Annual Report 2021-22

1946

Birbal Sahni Institute of Palaeosciences, Lucknow

An Autonomous Institute under Department of Science and 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 fossils and a few related studies were the focus of research at the BSIP. However, the mandate of the BSIP was recently expanded for interdisciplinary research in palaeosciences, and creating modern facilities to achieve this end. The newly widened mandate aims to look at

- Understanding the 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 for the 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 evolution of plant life and geological processes involved, environmental evolution and climate change through time.

Initially, the BSIP laid emphasis on more fundamental aspects of Indian fossil floras, but diversified in due course to include sequence biostratigraphy, magnetostratigraphy, and geochronology to help in the correlation of surface and subsurface sediments, geochemistry, vertebrate palaeontology, palaeogenomics and exploring areas favourable for fossil fuel deposits. The main research work involves the understanding of biotic evolution through geological time. Emphasis has been made to derive knowledge about the diversification of Precambrian life; diversity, distribution, origin, evolution of Gondwana and Cenozoic flora in a phylogenetic framework, intra- and inter-basinal correlation during Gondwanan and Cenozoic time-slices and work on organic petrology to evaluate the quality of Gondwana coals and Cenozoic lignites for their economic utilization, besides depositional conditions is well under way. In addition, research is being carried out on the origin, evolution, diversity, distribution of Mesozoic-Cenozoic vertebrate fauna in a palaeogeographic context apart from associated ichnofossils (coprolites) to established link(s) to producer taxa and evaluate the change(s) in the faunal dietary habit(s) across the critical Cretaceous-Paleogene transition. Understanding the link(s) between climate change and vegetation during the Quaternary Period is also an important part of research at the BSIP. Research on tree-rings to deduce palaeomonsoon/climatic fluctuations are significant aspects studied at the institute. Further, dating and study of samples for archaeobotanical research including ancient DNA analysis that are critical to understand the co-evolution of culture and civilization are also been carried out at the BSIP. Geological samples including fossils of both flora and fauna are constantly been explored at various locations (covering almost the entire length and breadth of our country) to study towards fulfilling the BSIPs mandate. In addition, geological samples have also been collected from the polar (Arctic/Antarctic) regions. The museum of the institute offers a rich repository of fossils collected from India and the ones received from abroad. A special attraction is the Foundation stone itself, put up in 1949, with 77 fossils inlaid. The Institute has 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, TFIR systems have been recently added for geochemical analyses, besides the establishment of the Palaeomagnetic Laboratory, Vertebrate Palaeontology and Preparation Laboratory, Ancient DNA laboratories, FE-SEM Laboratory, Confocal Laser and Raman Spectroscopy Laboratory and Industrial Micropalaeontology Laboratory. The institute hosts national/international scientific meets from time to time, and also publishes catalogues, atlases, etc. on special occasions, besides publishing a journal 'Journal of Palaeosciences' of international repute. 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
2021-22

1946

Birbal Sahni Institute of Palaeosciences, Lucknow

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

Published by

The Director
Birbal Sahni Institute of Palaeosciences (BSIP)
53, University Road, Lucknow – 226007, Uttar Pradesh
INDIA

Phone : +91-522-2740470 / 2740413 / 2740411
Fax : +91-522-2740485 / 2740098
E-mail : director@bsip.res.in, rdcc@bsip.res.in
Website : http://www.bsip.res.in

Compiled and Edited by : Dr Anupam Sharma, Dr Hukam Singh, Dr Vivesh Vir Kapur & Dr (Mrs) Neha Aggarwal
Assistance : Mr Madhukar Arvind
Visuals : Scientists and Photography Unit
Produced by : Research Development and Coordination Cell (RDCC) & Publication Unit

CONTENTS

Foreword

It is a matter of immense satisfaction to present the annual report (2021-2022) of the Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow. The Birbal Sahni Institute of Palaeosciences, Lucknow, a premier research centre under Department of Science and Technology, Government of India is a dedicated unique institution actively involved in a scientific discipline pertaining to the study of deep time and recent life and climate of our planet. During the initial phase of the institute, the BSIP was mostly devoted to basic as well as applied aspects of palaeobotanical (study of fossil plants), other associated life forms and allied disciplines. Although, the basic pursuit remained the same as envisaged by the Founder of the institute; however, with time, the approach, the tools and the materials have evolved in scientific research. Thus, lately, the institute has incorporated a multidisciplinary approach in the field of palaeosciences. The prime objectives of the research are focused on aspects related to origin of life on the planet, reconstruction of past vegetation, palaeoclimate (e.g., aspects related to monsoonal variability), biostratigraphy, sequence biostratigraphy, palaeobiogeography incorporating flora and fauna, hydrocarbon and fossil fuel exploration, to unravel the history and culture of past civilization. To achieve desired research objectives, scientific activities during the year 2021- 2022 have been reformulated and significant inputs in several frontline research areas under the umbrella of eight research themes - Early life and environment: evidence from Indian Precambrian basins; Biostratigraphy, basin correlation, climatic and biotic events during Palaeozoic and Mesozoic; Pre- and post-collision biotic turnover(s) and climate change(s) pertaining to India; Ocean and Polar palaeoclimatic reconstruction during Neogene and Quaternary; Biological and biogeochemical changes during Late Quaternary from coastal regions of India : insights into coastal dynamics and monsoonal variability; Holocene vegetation and climate reconstructions for the Himalayan region: understanding the dynamics and forcing mechanisms; Reconstructing human-environment interaction, and agricultural strategies using macrobotanics, isotopes and ancient DNA (aDNA); Quaternary Monsoon/ Climate reconstruction through high resolution multi-proxy studies of lacustrine archives from Central India (Core Monsoon Zone and Indo-Gangetic Plain). State-of-the-art instrumentation facilities at BSIP facilitate the generation of robust and precise knowledge, and its timely deliverance.

The continuous efforts and hard work being carried out by our scientists is reflected in the incessantly increasing number and quality of publications in high-impact journals of international repute. Many scientists have also received grants in the form of several sponsored projects funded by various agencies i.e., DST-SERB, INSPIRE, MoES-EEQ EMR, to name a few that has helped to generate funds and to carry out research on aspects other than in-house research projects. Institute is also actively involved in the consultancy services to generate funds. To enhance the visibility of our efforts and the organization, various conferences, workshops, symposia, seminars, outreach programmes and international collaborations, etc. within the organization and with other organizations have been successfully coordinated. In addition, various outreach programmes have also been organized under the flagship of

75th Azadi ka Mahotsav. Most of our findings are not limited to academics and have drawn curious attention in the general public. The BSIP is actively involved in the conceptualization of the "Mandro Fossil Park" including the "Rajmahal Fossil Museum & Interpretation Centre" at Mandro (Sahibganj District, Jharkhand) and a Marine Fossil Park at Manendragarh, Chhattisgarh.

BSIP has come a long way since its inception and drastic change in its modus operandi is clearly visible. Ongoing MoUs with the Geological Survey of India (GSI) and Oil and Natural Gas Corporation (ONGC) and other premier institutions have helped in solving the academic and core research problems and also for generating financial support and knowledge sharing. In addition, Ph.D. program being run under the tutelage of AcSIR has been advantageous for both research scholars and supervising scientists at the BSIP.

The construction of a multi-storey building of the institute is under way, and is aptly timed, in line with the expanded research mandate. Thus, the BSIP fraternity will be quite benefitted upon the completion of the new building in terms of setting up of new state-of-the-art laboratories at its premises. As the institute has adopted an integrated and multi-disciplinary approach to fulfil its aims and objectives as per the mandate, a number of analytical facilities such as Clumped-isotope Laboratory, Fourier Transform Infra-Red (FTIR) spectroscopy laboratory, Vitrinite Reflectance (VRo) have been introduced while a state-of-the-art Micro-CT laboratory is in the process of been introduced in the institute. In addition, the new building once complete, shall help in accommodating an increasing number of scientists and research students at the institute.

Collective efforts of scientific, technical and administrative staff have resulted in accumulating data profile useful for various research agencies, universities, funding sources, and related R&D units. This document includes the overall achievements and activities targeted for the year 2021-2022. Contributions during this period in terms of research have been reflected in the form of research papers which have been published in journals of international repute. Significant achievements in various researches, administrative, outreach activities and welfare measures have also been incorporated in this document.

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

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

Vandana Prasad

(Director)

Organizational Highlights

- The Director (Dr Vandana Prasad) of the institute was elected as a "Fellow" of the Indian Academy of Sciences, Bangaluru (IASc), India.
- A team of researchers led by Dr Vandana Prasad recently published a research article in an internationally reputed journal "Science" that suggested tropical-African origin of plant family Dipterocarpaceae during the mid-Cretaceous, and supports its 'Out-of-India' migration.
- Altered cropping patterns (from large-grained to small-grained millets) in relation to monsoonal climate change during the last two thousand years have been recorded from the archaeological site at Vadnagar, Gujarat.
- A revised clumped isotope calibration equation for otoliths (fish ear-bones) was established based on the International Union of Pure and Applied Chemistry parameter set. The new calibration equation is validated by quantifying the environmental water $\delta^{18}O$ from modern waters.
- A modified methodology has been developed that allowed to unveil clay minerals from a solid substrate (e.g., Rock Varnish) which can be identified utilizing XRD analysis.
- As part of the BSIPs efforts in the field of astrobiology and astrogeological studies, a two-week (i.e., from 19th July to 1st August, 2021) field training programme was conducted in the Ladakh region, in collaboration with Amity University, Mumbai.
- A few National facilities such as Clumped Isotope Laboratory, Fourier Transform Infrared Spectroscopy (FTIR), and Industrial Micropalaeontology Laboratory have been established within the institute for isotopic studies as well as to support the hydrocarbon industry to ensure the energy security of the country.
- An initiative has been taken to establish a state of the art micro-CT laboratory for digital archiving and study of fossils.
- A team of BSIP scientists has conceptualized a Fossil Park at Mandro (District Sahibganj, Jharkhand) including a "Museum and Interpretation Centre" within the Fossil Park.
- The institute is actively participating in the Govt. of India's flagship programmes such as Digital India, Swachh Bharat Mission, Namami Gange Mission, and Amrut Mahotasav.
- A Lake Drilling Flagship Program has been launched by the institute to understand the Monsoon variability in the Ganga Plain and adjoining regions, considering the Namami Gange Mission of the Govt. of India.
- A new multi-story building of the institute is under construction, which will enhance the capacity of the institute having wider implications in Palaeoscientific studies.

Research Highlights

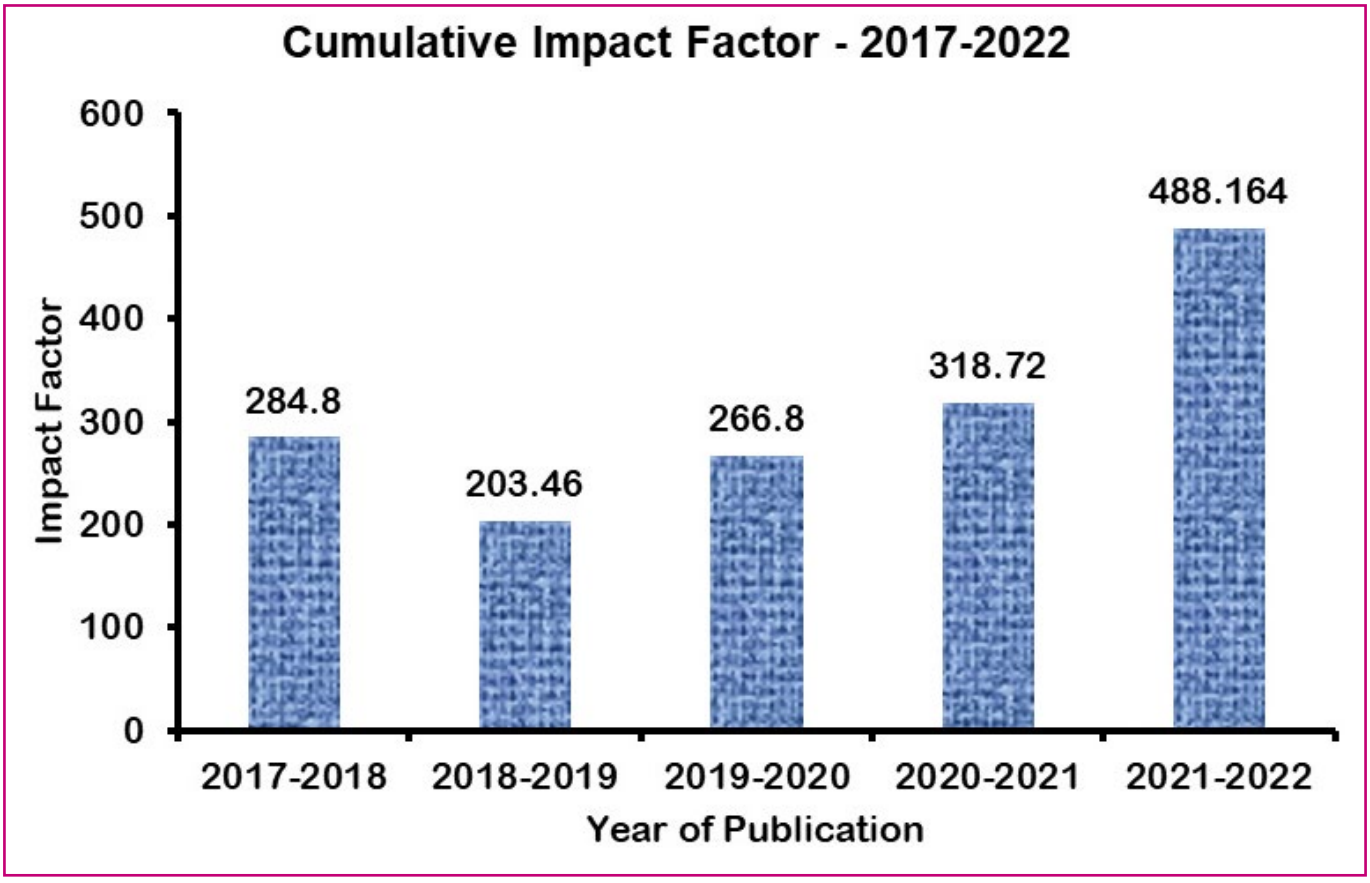
- *Tawuia* an elongated carbonaceous fossil recorded from Rajasthan and Madhya Pradesh has provided important constraints on the origin and early evolution of coenocytic eukaryotes, primary plastids, and is confirmed as macroalgae. They are rare and found in the 1600 million years old rocks of the country.
- Shale and Limestone samples from Rohtashgarh (Madhya Pradesh) were analysed for hydrocarbon potential. The total organic content (TOC) of the shale ranges from 0.22 wt. % to 1.08 wt.%, whereas hydrogen index (HI) ranges from 11 to 90 mg HC/g TOC, oxygen index (OI) ranges from 1.08 to 31.82 mg CO_2/gTOC, Tmax ranges from 431 to 525°C, production index (PI) ranges from 0.11-1.0. High thermal alteration index (TAI) of shale (3.5) suggests the presence of post maturated organic matters with gas prone type III & IV kerogen.
- A new invertebrate millipede trace fossil *Palliedaphichnium gondwanicum* gen. et sp. nov. has been reported from the Upper Permian (~260-250 million years old) Bijori Formation of Satpura Gondwana Basin, Madhya Pradesh. It makes a significant contribution to the meagre records of invertebrate trace fossils from Permian strata of Indian palaeosols.
- First occurrence of Cornulitids, and other tentaculitoids (extinct tubeworms) from the Ordovician times (~458-443 million years old) (Takche Formation) of Spiti (Himachal Pradesh), Tethyan Himalaya, India indicates its shallow marine settings.
- Macrofloral and palynological data from the Raniganj and Panchet formations (Tatapani-Ramkola Coalfield, Chhattisgarh) have provided the recovery and radiation of flora after the Permian-Triassic Extinction event (252.28±0.08 Ma). In addition, a rich megaspore assemblage hitherto unknown from the early Triassic of Tatapani-Ramkola Coalfield was recorded.
- A ~66-million-year-old permineralized wood similar to the modern genus *Lagerstroemia* and identified as *Lagerstroemioxylon* sp. was recorded within the Deccan intertrappean deposits of Dhagaon (Mandla District, Madhya Pradesh). This record is considerably older than the earlier known global fossil records of this genus.
- Analysis of biomarkers composition (terpenoids) from the Barsingsar lignite-bearing sequence has been done. The study shows high abundance of diterpenoids over triterpenoids pointing to the proliferation of conifer derived organic matter for the first time during early Palaeogene in western Indian sedimentary basin.
- The petrographical study of lignites from Sonari lignite-bearing sequence (Bamer Basin) suggests dominant huminite (oxygen rich) macerals with subordinate inertinite (carbon rich) macerals. Substantial amount of pyrites indicates an overall coastal swampy condition in the basin during deposition.
- A textural, petrological, mineralogical and multi-element geochemical investigations of a ~25 m sediment core from the lower reaches of the Mahi River Basin (at Rampura section: MIS5e to MIS1) allowed to understand the influence of climate and tectonics in the Gujarat Alluvial Plain (GAP) over the last >115 thousand years (ka). The data allowed to infer that the studied sedimentary profile was deposited under marine-fluvial-aeolian environments and showed a wetter MIS-5e, drier MIS-4, arid MIS-3 and LGM, O-YD.
- Tree-rings of *Pinus kesiya* from southern region of Manipur State (Northeast India) were used to develop chronologies of multiple tree-ring parameters that include: total-ring width (TRW), earlywood width (EW), latewood width (LW) and adjusted latewood (LW*adj*) spanning 39 years (i.e., 1980–2018 C.E.). The study argued that multiple parameters of *P. kesiya* provide a lucid understanding of climate response.
- Multiproxy approach for subsurface sedimentary profiles from the oak-pine dominated temperate forest at Nachiketa and sub-alpine meadow at Gangotri glacier valleys, western Himalaya were applied for past vegetation changes since 5 ka BP. The study recorded dry climate between 4.4−3.8 (4.2 ka event), 2.9−2.5, 0.6−0.2 (Little Ice Age) ka BP while moist conditions prevailed between 1.5−0.9 ka BP (Medieval warm Period) based on palynological and stable carbon isotope datasets.
- Examination (using multiproxy analysis) of modern feces samples of the endangered red panda (*Ailurus fulgens*) allowed characterizing the dietary patterns in their natural habitat in India. An abundance of *Lepisorus* spores

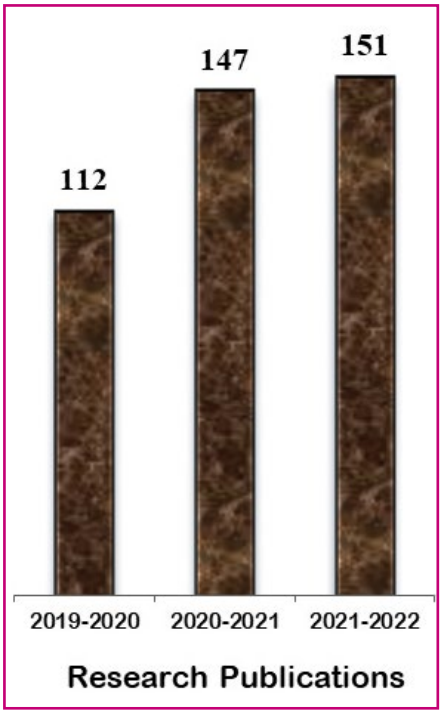
and its leaves along with broadleaved taxa, *Betula*, *Engelhardtia*, and *Quercus* are indicative of other important food sources.

