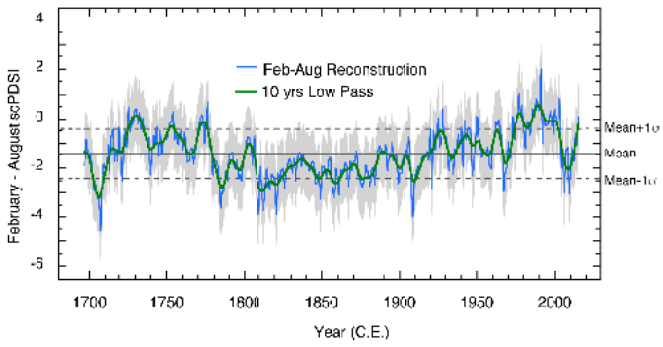


Fig. 16 - Reconstructed February-August scPDSI for 1697-2015C.E. along with 10 years low pass filter, mean of the long term reconstruction, upper and lower threshold based on mean ± 1 standard deviation. The reconstruction is based on *Pinus wallichiana* ring-width chronology from Dolpo area of Central Nepal Himalaya.

reconstructed and assessed for past dry and wet periods (Fig. 16). Manuscript submitted in Palaeo3 was accepted.

S.K. Shah [& N.P. Gaire & Z.X. Fan (XTBG, CAS China); Y.R. Dhakal, S. Aryal (Tree-ring of Society, Nepal); A Bräuning (Fredric Alexander University, Germany); D.R. Bhuju (Tribhuvan University, Nepal); U.K. Thapa (University of Minnesota, USA); S. Bhandari (Indiana State University, USA)]

A 357-year (1657-2013 C.E.) long tree-ring chronology of *Tsuga dumosa* was developed from Api Nampa Conservation Area, Western Nepal Himalayas (Fig. 17). The tree growth-climate response analysis showed a strong positive correlation with monthly spring (March-May) standardized precipitation evapotranspiration index (SPEI). Based on the obtained result, monthly spring SPEI was reconstructed from 1707 to

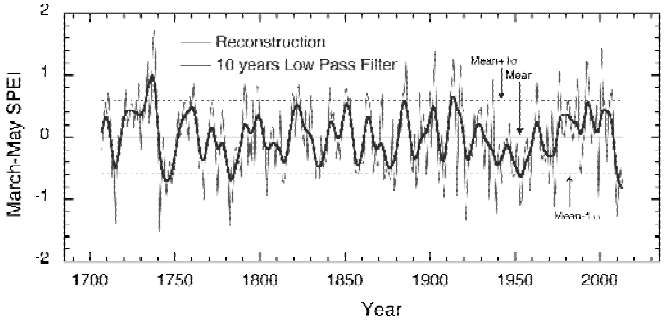


Fig. 17 - Spring reconstructed SPEI along with a 10-year low pass filter for the period 1707-2013 C.E. from Western Nepal Himalaya based on tree-ring data of *Tsuga dumosa*.

S.K. Shah [& S. Bhandari & J.H. Speer (Indiana State University, USA); N.P. Gaire (XTBG, CAS, China); D.R. Bhuju (Tribhuvan University, Nepal); U.K. Thapa (University of Minnesota, USA)]

The dendrochronological study on *Tectona grandis*, *Pinus kesiya* and *Quercus serrate* was carried out in two forest divisions of Mizoram, northeast India. Three tree-ring chronologies were developed and chronology statistics showed significant dendrochronological potential of these trees from Mizoram.

S.K. Shah & N. Mehrotra [& KK Upadhyay, S.K. Tripathi (Mizoram University, Mizoram); A. Roy (Indian Institute of Remote Sensing, Dehradun)]

The past flood and river flow variability from extreme events recorded in trees-rings on the Dhur River, Bhutan, eastern Himalaya was carried out during Pre-Conference Dendro Field-week Training under 10th World Dendro Conference, Bhutan during June 2018.

S.K. Shah [& J.H. Speer (Indiana State University, USA) and trainee participants]

Palynological analysis of a 1.3 m core from Chandra Tal, Lahaul-Spiti has been completed. Modern pollen analogues were also developed from fifteen surface

sediment samples, collected from the periphery of the lake and compared with the fossil pollen assemblages of the core. There is good compatibility between the modern and fossil pollen records. Other proxy data and dates are awaited from the collaborators for preparation of manuscript.

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

Phytoliths are known to be important environment indicators and thus hold significant prospect for present and past ecological and environmental interpretations. Morphometric and assemblage analyses of phytoliths from five Panicoid grasses, i.e. *Chrysopogon aciculatus*, *Imperata cylindrica*, *Oplismenus burmannii*, *Paspalum distichum* and *Echinochloa crus-galli* were studied which were collected separately from mesophyte-dominated low saline and halophyte-rich high saline phytoecological zones of the lower Gangetic Delta of West Bengal, India. Bilobate phytoliths with relatively longer shanks and rondel and tower morphotypes were recovered in significantly higher frequencies from samples of high salinity zones; whereas, cross, polylobate and trapeziform morphotypes were found predominantly in grasses from mesophyte-dominated low salinity zones. The above-mentioned morphotypes were found to be strongly correlated with soil salinity. The present investigation may serve as a basis to identify distinct phytoecological zones resulting from differences in salinity by using grass phytoliths. This study further explores the possibility of identifying different depositional environments when used during regional palaeovegetational and palaeoenvironmental reconstructions.

Ruby Ghosh & Shailesh Agrawal
[& Prof. Subir Bera, Department of Botany, University of Calcutta]

The present study aims to provide the palaeoenvironmental reconstruction of freshwater sequences in the Lingala-Koyagudem Coal belt of the Godavari Graben, using palynofacies. The palynofacies analysis was conducted on 57 samples from borehole MMK-19 (Mamakannu) and MLG-23 (Gundala) from the Lower Gondwana successions of the Godavari Graben. Palynofacies/Sedimentary Organic Matter (SOM) were analyzed quantitatively and cluster analysis was performed on different percentages of SOM to obtain zones for the depositional pattern in the lake deposit. The work is based on the hypothesis that huge coal bearing lacustrine deposits developed during the Gondwana time-span and these coal formations need to be fully understood in terms of the palynofacies to provide insight into the physical and biological processes. Based on the dominance and sub-dominance of the existing Sedimentary Organic Matter, four distinct palynofacies units were identified, representing the differential environmental setting in the lake. The palynofacies components are dominated by terrestrial palynomorphs, structured terrestrial particles, black oxidized particles (charcoal) and degraded terrestrial particles, respectively. The Palynofacies A has been attributed to the freshwater peat environment in a low energy setting; Palynofacies B has been inferred under shortly transported (high percentage of wood particles) large terrestrial influx in oxidizing environments; Palynofacies C indicates the redeposition of organic matter from fluvio-deltaic settings (oxic); Palynofacies D reflects low energy freshwater swamps (dysoxic-anoxic). The data demonstrate the combination of lacustrine and fluvio- deltaic depositional environments. The stratigraphic distribution of the four distinct palynofacies assemblages (A–D) indicates their deposition from terrestrial to the aquatic ecosystem. The findings in the Gundala deposits took place in the continental part as compared to the Mamakannu succession which sourced more towards the aquatic regime as Palynofacies A is more frequent in the Gundala deposits as compared to Mamakannu.

Biswajeet Thakur [& Neha Goel]

Collaborative work has been done with Dr. Anupam Sharma and Team (Project No. 6.6) for biomarker analysis on the samples collected from Varanasi to establish evaluate the changes in vegetation composition and palaeoclimate during pre and post warming.

Manoj M.C. [& Anupam Sharma, Runcie Paul Mathews, Pawan Govil, Anjali Trivedi & Kamlesh Kumar]

Quantitative Sea-surface Temperature (SST) and sea-ice reconstructions along with diatom absolute abundances and diatom biometry have been done from two sediment cores located at the Subantarctic Front (SAF) and Antarctic Polar Front (APF) in the southwest Indian sector of the Southern Ocean. The present study documents interaction between Southern Hemisphere high-latitude (Antarctica & Southern Ocean), southern Indian Ocean subtropics (Agulhas leakage) and Asian summer monsoon. The study uses SST and sea-ice reconstructions along with diatom absolute abundances and diatom biometry from two sediment cores located at the SAF and APF in the southwest Indian sector of the Southern Ocean. The comparative study between the records of Southern Hemisphere high latitude and Asian

Summer Monsoon climate variability revealed that the Asian Summer Monsoon variability could have been more likely forced by low latitude insolation gradient changes and supported by Antarctic climate changes via meridional shifts of the fronts and sea ice. The past changes in the intensity of Asian Summer Monsoon along with the Southern Ocean frontal variation might have influenced the Southern Indian Ocean surface circulation by changing the Agulhas leakage intensity.

Manoj M.C. [& Thamban Meloth, Rahul Mohan & Abhilash (NCPOR, Goa)]

A collaborative work has been carried out with Dr. Xavier Crosta, France during the SERB Overseas Postdoctoral Fellowship.

Sunil Kumar Shukla & Prasanna K. [& Dr. Xavier Crosta, France]

About 60 sediment layers for Total Carbon (TC), Total Organic Carbon (TOC) and total Nitrogen (TN) contents along with their stable isotopes ($\delta^{13}C_{TC}$, $\delta^{13}C_{TOC}$, $\delta^{15}C_{TN}$) were analyzed using our EA-IRMS facility in a high altitude AMS^{14}C dated lake sequence of Laddakh (India).

Binita Phartiyal, BSIP [Pradeep Srivastava Scientist 'E', Wadia Institute of Himalayan Geology, Dehradun]

Analyzed six tooth-enamel samples extracted from fossil-hippopotamus from Maharashtra area.

Niraj Rai(BSIP) [& Prof. Vijay Sathe from Deccan College Post-Graduate and Research Institute, Pune]

Analyzed ~4-5 bulk soil samples of megalithic archaeological site near Nagpur for stable C and N isotopes along with a few charcoal samples from Ubali were subjected to conventional radiocarbon ^{14}C dating.

Niraj Rai(BSIP) [& Prof. Preety A. Trivedi, Head of the Department, Ancient Indian History, Culture and Archaeology, R.T.M. Nagpur University Nagpur]

Diatoms from Zanskar Valley were analyzed using constrained ordination technique (Redundancy Analysis; RDA) to visualize the relationship of its assemblages with conductivity, pH and salinity and whether they are of lacustrine or riverine.

P. Morthekai, Biswajeet Thakur & S. Nawaz S. Ali

Micro-coprolites from India were analyzed and compared statistically with the global data. Hierarchical cluster analysis along with principal component analysis was used in this study.

P. Morthekai, Vivesh V Kapur, Kamlesh Kumar & Amrit Pal Chadda

In order to improve the eastern Himalayan climate index using phytoliths, we have compared two earlier developed indices (Ic & EhIc2) with the currently developed one (EhIc6). And the mean annual temperature (MAT) was estimated using EhIc6 from the published data for validation. In this study, robust statistical techniques have been used and above all, all the analyses were carried out in R, a freeware.

P. Morthekai, Ruby Ghosh & Shailesh Agrawal

Detailed statistical analysis was carried out for tree-ring oxygen isotope ($\delta^{18}O$) data from one site in western Himalaya with respect to rainfall, using both linear and non-linear functions. The sliding linear correlation depicts the main problem as multi-periodic fluctuations change sign for most box sizes making calibration unstable and erroneous. We tested if introducing non-linearity (in terms of the powers of $\delta^{18}O$) improves this variation in correlation, but the variability of correlation persists even if various powers and combined powers of $\delta^{18}O$ are correlated with rainfall. Converting the data-sets to the frequency space showed that precipitation and $\delta^{18}O$ match well in lowest frequencies but lose correspondence while going towards higher frequencies. This leads to the varying linear correlation observed earlier.

Trina Bose [& Saikat Sengupta & Supriyo Chakraborty]

X-Ray Fluorescence (XRF) measurements have been carried out on the archaeological samples derived from 4MSR site. The archaeological samples were also subjected to organic compound analysis using GCMS at Geochemistry Laboratory, BSIP.

Niteshkumar Khonde & Runcie P. Mathews

To characterize the subsurface sediments of Great Rann of Kachchh Basin, detail magnetic proxy measurements were carried at high resolution scales from two cores raised from GRK Basin by Prof. D.M. Maurya. These measurements were carried out at Palaeomagnetic Laboratory at BSIP. The interpretation part is in progress from this work.

Niteshkumar Khonde, Arif Mohammad & Binita Phartiyal [& Prof. D.M. Maurya (The M.S. Uni. of Baroda, Gujarat]

A coal-bearing, shallow-marine upper Paleocene-lower Eocene succession exposed at Jathang, East Khasi Hills, Meghalaya, northeastern India represent a transgressive systems tract (TST) deûned by seven parasequences, each starting with bay sediments deposited during transgression, followed by a shallowing-upward bay fill-marsh deposit. There is evidence from our data that seasonality of rainfall is the determining factor for the tropical forest vegetation pattern of the equatorial region rather than mean annual rainfall condition because of the fast northward movement of the Indian Plate.

V. Prasad, Anupam Sharma, R. Garg, J. Srivastava & P.R. Uddandam
[& T. Utescher, I.B. Singh, B. Gogoie & M.M. Joachimski]

A ~2400 years climatic history combining pollen, phytoliths, non-pollen palynomorphs (NPPs), $\delta^{13}C$ signatures, sediment texture and total organic carbon (TOC) was constructed over a lacustrine deposit of the Darjeeling area, eastern Himalaya to explore ecosystem response to climate change and to understand the possible forcing mechanisms behind it. Our results identify a humid climatic phase at the beginning of the last millennium, a pre-MWP less humid phase, while MWP was wetter than the former phase and a wet LIA in the Darjeeling Himalaya.

Ruby Ghosh, Shailesh Agrawal, Anupam Sharma & C.M. Nautiyal [Oindrila Biswas, Dipak Kumar, Paruya Meghma Bera & Subir Bera]

Systematic sedimentological, mineralogical, 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. 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, J. Rai, S. Farooqui & V. Prasad
[Mu. Ramkumar, M. Santosh, R. Nagarajane, S.S. Li, M. Mathew, D. Menier, N. Siddiquig, M.C. Poppelreiter & J. Lai]

TOC content and carbon isotope study of modern as well as ~50yrs old C_3 and C_4 plant samples have been carried out to understand carbon cycle and response of plants towards the CO_2 rise in the atmosphere through fossil fuel burning. Interestingly, our results show ~2.5‰ offset between older and younger C_3 as well as C_4 plants.

Shailesh Agrawal, Sheikh Nawaz Ali & Firoz Quamar
[& A. Garg, Botanical Survey of India, Prayagraj, UP]

TOC content and carbon isotopic study have been carried out in the Cambrian samples.

Shailesh Agrawal, Sheikh Nawaz Ali & Firoz Quamar
[& B.P. Singh, Associate Professor, Punjab University]

Independence Day

Sponsored Projects

1. **Project: Mesoproterozoic microbiotas of Eurasia: an integrated approach to the Indian and Russian early eukaryotes-dominated assemblages** (Sponsored by DST– RFBR, New Delhi; INT/RUS/RFBR/P-278, w.e.f. 01.04.2018).

   Investigators: Mukund Sharma (PI), Veeru Kant Singh Co-PI , Santosh K. Pandey & Yogesh Kumar [V. N. Sergeev, Russian Academy of Sciences, Moscow, Russia]

Mesoproterozoic rocks of Indian basin were studied for the better understanding of early eukaryotes - dominated assemblage which evolved during the late Palaeoproterozoic and early Mesoproterozoic time and diversified in the Neoproterozoic. Different eukaryotic fossils have been recovered from the various Mesoproterozoic rocks of India. Performed high spatial resolution (sub-micron level) morphological studies using Confocal Laser Scanning Microscopy (CLSM) on the three acritarchs species, viz. *Shuiyousphaeridium echinulatum, Cymatiosphaeroides kullingii* and *Trachysphaeridium* sp. recorded from the chert streaks of the late Palaeoproterozoic (>1.65 Ga) Chitrakut Formation, Vindhyan Supergroup, Central India (Fig. 1). The Suket Shale of the Vindhyan Supergroup has yielded microfossils which show complex ornamentations. The high resolution studies confirm that the body is covered by the multilaminated wall. CLSM studies revealed that the surface structure is of reticulate type, having a net like arrangement of unequal shape and size with hollow marks. The most important feature of these specimens is the presence of dark coloured intracellular inclusion. Some specimens show presence of another circular body inside these structures. Finalized an article entitled – *A new record of acanthomorphic acritarch Tappania Yin from the early Mesoproterozoic Saraipali Formation, Singhora Group, Chhattisgarh Supergroup, India and its biostratigraphic significance* and communicated to the journal *Alcheringa*.

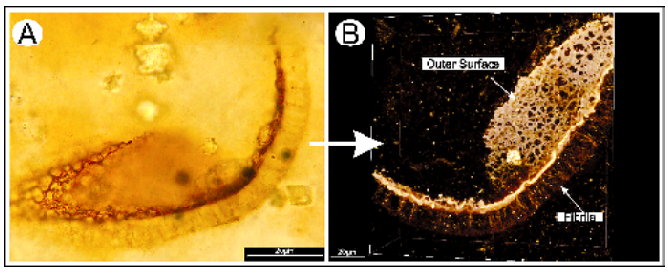


Fig. 1 - (A) Photomicrograph of small broken piece of *Shuiyousphaeridium echinulatum* Yin and Gao 1999 from Chitrakut Formation, (B) CLSM image showing reticulate pattern of the outer surface and arrangement of fibrils of the *Shuiyousphaeridium echinulatum*.

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

   Investigator: Shamim Ahmed (PI)

152 carbonate samples of Buxa Dolomite exposed in western Sikkim, NE Lesser Himalaya have been processed for various analytical studies such as, isotope and trace metal analyses. Stromatolites and microbial assemblage suggest intertidal to sub-tidal marine setting for the deposition of Buxa Dolomite. Stable isotopic values of carbonates ($\delta^{13}C$) range from -1 to + 2.5‰, on comparison, these values match with results of several carbonates units deposited during the Mid-Mesoproterozoic to terminal Proterozoic. Positive shift in $\delta^{13}C$ carb values indicates increase in biological productivity and decrease in dissolved inorganic carbon (DIC) in depositional milieu. This shift in $\delta^{13}C$ carb values have been noted globally around 1.3 Ga. No lithification alterations in $\delta^{13}C$ carbonate have been noted, however, $\delta^{18}O$ carbonate values are fairly altered. The *Leiosphaeridia crassa*, *Leiosphaeridia tenussima*, *Leiosphaeridia* sp. *Coneosphaera* sp., *Chlorogloeopsis contextus*, etc. have been recovered from the Buxa Formation through maceration which also indicates the Meso-Neoproterozoic age of this Formation.

3. **Project: Quest for signatures of early land plants, their subsequent evolution and biodiversity in the Early Palaeozoic sequences of Spiti Himalayas: palaeoenvironmental and palaeogeographical implications** (Sponsored by SERB/DST/ EMR/2016/006042 w.e.f. 05.06.2018)

   Investigators: Anju Saxena & K.J. Singh (Co-PI) (Suyash Gupta JRF)

A field excursion to Spiti area of Himachal Pradesh has been done (Fig. 2). Megafossils and samples for palynology and petrology were collected from the Carboniferous (Po Formation of Tabo Village and Gamnachidam Formation of Losar Village) and Early Permian (Lingti Valley). In addition, samples for

palynological study were collected from the Takche Formation exposed near Losar Village. A well preserved and diversified plant magafossils have been collected from the Tabo Bridge Section comprising possible elements of *Rhacopteris* flora. Poorly preserved fragmentary plant fossils have been collected from late Carboniferous (Po Formation). The megafossil specimens were photographed and their identification is in progress. Palynological samples have been macerated and have yielded dark brown to black coloured palynomorphs along with chitinozoa, scolecodonts, acritarchs and palynodebries. However, the yield of palynomorphs was relatively poor. The further study is in progress.

Fig. 2 - A. View of Spiti River, near Losar Village. B. Carboniferous exposure near Tabo Village, Spiti Valley, Himachal Pradesh.

4. Project: Study of floral evolution and macroscopic charcoal- an indicator of wild fire during the late Palaeozoic sediments of northeast India: implications in palaeoclimate, palaeoecology, biostratigraphy and palaeogeography (Sponsored by SERB, New Delhi; No. EMR/2017/001408, w.e.f. 15.06.2018)

Investigators: Deepa Agnihotri, Rajni Tewari & Alok Kumar Mishra

A field excursion was undertaken to Papum Pare, Lower Subansiri and West Kameng districts of Arunachal Pradesh. The lower Gondwana sediments of Arunachal Pradesh are known by Miri, Bichom, Bhareli formations and Abor Volcanics and Bichom Formation is well exposed in Lower Subansiri and Papum Pare districts (Fig. 3). Rock samples have been collected from the sections exposed near Potin Road, Lichi Village, Kheel Village, Gerum Village for the recovery of spores, pollen grains and megaspores. Plant megafossils were not found in these areas. Plant megafossils have been collected from the Bhareli Formation exposed in Pinjori Nala near Bhalukhpong, Sessa and Suparikemp areas. Rock samples have been collected from the sections exposed near Balemu Village of West Kameng District. Cleaning and sorting of plant mega fossils have been done and photography of the samples is being carried out. Chemical processing of the samples is in progress.

Fig. 3 - Exposure of Bichom Formation (Early Permian) near Gerum Village, Papum Pare District, Arunachal Pradesh.

5. Project: Investigation on phytoplankton diversity and geochemistry of the Miocene-Pliocene Sequence from the Andaman and Nicobar Islands: Its significance in past climate reconstruction [Sponsored by DST-INSPIRE (IF170181) w.e.f. November 23, 2017]

Investigators: Stuti Saxena (DST-INSPIRE JRF) & Amit K. Ghosh

Sediment samples collected from three outcrops on the Havelock Island, viz. Vijayanagar, Laccam Point and South Point sections yielded moderate to well preserved diatoms and calcareous nannofossils. The diatom assemblage from the Vijayanagar Section is characterized by marker species of late early to early Middle Miocene, namely *Cestodiscus peplum* (Fig. 4A) and *Rossiella paleacea* (Fig. 4B). Laccam Point Section also yielded the age diagnostic diatom taxa namely *Cestodiscus* sp., *Rossiella paleacea* and *Coscinodiscus lewisianus* (Fig. 4C) demarcating an age of late early to early Middle Miocene. In South Point Section the diatoms are moderately preserved. The diatom assemblage is represented by *Stictodiscus* sp., *Actinocyclus ellipticus*, *Arachnoidiscus* sp., *Grammatophora angulosa* (Fig. 4D), etc. The marker diatom species of late early to early Middle Miocene *Rossiella paleacea* also has been recorded from the South Point Section.

Calcareous nannofossil abundance for Vijayanagar Section has been carried out. The preservation of the nannofossils is moderate. Age diagnostic nannofossils, viz. *Sphenolithus heteromorphus* and *Helicosphaera ampliaperta* are present throughout the outcrop. Amongst the nannofossils, *Helicosphaera carteri* is the most abundant species followed by *Coccolithus pelagicus*.

Further work on the abundance of the calcareous nannofossils from the South Point Section and Laccam Point Section of the Havelock Island is in progress. Analysis and interpretation of data is underway.

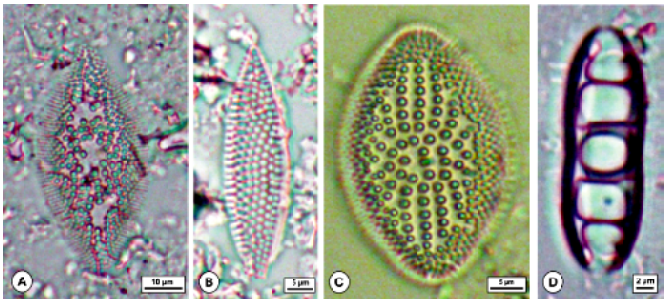


Fig. 4 – A. *Cestodiscus peplum* B. *Rossiella paleacea* C. *Coscinodiscus lewisianus* D. *Grammatophora angulosa.*

6. Project: Reconstruction of Miocene to Pleistocene palaeoclimate derived from the studies of silicified and calcified microfossils from Andaman and Nicobar Islands [Sponsored by DST-INSPIRE (IF170761) w.e.f. January 17, 2018]

Investigators: Rikee Dey (DST-INSPIRE JRF) & Amit K. Ghosh

The Pliocene - Pleistocene epochs are significant as the climatic condition during these epochs can be used as an analogue for the prediction of future climate change. Reconstruction of palaeoclimate with the help of siliceous and calcareous fossils is a significant tool. Planktonic foraminifers are important proxies for relative age determination and biostratigraphy. These zooplanktons are highly sensitive to environmental and climatic changes. Nine samples collected from Neil West Coast Section of Neil Island of Ritchie's Archipelago (northeastern Indian Ocean) were examined to demarcate the Pliocene - Pleistocene boundary. Some species of planktonic foraminifera, viz. *Globorotalia miocenica, Globigerinoides elongates* and *Globigerinoides extremus* have been recorded for the first time from the Northern Indian Ocean.

Presence of some age diagnostic species of planktonic foraminifera, namely *Dentoglobigerina altispira, Globorotalia miocenica* and *Globoturborotalita woodi* (Fig. 5A) is important as these species clearly demarcate the Pliocene - Pleistocene boundary in the upper part of the outcrop. Abundance of *Globoturborotalita rubescens*, *Neogloboquadrina pachyderma* (Fig. 5B) and *Trilobatus* sp. indicates fluctuation of warm and cold environmental conditions. Two different assemblage zones have been deduced with the help of CONISS cluster analysis. Zone I is dominated by *Trilobatus* sp. (36.84% to 21.95%), *Neogloboquadrina pachyderma* (21.06%), *Globoturborotalita rubescens* (19.51% to 15.09%), *Trilobatus* sp. cf. *trilobus* (18.91%) and *Globigerinoides ruber* (Fig. 5C) (15.45%). On the other hand, Zone II is dominated by *Globoturborotalita rubescens* (22.4% to 16.47%), *Neogloboquadrina pachyderma* (14.47%), *Globigerinoides* sp. (11.84%), *Trilobatus* sp. (14.18%) and *Neogloboquadrina dutertrei* (11.2%).

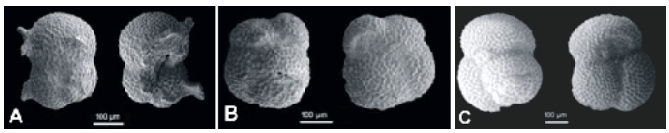


Fig. 5 - (A) *Globoturborotalita woodi* (B) *Neogloboquadrina pachyderma* (C) *Globigerinoides ruber.*

7. Project: Late Miocene to Pleistocene palaeoclimate reconstruction based on high resolution biotic proxies coupled with geochemical analysis from the sediment cores of Northeast Indian Ocean (Sponsored by DST-INSPIRE [IF180254] w.e.f. February 11, 2019)

Investigators: Lopamudra Roy (DST-INSPIRE JRF) & Amit K. Ghosh

Samples have been procured from the sediment core (NGHP-01-17A) recovered from the National Gas Hydrate Programme (Expedition-01). Some samples have been chemically processed according to the conventional method. Slides have been prepared for the study of different silicified and calcified microfossils like diatoms, radiolarians, silicoflagellates and calcareous nannofossils. Different silicified microfossils and calcareous nannofossils from the sediment core of northeastern Indian Ocean have been analysed thoroughly. Further study, i.e. microscopic observation, photography and identification of the different microfossils are in progress.

8. Project: Investigations on the Mio-Pliocene climate in the Northern Indian Ocean: An integrated micropalaeontological and geochemical approach (Sponsored by SERB, New Delhi, Grant-NPDF/2017/ 000690; from 1st April, 2018 to 27th February, 2019)

Investigator: Arindam Chakraborty (Joined as BSRA w.e.f. 28th February, 2019), (Mentor: Sunil Bajpai/ Amit K. Ghosh)

Previous work done on siliceous microfossils from

two outcrops of Sawai Bay Formation of Car Nicobar Island (Northern Indian Ocean) indicated that there was a biogenic silica crash (BSi) during Zanclean (early Pliocene). To reconfirm this event some geochemical analyses were carried out. The XRD analysis of selective samples from these outcrops revealed that they are mainly comprised of calcium carbonate ($CaCO_3$) and silicon oxide (SiO_2) (Fig. 6). The presence of broad peaks at 26.6° 2θ and 29.4° 2θ clearly indicates that they belong to quartz (SiO_2) and calcite ($CaCO_3$) respectively (Fig. 6). However, absence of broad peak at 22° 2θ and the intense peak at 21.7° 2θ envisages that they does not belong to opal A or opal CT. Overall, the spectrum shows the dominance of calcite followed by quartz.

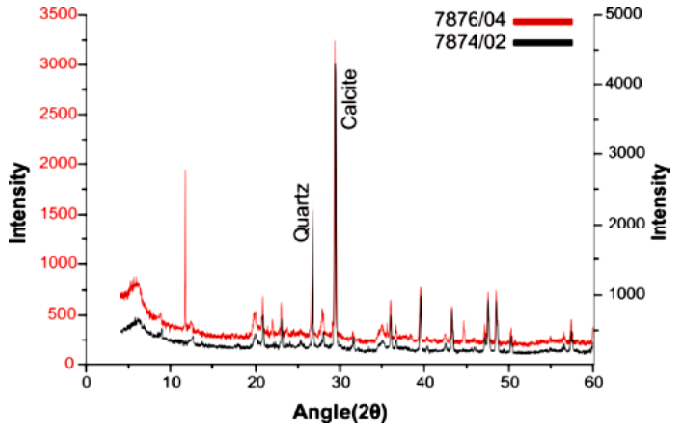


Fig. 6 - XRD spectra from selected sediment samples of Sawai Bay 'A' and 'B' sections.

The ATR-FTIR spectrum of the samples from both the outcrops showed more or less similar features (Fig. 7A and B). There are two major bands, one at 1414 cm^{-1} and the other one at 1000 cm^{-1} that indicates the presence of calcite and quartz as the principal components.

Based on these analyses it may be inferred that the sediments were in the process of diagenesis and the degradation of the silica percentage occurred which is clearly visible in the FTIR spectrums. In this present study the silicate content is considerably low as evident from the microfossil assemblage, XRD and FTIR analyses that in turn is responsible for the BSi crash which led to low phytoplankton primary production during Zanclean.

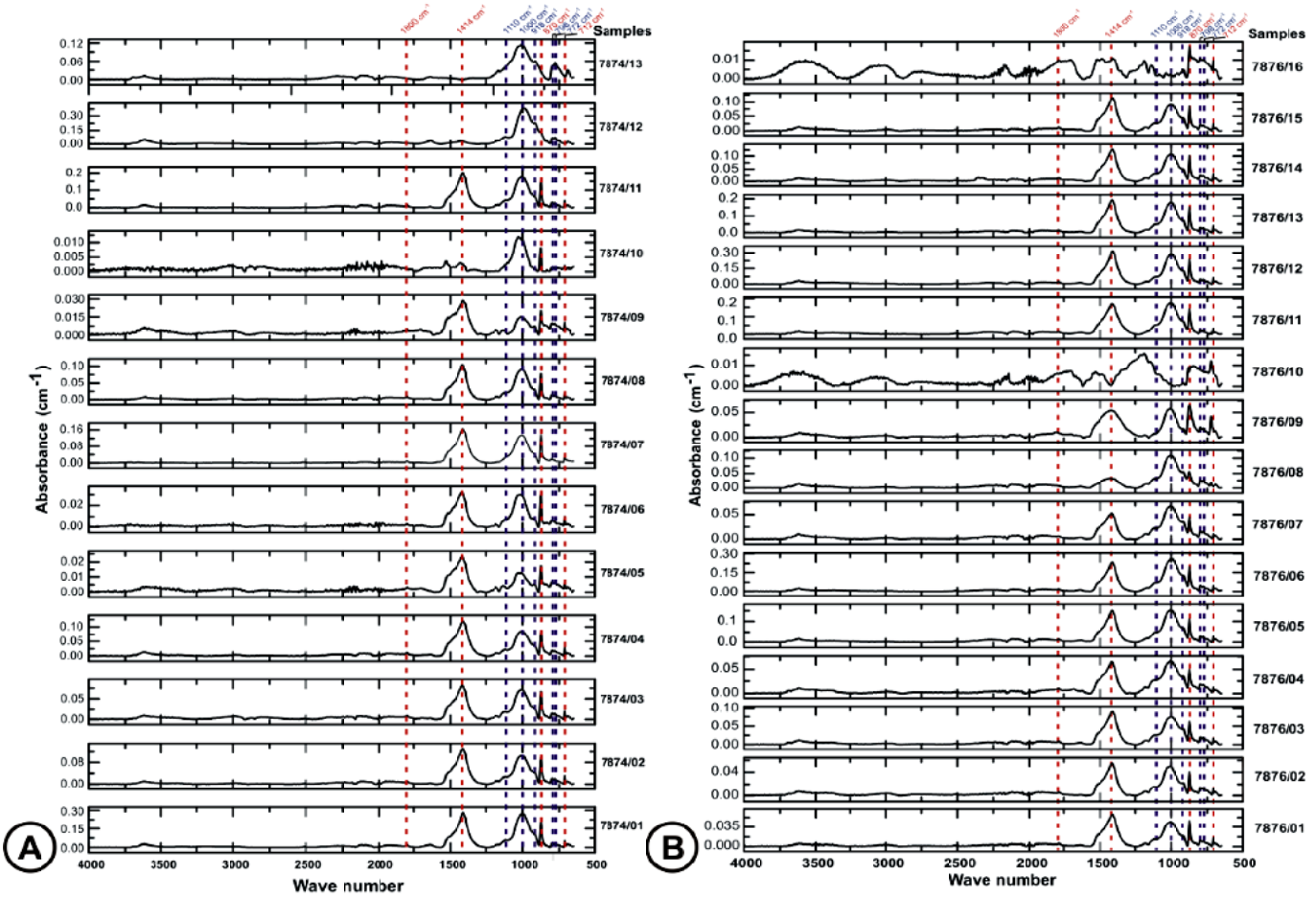


Fig. 7 - FTIR spectra from the sediment samples of (A) Sawai Bay 'A' Section, (B) Sawai Bay 'B' Section (blue colour denotes the bands for silica and red colour denotes bands for calcium carbonate).

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

Investigators: Neelam Das & Raj Kumar (Project Fellow)

About 58 samples are collected for microfossil and geochemical studies from different localities viz. Habur-Kuchri road section (Habur Formation), Serwa section (Pariwar Formation), Mokal Nala section (Mokal member, Bhadaser Formation) Bhadaser ridge section (Lanela member, Baisakhi Formation), Chhatrail village section (Rupsi member, Baisakhi Formation), Fort section (Fort member, Jaisalmer Formation), Rewanta Singh ki dhani section (Hamira member, Jaisalmer Formation) and Kuldhar village section (Kuldhar member, Jaisalmer Formation) during the field excursion that was undertaken in May, 2018.

Plant fossil and nannofossil have been recorded from a new locality of Jaisalmer Basin in the west Rajasthan Shelf. The lower Cretaceous sedimentary successions of Pariwar Formation are predominantly composed of medium to coarse-grained sandstone. A number of bennetitalean fronds *Ptilophyllum cutchense* Morris (Fig. 8), abundant wood fossils, trace fossils and reasonably well-preserved nannofossil assemblage comp-rising 10 nannotaxa, viz. *Ceratolithoides* sp., *Cyclagelosphaera margerelii*, *Calculites* sp., *Diazomatolithus galicinus*, *Discorahbdus ignotus*, *Faviconous multicolumnatus*, *Laguncula pitcherensis*, *Rhabdophidites* sp., *Watznaueria biporta*, *W. fossacincta*, *W. barnesae*, *W. britannica* and *Thoracosphaera* sp. are found from the new locality. The presence of leaf impression along with bioturbation and marine calcareous nannofossils indicates shallow marine depositional environment with low energy condition.

Fig. 8 - Plant megafossils from the Pariwar Formation of Jaisalmer Basin: *Ptillophyllum cutchense*

Plant fossil (Genus *Sphenopteris* Sternberg) is reported for the first time from the Mokal member of Bhadaser Formation. Mokal Member is typically exposed around Mokal village and comprises of brown, hard, argillaceous, ferruginous feebly calcareous sandstone. Previously fish teeth, fragments of broken reworked ammonites, gastropod, bivalve, etc. have been reported from Mokal Member of Bhadaser Formation.

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

Investigator: Srikanta Murthy

The project has been successfully completed within two years (August 2016 to August 2018). During the tenure of this project three field works have been undertaken and collected palynological samples (320 nos.), leaf impressions, root impressions, stem impressions of the plant and Ichno fossils.

One research paper entitled, "Early Permian palynomorphs from West Bokaro Coalfield, Damodar Basin, India: implication in palaeoenvironment" has been communicated in *J. Palaeont. Soc. India* (under review).

11. Project: Analysis of the Early Eocene amber from Cambay and Kutch basins, Gujarat, western India: Palaeoecological, environmental and climatic significance (Sponsored by DST No: EEQ/2016/000112) dated 07-03-2017).

Investigator: Hukam Singh

Specimens of fossilized fish Teleostean vertebrae were collected from Early Eocene lignite-bearing Cambay Formation (54 Ma; Fig. 9) of Cambay Basin, western India. Reported the presence of collagen in 2.5 Ma old fish scales and 54 Ma old Teleostean fish vertebrae using online pyrolysis-two dimensional gas chromatography-time-of-flight mass spectrometry and immune fluorescence studies. In addition, fish scale fossils were recovered from Kimin Formation of the upper part of the Siwalik sediments (2.5 Ma) of Arunachal foothills, eastern Himalaya (Fig. 10).

This study suggests that characterization of collagen of different body parts of fossilized animal remains can shed useful insights on macroevolution and physiology of organisms in deep time.

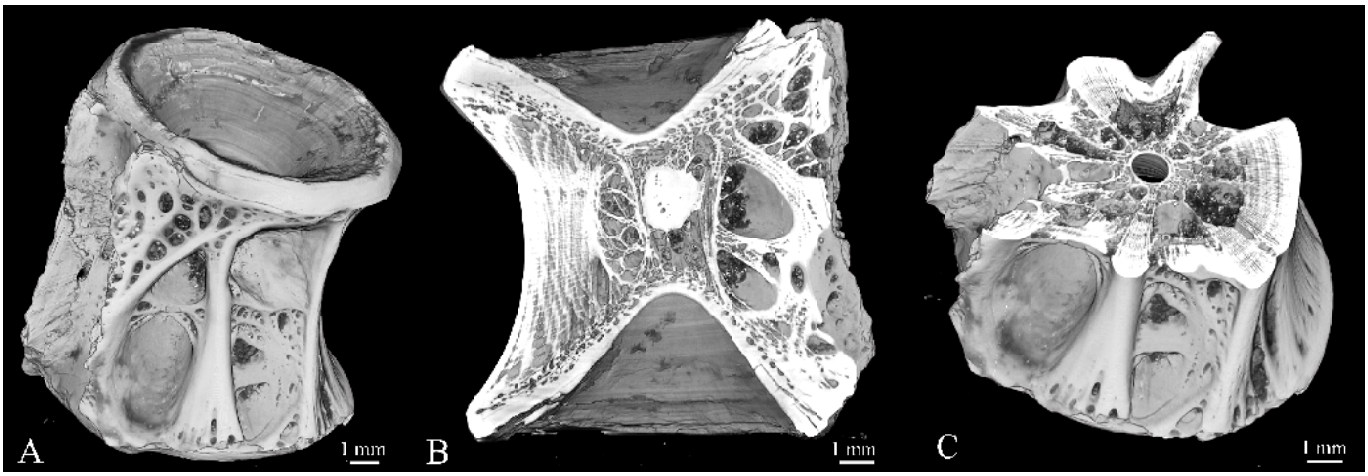


Fig. 9 - (A-C) Dossal & Ventral views of the fish vertebrae.

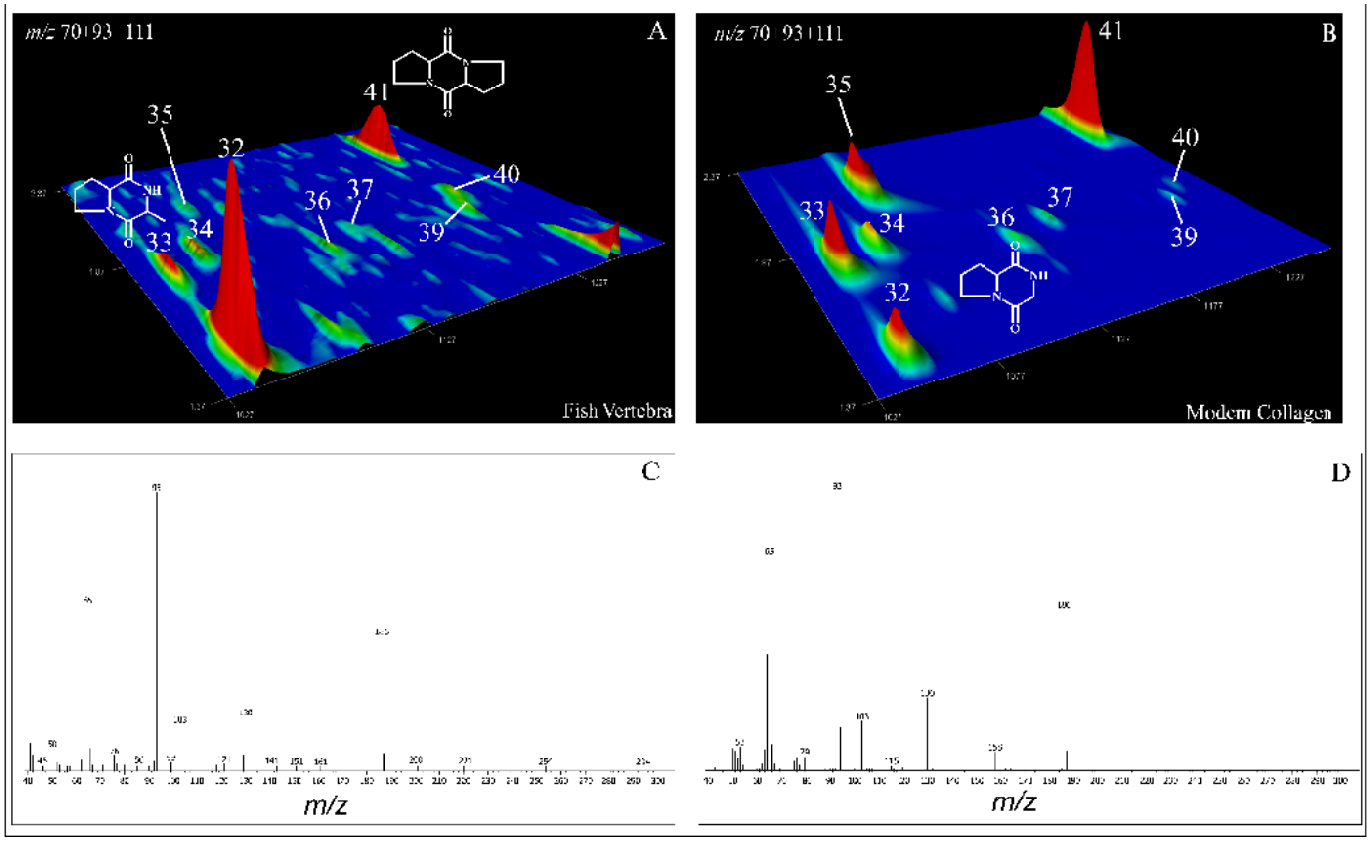


Fig. 10 - (A-B) Molecular preservation of soft tissues, (C-D) Pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS).

12. Project- Quantitative reconstruction of the Paleogene climate of paleoequatorial region based on Indian palynological records [MoES/P.O.(GeoSci)/36/2014, w.e.f. August 2015]

Investigators: Vandana Prasad, Ashish K. Mishra (JRF) & Mahi Bansal (JRF)

Fossil pollen recovered from Sonari Lignite Mine, Barmer Basin, Rajasthan and Vastan Lignite Mine, Cambay Basin, Gujarat showed affinity with the pollen of extant species of family Ebenaceae. Based on the phylogenetic study using present fossil records and molecular data (published), biogeographic history of family Ebenaceae was reconstructed. The pantropical distribution of Ebenaceae both in western and eastern Gondwanan continents, thought to be a result of much earlier diversification of family in Gondwanaland. However, recent molecular studies suggest a geologically

young origin of the family in Eocene. Due to lack of reliable fossil records, the complex biogeographic history of the family is yet unresolved. Based on a dated phylogenetic tree representing over 45% of global Ebenaceae species and calibrated with oldest pollen fossil records from western India dating back to late Cretaceous (65 Ma), the estimated divergence history of Ebenaceae is in agreement with the splitting order of Gondwana landmass and suggests that fragmentation of Gondwanan landmasses from early to late Cretaceous aided by short distance dispersal have shaped the early biogeographic history of the family. The historical biogeographic analysis suggests that ancestral stock of Ebenaceae originated in South America and dispersed to other continents. Further, the fossil palynological evidence and diversification analysis suggest that, initial diversification of the family occurred in Deccan platue prior to its collision with Asia in late Eocene. Our diversification analysis also suggests that, high endemism and diversification of family in Africa, Southeast Asia and New Caledonia is a result of rapid *in-situ* speciation coinciding with Miocene Climatic Optima. Overall, our study for the first time provide deeper insights into the origin and evolution of family Ebenacae, in general advance our understanding of angiosperm evolution.

13. **Project: Pliocene Arctic Climate Teleconnection (PACT) (**MoES/Indo-Nor/PS-8/2015, w.e.f. September 2016)

Investigator: Vandana Prasad

Sea surface temperature (SST) reconstruction of mid-Pliocene using marine microfossils have shown significant warming of ocean surface at mid and higher latitudes of both hemispheres with enhanced meridinonal ocean heat transport. However, owing to poor preservation of marine microfossils as well as dilution due to high terrestrial discharge, it was difficult to carry out high resolution biostratigraphy and palaeoenvironmental study in the Arctic region. Palynofacies study that involves qualitative and quantitative estimation of marine and terrestrial organic matter is a potential tool to detect fluctuation in the palaeoenvironmental conditions due to warming. At the margin of Arctic Ocean, Yermak Plateau, Ocean Drilling Program (ODP) Hole 910-C is strategically located for establishing a stratigraphic framework for the Arctic. The region experiences low diversity and poor representation of calcareous and siliceous microfossil records.

14. **Project: Biostratigraphy of Kerala Basin based on palynology and calcareous nannofossils: implications on palaeovegetation and palaeoclimate** (Sponsored by DST, New Delhi, No. EMR/2016/005983, w.e.f. 10.05.2018)

Investigators: Poonam Verma, Abha Singh & Yogesh Pal Singh (JRF)

The published palynological studies from Kerala Basin have been reviewed to draw an overview of the palaeovegetational history and depositional environments. In addition, a synthesis has been done in the perspective of future biotic proxies and palaeoclimatic studies in Kerala Basin. In addition, field work was carried out in the Cenozoic deposits of southern Kerala Basin to collect sediment samples from different exposures, type sections, sub-surface samples from the open cast mines in and around Trivandrum, Kollam, Manglapuram for palynological and geochemical studies.

15. **Project: Geological significance of early Miocene nonmarine fossils from NW Himalaya vis-à-vis their record from eastern Kutch, India"** (Sponsored by DST, New Delhi; No. SR/FTP/ES-91/2013 under SERB Young Scientist Scheme)

Investigator: Ansuya Bhandari

Discovery of *Sivapithecus* has played an important role in our study of evolutionary relationships among the living species of apes and humans. Today, most researchers believe that *Sivapithecus* is either a relative of the orangutan of Southeast Asia, or an ape that is part of an early radiation of fossil hominoids (the great apes, the chimps, gorillas, and orangutans, including also humans) that are not specially related to any of those. The Tapar specimen is interesting because of its relatively small body size compared to other members of the genus, and because it lived so far outside the previously known range. Recovery of a fossilised upper jaw (maxilla) at Tapar from the Kutch Basin, Gujarat turned out to be the oldest and the only known ape fossil discovered in Peninsular India.

This is a landmark discovery which represents a significant southern range extension of Miocene hominoids in the Indian peninsula. It is the farthest south that it has been found by about 1000 km.

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

Investigator: S. K. Basumatary

Studied pollen and non-pollen palynomoprhs of 15 surface soil samples collected in the semi-evergreen, deciduous and grassland vegetation from the Kaziranga National Park of Assam (Fig. 11). The palynodata reflected a good relationship between the modern pollen and extant vegetation. The continuous representation of the coprophilous fungi, especially, *Sporormiella*, *Saccobolus* and *Sordaria* indicates of the presence of herbivores in the National Park (Fig. 12). This data will be helpful for the reconstruction of the palaeoherbivory and palaeoecology through the sedimentary soil profiles in the region during Quaternary Period.

Fig. 11 - Wild animals, Elephant (*Elephas maximus*) and Indian Rhino (*Rhinoceros unicornis*) during grazing in Kaziranga National Park, Assam.

Sporormiella *Saccobolus*

Fig. 12 - Representation of coprohilous fungi.

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)

Investigator: Swati Tripathi

Palynological signals of human activity were detected from the sedimentary core of Loktak Lake, Bishnupur District, Manipur. A wide variety of cultivated plants were introduced into the agricultural system around the lake, as evidenced by an ethnobotanical survey of traditional edible plants (including cultivated plants) used by the local valley people in Imphal East, Imphal West, Bishnupur and Thoubal districts of Manipur. The most dominant families are Asteraceae and Lamiaceae with eight species each, followed by Zingiberaceae, Verbenaceae, Euphorbiaceae and Poaceae which are used to treat several diseases. Arboreal pollen of Dipterocarpaceae, *Terminalia* and *Syzygium* decreased distinctly at the depth of 0–35 cm, which is probably linked with the fact that local people utilized the trees for construction of buildings, fuel wood and agriculture expansion. The continuous rise in cereal pollen during recent times could be an important signal of human settlement around the study area, as the valley people continue to plant *Oryza sativa* as an important crop. The increase in Cyperaceae and *Polygonum* pollen may also be an indicator of anthropogenic activity in the region, as the continuous sediment influx gradually converts the submerged lake into marshy land. The high frequencies of non-cereal pollen in the fossil record could be owing to the luxuriant herbaceous vegetation growing around the sampling provenance, and might have been transported from the nearby croplands situated at a distance of 100–300 m through varied media (wind, water, etc.) to the lake. Thus, the presence of non-cereal pollen

Fig. 13 - A view of Keibul Lamjao National Park in Manipur.

could be related to opening of the forest, perhaps reflecting human activity.

The dung samples of endangered deer species (Sangai and Hog deer) from Keibul Lamjao NP, Manipur could serve as a potential modern botanical analogue for this flood-prone region, where surface soil fails to provide an extant vegetation picture, thus aid in palaeoecological interpretation (Fig. 13).

18. **Project: Land-sea interactions along coastal wetlands of Gujarat, western India: mangroves response to climate and sea-level changes during the Holocene (**Sponsored by SERB-DST, New Delhi, No. EMR/2017/004795; w.e.f. October 15, 2018).

    Investigators: Shilpa Pandey (PI) & Prof. Mahesh Thakkar (Co-PI), Kachchh University, Gujarat

Project started on October 15, 2018. During this period, an appointment of JRF and procurement of equipments have been done.

19. **Project: Mangrove dynamics and relative sea level changes during Late Quaternary in Godavari Delta** (Sponsored by DST SERB, New Delhi, No. SR/FTP/ES-84/2014 w.e.f. 17.03.2015).

    Investigator: Jyoti Srivastava

High-resolution palynological reconstruction of the vegetation successions in two sedimentary profiles from the Godavari Delta, India was done to decode the events of extreme climatic variability during the last 2 millennium. These historical records of natural climate variability are crucial in quantifying the future climate change with enhanced anthropogenic inputs. Climatic periods inferred from the pollen record include (1) a basal warm/humid period (BC 250 – AD 450) with dominance of mangroves and tropical moist deciduous taxa, (2) a gradual weakening of monsoon leading to arid conditions with a decline in true mangroves and arboreal taxa comparable to Dark Ages Cold Period (AD 450 - 910), (3) a Medieval Warm Period (AD 910 – 1385) with a strengthened summer monsoon as evidenced by rejuvenation of true mangroves and tree taxa (Fig. 14), (4) a relatively cool and dry condition with abundance of dry deciduous and non-arboreal taxa possibly corresponding to Little Ice Age (AD 1385–1850) with a weakened monsoon, and finally (5) the current warm period, since AD 1850. A semiquantitative aridity index based on variations in humidity has also been used to detect for the first time in India the millennial-scale climatic cyclicity in the pollen record. The Little Ice Age is recorded with high aridity values between AD 1385 and 1850, with a peak at AD 1700 (Maunder Minimum), whereas, the Roman and Medieval Warm Periods are noticed through low aridity values at BC 250-AD 450 and AD 910-1385, respectively.

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, w.e.f. 06.11.2013)

    Investigators: Santosh Kumar Shah & Uttam Pandey

Based on the work carried out from this project, Ph.D. thesis was submitted and Project compilation report was completed.

21. **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)

    Investigators: Ruchika Bajpai (& Ratan Kar, Mentor)

Multi-proxy studies on two profiles from Hamtah Glacier (90 cm) and Chhatru Glacial Valley (130 cm) were further refined. The profile from Hamtah has an extrapolated AMS date upto ~4800 yr BP and three pollen and climatic zones were demarcated on the basis of changing frequencies of AP/NAP ratios and that of the temperate broad-leaved elements. The climate was cold and arid from ~4800-3345 yr BP, which became relatively moist between ~ 3345-1740 yr BP. The last phase upto the present shows a return to colder conditions. Magnetic susceptibility studies have also demarcated three climatic

Fig. 14 - *Rhizophora apiculata, Excoecaria agallocha, Avicennia marina, Aegiceras corniculatum, Sonneratia apetala* and *Acanthus ilicifolius.*

phases, though not fully compatible with the pollen zones; while geochemistry (WIP) has broadly revealed two climatic zones with a short cold-arid phase of ~240 years in the recent times.

The subsurface profile from Chhatru has three AMS dates, which were extrapolated to provide a chronology up to ~ 11500 yr BP. A prolonged warm and comparatively moist phase is observed from 11500-6475 yr BP as evidenced by increased AP/NAP ratio. Within this long warm phase, cold-arid intervals have also been deduced. Onset of colder conditions is envisaged between ~ 6475-1100 yr BP by decreased values of conifers and broad-leaved taxa. A warmer phase thereafter returned, however, colder conditions are discernible in the later part. Magnetic susceptibility values are high before 7675 yr BP; around 6585 yr BP there is a decrease, which does not show much change in the susceptibility till about 1089 yr BP. Low values of WIP have been recorded from 11500-7075 yr BP indicating warm-moist conditions. Around 7075 to 871 yr BP, an increase in WIP values has been witnessed which decreased around 871 yr BP onwards. The magnetic susceptibility and WIP values are more or less synchronous with the palynological data.

22. 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)

Investigators: Amit K. Mishra & Ratan Kar

Palynological studies of surface samples along the altitudinal transect (2800 -3670 m) were undertaken from the road-head at Chopta to Chandrashila peak. Three vegetation zones were demarcated: Zone I (2900 – 3100 m; 20 samples) shows mixed vegetation dominated by *Quercus* and *Rhododendron arboreum* followed by *Acer* and *Abies*; Zone II (3100 – 3250 m; l7 samples) is characterized by *R. campanulatum* along with *Abies* and *Quercus*; Zone III (3250 - 3670 m; 8 samples) is characterized by alpine meadows and clusters of *R. anthopogon*. The pollen rain in each zone revealed high frequencies of arboreals over the non-arboreals. The arboreals include conifers and broad-leaved taxa which show an average pollen frequency of 56.96% and 17.96% respectively. Among the conifers, *Pinus* shows the highest frequency of 49.06%, followed by *Abies* (5.85%), *Cedrus* (1.80%) and *Picea* (0.21%). *Juniperus* is sporadically recorded (0.08%). Broad-leaved taxa are in variable amounts, represented by *Quercus* (7.69%), *Alnus* (6.73%), *Rhododendron* (1.33%), *Betula* (0.95%), *Corylus* (0.31%), *Ulmus* (0.28%), *Myrica* sp. (0.33%), *Acer* sp. (0.25%) and *Juglans* (0.06%).

Most frequently occurring non-arboreals are members of Poaceae (4.66%), Polygonaceae (1.95%), Solanaceae (1.54%), Rosaceae (0.71%), Ranunculaceae (0.50%), Apiaceae (0.45%), Saxifragaceae (0.41%), Euphorbiaceae (0.38%), Cyperaceae (0.32%) and Brassicaceae (0.30%), while the representation of Balsaminaceae, Acanthaceae, Geraniaceae, Lamiaceae, Papaveraceae, Liliaceae, Malvaceae, Convolvulaceae, Caprifoliaceae, Fabaceae, Rutaceae, Oleaceae and Potamogetonaceae is low. Amongst the steppe elements, Tubuliflorae (3.50%), Liguliflorae (0.60%), *Artemisia* sp. (average 0.83%), Amaranthaceae (0.71%) and Caryophyllaceae (0.09%) are represented in variable amounts. Amongst the non-pollen palynomorphs (NPPs), fern allies (*Davallia*, monoletes and triletes) are recovered from all the samples with varying frequencies (average 7.38%). Fungal elements along with *Glomus* (1.22%), *Nigrospora* (0.76%), *Tetraploa* (0.60%) and Microthyriaceae (0.11%) are also encountered. Algal spores along with *Spirogyra* and *Botryococcus* are also represented in lesser amounts. These modern-analogues would help in the better interpretation of fossil pollen assemblages.

23. 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)

Investigators: Kajal Singh & Ratan Kar

Quartz grain microtexture studies on twenty-eight sediment samples from a 140 cm deep trench from Ny-Alesund, Svalbard, were finalized. The trench has three AMS dates and extends up to ~ 19000 yr BP. Seven quartz grains from each sample were picked under reflecting microscope, placed on a stub and coated with platinum for SEM analysis. The quartz grain microtexture studies were primarily undertaken to decipher the past depositional setting (transport mechanism) and environmental changes in the region since the LGM. The most recognizable microtextures observed were angular fragments, high reliefs, conchoidal fractures, sub-parallel linear fractures, steps and crescentic gouges; all of which were formed as a result glacial activities. Etching patterns are also common in some grains that have long-term contact with water, such as grains from coastal environment. It may also refer to seawater acidification.

The study reveals high intensity of glacigenic microtextures, also with glacial reworking. Aqueous activities are also discernible in the microtextures. Besides, palynofacies and isotopic studies have also been initiated.

24. **Project: Tree growth response of selected tree species of timber line to climate variability across the Indian Himalayan region** [Sponsored by MoEF & CC (under NMHS Program); No. 1886/ XII-86/2016; w.e.f. 01.04.2016]

Investigators: Parminder Singh Ranhotra (PI); Amalava Bhattacharyya (Co-PI) & Bency David Chinthala (JPF)

Three tree ring chronologies (two of *Abies spectabilis* (fir) and one of *Pinus wallichana* (pine)) are developed from the Daksun-Sinthan area of Kashmir (J&K). Tree-line altitude (~ 3400 m amsl) fir and lower altitude (~ 2400 m amsl) fir respectively represent ~ 400 and 300 years old chronologies. Pine chronology extends to ~ 175 years back. The tree growth and climate relationships show variations in growth responses at altitudinal scale. For lower elevation fir, relatively higher temperature and early melting of snow at lower elevation could lead to early growth and hence more demand of moisture in summer months. Whereas, higher elevation fir show some lag in their growing period due to late melting of snow and low air/soil temperature.

With the glacier mass balance data, growth chronologies of both fir and pine show negative correlation. Prominent relationship for treeline fir (r= -0.54), compared to lower elevation pine (r= -0.394) and fir (r= -0.33) suggest strong sensitivity of higher elevation tree towards katabatic winds blowing through glaciers. This relationship could help in glacier mass balance reconstruction during the past for the region. The study could help to bring forth the behaviour pattern in the growth of taxa in response to localized climatic conditions at the altitudinal scale.

25. **Project: Quantifying the Holocene monsoonal variability using modern vegetation-climate relationships in the western margin of the Bengal Basin, India: development of transfer functions** (Funded by SERB, New Delhi, Sanction No. EMR/2016/005209 dated 28.05.18; w.e.f. 12.06. 2018).

Investigators: Ruby Ghosh (PI), Shailesh Agrawal (Co-PI) & Subir Bera (Co-PI)

A field work has been carried out in various sites of West Bengal during 17.01.19 to 11.02.19 for collection of surface and sub-surface sediment samples to explore the vegetation and climatic scenario of the West Bengal part of the Bengal Basin, India during the Holocene.

26. **Project: Testing the efficacy of grass phytoliths in discriminating rainfall variations and their application potential in the Holocene climate reconstructions: study along the rainfall gradient of the Western Ghats, India** (Funded by SERB, New Delhi, Sanction No. EMR/2016/ 006125 dated 16.07.18; w.e.f. 06.08. 2018).

Investigators: Subir Bera (PI) & Ruby Ghosh (Co-PI)

A field work has been carried out in various sites of Maharashtra part of the Western Ghats during 23.03.19 to 12.04.19 for collection of surface and sub-surface sediment samples to understand the Holocene monsoonal variations of the Western Ghats.

27. **Project: Late Quaternary biotic-abiotic interactions from the Harshad Estuary, Gujarat, India: Implications on palaeo-productivity and climate** (Sponsored by SERB-DST New Delhi; No. SR/FTP/ES-149/2014), w.e.f. 21.08.2015).

Investigator: Biswajeet Thakur (PI)

An assessment of palynofacies and sediment data from a core drilled at Harshad Estuary, Saurashtra, Gujarat, India was carried out for palaeoenvironmental and palaeoclimatic reconstruction. Drawing on these data we evaluate their relation to cultural/economic changes during the early to late Harappan phases in the peripheral zone of Southwest Monsoon. Between ca. 5400-5100 yr BP, palynofacies and sediment particle size indicated a high terrestrial influx, interpreted as a period of higher monsoon precipitation. These proxies then indicated a protracted period of diminished freshwater inundation between ca. 5100-1400 yr BP. At the start of this period, archaeobotanical evidence from studied sites in the region also shows the shift in cropping pattern from large grain winter cereals during the Urban Harappan phases to millet based agriculture during the Post-Urban phase, indicating human adaptation in response to climate change. These strategies also appeared contingent on the geographic niche and site type, size and density. The Harshad sediment core from 1400 yr BP to recent times also demonstrates fluctuating precipitation between lower and higher values which may be broadly correlated to climatic events such as the Medieval Climate Optimum (MCO) and Little Ice Age (LIA). This also reflects increasing anthropogenic pressures impacting the depositional environment of the estuary.

28. Project: Late Quaternary palaeoclimatic/sea level changes and anthropogenic responses from estuarine complexes of western India: A multi-proxy approach (Sponsored by SERB-DST EMEQ New Delhi; No. SB/EMEQ-244/2014), w.e.f. 23.01.2016).

Investigators: Biswajeet Thakur (PI) & Priyanka Seth (JRF)

Surface sediments were studied from the Dhadhar Estuary for diatom and palynofacies analysis. In the study fourty-three diatom genera were recorded belonging to pennate community, viz. *Surirella*, *Gyrosigma*, *Navicula*, *Cocconeis*, *Nitzschia*, *Gomphonema*, *Fragilaria*, *Achnanthes*, *Pinnularia*, *Diploneis*, *Grammatophora* with low counts of centric forms *Cyclotella*, *Campylodiscus* and *Thalassiosira*. The terrestrial palynofacies comprising of black oxidized (Charcoal), degraded brown OM, structured OM, oxidized land plant tissue are present in varying proportions while the marine palynofacies comprising of microforaminiferal linings, animal remains, tintinids, scolecodonts, copepods egg envelopes and framboidal pyrite are present in low percentage. The Amorphous OM (AOM) in Dhadhar is present in low percentages. The high diversity of freshwater benthic diatoms indicates low tidal/wave activity in flow regimes. The marine centric diatoms suggests marine incursion during high tide activity. The transportation and erosion of the organic matter is also not extensive as the river is ephemeral as evidenced by the palynofacies analysis.

In the Sabarmati Estuary the diatom diversity, palynofacies distribution, grain size and physical parameters were analyzed in the supratidal setting. The changes in the diatom diversity correspond to the surface processes in different capacity either in the form of runoff related changes, human interventions or estuarine complexity and this corroborates with palynofacies and grain size data. The varying proportion of freshwater, brackish, marine and polluted diatoms in varying capacity and terrestrial and marine inundation of organic matter also elucidates tidal influence, alkaline environment (based on pH), salinity variations, etc. The grain size and physical property of the sediments from Sabarmati Estuary also help to understand the winnowing process and mixed water condition of the study area with slight alkaline pH and moderate range of conductivity with low salinity of water. The study indicates high anthropogenic influence in the Sabarmati Estuary.

29. Project: Macro and micro-phytodiversity and behavioural pattern of pollen deposition in and around endangered wetlands of Assam: a palaeoecological and conservational perspective (Sponsored by SERB-DST EMR New Delhi; No. EMR/2014/000233, w.e.f. 17.03.2016).

Investigators: Abhijit Mazumder, Samir K. Bera & Amulya Saxena

Surface pollen samples from Nalapur and Sukurberia forest divisions of Rani Reserve Forest, Assam were analysed in order to establish pollen-vegetation relationship in the coveted region. The result shows a drastic depletion of sal (*Shorea robusta*) pollen frequency in open land (0.5-1%) as compared to the core forest (7%). Among the herbs, grasses occupy higher value (34%). Presence of a fair amount of fern spores indicate humid depositional environment. The occurrence of high value of *Melastoma*, Acanthaceae *Mikania* and *Mimosa pudica* is suggestive of forest clearance. Evidence of degraded pollen - spores festooned with fungal remains suggests the initiation of biological degradation in sediment. Surface and core samples from Rani Reserve Forest (Nalapur and Sukurberia) and Deepor Bil, Kamrup District, Assam have been analysed for the study of diatoms to identify and make distribution chart of all major diatom species. Forty major diatom taxa have been identified, among which pennate forms are predomination. Sand-Silt-Clay analysis of all the samples from surface and core sediments from Rani Reserve Forest and Deepor Bil, Kamrup District, Assam have been done. The results from this study show that number of diatom taxa and sand percentage shows inversely proportional relation and varies within different settings within the forest region.