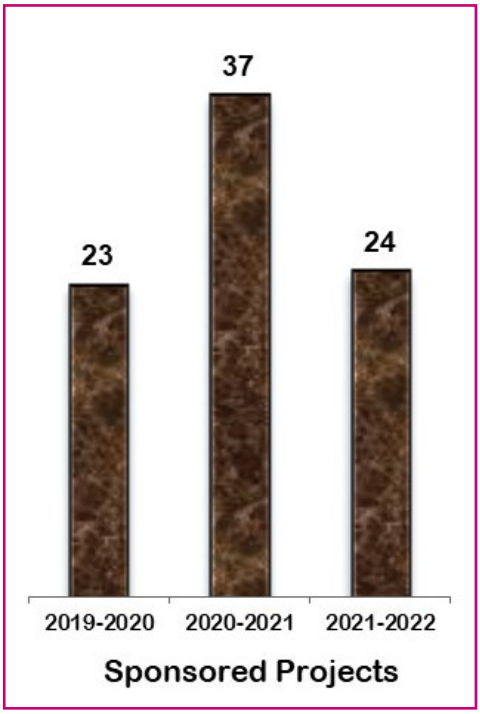
- Archaeobotanical investigation at Indus/Harappan site in the palaeo-Saraswati Basin (Bhiwani, Haryana) revealed evidence of kharif and rabi season crops which included cereals, pulses, oil and fiber-yielding crops. The favourable climatic conditions with sufficient precipitation during both summer and winter likely stimulated agricultural activities and it supported the urbanism around 4500-4200 yrs BP.
- A study reconstructed the past surface temperature, pH and pCO_2 in the seawater nearby the offshore Saurashtra NE Arabian Sea since last 8 ka by measuring the Mg/Ca ratio and stable isotopes of boron in fossil (foraminifera) shells. The study found that the increase in rainfall events around the Equatorial Pacific Ocean had a connection with the Arabian Sea and caused disturbance in the stability of ocean water that brought more acidic and CO_2-rich deep water near the sea surface (upwelling) in the NE Arabian Sea. These disturbances in the Arabian Sea surface caused acidification and release a high amount of CO_2 into the atmosphere.
- Discovered 1500 million years old eukaryotic Phaeophyte alga from Mahasamund District of Chhattisgarh State in the Saraipali Formation of Chhattishgarh Supergroup. It marks the advent of multicellular life on the Earth.
- The pollen and biomarker fossil records from the late Cretaceous of Africa and the Cretaceous-Paleogene (68.5–54 million years) of India, when combined with molecular data under a phylogenetic framework, suggested the evolution of Dipterocarpaceae in Africa around 102 million years ago. The family further dispersed to the Indian Plate during the late Maastrichtian-Paleocene via Kohistan-Ladakh Island arc, resulting in the diversification of aseasonal dipterocarps on the Indian Plate. Further diversification of Dipterocarpaceae took place around 20 Ma onwards in Southeast Asia, but most genera became extinct in India with the strengthening of the Indian Monsoon.
- A study documented the first fossil *Myrmecarchaea* (Aranea, Archaeidae) spiders in Cambay amber from India, of Eocene age. The new record has extended the distribution of these spiders to India 50–52 million years ago.
- A detailed review of the Early Eocene (~54.5-million-year-old) mammal fauna from the Cambay Shale of western India supports Out-of-India hypothesis (i.e., an Indian Origin). In addition, close affinities of primitive Indian Tapiromorphs with those recorded from China suggest contact between India-Asia landmasses, close to the Paleocene-Eocene boundary (i.e., ~56 million years ago).
- The study from the proglacial deposits of the Chorabari Glacier (Kedarnath, India) suggested high frequency of *Pinus* pollen which may lead to an erroneous interpretation of the existence of pine forests as no *Pinus* tree was observed to be present in the vicinity of the sampling sites. The dominance of *Betula* and *Quercus* from 4.2 to 3.6 kyr BP and a sharp decline in the frequencies of the broad-leaved tree taxa between 3.6 and 2.3 kyr BP were observed. However, on the onset of a warmer phase again from 2.3 kyr BP, the frequencies of *Betula* and *Quercus* increased only marginally which indicates due to anthropogenic pressure, the tree-line could not regenerate.
- Recent developments in the foraminifera boron isotope ($\delta^{11}B$) based seawater pH and pCO_2 proxy have been pivotal in understanding the various oceanic processes involved in air-sea gas exchange. Our record suggests that the region was overall a moderate to strong CO_2 sink during the last 7700 years.
- A modified methodology has allowed unveiling clay minerals from a solid substrate (e.g., Rock Varnish) that can be identified utilizing XRD analysis.
- Altered cropping patterns (from large-grained to small-grained millets) in relation to monsoonal climate change during the last two thousand years have been recorded from the archaeological site Vadnagar in Gujarat.
- Based on a new calibration equation a study made an attempt to quantify lower Miocene (Burdigalian) coastal conditions in southwest India utilizing fossil otoliths. The clumped isotope-based temperature estimates of 12.1°C–14.3°C and for “genus Ambassidarum” sp., and 10.2°C for “genus Gobiidarum” sp. certainly provides constraints on coastal conditions. The investigation opens future research avenues for assessing and predicting the coastal ecosystem in a warm climate.
- Pliocene (~3.40 to 2.62 Ma) palynological assemblages from ODP Hole 910C on the Yermak Plateau, Arctic Ocean indicated biome change. The study recorded a shift from Taiga to Tundra-steppe vegetation between

~2.73–2.64 Ma while and *Impatiens* pollen showed frost-free climate. In addition, the study suggested that the intensification before Northern Hemisphere Glaciation was characterized by intermittent short-term interstadials.

- BSIP's Radiocarbon dating Laboratory has provided chronologies along with Optically Stimulated Luminescence (OSL) method to archaeological excavations being conducted at Vadnagar (Gujarat).
- Industrial Micropalaeontology Laboratory: to be utilized to carry out sequence bio-stratigraphy for intra- and inter-basinal corrections, a data crucial for hydrocarbon exploration. The Clumped Isotope Laboratory: to be utilized to reconstruct and accurately quantify crucial climate parameters from the past (such as temperature) which is one of the most sophisticated and advanced palaeoclimate reconstruction tools available. Fourier Transform Infra-Red (FTIR) spectroscopy and ICP-AES laboratories: to be utilized to analyze both inorganic and organic materials from a wide array of geological fields, including coal, petroleum, rocks, and other energy-related fields.


Cumulative Impact Factor - 2017-2022
Impact Factor
600
500
400
300
200
100
0
284.8
203.46
266.8
318.72
488.164
2017-2018
2018-2019
2019-2020
2020-2021
2021-2022
Year of Publication


112
147
151
2019-2020
2020-2021
2021-2022
Research Publications


23
37
24
2019-2020
2020-2021
2021-2022
Sponsored Projects


70
78
87
2019-2020
2020-2021
2021-2022
Ph.D. Students

Governing Body

Research Advisory Council

Finance Committee

Building Committee

Governing Body

(w.e.f. June 29, 2021)

Chairman

Prof. Nitin R. Karmalkar
Vice Chancellor
Savitribai Phule Pune University
Ganeshkhind, Pune 411 007

Members

Secretary, DST (or his nominee)
Department of Science & Technology
Technology Bhawan, New Mehrauli Road
New Delhi 110 016

Professor Vasant Shinde
Former Vice Chancellor,
Deccan University, Pune 411006

Director General (Ex-officio)
Geological Survey of India
27, Jawaharlal Nehru Road
Kolkata 700 016

Professor R.P. Tiwari
Vice Chancellor
Central University of Punjab,
VPO-Ghudda, Bathinda
Punjab 151401

Professor Satish Chandra Garkoti
School of Environmental Sciences
Jawaharlal Nehru University
New Mehrauli Road, Munirka, New Delhi 110 067

Dr Ranjit Rath
Chairman and MD,
Mineral Exploration and Consultancy Ltd.
Dr Babasaheb Ambedkar Bhawan, Seminary Hills
Nagpur 440 006

Finance Advisor, **DST** (or his/her nominee)
Department of Science and Technology,
Technology Bhawan, New Mehrauli Road,
New Delhi 110 016

Professor H. B. Srivastava
Vice Chancellor, Siddharth University, Kapilvastu,
Siddharth Nagar 272 202

Dr Navin Juyal
Physical Research Laboratory
Ahmedabad

Dr Ashiho Asosii Mao
Director
CGO Complex, 3rd MSO Building,
Block F (5th and 6th Floor), DF Block,
Sector I, Salt Lake City, Kolkata 700 064

Dr Vandana Prasad
Director
Birbal Sahni Institute of Palaeosciences
53, University Road
Lucknow 226 007

Non-Member Secretary

Shri Sandeep Kumar Shivhare
Registrar
Birbal Sahni Institute of Palaeosciences
53 University Road
Lucknow 226 007

Research Advisory Council

(w.e.f. September 01, 2021)

Chairman

Professor L.S. Chamyal
Department of Geology,
The Maharaja Siyajirao University of Baroda
Main Office, Fatehganj, Vadodara 390 002

Members

Professor Subir Sarkar
Department of Geological Sciences
Jadavpur University, Kolkata 700 032

Professor G.V.R. Prasad
Department of Geology
University of Delhi, Delhi 110 007

Professor Arundeo Singh
Department of Geology
Banaras Hindu University
Varanasi 221 005

Professor Viswas S. Kale
Retd. Prof. of Geography
S.P. Pune University, Pune 400 076

Dr Navin Juyal
Physical Research Laboratory
Navrangpura, Ahmedabad 380 009

Prof. Ravi Bhusan
Geoscience Division
Physical Research Laboratory, University Area
Ahmedabad 380 009

Prof. Shanti Pappu
Sharma Centre for Heritage Education
28, I Main Road, Mylapore, Chennai 600 004

Dr Anupama Krishnamurthy
French Institute of Pondicherry
Puducherry 605 001

Prof. U.K. Shukla
Department of Geology
Banaras Hindu University, Varanasi 221 005

Sr. Dy. Director General (Ex-officio)
Incharge Northern Region
Geological Survey of India
Sector-E, Aliganj, Lucknow 226 020

Prof. Jyotiranjan S. Ray
Director
National Centre for Earth Sciences Studies
(NCES), Ulloor, Akkulam Road, Akkulam
Thiruvananthapuram 695 001

Shri Firoze Dotiwala
Retired ED, Basin Manager, ONGC
D-1301, Crystal Court, Hiranandani Complex, Sector 7
Kharghar, Navi Mumbai 410 210

Prof. Shreerup Goswami
Professor, Department of Geology
Utkal University, Vani Vihar
Bhubaneswar 751 004

Shri Manish Shukla
General Manager (Geology)
M.O. Block, 7th Floor, Q2 NBP Green Heights
C-69, BKC Road, Opp. MCA Club, G Block BKC
Bandra East, Mumbai 400 051

Member Convener

Dr Vandana Prasad
Director
Birbal Sahni Institute of Palaeosciences
53 University Road
Lucknow 226 007

Finance Committee

(w.e.f. September 01, 2021)

Chairman

Prof. Nitin R. Karmalkar
Vice Chancellor,
Savitribai Phule Pune University,
Ganeshkhind, Pune 411 007

Members

Financial Adviser (or his/her Nominee)
Department of Science and Technology,
Technology Bhawan, New Mehrauli Road,
New Delhi 110 016

Dr Gyanendra Mishra
Controller of Finance and Accounts,
CSIR-IITR, Vishvigyan Bhawan,
31, Mahatma Gandhi Marg,
Lucknow 226 001

Dr Vandana Prasad
Director
Birbal Sahni Institute of Palaeosciences,
53 University Road,
Lucknow 226 007

Non-Member Secretary

Shri Sandeep Kumar Shivhare
Registrar
Birbal Sahni Institute of Palaeosciences,
53 University Road,
Lucknow 226 007

Building Committee

(w.e.f. September 01, 2021)

Chairman

Prof. Nitin R. Karmalkar
Vice Chancellor
Savitribai Phule Pune University
Ganeshkhind, Pune, 411 007

Members

Nominee of the W & B
Department of Science and Technology,
Technology Bhawan, New Mehrauli Road,
New Delhi 110 016

Dr. Anupam Sharma
Scientist "F"
Birbal Sahni Institute of Palaeosciences,
53 University Road,
Lucknow 226 007

Er. Parvez Mahmood
Principal Technical Officer
Laboratory Engineering Services, CSIR-CDRI
Lucknow

Dr Vandana Prasad
Director
Birbal Sahni Institute of Palaeosciences,
53 University Road,
Lucknow 226 007

Non-Member Secretary

Shri Sandeep Kumar Shivhare
Registrar
Birbal Sahni Institute of Palaeosciences,
53 University Road,
Lucknow 226 007

OUR EXPERTISE

EVOLUTION

MORPHOLOGY & TAXONOMY

HIGH RESOLUTION BIOSTRATIGRAPHY

PALAEOBIOGEOGRAPHY

PALAEOCLIMATE, PALAEOECOLOGY & PALAEOENVIRONMENT

VERTEBRATE & INVERTEBRATE PALAEONTOLOGY

RADIOCARBON GEOCHRONOLOGY 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

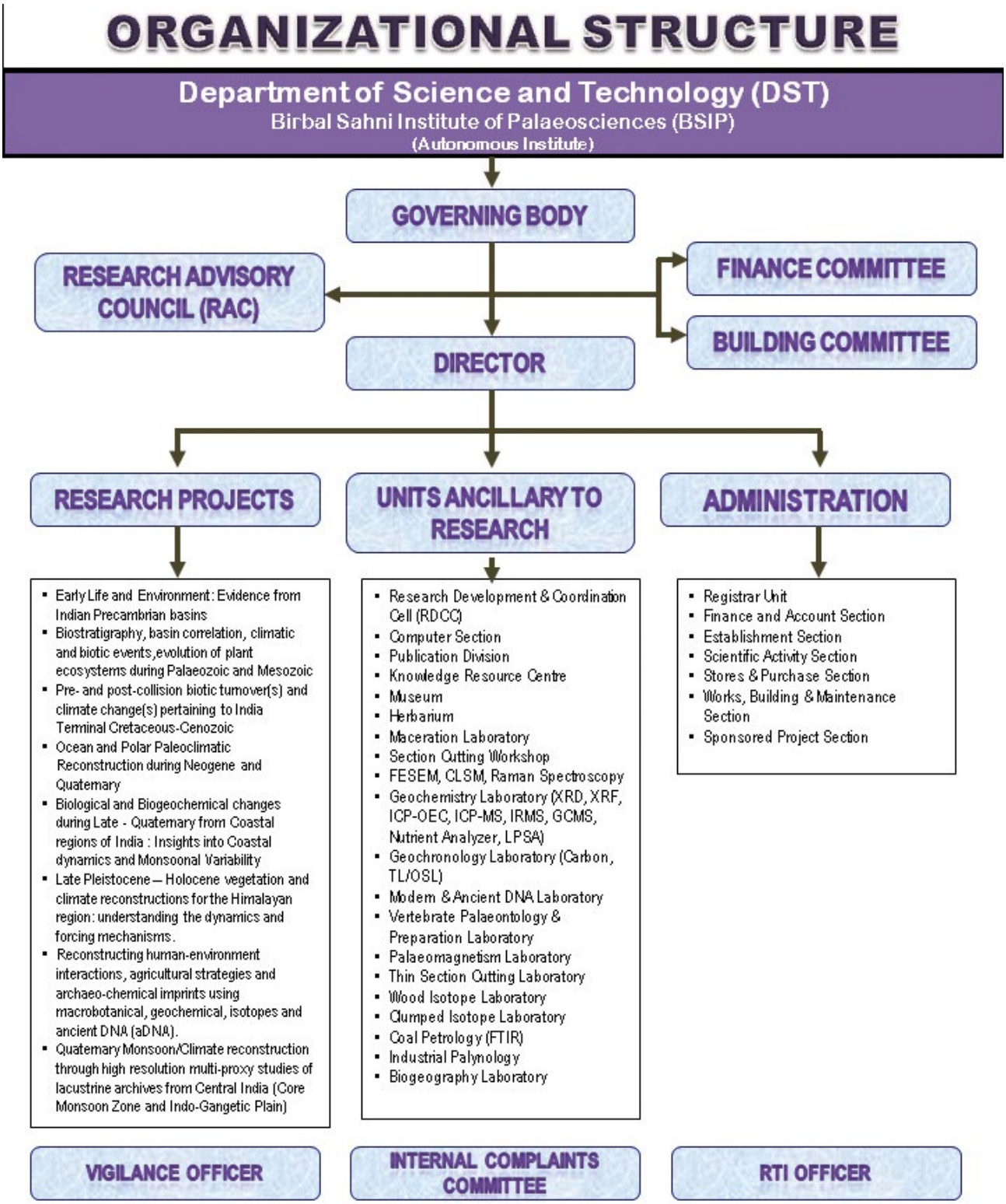
GEOCHEMISTRY: XRD, XRF, ICP-MS, IRMS, GC-MS, LPSA NUTRIENT

LUMINESCENCE DATING

CONFOCAL LASER SCANNING MICROSCOPY WITH RAMAN SPECTROSCOPY

FIELD EMISSION SCANNING ELECTRON MICROSCOPY

ORGANIZATIONAL STRUCTURE



RESEARCH

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

Group Coordinator: Mukund Sharma (Scientist G) **Co-coordinator:** Veeru Kant Singh (Scientist E)

OBJECTIVES

- *Tracing the antiquity of various life forms.*
- *To trace the emergence of photosynthetic oxygenation and subsequent changes in ocean redox structure.*
- *To understand the role of operative processes and depositional environment in the associated sedimentary formations.*
- *Study of life forms and associated biogeochemical processes in the extreme environment from the Archaean and Modern analogues.*

PREAMBLE

Understanding the periods and pathways of the evolution of early life from an anucleated single cell to nucleated cells, converting into multicellular organisms, and their transformation into complex metaphyte and metazoan forms are the main questions investigated under the Precambrian palaeobiology. Megascopic structures formed by simple cells, called stromatolites and microbial mat features, are recorded from the Archaean Eon (4000-2500 Ma) Singbhum and Dharwar Cratons of India. Studies show that most of the early stromatolites and aggregated structures were formed in an anoxic environment. Oxygen, the lifeline of the present biosphere came into the biosphere during the Proterozoic (2500-539 million years before the present). Evidence suggests that the oxygen triggered the eukaryotic diversification, but much is yet to be learned. It can be deciphered through robust geochemical studies (Trace Elements, REE, TOC, carbon isotope, and if possible, sulfur isotope). For these studies, the Vindhyan, the Chhattisgarh, and the Cuddapah Supergroup sediments in central India are investigated. Much older Suket Shale of the Vindhyan Supergroup and younger formations of the Chhattisgarh Supergroup revealed the presence of microbial remains conspicuously similar to 635-539 million years old Ediacaran Complex Acanthomorphic Palynoflora (ECAP). A few Cambrian elements are also recorded. In some cases, the status of fossils and radiometric ages puzzle the normal stratigraphy of the rock units of the Bhander Group of the Vindhyan Supergroup. To address this question, various proxies are being used to resolve this problem of the Suket Shale, Maihar Sandstone, and the Chhattisgarh Supergroup.

PERSONNEL INVOLVED

Team Members: S. K. Pandey (Scientist D), A. H. Ansari (Scientist D), Yogmaya Shukla (Scientist C), Arvind K. Singh (Scientist C), Gurumurthy, G. P. (Scientist C)

Technical Staff: Shivalee Srivastava (TA 'B'), Archana Sonker (TA 'A')

Research Associate: Shamim Ahmad , Bandana Shukla

Research Scholars: Divya Singh, Yogesh Kumar

SIGNIFICANT FINDINGS

Tracing the antiquity of various life forms

On the onset of the Cambrian Period (after 539 million years), some of the complex biota came in existence, unique to their preservation style named as 'Burgess Shale Type Preservation' (BSTP). Elements like, Al, Si, K, and O play an important role for the preservation of BSTP style. The present study has documented the BSTP-style carbonaceous fossils in the rocks of the Singhora Group (~1500–1300 Ma), Chhattisgarh Supergroup. Laser Raman Spectroscopy and Energy Dispersive X-ray Spectroscopy were conducted on these fossils to understand their type of preservation, origin, and affinity of these fossils. The study demonstrates that these fossils are enriched in organic carbon (Fig. 1) and depleted of Al, Si, K, and O in the parts of carbonaceous compressions and show exactly opposite pattern of depletion and enrichment in shale matrix. The Singhora carbonaceous fossils thus indicate the Burgess Shale Type preservation in the Mesoproterozoic sediments.

The abundance of sediment bulldozers, namely crustaceans, coelenterates, arthropods, and different types of bilaterian organisms, are profusely preserved in the lower Cambrian sediments. Their lifestyles, movements, and burrowing activities are collectively known as bioturbation and resultant structures are called ichnofossils such as, *Planolites, Palaeophycus, Treptichnus pedum, Monocraterion, Bergaueria, Skolithos,* etc. to name a few. These ichnofossils are extensively found in the Nagaur Sandstone of the Marwar Supergroup exposed in the Bikaner District of Rajasthan. Interpreting a large dataset of such ichnofossils suggests that the burrowing habit was very dominant in the lower Cambrian Period but gradually decreased in the middle and upper Cambrian and in successive younger stratigraphic stratum. Plotting of the above-mentioned ichnogenera against the palaeoecology suggests that all six ichnofossils are preserved in two different major depositional regimes such as the intertidal and subtidal (Fig. 2). However, burrowing activity was more common in the intertidal regime.

The Biomineralization, a biological advancement and an important step towards the evolution of organisms has generally been noted starting in the Ediacaran-Cambrian transitional sediments. The Bilara Group of the Marwar Supergroup in NW India is the most likely an Ediacaran-Cambrian transition succession and therefore an outcrop section of 23 meters thick Barna II Mine was explored. A transitionary succession encompassing the upper part of the Gotan Limestone and lower part of the Pondlo Dolomite revealed the presence of *Cambrotubulus* sp., a biomineralized tubular calcareous fossil in those sediments. Stable carbon isotope signature and maximum depositional age (based on detrital zircon age) of the sediments also support that this succession witnessed the Ediacaran-Cambrian boundary.