30. Project: Palaeoclimate and palaeoceanography of the Lower Bengal Fan from late Paleogene to present – IODP Expedition 354 [Sponsored by IODP India, NCAOR - Ministry of Earth Sciences. Project No. NCAOR/IODP/20-15/15(V), w.e.f. March 2017].

Investigators: Manoj M.C. & Masud Kawsar

The lower Bengal Fan sediments, retrieved during IODP Expedition 354 from the Site U1452C chiefly dominate in hemipelagic deposits with minimal or no sand. Non cohesive sortable silt (SS) and mean sortable silt (*S^S*) have been used to estimate the critical bed shear stress associated with grain movement using standard empirical equations for ocean waters. The Dimensionless Shear Stress measured from SS means vs. the

dimensionless grain Reynolds number in the modified shield diagram fall within the rising arm, accounting the greater shear stress for lower grain Reynolds number. Threshold bed shear stresses calculated, are positively correlated with the mean, sorting and volume percent of sortable silt and have no correlation with sand. Hence threshold grain motion associated with sortable silt has been taken into consideration to describe the hydrodynamic processes which are operated at the bed bottom undertaking the sorting processes of non cohesive silt fraction of bulk sediments. Changes in bottom water current strength has been expressed in terms of changes in *S^S* variability and in threshold bed shear stress for silt grain movement. Variation in the bottom water current strength expressed in terms of threshold bed shear stress may account for the climate driven variation in physical oceanographic parameters throughout last two glacials. Several microscopic spherical, dumbbell, teardrop, disc and irregular shaped glassy objects have been found in deep-sea sediment cores collected during the Bengal Fan Expedition. SEM and EDS analysis has been carried out on these grains of microtektites to study the morphological variation, chemical composition and physical properties (Fig. 15). Other than microtektites, the presence of a possibly polymetallic exsolution structure (Widmanstatten texture), shocked minerals and unmelted and partly melted ejecta within the microtektite-bearing layer in the Northern Indian Ocean provides further evidence that the Australasian microtektites might have been formed by the impact of an extra terrestrial projectile at ~ 0.8 Ma, somewhere in Indo-China.

31. Project: Provenance and environmental records of lake sediments from Kerala, south India - using a suite of geochemical proxies (Sponsored by DST-SERB Young Scientist Scheme No. SR/FTP/ES-153/2014, w.e.f. August 2015).

Investigator: Manoj M.C. (PI)

The effect of climatic events from the lake sediments of the Kerala State is poorly understood, and the knowledge on the relationship of such climatic changes with the monsoonal activities are limited. Geochemical

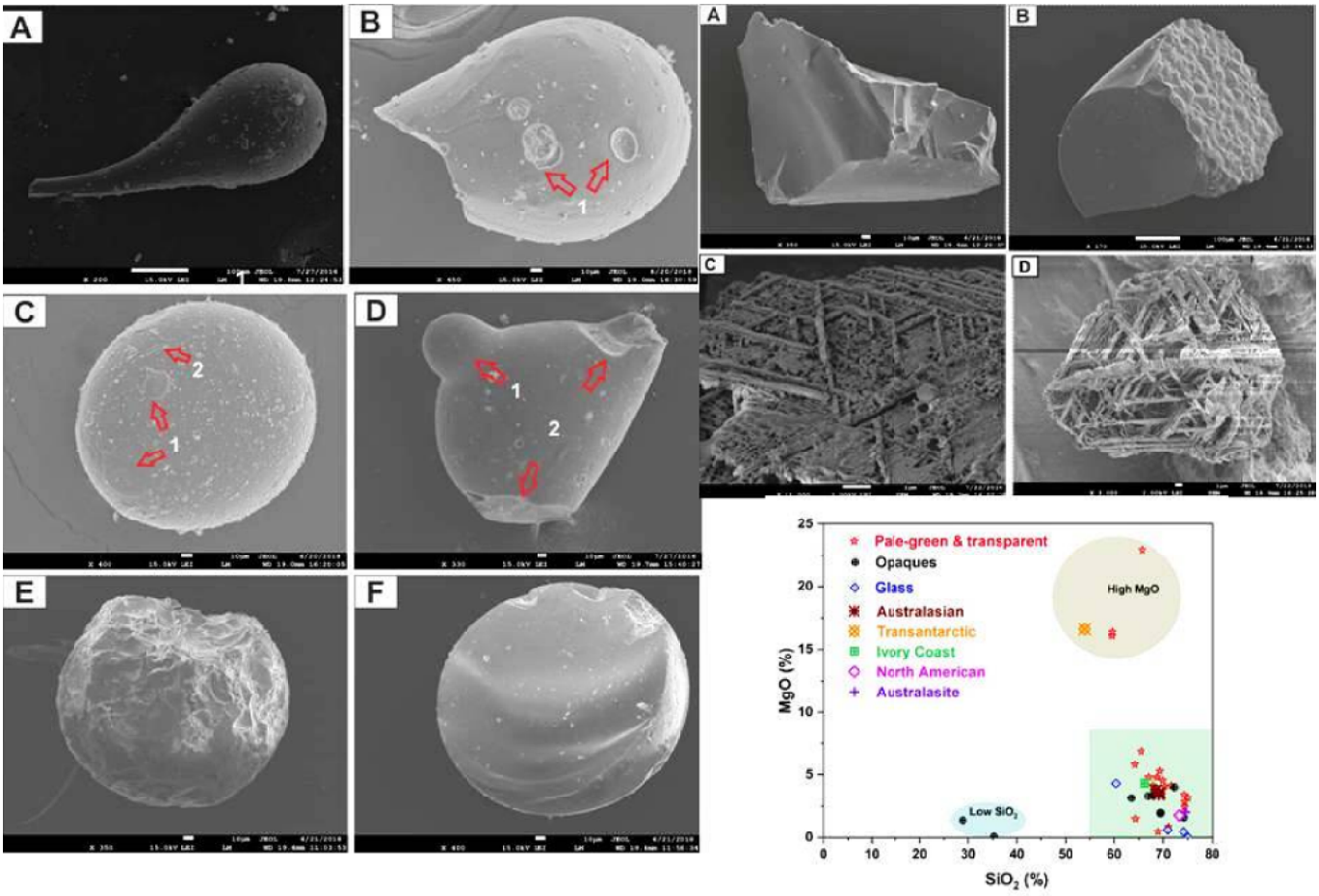


Fig. 15 - SEM images of the microtektite grains with surface features and polymetallic exsolution structure and SiO_2 Vs MgO plot of the microtektite, opaques and glass and records from Australasian, Ivory Coast, Transantarctic Mountain and Australites microtektites.

and sedimentological analysis on sediment samples collected from Vellayani, Pookode and Vagamon lakes has been carried out to study the provenance, palaeoenvironment and its impact on monsoon and climate. Sediment cores have been collected from the Vellayani Lake, Kerala, India to study the environmental variability, provenance, and to reconstruct the palaeoclimatic and palaeomonsoon variation during the late Quaternary. Vellayani Lake lies ideally under the influence of SW monsoon and the knowledge on the relationship of such climatic changes with the monsoonal activities are limited. The AMS ^{14}C ages of the top 6.5 m sediment represents the past ~ 12,000 years before present (12 ka BP) and the rate of sedimentation of different intervals of the core varies from 3 cm/yr to 59 cm/yr and is the highest for early Holocene sediments. The sediments mainly composed of sand and silt contributing < 80% at all the sites, indicating that a relatively violent environment prevailed during the deposition of sediments. To a depth of 140 cm, the core consists of dark brown clay rich in organic materials, which is followed by light brown clayey silt between 140- 550 cm which also contain the root and leaf remnants in the sediments. The bottom part of the sediment, between 550-1400 cm consisted of layers of white sandy silt followed by silty clay with calcareous molluscan shells. The $\delta^{13}C$ values of the organic matter in the core shows huge variation (-29.01 to -21.13) and vary mostly in the range typical for C3 plants (Fig. 16). The shift in $\delta^{13}C$ values indicates dramatic temperature changes during the late Quaternary.

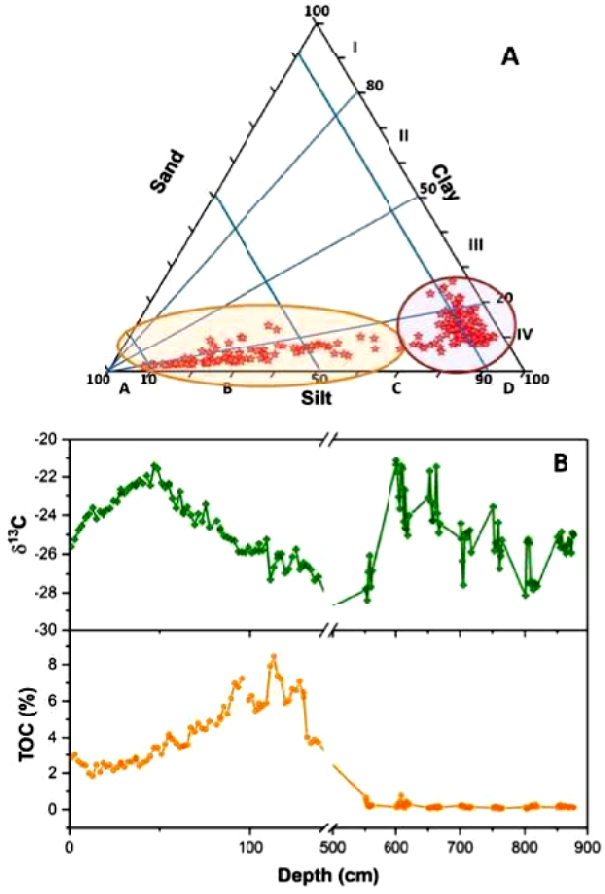


Fig. 16 - Ternary diagram showing deposition of sand, silt and clay under varying hydrodynamic energy conditions and (B) TOC and ä^{13}C values of the organic matter at Vellayani Lake.

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

Investigators: Anil K. Pokharia, Shalini Sharma & Neelam Mishra (till June 2018)

To gain insights into the palaeoclimatic conditions and subsistence during past millennia, the sediments samples collected from the trench (P-35) at 15 cm interval from the archaeological site Chandravati, Rajasthan were

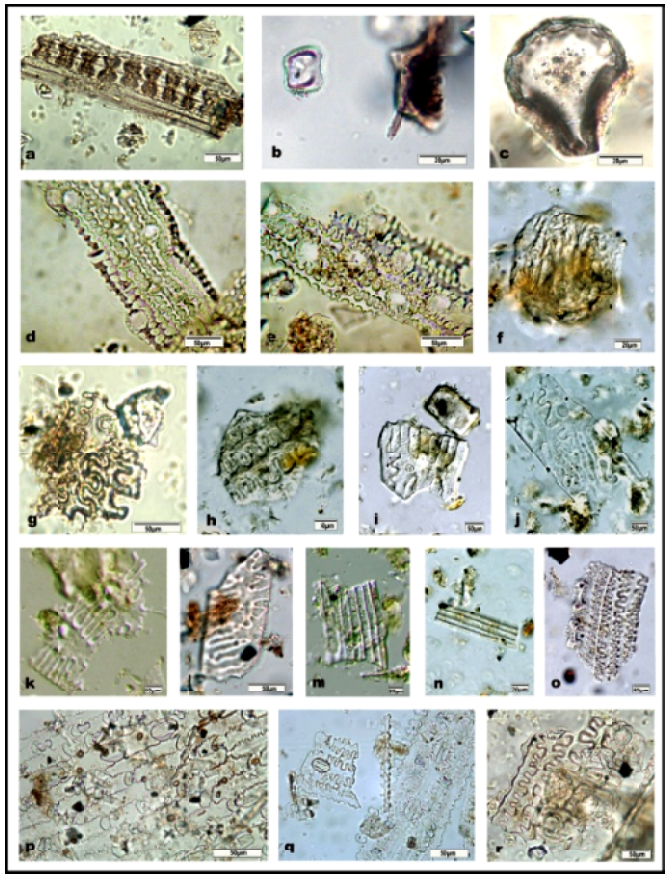


Fig. 17 - Phytolith morphotypes obtained from Chandrawati- multicell panel of scooped bilobates (a) rice husk phytoliths (b, f) cuneiform bulliform of rice (c) barley (d) wheat (e) remains of millets (g-l) cut phytoliths (m,n) indet leaf/ culm multicell panel (o-r)

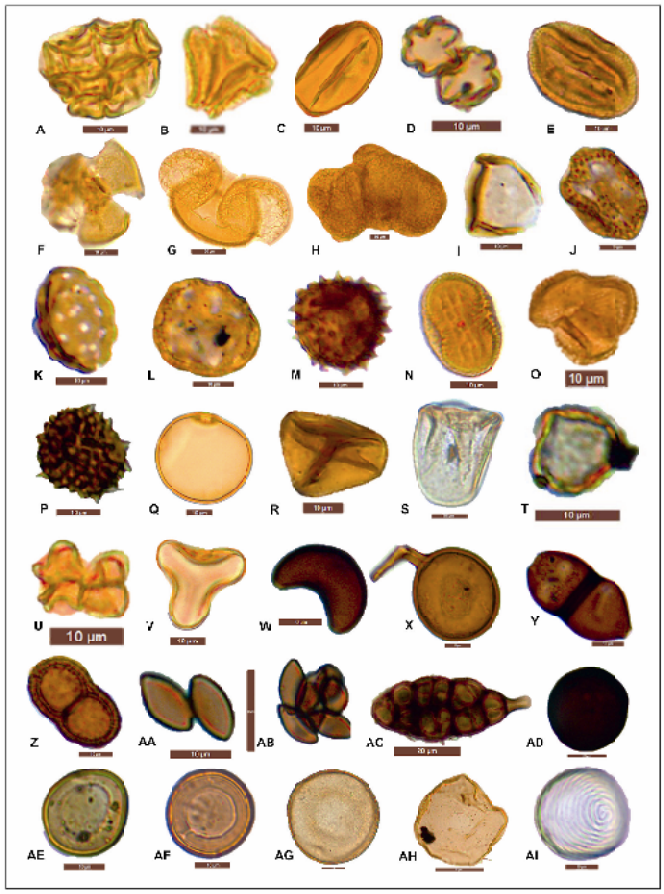


Fig. 18 - Palynoassemblage recovered from the Mandovari Lake, Rajasthan. A. *Acacia*, B. *Syzygium*, C. *Lagerstroemia*, D. *Terminalia*, E. Anacardiaceae, F. Fabaceae, G. *Pinus*, H. *Abies*, I. *Betula*, J. Amaranthaceae, K. Chenopodiaceae, L. Caryophyllaceae, M. Asteroideae, N. *Justicia*, O. *Artemisia*, P. Malvaceae, Q. Poaceae, R. Cerelia, S. Cyperaceae, T. Onagraceae, U. *Typha*, V. Trilete fern spore, W. Monolete fern spore, X. *Glomus*, Y. *Cookeina*, Z. Teliospore, AA & AB. *Saccobolus* clumping, AC. *Alternaria*, AD. *Nigrospora*, AE-AH. *Arcella* (Thecamoebians), AI. Pseudoschizae.

analysed for phytoliths. Diverse morphotypes were identified (Fig. 17). Two zones "I and II, have been identified based on the frequency of phytolith morphotypes. Both zones were dominated by Grass Silica Short Cell phytoliths (GSSC). In Zone I, various crop phytoliths were recorded including millets (2-4%), wheat (2.5-5%), barley (2-5.5%) and rice husk (3-4.5%). The presence of cut phytoliths indicates anthropogenic/agricultural activities. While Cyperaceae phytoliths account from1 to 4%. Crop phytoliths in Zone II include millets (2-6%), wheat (1.5-4.5%), barley (2-7%) and rice husk (1.5-2.5%). Cyperaceae phytoliths were almost absent in this zone except from one strata. The percentage of millets was somewhat higher in this zone ranging from (2-6%).

The multiproxy study indicates the diversification of crop assemblage along with trees, aquatic and marshy plants (members of Polygonaceae, Fabaceae and Cyperaceae) suggesting occurrence of warm and humid climate with favourable monsoonal conditions between ~ 650"1450 CE (Fig. 18). This period overlaps with globally recognized Medieval Warm Period (~ 750"1250 CE), known for better monsoonal conditions. However, during ~ 1450"1900 CE the dominance of non-arboreal taxa (*Xanthium*, Onagraceae) and millets (drought resistant crops) along with scanty large grained cereals and pulses suggests warm but relatively dry climatic conditions. This period corresponds to globally known Little Ice Age (1450-1850 CE).

Photo-documentation of the palynomorphs from Mandovari Lake (neighbouring archaeological site Chandravati) and phytoliths were also carried out. Finalization of the project report is in progress.

33. Project: Glacial chronology, palaeoclimatic reconstruction and their climatic implications in the Thangu Valley, Sikkim Himalaya, India with special emphasis on luminescence characteristics of feldspar and quartz (Sponsored by DST, New Delhi; No. SR/DGH/PAC-HG/2012, w.e.f. 10.08.2015).

Investigators: Sheikh Nawaz Ali (PI) & P. Morthekai (Co-PI)

Indian Summer Monsoon (ISM) variability was quantified using combined high resolution $\delta^{13}C$, Total Organic Carbon (TOC), sediment texture and environmental magnetic data of the samples from a ~ 3 m deep glacial outwash sedimentary profile from the Sikkim Himalaya. Further, decadal to centennial times scale records were identified as well.

Glacial geomorphology and landscape evolution of the Thangu Valley, North Sikkim has been established.

Based on the morpho-stratigraphical mapping of the moraines supported by limited optical chronology, four events of glaciations have been identified in the Lashar, Chopta and Kalip valleys that date back to last glacial maximum and advocate for a widespread ice cover with large outlet tributary glaciers (Fig. 19). Optically stimulated luminescence (OSL) dating of the stratigraphically oldest glacier advance and its retreat in the Chopta Valley revealed that the glacier advanced at 28 ± 2.8 ka and sustained through the global Last Glacial Maximum (gLGM; 26.5 ka and 19 ka). The deglaciation is manifested by recessional moraine (ridge) dated at 18 ± 2.2 ka.

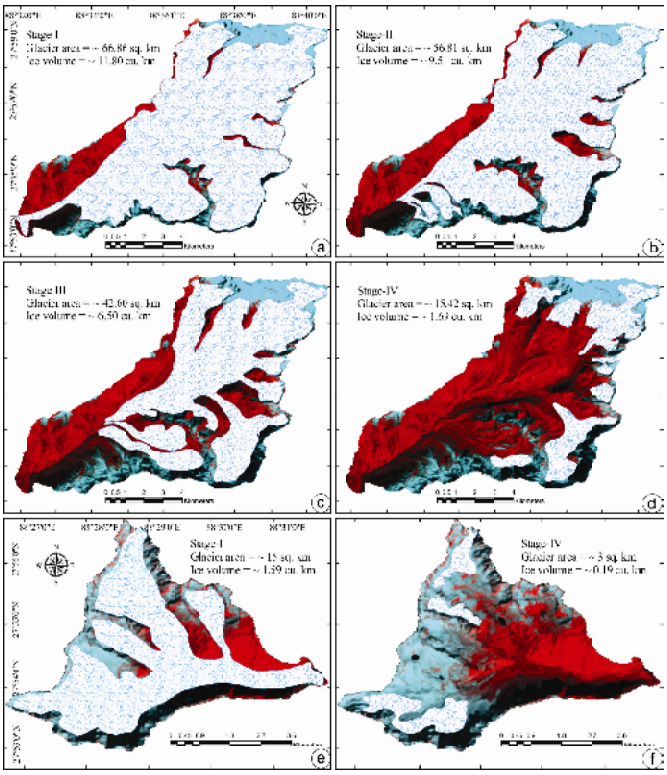


Fig. 19 - Reconstruction of the glacial extent during different glacial stages in Lashar and Chopta Cvalleys overlain on a Landsat ETM+ imagery (a) Lashar Valley Stage-I. (b) Lashar Valley Stage-II. (c) Lashar Valley Stage-III. (d) Lashar Valley Stage-IV. (e-f) Stage-I and Stage- IV in Chopta Valley.

34. Project: Holocene monsoon evolution in SE Asia (Myanmar) as reflected by the provenance and weathering of Ayerawady River sediments (Sponsored by The Open Science Fund project from Tongji University, China; w.e.f. January 2018 to January 2020).

Investigators: Niteshkumar Khonde, Liviu Giosan & Shouye Yang

Clay mineralogical studies were carried out using X-Ray Diffraction (XRD) analysis on two sediment cores raised from the Ayerawady River Delta, Myanmar. The semi quantification of each major clay mineral group was then calculated from the data generated using X-Ray Diffraction. This analysis was carried out by PI during his visit to Tongji University, China.

Major and minor element geochemical analysis of the Ayerawady Delta core sediments was carried out by PI at Tongji University, China.

35. Project: Multiproxy palaeoclimatic studies of Quaternary lake sediments from southern Madhya Pradesh, India. [DST (SERB) SR/FTP/ES-16/2014, w.e.f. November 2014 – November 2017].

Investigator: Kamlesh Kumar (PI)

The multiproxy study of 1.54 m long sediment core obtained from the CMZ of Indian subcontinent reveals that vegetation pattern in central India varied significantly during the last 11.4 ka BP due to substantial ISM variability in the region. Overall, the study shows that the early Holocene Period (~ 11.4 to 9.5 ka BP) was marked by the intensification of ISM which is explained by the stimulus of warm and humid climate that results in reinforcement of moisture transport. A stepwise expansion of C_4 plants is observed between 9.5 to 2.0 ka BP (from ~ 8.1 and 6.3 ka BP, ~ 6.3 to 4.7 ka BP and ~ 3.0 to 2.0 ka BP) under the influence of a gradual weakening of ISM. The highest abundance of C_4 plants at about 2.0 ka suggestive of weakest ISM rainfall in the CMZ. An abrupt increase in ISM from 2.0 to 1.4 ka BP is observed, and it causes expansion of C_3 plants in the CMZ. Following this, our study shows amelioration in ISM till present.

36. Project: Analysis of Holocene Climate change in Tripura and Mizoram based on pollen, environmental geomagnetism and isotope data. SR/WOS-A/ES-18/2014(C), w.e.f. March 2016).

Investigator: Nivedita Mehrotra & Dr. Ratan Kar (Mentor)

Prepared and submitted manuscript for the study carried out in Charilam, Tripura based on palynological and mineral magnetism records of Holocene sub-surface sediments.

Palynological investigation of sub-surface sediments from Hmuntha, Mizoram was carried out and fossil pollen data shall be further analysed. Manuscript was prepared based on modern pollen study of surface samples from Mizoram. Processing for fossil pollen study of 3 sub-surface sediment profiles collected from northern, eastern and western Mizoram was carried out.

This project was sanctioned for the support towards the Ph.D. submission of PI Nivedita Mehrotra who has successfully submitted and has been awarded her Ph.D. degree from the Department of Geology, University of Lucknow, Lucknow, India.

Research Papers Published

In SCI (Science Citation Index) Journals:

Aggarwal N, Thakur B & Jha N 2018. Palaeoenvironmental changes in the Lower Gondwana succession of the Godavari Graben (South India) inferred from palynofacies. *J Paleolimnol.* **61:** 329–343. **IF: 2.168.**

Agnihotri Deepa, Pandita Sundeep K, Tewari Rajni, Ram-Awatar, Linnemann Ulf, Pillai S Suresh K, Joshi Arun, Gautam Saurabh & Kumar Kamlesh 2018. Palynology and detrital zircon geochronology of the Carboniferous Fenestella Shale Formation of the Tethyan realm in Kashmir Himalaya: Implications for global correlation and floristic evolution. *Journal of Asian Earth Sciences* **157:** 348-359. **IF: 2.86.**

Ali SN, Dubey J, Ghosh R, Quamar MF, Sharma A, Morthekai P, Dimri AP, Shekhar M, Arif Md & Agrawal S 2018. High frequency abrupt shifts in the Indian Summer Monsoon since Younger Dryas in the Himalaya 2018. *Scientific Report* **8(1):** 9287. **IF: 4.609.**

Ali SN, Dubey J, Morthekai P, Sharma A, Singh R & Prizomwala S 2019. Climate forcing and the initiation of glacier advance during MIS-2 in the North Sikkim Himalaya, India. *J Asian Earth Sciences* **174:** 381-388. **IF: 2.767.**

Ali SN, Thakur B, Morthekai P, Farooqui Shazi, Phartiyal B, Seth P & Sharma A 2018. Diatom diversity under extreme climate: a study from Zanaskar Valley, NW Himalaya, India. *Journal of the Palaeontological Society of India* **63(1):** 119-126. **IF: 0.667.**

Ali SN, Liu ZF, Stattegger K, Khelifi N & Kuhnt W 2018. Paleoclimatic and paleoenvironmental reconstruction at Tarfaya Atlantic Coastal Basin (Morocco) based on clay mineral records from Upper Cretaceous to Quaternary. *Arabic Journal of Geosciences* **12(6):** 1-12. **IF: 1.141.**

Ali SN, Quamar MF, Phartiyal Binita & Sharma Anupam 2018. Need for Permafrost Researches in Indian Himalaya. *Journal of Climate Change* **4 (1):** 33-36. **IF: 3.344.**

Ansari AH, Singh IB, Kumar S, Pandey SK & Kumar Y 2019. Note on the C and O stratigraphy of the Garbyang Formation (Malla Johar Area), Tethyan Himalaya, India. (Paper accepted in *Journal of the Palaeontological Society of India*). **IF: 0.667.**

Basumatary SK, Singh H, McDonald HG, Tripathi S & Pokharia A 2019. Modern botanical analogue of endangered Yak (*Bos mutus*) dung from India: Plausible linkage with living and extinct megaherbivores. *PLOS ONE* **14(3):** e0202723 https://doi.org/10.1371 / journal.pone.0202723. **IF: 2.8.**

Benjamin R Fosu, Ghosh Prosenjit, Mishra Divya, Banerjee Yogaraj, Prasanna K & Sarkar Amrita 2019. Acid digestion of carbonates using break seal method for clumped isotope analysis. *Rapid Communications in Mass Spectrometry* **33**: 203–214. **IF: 1.97.**

Bhandari A, Kay RF, Williams BA, Tiwari BN, Bajpai S & Hieronymus T 2018. First record of the Miocene hominoid *Sivapithecus* from Kutch, Gujarat State, western India. *PLOS ONE* **13(11):** 1-20. **IF: 2.766.**

Bhandaria S, Gaire NP, Shah SK, Speerb JH, Bhuju DR & Thapa UK 2019. A 307-year tree-ring SPEI reconstruction indicates modern drought in western Nepal Himalayas. *Tree-ring Research* (accepted). **IF: 2.183.**

Bhattacharyya Ranjan, Das TK, Das S, Dey A, Patra AK, Agnihotri R & Ghosh A 2019. Four years of conservation agriculture affects topsoil aggregate-associated 15 nitrogen but not the 15 nitrogen use efficiency by wheat in a semi-arid climate. *Geoderma* **337:** 333-340. **IF: 4.336.**

Chakraborty A, Ghosh AK, Dey R, Saxena S & Mazumder A 2018. Record of Miocene Climate Optimum in the Northeast Indian Ocean: Evidence from the microfossils. *Palaeobiodiversity and Palaeoenvironments,* https://doi.org/10.1007 / s12549-018-0342-3. **IF: 1.229.**

Das N & Prakash N 2018. Occurrence of *Brachyphyllum regularis* Borkar & Chiplonkar from Himmatnagar Sandstone and its geographic distribution in Indian Gondwana basins. *J. Palaeontol. Soc. India* **63:** 163-168. **IF: 0.667.**

Dubey J, Ali SN, Sharma A, Morthekai P, Singh R, Sharma RK, Pandey P, Thakur B & Srivastava V 2019.

Glacial Geomorphology and Landscape Evolution of the Thangu Valley, North Sikkim Himalaya, India. *Journal of the Indian Society of Remote Sensing*. https://doi.org/10.1007/s12524-019-00943-5. **IF: 0.810.**

Farooqui Anjum 2018. Epidermal morphological features and phytolith variation in the leaf of *Oryza sativa* l., IJRAR - *International Journal of Research and Analytical Reviews* (IJRAR), E-ISSN 2348-1269, P- ISSN 2349-5138, **5(4):** 45-53. **IF: 3.215.**

Gaire NP, Dhakal YR, Shah SK, Fan ZX, Bräuning A, Thapa UK, Bhandari S, Aryal S & Bhuju DR 2019. Drought (scPDSI) reconstruction of trans-Himalayan region in western Nepal using *Pinus wallichiana* tree-rings. *Palaeogeography, Palaeoclimatology, Palaeoecology* **514:** 251-264. **IF: 2.375.**

Ghosh Avijit, Bhattacharyya Ranjan, Agarwal BK, Mahapatra P, Shahi DK, Singh Geeta, Agnihorti Rajesh, Sawlani Ravi & Sharma Chhemendra 2018. Long-term fertilization effects on 13C natural abundances, soil aggregation and deep soil organic carbon sequestration in an alfisol, land degradation and development. *Land Degradation & Development*. https://doi.org/10.1002/ldr.3229, **IF: 7.27.**

Ghosh R, Biswas O, Paruya DK, Agrawal S, Sharma A, Nautiyal CM, Bera M & Bera S 2018. Hydroclimatic variability and corresponding vegetation response in the Darjeeling Himalaya, India over the past 2400 years. *Catena* **170:** 84-99. **IF: 3.256.**

Goswami S, Das K, Sahoo M, Bal S, Pradhan S, Singh KJ & Saxena A 2018. Biostratigraphy and floristic evolution of coal swamp floras of a part of Talcher Basin, India: a window on a Permian temperate ecosystem. *Arabian Journal of Geosciences* **11:** 524-538. **IF: 0.866.**

Govil P, Mazumder A, Ram R, Singh DS & Azharuddin S 2018. Melt water flux and climate change record of last 18.5 ka from Schirmacher Oasis, East Antarctica. *Polar Science* **18:** 135-141. **IF: 1.031.**

Harini Santhanam, Farooqui Anjum & Karthikeyan Anandasabari 2018. Bloom of the diatom, *Biddulphia* sp. and ecology of Pulicat lagoon, Southeast India in the aftermath of the 2015 north eastmonsoonal rainfall. *Environ Monit Assess* 190:636 https://doi.org/10.1007/s10661-018-7020-9. **IF: 1.804.**

Iliescu Florin Mircea, Chaplin George, Rai Niraj, Jacobs Guy S, Mallick Chandana Basu, Mishra Anshuman, Thangaraj Kumarasamy & Jablonski Nina G 2018. The influences of genes, the environment, and social factors on the evolution of skin color diversity in India **30(5):** *e23170, American Journal of Human Biology.* **IF: 1.575.**

Jha N, Aggarwal N & Mishra S 2018. A review of the palynostratigraphy of Gondwana sediments from Godavari Graben, India: Global comparison and correlation of Permian-Triassic palynoflora. *J. Asian earth Sci.* **163:** 1-21. **IF: 2.86.**

Kapur VV & Khosla A 2018. Faunal elements from the Deccan volcano-sedimentary sequences of India: a reappraisal of biostratigraphic, palaeoecologic and palaeobiogeographic aspects. *Geological Journal*. DOI: 10.1002/gj.3379. **IF: 2.978.**

Kar R & Ghosh AK 2018. First record of *Reduviasporonites* from the Permian–Triassic transition (Gondwana Supergroup) of India. *Alcheringa* **42(3)**: 1-10. **IF: 1.033.**

Kar R, Mazumder A, Mishra K, Patil SK, Ravindra R, Ranhotra PS, Govil P, Bajpai R & Singh K 2018. Climatic history of Ny-Alesund region, Svalbard, over the last 19,000 yr: Insights from quartz grain microtexture and magnetic susceptibility. *Polar Science* **18:** 189-196. **IF: 1.031.**

Kumar K, Agrawal S, Sharma A & Pandey S 2019. Indian Summer Monsoon (ISM) variability and vegetation changes in Core Monsoon Zone (CMZ), India during the Holocene: a multiproxy study. *The Holocene* **29(1):** 110-119. **IF: 2.547.**

Liu J, Spicer RA, Tang H, Deng WYD, Wu FX, Srivastava G, Spicer TEV, Do TV, Deng T & Zhou ZK 2019. Biotic interchange through lowlands of Tibetan Plateau suture zones during Paleogene. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **524:** 33-40. **IF: 2.375.**

Lu Kai-Qing, Min Li, Guo-Hong Wang, Lian-Sheng Xu, David K Ferguson, Trivedi Anjali, Jing Xuan Ying Feng, Jin-Feng Li, Gan Xie Yi-Feng Yao & Yu-Fei Wang 2018. New pollen classification of Chenopodiaceae for exploring and tracing desert vegetation evolution in eastern arid central Asia. *J. Syst. Evo.* **52(2)**: 1-10. **IF: 3.657.**

Lu Kai-Qing, Xie, GM, Li Jin-Feng Li, Trivedi Anjali, Ferguson DK, Yao Yi-Feng, Wang Yu-Fei 2018. Data

set of pollen morphological traits of 56 dominant species among desert vegetation in the eastern arid central Asia. *Data in Brief*. 18. 10.1016/ j.dib.2018.03.122. **IF: 0.85.**

Makwana N, Prizomwala S, Chauhan G, Phartiyal B & Thakkar MG 2018. Late Holocene palaeo-environmental change in the Banni Plains, Kachchh, western India. *Quaternary International*, doi: 10.1016/j.quaint.2018.11.028. **IF: 2.163.**

Manoj MC, Thakur B, Prem Raj U & Prasad V 2018. Assessment of metal contamination in the sediments of Vembanad wetland system, from the urban city of southwest India. *Environmental Nanotechnology, Monitoring & Management* doi.org/10.1016/ j.enmm.2018.07.004. **IF: 3.96.**

Mathews RP, Singh BD & Singh VP 2018. Evaluation of organic matter, hydrocarbon source, and depositional environment of onshore Warkalli sedimentary sequence from Kerala-Konkan Basin, south India. *Journal of Geological Society of India* **93(4):** 407-418. **IF: 0.6.**

Mehrotra N, Shah SK, Basavaiah N, Laskar AH & Yadava MG 2019. Resonance of the '4.2 ka event' and terminations of global civilizations during the Holocene, in the palaeoclimate records around PT Tso Lake, Eastern Himalaya. *Quaternary International* **507:** 206-216. **IF: 2.199.**

Morthekai P, Biswas RH & Singhvi AK 2019. Charge transport in band-tail states of irradiated alkali feldspar I: Super-Arrhenius kinetics. *Physica B: Condensed Matter* (Theory) **561:** 103-110. **IF: 1.453.**

Mukherjee B, Biswas O, Ghosh R, Paruya DK & Bera S 2018. Phytolith spectra of some eastern Himalayan pteridophytes: Assessing potential for distinguishing different vegetation–climate zones along the elevation gradient. *Flora* doi.org/10.1016/ j.flora.2018.08.013. **IF: 1.423.**

Murthy S, Kavali PS, Mercedes di Pasquo & Chakraborti B 2018. Late Pennsylvanian and Early Cisuralian palynofloras from the Rajmahal Basin, eastern India, and their chronological significance. *Historical Biology* https://doi.org/10.1080/08912963. 2018.1529763. **IF: 1.249.**

Murthy S, Sarate OS & Aggarwal N 2019. Palynofloral and palynofacies evidences and its implication on the depositional environment from Wardha Valley Coalfield, Maharashtra. *J. Geol. Soc. India* **93:** 85-94. **IF: 0.632.**

Nair A, Mohan R, Crosta X, Manoj MC, Thamban M & Marieu V 2019. Southern Ocean sea ice and frontal changes during the late Quaternary and their linkages to Asian Summer Monsoon. *Quat. Sci. Rev.* **213:** 93-104. **IF: 4.334.**

Naskar M, Ghosh R & Bera S 2018. Variability in phytolith spectra of some Panicoid grasses from different soil salinity zones of the deltaic West Bengal, India: implications in understanding depositional environments. *Botany Letters* **165(2):** 255-264. **IF: 0.883.**

Parthasarathy G, Pandey OP, Sreedhar B, Sharma Mukund, Tripathi Priyanka & Vedanti Nimisha 2019. First observation of microspherule from the infratrappean Gondwana sediments below Killari region of Deccan LIP, Maharashtra (India) and possible implications. *Geoscience Frontiers* doi.org/ 10.1016/j.gsf.2019.04. 005. **IF: 4.051.**

Pathak Ajai K, Kadian Anurag, Kushniarevich Alena, Montinaro Francesco, Mondal Mayukh, Ongaro Linda, Singh Manvendra, Pramod Kumar, Rai Niraj, Parik Jüri, Metspalu Ene, Rootsi Siiri, Pagani Luca, Toomas Kivisild, Mait Metspalu, Gyaneshwer Chaubey & Richard Villems 2018. The Genetic Ancestry of Modern Indus Valley Populations from Northwest India. *American Journal of Human Genetics* **103(06)**: 918-929. **IF: 9.025.**

Pillai SSK, Agnihotri D, Gautam S & Tewari R 2018. Glossopteris flora from the Pali Formation, Johilla Coalfield, South Rewa Gondwana Basin, Madhya Pradesh, India: palynological evidence for a late Permian age. *J. Palaeontol. Soc. India* **63(1):** 53–72. **IF: 0.667.**

Priyanka Raja, Hema Achyuthan, Anjum Farooqui, Rengaswamy Ramesh, Pankaj Kumar & Sundeep Chopra 2018. Tropical rainforest dynamics and palaeoclimate implications since the late Pleistocene, Nilgiris, India. *Quaternary Research* 1–16. doi:10.1017/qua.2018.58. **IF: 2.329.**

Quamar M Firoze 2019. Surface pollen distribution from Akhnoor of Jammu District (Jammu and Kashmir), India: implications for the interpretation of fossil pollen records. *Palynology*. DOI: 10.1080/ 01916122.2019.1568317. **IF: 1.383.**

Quamar M Firoze 2019. Vegetation dynamics in response to climate change from the wetlands of western Himalaya, India: Holocene Indian Summer Monsoon variability. *The Holocene* **29(2):** 345-362. DOI: 10.1177/0959683618810401. **IF: 2.419.**

Quamar MF & Kar R 2019. Modern pollen dispersal studies in India: a detailed synthesis and review. *Palynology*: doi.org/10.1080/01916122.2018. 15572 74. **IF: 1.383.**

Quamar MF, Ali SN, Pandita SK & Singh Y 2018. Modern pollen assemblages from Reasi (Jammu and Kashmir), India: a tool for interpreting fossil pollen records. *Grana* **57(5):** 364-376. **IF: 1.128.**

Ram-Awatar, Tewari R, Gautam S, Goswami S, Brookfield M, Agnihotri D & Williams J 2018. Palynology of the *Cyclolobus walkeri* bed, Gungri Formation (Late Permian), Spiti Valley, Northwest Himalaya, India. *J. Palaeontol. Soc. India* **63(2):** 141–154. **IF: 0.667.**

Raza MA, Saraswat R, Bhadra SR, Naik DK, Khare N, Govil P & Mazumder A 2018. Inverted sediments in the coastal Antarctic lake: Evidence of paleostorm? *Polar Science* **18:** 213-219. **IF: 1.031.**

Roy I, Ranhotra PS, Shekhar M, Bhattacharyya A, Pal AK, Sharma YK, Singh SP & Singh U 2018. Over-representation of some taxa in surface pollen analysis misleads the interpretation of fossil pollen spectra in terms of extant vegetation. *Tropical Ecology* **59(2):** 327-338. **IF: 0.8.**

Sawlani Ravi R, Agnihotri Rajesh, Sharma C, Patra PK, Dimri AP, Ram K & Verma RL 2019. The severe Delhi SMOG of 2016: A case of delayed crop residue burning, coincident firecracker emissions, and atypical meteorology. *Atmospheric Pollution Research,* https://doi.org/10.1016/j.apr.2018.12.015. **IF: 2.3.**

Saxena A, Murthy S & Singh KJ 2019. Floral diversity and environment during the Early Permian: A case study from Jarangdih Colliery, East Bokaro Coalfield, Damodar Basin, India. *Palaeobiodiversity and Palaeoenvironments*, (https://doi.org/10.1007 / s12549-019-00375-6). **IF: 1.229.**

Saxena A, Singh KJ, Cleal CJ, Chandra S, Goswami S & Shabbar H 2018. Development of the Glossopteris flora and its end Permian demise in the Tatapani–Ramkola Coalfield, Son–Mahanadi Basin, India. *Geological Journal* DOI: 10.1002/gj.3307. **IF: 1.654.**

Sharma A & Phartiyal B 2018. Late Quaternary palaeoclimate and contemporary moisture source to extreme NW India: A review on present understanding and future perspectives. *Frontiers Earth Science* 6 Article 150 doi:0.3389/ feart.2018.00150. **IF: 1.66.**

Sharma Mukund & Shukla B 2019. Akinetes from Late Paleoproterozoic Salkhan Limestone (>1600 Ma) of India: A proxy for understanding life in extreme conditions. *Front. Microbiol.* 10: 397.doi: 10.3389/ fmicb.2019.00397. **IF: 4.259.**

Sharma Mukund, Ahmad S, Pandey SK & Kumar K 2018. On the ichnofossil *Treptichnus pedum*: inferences from the Nagaur Sandstone, Marwar Supergroup, India. *Bulletin Geoscience* **93(3):** 305-325. **IF: 1.395.**

Sharma Mukund, Pandey SK, Ahmad S, Kumar K & Ansari AH 2018. Observations on the ichnospecies *Monomorphichnus multilineatus* from the Nagaur Sandstone (Cambrian Series 2-Stage 4), Marwar Supergroup, India. *Journal of Earth System Sciences* **127:** Article 75. **IF: 0.890.**

Shukla A & Mehrotra RC 2018. Early Eocene plant megafossil assemblage of western India: Palaeoclimatic and palaeobiogeographic implications. *Rev. Palaeobot. Palynol.* **258:** 123–132. **IF: 1.665.**

Shukla A & Mehrotra RC 2019. First record of *Dioscorea* from the early Eocene of northwestern India: Its evolutionary and palaeoecological importance. *Rev. Palaeobot. Palynol.* **261:** 11–17. **IF: 1.665.**

Shukla A, Mehrotra RC & Ali SN 2018. Early Eocene leaves of northwestern India and their response to climate change. *J. Asian Earth Sci.* **166:** 152–161. **IF: 2.762.**

Shukla MK & Sharma A 2018. Carbon isotope and REE characteristics of the Paleocene–Eocene shallow marine Subathu Formation from the NW Himalaya (India) and their palaeoenvironmental implications. *Chemie der Erde* **78:** 314–322. **IF:** 1.723

Singh AK, Chakraborty PP & Sarkar S 2018. Redox structure of Vindhyan hydrosphere: clues from TOC, transition metal (Mo, Cr) concentrations and stable isotope ($\delta^{13}C$) chemistry. *Current Science* **115(7)** 1334-1341. **IF: 0.883.**

Singh U, Phulara M, David B, Ranhotra PS, Shekhar M, Bhattacharyya A, Dhyani R, Joshi R & Pal AK 2018. Static tree line of Himalayan silver fir since

last several decades at Tungnath, western Himalaya. *Tropical Ecology* **59(2):** 351-363. **IF: 0.8.**

Singh Rupendra, Chandra Ram, Tangri Anjani K, Kumar Rajesh, Bahuguna IM, Latief Syed Umer, Pandey Pratima & Ali Sheikh Nawaz 2018. Long-term Monitoring of Surging Glaciers in Upper Shyok Valley, Karakoram Range, India: A case study of Rimo and Kumdan groups of Glaciers. *Journal of Climate Change* **4 (1):** 1-12. **IF: 4.168.**

Srivastava G, Mehrotra RC & Dilcher DL 2018. Paleocene *Ipomoea* (Convolvulaceae) leaves from India with implications for an East Gondwana origin of Convolvulaceae. *Proc. Natl. Acad. Sci., USA* **115:** 6028–6033. **IF: 9.504.**

Srivastava G, Mishra SR, Barman P, Mehrotra RC & Tripathi SC 2018. *Lagerstroemia* L. fossil wood from the Indus molasse sediments (possibly late Miocene) of Trans-Himalayan region and its phytogeographic and climatic significance. *Rev. Palaeobot. Palynol.* **255:** 14–21. **IF: 1.674.**

Srivastava G, Paudayal KN, Utescher T & Mehrotra RC 2018. Miocene vegetation shift and climate change: evidence from the Siwalik of Nepal. *Glob. Planet. Change* **161:** 108–120. **IF: 4.100.**

Srivastava G, Su Tao, Mehrotra RC, Kumari P & Shankar U 2019. Bamboo fossils from Oligo-Pliocene sediments of northeast India with implications on their evolutionary ecology and biogeography. *Asia. Rev. Palaeobot. Palynol.* **262:** 17–27. **IF: 1.674.**

Srivastava HB, Shrivastava PK, Roy SK, Beg MJ, Asthana R, Govil P & Verma K 2018. Transition in Late Quaternary palaeoclimate in Schirmacher region, East Antarctica as revealed from lake sediments. *Journal of Geological Society of India* **91**: 651-663. **IF: 0.632.**

Srivastava P, Sinha R, Deep V, Singh AK & Upreti N 2018. Micromorphology and sequence stratigraphy of the interfluve palaeosols from Ganga plains: A record of alluvial cyclicity and palaeoclimate during the late quaternary. *Journal of Sedimentary Research* **88**: 105-128. **IF: 2.41.**

Su Tao, Farnworth A, Spicer RA, Huang J, Wu FX, Liu J, Li SF, Xing YW, Huang YJ, Deng WY-D, Tang H, Xu CL, Zhao F, Srivastava G, Valdes PJ, Deng T & Zhou ZK 2019. No high Tibetan Plateau until the Neogene. *Sci. Adv.* 5, eaav2189. **IF: 12.804.**

Thakur B, Saxena A & Singh IB 2018. Paddy cultivation during early Holocene: evidence from diatoms in Lahuradewa Lake sediments, Ganga Plain. *Current Science* **114:** 2106-2115. **IF: 0.866.**

Thakur B, Seth P, Sharma A, Pokharia A, Spate M & Farooqui S 2019. Linking past cultural developments to palaeoenvironmental changes from 5000 years ago to present: A climate-culture reconstruction from Harshad Estuary, Saurashtra, Gujarat, India. *Quaternary International* **507:** 188–196. **IF: 2.199.**

Tripathi S, Basumatary SK, Singh YR, McDonald HG, Tripathi D & Singh LJ 2019. Multiproxy studies on dung of endangered Sangai (*Rucervus eldii eldii*) and Hog deer (*Axis porcinus*) from Manipur, India: Implications for palaeoherbivory and palaeoecology. *Rev. Palaeobot. Palynol.* **263:** 85-103. **IF: 1.7.**

Tripathi Swati, Farooqui Anjum, Singh Veeru Kant, Singh Shilpi & Roy Rup Kumar 2018. Morphometrical analysis of *Ceiba* Mill. (Bombacoideae, Malvaceae) pollen: a sacred plant of the Mayan (Mesoamerican) civilisation. *Palynology* DOI: 10.1080/01916122.2018.1467350. **IF: 1.383.**

Tripathi S, Murthy S & Saxena A 2018. The 10th European Palaeobotany and Palynology Conference-2018, Dublin, Ireland. *Journal Geological Society of India* **92:** 769-769. **IF: 0.866.**

Trivedi Anjali, Saxena Anju, Chauhan MS, Sharma Anupam, Farooquii Anjum, Nautiyal CM, Yao Yi-Feng, Yu-Fi Wang, Li Cheng-Sen & Tiwari DP 2019. Vegetation, climate and culture in Central Ganga plain, India: A multi-proxy record for Last Glacial Maximum. *Quat. Intern.* **507(25)**: 134-147. **IF: 1.952.**

Uddandam P, Prasad V, Thakur B & Manoj MC 2018. *Cristadinium striaospinosa*, a dinoflagellate cyst from the tropical region. *Journal of Paleontological Society of India* **63(1):** 73-80. **IF: 0.5.**

Van Hardenbroek, M, Chakraborty A, Davies K, Harding P, Heiri O, Henderson A, Holmes J, Lasher GE, Leng M, Panizzo V, Roberts L, Schilder J, Trueman C & Woller M 2018. The stable isotope composition of organic and inorganic fossils in lake sediment records: Current understanding, challenges, and future directions. *Quaternary Science Reviews* **196:** 154-176. **IF: 4.334.**

Weerakoon WAP, Aggarwal N, Jha N, Jayasena HAH, Joshi H, Yakandawala D, Chandrajith R, Perera KVGS & Ratnayake NP 2019. Reconstruction of the Upper Gondwana palaeoclimates based on palynostratigraphy, palynofacies and sedimentology of the Jurassic sequences in the Tabbowa Basin, Sri Lanka. *J. Asian earth Sci.* https://doi.org/10.1016/j.jseaes.2018.09.004. **IF: 2.8.**

Xie G, Yao Yi-Feng, Jin-Feng Li, Jian Yang, Jia-De Bai, Ferguson DK, Trivedi Anjali, Li, Cheng-Sen Wang & Yu-Fei 2019. Holocene climate, dynamic landscapes and environmentally driven changes in human living conditions in Beijing. *Ear. Sci. Rev.* **191:** 57-65. **IF: 9.530.**

Refereed Non-SCI Journals:

Adhikari P, Srivastava G, Mehrotra RC, Adhikari D, Shrestha K, Uhl D & Paudayal KN 2018. Leaf impressions of *Terminalia* (Combretaceae) and *Daphnogene* (Lauraceae) from the Middle Siwalik of the Chatara-Barahakshetra area, eastern Nepal. *Bull. Depart. Geology, Tribhuvan University, Nepal* **20-21**: 21–28.

Aggarwal N, Mishra S, Jha N & Rao PV 2018. Palynostratigraphy and correlation of Gondwana sediments in Kothagudem sub-basin of Godavari Graben, south India. *Palaeobotanist* **67:** 123-138.

Agnihotri D, Pillai SSK, Aggarwal N, Tewari R, Jasper A & Uhl D 2018. Palynomorphs from the Barakar Formation of Dhanpuri Open Cast Mine, Sohagpur Coalfield, Madhya Pradesh. *Palaeobotanist* **67(2):** 171–184.

Awasthi N, Mehrotra, RC & Shukla A 2018. Some new fossil woods from the Cuddalore Sandstone of south India. *Palaeobotanist* **67:** 33–46.

Basumatary SK, Tripathi S, Thakur B, Jalil A & Rahman A 2018. Mid-Holocene vegetation and climatic changes in southwestern Garo Hills, Meghalaya, northeast India based on pollen records. *Geophytology* **48:** 103-112.

Chakraborty A & Pramanik S 2018. The changing scenario of morpho-taxonomic research and an accelerated demand of morphotaxonomists in bio-systematics. *Geophytology* **48(2):** 157-160.

Chinnappa C, Rajanikanth A & Kavali PS 2019. Palaeofloras from the Kota Formation, India: palaeodiversity and ecological implications. *Volumina Jurassica* **XVII:** 1–16.

Kar R, Saha S, Haque F, Pramanik S & Ghosh Amit K 2018. Occurrence of Barakar (Early Permian) coal from Barapukuria Basin, Bangladesh. *Geophytology* **48(2):** 125-129.

Kawsar M, Manoj MC, Yoshida K, Baxter A & Reilly BT 2019. Morphological and chemical properties of microtektite grains from Bay of Bengal (IODP Expedition 354). *Society of Earth Scientists Series* (Springer SES). 10.1002/essoar.10500240.1.

Mehrotra N & Shah SK 2018. A preliminary study of the modern pollen of Tripura, Northeast India. *Palaeobotanist* **67(1)**: 21-31.

Mehrotra RC & Srivastava G 2018. Neogene flora of Arunachal Himalaya. *In*: Das AP & Bera S (Editors) - *Plant diversity in the Himalaya hot spot region*. Bishen Singh, Mahendra Pal Singh, Dehradun **1:** 399–412.

Morthekai P 2018. Philosophies for the palaeosciences - A review. *Proceedings of Indian National Science Academy* (DOI:10.16943/ptinsa/2018/49476).

Pandita SK, Siddaiah NS, Tewari R, Chatterjee S & Agnihotri D 2018. Geochemistry of coal–bearing Permo"Triassic strata in Allan Hills, South Victoria Land, Antarctica: Implications for palaeoclimate. *Palaeobotanist* **67(1):** 89–97.

Prakash N & Das N 2018. A Catalogue of upper Gondwana (Jurassic–Early Cretaceous) plant megafossil genera of India. *BSIP Publication*, India. 59. pp.

Sharma Mukund & Singh VK 2019. Megascopic carbonaceous remains from Proterozoic basins of India. *In: Geological Evolution of the Precambrian Indian Shield*, Springer (DOI: 10.1007/978-3-319-89698-4_27).

Shukla MK & Sharma A 2018. A brief review on breccia: it's contrasting origin and diagnostic signatures. *Solid Earth Science* **3**: 50-59.

Singh A 2018. Latest Maastrichtian palaeoclimatic and depositional environmental perturbations, a record from *Micula prinsii* Zone of Meghalaya, northeastern India. *Palaeobotanist* **67**: *209-219.*

Singh N, Singh V & Krishnaiah C 2018. The study of atmospherically deposited Spheroidal Carbonaceous Particles (SCP) from the Kongsfjorden, Svalbard. *Czech Polar Reports* **7(2)**: 206-215.

Singh R, Phartiyal B, Patnaik R & Pandey B 2018. Record

of a ~3000 year old bird humerus from Ladakh. *Anusandhan* **6(1):** 12-17 DOI 10.22445/asvp.v6.l.13889 (in Hindi)

Spate M, Betts A, Yatoo M, Kaloo Z, Fraser J, Rashid Y, Pokharia Anil K & Zhang G 2019. The northern Neolithic of the western Himalayas: New research in the Kashmir Valley. *Archaeological Research in Asia* https://doi.org/10.1016/j.ara.2019.02.001

Srivastava A & Pokharia Anil K 2019. Pollen photomicrographs of traditional herbal medicinal plants as an aid to archaeopalynology of archaeological sites. *Pragdhara* **26:** 44-68.

Srivastava G & Mehrotra RC 2018. *Barringtonia* Forster & Forster (Lecythidaceae) leaf from the late Oligocene of Assam, India. *Palaeobotanist* **67:** 139–145.

Verma P & Singh A 2018. Palynology of Cenozoic successions of Kerala Basin: a review from the perspective of biostratigraphy and palaeoclimatic studies. *Palaeobotanist* **67(1)**: 99-111.

Verma P 2018. A technique for the extraction of palynomorphs from Eocene amber. *Palaeobotanist* **67(2):** 201-208.

General Articles/Reports Published

Das N 2019. National Workshop on Sequence Stratigraphy and Basin Analysis. *Jour. Geol. Soc. India*. **93:** 623.

Lone AM, Shah RA, Dey R, Ghadi P, Nuruzzama M & Rehman A 2018. Report on Quantitative reconstruction and numerical methods for analysis of past climate variability using diatoms. *Journal of the Geological Society of India*, doi: 10.1007/s12594-018-0966-y.

Khan S, Azharuddin S & Tripathi S 2018. National Conference on Climate Change and Natural Resources: Impact and Sustainable Development in Indian Perspective. *Journal of the Geological Society of India* **91:** 643. *(Conference report published).*

Tripathi S, Murthy S, Saxena A. 2018. The 10th European Palaeobotany and Palynology Conference-2018, Dublin, Ireland. *Journal of the Geological Society of India* **92:** 769. *(Conference report published).*

In Edited Volumes/Books Chapter

Misra S & Misra KG 2019. Phytoremediation: an alternative tool towards clean and green environment. Springer Nature Singapore Pte Ltd. *In*: Shah S. *et al.* (Editors) - *Sustainable green technologies for environmental management*, https://doi.org/10.1007/978-981-13-2772-8_5.

Misra S, Srivastava PK & Arif Md 2018. Remote sensing, structural and rock magnetic analyses of the Ramgarh structure of SE Rajasthan, central India - Further clues to its impact origin and time of genesis. "Tectonics and Structural Geology: Indian Context", *Springer Geology* Book Edited by Dr. Soumyajit Mukherjee, IIT Mumbai: 327-352.

Padmalal Akash, Khonde Nitesh, Maurya DM, Shaikh Mohammed Haroon, Kumar Abhishek, Vanik Naimisha & Chamyal LS 2019. Geomorphic characteristics and morphologic dating of the Allah Bund Fault scarp, Great Rann of Kachchh, western India. *Invited book chapter in* Springer *Tectonics and Structural Geology: Indian Context; Mukherjee S (Editor), pp 55-74 https://doi.org/10.1007/978-3-319-99341-6_3.*

Vice-Chancellor, Chitrakoot University, Chitrakoot visiting Institute's Museum

Papers presented at Conferences/Seminars/Workshops

In International Meets

Farooqui A 2018. *Meeting: Indo-Nor Project MoES.* Palynological results in the borehole 910C, Yermak Plateau, Arctic in Tromso, Norway September, 2018.

Ahmad Shamim & Pandey SK 2018. Life in Late Neoproterozoic to Early Cambrian biosphere: Insight from the Marwar Supergroup. *International Conference on Ediacaran and Cambrian Sciences*, China, August 12-16, 2018. (pp. 55-56).

Ali SN *et. al.* 2018. Climate variability in the Central Indian Himalaya during the last ~15 ka: Evidences of ISM variability from multiproxy studies. *Himalaya-Karakoram-Tibet Workshop* 2018, Switzerland, September, 2018.

Azharuddin S & Govil P 2018. Variation in depositional conditions due to oxygen minimum zone influence in the northeastern Arabian Sea. *American Geophysical Union (AGU) Fall Meeting*. December, 2018 (Paper No- PP1C-1272).

Chakraborty A & Ghosh AK 2018. Diatoms – indicator of past sea-level changes: A case study from the Neogene sediments of Andaman and Nicobar Basin, India. *25th International Diatom Symposium*, Berlin, 25th-30th June, 2018 (Abstract: p. 34).

Farooq Umar, Chetia Rimpy, Mathews Runcie, Srivastav Shalivahan, Singh Bhagwan & Singh Vikram 2019. Palaeodepositonal conditions and hydrocarbon source characteristics of lignites from Bikaner-Nagaur Basin (Rajasthan) western India based on organic petrographic studies. In: Naj Aziz & Bob Kininmonth (Editors) - *Proceedings of the 2019 Coal Operators Conference,* Mining Engineering, University of Wollongong, Australia, 18-20, February 2019: 352-367.

Gaire NP, Fan ZX, Sharma B, Aryal PC, Thapa UK, Shah SK & Bhuju DR 2018. Response of multiple tree species to climate change and variability in Mt. Kanchenjunga area in Nepal Himalaya. *10th World Dendro Conf., Thimpu, Bhutan*, June, 2018 (Abstract: 46)

Ghosh AK, Chakraborty A, Saxena S & Dey R 2018. Variations of Indian Summer Monsoon during the Miocene: evidences from diatom assemblages of the Northern Indian Ocean. *25th International Diatom Symposium*, Berlin, 25th-30th June, 2018 (Abstract: p. 56).

Ikehara M, Crosta X, Kimoto K & Manoj MC 2018. Large impact of the Agulhas Return Current on Late Glacial Indian Southern Ocean. POLAR 2018. *Open Science Conference. Switzerland*. June, 2018 (Abstract).

Ikehara M, Crosta X, Shukla S, Kimoto K, Itaki T, Matsui H & Manoj MC 2018. Large impact of the Agulhas Return Current on SW Indian sector of the Southern Ocean during late Glacial. *Japan Geoscience Union Meeting (JpGU)* 2018. May, 2018 (Abstract).

Jonell Tara, Giosan Liviu, Carter Andrew, Hathorne Ed, Bretschneider Lisa, Clift Peter, Blusztajn Jerzy, Khonde Nitesh, Naing Thet & Tun Myo Min 2019. Evolution of Irrawaddy megadelta sediment provenance since the Last Glacial Maximum, *EGU 2019 held at Vienna* 7-12 April,2019; Austria (Abstract: EGU 2019-16882).

Kapur VV & Bajpai S 2018. Size variations amongst non-volant mammals from the early Eocene Cambay Shale deposits of western India: Implications for palaeobiogeography and palaeohabitat. *5th International Palaeontological Congress (IPC),* Paris, France, July, 2018 (Abstract: 335).

Kar R & Bajpai R 2018. Climatic and vegetational changes during the last 11,500 years from glacial sites in Lahaul Valley, western Himalaya, India. *4th Annual Int. Conf. Geology & Earth Sci., Athens*, June, 2018.

Khonde N, Maurya DM, Bhushan Ravi, Giosan Liviu & Chamyal LS 2018. Geochemical studies on late Quaternary sediments from Great Rann of Kachchh (GRK) Basin, western India. *9th International Conference on Asian Marine Geology (9th ICAMG)* held at Tongji University, Shanghai, China during 11-12 October, 2018. PI presented this research work at the conference.

Kohki Y, Cruz JW, Osaki A, Manoj MC, Hatano N, France-Lanord C 2018. Miocene denudation history of Himalaya deduced from IODP Exp. 354 Bengal Fan. *AOGS 15th Annual Meeting. Hawaii*. June, 2018 (Abstract).

Kumar R, Das N, Kumar K & Pandey B 2018. First report of plant fossils from the Bhadasar Formation of Jaisalmer Basin, western India. *4th India Internatn. Sci. Festiv.,* October, 2018 (Abstract: p. 5).

L Giosan, SE Munoz, NN Khonde, T Naing, Q Yang, M Min Tun & PD Clift 2018. The Ayerawady Delta: Links between monsoon, floods and sediment fluxes. *AGU Fall Meeting*, held during 10-14 Dec, 2018 at Washington DC, USA (Abstract: EP13C-2115).

Manoj MC, Srivastava J, Uddandam P, Thakur B & Seth P 2018. A 2000 year record of palaeoclimatic variability from Kerala Coast, southwest India. *AGU Fall Meeting* 2018 at Washington DC, 10-14 December, 2018.

Mehrotra N, Kar R & Shah SK 2018. A comparative study of the modern pollen taxa observed in surface deposits from Tripura and Mizoram in northeastern India. *European Palaeobotany and Palynology Conference*, Dublin, Ireland, August, 2018 (Poster Abstract No. P119).

Murthy S 2018. Early Permian palynomorphs and their palaeoclimatic implication: A case study from Rajmahal Basin, India. *10th European Palaeobotany and Palynology Conference*, Dublin, Ireland, August 2018 (Abstract p. no. 248).

Nair A, Mohan R, Crosta X, Manoj MC, Meloth T & Miettinen A 2018. Southern Ocean SST & Sea Ice Changes: Southern Ocean and Indian Monsoon Linkages. *POLAR 2018. Open Science Conference. Switzerland.* June, 2018 (Abstract).

Pandey SK, Wan Bin, Yuan Xunlai, Sharma Mukund, Ahmad Shamim & Ansari AH 2018. Ediacaran benthic macro-metaphyte/seaweed: A feasible source for sustenance of large body plan of Ediacara biota. *International Conference on Ediacaran and Cambrian Sciences*, China, August 12-16, 2018 (pp. 17-18).

Pandey U & Shah SK 2018. Tree-ring based drought (scPDSI) reconstruction for the Lidder Valley, Kashmir, Northwest Himalaya. *10th World Dendro Conf., Thimpu, Bhutan*, June 2018 (Abstract: 23).

Prasanna K & Kapur VV 2018. Oxygen isotopic studies of a species of *Pitar* (*Hyphantosoma*) from Quilon beds, Kerala, southwest India: Inferences on seasonality during the Miocene. *Goldschmidt Conference, Boston, USA*, August, 2018 (Abstract: 1847).

Rai Niraj 2018. Reconstructing the peopling of old world South Asia: from modern to ancient genomes. Invited talk at Complexity Institute, Nanyang Technological University, Singapore on June 07, 2018.

Saxena A, Singh KJ & Cleal CJ 2018. Permo-Carboniferous biodiversity and phytogeographic distribution of Sphenophytes in India. *The 10th European Palaeobotany and Palynology Conference, University College Dublin, Dublin, Ireland*, August, 2018 (Abstract: 142).

Shah SK 2018. Spatial rainfall reconstruction for the districts of Kerala, South India inferred from tree-rings of *Tectona grandis*. *10th World Dendro Conf., Thimpu, Bhutan*, June, 2018 (Abstract: 55).

Shah SK, Wiles GC, Mehrotra N, Pandey U & Chandra R 2018. Shingo River flow reconstruction from Upper Indus Basin using ring-widths of *Abies pindrow*. *10th World Dendro Conf., Thimpu, Bhutan*, June, 2018 (Abstract: 58).

Shukla A & Mehrotra RC 2018. India-Asia collision and biotic exchange: evidences from Cenozoic plant megaremains. *Himalayan Karakorum Tibet Workshop (HKT-2018)*, Switzerland, September, 2018.

Singh Arvind K 2018. *Workshop on - What we can learn from past and future: Stable isotopes in ancient and contemporary environments*. 15th-19th April, 2018 at Limnological Institute, University of Konstanz, Germany.

Singh BD*, Mathews RP, Singh VP, Verma P, Singh A, Mendhe VA, Mishra S, Dutta S & Shivanna M 2018. Organic composition, depositional environment and hydrocarbon source potential of the lignite deposits from Sonari Mine, Barmer Basin (Rajasthan), north-western India: petrographical, palaeopalynological and geochemical approaches. *70th Annual International Committee for Coal and Organic Petrology Meeting, Brisbane, Australia*. September, 2018 (Abstract: 56-57) (* presenter).

Tripathi S, Farooqui A, Singh VK, Singh S & Roy RK 2018. Comparative morphological analysis of *Ceiba* Mill. (Bombacoideae, Malvaceae) pollen through FESEM, CLSM and LM: A sacred plant of Maya (Mesoamerican) Civilization. *10th European Palaeobotany and & Palynology Conference,* at University of Dublin, Ireland, August, 2018. (Abstract: O135).