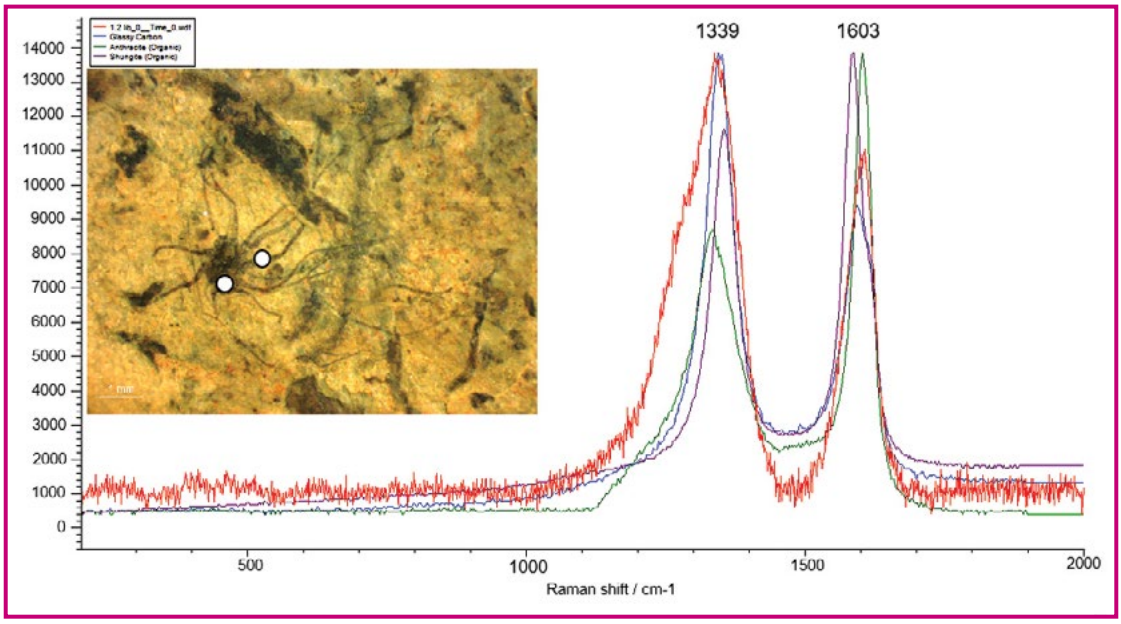


Fig. 1 - Micro-Raman spectra of the Singhora carbonaceous fossil Palaeoscytosiphon shuklaii reflect the concentration of D (disorder) and G (Graphite) bands. Specimen no. BSIP 41897, Scale bar equals 2.0 mm.

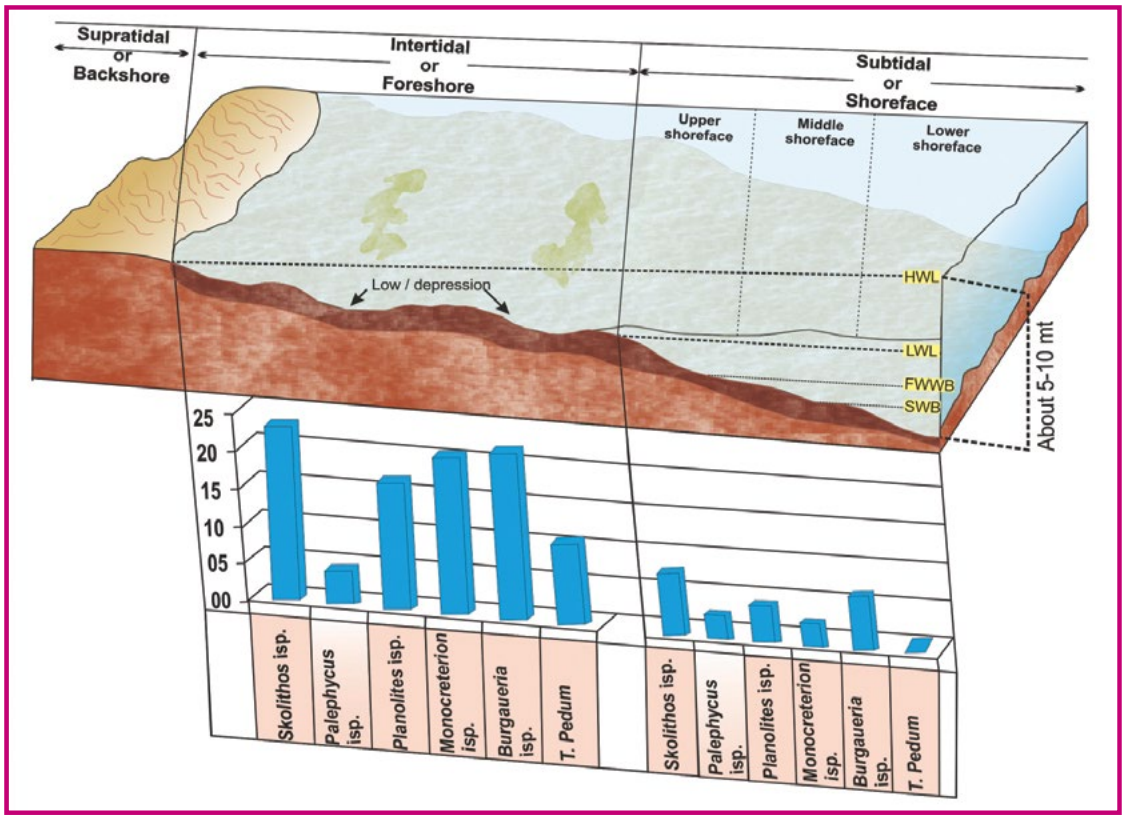


Fig. 2 - A schematic diagram shows the distribution pattern of all six listed ichnogenera in two major depositional regimes: intertidal and subtidal. Significant abundance was seen in the intertidal depositional environment as compared to the subtidal.

To trace the emergence of photosynthetic oxygenation and subsequent changes in ocean redox structure.

The Palaeoproterozoic Era marks the rapid transition of the Precambrian hydrosphere and biosphere where the Earth's surface experienced a major shift from largely reducing to oxidizing conditions. The hydrographic and redox conditions of the Palaeoproterozoic Ocean as recorded in the Vempalle and Tadpatri Formations, lower Cuddapah Basin, Peninsular India were investigated. The negative to positive Eu/Eu* anomaly, light-REE depletion, and enrichment of mid-REE suggest that the precipitating fluid was at high temperature (>250°C) and acidic. The cerium (Ce/Ce*) anomaly is conspicuously missing in the carbonates. This could be due to the dominance of hydrothermal fluid REY signature over the seawater. The chondritic Y/Ho and sub-chondrite Zr/Hf of carbonates suggest that the seawater conditions were acidic and hypersaline with rigorous microbial activity. The redox conditions in the Vempalle and Tadpatri sedimentation are anoxic type, and the sediments are deposited in a restricted environmental condition (Fig. 3).

To understand the role of operative processes and depositional environment in the associated sedimentary formations.

Sedimentological investigation based on grain size, lithology, sedimentary structures, bed geometry, and algal mat structures reveals a total of ten (10) lithofacies in the Vempalle Formation and seven (7) lithofacies

in the Tadpatri Formation. Facies analysis indicates that the Vempalle Formation deposited in inner-outer mixed siliciclastic-carbonate ramp setting, which is occasionally reworked by tidal and storm currents, whereas sedimentation in Tadpatri Formation initiated on proximal to inner shelf setting which gradually transformed into mixed siliciclastic-carbonate ramp setting. The growth of various types of stromatolites on the Vempalle and Tadpatri carbonate platforms suggest that it maintained a shallow depth throughout its life, keeping pace with subsequent sea-level changes. Quartz overgrowth and interlocking texture in recrystallized vein intrusion within the Vempalle carbonates indicate evidence of hydrothermal fluid activity (Fig. 4).

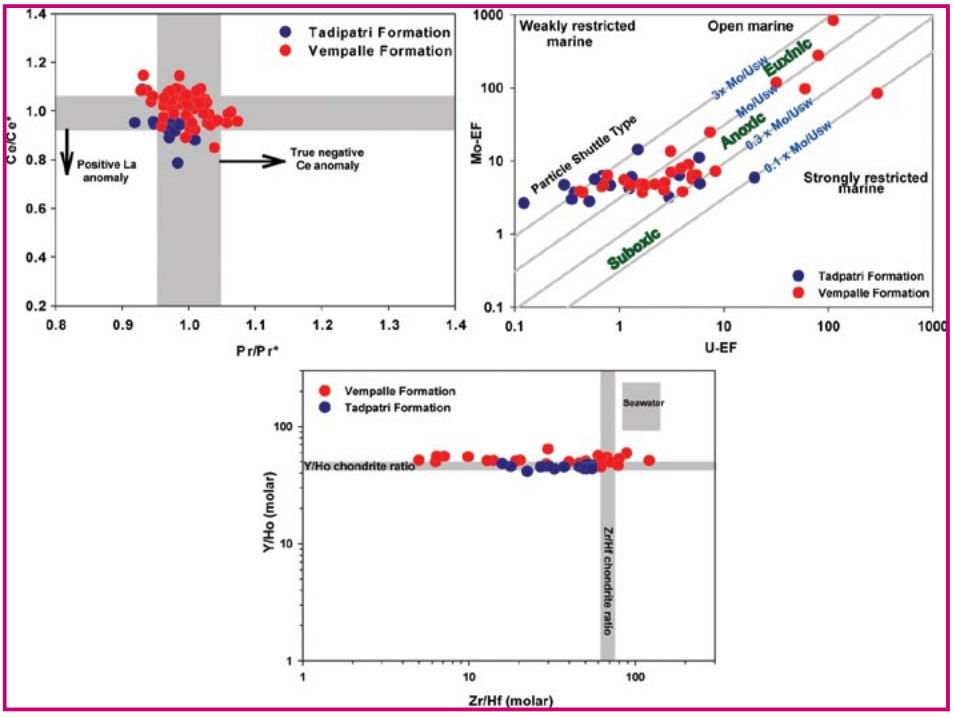


Fig. 3 - Trace and rare earth elements ratio plots show anoxic conditions in a restricted environment with rigorous microbial activity.

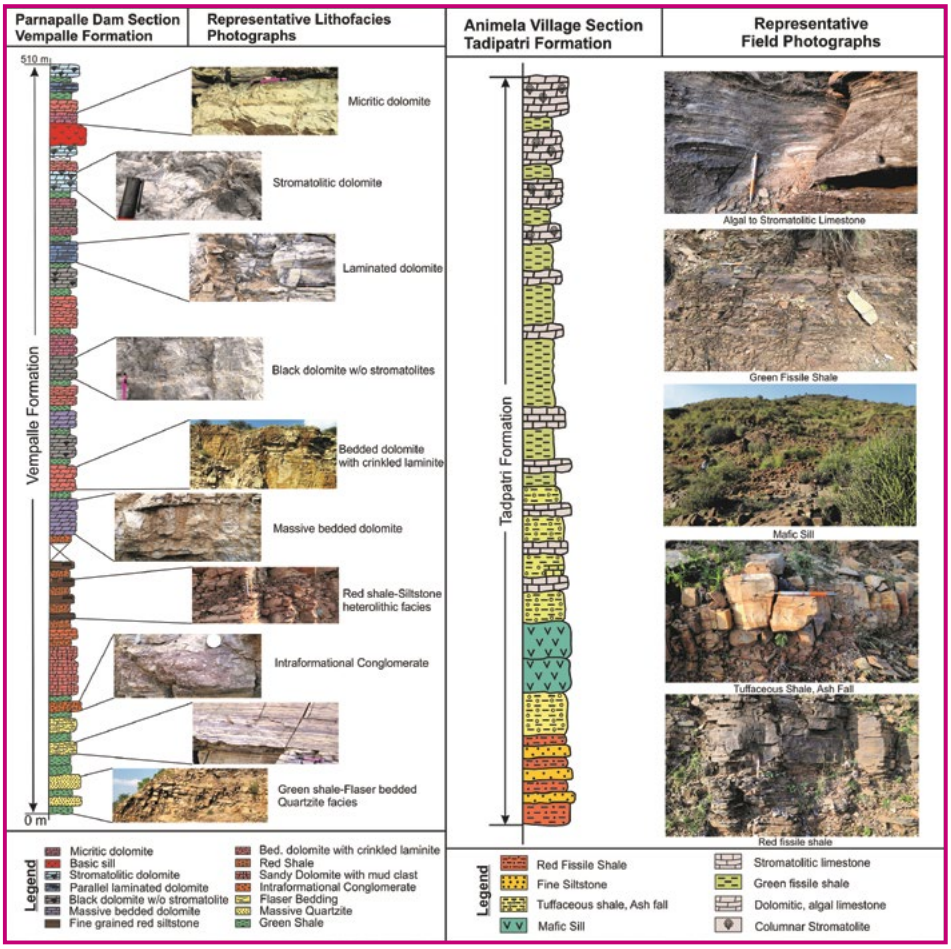


Fig. 4 - Facies lithology shows the total of ten lithofacies in the Vempalle Formation and seven lithofacies in Tadpatri Formation based on grain size, lithology, sedimentary structures, bed geometry, and algal mat structures.

Study of life forms and associated biogeochemical processes in the extreme environment from the Archaean and Modern analogues.

New Archaean stromatolites from the Kumsi Village, Shivamogga District, Karnataka have been studied. The stromatolites belong to the Joldhal Formation (>2.6 Ga), Chitradurga Group, Shimoga Schist Belt, Dharwar Craton India (Fig. 5).

The field work has been carried out in the Ladakh region and covered 10 localities encompassing modern hypersaline lakes, dunes, and hot springs (Fig. 6). Field work was targeted for the characterization and documentation of extremophiles for the Mars analogue studies on Earth. In this regard, water, biofilms, sediments, rocks, lichens, and shrub leaves were collected. Processing and analysis of the samples are in progress.

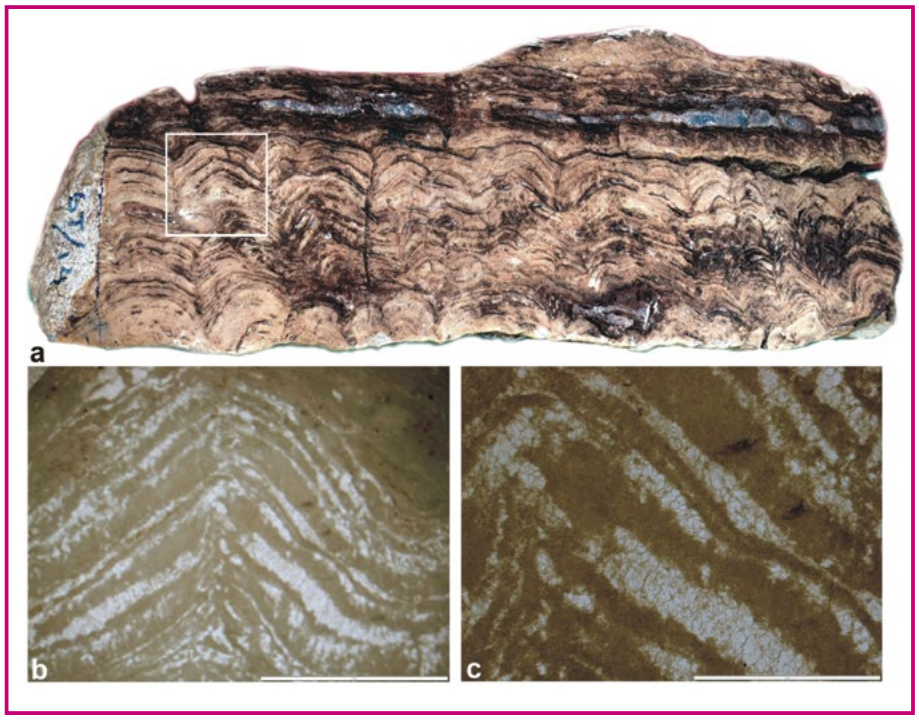


Fig. 5 - Archaean (>2.6 Ga) stromatolites from Shimoga Schist Belt, Dharwar Craton, India.

Fig. 6 - Field photographs of the Puga Hotspring showing collection process of algal sample.

PROJECT OUTCOME

In SCI (Science Citation Index) Journals

1. Ahmad S, Pandey SK, Sharma M & Srivastava A 2021. The early Cambrian (Series 2, Stage 3) burrows from the Nagaur Sandstone, Marwar Supergroup, Rajasthan, India: palaeoenvironmental and palaeoecological considerations. Journal of the Palaeontological Society of India 66(2): 271-289. **(IF: 0.652)**
2. Ansari AH, Singh VK, Sharma M & Kumar K 2022. High authigenic Co enrichment in the non-euxinic buff-grey and black shale of the Chandarpur Group, Chhattisgarh Supergroup: Implication for the late Mesoproterozoic shallow marine redox condition. Terra Nova 34(1): 72-82. **(IF: 3.271)**
3. Ansari AH & Pandey SK 2021. Authigenic δ^{13}C-carb Negative Excursion in the Late Ediacaran–Early Cambrian Bilara Group, Marwar Supergroup, India. Journal of the Geological Society of India 97(6): 615-624. **(IF: 1.466)**
4. Bhan U, Singh D, Sharma M, Singh D & Pandey SK 2021. A note on the Fan-Fabric Structures in the late Palaeoproterozoic Kajrahat Limestone, Katni, M.P., India. Journal of the Palaeontological Society of India 66(2): 315-322. **(IF: 0.652)**
5. Kumar Y, Shukla Y, Singh VK, Sharma M & Goswami S 2021. Confocal Laser Scanning Microscopy (CLSM) of newly recovered microfossil assemblage from the Kurnool Group, South India: New insights on microfossil morphology. Journal of the Palaeontological Society of India 66(2): 258-270. **(IF: 0.652)**
6. Lan Z, Pandey SK, Zhang S, Sharma M, Gao Y & Wu S 2021. Precambrian crustal evolution in Northern Indian Block: Evidence from detrital zircon U-Pb ages and Hf-isotopes. Precambrian Research 361: 106238. **(IF: 4.261)**
7. Singh D, Sharma M, Bhan U, Pandey B, Pandey SK & Deepak Singh 2021. Carbonate Fan Fabric Structures (FFS) in time and space: A case study from the Palaeoproterozoic Kajrahat Limestone, Vindhyan Supergroup, India. Journal of the Palaeontological Society of India 66(2): 290 - 302. **(IF: 0.652)**
8. Singh VK & Sharma M 2021. *Dictyosphaera macroreticulata* and *Valeria lophostriata* from the late Mesoproterozoic Chaporadih Formation, Chhattisgarh Supergroup and their significance. Journal of the Palaeontological Society of India 66(2): 141-155. **(IF: 0.652)**
9. Sharma M, Shukla Y & Sergeev VN 2021. Microfossils from the Krol 'A' of the Lesser Himalaya, India: Additional supporting data for its early Ediacaran age. Palaeoworld 30(4): 610-626. **(IF: 2.717)**
10. Tang Q, Pang K, Li G, Chen L, Yuan X, Sharma M & Xiao S 2021. The Proterozoic macrofossil *Tawuia* as a coenocytic eukaryote and a possible macroalga. Palaeogeography, Palaeoclimatology, Palaeoecology 576: 110485. **(IF: 3.565)**

Refereed Non-SCI Journals

1. Sharma M, Singh VK, Pande SK, Ansari AH, Shukla Y, Ahmad S, Kumar Y & Singh D 2021. Precambrian and early Cambrian palaeobiology of India: *Quo Vadis*. Proceedings of the Indian National Science Academy 87: 199-233.

Publications other than the Project Work

1. Aggarwal N, Mathews RP, Ansari AH, Thakur B & Agrawal S 2022. Palaeoenvironmental reconstruction for the Permian (lower Gondwana) succession of the Godavari Valley Coalfield in southern India based on a combined palynofacies, carbon isotope, and biomarker study. Journal of Palaeogeography 11(1): 123-144. **(IF: 2.789)**
2. Colleps CL, McKenzie NR, Guenthner WR, Sharma M & Gibson TM 2021. Apatite (U-Th)/He thermochronometric constraints on the northern extent of the Deccan large igneous province. Earth and Planetary Science Letters 571: 117087. **(IF: 5.785)**
3. Colleps CL, McKenzie NR, Sharma M, Liu H, Gibson TM, Chen W & Stockli DF 2021. Zircon and apatite U-Pb age constraints from the Bundelkhand craton and Proterozoic strata of central India: Insights into craton stabilization and subsequent basin evolution. Precambrian Research 362: 106286. **(IF: 4.261)**
4. Kavali PS, Roy A, Pasquo MD, Gurumurthy GP, Sharma G & Kumar A 2021. New age of the lower Talchir Formation in the Wardha Basin, central India, based on guide palynomorphs present in radiometrically- dated palynozonations in South America, Africa, and Australia. Ameghiniana 58(4): 318-344. **(IF: 1.5)**
5. Mishra S, Singh SP, Arif M, Singh AK, Srivastava G, Ramesh BR & Prasad V 2022. Late Maastrichtian vegetation and palaeoclimate: palynological inferences from the Deccan Volcanic Province of India. Cretaceous Research 133: 105126. **(IF: 2.432)**

6. Quamar MF, Thakur B, Singh VK & Pandey SK 2021. Pollen heteromorphism in *Schleichera* Lour. (Sapindaceae), observed in surface soil samples from central India. Acta Palaeobotanica 61(1): 32-41. **(IF: 0.69)**

7. Sarath PK, Mangalaa KR, Cardinal D, Gurumurthy GP, Dapoigny A, Sarma VVSS & Riotte J 2022. Seasonal, weathering and water use controls of Si cycling along the river flow in two contrasting basins of south India. Chemical Geology https://doi.org/10.1016/j.chemgeo.2022.120883. **(IF: 4.685)**

8. Schwendimann L, Sivaprakasam I, Buvaneshwari S, Gurumurthy GP, Mishra S, Ruiz L, Sekhar M, Fleiss B, Riotte J, Mani S & Gressens P 2021. Drinking groundwater from an agricultural area in India has negative effects on mouse brain development. Ecotoxicology and Environmental Safety 224: 112635. **(IF: 7.129)**

9. Singh AK & Chakraborty PP 2021. Geochemistry and hydrocarbon source rock potential of shales from the Palaeo-Mesoproterozoic Vindhyan Supergroup, central India. Energy Geoscience https://doi.org/10.1016/j.engeos.2021.10.007.

SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

SP 1.1: Correlation of Vindhyan in Son and Chambal valleys by using High-resolution Biostratigraphy, Chemostratigraphy, Palaeoredox reconstruction, Palaeoenvironment, and Palaeogeography *(*Sponsored by Oil and Natural Gas Corporation Ltd. (ONGC) w.e.f. 06/09/2021).

Investigators: Mukund Sharma, Veeru Kant Singh, S. K. Pandey, Bandana Shukla & Yogesh Kumar

A preliminary set of 56 samples, provided by the Oil and Natural Gas Corporation Limited (ONGC) was processed. The palaeobiological investigations, viz. scanning, photo documentation, and identification of extracted organic matter are in progress using a high-resolution optical microscope. An additional 464 cutting samples from well SK-A, CH-A, Pl-A of the Chambal Valley section were collected from the ONGC core library.

SP 1.2: Ediacaran Complex Acanthomorph Palynoflora (ECAP) based biostratigraphy of the Krol Belt of the Lesser Himalaya, northern India: Significance for global correlation (SERB, New Delhi, No: EEQ/2021/000787 w.e.f. 09.03.2022).

Investigator: Veeru Kant Singh

The project aims to establish the Ediacaran Complex Acanthomorph Palynoflora (ECAP) based biostratigraphy of the Krol Belt exposed in the Lesser Himalaya to understand the origin, antiquity, and affinity, evolution, diversification, and potential refinement of biostratigraphic zonation during the Ediacaran Period. The intended research will strengthen the taxonomic foundation for acanthomorph biostratigraphy on a global scale and provide a better framework to support the investigation of Ediacaran biological and environmental evolution.

SP 1.3: Probing the evolution of Late Miocene bottom water oxygenation: A stable metal isotope constraints (Sponsored by NCPOR, No.: NCAOR/IODP/20-15/15(V))

Investigator: Gurumurthy G.P.

Geochemical and isotopic studies have been carried out on marine sediments collected from the Arabian Sea to probe the late Miocene oxygenation history. The sediment depositional environment from late Miocene to Pliocene was oxic in the Arabian Sea. The sediment depositional environment since the Pleistocene was weakly-oxic in the Arabian Sea. Fractionated isotopic ratio role of Fe-Mn cycling was determined with the help of $\delta^{98/95}$Mo (-0.70 to 1.18 ‰) and $\delta^{186/184}$W (-0.02 to 0.21 ‰).

SP 1.4: Advent of Motile life (Sponsored by DST, New Delhi as part of DST Inspire Faculty programme; Project No. DST/INSPIRE/04/2017/002038)

Investigator(s): Adrita Choudhuri (PI)

Some suspected behavioural patterns by primitive life from the Sirbu Shale Member of Bhander Formation, Upper Bhander Group were observed at the sole of the storm-laid sandstone, deposited at the basal part of the shelf where the mud is thickest. The suspected features are diverse in orientation, numerous in numbers and ridge like in morphology having positive relief at the bed sole. Close inspection reveals two types of morphological patterns (a) short (<1 cm in length) ridges and (b) long ridges continuing up to 2.5 cm in length. Both these varieties are often associated with remnant of microbial mat fragments showing wrinkle structures (Fig. SP 1.4).

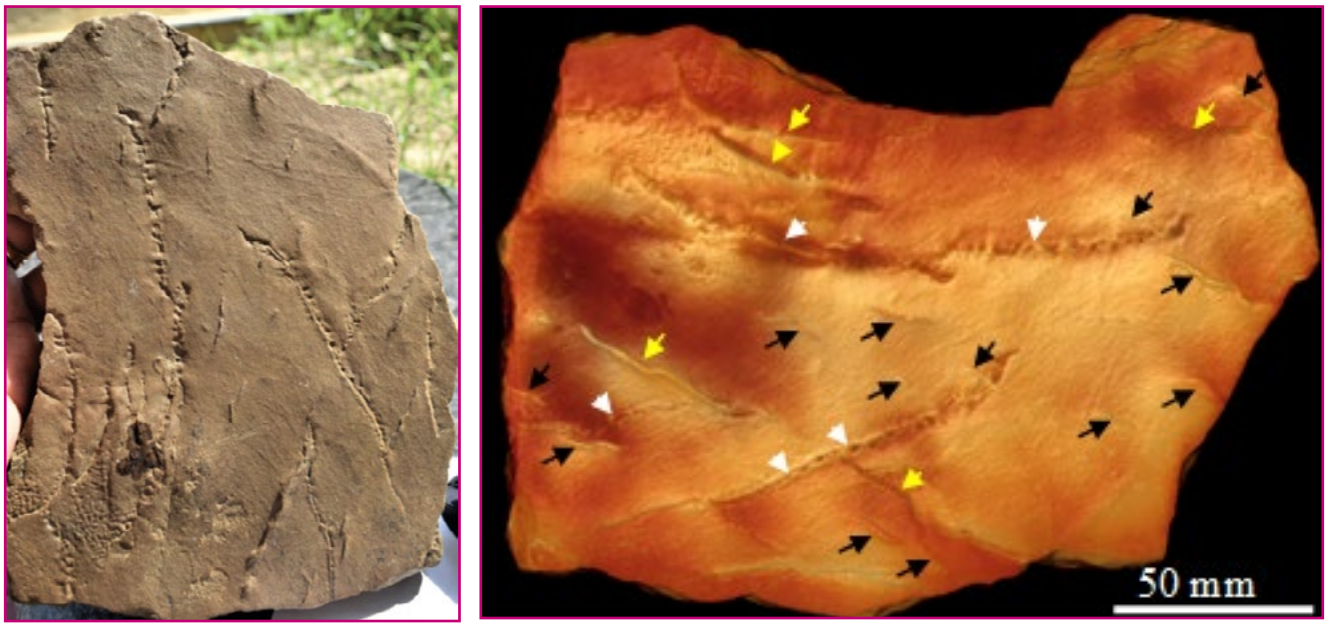


Fig. SP 1.4 - Field photograph and Micro-CT image of some suspected behavioural patterns of primitive life recorded from the Sirbu Shale Member of Bhander Formation, Vindhyan Supergroup, India.

CP 1.1: Veeru Kant Singh & [Uday Bhan, Annapurna Boruah, Maurya, D.S. (UPES, Dehradun), Rai, S.K. (WIHG, Dehradun), Goswami, L. (IITG, Assam & Chandigarh University, Chandigarh)]

The Proterozoic black shales of the Rohtas Subgroup in the Vindhyan Basin are analyzed to assess their hydrocarbon generation potential. A total of 50 core samples of shales and limestones were collected from the borehole core of the Rohtasgarh Limestone in Amehta Mine, located in Katni District, Madhya Pradesh. The total organic content (TOC), hydrogen index (HI), oxygen index (OI), Tmax ranges, production index (PI) and the thermal alteration index (TAI) analysis suggest that the Rohtasgarh shales fall within the window of maturated organic matters with gas-prone type III & IV kerogen.

CP 1.2: Arvind K. Singh & [Prof. P. P. Chakraborty, University of Delhi, New Delhi]

With growing shale gas exploration, the six argillaceous intervals (the Arangi, Koldaha, Rampur, Bijaigarh, Rewa, and Sirbu shales) from Son Valley of the Vindhyan Basin were explored to understand provenance, palaeoclimate, and hydrocarbon generation potential. Geochemical investigation indicates that the Vindhyan sediments derived from felsic source(s) except for the Sirbu Shale which has an additional influx of mafic rocks. A comparative study of Vindhyan Shale rare earth elements (REEs) points to Mahakoshals and Chhotanagpur Gneissic Complex (CGC) as probable sediment provenance for Vindhyan sediments. The evolution in weathering and palaeoclimate indicates a transformation from moderate weathering conditions with warm and humid climate during lower Vindhyan to intense weathering conditions with hot and humid climate during upper Vindhyan. Based on the modified Van Krevelen correlation (HI vs. Tmax) diagram, organic matter from Arangi and Bijaigarh shales is characterized as thermally mature, Type III kerogen of gas-prone character indicating good to very good gas generation potential (Fig. CP 1.2).

CP 1.3: Gurumurthy G.P. & [Tripti Muguli, DST-Inspire Faculty, NCESS, Trivandrum]

The changes in redox conditions in the southeastern Arabian Sea due to orbital forcing have been investigated using geochemical and isotopic proxies. The study reveals that the productivity was high and bottom water condition was suboxic to anoxic during LGM (18.5-22.8) in the southeastern Arabian Sea. The sea surface temperature (SST; basic temperature during calcification) has been estimated based on Mg/Ca molar ratio for Quaternary using *Globigerinoides ruber* retrieved from southeastern Arabian Sea sediment core to back validate the elemental analysis in natural carbonates. The estimated mixed layer SST of the eastern Arabian Sea since the last glacial maximum (LGM) clearly reflected the ramping temperature trend of the southeastern Arabian Sea's Pleistocene to Holocene transition.

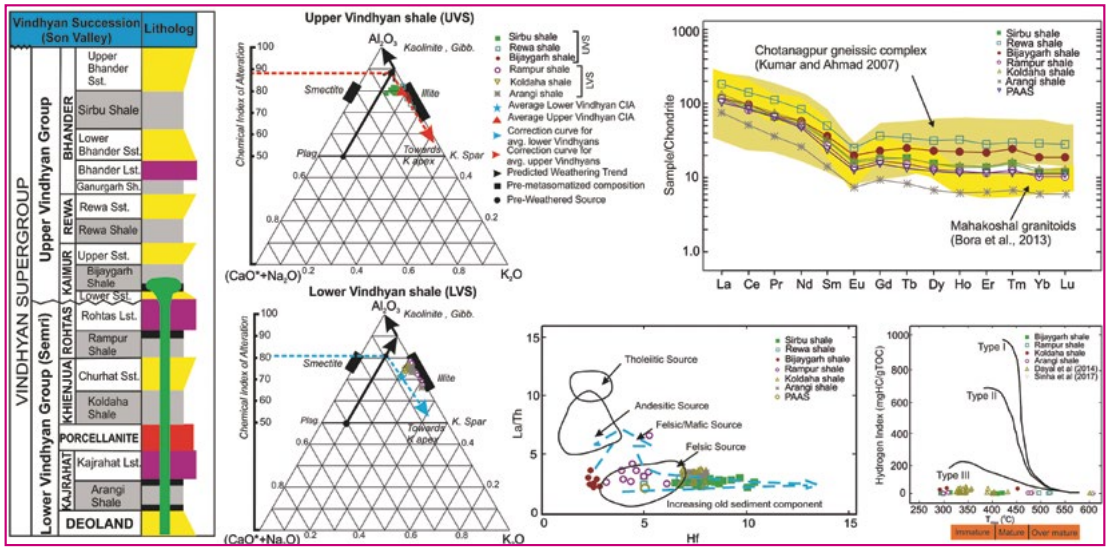


Fig. CP 1.2 - Schematic diagram showing lower and upper Vindhyan stratigraphy in Son Valley. Trace, rare earth element, and hydrogen index ratio plots represent palaeoweathering, provenance, mineral sorting, and organic matter maturation of Vindhyan sediments.

CP 1.4: Gurumurthy G.P. & [Jean Riotte (GET Toulouse), Damien Cardinal (LOCEAN, France), VVVS Sarma (NIO Visakhapatnam)]

The river waters of the east-flowing Kaveri River and west-flowing Netravathi River, both originating in the Western Ghats, were studied for determining the silicon isotopic compositions of the two contrasting basins in south India. The $\delta^{30}Si$ values range from 0.42 to 1.65‰ for the Netravathi Basin and 0.32 to 2.85‰ for the Kaveri River Basin. Re index shows intense weathering associated with monosiallitization (kaolinite-gibbsite formation) in the Netravathi Basin and relatively moderate weathering with bisiallitization (smectite-kaolinite formation) in the Kaveri Basin. The influence of diatom uptake was negligible in the Kaveri River water and dams, except in one reservoir with higher $\delta^{30}Si$ and lower DSi. $\delta^{30}Si$ values of Kaveri and Netravathi agree with river water across the globe and a compilation of silicon isotopic composition and Re index shows a linear trend indicating lower $\delta^{30}Si$ associated with intense weathering.

CP 1.5: Gurumurthy G.P. & [Jean Riotte (GET Toulouse)]

The consequence of drinking groundwater from an agricultural area, rich in nitrates with high salinity, on the development of the brain of the mouse, is studied. For this, water from a borewell located in an intensely cultivated land was given to mice during pregnancy and lactation. The brains of the off springs born to these mothers were analysed and compared on several cellular parameters across many brain regions with brains from offspring's born to mothers who had been given water from a borewell located in a nearby pristine forest. At the time of weaning, the brains of pups born to mothers who had ingested borewell water located in highly cultivated land had a significant loss of neurons in the motor cortex. White matter astrocytes numbers were significantly decreased. This study shows that brain development is sensitive to water composition and points to the importance of assessing neurodevelopmental delays when studying environmental hazards, including water with agricultural runoffs, on human health.

OTHER ACADEMIC WORKS

Research Papers presented

1. Alam M, Gurumurthy GP, Tripti M, Arif M, Sohrin Y, Singh AD, Radhakrishna T, Pandey DK & Verma K - The late Miocene monsoon evolution and erosion history of the western Himalaya: insight from IODP Site U1457. Frontiers in Geosciences Research Conference (FGRC) – 2021 (online) organized by Physical Research Laboratory, Ahmedabad.
2. Basu P, Ansari AH, Chakrabarti R & Sharma M - Geochemical and $^{87}Sr/^{86}Sr$ and $\delta^{44/40}Ca$ compositions of Ediacaran Carbonates from the Indian Shield: Understanding Preservation of Local versus Global Biogeochemical Signatures during Periods of Extreme Environmental Changes**.** AGU Fall Meeting organized by American Geophysical Union, USA, 13-17 December 2021.

3. Kumar Y, Shukla Y, Singh VK, Sharma M & Goswami S - Investigations on the OWMs under the Confocal Laser Scanning Microscope (CLSM): A case study from the Owk Shale. National Seminar on 'Recent Advances in Geoscience Research in India' organized by Delhi University, 01-02 July 2021.
4. Shukla Y & Sharma M- Microfossils and age controversy on the rocks of Kurnool Group of south India: A debate" by (oral presentation). 53rd Annual Meeting of the AASP-The Palynological Society" organized by Natural History of Museum, London, 09-13 August 2021.
5. Singh VK, Sharma M, Ansari AH & Lan Z - New assemblage of Organic-Walled Microfossils (OWM) from the Mesoproterozoic Chandarpur Group, Chhattisgarh Supergroup, Peninsular India. 53rd Annual Meeting of the AASP-The Palynological Society" organized by Natural History of Museum, London, 09-13 August 2021.

Deputation to Conferences/Seminars/ Workshops (both online and offline)

Veeru Kant Singh

- 53rd Annual Meeting of the AASP-The Palynological Society organized by Natural History of Museum, London from August 09-13, 2021 (Virtual).
- International Workshop on "Bias in the Fossil Record" organized by Natural History of Museum, London on August 05, 2021 (Virtual).

Training/Study Visits

- **vind K. Singh** - 'Palynology and its application in climate change studies' held online at Regional Training Division (RTD), GSI, Lucknow from 26th – 30th November 2021.

Lectures delivered

Arvind K. Singh

- 'Sediment dynamics and basin tectonics evolution of Vindhyan Basin'. Training titled "Course on sedimentary mapping techniques in Vindhyans". Regional Training Division, GSI, Northern Region, Lucknow, from 22nd – 27th November 2021.
- Palaeobotany: an insight on sediment-fossil interaction as well as the gateway to palaeoclimatic studies" at UGC-HRDC, B.R.A. Bihar University, Muzaffarpur on 14th January 2022.

Gurumurthy G.P.

- Ocean oxygen past and present. International Conference on Earth and Environment in Anthropocene (ICEEA- 2021), Central University of Karnataka, Gulbarga held on 29th -30th October 2021.

Mukund Sharma

- An odyssey of life on the Earth: A Saga of three billion years. National Conference on Indian Scientific Heritage, Hindu Girls College, Sonipat, 26th - 28th February 2022.
- Palaeobiology and Biostratigraphy of the Vindhyan Supergroup. Geological Survey of India, Training Institute, Northern Region, Lucknow 24th October 2021.
- Answer to Darwin's Question on Evolution lies in Precambrian Palaeobiology Department of Geology, University of Delhi, Webinar, Friday, 22nd October 2021.
- Hamari Bhu Virasat: Dasa aur Disha, BSIP Hindi Pakhwara, 14th September 2021.

S.K. Pandey

- Status of the Bhander Group (the youngest succession of the Vindhyan Basin) and correlation: A promising window to encounter the Ediacaran biosphere! e-training on "Course on sedimentary mapping techniques in Vindhyan", Regional Training Division, GSI-NR, Lucknow on 24th November 2021.

Yogmaya Shukla

- Course 1(a) Research Methodology Module Title: Writing & Communication of Research Results and Inferences

PH.D. PROGRAMMES

Nandita Tiwari (2014). Neogene Chara fossils assemblages from India, in the context of extant forms, palaeobiological issues, and geological inferences under the supervision of **Mukund Sharma (BSIP)**, Uday Bhan (UPES), UPES, Dehradun. Status: In progress.

Yogesh Kumar (2017). Palaeobiology and chemostratigraphy of the Kurnool Group, South India under the supervision of **Mukund Sharma (BSIP)**, Prof. Shreerup Goswami, Sambalpur University, Odisha. Status: In progress.

Chethan Kumar (2018). Signatures of Archaean Microbial life records in the Greenstone Belts of the Dharwar Craton, India under the supervision of **Mukund Sharma (BSIP)**, N. Malarkodi, Bangalore University, Karnataka. Status: In progress.

Mahboob Alam (2018). Palaeoclimatic and palaeoceanographic studies of eastern Arabian Sea using geochemical and isotopic proxies under the supervision of **Gurumurthy GP (BSIP)**, Komal Verma (BHU), Banaras Hindu University, Varanasi. Status: In progress.

Mohammad Arif Ansari (2021). Study of the Holocene OMZ dynamics in the Eastern Arabian Sea (EAS) under the supervision of **Arif Husain Ansari (BSIP)**, registered with AcSIR, New Delhi. Status: In progress.

Divya Singh (2019). Palaeobiology and geochemistry of chemically precipitated rocks of the Semri Group, Vindhyan Supergroup in understanding the evolution of life under the supervision of **Mukund Sharma (BSIP)**, **S. K. Pandey (BSIP) &** Bindhyachal Pandey (BHU), Banaras Hindu University, Varanasi. Status: In progress.

Ananya Deepak (2021). Testing the Precambrian reverse weathering hypothesis using a 1- billion- year record of marine shales under the supervision of Stefan Loehr, Macquarie University, NSW, Australia, and co-supervision of **Mukund Sharma (BSIP)**, India. Status: In progress.

ACCOLADES RECEIVED

Representation in Committees/Boards

Mukund Sharma

- President, The Society of Earth Scientists, India (2020-2023).
- Vice President, The Palaeobotanical Society, India (2019-2021).
- Fellow, The Geological Society of India, Bangalore.
- Fellow, The Palaeontological Society of India, Lucknow.
- Fellow, The Palaeobotanical Society, Lucknow.
- Fellow, Gondwana Society, Nagpur.
- Editor, Journal of the Palaeontological Society of India, Lucknow (2020-2022).
- AcSIR Dean's nominee for Biological Sciences.
- Voting Member, Sub-commission on Ediacaran Stratigraphy.
- Member, Sub-commission on Cryogenian Stratigraphy.
- Member, The Indian Museum of Earth Science (TIME) Establishment Committee.
- Member, The Indian Science Congress Association, Kolkata.
- Member, Indian Geological Congress, Roorkee.

Veeru Kant Singh

- Fellow, The Palaeontological Society of India, Lucknow.
- Fellow and Member Executive body, The Palaeobotanical Society, Lucknow.
- Fellow, The Society of Earth Scientists, India.
- Fellow, The Geological Society of India.

S.K. Pandey

- Life Member-Indian Science Congress Associations.
- Life Member-The Palaeontological Society of India.

Yogmaya Shukla

- Life Member, The Indian Science Congress Associations.
- Life Member, The Palaeontological Society of India.
- Voting Member**,** The Sub-commission on Pre-Cryogenian Stratigraphy –International Commission of Stratigraphy.

Gurumurthy G.P.

- Member -Doctoral Advisory Committee (DAC), Manipal Academy of Higher Education (MAHE), Manipal 2018- 2021.
- Associate Editor- Arabian Journal of Geosciences, Springer Verlag.

- Reviewer for Science of the Total Environment, Elsevier.

Arvind K. Singh

- Life Member - Himalayan Geology, Wadia Institute of Himalayan Geology, Dehradun.
- Life Member - Indian Science Congress Association, Kolkata.
- Sponsored Member - International Association of Sedimentologists.

Shamim Ahmad

- Life Member - The Palaeontological Society of India.
- Academic Editor - PLoS ONE journal.

Project 2: Biostratigraphy, Basin Correlation, Climatic and Biotic Events during Palaeozoic and Mesozoic

Coordinator: Srikanta Murthy (Scientist E) **Co-coordinator:** Anju Saxena (Scientist D)

OBJECTIVES:

- *To resolve the age constraints of the Talchir Formation based on palynological correlations with radiometrically constrained assemblages across Gondwana and associated palaeoclimate changes across the glacial and postglacial sequences.*
- *To comprehend pathways and timings of marine incursions and sequence biostratigraphic framework across Gondwana deposits during the late Palaeozoic-Mesozoic sequences.*
- *To assess and delineate the events of biotic crisis-recovery and subsequent radiation of biota and extreme climatic events (OAEs) across the Permian-Triassic and Jurassic-Early Cretaceous sequences.*
- *Evolution of plant ecosystem with special emphasis on radiation of seed plants and phylogenetic studies to trace the early Angiosperms evolution in Indian context.*

PREAMBLE

The research work deals with deep time sediments which are 100 to 300 million years old and geologically belong to the Gondwana System. The Geological Survey of India initially characterised these sediments in east central India, south of the Narmada River, an area inhabited by Gond tribe and thus designated them as Gondwana. Later, coeval successions with similar lithological and palaeontological signatures were discovered in most of the Southern Hemisphere continents of the earth which suggest former continuity of these landmasses. In India, these successions distributed both in surface and subsurface profile in Damodar, Rajmahal, Son-Mahanadi, Satpura and Wardha-Godavari along with some parts of extra peninsular regions. The research activities mainly aim to resolve issues related to biostratigraphy, palaeoclimate and hydrocarbon exploration with integration of microfossils and macrofossils assemblage, along with sedimentological and geochemical parameters. The research findings contribute towards the understanding of the geochronological framework of Gondwana regions, origin, and evolution of land plants during the Paleozoic and Mesozoic times and the potential influence of latitudinal controls on the flora and fauna through time. It also provides insights into the vegetation, palaeoclimate and associated tectonics that contributed to the formation of coal, which meets the current energy demands of the nation. Gondwana Basins of India account for nearly 99% of coal resource of the country and hold a premier position in India for having a considerable share of reserve of thermal grades non-coking coal for catering to the demand of coal in various parts of the country.

PERSONNEL INVOLVED

Team Members: K. Pauline Sabina (Scientist E), Suresh K. Pillai (Scientist E), Deepa Agnihotri (Scientist D), Abha Singh (Scientist D), Neha Aggarwal (Scientist D), Neelam Das (Scientist D), Divya Kumari Mishra (Scientist B), Ranveer S. Negi (Scientist B), Sabyasachi Mandal (Scientist B)

Associate Members: G.P. Gurumurthy (Scientist C), Runcie Paul Mathews (Scientist C)

Technical Support: Ms. Shivalee Srivastava (TA B)

Research Associate: Saurabh Gautam

Research Scholars: Raj Kumar, Husain Shabbar, Suyash Gupta, Alok Mishra, Deveshwar P. Mishra, Nazim Deori, Suraj Kumar

SIGNIFICANT FINDINGS

Climatic oscillations, vegetation and sea level changes were mostly driven by glacial–interglacial fluctuations, controlled by factors such as orbital cycles, plate tectonic and volcanic events among others. These oscillations accompanied strong floristic signals represented by seasonally dry- to humid vegetation depending on local latitudinal and altitudinal positions, and climatic conditions. The Late Carboniferous and Early Permian interval (ca. 300 Ma) is best time to analyse responses of vegetation to glacial-interglacial oscillations, as it records the termination of the Late Paleozoic Ice Age (LPIA) and its transition from cold to warm-climate conditions which was well established in the mid- late Permian. In India, this phase is documented in the Talchir Formation, base of the Gondwana sequence located in the southern temperate high palaeolatitude. The palynological investigation of the borehole samples of the Talchir Formation, comprising trilete spores of lycophytes and monilophyte affinities and pollen grains of gymnosperm groups along with algal remains. The floristic variation enabled demarcation of five climatic phases in response to glacial-interglacial rhythms as depicted in Fig 1. These climatic shifts are also supported by geochemical results from TOC and δ^{13}Corg analyses.

To understand the marine incursions in fluviatile dominated Gondwana deposits, Barakar sediments of the Damodar Basin (Ashoka Mine) were analysed for multiproxy study involving palaeofloral content, organic geochemistry, and coal petrographic studies (Fig. 2). The studied coal samples are mainly constituted by the

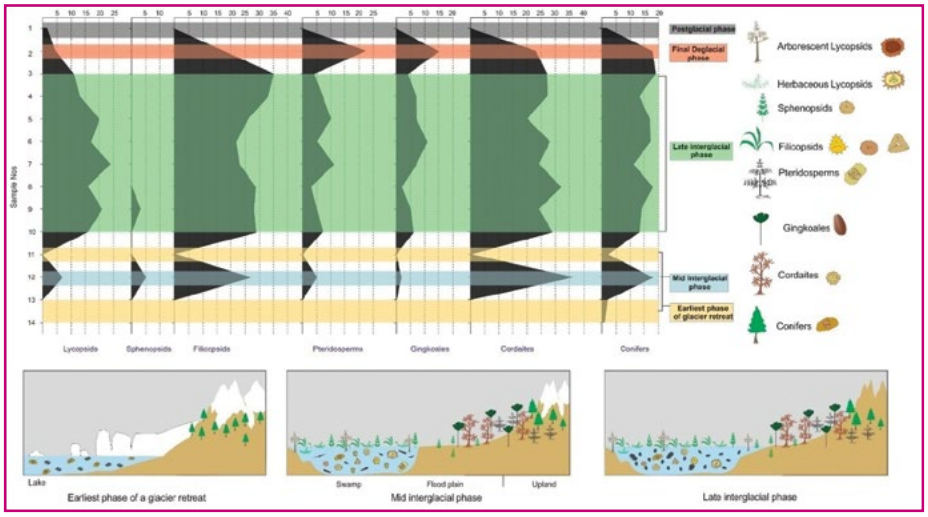


Fig. 1 - Demarcation of five palaeoenvironmental stages in the studied sequence based on the relative abundance of the plant groups.

inertinite group of macerals followed by vitrinite group showing higher plants mainly contribute to the peat, while liptinite group contribute least to the organic composition. The petrographical indices suggest that these coals were deposited in limno-telmatic to telmatic settings under ombrotrophic hydrological conditions. However, the relative high mineral matter contents indicate a sudden change in the hydrological settings (rheotrophic) could be related to flood-event during the peat-accumulation. Further, the presence of framboidal pyrite suggests progress of brackish water condition in the mire signifying a probable marine influence.

Besides providing viable inputs for age assessment, palaeovegetation and palynological studies are feasible to understand the concept holding both tectonic and chronostratigraphic attributes of any succession. Palynological investigation of four boreholes of the Godavari Valley Coalfield have been performed to understand the stratigraphic status of that area. Based on the occurrence of the palynoflora, four distinct palynozones are identified. These palynozones are dated as Artinskian, Wordian—Capitanian, Wuchiapingian—Changhsingian and Induan—Olenekian respectively (Fig. 3). Based on the occurrence of the palynozones in the boreholes it has been interpreted that the identified palynozones are completely interrupted/discontinuous. The significance of the present investigation lies in the fact that how palynology can be used to recognize the disturbed chronostratigraphic units in coal and coal associated sequences along within solving the problem of stratigraphic set up, dating and correlation of the sediments.

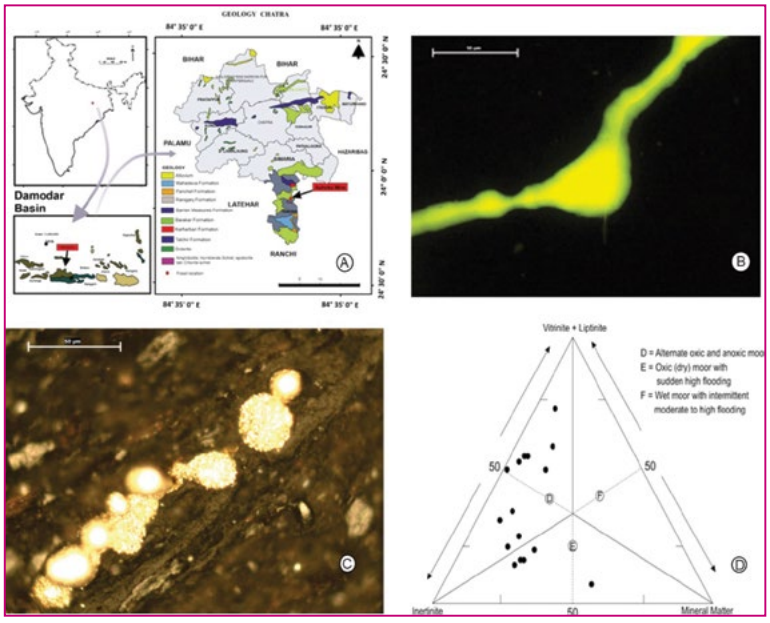


Fig. 2 - A. Location map of the Ashoka Mine in Damodar Basin. B. Exsudatinite maceral indicating expulsion of hydrocarbon C. Framboidal Pyrite suggests a (probable) marine incursion. D. Figure describing the anoxic-oxic condition of the mire with high flooding events.

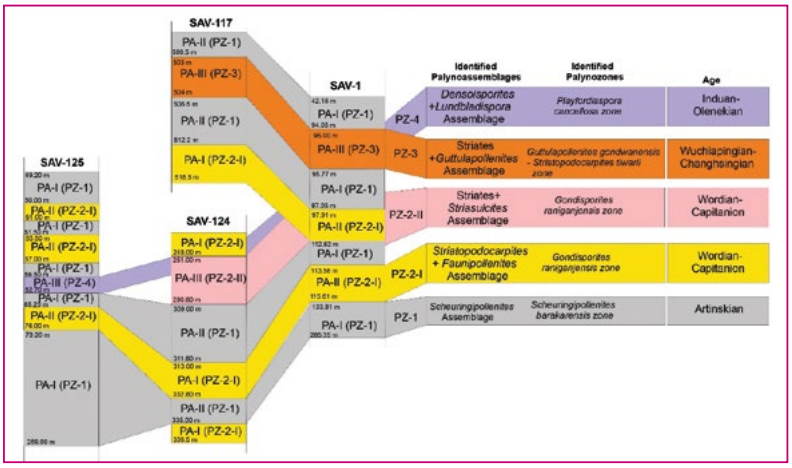


Fig. 3 - Showing the correlation of the studied boreholes (SAV-1, SAV-117, SAV-124 and SAV-125), Godavari Valley Coalfield, south India.

Hydrocarbon generation potential is based on two significant parameters, i.e. organic content and thermal maturation. To know the thermal maturation, spore coloration index (palynology) and hydrous pyrolysis applying artificial thermal maturation was done on the samples procured from the Godavari Basin. The results show immature-early ranging (from lemon- orange yellow colour index) maturation of organic content indicating low hydrocarbon generation potential of the basin (Fig. 4). The maturation kinetics study through hydrous pyrolysis suggests that thermal evolution of the vitrinite maceral is principally controlled by inherent rate-limiting kinetic parameters related to its molecular structure. Whereas, the stratigraphic age, sedimentary environment, surrounding organic matter, enclosing lithology, and mineral catalysis have less effect.

To strengthen the biostratigraphy of the Jurassic/early Cretaceous strata, sediments of the Giumal Formation exposed on the Gete-Tashigong Road near to Tashigong Village, Spiti Valley were studied for nannofossil assemblage. Fairly productive and moderate to poorly preserved calcareous nannofossils [12 species of 5 genera and 5 families; (Fig. 5)] were recorded. The assemblage is dominated by genus *Watznaueria* and *Nannoconus*. The assemblage shows various species of *Nannoconus* along with the total range of *Nannoconus steinmannii* sub sp. *minor* (Last Occurrence (143.57 Ma) and First Occurrence (144.5 Ma) within Early Berriasian Substage,) which suggested that the age of the studied section is early Berriasian (144.5-143.57 Ma) which is very close to Jurassic-Cretaceous boundary (145.0 Ma).

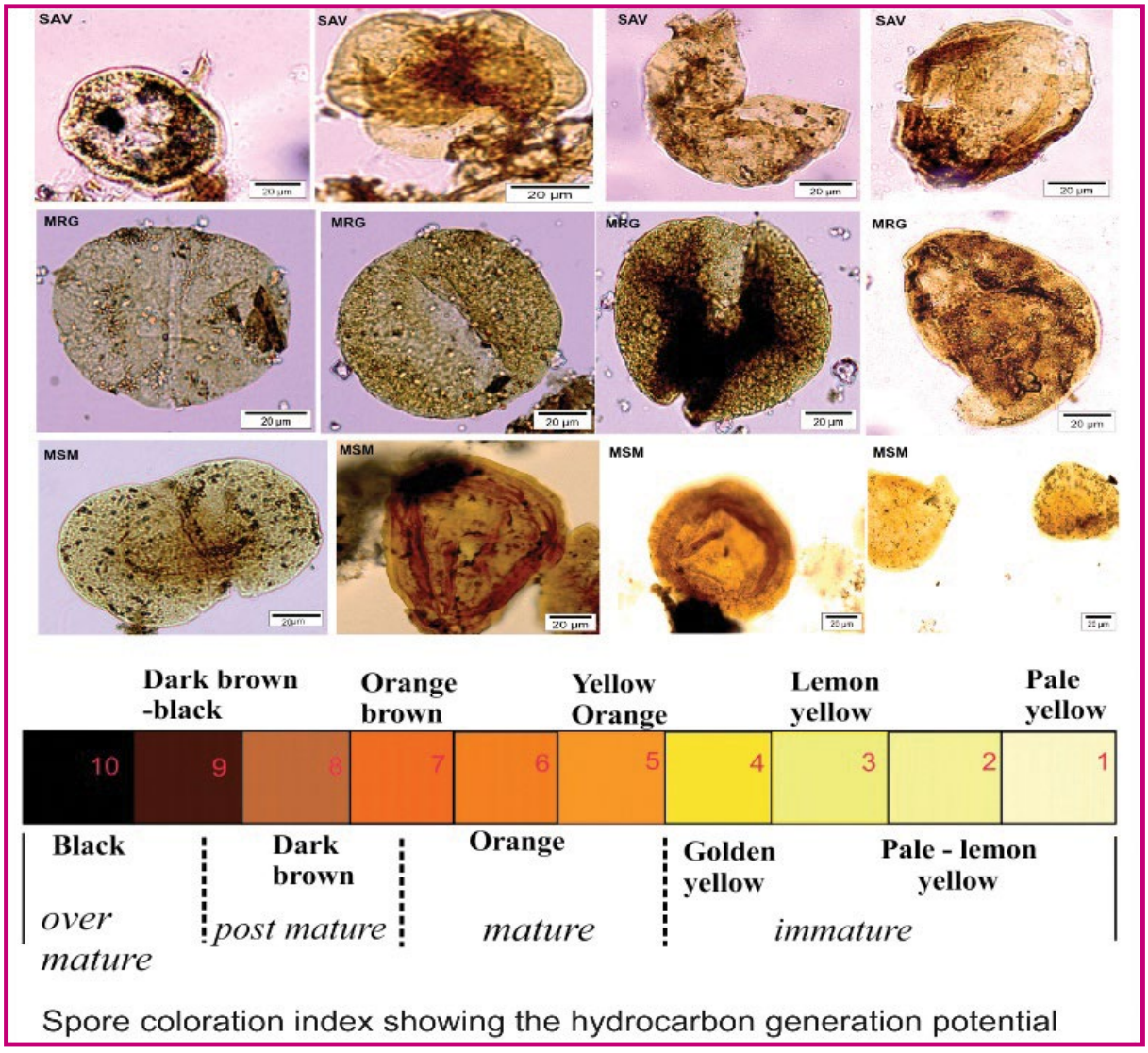


Fig. 4 - Spore coloration index showing the hydrocarbon generation potential.

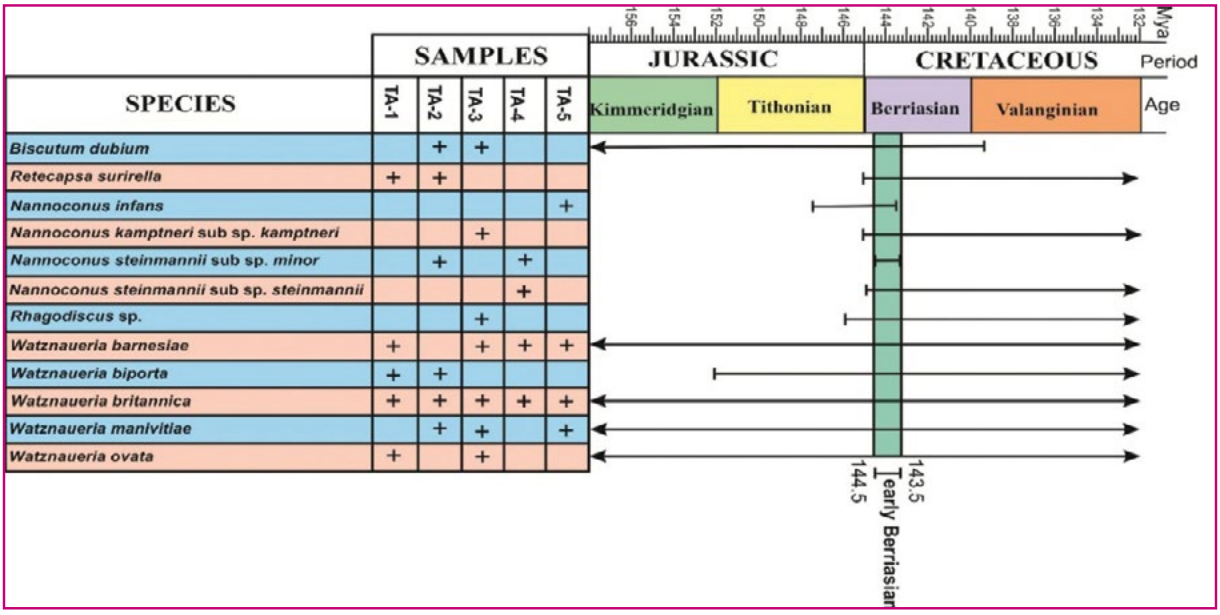


Fig. 5 - Age assignment of the Giumal Formation, Spiti Valley based on the ranges of calcareous nannofossils recorded.

The Tagling Formation composed of limestone with thin shale intervention, the Ferruginous Oolitic Formation with alternation of oolitic limestone and shale and lower member of Spiti Formation composed of black shale with occasional calcareous beds representing early to middle Jurassic sequence of the Tethys Himalaya were studied to understand the depositional environment and palaeogeography. A detailed facies analysis was carried out in around Kaza, Spiti, Himachal Pradesh. Unit I (top part of Tagling Formation) represents shallow marine onshore deposition. Unit II (Ferruginous Oolitic Formation) infers slightly deeper environment with full of agitation by which Ooids Formation has enhanced. Unit III (Lower Member of the Spiti Formation) demonstrates the deepest offshore environment (Fig. 6). The change of depositional environment, i.e. onshore to offshore from bottom to top of sequence (Tagling to Lower Member of Spiti Formation) considered because of sea level rise. This overall fining upward succession is an evidence of transgressive system track deposition.

Recovered fossil of beetle elytron from the Early Cretaceous beds of South Rewa Gondwana Basin for the first time (Fig. 7). The elytron is a hardened forewing that covers and protects the membranous hindwings. Adult beetles are distinguished from all other insects by the presence of this elytron. The beetle elytron is preserved as an impression on grey shale, exposed in village Jhala, Chandia District, M.P., central India. The beetle had a 5 mm long fore wing or elytron with reticulate ornamentation and is assigned to the family Cupedidae (a family having reticulated beetle) and belong to the family of wood-eating beetles. They are also known as Xylophagous beetle, due to their diet which is principally or solely of wood. The plant megafossil assemblage is dominated by conifers in this region. Ferns are comparatively less in occurrence as well as in diversity.