Trivedi Anjali & Farooqui A 2019. Pollen-vegetation relationship in surface sediments of Renuka region, Sirmaur, Himachal Pradesh, India *ICPEP 6 (International Conference on Plant Environment and Pollution)* the National Botanical Research Institute, Lucknow November, 2019 (Abstract: 228)

In National Meets:

Ali SN 2018. Persistent South Asian Monsoon induced erosion over the past 26 Myrs. *International Indian Science Festival, Lucknow*, October 2018.

Ali SN *et. al.* 2019. High-resolution centennial to millennial-scale late Holocene monsoon fluctuations in Zanskar Valley northwestern Himalaya. *GEM-2019,* Kerala, January, 2019.

Azharuddin S & Govil P 2018. Trends and episodes of southwest monsoon during the Holocene. *National Conference on Climate Change and Natural Resource; Impacts and Sustainable Development in Indian Perspective*. Centre of Advance studies in Geology, University of Lucknow, Lucknow (Abstract: 6).

Bhandari Ansuya & Tiwari BN 2018. Significant pre-Siwalik Miocene fauna from NW Himalaya, India on *National Conference on Earth System Science with special reference to Himalaya: Advancement and challenges at Wadia Institute of Himalayan Geology, Dehradun* May 16-18, 2018 (Abstract: 119; Volume of Golden Jubilee Celebration 1968-2018).

Chakraborty A, Dey R, Saxena S, Pramanik S, Roy L & Ghosh AK 2019. Global Warming: Natural or Anthropogenic? *National Seminar on "Environmental Issues: Current Scenario from the view point of Scientific Studies",* Cooch Behar, W.B., 19th-20th February, 2019 (Abstract: 42).

Das N, Kumar R, Kumar K, Singh A, Pandey B & Prakash N 2018. Palaeoenvironmental and palaeoecological implications of freshwater and marine mixed biota from Early Cretaceous succession of Jaisalmer Basin, western India. *National Seminar on Effects of Palaeo and Anthropogenic Events on Earth System & Annual General Meeting of GSI*, September, 2018 (Abstract: 23).

Farooqui A 2018. Mid-Pliocene and the Present Climate -Vegetation Equilibrium: Arctic-Asian Monsoon Teleconnections. *International Conferences on Plants and Environmental Pollution,* NBRI. 27-30 Nov. 2018.

Farooqui A 2018. *National Conference on Climate Change and Natural Resources*, 20-21 Feb, 2018. University of Lucknow, Lucknow.

Ghosh AK, Chakraborty A, Saxena S, Dey R & Roy L 2018. Indian Summer Monsoon during 16.4 to 4 Ma: Evidences from Diatom assemblages of Northern Indian Ocean (Invited Lecture). *National Seminar on "Biological Sciences for Human Welfare: Teaching and Research in Modern Perspective"*, Berhampore, Murshidabad, W.B., 29th-30th September, 2018 (Abstract: p. 37).

Jain S & Singh A 2018. The age of genus *Macrocephalites* Zittel and the Bathonian biostratigraphy of Kachchh, western India (South Tethys). *National Seminar on Effects of palaeo and anthropogenic events on earth system and Annual General Meeting (AGM)-2018 of Geological Society of India*, Department of Geology, Periyar University, Salem, Tamil Nadu, September, 2018 (Abstract: 19).

Kapur VV 2018. Paleontological collections of a National Earth Museum and their socio-economic relevance. *Brainstorming Meet on Rejuvenating Indian Palaeontology & Establishing a National Earth Museum, Indian National Science Academy & University of Delhi, India*, September 2018 (Abstract: 41).

Kapur VV, Bajpai S & Domning DP 2018. An overview of the fossil sirenians (Mammalia: Sirenia) record from the Kutch (Kachchh) Basin, Gujarat, western India. *Second National Conference and Field Workshop on Recent studies on the Geology of Kachchh, Department of Earth and Environmental Sciences, KSKV Kachchh University, Bhuj, Gujarat, India,* December 2018 (Abstract: 76).

Misra KG, Yadava AK, Singh V, Misra S & Yadav RR 2018. Tree-ring deduced snowfall variation over the western Himalaya, India. *4th India International Science Festival (IISF)* at Indra Gandhi Pratishthan, Lucknow, October, 2018.

Pandey S 2018. Mangrove response to climate and sea-level changes during Holocene in Gujarat, western India. *National Conference on Recent studies on the Geology of the Kachchh Basin, Kachchh University, Bhuj, Gujarat,* December 30th 2018-January 1st, 2019.

Pandey S 2018. Modern pollen rain studies from mangrove forests of the Sundarbans, Ganges Brahmaputra Delta, India. *4th India International Science Festival*, Lucknow, October, 05-8, 2018.

Phartiyal Binita 2018. Third Pole: Opportunities and Challenges. Open Day at BSIP for *Indian Science Festival 2018*; Lucknow.

Rai Niraj 2018. Genetic makeup of South Asian populations. Key-note Lecture at *International Conference GenoPro 2018* at Invertis University, Bareilly during 5-6 October, 2018.

Rai Niraj 2018. Next Gen Genomics, Biology, Bioinformatics and Technologies, Chaired Session (Session 49, short talks) at *International Conference (NGBT-2018),* Jaipur during Sept 30th to Oct 2nd 2018.

Rai Niraj 2018. Reconstructing the peopling of old world South Asia: from modern to ancient genomes. Invited talk at *International Conference "Next Gen Genomics, Biology, Bioinformatics and Technologies" (NGBT-2018),* Jaipur during Sept 30th to Oct 2nd 2018.

Rai Niraj 2019. aDNA analysis of the museum samples and its application in Human Population and Wildlife Genetics. Invited Lecture at two days' *Workshop on Wildlife Forensics and Crime Control* at Zoological Survey of India, Headquarter, Kolkata during 21st -22nd January, 2019.

Saxena A, Bera SK & Mazumder A 2018. Study of freshwater diatom abundance and sedimentology from the Rani-Garbhanga Reserve Forest, Assam, India. *National Seminar of Effects of Palaeo and Anthropogenic Events on Earth System*. September 2018, Periyar University, Salem (Abstract).

Saxena A, Gupta S & Singh KJ 2019. Diversity of the genus *Gangamopteris* McCoy in the Early Permian sequences of Singrauli Coalfield, Son-Mahanadi Basin, India. *National Seminar cum Workshop on Recent Advances in the Indian Earth Science Kumaun University, Nainital,* March, 2019 (Abstract: p. 83).

Saxena A, Mazumder A, Singh DS & Bera SK 2018. Relation between present freshwater diatom assemblage and grain size of the lake: A case study from the Rani-Garbhanga Reserve Forest, Assam. *India International Science Festival 2018,* Gomti Nagar, Lucknow. October, 2018.

Sharma A, Chadda A, Mathews RP, Manoj MC & Pharthyal B 2018. Evidences of Anthropogenic activities in the Isolated Caves of Laddakh, Jammu and Kashmir. *India International Science Festival (IISF)*. Lucknow, India, October, 2018.

Sharma Anupam 2018. Challenges in estimation of Upper continental Crust (UCC) composition and geochemical cycling of elements. Delivered a key-note address in *National Conference on Biogeochemical Cycles and Climate Change.* 10-11 August 2018, IIT (ISM) Dhanbad.

Sharma S, Pokharia Anil K, Pande PC, Basumatary SK, Thakur B & Kharakwal JS 2019. Evidence of the medieval warm period and little ice age from southern Rajasthan, India: A multiproxy approach for vegetation and climate change. *National Conference on Sedimentary Researches: Last five decades of advancement and prospects in future & 35th Convention of Indian Association of Sedimentologists, Sagar*, January, 2019 (Abstract: 75-76).

Shukla A, Mehrotra RC, Kumaran KPN & Padmalal D 2019. Subfossil wood based vegetation and climate variability during the Holocene from the southwest coast of India. *2nd International Conference on Geology: Emerging Methods and Applications (GEM-2019), Kerala,* January, 2019.

Singh Priyanka 2019. Attempt to date dull and dirty quartz using OSL and IRSL signals. *GEM-2019 (Geology: Emerging Methods and Applications) in Christ College (Autonomous), Irinjalakuda, Thrissur* during January 17-19, 2019 (Abstract).

Singh VK, Sharma Mukund, Ansari AH & Agarwal S 2019. C and O isotope studies of the Pre- Cryogenian (Tonian) carbonate successions of the Raipur Group, the Chhattisgarh Supergroup, central India. *National Seminar on Sedimentary Research: Last five decades of advancement and prospects in future & 35th Convention of Indian Association of Sedimentologist*, at Dr. Harisingh Gour Vishwavidyalaya, Sagar, January, 2019 (Abstract, P. 20).

Singh V, Misra KG, Yadava AK & Yadav RR 2018. Tree-ring based winter-spring drought reconstruction from Kishtwar, Jammu & Kashmir, India. *4th India International Science Festival (IISF) at Indra Gandhi Pratishthan, Lucknow,* October, 2018.

Srivastava J & Manoj MC 2019. Palaeoclimate studies along Kanara coast, India and their implications on vegetation diversity and shoreline variations: A review. *National symposium on Current trends and future prospects in plant science research at Department of Botany, Banaras Hindu University, Varanasi,* 01-03 February, 2019.

Thomte L, Shah SK, Singh R & Mehrotra N 2019. Hydro-climatic events recorded in a 154-year river flow reconstruction of the Lohit River Basin, North-east India based on tree-rings. *Nat. Conf. Role of Remote Sensing and GIS in Natural Hazard Assessment for Sustainable Development: Present Scenario and Future Perspective, Lucknow,* March, 2019 (Abstract: 42)

Tiwari P, Srivastava P & Thakur B 2019. Palynofacies as a tool to infer organic matter variability in sub-urban and urban flood plain deposits of Gomti River, Lucknow, Uttar Pradesh, India. *National Seminar cum Workshop on Recent Advances in the Indian Earth Science. CAS in Geology, Kumaun University, Nainital,* March, 2019 (Abstract: 10).

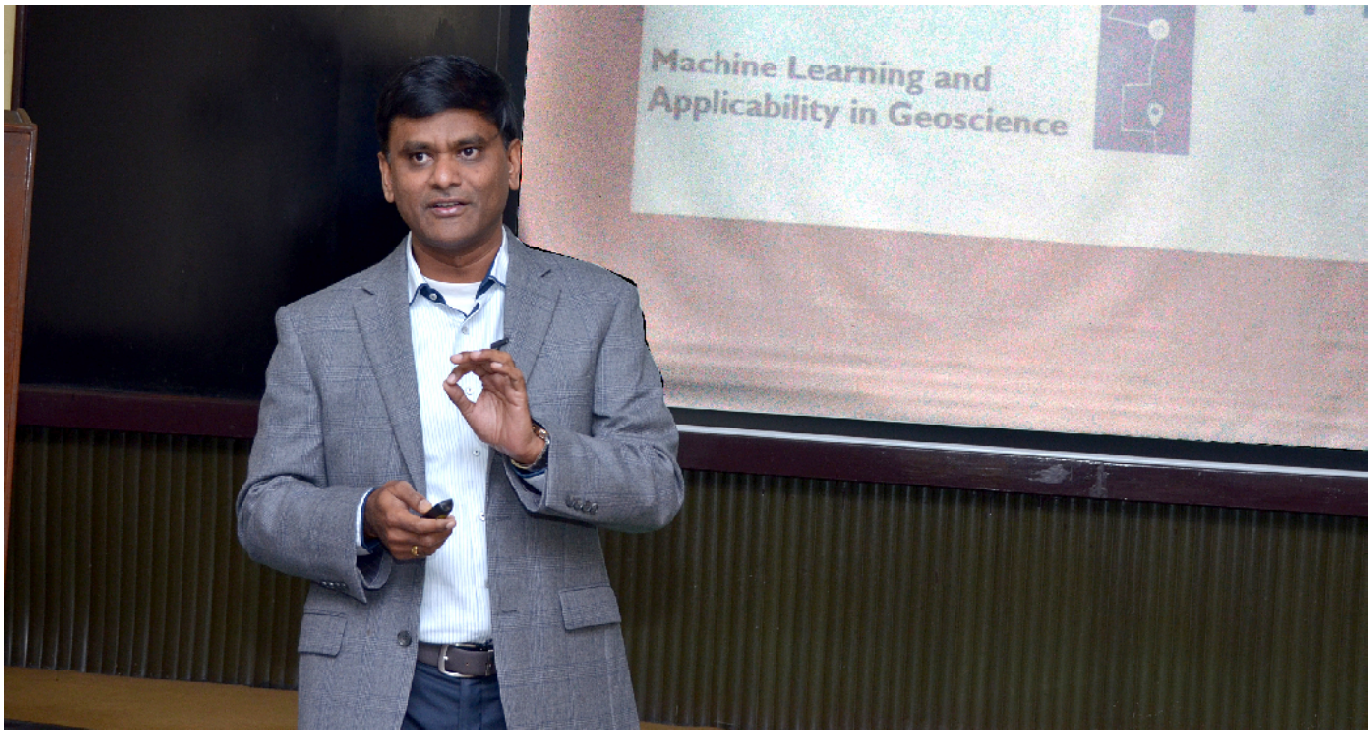
Trina Bose, Saikat Sengupta & Supriyo Chakraborty 2018. Non-linear analysis is essential for reconstruction of precipitation from tree-ring oxygen isotope in Himalayas. *Young Scientists' Conference in 4th India International Science Festival Lucknow, India*, October, 2018 (Abstract 12004).

Tripathi S 2018. Botanical origin of honeys from Brahmaputra Valley of Assam, northeast India based on pollen analysis. *Women Scientists and Entrepreneurs conclave in India Internat. Sci. Festival, Lucknow*, October, 2018 (Abstract: 82).

Tripathi S 2018. Multiproxy studies on dung of endangered Sangai (*Rucervus eldii eldii*) and Hog deer (*Axis porcinus*) from Manipur, India: Implications for palaeoherbivory and palaeoecology. *84th Annual Meeting of Ind. Acad. Sci., Banaras Hindu University, Varanasi*, November, 2018 (Abstract: 4).

Verma P & Singh A 2018. Rupelian (Early Oligocene) calcareous nannofossils and dinoflagellate cysts from Lumpy clay Member of Maniyara Fort Formation, Kutch. *National seminar on Effects of palaeo and anthropogenic events on earth system and Annual General Meeting (AGM)-2018 of Geological Society of India, Department of Geology, Periyar University, Salem, Tamil Nadu*, September, 2018 (Abstract: 27).

Yadava AK, Misra KG, Singh V, Misra S & Yadav RR 2018. Long-term pre-monsoon precipitation variations over Uttarakhand, western Himalaya using Himalayan cedar chronology. *4th India International Science Festival (IISF) at Indra Gandhi Pratishthan, Lucknow,* October, 2018.



Deputation to Conferences/Seminars/Symposia/Meetings/ Workshops/Fellowships

Abroad

Amit K. Ghosh participated and presented a paper in the *25th International Diatom Symposium*, Berlin, Germany held during 25-30 June, 2018.

Anju Saxena participated and presented a paper in the *10th European Palaeobotany and Palynology Conference*, Dublin, Ireland held during 12-17 August, 2018.

Anju Saxena visited China under INSA-CAS China Bilateral Exchange Programme 2018 as visiting Scientist for Collaborative research work at *Indo-Norwegian Joint 2nd Meeting of PACT Project* during 07 May, 2018 to 05 June, 2018.

Anjum Farooqui attended and presented progress of research at a meeting of *Indo-Nor Project MoES*, Tromso, Norway during 17-19 September, 2018.

Anumeha Shukla participated and presented her contributions at *Himalaya – Karakorum – Tibet (HKT) Workshop* held at Switzerland during 10-12 September, 2018.

Arindam Chakraborty participated and presented a paper in the *25th International Diatom Symposium* held at Berlin, Germany during 25-30 June, 2018.

Arvind Kumar Singh participated in the *Workshop Summer School on Stable Isotopes in Ancient and contemporary environments* for its application in ongoing research held at Germany on 15-19 April, 2018.

B.D. Singh participated and presented a paper in the Conference on *70th International Committee for Coal and Organic Petrology (ICCP)* held at Australia during 15-29 September, 2018.

Gaurav Srivastava visited China during 30 October - 30 November 2018 on *President's International Fellowship* as Visiting Scientist.

Gaurav Srivastava visited and worked on palm fossils with Prof. Su Tao in Xishuangbanna Tropical Botanical Garden (XTBG), Yunnan Province, China under *President's International Fellowship of Chinese Academy of Sciences, China* during 10 April, 2018 to 10 June, 2018.

Gurumurthy G.P. visited France during 11 November – 22 December 2018 as Visiting Scientist for Post-doctoral and collaborative research work.

Gurumurthy G.P. visited Japan as Visiting Scientist during 25 January 2019–15 July, 2019 on *INSA-DST JSPS Fellowship Programme* for collaborative research.

Jyotsana Dubey participated and presented a paper in the *10th European Palaeobotany and Palynology Conference* at Dublin, Ireland during 12-17 August, 2018.

L. Thomte participated and presented a paper in the *10th World Dendro Conference* at Thimpu, Bhutan during 2-22 June, 2018.

Manoj M.C. participated and presented a paper in the *AGU Fall Meeting* held at Washington, USA during 10-14 December, 2018.

Niraj Rai attended a *Meeting on Fossil DNA* and delivered an invited talk in Singapore during 02-09 June, 2018.

Niraj Rai Participated and presented his contribution in *Meeting-cum-Workshop* at Germany during 5-16 December, 2018.

Nitesh Kumar Khonde visited China under Visiting Scientist Programme for Collaborative research work during 12 September – 11 October, 2018.

Nitesh Kumar Khonde participated and presented a paper in *9th International Conference on Asian Marine Geology* held at Shanghai, China during 11-12 October, 2018.

Nivedita Mehrotra participated and presented a paper in the *ICDP Workshop on Scientific Drilling of Lake Nam Co (Tibetan Plateau)* held at Beijing, China during 22-24 May 2018.

Nivedita Mehrotra participated and presented a paper in *10th European Palaeobotany and Palynology Conference* held at Dublin, Ireland during 12-17 August, 2018.

Nivedita Mehrotra participated in *ICDP- Training Course on Continental Scientific Drilling* held at Windischeschenbach, Germany 18-23 November, 2018.

Prasanna K. visited and worked on clumped isotope geochemistry of deep sea corals, Otoliths and dinosaur eggs to study the paleoclimatic variation at the University of California, Los Angeles under *Indo-US postdoctoral Fellowship Programme* as Visiting Scientist during 10 January – 20 December, 2018.

Ratan Kar participated and presented a paper in *4th Internatonal Conference on Geology and Earth Sciences* held at Athens, Greece 04-07 June, 2018.

Ruby Ghosh participated and presented a paper in the *XIX International Botanical Congress 2017* held at Shenzen, China during 23-29 July, 2018.

Sajid Ali visited Germany on *DAAD Fellowship* as Visiting Scientist during November 2018-December, 2018.

Santosh Kumar Pandey participated and presented a paper in the *International Conference on Ediacaran and Cambrian Sciences* held at Xian, China during 12-16 August, 2018.

Santosh K. Shah visited *Xishuangbanna Tropical Botanical Garden*, CAS, Menglun, Yunnan, China as Visiting Scientist during 22 January – 05 February, 2018.

Santosh K. Shah participated and presented a paper in the *10th World Dendro Conference* held at Thimpu, Bhutan during 2-22 June, 2018.

Santosh K. Shah visited Tribhuvan University, Kathmandu, Nepal as Ph.D. External Examiner during 22-24 August, 2018.

Sheikh Nawaz Ali participated and presented his contributions in *Himalaya – Karakorum – Tibet (HKT) Workshop* held at Switzerland during 10-12 September, 2018.

Sajid Ali visited GEOMAR Kiel, Germany under DAAD Fellowship Programme for Collaborative research work during October 2018 -January, 2019.

Srikanta Murthy participated and presented a paper in the *10th European Palaeobotany and Palynology Conference* held at Dublin, Ireland during 12-17 August, 2018.

Sunil Kumar Shukla visited France on Post Doctoral Fellowship (SERB) as Visiting Scientist for collaborative research work during 20 December 2017 – 19 December, 2018.

Swati Tripathi participated and presented a paper in the *10th European Palaeobotany & Palynology Conference* held at Dublin, Ireland during 12-17 August, 2018.

Thomte L. participated in Pre-Conference Dendro Field week Training under *10th World Dendro Conference* at Ugyen Wangchuck Institute for Conservation & Environment (UWICER), Bumthang, Bhutan during 2-29 June, 2018.

Uttam Pandey participated and presented a paper in the *10th World Dendro Conference* held at Thimpu, Bhutan during 2-22 June, 2018.

Vandana Prasad attended the meeting and presented progress of research in *Indo-Norwegian Joint 2nd Meeting of PACT Project* held at Tromso, Norway during 17-19 September, 2018.

In India

Anju Saxena participated in *4th India International Science Festival*, 2018 held at Indira Gandhi Pratisthan, Lucknow for Museum Expo of BSIP, under the DST Banner during October 04-08, 2018.

Anjali Trivedi attended short term training programme on Role of remote Sensing, Geographical *Information System (GIS) and GPS in natural resources Management* in Remote sensing Application Centre, Uttar Pradesh, Lucknow during February 18-22, 2019.

Deepa Agnihotri participated in *4th India International Science Festival, 2018* held at Indira Gandhi Pratisthan, Lucknow during October 05–08, 2018.

Neelam Das participated in *4th India International Science Festival*, 2018 held at Indira Gandhi Pratisthan, Lucknow during October 05–08, 2018.

Neelam Das attended the *National Workshop on 'Sequence Stratigraphy and Basin'* held at Department of Geology, Nagaland University, Kohima, during 26-30 November 2018.

Suyash Gupta participated in the *National Seminar-cum- Workshop on Recent Advances in the Indian Earth Science* held at Kumaun University, Nainital, during March 25-26, 2019.

Amit K. Ghosh participated and delivered an Invited Lecture in the *National Conference on Biological Sciences for Human Welfare: Teaching and Research in Modern Perspective*, Berhampore, Murshidabad, W.B., 29-30 September, 2018.

Amit K. Ghosh participated and delivered a plenary lecture in the *National Conference on "Environmental Issues: Current Scenario from the view point of Scientific Studies",* Cooch Behar, W.B., 19-20 February, 2019.

Arindam Chakraborty participated and presented a paper in the *National Conference on Environmental Issues: Current Scenario from the view point of Scientific Studies,* Cooch Behar, W.B., 19-20 February, 2019.

Arindam Chakraborty participated in First SERB School on Evolutionary Biology JNCASR, Bangalore, India during 12-26 March, 2019.

Neelam Das participated in *National Seminar on Effects of Paleo and Anthropogenic Events on Earth System & Annual General Meeting of GSI*, September 2018.

Arif Md. participated in the young scientist program enclave of *India International Science Festival (IISF)* held at Lucknow during October 5-8, 2018.

Anumeha Shukla deputed as Women Scientist at *India International Science Festival*, 5-8 October, 2018, Lucknow.

Anumeha Shukla participated *Himalayan Karakorum Tibet Workshop (HKT-2018)*, Switzerland, September, 2018.

Anumeha Shukla attended *2nd International Conference on Geology: Emerging Methods and Applications (GEM-2019)*, Kerala, January, 2019.

Vivesh Vir Kapur participated in the *Brainstorming Meet on Rejuvenating Indian Palaeontology & Establishing a National Earth Museum* held at Indian National Science Academy, Delhi during September 10-11, 2018.

Vivesh Vir Kapur participated in the *Second National Conference and Field Workshop on "Recent studies on the Geology of Kachchh"* held at Department of Earth and Environmental Sciences, KSKV Kachchh University, Bhuj, Gujarat during 30 December 2018 - 01 January, 2019.

Arvind K. Singh participated in the *Young Scientist Conference (YSC) under India International Science Festival (IISF)* at Lucknow, India during October 5–8, 2019.

Ali S. participated in the *National Conference during International Indian Science Festival*, Lucknow, October 2018.

Runcie Paul Mathews participated in a *Seminar on 'Advanced Detection and Separation'* organized by Agilent technologies at Sapna Clarks Inn, Lucknow, 18 May, 2018.

Anjum Farooqui attended *National Conference on Climate Change and Natural Resources*, 20-21 February, 2018. Lucknow University, Lucknow.

Anjum Farooqui participated in *International Conferences on Plants and Environmental Pollution*. NBRI, Lucknow, 27-30 November, 2018

Swati Tripathi participated in the Women Scientists and Entrepreneurs conclave at *India International Science Festival* held at Indira Gandhi Prastisthan, Lucknow during October 7-8, 2018.

Swati Tripathi participated in the *84th Annual Meeting of Indian Academy of Sciences* at Banaras Hindu University, Varanasi during November 2-4, 2018.

Pandey S. participated in the *4th India International Science Festival* held at the Indira Gandhi Pratishthan, Lucknow during October 05-8, 2018.

Trivedi A. participated in the *4th India International Science Festival*, Lucknow, India during October 05- 08, 2018.

Jyoti Srivastava participated in *National Symposium on Current trends and future prospects in plant science research* held at Department of Botany, Banaras Hindu University, Varanasi during 01-03 February, 2019.

S.K. Shah participated in Session Earth Science of *4th India International Science Festival*, Lucknow, on October 7, 2018.

L. Thomte participated in the *National Conference on Role of Remote Sensing and GIS in Natural Hazard Assessment for Sustainable Development: Present Scenario and Future Perspective* held at CAS Geology, University of Lucknow, Lucknow on March 15, 2019.

Veeru Kant Singh participated in the *India International Science Festival-2018*, Lucknow during October 05-08, 2018.

Yogmaya Shukla attended the *Training Program on Microbial Carbonates in Time and Space* held at Indian Institute of Sciences, Bengaluru during November 19-25, 2018.

Lectures Delivered

Late Palaeozoic biodiversity and climatic implications of the coal forming flora of Singrauli Coalfield, Son Basin, India. Nanjing Institute of Geology and Palaeontology, Nanjing, P.R. China (on May 25, 2018) - delivered by Anju Saxena.

Floristics and climatic significance of the Permian Gondwana of India: Evidences from the Mahanadi Basin at Nanjing Institute of Geology and Palaeontology, Nanjing, P.R. China (on May 25, 2018) - delivered by Anju Saxena.

Fossil evidence depicts ancestors of sweet potato are from East Gondwana (Invited talk) at Xishuangbanna Tropical Botanic Garden (XTBG) Chinese Academy of Sciences, P.R. China (on May 29, 2018) – delivered by Gaurav Srivastava.

Reconstructing the peopling of old world South Asia: from modern to ancient genomes at Complexity Institute, Nanyang Technological University, Singapore (on June 07, 2018) – delivered by Niraj Rai.

Tree-ring based drought (scPDSI) reconstruction for the Lidder Valley, Kashmir, Northwest Himalaya at 10th World Dendro Conf., Thimpu, Bhutan (on June 12, 2018) – delivered by Uttam Pandey.

Spatial rainfall reconstruction for the districts of Kerala, south India inferred from tree-rings of Tectona grandis at 10th World Dendro Conference, Thimpu, Bhutan (on June 13, 2018) – delivered by Santosh K. Shah.

Shingo River flow reconstruction from Upper Indus Basin using ring-widths of Abies pindrow at 10th World Dendro Conference, Thimpu, Bhutan (on June 13, 2018) – delivered by Santosh K. Shah.

Calcareous Nannoplankton: a tool to assign age and environmental changes at Postgraduate Institute of Sciences, University of Peradeniya, Sri Lanka (on June 22, 2018) – delivered by Abha Singh.

Shudhtha avam allergy ke sandarbh mei uttarpoorvi bhaarat ke asam se prakratik shahad (honeys) ka paragaarvik adhyan (Special Lecture) at Hindi Workshop, BSIP, Lucknow (on June 25, 2018) - delivered by Swati Tripathi.

Paleontological collections of a National Earth Museum and their socio-economic relevance (Invited Talk) at Brainstorming Meet on Rejuvenating Indian Palaeontology & Establishing a National Earth Museum, Indian National Science Academy, Delhi (on September 10, 2018) – delivered by Vivesh V Kapur.

Origin of life and journey towards the emergence of first animal under Pre-Event-Outreach Programme of India International Science Festival (IISF) 2018 In BSIP, Lucknow (28th September, 2018) – delivered by Santosh K. Pandey.

Tree-rings: The story tellers of the Environment at Outreach Programme under 4th India International Science Festival, BSIP, Lucknow (on September 28, 2018) – delivered by Santosh K. Shah.

Palaeovegetation and environments during Eocene warming event in Pre-event- Outreach Programme of India International Science Festival 2018 at BSIP, Lucknow (September 28, 2018) – delivered by Poonam Verma

Flavour(s) of Vertebrate Palaeontology on Open Day for Public Outreach, 4th India International Science Festival (IISF), Birbal Sahni Institute of Palaeosciences, Lucknow, India (on September 28, 2018) – delivered by Vivesh V Kapur

Reconstructing the peopling of old world South Asia: from modern to ancient genomes (Invited Talk) Next Gen Genomics, Biology, Bioinformatics and Technologies - at International Conference (NGBT-2018), Jaipur (during Sept 30 to Oct 2, 2018) – delivered by Niraj Rai.

Genetic makeup of South Asian populations (Keynote Lecture) on International Conference *GenoPro 2018* at Invertis University, Bareilly (during 5-6 October, 2018) – delivered by Niraj Rai.

Reconstructing the Peopling of old world South Asia: from Modern to Ancient Genomes (invited talk) at Department of Archaeology, HNB Garhwal University, Srinagar (on October 26, 2018) – delivered by Niraj Rai.

Multiproxy studies on dung of endangered Sangai (Rucervus eldii eldii) and Hog deer (Axis

porcinus) from Manipur, India: Implications for palaeoherbivory and palaeoecology (invited talk) at 84th Annual Meeting of Indian Academy of Sciences, Banaras Hindu University, Varanasi (on November 2, 2018) - delivered by Swati Tripathi.

Fossils a tool to resolve the buried mystery at St. Thomas Sr. Sec School, Mainpuri (on November 3, 2018) - delivered by S.Suresh Kumar Pillai.

Palaeontology and its importance at Monfort Inter College, Lucknow (on December 13, 2018) - delivered by S.Suresh Kumar Pillai.

Introduction to Research Methodology, Hypothesis and Ethics, Ph.D. Course work BSIP, Lucknow (on December, 18, 2018) - delivered by Amit K. Ghosh.

Research paper and Ph. D. thesis writing, communication skills and presentations, Ph.D. Course work BSIP, Lucknow (on December 18, 2018) - delivered by Ratan Kar.

Basic Geology: Documenting the field observations, Ph.D. Course work at BSIP, Lucknow (on December 18, 2018) - delivered by Anju Saxena.

Depositional Environments and Facies, Ph.D. Course work at BSIP, Lucknow (on December 18, 2018) - delivered by Anju Saxena.

Macroflora of Permian Gondwana, Ph.D. Course work at BSIP, Lucknow (on December 19, 2018) - delivered by Deepa Agnihotri.

Origin and evolution of Early land plants, Ph.D. Course work at BSIP, Lucknow (on December 19, 2018) - delivered by Amit K. Ghosh.

Flora of Permian Gondwana (Miofloristics), Ph.D. Course work at BSIP, Lucknow (on December 19, 2018) – delivered by Neha Aggarwal.

Dendrochronology and its application in the reconstruction of past climate at Course work of PhD Scholars at BSIP, Lucknow (on December 20, 2018) – delivered by Santosh K. Shah

Basics of Cenozoic palynology in Ph.D. Course work at BSIP, Lucknow (December 20, 2018) – delivered by Poonam Verma.

Evolution and extinction of Mesozoic flora, Ph.D. Course work at BSIP, Lucknow (on December, 20, 2018) - delivered by Amit K. Ghosh.

Stratigraphic principles and practice, Ph.D. Course work at BSIP, Lucknow (on December 20, 2018) - delivered by Ratan Kar.

Silicified and calcified microfossils, Ph.D. Course work at BSIP, Lucknow (on December 24, 2018) - delivered by Amit K. Ghosh.

Gondwana palynology and stratigraphy, Ph.D. Course work at BSIP, Lucknow (on December 24, 2018) - delivered by Ratan Kar.

Statistical analysis in palaeoclimate studies at Course work of Ph.D scholars at BSIP, Lucknow (on December 24, 2018) – delivered by Santosh K. Shah.

An overview of the fossil sirenians (Mammalia: Sirenia) record from the Kutch (Kachchh) Basin, Gujarat, western India at Second National Conference and Field Workshop on "Recent studies on the Geology of Kachchh", Department of Earth and Environmental Sciences, KSKV Kachchh University, Bhuj, Gujarat, India (on December 31, 2018) – delivered by Vivesh V Kapur.

Application of NGS in forensics and evolutionary biology (Invited talk) in Next Generation Sequencing Workshop at Central Drug Research Institute, Lucknow (on January 09, 2019) delivered by Niraj Rai

aDNA analysis of the museum samples and its application in Human Population and Wildlife Genetics (Invited Lecture) at two days' Workshop on Wildlife Forensics and Crime Control at Zoological Survey of India, Headquarter, Kolkata (during 21st -22nd January 2019) – delivered by Niraj Rai.