For understanding the ecosystem and radiation of seed plants, carbonaceous shales of Ashoka Coalmines, Jharkhand have been explored, and low diversity flora is recorded, including 3 genera (*Gangamopteris, Glossopteris, Vertebraria*) and 14 species of Artinskian to Kungurian age. The palyno-assemblage is categorized by the dominance of the non-striate bisaccate pollen *Scheuringipollenites* sp. and sub-dominance of the striate bisaccate pollen *Faunipollenites* (=*Protohaploxypinus*) sp. of Early Permian (Artinskian) age. Macrofossil assemblage of Bijori Formation of Satpura Basin, comprising 15 species of *Glossopteris*. The study reveals that Bijori flora is less diversified in comparison to upper Permian Raniganj Formation flora which indicate a diminishing trend in the overall diversity of Glossopteris flora towards the end Permian.

To understand the Palaeo-wildfire, the macroscopic fossil charcoal fragments recovered at depth of 120 m in the borehole AK-19 from Astona-Kothurna Coal Block, Wardha Valley Coalfield. In general, the occurrence of charcoal in sediments is accepted as a direct indicator for palaeo-fires. FESEM provides anatomical details, suggesting a gymnospermous wood affinity for the studied material. Findings suggested widespread occurrence of such wildfires during the Early Permian not only in India, but on the entire continent Gondwana.

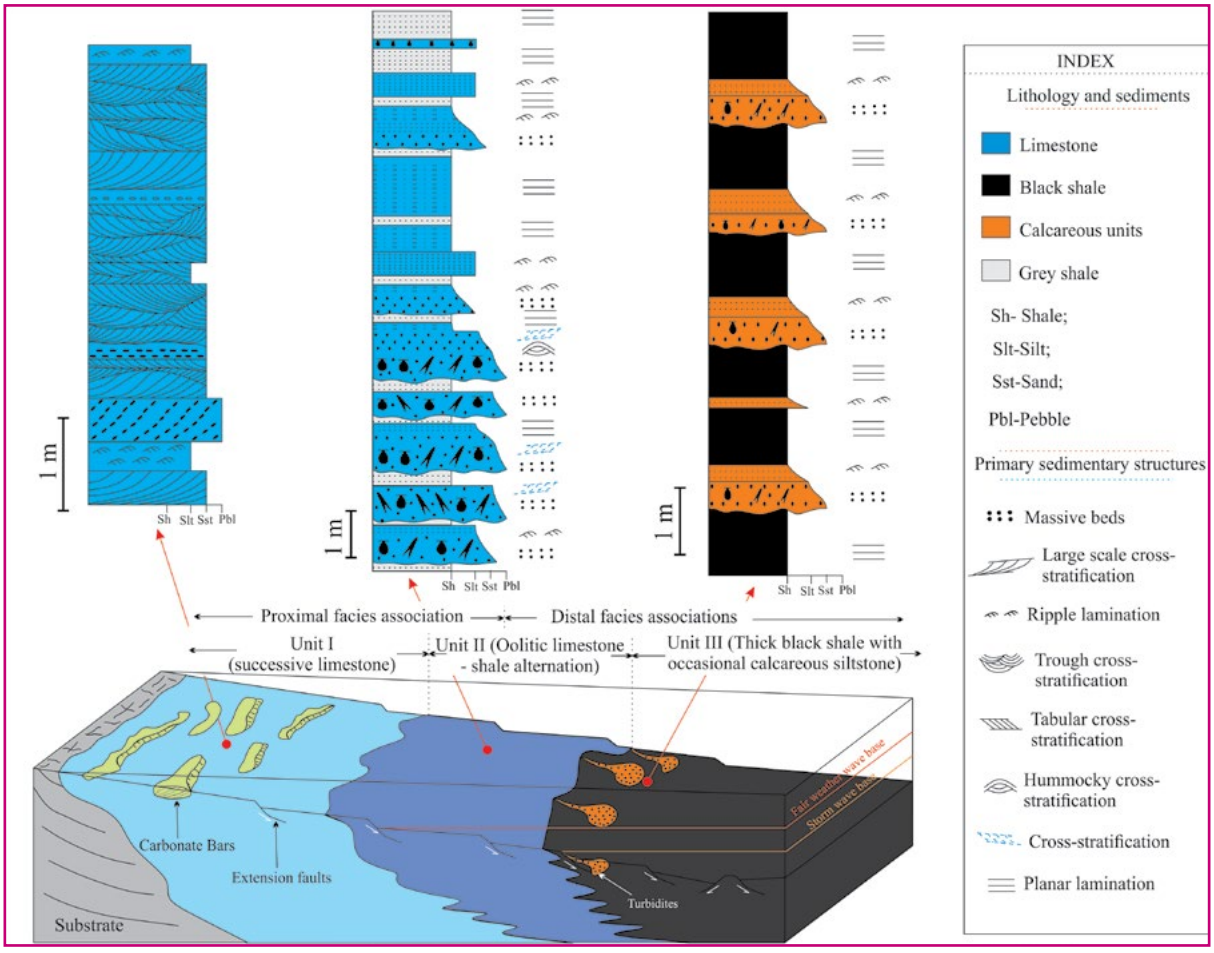


Fig. 6 - A schematic depositional model for the top part of Tagling Formation to Lower Member of Spiti Formation. Unit I (successive limestone) deposited in shallow marine bar-inter bar setup. Unit II (alternation of Oolitic limestone and shale beds) was deposited in slight deeper water with frequent storm intervention. Unit III (thick black shale with occasional calcareous siltstone) was in deepest palaeogeographical offshore set-up. Note the onshore to offshore transition.

Fig. 7 - (A) Photograph of the studied section of Jhala Village, Bansa Formation. (B) Specimen of beetle forewing (elytra).

PROJECT OUTCOME

Publications in SCI (Science Citation Index) Journals

1. Aggarwal N 2022. Sedimentary organic matter as a proficient tool for the palaeoenvironmental and palaeodepositional settings on Gondwana coal deposit. Journal of Petroleum Exploration and Production Technology 12: 257-278. https://doi.org/10.1007/s13202-021-01331-x. **(IF: 2.508)**
2. Aggarwal N, Mathews RP, Ansari AH, Thakur B & Agrawal S 2022. Palaeoenvironmental reconstruction for the Permian (lower Gondwana) succession of the Godavari Valley Coalfield in southern India based on a combined palynofacies, carbon isotope, and biomarker study. Journal of Palaeogeography 11(1): 123-144. https://doi.org/10.1016/j.jop.2021.07.001. **(IF: 2.789)**
3. Agnihotri A, Genise JF, Saxena A & Srivastava A 2021. *Palliedaphichnium gondwanicum* new ichnogenus new ichnospecies, a millipede trace fossil from paleosols of the upper Permian Gondwana sequence of India. Journal of Paleontology. https://doi.org/10.1017/ jpa.2021.38. **(IF: 1.628)**
4. Kavali PS, Roy A, di Pasquo M, Gurumurthy GP, Sharma G & Kumar A 2021. New age of the Talchir Formation in the Wardha Basin, central India, based on guide palynomorphs present in radiometrically-dated palynozonations in South America, Africa and Australia. Ameghiniana 58(4): 318-344. https://doi.org/10.5710/AMGH.29.03.2021.3423. **(IF: 1.5)**
5. Murthy S, Mendhe VA, Uhl D, Mathews RP, Mishra VK & Gautam S 2021. Palaeobotanical and biomarker evidence for Early Permian (Artinskian) wildfire in the Rajmahal Basin, India. Journal of Palaeogeography 10(5): 01-21. https://doi.org/10.1186/s42501-021-00084-2. **(IF: 2.789)**
6. Saxena A, Gupta S, Murthy S, Singh KJ, Prakash A & Singh PK 2021. Diversity of the genus *Gangamopteris* McCoy in the Early Permian sequences of Singrauli Coalfield, Son-Mahanadi Basin, India. Journal of Palaeontological Society of India 66: 23-34. **(IF: 0.652)**
7. Saxena A, Khan M, Raychowdhury N & Singh KJ 2022. Early Permian macrofloral diversity in Indian Gondwana: Evidence from Talchir Formation of Singrauli Coalfield, Son-Mahanadi Valley Basin, central India. Journal of Earth System Sciences. https://doi.org/10.1007/s12040-021-01805-w. **(IF: 1.912)**

Book Chapters/Memoirs/Bulletins

1. Chopparapu C, Kavali PS, Annamraju R, di Pasquo M & Bernardes-de-Oliveira MEC 2021. Early Cretaceous flora from the East Coast sedimentary basins of India and their chronostratigraphic significance. *In*: Banerjee S & Sarkar S (Editors) - Mesozoic Stratigraphy of India : 469-528. Society of Earth Scientists Series, Springer Nature Switzerland. https://doi.org/10.1007/978-3-030-71370-6_17_
2. Singh A, Deori N, Pandey DK, Shekhawat RS & Verma P 2021. Biostratigraphic implications of the calcareous nannofossils from the Spiti Formation at Langza, Spiti Valley. *In*: Banerjee S & Sarkar S (Editors) - Mesozoic Stratigraphy of India: A Multi-proxy approach, Society of Earth Scientists Series, Springer, pp. 429-442.

Publications as an outcome of Sponsored Projects

1. Gupta S, Saxena A, Shabbar H, Murthy S, Singh KJ & Bali R 2022. First record of late Carboniferous palynoassemblage from Ganmachidam Formation, Spiti Valley: Implications for age assessment and extent of Glossopterid elements in the Tethyan realm. Geological Journal https://doi.org/10.1002/gj.4400. **(IF: 2.128)**
2. Shabbar H, Saxena A, Gupta S, Singh KJ & Goswami S 2022. The first record of cornulitids tubeworms from the early Late Ordovician of Spiti, Tethyan Himalaya, India. Historical Biology 34(1): 176-187. https://doi.org/10.1080/08912963.2021.1905634. **(IF: 1.942)**
3. Mishra DP, Murthy S, Pandey B & Singh AK 2021. Palaeobotanical evidence for Artinskian wildfire in the Talcher Coalfield, Mahanadi Basin, India. Journal of the Palaeontological Society of India 66 (2): 303-314 **(IF: 0.652)**

Publication Other than the Project Work

1. Aggarwal N, Patel R & Goswami S 2022. A study on megafloral, palynofloral, and palynofacies of Barakar sediments at and around Balaram Opencast Coal Project, Talcher Basin, Odisha, India: inferences on palaeodepositional settings, palynodiversity, palaeovegetation, and palaeoclimate. Arabian Journal of Geosciences 15: 243. https://doi.org/10.1007/s12517-022-09554-w **(IF: 1.827).**

2. Bhattacharya S, Yadav A, Murthy S & Kushwaha V 2021. Biotic response to environmental shift during the Permian-Triassic transition: Assessment from organic geochemical proxies and palynomorphs in terrestrial sediments from Raniganj Sub-basin, India. Palaeogeography, Palaeoclimatology, Palaeoecology 576: 110483. https://doi.org/10.1016/j.palaeo.2021.110483. **(IF: 3.565)**

3. Chopparapu C, Annamraju R, Kavali PS & Gonçalves SD 2021. Monocotyledon fossil leaf from the Early Cretaceous of India. Acta Botanica Brasilica 35(4): 621-626. https://doi.org /10.1590/0102-33062020abb0542. **(IF: 1.395)**

4. Farooqui A, Pillai SSK, Agnihotri D, Khan S, Tewari R, Shukla SK, Ali S, Trivedi A, Pandita SK, Kumar K & Bhat GD 2021. Impact of climate on the evolution of vegetation in tectonically active Karewa Basin, Kashmir Himalayas. Journal of Earth System Science https://doi.org/10.1007/s12040-021-01586-2. **(IF: 1.912)**

5. Kumar R, Das N, Aggarwal N & Pandey B 2021. Palynofacies of Early Cretaceous sediments of Pariwar Formation, Jaisalmer Basin, Rajasthan, India: palaeoenvironmental interpretation. Journal of the Palaeontological Society of India 66(2): 251-257. **(IF: 0.652)**

6. Mandal S, Roy Choudhury T, Das A, Sarkar S & Banerjee S 2022. Shallow marine glauconitization during the Proterozoic in response to intra basinal tectonics: A study from the Proterozoic Lower Bhander Sandstone, central India. Precambrian Research 372: 1-18. https://doi.org/10.1016/j.precamres.2022.106596. **(IF: 4.261)**

7. Mishra DK, Hackley PC, Jubb AM, Sanders MM, Agrawal S & Varma AK 2022. Maturation study of vitrinite in carbonaceous shales and coals. U.S. Geological Survey data release. https://doi.org/10.5066/P9KNB6GP.

8. Panchala WAW, Joshi H, Aggarwal N, Jha N, Jayasena HAH, Yakandawala D, Chandrajith R & Ratnayake NP 2021. Late Jurassic-Early Cretaceous palynostratigraphy, palynofacies and sedimentology from the Andigama Basin, Sri Lanka. Journal of Asian Earth Sciences-X 6: 100067. https://doi.org/10.1016/j.jaesx.2021.100067. **(IF: 3.374)**

9. Pandey DK, Prakash N, Fürsich FT, Alberti M, Shekhawat RS, Das N, Bhosale S, Caskar K & Page KN 2021. New record of *Ptilophyllum* and related leaf fossils from Kimmeridgian sediments of the Kachchh Basin, western India. The Journal of the Palaeontological Society of India 66(2): 251–257. **(IF: 0.652)**

10. Patel R, Goswami S, Aggarwal N & Mathews RP 2021. Palaeofloristics of Lower Gondwana exposure in Hingula area, Talcher Basin, Odisha, India: An inclusive study on biomarkers, megafloral and palynofloral assemblages. Historical Biology https://doi.org/10.1080/08912963.2021.1986039. **(IF: 1.942)**

11. Patel R, Goswami S, Aggarwal N & Mathews RP 2021. Lower Gondwana megaflora, palynoflora and biomarkers from Jagannath Colliery, Talcher Basin, Odisha, India and its biostratigraphic significance. Geological Journal 57(3): 986-1004. https://doi.org/10.1002/gj.4318. **(IF: 2.128)**

12. Shukla A, Mehrotra RC, Verma P, Chandra K & Singh A 2021. "Out-of-India" dispersal for Adina (tribe Naucleeae; family Rubiaceae): evidence from the early Eocene fossil record from India. Palaeoworld 30(4): 737-745. https://doi.org/10.1016/j.palwor.2021.01.001. **(IF: 2.717)**

SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

SP 2.1: 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, New Delhi; No.: EMR/2016/006042, Core Research Grant, SERB, DST Govt. of India, PI: (Completed on 31.12.2021)].

Investigators: Anju Saxena, K.J. Singh & Suyash Gupta (SRF).

The Ganmachidam Formation of the Tethyan Himalaya was hitherto considered as unfossiliferous, both for the faunal as well floral records, and has been subjected to contentious age assessment. The present study shows the first record of palynomorphs from the unfossiliferous

Ganmachidam Formation, Spiti Valley. From the splintery shale sequence, a rich assemblage of palynomorphs was recovered having a dominance of monosaccate pollen grains, followed by diverse bisaccate pollen grains and the spores in addition to woody fragments and fungal spores. Three palynoassemblages were identified (Fig. SP 2.1). The recovered palynomorphs and their global correlation suggest that the age of Ganmachidam Formation is late Pennsylvanian-Early Permian. The occurrence of the palynomorphs of Glossopteridales along with Coniferales and Cordaitales affinities further strengthen the idea that glossopterids might have originated in Carboniferous.

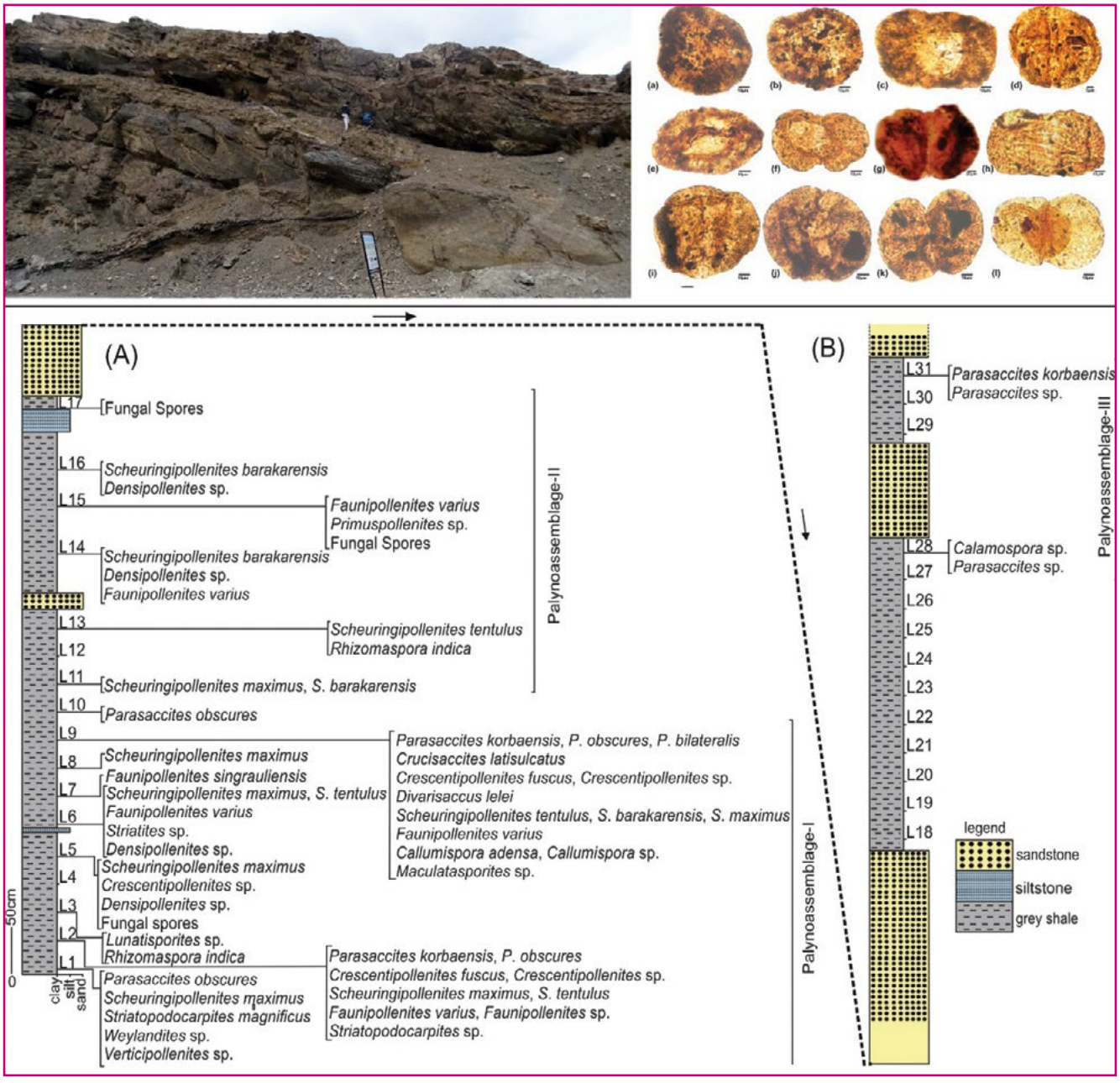


Fig. SP 2.1 - Photograph of section and recovered palynomorphs along with litholog of the studied section of Ganmachidam Formation exposed near the Lingti River, along with sample positions and recovered palynomorphs. (B) is the part of litholog overlying part (A).

SP 2.2: 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 (SRF).

Chemical processing of the rock samples collected from the Garu Formation in Yembung and Rengging Village, East Siang District; Kalamati area, West Siang District and, Geying and Bodhak villages, upper Siang districts have been done. Well preserved palynomorphs have been recovered from the Rengging Village and Kalamati areas. Detailed analysis is in progress. Cleaning, sorting, grouping, photo-documentation and systematic description of plant megafossils collected from the Bhareli Formation of Bhalukhpong- Sessa Road have been carried out. Floral assemblage shows the dominance of *Glossopteris* species.

SP 2.3: Biozonation and palaeoclimatic reconstruction of Permo-Triassic sediments from Talcher Coalfield, Mahanadi Basin, Odisha, India [Sponsored Project EEQ/2018/000303, w.e.f 26.03.2019].

Investigator: Srikanta Murthy & Deveshwar Prakash Mishra (SRF).

Petrographic palynofacies, charcoal and palaeobotanical (micro- and mega-) analyses of coal and associated clastic sediments from the Jagannath section in the Talcher Coalfield, Mahanadi Basin have been carried out. Implications of the research to establish age and better comprehension of palaeovegetation, palaeoecology including palaeowildfires and reconstruction of the palaeodepositional setting during deposition. (Fig. SP 2.3).

The petrographic analysis of the studied coal samples shows dominance of vitrinite while palynology demonstrates a high incidence of trilete spores. Similarly, the megafloral investigation shows a less diversified remains of Equisetales followed by Glossopteridales and Filicales (*Dichotomopteris*) enlighten over the presence of a probably thick, arborescent palaeovegetation. Palynological investigation reveals the presence of *Scheuringipollenites barakarensis*, suggesting an Early Permian (Artinskian) age for the studied section. Occurrence of fossil charcoal fragments within sediments indicates the occurrence of palaeo-wildfires. The macroscopic charcoal suggests its gymnospermous affinity and is probably of parautochthonous origin.

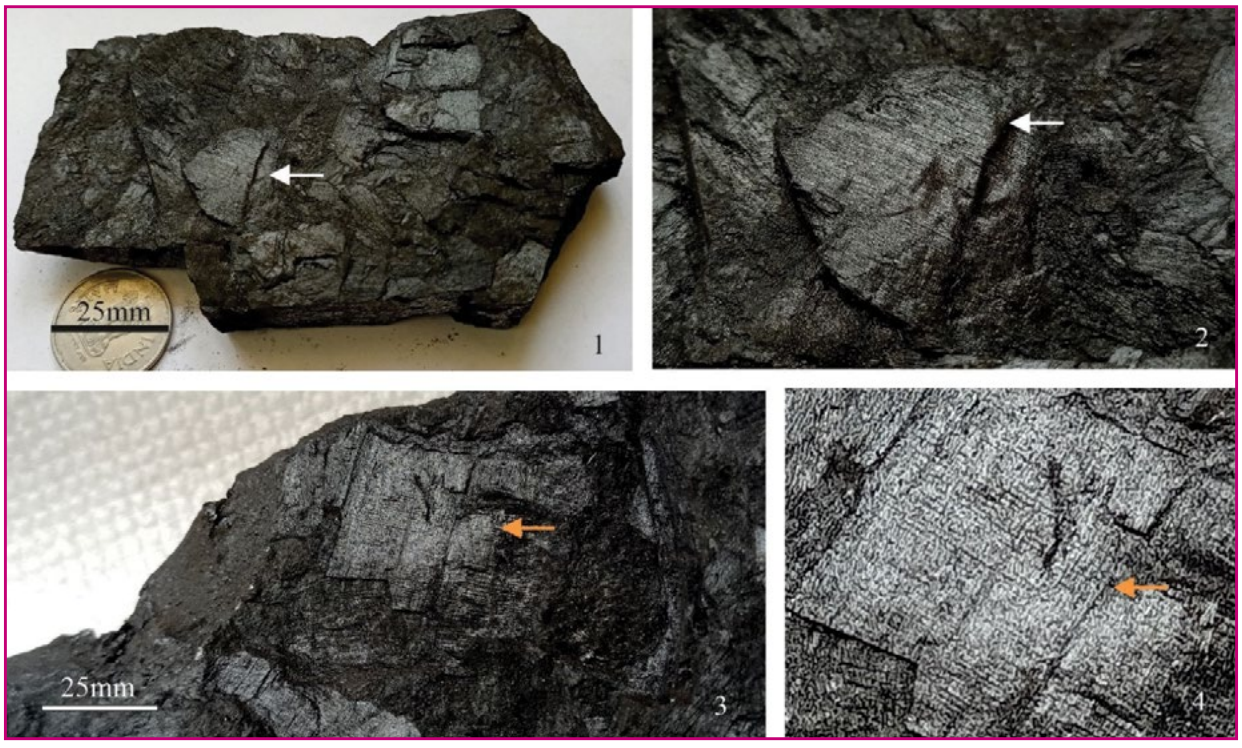


Fig. SP 2.3 - Photographs of charcoal fragments embedded in the carbonaceous shale and exhibiting the black, silky lustre at the level of JOCM-1, 2 & 3 in the Jagannath coalmine section of the Talcher Coalfield, 2-4. Detailed view of charcoal fragments with relatively large size, sharp unabraded edges indicative of very short distance travels before deposition (scale 25 mm).

CP 2.1: Neha Aggarwal [& Prof. S. Goswami, Sambalpur University, Odisha]

Integrated work on palynofloral and palynofacies along with megafloral analysis has been carried out on recovered samples from Balaram Opencast Mine, Talcher Basin, Odisha, India. The analyzed samples are characterized by the dominance of degraded organic matter and sub-dominance of palynomorphs. Recovered palynoflora of the studied area explicitly depicts that the investigated sediments belong to the Barakar Formation (late Artinskian to Kungurian age). For the first time, *Vertebraria* recovered from this location, demonstrating the presence of a deciduous Glossopterids forest during the deposition of Barakar sediments. In addition, the present study also reveals a warm, humid, temperate climate with abundant rainfall during this period. The palynofacies analysis demonstrates a flooded palaeomires/marshy condition in the distal dysoxic-oxic low energy settings during late Artinskian to Kungurian (Fig. CP 2.1).

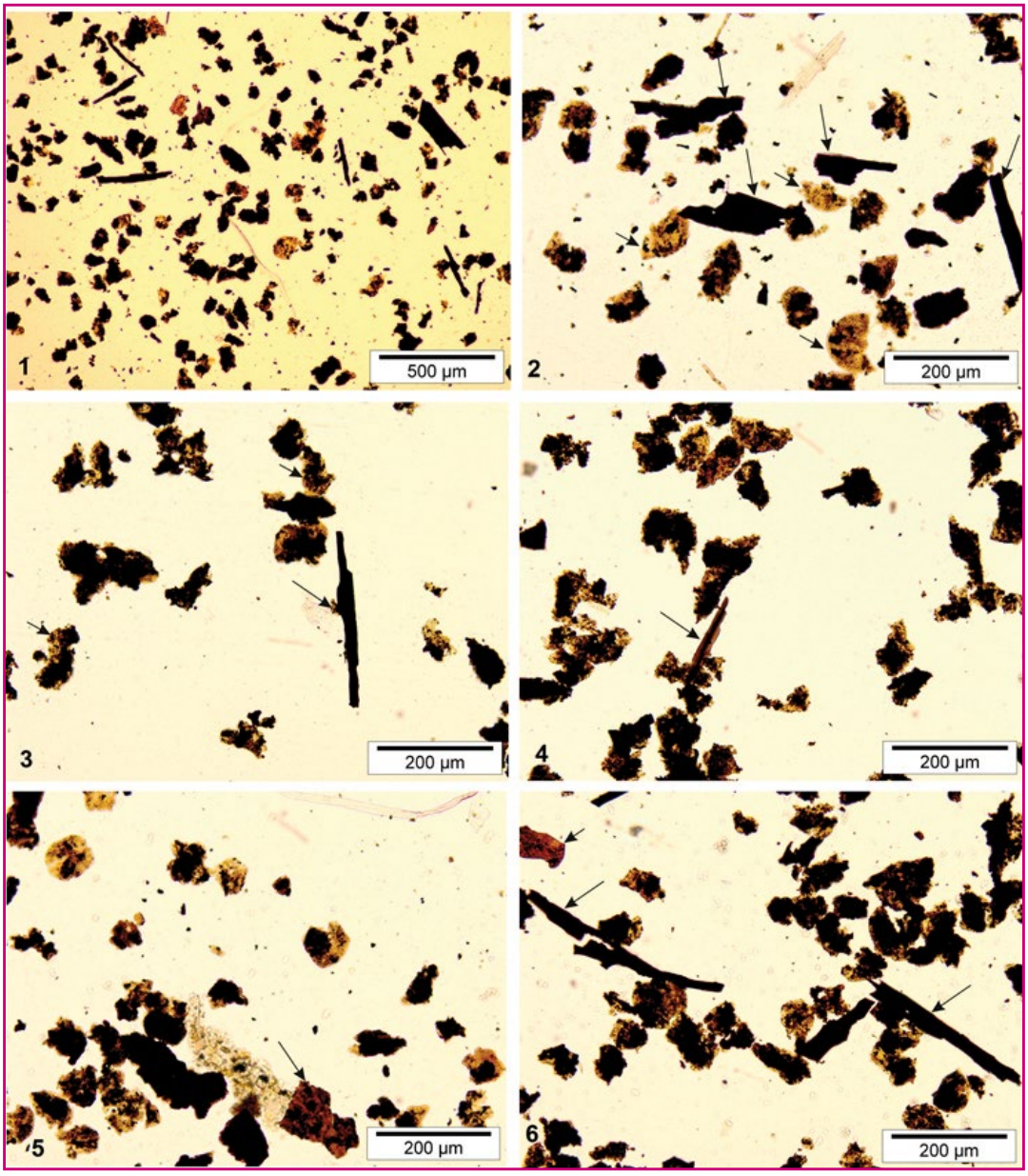


Fig. CP 2.1 - 1. An overview of the different types of palynofacies, 2. Palynofacies showing the broken palynomorphs (short arrow) with opaque phytoclasts (long arrow), 3. Palynofacies showing DOM (short arrow) along with opaque phytoclasts (long arrow), 4. Palynofacies showing structured phytoclasts (arrow marked) along with the dominant occurrence of the DOM, 5. Palynofacies showing AOM (arrow marked), 6. Palynofacies showing AOM (short arrow) along with opaque phytoclasts (long arrow).

CP 2.2: Abha Singh, as a Co-PI in ONGC sponsored project

Initiated collaboration with ONGC - RGL Vadodara. Led the team and visited to the RGL, Vadodara for a week and examined already prepared palynological and palaeontological slides and based on the examination a collaborative project between ONGC-RGL, Vadodara and BSIP, was formulated, finalized, submitted and awarded for funding.

CP 2.3: Neelam & [Neha Aggarwal & Raj Kumar, BSIP, Lucknow]

Worked on Mokal Nala Section of the Bhadasar Formation in the Jaisalmer Basin, western India, using palynological, palynofacies and geochemical techniques. The study investigates the age and palaeoenvironmental settings of the sediments. The palynological investigation of the section reveals Late Jurassic - Early Cretaceous age having the marker taxa *Callialasporites dampieri*, *Contignisporites cooksoniae*, *C. fornicatus*, *C. multimuratus*, *Concavissimisporites* sp., *Lametatriletes indicus*, *Microcachryidites antaricus* which are correlatable with Late Jurassic - Early Cretaceous *Retitriletes watherooensis – Balmeiopsis limbata* palynozone of Perth Basin, Australia (Fig. CP 2.3). The presence of the phytoplankton derived organic matter and rare occurrence of scolecodont, suggests the marginal marine settings. Based on the palynofacies analysis the succession is mainly prevailed by the marginal oxic-dysoxic settings. Geochemical analysis indicates the poor organic matter preservation causing a reduction in their hydrocarbon generation potential.

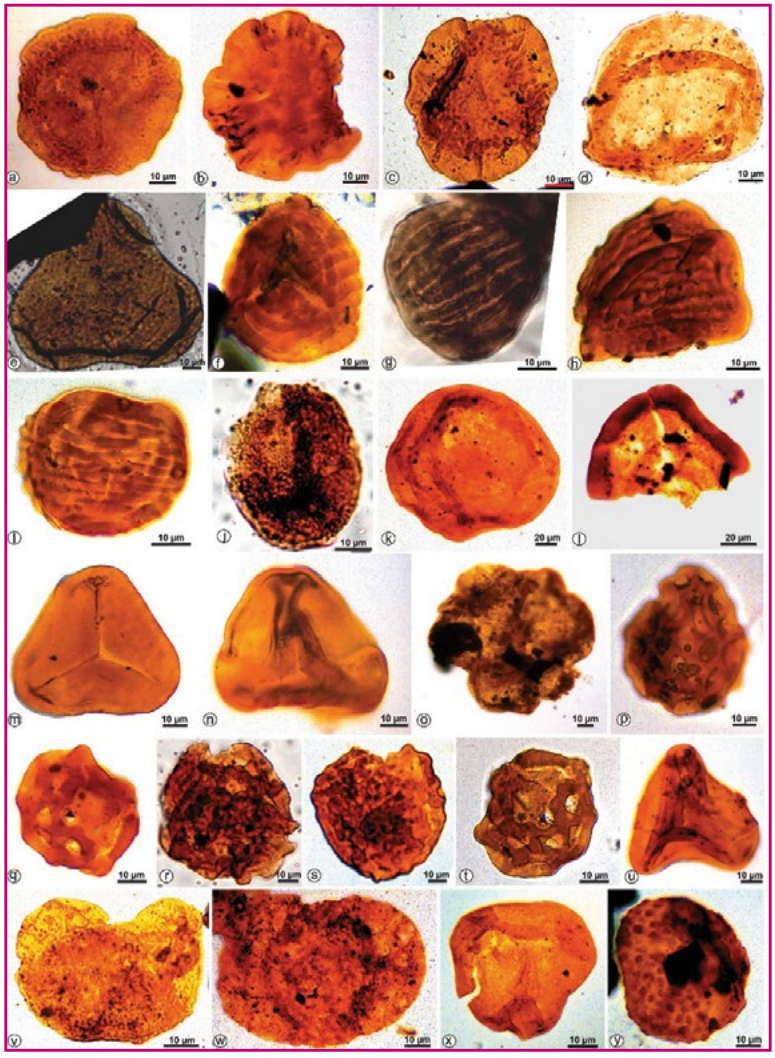


Fig. CP 2.3- Palynotaxa recorded from the Mokal Nala Section, a, Callialasporites dampieri b, C. segmentatus c, C. trilobatus d, C. grandis e, Concavissimisporites sp. f, Contignisporites glebulentus g, C. multimuratus, h, C. cooksoniae, i, C. fornicatus, j, Classopollis sp. k, C. simplex l, Cooksonites sp. m, Deltoidospera junta n, Dictyophyllidites harrisii o, Goubinospora indica. p, Ischyosporites sp. q, Klukisporites faveolatus r, K. variegatus s, K. apunctus, t, K. areolatus u, Lametatriletus indicus v, Microcachryidites antarcticus Cookson w, Podocarpiditus canadensis, x, Podosporitus microsaccatus y, Verrucusisporites dubius.

OTHER ACADEMIC WORKS

Research Papers presented

1. Mishra DK, Hackley PC, Jubb AM, Sanders MM, Agrawal S & Varma AK. Maturation study of vitrinite from carbonaceous shales and coal: Preliminary insights from hydrous pyrolysis. 37th Annual Meeting at Bulgaria, The Society of Organic Petrology (TSOP), September 12-14, 2021: 44-46.
2. Kavali PS, di Pasquo M, Roy A, Gurumurthy GP & Silvestri L. Redating the Lower Talchir Formation (Wardha Basin, central India) to the Upper Pennsylvanian by palynomorphs. 3rd International Palaeontological Virtual Congress, December 1-15, 2021.

Deputation to Conferences/Seminars/ Workshops (both online and offline)

- **Pauline Sabina K-**Redating the Lower Talchir Formation (Wardha Basin, central India) to the Upper Pennsylvanian by palynomorphs. 3rd International Palaeontological Virtual Congress, December 1-15, 2021.
- **Ranveer Singh Negi** attended the Virtual 36th International Geological Congress, 2022 on theme "Geoscience for next decade: Challenges for society" (online) 20-22 March 2022.

Deputation to Training/Study Visits:

Abha Singh

- Applied Biostratigraphy Course. Course by Ingeoexpert. March 29-May 10, 2021 (online mode).

Neha Aggarwal

- Applied Biostratigraphy Course. April 6- May 10, 2021 (online mode).

Neelam Das

- e-Training Programme on "Gondwana Paleontology with an emphasis on the Biostratigraphy, Palaeobiogeography and Palaeoclimate interpretation", conducted over e-Platform by Geological Survey of India, Training Institute, Technical Coordination Division at FTC-Kuju, June 15-18, 2021.
- e-Training Programme on "Art of Publication, Effective Writing and Presentation skills in Earth Sciences", conducted over e-Platform by Geological Survey of India, Regional Training Division, Eastern Region at RTD-SR, June 23-25, 2021.

Pauline Sabina K

- Applied Biostratigraphy Course. March 29-May 10, 2021 (online mode).

Ranveer Singh Negi

- e-training on "Fundamentals of Geological Mapping" conducted by The Regional Training Division, Geological Survey of India, Central Region, Nagpur, online via video conference, February 24, 2022.
- Participated in "Academic Integrity for Research Scholars" organised by Turnitin Education Network, online via video conference, February 26, 2022.
- Attended webinar on "Research smarter and maximize your IP creation" organised by Clarivate, online via video conference, March 22, 2022.
- Attended webinar on "Web of Science Core Collection Journals Selection Process" organised by Clarivate, online via video conference, March 29, 2022.

Lecture delivered

Anju Saxena

- Gondwana Flora of India: Biostratigraphical, Evolutionary and Climatic Perspective-e-Training entitled "Gondwana Paleontology with an emphasis on the Biostratigraphy, Palaeobiogeography and Palaeoclimate interpretation" conducted by Field Training Centre-Kuju (online) on 16/06/2021.

S. Suresh Kumar Pillai

- Fossil and its importance-Vigyan Manthan Yatra 2021-22- Inauguration Session on 22.02.2022.
- Scientific paper writing-Workshop Medical Lab Technology Department of Pt. L.M.S. Sri Dev Suman Uttarakhand University Campus, Rishikesh, Uttarakhand, 30.03.2022.

Neelam Das

- Early Cretaceous insects and their relation to plants: Hindi Workshop, BSIP, Lucknow, 21.12.2021.

PH.D. PROGRAMME

Anand Prakash (2016). Palaeobiodiversity of coal forming flora of western apart of the Son-Mahanadi Basin: depositional, petrological and palaeocological implications, under the supervision of **Anju Saxena (BSIP)** and P.K. Singh (BHU), registered with Banaras Hindu University. Status: in progress.

Raj Kumar (2016). Palaeontological record from the Mesozoic sediment of the Jaisalmer Basin, Rajasthan: biostratigraphic, palaeobiogeographic and palaeoclimatic implications, under the supervision of **Neelam Das (BSIP)** and Bindhyachal Pandey (BHU), registered with Banaras Hindu University. Status: In progress.

Husain Shabbar (2017). Ordovician-Silurian Biodiversity of the Tethyan Himalayan strata, Spiti, H.P., India, under the supervision of **Anju Saxena (BSIP)** and S. Goswami, Sambalpur University, Odisha. Status: Awarded in December 2021.

Suyash Gupta (2018). **Floristic evolution and biodiversity in the Late Palaeozoic sequences of Spiti Himalayas: palaeoenvironmental and palaeogeographical implications,** under the supervision of **Anju Saxena (BSIP)** and R. Bali (LU), registered with Lucknow University, Lucknow. Status: In progress.

Nazim Deori (2019). High resolution biostratigraphy and depositional environment of Cenozoic succession of Kachchh Basin, western India, Gujarat, under the supervision of **Abha Singh (BSIP)**, Dr J.M. Patel, R.R. Lalan College Bhuj, Kachchh and M.G. Thakkar KSKV, Kachchh University, registered with K.S.K.V. Kachchh University. Status: In progress.

Alok Kumar Mishra (2020). Floristic changes in late Palaeozoic sediments of northeast India: implications in biostratigraphy and palaeoecology, under the supervision of **Deepa Agnihotri (BSIP)** registered with AcSIR (Academy of Scientific and Innovative Research). Status: In progress.

Deveshwar Prakash Mishra (2019). Biozonation and palaeoclimatic reconstruction of Permo-Triassic Sediments from Talcher Coalfield, Mahanadi Basin, Odisha, India, under the supervision of **Srikanta Murthy (BSIP).** Status: In progress.

Suraj Kumar (2022). Marine–non marine correlations of Permian exposures in eastern Gondwana of India – a multiproxy perspective, under the supervision of **S. Suresh Kumar Pillai (BSIP)**, registered with AcSIR (Academy of Scientific and Innovative Research). Status: In progress.

Consultancy/Technical support rendered

S. Suresh Kumar Pillai

- Development of Mandro Fossil Park, located in Mandro, a community block in the Sahibganj District of Jharkhand and Marine Fossil Park at Manendragarh District, Chhattisgarh.

Representation in Committees/Board:

Anju Saxena

- Member of Executive Council (The Palaeontological Society of India, Lucknow) since 2020.
- Co-Editor in the Editorial Board, Geophytology Journal, since 2019.
- Co-Editor, open Access journal 'Earth Science India' since 2010.

Project 3: Pre- and Post-Collision Biotic Turnover(S) and Climate Change(S) pertaining to India (Terminal Cretaceous-Cenozoic)

Coordinator: Vandana Prasad (Director)

Co-coordinator: Hukam Singh (Scientist E)

OBJECTIVES

- *Biotic turnover(s) across K-Pg transition: palaeobiodiversity and Palaeobiogeography*
- *Biostratigraphy, age correlation, Sequence biostratigraphy and source rock characterization of lignite-bearing sequences of western India*
- *Origin, evolution, Palaeobiodiversity, extinction, and Palaeobiogeographic aspects of Cenozoic biota of India*
- *Quantification of late Cretaceous to Cenozoic climate and monsoon evolution of India based on biotic and abiotic proxies*

PREAMBLE

After its breakup from the erstwhile Gondwanan continents close to 90 Ma, the Indian Plate witnessed significant climatic and palaeobiogeographic changes as a consequence of its northward voyage that culminated in a collision with Eurasia during the Palaeogene. The four components (details underneath) of the Project 3 aim to understand the origin, early evolution and palaeobiogeographic history of the Indian subcontinent's biota and climatic change(s) from the late Cretaceous to Cenozoic (67 to 2.5 Ma) interval. Important fossil data on mega-flora and fauna, insects, ostracods, pollen and spores, nannofossils, dinoflagellate cysts, and other proxies such as inorganic and organic geochemistry, sedimentology, and stratigraphy (-bio, -chemo, and magneto-) will be utilized to achieve the objectives of Project 3.