Variable range hopping in feldspar (Invited talk) at Annual Seminar in Physics Department of Pope's College (Autonomous), Sawyerpuram, Tamil Nadu (on January 30, 2019) – delivered by P. Morthekai

Charge transport in band-tails of irradiated natural alumino-silicates (feldspar) (Invited talk) at National Conference on Recent Developments in Effective Materials - REDEEMS '19 in Physics Department of Sarah Tucker College (Autonomous), Tirunelveli (on February 1, 2019) – Delivered by P. Morthekai

Aryan Invasion Theory: A Myth or Reality? (Invited Lecture) at Arth- A Culture Fest sponsored by Zee TV at Indira Gandhi National Centre for the Arts (IGNCA), New Delhi (during 9-11 February, 2019) – delivered by Niraj Rai

Precambrian Biosphere: An Analogue for Astrobiology at Sampat Iyenger Hall, Geological

Survey of India, GSI Monthly Meeting, (13 February, 2019) - delivered by Mukund Sharma.

Dating sand using luminescence (Invited talk) at National Seminar on Frontiers in Geophysics and Climate Change in Physics Department of Holy Cross College (Autonomous), Trichy (on February 21, 2019) – delivered by P. Morthekai

Origin of Life & When the Life got Big! on National Science Day at BSIP, Lucknow (28th February, 2019) - delivered by Santosh K. Pandey

Climate Variability and Monsoonal Intensity of the Past: Evidence from ~20 to ~4 Million Years old sediments of Indian subcontinent with special emphasis on Andaman and Nicobar Islands. (Plenary Lecture) - at National Seminar on "Environmental Issues: Current Scenario from the view point of Scientific Studies", Cooch Behar, W.B., February 19-20, 2019 - delivered by Amit K. Ghosh.

Reconstructing the Population History of South Asia using Ancient Genomics (Invited Lecture) at Department of Archaeology and Ancient History, MS University, Baroda (on March 08, 2019) - delivered by Niraj Rai.

Archaeo-Genetics: Modern Advances (Invited Lecture) in two days' Workshop on "Methods of Scientific Analysis of Archaeological Material" at Nagpur University (during March 14-15, 2019) – delivered by Niraj Rai.

Methods of Retrieval of Archaeological Material for Analysis (Invited Lecture) in two days' Workshop on "Methods of Scientific Analysis of Archaeological Material" at Nagpur University (during 14th and 15th March, 2019) – delivered by Niraj Rai.

Magnetostratigraphy and Biostratigraphy, Palaeoclimate, Course work for Masters students at Department of Geology, Kumaun University, Nainital (on March 17, 2019) – delivered by Binita Phartiyal.

Dating techniques and late Quaternary Himalayan Palaeoclimates at University of Lucknow (2019) - delivered by S. Nawaz Ali.

Endnote: A Reference Manager to Ph. D. Scholars of BSIP - delivered by Veeru K Singh.

Lectures as a part of course work for Ph.D. to BSIP research scholars, 2019 - delivered by Anumeha Shukla.

Professor Alok Dhawan, Director CSIR-IITR Lucknow delivering a lecture during IISF 2018 in Lucknow

Consultancy/Technical Support Rendered

Veeru Kant Singh and Mukund Sharma provided Laser Raman Spectroscopy to following:

1. Mr. Vishwas Paridhi, NIPER, Raibarely [October, 2018]
2. Dr. R. Rajagopal, IITR, Lucknow [January 2019]
3. Mr. Kapil Pandey & Mr. Pradeep Kumar, SMPU, Lucknow [March 2019]

Rajesh Agnihotri processed a total of 75 samples (including blanks and standards) for conventional C-14 dating. This includes 22 Institute samples, 27 consultancy samples, and 13 samples carried out based on collaborative research.

P. Morthekai, Nawaz S. Ali, Ishwar Chandra Shukla & Priyanka Singh - Around 140 samples have been measured which include consultancy and in-house project samples, in both Luminescence Reader 1 and Luminescence Reader 2 (~ 6 months old).

Name of client	Type of services rendered	Period
Lucknow University	OSL Dating	14/05/2018
Jammu University	OSL Dating	11/05/2018
Mike Synor, Australia	OSL Dating Analyses	01/06/2018

Anupam Sharma, Kamlesh Kumar & Amrit Pal Singh Chaddha:

Name of Client	Type of services rendered	Periods
BBAU Univ. Lko.	XRD	09/04/2018
Integral Univ.	XRD	27/04/2018
BBAU Univ.	XRD	12/06/2018
Lucknow Univ.	XRD	14/06/2018
Patna Univ.	XRD	10/07/2018
Ranchi Univ.	XRD	25/07/2018
Ranchi Univ.	XRD	25/07/2018
BBAU Univ, Lko.	XRD	01/08/2018
NIPER	XRD	24/09/2018
Ranchi Univ.	XRD	22/10/2018
Integral Univ, Lko.	XRD	31/10/2018
BBAU Univ, Lko.	XRD	20/11/2018
BSIP, Lko.	XRD	29/11/2018
DSMNRU, Lko.	XRD	0312/2018
BBAU Univ. Lko.	XRD	03/12/2018
BBAU Univ. Lko.	XRD	10/12/2018
DSMNRU, Lko.	XRD	20/12/2018
IIT-BHU	XRF	01/10/2018
DSMNRU, Lko.	XRF	20/12/2018

Anupam Sharma, Pawan Govil, Ishwar Chandra Rahi & Jitendra Yadav:

Name of client	Type of services rendered	Period
M.Venkatesh (IIT ISM)	Geochemical analysis (ICP-MS)	19/06/2018
Ms. ShimYaphy (LU)	Geochemical analysis (ICP-MS)	27/07/2018
Aparna Sinha (AMU)	Geochemical analysis (ICP-MS)	21/08/2018
Sandeep Kumar Gautam (Geol. Dept. LU)	Geochemical analysis (ICP-MS)	28/11/2018
Nirmal Purty (Geol. Dept., Ranchi Univ.)	Geochemical analysis (ICP-MS)	30/11/2018
NCESS, Thiruvanantpuram	Geochemical analysis (ICP-MS)	22/04/2018
IIT, ISM, Dhanabad	Geochemical analysis (ICP-MS)	12/03/2019
Geology Department, Sikkim University	Geochemical analysis (ICP-MS)	30/01/2019

Binita Phartiyal, Mohd. Arif & Prasanta Kumar Das:

Name of client	Type of services rendered	Period
Dr. Siddharth P. Prizomwala, ISR, Raisan, Gandhinagar	Analysis of Susceptibility, ARM and IRM's of samples from Western India	November 2018

Shailesh Agrawal & Sandeep Kumar Kohri:

Name of client	Type of services rendered	Period
Jawaharlal Nehru University	Carbon isotope analysis (IRMS)	December, 2018
Wadia Institute of Himalayan Geology, Dehradun	Carbon and nitrogen isotope analysis (IRMS)	July, 2018
Indian Institute of Science Education and Research, Mohali	Carbon and nitrogen isotope analysis (IRMS)	July, 2018
Central Institute of Fisheries Education, Mumbai	Carbon and nitrogen isotope analysis (IRMS)	February, 2019

Runcie Paul Mathews:

Name of client	Type of services rendered	Period
Integral University, Lucknow	GCMS analysis	2018
Department of Archaeology, Govt. of Tamilnadu, Chennai	GCMS analysis	2018

Summer/Winter internship training:

Imparted winter internship training to Ms. Umme Kulsum, M.Sc. (Geology), Semester-IV, Banasthali Vidyapith, Rajasthan for one month on the topic "*Palaeobiological investigation of Chuaria: insight from the Bhander Limestone, Vindhyan Supergroup, India"* (December 2018-January 2019) by Dr. Santosh K. Pandey.

Imparted summer internship training to Ms. Ayushi Srivastava, M.Sc. (Geology), Semester-IV, University of Lucknow for three months on "*Behavioural traits, palaeoecology and diversification of bioturbation: a case study from the Nagaur Sandstone, Marwar Supergroup, India*" (15th February – 15th May, 2019) by Dr. Santosh K. Pandey.

Imparted summer internship training to Ms. Anjali Verma M.Sc. (Geology), Semester-IV, University of Lucknow undergoing for two months on "*Microfossils from the Meso-Neoproterozoic rocks: A case study from the Vindhyan Supergroup, India"* (14th March – 13th May, 2019) by Dr. Veeru Kant Singh.

Imparted two days training as Invited Resource person to Indian Arm forces, Law enforcement agencies and Scholars on "*Wildlife Forensics and Crime Control"* during 21st -22nd January 2019 at Zoological Survey of India, Headquarter, Kolkata by Niraj Rai

Imparted training to Mr. Mrutyunjaya Sahoo, SRF (CSIR-UGC) who is pursuing Ph.D from Ravenshaw University, Cuttack, Odisha on topic "*Palaeofloral investigation based on morphotaxonomy, palynomorphs and biomarker from Lalmatia Colliery of Rajmahal Basin, Godda District, Jharkhand*" at BSIP, Lucknow during 25th September 2018 – 10 October 2018 by S. Suresh Kumar Pillai.

Imparted training to Dr. Saurab Gautam, SERB-National Post Doctoral Fellowship (N-PDF) student of Fakir Mohan University Vyasa Vihar, Nuapadhi, Balasore, Odisha on "*Palynostratigraphy, Palaeoclimate, Palaeogeography and evolutionary trend of palynofloras through Gondwana sediments in Mand-Raigarh Coalfield, Chhattisgarh, India*" at BSIP, Lucknow during August, 2018 by S. Suresh Kumar Pillai.

Shri B. Anand, Finance Advisor, DST visiting the Geochemistry Laboratory

Recognition

Mukund Sharma

Awarded *L Rama Rao Birth Centenary Award 2018* by the Geological Society of India, Bangalore, September 19, 2018.

Santosh K. Pandey

Awarded *Mani Shankar Shukla Memorial Gold Medal* for outstanding contributions in the field of Micropalaeontology for the year of 2018 by the Palaeontological Society of India (March 6, 2019).

Anju Saxena

Awarded one month INSA-CAS (Indo-China) Exchange Fellowship for the year 2018 to work with Prof. Jun Wang, at Nanjing Institute of Geology and Palaeontology, Nanjing, China PR (May 7 –June 8, 2018).

Gaurav Srivastava

Awarded *President's International Fellowship* (2018) from the Chinese Academy of Sciences, China and *Diamond Jubilee Medal* (2018) from the Birbal Sahni Institute of Palaeosciences for publishing paper in high quality refereed journals.

Hukam Singh

Awarded '*Team Medal 2018*' for a best quality research works within the Institute and articles are published in Scientific Report (One article) and PLOS ONE (Two articles).

Vandana Prasad

Nominated as a Member of the Inter-Institutional Committee of 36th IGC to be held during March 2-8, 2020 as DST Nominee.

Vivesh Vir Kapur

Awarded *Sharda Chandra Gold Medal - 2017* for the best Scientific contribution in Palaeontology by The Palaeontological Society of India (September 6, 2018).

Sajid Ali

Awarded *DAAD Fellowship* under the scheme "Research Stays for University and Academics and Scientists" to work at GEOMAR, Kiel, Germany; October 2018-January 2019

Swati Tripathi

Received best *Poster Award in Women Scientists and Entrepreneur Conclave* at India International Science Festival, Lucknow (October 07-08, 2018).

Santosh Kumar Shah

Selected for *INSA- Bilateral Exchange Fellowship* for the year 2019, to carry out research work Tree-ring and Environmental Change Group, Xishuangbanna Tropical Botanical Garden (XTBG), CAS, Yunnan, China.

Ratan Kar

Chaired a session in the 5th Annual International Conference on Geology & Earth Science – 2018 at Athens (June 04-07, 2018).

Rajesh Agnihotri

Received *External Budgetary Resource Medal-2018* given by Birbal Sahni Institute of Palaeosciences Lucknow.

S. Nawaz Ali

Awarded Prof. S.K. Singh Memorial Gold Medal for 2018 by Paleontological Society of India.

Binita Phartiyal

Awarded *Distinguished Alumni Award-2018* for Science and Research from by SJC and SMC Alumni, during Award Ceremony, New Delhi, (May 25, 2018).

B.D. Singh

Awarded 'Scientific Output Medal-2018' of BSIP for the best piece of research work done amongst Scientists-E, F, and G during the preceding two years (2016 & 2017)

Anupam Sharma

Nominated by Department of Science and Technology (DST), New Delhi as a Member of the Facility Management Committee (FMC) for Sophisticated Analytical Instrument Facility (SAIF) of Central Drug Research Institute (CDRI), Lucknow for three years in 2018.

Invited as a popular Keynote Speaker and Chaired a Session in two days National Conference on 'Biogeochemical Cycles and Climate Change" held at Department of Environmental Science and Engineering, IIT(ISM), Dhanbad (August 10-11, 2018).

Nominated by The Geological Survey of India (GSI), Lucknow as an External Expert of Regional Expert Committee for Mission-IV activities at GSI. NR. Lucknow in 2018.

Representation in Committees/Boards

Mukund Sharma

- President, The Society of Earth Scientists, India (2017-2019)
- Vice President, Palaeobotanical Society, India (2019-2021)
- Editor, Journal of the Palaeontological Society of India, Lucknow (2018-2020)
- Member, 36th IGC Geohost Support Committee, New Delhi (2018-2020)
- Member, The Indian Museum of Earth Science (TIME) Establishment Committee
- Voting Member, Sub-commission on Ediacaran Stratigraphy
- Corresponding Member, Sub-commission on Cryogenian Stratigraphy
- Distinguished Guest, National Workshop on Science Communication & Film-making
- Member, Screening Committee for Assessment Promotion of Scientific Staff of BSIP
- Convener, Office Automation Committee
- Convener, Purchase Committee

K.J. Singh (Till 31.07.2018)

- Convener, Works and Building Committee, BSIP
- Convener, Museum Committee, BSIP

Amit K. Ghosh

- Member, RDCC, BSIP
- Member, Purchase Committee, BSIP
- Convener, Investment Committee, BSIP
- Convener, Museum Committee, BSIP (w.e.f. 01.08.2018)
- Co-ordinator, Ph. D. Course Work, BSIP
- Examiner, Ph. D. thesis University of Burdwan
- Examiner, M.Sc. Practical Examination, Visva - Bharati University

Neeru Prakash

- Convener, Purchase Committee, BSIP
- Convener, Garden Committee, BSIP
- Convener, Section Cutting Committee, BSIP
- Convener, Rajbhasha Karyanvayan Samiti, BSIP
- Convener, Deputation Committee, BSIP

Srikanta Murthy

- Convener for SEM Committee, BSIP.
- Member for Maceration Committee, BSIP.

Gaurav Srivastava

- Editor, Geophytology

Anumeha Shukla

- Member in Herbarium Committee, BSIP
- Member in Section Cutting Improvement Committee, BSIP

Hukam Singh

- Life Member, Journal of Palaeontological Society of India
- Life Member, Himalayan Geology, Dehradun, India

Vandana Prasad

- Member, Science Subcommittee and Theme Coordinator for the theme *"Critical events, mass extinctions and evolution of biosphere"* for IGC 2020 to be held during 2-8 March, 2020

Poonam Verma

- Member, Maceration Committee, BSIP

Vivesh Vir Kapur

- Editor, Geophytology
- Member, Museum Committee, BSIP

Runcie Paul Mathews

- Deputed as an External Member of the Technical Committee for purchasing of GCMS and AAS for USIC, Bhimrao Babasaheb Ambedkar Central University (BBAU), Lucknow held at Ambedkar Bhawan, BBAU on 19-02-2019 and on 25-03-2019.

Anjum Farooqui

- Life Member, Int. Soc. of Plant and Environment, NBRI, Lucknow

- Member, International Geological Correlation Programme (IGCP-495).
- Life Member, Palaeontological Society of India, Lucknow
- Life Member, Palaeobotanical Society of India, BSIP, Lucknow
- Member, International Council for Biodeterioration of Cultural Properties, Lucknow
- Member, Int. Society of Applied Geochemists, Hyderabad
- Member Int. Jour. Plant Morphologists, Delhi

S.K. Basumatary

- Life Member, The Palaeobotanical Society of India
- Life Member, The Palynological Society of India
- Member, Editorial Board, Bio-Science Letters (an e-journal of Bodoland University, Assam, India)

Swati Tripathi

- Life Member, The Palaeobotanical Society of India
- Life Member, The Palaeontological Society of India
- Annual Member, American Association of Stratigraphic Palynologists
- Life Member, Journal of Applied Biosciences

Anjali Trivedi

- Member, NECLIME (Neogene Climate Evolution in Eurasia) Frankfurt, Germany
- Member, INQUA (International Union for Quaternary)
- Life Member, Palaeontological Society of India, Department of Geology, Lucknow
- Life Member, Academy of Environmental Biology, ITRC, Lucknow
- Fellow, Palaeobotanical Society of India, BSIP, Lucknow
- Member, Library Committee, BSIP, Lucknow

Jyoti Srivastava

- Member of the Editorial board of Journal Geophytology of The Palaeobotanical Society, Lucknow

Santosh Kumar Shah

- Group Leader/ Instructor for field week of project "Dendroclimatology and Dendrohydrology" during Pre-Conference Dendro Field week Training under 10th World Dendro Conference at Ugyen Wangchuck Institute for Conservation & Environment (UWICER), Bumthang, Bhutan (June 2-9, 2018)
- Scientific Committee Member for 10th World Dendro Conference, Bhutan (June 2-22, 2018)
- Session Chairs for Dendrohydrology sessions during 10th World Dendro Conference, Bhutan (June 2-22, 2018)
- External PhD Examiner in Department of Environmental Science, Tribhuvan University, Kathmandu, Nepal (August 23, 2018)
- Resource Person for "Training on Dendrochronology and its application" held at Resources Himalaya Foundation, Kathmandu, Nepal; organized by Tree-ring Society of Nepal (August 24-25, 2018)
- Supervised BSc Forestry Thesis of Laikitkupar Lyngdoh, College of Natural Resources, Royal University of Bhutan, Lobesa, Bhutan on the topic "Response of climate on radial growth of *Pinus kesiya* in East Khasi Hills of Meghalaya, India"
- Trained Mr. Keshav Kumar Upadhyay, Assistant Professor from Department of Forestry, School of Earth Sciences and Natural Resource Management, Mizoram University, Mizoram for tree-ring data analysis towards his Ph.D. Thesis
- Editorial Advisory Board, Himalayan Research Journal (UGC Recommended)

Ratan Kar

- Chief Editor, Geophytology

Anil K. Pokharia

- Member, Executive Committee, Indian Society for Prehistoric and Quaternary Studies
- Member, The Palaeobotanical Society of India

Rajesh Agnihotri

- Member, Indian Geophysical Union (IGU), Hyderabad
- Member, Earth Science Society of India

S. Nawaz Ali

- Member, Luminescence Dating Society of India

Binita Phartiyal

- External Examiner for PhD viva in the Department of Geology, Kumaun University, Nainital at Nainital (25th April, 2018)
- Expert Member in Women Scientist Scheme (WOS-A); Department of Science and Technology, New Delhi; 2016-2019

Anupam Sharma

- Member, Sophisticated Analytical Facility, CSIR-Central Drug Research Institute, Lucknow
- External Expert, Regional Expert Committee for Mission-IV activities at GSI. NR. Lucknow
- Convener of Building & Electrical Maintenance (BEMC) Committee, BSIP, Lucknow
- Member, Purchase Committee, BSIP, Lucknow
- Convener-Member of KRC (Library) Committee

Pawan Govil

- Convener of Staff Welfare Committee
- Member of Internal Lecture Committee (ILC)
- Member of Building & Electrical Maintenance (BEMC) Committee

Abha Singh

- External Supervisor for 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.

Sajid Ali

- Key reviewer for Arabian journal of Earth Sciences and African Journal of Earth sciences

Shilpa Pandey

- Member of the National Advisory Committee of the National Conference on "Recent studies on the Geology of the Kachchh Basin", Kachchh University, Bhuj, Gujarat, 2018.

P. Morthekai

- Asia-Pacific Regional Member for Trapped Charge Dating Association.
- Coordinator of Indian Luminescence Dating Association.
- Convener of Luminescence Applications in Earth Sciences by the Luminescence Society of India.

Dr. C.M. Nautiyal delivering a lecture on IISF

Ph.D. Programmes

Name of Ph.D. Scholar	Subject	Date of Award/ Registration	University	Supervisor (s)	Title of Ph.D. Thesis
Ruchika Bajpai	Geology	May, 2018 Awarded	BHU, Varanasi	Dr. Ratan Kar Prof. A.D. Singh	Investigation of the Holocene climate variability from the Glacial sites in Lahaul Valley, western Himalaya, India
Debarati Nag	Geology	September, 2018 Awarded	BHU, Varanasi	Dr. Binita Phartiyal Prof. M. Joshi	Geomorphological architecture and palaeoclimate of the Late Quaternary sequence of Indus catchment (between Gupuk and Batalik), Ladakh.
Syed Azharuddin	Geology	January, 2019 Awarded	BHU, 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	October, 2018 Submitted	University of Lucknow, Lucknow	Dr. Santosh Kumar Shah Prof. Munendra Singh	Dendroclimatology of Liddar Valley and adjoining areas in Kashmir Himalaya
Kriti Mishra	Geology	August, 2018 Submitted	University of Lucknow, Lucknow	Dr. Ratan Kar Prof. M. Singh	Analysis of Holocene climate variability using multi-proxy data around Chorabari Glacier (Kedarnath), western Himalaya, India
Bandana Dimri	Geology	March, 2013 Ongoing	BHU, Varanasi	Prof. 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	Prof. Mukund Sharma Prof. Rajesh K. Srivastava	Biostratigraphy of the Mesoproterozoic Chhattisgarh Basin exposed in the Bargarh District, Odisha, India
Nandita Tiwari	Environ-mental Sciences	January, 2014 Ongoing	UPES, Dehradun	Prof. Mukund Sharma Dr. Uday Bhan	Neogene *Chara* fossils assemblage from India in the context of extant forms, palaeobiological issues and geological inferences
Yogesh Kumar	Geology	January, 2017 Ongoing	Sambalpur University, Odisha	Prof. Mukund Sharma Prof. Shreerup Goswami	Palaeobiology and chemostratigraphy of the Kurnool Group, South India
Chethan Kumar	Geology	October, 2018 Ongoing	Bangalore University, Benguluru	Prof. Mukund Sharma Prof. N. Malarkodi	Signatures of Archaean microbial life records in the greenstone belts of the Dharwar Craton, India
Ashish K. Mishra	Geology	July, 2015 Ongoing	BHU, Varanasi	Dr. Vandana Prasad Professor A.D Singh	Cretaceous-Early Palaeogene biostratigraphy and palaeoclimate of Krishna Godavari Basin
Mahi Bansal	Geology	July, 2016 Ongoing	Panjab University, Punjab	Dr. Vandana Prasad Professor Rajeev Patnaik	Phylogenetic structure and biogeography of Indian Paleogene vegetation: A study based on pollen fossil records from western Indian lignites
Yogesh Pal Singh	Geology	January, 2016 Ongoing	University of Lucknow, Lucknow	Dr. Poonam Verma Prof. R. Bali	Biostratigraphy and Palaeoclimate reconstruction of Cenozoic successions of Kerala Basin
Md Shadman	Sedimento-logy	2018 Ongoing	BHU & BSIP	Dr. A.K. Singh Prof. S.K. Tiwari	Physical sedimentology and geochemistry of Paleogene sequences of Rajasthan, India
Rimpy Chetia	Organic Geo-chemistry and coal petrology	January, 2019 Ongoing	BHU, Varanasi	Dr. Runcie Paul Mathews Prof. P.K. Singh	Organic geochemical and petrographic characterization of lignites from Barsingsar and Jalipa Mines of western Rajasthan

Lamginsang Thomte	Geography	August, 2017 Ongoing	Gauhati University, Guwahati	Dr. Santosh Kumar Shah Prof. A.K. Bhagabati	Past climate reconstruction of the Eastern Himalaya region based on tree-rings
Vikram Singh	Geology	March, 2016 Ongoing	BHU, Varanasi	Dr. K.G. Misra Prof. A.D. Singh	Tree-Ring based Climate variability in Jammu and Kashmir since Little Ice Age
Amit K Mishra	Geology	September, 2018 Ongoing	BHU, Varanasi	Dr. Ratan Kar Prof. U.K. Shukla	Tree-line shifts climate change and anthropogenic impact during the Holocene from Chopta-Tungnath region, Garhwal Himalaya, India
Kajal Singh	Geology	September, 2018 Ongoing	BHU, Varanasi	Dr. Ratan Kar Prof. UK Shukla	Study of the Late Quarternary climatic and environmental changes around Ny-Alesund, Svalbard
Sanjay K.S. Gahlaud	Geology	September, 2018 Ongoing	BHU, Varanasi	Dr. Rajesh Agnihotri Prof. Bindyachal Pandey (from 2018)	Geochemical and Isotopic characterization of sedimentary succession of Spiti Valley Himachal Pradesh deposited from late-Jurassic to early Cretaceous
Nikhil Patel	Geology	September, 2018 Ongoing	BHU, Varanasi	Dr. Rajesh Agnihotri Prof. Alok Saini	Geochemical and Isotopic characterization of soil-sediments and archaeological remains from north India: Implications to palaeo-agriculture and human environment interactions
Meenakshi Hira	Enviro-mental Sciences	2013 Ongoing	Central University of Himachal Pradesh, Dharamshala	Dr. Anupam Sharma, Dr. Anurag Linda, CUHP, Dharamshala Dr. Sudesh Yadav, JNU, New Delhi	Mobility of elements during leaching of electronic waste: implications to environment
Shazi Farooqui	Geology	November, 2014 Ongoing	University of Lucknow, Lucknow	Dr. Anupam Sharma Prof. Munenedra Singh	Geochemical study of Late Quaternary sub surface sediments of Lower Mahi River, Gujarat, western India
Tarasha Chitkara	Geology	2015 Ongoing	Kurukshetra University, Kurukshetra	Dr. Anupam Sharma Dr. O.P. Thakur	Quaternary palaeoclimatic studies using multi-proxy approach around Kurukshetra, Haryana, India
Mukesh Yadav	Geology	2015 Ongoing	Banaras Hindu University	Dr. Anupam Sharma Prof. U.K. Shukla	secondary mineralization in Central Ganga Plain: implications to climate and earth surface processes
Shalini Sharma	Botany	July, 2017 Ongoing	Kumaun University, Nainital	Dr. A.K. Pokharia Prof. P.C. Pandey	Exploring plant-food resources, vegetation and climate of Indus (Harappan) and subsequent cultures in north-western India
Himani Patel	Archaeo-botany	March, 2018 Ongoing	BHU, Varanasi	Dr. Niraj Rai Prof. R.P. Sinha	Understanding genetic diversity and Palaeoenvirnmental reconstruction of crop pattern in prehistoric India
Husain Shabbar	Geology	January, 2017 Ongoing	Sambalpur University, Odisha	Dr. Anju Saxena Prof. Shreerup Goswami	Ordovician-Silurian biodiversity of the Tethyan Himalayan strata, Spiti, H.P., India.
Suyash Gupta	Geology	January, 2017 Ongoing	University of Lucknow, Lucknow	Dr. Anju Saxena Prof. Rameshwar Bali	Floristic evolution and biodiversity in the Late Palaeozoic sequences of Spiti Himalayas: palaeoenvironmental and palaeogeo-graphical implications.
Supriya Kumari	Environment al Sciences	January, 2017 Ongoing	University of Lucknow, Lucknow	Dr. Kamlesh Kumar Prof. Dhruvsen Singh	Palaeolimnology and geochemistry of Quaternary lake sediments deposits from Lucknow to Begusarai transect of Ganga Plain.
Mohan Kumar	Stable isotope geo-chemistry and paleo-climate	January, 2017 Ongoing	University of Lucknow, Lucknow	Dr. Shailesh Agrawal Dr. Dhruv Sen Singh	Indian summer monsoon rainfall (ISMR) reconstruction from the northern Ganga plain: forcing factors and implication to C_3-C_4 vegetation change

Stuti Saxena	Botany	2018 Ongoing	University of Burdwan, Burdwan	Dr. Amit K. Ghosh Prof. J.P. Keshri	Investigation on phytoplankton diversity and geochemistry of the Miocene-Pliocene Sequence from the Andaman and Nicobar Islands: Its significance in past climate reconstruction
Rikee Dey	Geology	2018 Ongoing	IIT – ISM, Dhanbad	Dr. Amit K. Ghosh Prof. A.K. Bhoumik	Reconstruction of Miocene to Pleistocene palaeoclimate derived from the studies of silicified and calcified microfossils from Andaman and Nicobar Islands
Subhankar Pramanik	Botany	2018 Ongoing	University of Burdwan, Burdwan	Dr. Amit K. Ghosh Prof. J.P. Keshri	Floral transition across the non-marine Permian - Triassic sequence in Peninsular India
Lopamudra Roy	Geology	2019 Registration	University of Lucknow, Lucknow	Dr. Amit K. Ghosh Prof. Sarajit Sensarma	Late Miocene to Pleistocene palaeoclimate reconstruction based on high resolution biotic proxies coupled with geochemical analysis from the sediment cores of northeast Indian Ocean
Raj Kumar	Geology	September, 2016 Ongoing	BHU, Varanasi	Dr. Neelam Prof. B. Pandey	Palaeontological record from the Mesozoic sediments of the Jaisalmer Basin, Rajasthan: biostratigraphic palaeobiogeographic and palaeoclimatic implications
Randheer Singh	Geology	March, 2013 Ongoing	BHU, Varanasi	Dr. Binita Phartiyal Prof. B. Pandey	चतुर्थ कल्प के दौरान तांगसे (टांगचे) घाटी, लद्दाख, उत्तर परिश्चम हिमालय की भू–आकृति, विवर्तनिक और जलवायु
Pavni Misra	Geology	2016 Ongoing	IIT Kanpur, Kanpur	Dr. Anjum Farooqui Prof. Rajiv Sinha	Climate and vegetation during Holocene in the Gangetic plain
Salman Khan	Geology	September, 2016 Ongoing	BHU, Varanasi	Dr. U.K. Shukla Dr. Anjum Farooqui	Pliocene-Pleistocene changes in vegetation, climate and sedimentation in Middle and High latitudes
Priyanka Joshi	Geology	March, 2016 Ongoing	BHU, Varanasi	Dr. Binita Phartiyal Prof. M. Joshi	Geomorphological evolution and the climatic variations in the ChangLa-Tangste Basin, Ladakh Range, Trans-Himalayas
Jyotsana Dubey	Geology	2017 Ongoing	BHU, Varanasi	Dr. S. Nawaz Ali Prof. V. Srivastava	Chronology of glaciation, palaeoclimatic reconstruction and their climatic implications in the Thangu valley, Sikkim Himalaya, India
Priyanka Singh	Geology	April, 2018 Ongoing	BHU, Varanasi	Dr. P. Morthekai Prof. Kuldeep Prakash (BHU)	High resolution palaeoclimate reconstruction from Kunti Banar valley, central Himalaya: A multi-proxy approach
Deepa Tewari	Geology	September, 2018 Ongoing	BHU, Varanasi	Dr. Binita Phartiyal Dr. Sayandeep Banerjee	Morphometry and Soft Sediment Deformation in the Late Quaternary sediments in NW Himalaya: Implications to Landscape Evolution, Chronology and Neotectonics
Sarvendra Pratap Singh	Geology	January, 2019 Ongoing	BHU, Varanasi	Dr Mohd. Arif Dr Amiya Shankar Naik	Integrative palynological, magnetostratigraphic, and sedimentological studies of selected Deccan volcano-sedimentary sections of peninsular India: implications for age, paleoclimate, paleobiogeography and evolutionary history of infra- and intertrappean biotas
Nazim Deori	Geology	January, 2019 Registration	K.S.K.V. Kachchh University, Gujarat	Dr. Abha Singh, BSIP, Lucknow Dr. J.M. Patel, Dr. R. R. Lalan College, Bhuj, Kachchh Dr. M.G. Thakkar KSKV, Kachchh University	High resolution biostratigraphy and depositional environment of Cenozoic succession of Kachchh Basin, Western India, Gujarat

Units

Publication

The Palaeobotanist

This year two issues of the journal *The Palaeobotanist* were published. The first 67(1) incorporated 7 research papers and the second 67(2) contained 8 research papers.

Annual Report

Bilingual Annual Report of the Institute was published in Hindi and English containing pertinent information related to research work carried out in the Institute under different research projects from 1st April, 2017 to 31st March, 2018. Apart from this conference participation, awards distribution, 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 also included.

Catalogue

A Catalogue entitled "A Catalogue of Upper Gondwana (Jurassic – Early Cretaceous) plant megafossil

genera of India" by Neeru Prakash and Neelam Das was published.

Miscellaneous

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

Releasing the Institute's Journal *The Palaeobotanist*

Knowledge Resource Centre

Knowledge Resource Centre (KRC) is committed in providing 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 through National Knowledge Resource Consortium (NKRC) of CSIR- DST. Weekly services like '*New Arrivals*' having content pages of journals/ books acquired by KRC and *News Clippings* having scientific contents from Newspapers and magazines purchased are regularly 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 literature is being continuously added to the database.

The current holdings of library are as under:

Particulars	Additions during 2018-19	Total
Books in English	32	6,367
Journals (bound volumes)	142	17,666
Reprints	-	40,179
Reference Books	-	351
Books in Hindi	44	739
Ph.D. Thesis	15	125
Reports	-	46
Maps & Atlas	-	61
Microfilm/ Fisches	-	294
Compact Disk	-	74

(Working hours 9.30-18.00 Mon-Fri)

Currently, the library receives 161 journals (111 through subscription and 50 through exchange). There are 187 registered card holders using the library facilities.

The following institutions / organizations availed the library facilities:

1. Department of Geology, University of Lucknow, Lucknow
2. Botanical Survey of India, Central Regional Centre, Allahabad
3. HNB Garhwal University, Srinagar, Uttarakhand

e- Journals

Web based access of the journals is available over the Institute' s LAN (Local Area Network) 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 and three magazines.

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 a lamination machine to preserve the old and fragile scientific literature.

Exchange Facility-

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

Museum

Museum plays a vital role in popularizing and disseminating the knowledge of palaeosciences amongst the students and young researchers within the country and abroad. During this period, the exhibits of the Museum were displayed in IISF (India International Science Festival) 2018 that was held at Indira Gandhi Pratishthan, Gomti Nagar, Lucknow from 05 to 08 October, 2018.

National Science Day was celebrated on 28th February, 2019 in a befitting manner. It was observed as an Open House and around 200 students from various colleges visited the Institute's Museum and different Laboratories. On this occasion, prominent scientific lectures were delivered by the Institute's scientists and research scholars.

Research materials (megafossil and palynological samples) were collected from 283 different localities across the country by the scientists working in the projects of the Institute's Projects as well as on various other Sponsored Projects. Type specimens designated in 31 research papers were also submitted in the repository during this period.

Three sets of plant fossils were gifted to various colleges within the country and fossil specimens as souvenirs were also presented to the distinguished visitors and invited speakers in the Institute.

Museum holdings:

Particulars	Addition during 2018-19	Total
Type and Figured Specimens	097	09,164
Type and Figured Slides	167	15,698

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

Project	Megafossil Specimens	Palynological Samples
Project-1	.....	438
Project-2	725	2922
Project-3	.....	96
Project-4	.....	785
Project-5	.....	583
Project-6	.....	95

Samples / Specimens deposited in the repository under Sponsored/ Collaborative Projects:

MoES Po/(Geo Sci) 36/2014	664
SERB-DST Sponsored Project/SB/ EMEQ-161/2014	51; 07 Sp.
SERB Sponsored Project EMEQ-139/2014	232
SR/FTP/ES/16/2014	64
SB/DGH-89/2014	158
SB/EMQ-225/2014	131
(INSPIRE FIELD WORK) (IGC-2020 FIELD)	99
(INSPIRE FIELD WORK) (IGC-2020 FIELD)	637
EMR/2016/6042	05; 27 Sp.
MOES/PO/Geo Sci/36/2014	221
PDF/2016/000129	164 Core
NDPF/2017/690	40
IF 17076D1 (DST-INSPIRE)	30
IF170181 (DST-INSPIRE)	30
SERB Sponsored Project EMR/2017/001408	50; 67 Sp.
NMHS (Mo EF& CC) Sponsored Project No. 1886/XII-86/2016	116 Core
EMR/2016/005983	89
Project No. EMR/2016/005209	328
36th IGC 2020 Field Transects CR001	60; 10 Sp.

Specimens / Slides gifted to the Educational Centers:

1. Department of Botany, D.N. Post Graduate College, Meerut 250002.
2. Principal, Exon Montessori Girls College, Lucknow.
3. Prof. Rajesh K. Srivastava, FASc, FNASc, Professor & Head, Center of Advance Study in Geology, Institute of Science, Banaras Hindu University, Varanasi 221005, India

Fossil mementos presented to the Distinguished Guests:

1. Prof. T.N. Singh, Vice Chancellor, Mahatma Gandhi Kashi Vidyapith, Varanasi.

2. Prof. Nitin R. Karmalkar, Chairman, Governing Body BSIP and Vice Chancellor, Savitribai Phule Pune University, Maharashtra.
3. Prof. Vasant S. Shinde, Vice Chancellor, Deccan College Pune, Maharashtra.
4. Prof. Vinay K. Srivastava, Director, Anthropological Survey of India.
5. Prof. Kishore M. Paknikar, Director, Agarkar Research Institute Pune, Maharashtra.
6. Prof. Vishwas S. Kale, Savitribai Phule Pune University Pune, Maharashtra.
7. Dr. Tulika Chandra, K.G.M.U., Lucknow.
8. Prof. Ashutosh Sharma, Secretary, DST, New Delhi (India International Science Festival, Lucknow).
9. Dr. Rafat Jamal Azami, Ex-Scientist, Wadia Institute of Himalayan Geology, Dehradun.
10. Prof. S.N. Tripathi, I.I.T. Kanpur, Kanpur.
11. Dr. Sunil Kumar Singh, Director, N.I.O., Goa.
12. Dr. Anil Bhardwaj, Director, P.R.L., Ahmedabad.
13. Dr. Jonthan Clark, M.S.A., Australia.
14. Dr. Jen Blank, NASA, AMES, USA.
15. Dr. Kalachand Sain, Director, Wadia Institute of Himalayan Geology, Dehradun.
16. Prof. Motohika Koga, University of Tokyo, Tokyo, Japan
17. Dr. Kiyomio Kogo, University of Tokyo, Tokyo, Japan
18. Professor David Grimaldi Curator, Division of Invertebrate Zoology, Glide Graduate School American Museum of Natural History Central Park West at 79th ST. New York (USA).
19. Dr. Phil Barden Assistant Professor Department of Biological Sciences New Jersey Institute of Technology Central King Building Newyark (USA).

Institutional Visitors:

1. Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot.
2. University of Gour Banga, Malda, West Bengal.
3. Shri Nishadraj Akhandanand Mahavidyalaya, Kitiyawan, Shahgarh, Sultanpur, U.P.
4. B.S.N.V., P.G. College, Lucknow.
5. Rashtrasant, Tukadoji Maharaj Nagpur University, Nagpur, Maharashtra.
6. Trinity International Public School, Eldeco Udyan, Lucknow.
7. J.N. P.G. College, Lucknow.
8. Bright Way Inter College, Lucknow.

Chairman of Governing Body, BSIP inaugurating the Geological Time Machine in the Institute

Electronic Data Processing

Computer Section is maintaining NKN (National Knowledge Network) internet connectivity in the Institute to provide 24 hours high speed internet facility to the Institute's employees and research scholars. All the 150 computer systems are protected from viruses and malware by Anti Virus Program Quick Heal Endpoint Security 6.0 business edition. Institute is fully covered with Wi-Fi and staff members are using high speed Wi-Fi connectivity on their computer as wells as on mobile phones.

Computer Ssection is maintaining and updating the Institute's Website (www.bsip.res.in) regularly. Intranet website has also been launched for Institute users/ research scholars. Various essential forms are bilingual and available in PDF and Word format.

Institutional e-mail accounts for BSIP staff, units/ sections and research scholars have been opened on Institute Domain (BSIP.RES.IN). Circular/Notices are circulated to everyone through Mail. Institute Face book page and Twitter account have been created and are regularly updated with recent information and photographs. Online Interview and video conferencing through SKYPE is arranged as per requirement.

Computer Section is also helping in preparing the reports of 7 CPC, Election Commission, DST, Govt queries, etc. It is also helping in the calculation of Employees and Pensioners 7th CPC pay arrears.

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, litho logs and diagrams for their scientific publications and documentation.

TL/OSL and Geochemistry Facility

TL/OSL and Geochemistry facility of the Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow is dedicated to serve as a national facility providing data to users throughout the country as well as abroad. The facility has been providing support in frontline research, skill development and advancement opportunities in research. The Birbal Sahni Institute of Palaeosciences has emerged as a premier centre for fossil research and mainly emphasising on evolutionary history and palaeoclimatic studies. In order to give better shape and clearer picture of the past, classical palaeobotany has to be supported with diverse lines of investigations. In this situation, integration of biotic and abiotic component in combination with modern geochemical and chronological support is required to get a more reliable picture of the past, and to address issues of global significance. Environmental issues during the geological past to solve geological boundary problems, and high resolution climatic fluctuations, can be better understood by integrating fossil data with modern lines of research in sedimentology, geochemistry and geochronology. Towards this, the TL/ OSL and Geochemistry facility of BSIP equipped with sophisticated instruments such as ICP-MS, XRD, XRF, IRMS, GC-MS, Particle Size Analyzer, TL/OSL reader, HPGe, Isodynamic magnetic separator along with all necessary infrastructure facility has become an important centre of high end research. Apart from this, the facility is also providing consultancy services to several universities/institutes as well as to industries.

Consultancy / Technical support rendered:

1. **Luminescence Dating Laboratory (TL/OSL Laboratory)**

   University of Jammu, Jammu and Kashmir.

   University of Lucknow, Lucknow.

   Australia (Prof. Mike Synor).

2. **ICP-MS**

   National Centre for Earth Science Studies, Thiruvananthapuram, Kerala.

   Indian Institute of Technology (Indian School of Mines), Dhanbad.

   University of Lucknow, Lucknow.

   Aligarh Muslim University, Aligarh.

   Ranchi University, Jharkhand.

   Sikkim University, Sikkim.

3. XRD

Integral University, Lucknow.

Patna University, Bihar.

D-Maps, New Delhi.

University of Lucknow, Lucknow.

Ranchi University, Jharkhand.

National Institute of Pharmaceutical Education and Research.

Dr. Shakuntala Misra National Rehabilitation University, Lucknow.

Indian Institute of Technology, Banaras Hindu University, Varanasi.

4. XRF

Indian Institute of Technology, Banaras Hindu University, Varanasi.

University of Lucknow, Lucknow.

The Indian Institute of Technology (Indian School of Mines), Dhanbad.

5. IR-MS

Geological Survey of India, Kolkata.

Jawaharlal Nehru University, New Delhi.

Wadia Institute of Himalayan Geology, Dehradun.

Indian Institute of Science Education and Research, Mohali.

Central Institute of Fisheries Education, Mumbai.

Radiocarbon Dating and Isotope characterization Laboratory

Conventional Radiometric Radiocarbon Dating Facility

Radiocarbon Dating Facility of the Birbal Sahni Institute of Palaeosciences continues to serve as a National facility across India and abroad. The traditional radiometric method utilizes conventional beta-counting of benzene prepared by trimerization of CO_2 extracted from organic and inorganic carbon contained in any natural/ environmental sample. The set-up comprises an offline glass line vacuum extraction system to produce 1-3 ml of liquid benzene (C_6H_6) 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. Processing

for benzene extraction involves combustion (or hydrolysis) of the pre-treated organic (inorganic) samples followed by trimerization 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, wood-charcoal pieces, organic rich sediments, peat layers, etc.) are routinely dated.

Consultancy / Technical support rendered –

A total of 75 samples (including blanks and standards) were processed. This includes 22 Institute samples, 27 consultancy samples and 13 samples carried out based on collaborative research. Major collaborators and clients of BSIP Radiocarbon Laboratory are listed below in Tables 1 and 2 respectively.

Table 1- Collaborators from the Institute and other sister organizations:

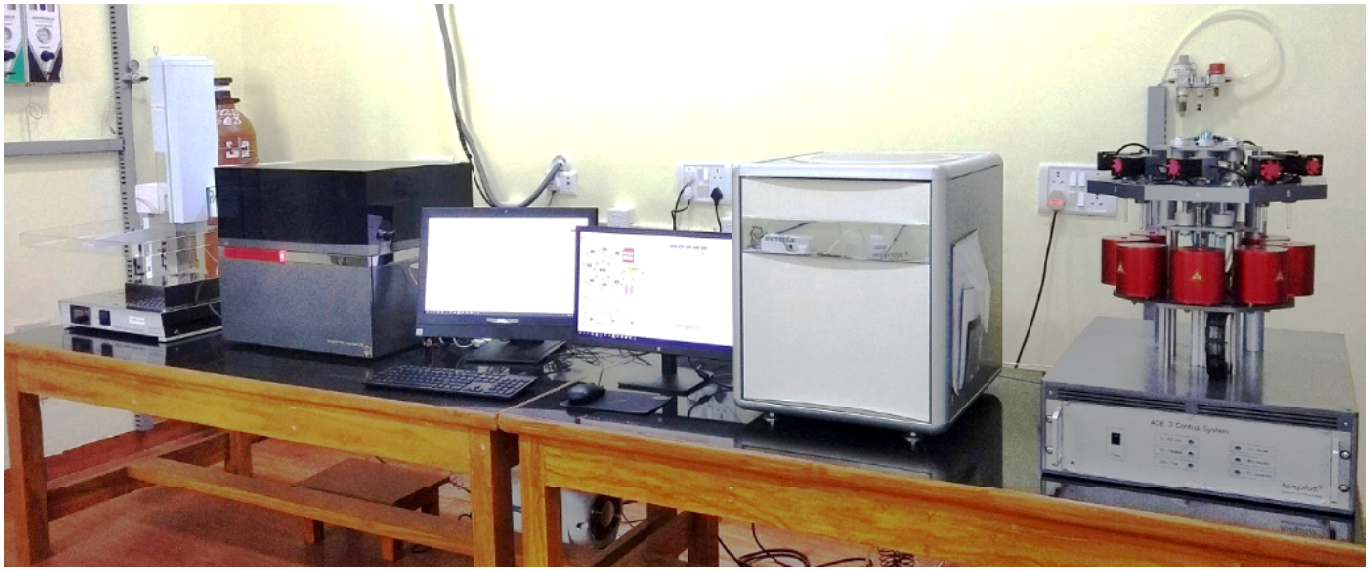
1	Dr. Niraj Rai, BSIP, Lucknow
2	Dr. Anjum Farooqui, BSIP, Lucknow
3	Prof. Preety Trivedi, Head of the Archaeology Department, Nagpur University, Nagpur
4	Dr. Pradeep Srivastava, Scientist E and Co-OIS OSL Dating Laboratory, Wadia Institute of Himalayan Geology, Dehradun
5	Dr. Banani Bhattacharya, ASI, Haryana Circle, Hissar
6	Dr. Abhijit Ambekar, ASI Baroda Circle, Gujarat

Table 2- Clients from other institutes:

1	Dr. Indu Prakash, Archaeological Survey of India, Lucknow Circle.
2	Dr. Watinaro Imsong, Department of Geology, Nagaland University, Nagaland
3	Dr. R.G. Robinson, Department of Geology, IIT Madras, Chennai
4	Virag Sontakke, Department of State Archaeology, Nagpur
5	General Manger, BBTC Ltd., Singampatti, Tirunalvelli, Tamilnadu

A graphite target preparation laboratory for AMS radiocarbon dating at BSIP Lucknow

As conventional radiometric ^{14}C dating is highly labour-intensive, time-consuming and requires several grams of dateable material, it preventing dating of certain objects (available in lesser amounts). Accelerator Mass Spectrometry (AMS) for ^{14}C dating requiring only ~1 mg of solid carbon (in form of graphite powder) with analysis time <50 minutes is the future step. BSIP's Radiocarbon Dating Laboratory has procured and installed an Automated Graphitization Equipment (AGE) coupled with sample preparatory systems, *e.g.* Elemental Analyzer (EA) (for organic samples) and Carbonate Handling System (CHS) (for inorganic samples) along with an Isotope Ratio Mass-Spectrometer (IRMS). The EA-IRMS unit has been established and standardized 'independently' as well as 'in-line with AGE' for generating stable isotopic data ($\delta^{13}C$, $\delta^{15}N$) together with $\delta^{14}C$ data. Desired accuracy and analytical precisions were achieved using a suite of IAEA and *in-house* reference standards. Procedures were set up to prepare reproducible graphite targets (for AMS measurements) from both organic and inorganic sample using EA and CHS systems respectively following standard Acid-Base-Acid (ABA) pre-treatment steps. Working protocols for extortion of dateable carbon from wood material, bone collagen, etc. preparation of graphite powder and measuring their $\delta^{13}C$, $\delta^{15}N$ values (for diagnostic purpose) are currently underway. About 500 samples (including standards and blanks) were subjected to C, N stable isotopic analysis. ~60 graphite powders were successfully prepared via EA-IRM-AGE set-up. A snapshot of EA-CHS-IRMS-AGE coupled set of various instruments are shown below.



Scanning Electron Microscopy

The unit is equipped with Field Emission Scanning Electron Microscope (FESEM - JEOL 7610F), JEOL Auto fine Sputter Coater, JEOL Carbon Coater and Bal-Tec Critical Point Dryer (CPD). EDAX make peltier cooled EDS spectroscopy detector is attached with FESEM for elemental analysis of the user samples. Scanning Electron Microscopy (SEM) unit of the Institute is dedicated for providing support frontline research in the geological, biological, 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.

Around 400 specimens provided by the scientists of various disciplines of the Institute were investigated for morphological features using FESEM. Various methods and operating techniques are used for getting better images to variety of samples (e.g. living & fossil, tooth, quartz grain, charcoal, wood, megaspores, pollen grains, sediments, etc.). Besides, Consultancy services have also been rendered to researchers of around 26 departments of various universities, academic institutions and colleges of India for studying their samples. All the user of SEM facility are happy with the outcome of this facility.

Dr. Shakuntala Mishra National Rehabiliation University Lucknow *(Nono material powder)*

School of Engineering, BBD University, Lucknow *(Aluminium metal alloy)*

Department of Geology, University of Lucknow, Lucknow *(quartz grains, river sediments EDAX)*

Department of Orthodontics, Saraswati Dental College, Faizabad Road, Lucknow *(Teeth, tooth filing materials)*

Department of Botany, University of Lucknow, Lucknow *(Leaf, stem)*

Department of Zoology, University of Lucknow, Lucknow *(Micro particles, wood extract)*

Department of Bioengineering, Integral University, Lucknow *(Leaf, roots)*

Career PG Institute, Dental Sciences & Hospital, Lucknow *(Dental materials)*

Department of Physics, University of Lucknow, Lucknow *(Polymers composites, nano powder materials, ceramics, nano films, metal oxides, metal alloy)*

Department of Chemistry, University of Lucknow, Lucknow *(Polymer/powder samples)*

Centre for Nanoscience & Technology, Pondicherry University, Pondicherry 605014 *(Bio film membrane)*

Saraswati Medical & Dental College, Faizabad Road, Lucknow *(Tooth samples)*

Guru Ghasidas Vishwavidyalaya, Bilaspur (CG) 495009 *(Leaf and seed samples)*

Distinguished Visitors

Prof. T.N. Singh, Vice Chancellor, Mahatma Gandhi Kashi Vidyapith, Varanasi.

Prof. Nitin R. Karmalkar, Chairman, Governing Body BSIP and Vice Chancellor, Savitribai Phule Pune University, Maharashtra.

Prof. Vasant S. Shinde, Vice Chancellor, Deccan College Pune, Maharashtra.

Prof. Vinay K. Srivastava, Director, Anthropological Survey of India.

Prof. Kishore M. Paknikar, Director, Agarkar Research Institute Pune, Maharashtra.

Prof. Vishwas S. Kale, Savitribai Phule Pune University Pune, Maharashtra.

Dr. Tulika Chandra, K.G.M.U., Lucknow.

Prof. Ashutosh Sharma, Secretary, DST, New Delhi (India International Science Festival, Lucknow).

Dr. Rafat Jamal Azami, Ex-Scientist, Wadia Institute of Himalayan Geology, Dehradun.

Prof. S.N. Tripathi, I.I.T. Kanpur, Kanpur.

Dr. Sunil Kumar Singh, Director, N.I.O., Goa.

Dr. Anil Bhardwaj, Director, P.R.L., Ahmedabad.

Dr. Jonthan Clark, M.S.A., Australia.

Dr. Jen Blank, NASA, AMES, USA.

Dr. Kalachand Sain, Director, Wadia Institute of Himalayan Geology, Dehradun.

Prof. Motohika Kogo, University of Tokyo, Tokyo, Japan

Dr. Kiyomio Kogo, University of Tokyo, Tokyo, Japan

Prof. David Grimaldi, Curator, Division of Invertebrate Zoology, Glide Graduate School American Museum of Natural History Central Park West at 79th ST. New York (USA).

Dr. Phil Barden, Assistant Professor Department of Biological Sciences New Jersey Institute of Technology Central King Building Newyark (USA).

Activities in Official Language

The Institute continues to endeavour to attain the set target for Official Language implementation. The Institute participated in both the Half Yearly meetings of the Town Official Language Implementation Committee (TOLIC) during the year 2018 at 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.

Hindi Fortnight

Hindi Fortnight was celebrated from September 10-25, 2018. During the Hindi Fortnight, Fifty Eight staff members participated in a series of competitions including Hindi Typing (computer), Noting, Essay, Debate, Dictation and Antyaakshree. The Director of the Institute attended and encouraged the participants during the competitions. Kavi Sammelan was also organized on September 25, 2018 in which poetry of Bharat Ratna Shri Atal Bihari Vajpayee were presented by staff members.

Results of various competitions are given below:

Typing Encouragement : I – Mr. Rahul Gupta, II – Mrs. Sudha Kureel, III Mr. Raj Kumar, Mr. Pushkar Verma, Mr. Ram Ujagar

Essay Encouragement : I – Ms. Sandhya Singh, II – Mr. Ashish Mishra, III – Mrs Sandhya Mishra, Mr. Yogesh Kumar, Ms. Priyanka Seth, Mr. Amit Kumar Mishra

Noting Encouragement : I – Mr. Rahul Gupta, II – Mrs Sandhya Mishra, III – Mr. Yogesh Kumar, Mr. Raj Kumar, Dr. Deepa Agnihotri, Mr. Vikram Singh

Debate Encouragement : I – Mr. Yogesh Kumar, II – Mrs. Sandhya Mishra, III – Mr. Dhan Bahadur Kunwar, III – Mr. Y.P. Singh, Ms. Shalini Sharma, Ms. Rimpee Chetia

Antyaakshree Encouragement : I – Dr. (Mrs.) Shilpa Pandey, Mr. Rajesh Kumar Mishra, Ms. Shalini Sharma; II – Mrs. Shandhya Mishra, Mr. Yogesh Kumar, Ms. Supriya, Mr. Amit Mishra, Mr. Vishwanath Gaikwad, Ms. Archana Sonkar; III – Ms. Harshita, Mrs. Kanika Singh, Ms. Sandhya Singh, Dr. Neelam Das, Ms Himani Patel, Mrs. Shaazi Farooqui, Dr. (Mrs.) Trina Bose, Dr. (Mrs.) Nivedita Mehrotra, Mr. Uttam Pandey

Dictation (For MTS) Encouragement : I – Mr. Raj Kumar, II – Mr. Indra Kumar, Mr. Rajesh Kumar Awasthi, III – Ms. Sandhya Singh, Mr. Ankit Pratap SinghMr. Deepak Kumar, Mr. Shailesh Kumar, Mr. Vishwanath Gaikwad, Mr. Dhan Bahadur Kunwar, Mr. Indra Kumar Yadav

Prize distribution on Hindi Pakhwada

Hindi Workshop

Quarterly Workshops were organized on the following subjects. Workshops were followed by lively discussions related to the topics of talks and related terminology:

1. **Shudhhta evam allurgee ke sandarbh mein Uttar Purvi Bharat ke Assam se praakritik shahad ka Paragaanvik adhyayan** – Dr. Swati Tripathi, Scientist 'C', BSIP (25.06.2018).
2. **Unicode mein kaarya kaise karein** – Mr. P.S. Katiyar, T.O. 'D', Mr. Y.P. Singh, T.O. 'D'and Dr. Nilay Govind, T.A. 'E', BSIP, Lucknow (14.12.2018)
3. **Bhaartiya Grahiya Kaaryakram** – Prof. Anil Bharadwaj, Physical Research Laboratory, Ahmedabad (23.01.2019).

Bhasha Utsav

On March 27, 2019 a programme "Bhasha Sangosthi" 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. Shraawanee Bhattacharyaa from Chennai, 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

Meeting of the Official Language Implementation Committee of the Institute was organized in every quarter of the year. The computers of the Institute with net facility have multi-lingual software. The process of making forms bilingual is nearly complete. 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 were also published in hindi. In adherence to the section 3(3) of the Official Language Act 1963, efforts are in progression to improve correspondence in hindi. The work of bilingual website of the Institute is under progress.

Dr. Swati Tripathi

Mr. Y.P. Singh

Prof. Anil Bharadwaj

Governing Body

(w.e.f. 29.06.2018)

Chairman
Prof. Nitin R. Karmalkar
Vice Chancellor
Savitribai Phule Pune University
Ganeshkhind Road
Pune 411 007

Members

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

Prof. Sunil Kumar Singh
Director
National Institute of Oceanography
Dona Paula, Goa 403 004

Director General (Ex-officio)
Geological Survey of India
27, Jawaharlal Nehru Road, Kolkata 700 016

Dr. Rajiv Nigam
Emeritus Scientist
National Institute of Oceanography (NIO)
Dona Paula, Goa 403 004

Prof. Satish Chandra Garkoti
School of Environmental Sciences
Jawaharlal Nehru University,
New Mehrauli Road, Munirka,
New Delhi 110 067

Prof. P.K. Saraswati
Department of Earth Sciences,
IIT Bombay, Mumbai 400 076

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

Prof. Anindya Sarkar
Head, Department of Geology & Geophysics,
Indian Institute of Technology Kharagpur,
Kharagpur 721 302

Prof. Pulok Mukherjee
Department of Pharmaceutical Technology
Jadhavpur University
Kolkata 700 032

Dr. R. Prakash Kumar
Director
KSCSTE-Jawaharlal Nehru Tropical Botanic
Garden & Research Institute (JNTBGRI),
National Centre of Excellence, Palode,
Thiruvananthapuram 695 562

Dr. Vandana Prasad
Director
Birbal Sahni Institute of Palaeosciences
53 University Road,
Lucknow 226 007

Non-Member Secretary
Registrar
Birbal Sahni Institute of Palaeosciences, Lucknow 226 007

Research Advisory Council

(w.e.f. 22.10.2018)

Chairman

Prof. L.S. Chamyal
Department of Geology
The Maharaja Siyajirao University of Baroda
Main Office, Fatehganj, Vadodra 390 002

Member-Convener (Ex-officio)
Director
Birbal Sahni Institute of Palaeosciences, Lucknow

Members

Prof. Subir Bera
Department of Botany,
University of Calcutta, Kolkata 700 019

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

Prof. Tarun Kumar Dalai
Associate Professor
Department of Earth Sciences
Indian Institute of Science Education
And Research, IISER Kolkata Main Campus
PO Mohanpur, Nadia 741 246

Dr. Som Nath Chandel
Additional Director General & HoD (Ex-officio),
Incharge Northern Region
Geological Survey of India,
Sector 'E', Aliganj, Lucknow 226 020

Prof. Anupama Krishnamurthy
French Institute of Pondicherry,
Puducherry 605 001

Prof. Uma Shankar
Department of Botany,
North Eastern Hill University (NEHU),
Shillong 793 022

Prof. A.D. Singh
Department of Geology,
Banaras Hindu University,
Varanasi 221 005

Prof. Viswas S. Kale
Retd. Professor of Geography
Savitribai Phule Pune University
Ganeshkhind Road, Pune 411 007

Prof. Shantanu Banerjee
Department of Earth Sciences
Indian Institute of Technology Bombay
Powai, Mumbai – 400 076

Prof. Navin Juyal
Physical Research Laboratory
Ahmedabad, Gujarat

Finance Committee

(w.e.f. 22.10.2018)

Chairman
Prof. Nitin R. Karmalkar
Vice Chancellor
Savitribai Phule Pune University,
Ganeshkhind Road,
Pune 411007

Members
Finance Adviser, DST, New Delhi

Dr. Gyanendra Mishra
Controller of Finance & Accounts,
CSIR-IITR, Vishvigyan Bhawan,
31, Mahatma Gandhi Marg,
Lucknow 226 001

Director
Birbal Sahni Institute of Palaeosciences,
53 University Road,
Lucknow 226 007

Non-Member Secretary

Registrar
Birbal Sahni Institute of Palaeosciences,
53 University Road,
Lucknow 226 007

Building Committee

(w.e.f. 22.10.2018)

Chairman
Prof. Nitin R. Karmalkar
Vice Chancellor
Savitribai Phule Pune University
Ganeshkhind Road, Pune 411007

Members
Nominee of the W & B, DST, New Delhi

Er. Atul Kumar Goel
Chief Engineer, Engineering Service Division
CSIR Complex (Opp Inst. Of Hotel Management)
Library Avenue, Pusa, New Delhi 110 012

Dr. Gyanendra Mishra
Controller of Finance & Accounts,
CSIR-IITR, Vishvigyan Bhawan,
31, Mahatma Gandhi Marg, Lucknow 226 001

Director
Birbal Sahni Institute of Palaeosciences,
53 University Road, Lucknow 226 007

Non-Member Secretary
Registrar
Birbal Sahni Institute of Palaeosciences,
53 University Road, Lucknow 226 007

Staff

Director

Prof. Sunil Bajpai
Till 22.01.2018 (extended period)
w.e.f. 23.01.2018 to 22.07.2018

Dr. R.C. Mehrotra
Scientist 'G' with Additional Charge of Director
w.e.f. 23.07.2018 to 28.02.2019

Dr. Mukund Sharma
Scientist 'G' with Additional Charge of Director
w.e.f. 01.03.2019

Scientists

Scienist 'G'

Dr. Madhav Kumar [w.e.f. 01.07.2018, Retired w.e.f. 31.07.2018 (AN)]
Dr. R.C. Mehrotra [w.e.f. 01.07.2018, Retired w.e.f. 28.02.2019 (AN)]
Prof. Mukund Sharma [w.e.f. 01.07.2018 (On Lien w.e.f. 25.04.2018 to 24.09.2018]

Scientist 'F'

Dr. (Mrs) Anjum Farooqui (w.e.f. 01.07.2018)
Dr. Amit K. Ghosh (w.e.f. 01.07.2018)
Dr. (Mrs) Neeru Prakash
Dr. (Mrs)Vandana Prasad
Dr. Anupam Sharma
Dr. Bhagwan D. Singh [Retired w.e.f. 31.12.2018 (AN)]
Dr. Kamal Jeet Singh [Retired w.e.f. 31.07.2018 (AN)]

Scientist 'E'

Dr. Rajesh Agnihotri
Dr. Ratan Kar
Dr. (Mrs) Binita Phartiyal
Dr. Anil Kumar Pokharia
Dr. G.K. Trivedi

Scientist 'D'

Dr. Sadhan Kumar Basumatary
Dr. (Ms) Ruby Ghosh (w.e.f. 01.01.2019)
Dr. Pawan Govil
Dr. Abhijit Mazumdar (w.e.f. 01.01.2019)
Dr. Krishna Gopal Mishra
Dr. Srikanta Murthy
Dr. S. Suresh K. Pillai
Dr. Parminder Singh Ranhotra (w.e.f. 01.07.2018)
Dr. (Mrs) K. Pauline Sabina
Dr. (Mrs) Anju Saxena
Dr. Santosh Kumar Shah
Dr. Hukam Singh
Sri Veeru Kant Singh
Dr. (Ms) Vartika Singh
Dr. Biswajeet Thakur
Dr. (Mrs) Anjali Trivedi (w.e.f. 01.01.2019)
Dr. (Mrs) Poonam Verma (w.e.f. 01.01.2019)

Scientist 'C'

Dr. (Mrs) Neha Aggarwal
Dr. Shailesh Agarwal
Dr. (Mrs) Deepa Agnihotri
Dr. Sheikh Nawaz Ali
Dr. Arif Hussain Ansari
Dr. Manoj M.C.
Dr. (Ms) Ruby Ghosh
Dr. Vivesh Vir Kapur
Dr. Kamlesh Kumar
Dr. Runcie Paul Mathews (w.e.f. 01.07.2018)
Dr. Abhijit Mazumdar
Dr. P. Morthekai
Dr. (Mrs) Neelam
Dr. Santosh Kumar Pandey
Dr. (Mrs) Shilpa Pandey
Dr. Mohd. Firoze Quamar
Dr. Niraj Rai
Dr. (Mrs) Anumeha Shukla
Dr. Sunil Kumar Shukla
Dr. (Mrs) Abha Singh
Dr. (Mrs) Jyoti Srivastava
Dr. Gaurav Srivastava
Dr. (Mrs) Swati Tripathi

Scientist 'B'

Dr. Sajid Ali
Dr. Mohd. Arif
Dr. (Ms) Ansuya Bhandari
Dr. (Mrs) Trina Bose
Dr. Prasanna K.
Dr. Niteshkumar Narendra Khonde

(The names are in alphabetical order according to 'surnames')

Dr. Gurumurthy G.P.
Dr. Arvind Kumar Singh
Dr. (Mrs) Yogmaya Shukla

Technical Personnel

Technical Officer 'D'
Sri Madhukar Arvind
Mrs Reeta Banerji
Sri Pavan Singh Katiyar
Sri Tapan K. Mandal [Retired w.e.f. 31.08.2018 (AN)]
Sri Rattan Lal Mehra
Sri R.C. Mishra
Sri Pradeep Mohan
Sri V.K. Nigam (w.e.f. 01.07.2018)
Sri Vinod Kumar Singh
Sri Vijay Pratap Singh
Sri Yogendra Pratap Singh

Technical Officer 'C'
Dr. Subodh Kumar

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
Sri Ishwar Chandra Rahi
Mrs Nandita Tiwari

Technical Assistant 'E'
Sri Amrit Pal Singh Chaddha
Dr. Prasanta Kumar Das
Dr. Nilay Govind
Sri Avanish Kumar [Retired w.e.f. 28.02.2019 (AN)]
Sri Subhash C. Singh
Sri Madan Singh Rana
Mrs Kirti Singh
Sri Ajay Kumar Srivastava

Technical Assistant 'D'
Sri Sandeep Kumar Kohri
Sri Pawan Kumar
Sri Ishwar Chandra Shukla
Sri Jitendra Yadav

Technical Assistant 'B'
Sri J. Baskaran
Sri Ashok Kumar Sharma
Miss Shivalee Srivastava
Ms Richa Tiwari (On Lien)
Sri Ram Ujagar
Sri Raja Ram Verma

Technical Assistant 'A'
Miss Archana Sonker

Administrative Personnel

Registrar
Sri Sandeep Kumar Shivhare

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
Sri Rahul Gupta [w.e.f. 19.07.2018 (AN)]
Ms Anupam Jain [w.e.f. 19.07.2018 (AN)]
Ms Sudha Kureel
Sri Rajesh Kumar Mishra
Sri Manoj Singh [w.e.f. 19.07.2018 (AN)]
Miss Manisha Tharu

(The names are in alphabetical order according to 'surnames')

Lower Division Clerk
Sri Mahesh Nair
Mrs Vijaya Venkateshwari

Drivers
Sri Nafis Ahmed, Driver 'IV'
Sri Devendra Kumar Misra, Driver 'IV'
Sri Madan Mohan Misra, Driver 'IV'
Sri Vijay Pratap Singh, Driver 'IV'
Sri Pushpendra Kumar Misra, Driver 'IV'

Multi Tasking Staff 'II'
Sri K.C. Chandola [Retired w.e.f. 31.07.2018 (AN)]
Sri K.K. Bajpai
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
Mrs Beena
Sri Ram Chander
Sri Vishwanath S. Gaikwad
Mrs Ram Kali
Sri Hari Kishan
Sri Deepak Kumar
Sri Indra Kumar
Sri Raj Kumar
Sri Ramesh Kumar
Sri Shailesh Kumar
Sri Suneet Kumar
Ms Nandani
Sri Kailash Nath
Sri Mathura Prasad
Sri Ravi Shankar
Sri Ankit Pratap Singh
Ms Sandhya Singh
Sri Ram Kewal Yadav

Birbal Sahni Research Scholars
Ms Shubhangi Baranwal
Ms Rimpy Chetia
Ms Himani Patel
Sri Subhankar Paramanik
Sri Mohd. Shadman
Ms Priyanka Singh

Project Staff
Sri Mahboob Alam, JRF
Ms Mahi Bansal, JRF
Ms Jyotsana Dubey, JRF
Ms Priyanka Joshi, JRF [Relieved w.e.f. 22.05.2018 (AN)]
Sri Masud Kawsar, JRF
Sri Raj Kumar, JRF
Sri Salman Khan, JPF
Sri Ashish Kumar Mishra, JRF
Sri Uttam Pandey, JRF
Sri U. Prem Raj, JRF
Ms Amulya Saxena, JRF
Ms Priyanka Seth, JRF
Ms Shalini Sharma, JRF
Ms Sakshi Srivastava, Project Assistant
Sri Sumit Singh, Project Assistant
Sri Pranav Raj Tyagi, JRF [Relieved w.e.f. 11.07.2018 (AN)]
Ms Neelam Mishra, Technical Assistant [Relieved w.e.f. 31.05.2018 (AN)]

Junior Project Fellow
Ms Bency David Chinthala, JPF (Tenure completed w.e.f. 31.03.2019)

D.S.T. Inspire Fellow
Ms Rikee Dey, DST Inspire Fellow
Ms Ipsita Roy, DST Inspire Fellow
Ms Stuti Saxena, DST Inspire Fellow

Young Scientist
Dr. Mayank Shekhar, Young Scientist in DST Sponsored Project [Relieved w.e.f. 27.02.2019 (AN)]
Dr. Suman Sarkar, Young Scientist
Dr. (Mrs) Sandhya Misra, D.S.T. Young Scientist (Resigned w.e.f. 15.03.2019)

SRF Under BSIP Ph.D. Programme Self Supported Category-II
Sri Husain Shabbar, SRF [Supervisor - Dr. (Mrs) Anju Saxena, Scientist 'D']

JRF Under BSIP Ph.D. Programme Self Supported Category-II
Sri Yogesh Kumar, JRF [Relieved w.e.f. 31.05.2018 (AN)]
Sri Sachin Kumar, JRF

JRF Under BSIP Ph.D. Programme Under BSIP Self Supported Category-I
Sri Mukesh Kumar Yadav, JRF

(The names are in alphabetical order according to 'surnames')

Sri Amit Kumar Mishra, JRF
Miss Shachi Bajpai, JRF [Relieved w.e.f. 29.05.2018 (AN)]
Sri Sanjay Kumar Singh Gahlaud, JRF (under CSIR Fellowship)

Principal Investigator
Dr. Shamim Ahmad, Principal Investigator/Post Doctoral Fellow [Relieved w.e.f. 27.02.2019 (AN)]

Women Scientist Under Women Scientist Scheme A (WOS-A)
Mrs Ruchika Bajpai

Women Scientist Under-DST Women Scientist Scheme A (WOS-A)
Dr. (Mrs) Nivedita Mehrotra

National Post Doctoral Fellow
Dr. Arindam Chakraborty [w.e.f. 23. 07.2018; Relieved w.e.f. 27.02.2019 (AN)
Dr. Chinnappa Chopparapu
Dr. Akhilesh Kumar Yadava (Tenure completed w.e.f. 15.11.2018)
Dr. Matsyendra Kumar Shukla [Resigned w.e.f. 31.05.2018 (AN)]

Appointments

Birbal Sahni Research Associate
Dr. Mayank Shekhar (w.e.f. 28.02.2019)
Dr. Arindam Chakraborty (w.e.f. 28.02.2019)
Dr. Saurabh Gautam (w.e.f. 01.03.2019)
Dr. (Ms) Rupa Ghosh (w.e.f. 05.03.2019)
Dr. Kamlesh Singh Mahar (w.e.f. 27.02.2019)
Dr. (Ms) Deepika Tripathi (w.e.f. 27.02.2019)
Dr. (Ms) Shreya Mishra (w.e.f. 15.05.2019)
Dr. Shamim Ahmad (w.e.f. 28.02.2019)
Dr. (Mrs) Sandhya Mishra (w.e.f. 18.03.2019)
Dr. Debarati Nag (w.e.f. 07.02.2019)

Birbal Sahni Research Scholar
Ms Priya Agnihotri (w.e.f. 28.02.2019)
Ms Divya Singh (w.e.f. 01.03.2019)
Ms Prachita Arora (w.e.f. 15.03.2019)
Ms Shalini Parmar (w.e.f. 28.02.2019)
Ms Pooja Tiwari (w.e.f. 27.02.2019)
Sri Pawan Kumar Singh (w.e.f. 27.02.2019)
Ms Harshita Bhatia (w.e.f. 05.03.2019)
Ms Harshita Srivastava (w.e.f. 28.02.2019)
Ms Supriya Kumari (w.e.f. 28.02.2019)
Ms Kajal Chandra (w.e.f. 01.03.2019)

CSIR SRF
Sri Syed Azharuddin [w.e.f. 01.05.2018 (FN)]
Sri Vikram Singh [w.e.f. 14.05.2018 (FN)]

CSIR-SRA (Pool Scientist)
Dr. Akhilesh Kumar Yadava [w.e.f. 16.11.2018 (FN)]

JRF under BSIP Ph.D. Programme, Category 'II'
Ms Anjali Kushwaha (w.e.f. 01.05.2018)
Ms Supriya Kumari (w.e.f. 01.05.2018)
Ms Harshita Srivastava (w.e.f. 01.08.2018)
Ms Shalini Parmar (w.e.f. 21.08.2018)
Ms Priya Agnihotri (w.e.f. 30.07.2018)

JRF under BSIP Ph.D. Programme, Category 'I'
Sri Hidayatullah (w.e.f. 01.05.2018)
Sri Mohan Kumar (w.e.f. 01.05.2018)
Sri Sarvendra Pratap Singh (w.e.f. 01.05.2018)
Sri Lamginsang Thomte (w.e.f. 14.05.2018)

DST Inspire Fellow (JRF)
Ms Shachi Bajpai [w.e.f. 30. 05.2018 (FN)]
Ms Lopamudra Roy [w.e.f. 04.09.2018 (FN)]

DST-SERB Sponsored Project (JRF)
Sri Suyash Gupta, JRF [w.e.f. 30.08.2018(FN)]

CSIR-UGC (JRF)
Sri Ravi Shankar Maurya (w.e.f. 17.01.2019)
Sri Harsh Kumar (w.e.f. 05.02.2019)
Ms Richa Rajpal (w.e.f. 28.03.2019)

JRF
Sri Yogesh Kumar [w.e.f. 01.06.2018 (FN)]
Ms Korobi Saikia [w.e.f. 12.09.2018 (FN)]
Sri Alok Kumar Mishra [w.e.f. 13.09.2018 (FN)]
Ms Akansha Tyagi [w.e.f. 25.09.2018 (FN)]
Ms Debika Deori [w.e.f. 24.12.2018 (FN)]

Emeritus Scientists
Dr. R.C. Mehrotra [w.e.f. 01.03.2019 (FN)]
Dr. B.D. Singh [w.e.f. 01.03.2019 (FN)]
Dr. Kamal Jeet Singh [w.e.f. 01.03.2019 (FN)]

Promotions

Scientific Staff

Dr. R.C. Mehrtora, Scientist 'G' (w.e.f. 01.07.2018)

Dr. Madhav Kumar, Scientist 'G' (w.e.f. 01.07.2018)

Dr. Mukund Sharma, Scientist 'G' (w.e.f. 01.07.2018)

Dr. Amit K. Ghosh, Scientist 'F' (w.e.f. 01.07.2018)

Dr. (Mrs) Anjum Farooqui, Scientist 'F' (w.e.f. 01.07.2018)

Dr. Parminder Singh Ranhotra, Scientist 'D' (w.e.f. 01.07.2018)

Dr. Runcie Paul Mathews, Scientist 'C' (w.e.f. 01.07.2018)

Dr. Abhijit Mazumder, Scientist 'D' (w.e.f. 01.01.2019)

Dr. (Mrs) Anjali Trivedi, Scientist 'D' (w.e.f. 01.01.2019)

Dr. (Mrs) Poonam Verma, Scientist 'D' (w.e.f. 01.01.2019)

Dr. (Ms) Ruby Ghosh, Scientist 'D' (w.e.f. 01.01.2019)

Technical Staff

Sri Vijai Kumar Nigam, Technical Officer 'D' (w.e.f. 01.07.2018)

Administrative Staff

Miss Anupam Jain, UDC [w.e.f. 19.07.2018 (AN)]

Sri Rahul Gupta, UDC [w.e.f. 19.07.2018 (AN)]

Sri Manoj Singh, UDC [w.e.f. 19.07.2018 (AN)]

Grant of M.A.C.P. (Financial Upgradation)

Sri Gopal Singh, Assistant (w.e.f. 15.01.2016)

Sri Vishwanath S. Gaikwad, MTS 'I' (w.e.f. 24.11.2015)

Sri Ramesh Kumar, MTS 'I' (w.e.f. 24.11.2015)

Sri Rajesh Kumar Awasthi, MTS 'I' (w.e.f. 24.11.2015)

Sri Indra Kumar, MTS 'I' (w.e.f. 30.07.2017)

Sri Deepak Kumar, MTS 'I' (w.e.f. 30.07.2017)

Additional Charge

Prof. Sunil Bajpai, Director (w.e.f. 23.01.2018 to 22.07.2018)

Dr. R.C. Mehrotra, Scientist 'G' with Additional Charge of Director (w.e.f. 23.07.2018)

Dr. Mukund Sharma, Scientist 'G' with Additional Charge of Director (w.e.f. 01.03.2019)

On Lien

Dr. Mukund Sharma, Scientist 'G' Proceeded on-lien of two years w.e.f. 25.04.2018 (to join the post of Professor in Banaras Hindu University)

Repatriation

Dr. Mukund Sharma, Scientist 'G' repatriated to BSIP, Lucknow, from B.H.U., Varanasi, during- Lien Period w.e.f. 25.09.2018 (FN)

Resignation

Ms Shachi Bajpai, JRF. BSIP Ph.D. Programme Category-I [w.e.f. 29.05.2018 (AN)]

Dr. Matsyendra Kumar Shukla, National Post Doctoral Fellow [w.e.f. 31.05.2018 (AN)]

Mrs Neelam Mishra, Technical Assistant [w.e.f. 31.05.2018 (AN)]

Sri Pranav Raj Tyagi, JRF [w.e.f. 11.07.2018 (AN)]

Sri Ashish Kumar Mishra, JRF [w.e.f. 30.11.2018 (AN)]

Ms Shachi Bajpai, DST Inspire Fellow [w.e.f. 19.12.2018 (AN)]

Ms Akanshi Tyagi, JRF [w.e.f. 11.03.2019 (AN)]

Relieved

Ms Sachi Bajpai, JRF BSIP Ph.D. Programme, Category-I [w.e.f. 29.05.2018 (AN)]

Sri Yogesh Kumar, JRF BSIP Ph.D.Programme, Category-II [w.e.f. 31.05.2018 (AN)]

Ms Neelam Mishra, Technical Assistant [w.e.f. 31.05.2018 (AN)]

Dr. Matysendra Kumar Shukla, National Post Doctoral Fellow [w.e.f. 31.05.2018 (AN)]

Sri Pranav Raj Tyagi, JRF [w.e.f. 11.07.2018 (AN)]

Dr. Akhilesh Kumar Yadava, National Post Doctoral Fellow

Ms Priyanka Joshi, JRF [w.e.f. 22.05.2018 (AN)]

Ms Harshita Srivastava, JRF BSIP Ph.D. Programme, Category 'II' [w.e.f. 28.02.2019 (AN)]

Ms Supriya Kumari, JRF BSIP Ph.D. Programme, Category 'II' [w.e.f. 28.02.2019 (AN)]

Ms Shalini Parmar, JRF BSIP Ph.D. Programme, Category 'II' [w.e.f. 28.02.2019 (AN)]

Dr. Mayank Shekhar, Young Scientist [w.e.f. 27.02.2019 (AN)]

Dr. Shamim Ahmad, Principal Investigator/Post Doctoral Fellow [w.e.f. 27.02.2019 (AN)]

Dr. Arindam Chakraborty, National Post Doctoral Fellow [w.e.f. 27.02.2019 (AN)]

Ms Ch. Bency David, JPF [w.e.f. 31.03.2019]

Superannuation

Dr. Madhav Kumar

Dr. Kamal Jeet Singh

Sri K.C.Chandola

Sri T.K.Mandal

Dr. B.D.Singh

Dr. R.C.Mehrotra

Sri Avanish Kumar

Dr. Madhav Kumar, Scientist 'G' [w.e.f. 31.07.2018 (AN)]

Dr. Kamal Jeet Singh, Scientist 'F' [w.e.f. 31.07.2018 (AN)]

Sri K.C. Chandola, Multi Tasking Staff [w.e.f. 31.07.2018 (AN)]

Sri T.K. Mandal, Technical Officer 'D' [w.e.f. 31.08.2018 (AN)]

Dr. B.D. Singh, Scientist 'F' [w.e.f. 31.12.2018 (AN)]

Dr. R.C. Mehrotra, Scientist 'G' [w.e.f. 28.02.2019 (AN)]

Sri Avanish Kumar, Technical Assistant 'E' [w.e.f. 28.02.2019 (AN)]

Obituary

Sri N.K. Khasnavis, Ex-Section Officer on 13.06.2018

Prof. H.Y. Mohan Ram, FNA, Ex-Chairman, Governing Body, BSIP, Lucknow on 18.06.2018

Sri V.S. Panwar, Ex-Technical Assistant 'E' on 27.09.2018

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 2019 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 2019, and

   ii. In the case of the Income & Expenditure account, of the surplus of the society for the year ended on that date.

iii. In the case of the Receipt & Payment account, of the receipts and payments of the society for the year ended on that date.

Report on Other Legal and Regulatory Requirements

7. As required by Section 12A(b) of Income Tax Act, 1961:

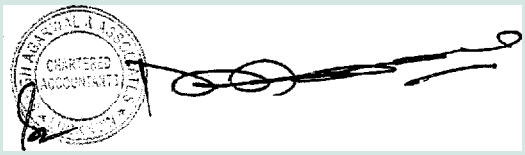
a) We have sought and obtained all the information and explanations, which, to the best of our knowledge and belief, were necessary for the purposes of the audit.

b) In our opinion, proper books of account have been kept by the society so far as appears from our examination of the books.

c) The balance sheet, the Income & Expenditure Account and the Receipt & Payment account are in agreement with the books of account maintained at the head office at Lucknow.

d) In our opinion, there are no observations or comments on the financial transactions, which may have an adverse effect on the functioning of the Society.

For: Singh Agarwal & Associates
Chartered Accountants



(Mukesh Kumar Agarwal)
FCA, DISA (ICAI)
Partner
Membership No - 073355
UDIN: 19073355AAAAAK9392

Place: Lucknow

Date: 25th July 2019

ANNEXURE - 'A'

(Annexed to and forming part of the Audit Report for the year ended 31st March, 2019)

COMMENTS / AUDIT OBSERVATIONS ON ACCOUNTS OF 'BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES' - LUCKNOW

LOANS & ADVANCES:

1. The internal control over loans and advances is not adequate and requires strengthening. There should be a process of periodic reconciliation & eventual adjustment / settlement of advances. During our verification, it was noticed that adequate record is not being maintained and the advances are not being reconciled / settled periodically. Strengthening required at both Institute as well as project accounts level;

2. Advances (capital head) unsettled and pending for recovery / adjustment as on 31.03.2019 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 Spem A/c	Several years	88257.00
Perkin Elmer	2014-15	396435.00

3. Rs. 775635/- 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. 180452/. The difference of Rs. 595183/- 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. Rs. 283230.52 is outstanding in "LC Charges". Complete details of the same is not available. The break-up of the same with corresponding advances should be identified so that the same can be capitalized correctly.

5. Rs. 1021/- (Cr) is outstanding in "Oriental Insurance". It seems that proper capitalization of insurance cost was not done in previous years resulting in (-)ve balance in advance head. Appropriate action should be taken in this respect.

6. Register of staff Advance is not updated and reconciled with financial accounts on regular basis. As on 31st March 2019, a sum of Rs. 4286062.45 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. Kamlesh Kumar	May-17 & Jan-18	106119.00
Dr. Manoj MC	Oct-2017	95000.00
Dr. P. Morthekai	Jun-2017	125000.00
Dr. Shilpa Pandey	Jul-17 & Jan-18	224003.00
Mr. Ashok Kumar	Feb-2018	2950.00
Rajesh Mishra	Feb-2018	115500.00
George Society of India	Before 2012-2013	12000.00

BANK RECONCILIATION STATAEMENT:

7. In Bank reconciliation statement as on 31st of March 2019, Credit without advice amounting to Rs. 3463193/- which includes Rs. 1960468/- for more than 3 months are lying. Similarly, a sum of Rs. 334036.32 is outstanding in debit without advice which includes 2 entries of Rs. 173541.84 relating to year 2016-2017. The details of these entries to be identified and appropriate action to be taken.

PROJECT ACCOUNTS:

8. Advance made for purchase of capital assets is not adjusted and is recorded as expenditure in the project accounts. For Instance, a sum of Rs. 1107865/- was paid as advance to M/s Lica Microsystem in previous years DST project of Dr. Neelam but the settlement of the same was not yet done. Similarly, in DST Project of Dr. Binita Phartiyal, a sum of Rs. 1012641/- was paid to M/s Decell Electronic and a sum of Rs. 966424/- to M/s A.K.V. Enterprises but settlement of the same was not done.

STORES AND WORKS & BUILDING:

9. 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.

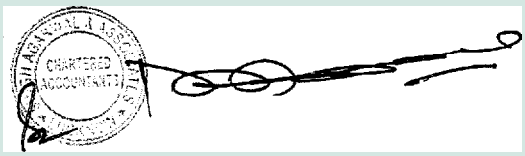
10. Physical verification of Non-Consumable assets & Consumable items for the year ended 31.03.2019 was done in April 2018. While verification no summary of Fixed Assets was being prepared. Only a certificate has been issued that "Physical Verification has been done as per books and no discrepancies 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.

OTHER ISSUES:

11. A sum of Rs. 74862/- was overspent over the fund received in "Brainstorming workshop" and the same is being reflected as "Recoverable" since 2017-2018. The correct status is to be ascertained and appropriate action to be taken.

12. There is no process of periodic reconciliation of GPF advances as per accounts with the base record maintained by concerned section. Periodic reconciliation should be done.

For: Singh Agarwal & Associates
Chartered Accountants



(Mukesh Kumar Agarwal)
FCA, DISA (ICAI)
Partner
Membership No - 073355
UDIN: 19073355AAAAAK9392

Place: Lucknow

Date: 25th July 2019

ANNEXURE - 'A'

(Annexed to and forming part of the Audit Report for the year ended 31st March 2019)
BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES, LUCKNOW

AUDIT OBSERVATIONS - FINANCIAL YEAR - 2018-2019

Loans & Advances:

Particulars/ Observations	Action Taken
01. The internal control over loans and advances is not adequate and requires strengthening. There should be a process of periodic reconciliation & eventual adjustment/ settlement of advances. During our verification, it was noticed that adequate record is not being maintained and the advances are not being reconciled /settled periodically. Strengthening requires at both institute as well as project accounts level	The advances register is being maintained & Periodic review of the advances /reconciliation is being done at Institute level in FY 2019-20.
02. Advances (capital head) unsettled and pending for recovery / adjustment as on 31.03.2019 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:	The settlement of advances is under process in FY 2019-20.

Particulars	Year	Amount	
Chempharam Industries, India	Since 2014-15	8220731.00	The advance settlement is under process in FY 2019-20.
Alliance Book Suppliers, Delhi	2014-15	200883.89	The advance settlement is under process in FY 2019-20.
M/s Spem A/c	Several years	88257.00	The advance settlement is under process in FY 2019-20.
Perkin Elmer	2014-15	396435.00	The advance settlement is under process in FY 2019-20.

03. Rs. 775635/- 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. 180452/. The difference of Rs. 595183/- 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.	The advance settlement is under process
04. Rs. 283230.52 is outstanding in "LC Charges". Complete details of the same are not available. The break-up of the same with corresponding advances should be identified so that the same can be capitalized correctly.	Noted, The reconciliation & capitalization of LC charges is under process.
05. Rs. 1021/- (Cr) is outstanding in "Oriental Insurance". It seems that proper capitalization of insurance cost was not done in previous years resulting in (-)ve balance in advance head. Appropriate action should be taken in this respect.	Noted for needful action.
06. Register of staff Advance is not updated and reconciled with financial accounts on regular basis. As on 31st March 2019, a sum of Rs. 4286062.45 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:	The advances settlement is under process in FY 2019-20. The pending advances settlement status as per list is as given-

Name Of Person/ Staff	Pending Since	Amount	Name Of Person/ Staff	Unsettled Advance Amount
Dr. Kamlesh Kumar	May-17 & Jan-18	106119.00	Dr. Kamlesh Kumar	54,500.00
Dr. Manoj MC	Oct-2017	95000.00	Dr. Manoj MC	95000.00
Dr. P. Morthekai	Jun-2017	125000.00	Dr. Shilpa Pandey	84003.00
Dr. Shilpa Pandey	Jul-17 & Jan-18	224003.00	Rajesh Mishra	115500.00

Mr. Ashok Kumar	Feb-2018	2950.00	
Rajesh Mishra	Feb-2018	115500.00	
George Society of India	Before 2012-2013	12000.00	
Bank Reconciliation Stataement:			
07. In Bank reconciliation statement as on 31st of March 2019, Credit without advice amounting to Rs. 3463193/- which includes Rs. 1960468/- for more than 3 months are lying. Similarly, a sum of Rs. 334036.32 is outstanding in debit without advice which includes 2 entries of Rs. 173541.84 relating to year 2016-2017. The details of these entries to be identified and appropriate action to be taken.			The reconciliation of LC charges is under process and updated status is as given below- Credit without advise (Unsettled) – 1773481.00 Debit without advise- 334036.00
Project Accounts:			
08. In Project accounts, advance given to staff / other parties is not being recorded separately. Instead, the same is directly debited to Project account and no separate controlling record is being maintained for recording advances. The advance given to party / staff should be recorded as advance and the same should be adjusted on settlement to tract the actual outstanding position of advance in project accounts.			The advance register is being maintained at Institute level
Stores And Works & Building:			
09. Maintenance & updation of Fixed Assets register & Stores register needs to be strengthened. The value of fixed assets as per fixed assets register and stores register must match with the value in the fixed assets schedule. Proper reconciliation needs to be done and registers to be updated on regular basis.			Noted for future compliance and necessary instructions have been given to Store & purchase section.
10. Physical verification of Non-Consumable assets & Consumable items for the year ended 31.03.2019 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.			Noted for future compliance and necessary instructions have been given to Store & purchase section.
Other Issues			
11. A sum of Rs. 74862/- was overspent over the fund received in "Brainstorming workshop" and the same is being reflected as "Recoverable" since 2017-2018. The correct status is to be ascertained and appropriate action to be taken.			Noted for future Compliance and needful action.
12. In GPF Advance, a sum of Rs. (-)107600.00 is outstanding as on 31st March 2019 which means that excess recovery was made but details of staff from whom excess recovery has been done is not available.			The reconciliation of GPF register has been done.

(Ashutosh Shukla)
Accounts Officer

(Sandeep Kumar Shivhare)
Registrar

(Dr. Vandana Prasad)
Director

Form of Financial Statements (Non-Profit Organizations)

Birbal Sahni Institute of Palaeosciences, Lucknow

Balance Sheet as at March 31, 2019

(Amount - Rs.)

Particulars	Schedule No.	Current Year 31.3.2019	Previous Year 31.3.2018
CORPUS/CAPITAL FUND AND LIABILITIES			
CORPUS/CAPITAL FUND	1	680,395,809.43	663,750,297.13
RESERVES ANS SURPLUS	2	3,210,903.00	33,210,903.00
EARMARKED/ENDOWMENT FUNDS	3	387,073,567.53	353,977,519.03
SECURED LOANS AND BORROWINGS	4	-	-
UNSECURED LOANS AND BORROWINGS	5	-	-
DEFERRED CREDIT LIABILITIES	6	-	-
CURRENT LIABILITIES AND PROVISIONS	7	19,918,584.28	12,335,489.85
TOTAL		**1,090,598,864.24**	**1,063,274,209.01**
ASSETS			
FIXED ASSETS	8	222,431,143.75	202,708,507.71
INVESTMENTS-FROM EARMARKED/ENDOWMENT FUNDS	9	387,073,567.53	353,977,519.03
INVESTMENTS-OTHERS	10	64,798,113.00	63,317,239.00
CURRENT ASSETS,LOANS,ADVANCES ETC.	11	416,296,039.96	443,270,943.27
MISCELLANEOUS EXPENDITURE			
(to the extent not written off or adjusted)			
TOTAL		**1,090,598,864.24**	**1,063,274,209.01**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

For **Singh Agarwal & Associates**
Chartered Accountants

CA. Mukesh Kumar Agarwal
(Partner)

(Ashutosh Shukla)
Accounts Officer

(Sandeep Kumar Shivhare)
Registrar

(Dr. Vandana Prasad)
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, 2019

Fig. in Rupees

Particulars	Schedule	Current Year 2018-19	Previous Year 2017-18
INCOME			
Income from Sales/Services	**12**	1,591,838.10	900,052.00
Grants/subsidies (OB, Deposit A/C and Transfer from Cap. Fund)	**13**	412,884,000.00	339,893,000.00
Fees/Subscriptions	**14**	-	-
Income from Investments (Income on Invest. From earmarked/endow. Funds transferred to Funds)	**15**	1,480,874.00	187,041.00
Income from Royalty, Publication etc.	**16**	36,733.00	123,306.00
Interest Earned	**17**	8,287,812.00	16,452,893.50
Other Income/Adjustments	**18**	1,830,139.00	1,742,071.87
Increase/(decrease) in stock of Finished goods and works-in-progress	**19**	-	-
TOTAL(A)		**426,111,396.10**	**359,298,364.37**
EXPENDITURE			
Establishment Expenses	**20**	311,507,548.00	254,369,607.00
Other Administrative Expenses etc.	**21**	60,851,694.22	47,602,052.40
Expenditure on Grants, Subsidies etc.	**22**	-	-
Interest	**23**	-	-
Depreciation (Net Total at the year-end-corresponding to Schedule 8)		37,106,641.58	31,213,963.26
TOTAL (B)		**409,465,883.80**	**333,185,622.66**
Balance being excess of Income over Expenditure **(A-B)**		16,645,512.30	26,112,741.71
Transfer to Special Reserve (Sepecify each)		-	-
Transfer to/from General Reserve to Pension Fund		-	-
BALANCE BEING SURPLUS/DEFICIT CARRIED TO CORPUS/CAPITAL FUND		**16,645,512.30**	**26,112,741.71**
SIGNIFICANT ACCOUNTING POLICIES	**24**		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	**25**		

For **Singh Agarwal & Associates**
Chartered Accountants

CA. Mukesh Kumar Agarwal
(Partner)

(Ashutosh Shukla)
Accounts Officer

(Sandeep Kumar Shivhare)
Registrar

(Dr. Vandana Prasad)
Director

Form of Financial Statements (Non-Profit Organizations)
Birbal Sahni Institute of Palaeosciences, Lucknow
Receipts and Payments Account for the period / year ended March 31, 2019

Fig. in Rupees

RECEIPT	Current Year 2018-19	Previous Year 2017-18	PAYMENTS	Current Year 2018-19	Previous Year 2017-18
I. Opening Balances			**1) Expenses**		
a) Cash in hand	-	115.00	a) Establishment Expenses(Corresponding to Schedule 20)	311,507,548.00	254,369,607.00
b) Bank Balances			b) Administrative Expenses(Corresponding to Schedule 21)	60,851,694.22	47,602,052.40
i) In current accounts					
ii) In deposit accounts	376,447,435.38	383,471,280.50	**II) Payments made against funds for various projects**	25,880,874.57	35,068,965.21
iii) Endowment deposits			(Name of the fund or project should be shown along with		
iv) TDS on other grant	340,444.00	305,157.00	the particulars of payments made for each project)		
II. Grants Received			**III. Investments and deposits made**		
a) From Government of India	412,884,000.00	339,893,000.00	a) Out of Earmarked/Endowment funds		
b) From State Government			b) Out of Own Funds (Investments-Others)		
c) From other sources(details)			**IV. Expenditure on Fixed Assets & Capital Work-in-Progress**		
(Grant for capital & revenue exp.	-	-	a) Purchase of Fixed Assets	56,829,277.62	43,561,001.09
To be shown separately)			b) Expenditure on Capital Work-in-Progress		
d) Deposit Account			**V. Refund of surplus money/ Loans**		
III. Income on Investment from			a) To the Government of India		
a) Earmarked/Endow. Funds			b) To the State Government		
b) Own Funds (Utilized)			c) To other providers of funds		
IV. Interest Received			**VI. Finance Charges (Interest)**		
a) On Bank deposits	7,420,079.00	15,329,729.50	**VII. Other Payments (Specify)**		
b) Loans, Advances etc.	867,733.00	1,123,164.00	i) Advances to Staff	647,630.00	1,078,851.00
i) Sale proceeds of Publications	36,733.00	123,306.00	ii) Earnest Money Refunded	(22,660.00)	98,000.00
ii) Miscellaneous Income	1,830,139.00	1,742,071.87	iii) Advances to Parties	31,626,660.84	65,409,665.89
iii) Sale of Services (Consultancy)	1,591,838.10	900,052.00	iv) Pension Fund		
iv) Group Insurance			v) Transfer to reserve & surplus	-	-
VI. Amount Borrowed	-	-	**VIII. Closing Balances**	-	-
VII. Any other receipts (give details)	(1,634,243.00)	1,338,980.25	a) Cash in hand	-	-
(Pension Contribution)			b) Bank Balances	-	-
Transfer from Reserve Fund	(30,000,000.00)	(25,000,000.00)	i) In current accounts	-	-
Net Receipt from Project	35,075,552.00	24,802,375.81	ii) In deposit accounts	-	-
TDS Refund	-	-	iii) Saving account	383,653,670.12	376,447,435.38
i) Recovery of Advances	66,488,516.89	79,946,790.04	iv) Endowment deposit account	-	-
ii) Earnest Money Deposit	-	-	v) TDS on other grant	373,532.00	340,444.00
iii) FDR Matured				-	-
				-	-
				-	-
TOTAL	**871,348,227.37**	**823,976,021.97**		**871,348,227.37**	**823,976,021.97**

For **Singh Agarwal & Associates**
Chartered Accountants

CA. Mukesh Kumar Agarwal
(Partner)

(Ashutosh Shukla)
Accounts Officer

(Sandeep Kumar Shivhare)
Registrar

(Dr. Vandana Prasad)
Director


बीरबल साहनी पुराविज्ञान संस्थान
BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES

ISSN 0972-2726

army printing press
www.armyprintingpress.com
Lucknow (0522) 6565333