Deccan Traps and associated sedimentary successions are the remnants of the large-scale volcanic activity that the Indian Plate witnessed during its northward voyage as a consequence of passing over the Reunion Hotspot. The study of the Deccan Volcano-Sedimentary Successions (DVSS) (in a chronological framework) is crucial to comprehend the timing and the extent of the volcanic activity. There covered fossil biota from the DVSS may provide vital data to understand the biotic turnovers across the Cretaceous–Palaeogene (K–Pg) transition. In addition, the palaeontological data from the Palaeogene lignite-associated sedimentary successions of western India may help in understanding the origin, early evolution and historical distribution (in a palaeogeographic framework) of fossil biota. The globally warm events during the Palaeogene (e.g., PETM; ~56 Ma) are considered as the best analogs to understand the effect(s) of warming in tropics and efforts will be made to delineate these warming events within the lignite associated sedimentary successions of western India. Changing vegetation pattern due to climate change at the end of Palaeogene and during the Neogene interval is also being pursued as part of Project 3.

PERSONNEL INVOLVED

Team Members: Poonam Verma (Scientist D), Gaurav Srivastava (Scientist D), Anumeha Shukla (Scientist D), Vivesh Vir Kapur (Scientist D), Runcie P. Mathews (Scientist C), Md. Arif (Scientist C), Ansuya Bhandari (Scientist C), Sajid Ali (Scientist C), Shreya Mishra (Scientist B), Prem Raj Uddandam (Scientist B), Adrita Choudhuri (Scientist B), Suman Sarkar (Scientist B)

Collaborators: Abha Singh (Scientist D), Arvind Kumar Singh (Scientist C)

Technical Support Members: Nil

Research Associate: Debarati Nag

Research Scholars: Rimpy Chetia, Priya Agnihotri, Shalini Parmar, Kajal Chandra, Harshita Bhatia, Samiksha Shukla, Pawan Kumar Singh, Sarvendra Pratap Singh, Mohd Munazir Chauhan, Ramanand Sagar, Sadanand Pathak..

SIGNIFICANT FINDINGS

Sedimentology and Magnetostratigraphy have been used to ascertain the depositional environment, palaeoclimate and palaeomagnetic age constraints of Deccan Intertrappean successions exposed near Gujri-Dugni Village, Dhar District, Madhya Pradesh. Gujri-Dugni Intertrappean deposits are unique in its constitution due to occurrence of three sedimentary units associated with four Deccan basaltic lava flows as a continuous succession. Sedimentological analysis of these three intertrappean deposits associated with the basaltic lava flows reveals a total of five lithofacies based on lithology, sedimentary structure, bed geometry, sediment stacking, fossil content and mineral composition. These five lithofacies include (a) fossiliferous marly limestone; (b) Silty carbonaceous mud with fossils; (c) Limy fossiliferous shale; (d) Nodular calcrete layer; and (e) Carbonaceous mud, suggesting their deposition in a shallow freshwater lacustrine system with low to moderate energy conditions under hot and humid climate. Palaeomagnetic data revealed normal-reverse-normal magnetic polarity for the lava flows corresponding to C30n - C29r - C29n magnetochrons (Fig. 1).

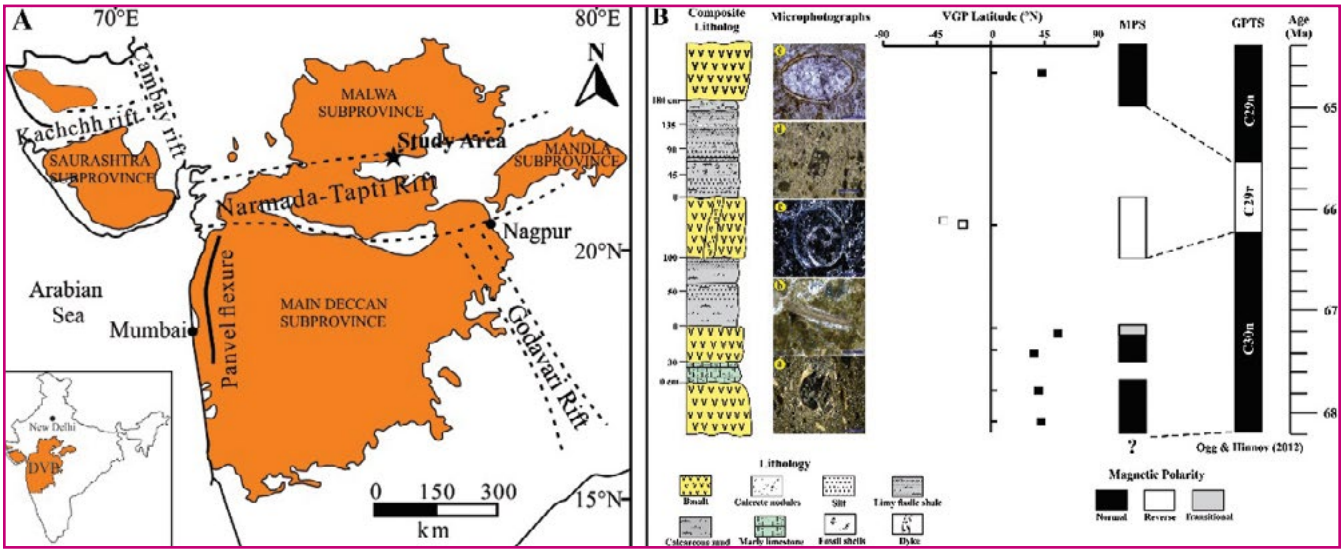


Fig. 1 - (A) Map of India with exposed geological extent of Deccan Volcanic Province (DVP) showing location of study area (black star) within Malwa subprovince (modified after Verma & Khosla 2019); (B) Panel diagram showing composite litholog with lithofacies, microphotographs and magnetostratigraphy of the Intertrappean successions exposed near Gujri-Dugni Village.

The pollen and biomarker fossil records from the Late Cretaceous of Africa and the Cretaceous-Palaeogene (68.5–54 million years) of India, when combined with molecular data under a phylogenetic framework, suggested the evolution of Dipterocarpaceae in Africa around 102 million years ago (Fig. 2). The family further dispersed to the Indian Plate during the Late Maastrichtian-Palaeocene via Kohistan-Ladakh Island Arc, resulting in the diversification of a seasonal dipterocarps on the Indian Plate. The similar climatic zones across India and Southeast Asia post India-Asia collision facilitated the subsequent dispersal of the family to Southeast Asia.

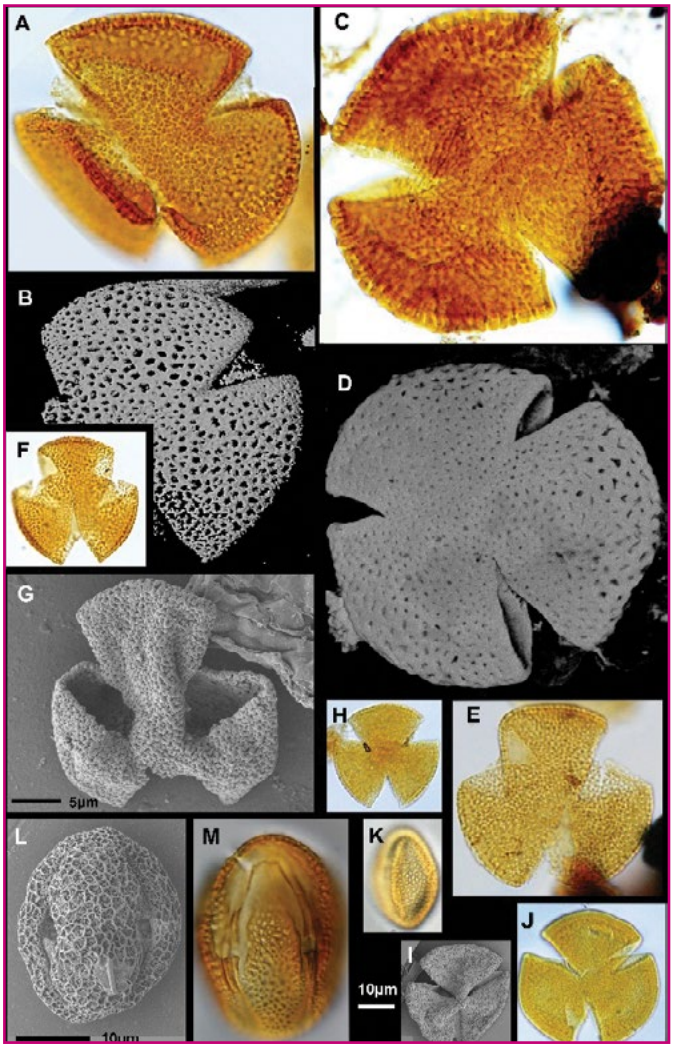


Fig. 2 - Pollen of Dipterocarpaceae from India and Sudan. (A-B) Dipterocarpus type from the earliest Eocene of India; (C-D) Dipterocarpus type from the Cretaceous of Sudan; (E) Dipterocarpus type from the Indian Palaeocene; (F-G) Dryobalanops type from the Indian Eocene; (H) Shorea type from the Indian Eocene; (I) Vatica type from the Indian Eocene; (J-K) Vateriopsis type from the Indian Palaeocene; (L-M) Monotes type from the Indian Palaeocene.

Further diversification of Dipterocarpaceae took place around 20 Ma onwards in Southeast Asia, but most genera became extinct in India with the strengthening of the Indian Monsoon.

A detailed palynofacies analysis and morphological study of dinoflagellate cysts recovered from the sediments belonging to the Tura Formation exposed along a river section in the vicinity of Tura-Dalu Road, Garo Hills, Meghalaya was carried out (Fig. 3). The dinoflagellate cyst assemblage and palynofacies composition revealed that the deposition of the sediments belonging to the Tura Formation occurred in a shallow marine setting.

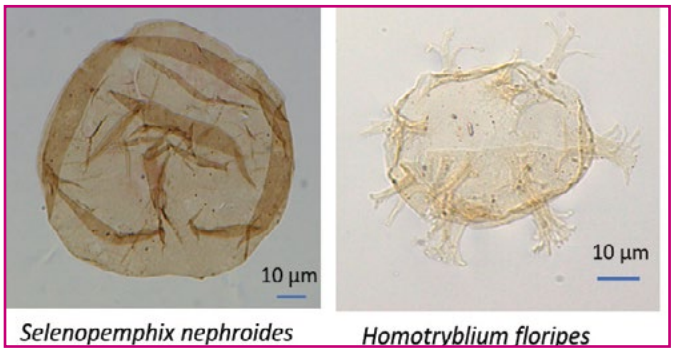


Fig. 3 - Dinoflagellate cysts recorded from the Tura Formation.

Field based sedimentological observations of the Cretaceous-Palaeocene Basal Conglomerate/Jadukata Formation, Khasi Group, Meghalaya suggests that the studied succession is entirely massive clast-supported and the clasts are abraded due to very dense flow as a consequence of a slope break (Fig. 4). Lack of mud suggests physical weathering dominated chemical weathering, an arid climate and lack of vegetation. The clast-supported conglomerates generally have convex-up geometry and often sandstone lenses occur between them. Imperative is that rapid flow transformation took place because of increase in flow intensity between the two gravel bars. In the down flow direction from the said slope-break channelized flow products are found

Fig. 4 a-c - Field photographs of the Cretaceous-Palaeocene Basal Conglomerate/Jadukata Formation, Khasi Group, Meghalaya.

associated with shales of floodplain origin. In the top part of the succession also channelized products are associated with floodplain shales. The base profile of the river was raised either due to subsidence or sea level rise or both. There are local diversions in palaeocurrent and along with change in clast composition. Addition of non-labile component strongly suggests derivation from one of many tributaries.

Eocene amber from the Kutch (=Kachchh) region (western India) holds significance in understanding the biotic reconstruction of a tropical angiosperm rainforest. Interesting inclusions were extracted from the amber utilizing the chemical dissolution and residue method. Extracted inclusions comprised abundant fragmentary body parts of insects (e.g., Oribatid mites) and abundant remains of pollen and spores (Fig. 5). The insect assemblage along with other biotic inclusions provides crucial information on the composition of the diversified forest communities, their habitat, distribution, and environment prevalent during the Eocene (Fig. 6).

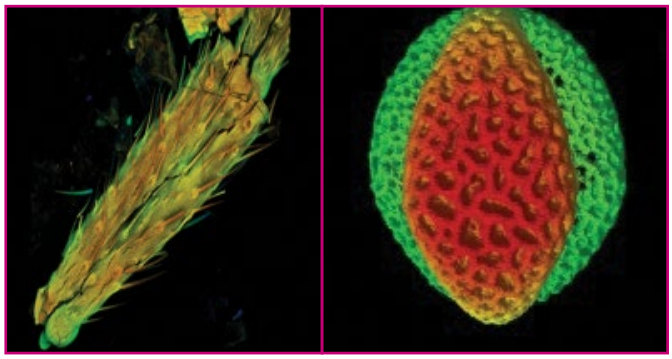


Fig. 5 - Confocal Laser Scanning images showcasing excellent preservation of insects broken body part and pollen morphology in Eocene amber from Kutch (=Kachchh) region, western India.

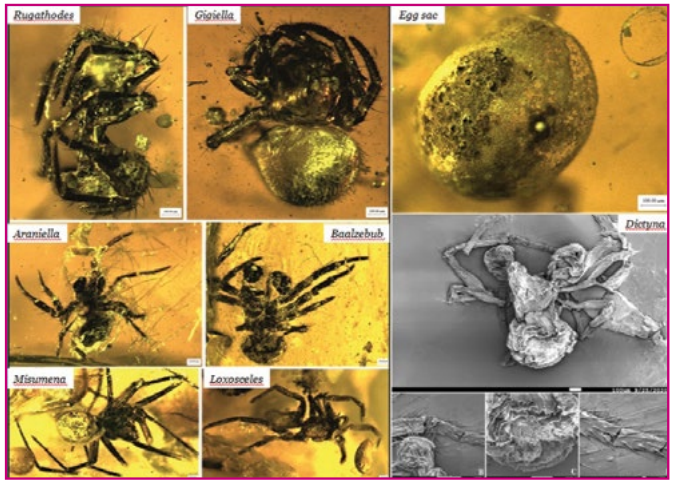


Fig. 6 - Digital and SEM photographs showcasing insect inclusions in Eocene amber from Kutch (=Kachchh) region, western India.

Well-preserved 74 morphospecies of pollen recovered from the Panandhro Lignite Mine, Kutch Basin, Gujarat were used to trace the changes in palaeofloristics and taxonomic diversity pattern of palaeotropical vegetation across the ETM2. The standing diversity calculated using Range-through method yielded the mean diversity of 27.5 spore/pollen species per sample during pre-ETM2 warming, whereas this diversity increased to 44 spore/pollen species per sample during the ETM2 phase (Fig. 7). The same pattern is replicated by other diversity estimation methods after accounting for sample size, number of samples/time unit, lithofacies and depositional systems. The distinct increase in taxonomic diversity during high temperatures can be attributed to high level of precipitation and soil moisture that contributed to success of families typical of wet tropical rainforests in palaeotropical region during extreme warming events.

In a first, three early to middle Miocene plant genera belonging to the families Fabaceae and Combretaceae were described from the Gaj Formation sediments exposed within the vicinity of Lakhanka-Mithi Virdi villages, Bhavnagar District, Saurashtra Basin, Gujarat, western India. The fossil woods were found similar to the modern genera *Millettia* Wight & Arn, *Sindora* Miq. (Fabaceae) and *Terminalia* L. (Combretaceae). The present distribution of modern comparable forms of the fossil taxa suggests existence of tropical to subtropical forests and warm and humid climatic conditions in the region during the Miocene in contrast to present-day sub-humid to dry climate observed in this region (Fig. 8).

Reappraisal of ~54.5-million-year-old terrestrial mammal fauna from the Cambay Shale of western India supports Out-of-India hypothesis (i.e., an Indian Origin) for the perissodactyls (e.g., Cambaytheres) and primates (e.g., adapoids and omomyids) (Fig. 9). In addition, close affinities of primitive Indian tapiromorphs with those recorded from China suggests contact between India-Asia landmasses, close to the Palaeocene-Eocene boundary (i.e., ~56 million years ago) (Fig. 10). Further, Kohistan-Ladakh Arc is likely to be one of the filter bridges between the two landmasses that facilitated the terrestrial faunal exchange.

Detailed organic geochemical study of the Palaeogene sediments from Barsingsar Lignite Mine (Bikaner-Nagaur Basin, Rajasthan, western India) was carried out using gas chromatography-mass spectrometry (GC-MS) at BSIP. The study shows significantly different terpenoid suite characterized chiefly by diterpenoids, sesquiterpenoids and few triterpenoids. The study thus pointed to a distinct floral composition existed in the basin with a significant number of conifers along with angiosperms in the canopy. More importantly, such significance of conifers is not yet reported from any western Indian basins. The biomarker evidences point to

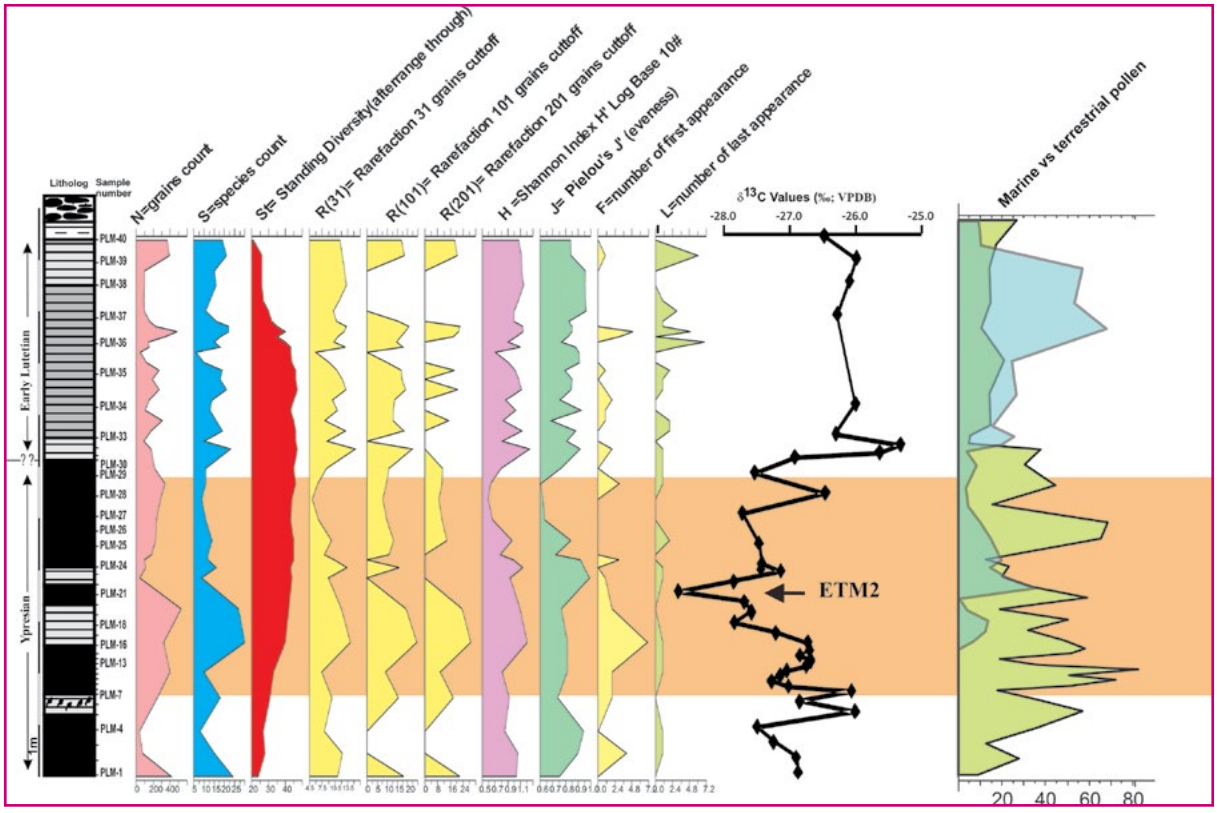


Fig. 7 - Taxonomic diversity pattern of palaeotropical vegetation across the ETM2 warming event from the Panandhro Lignite Mine, Kutch Basin, Gujarat.

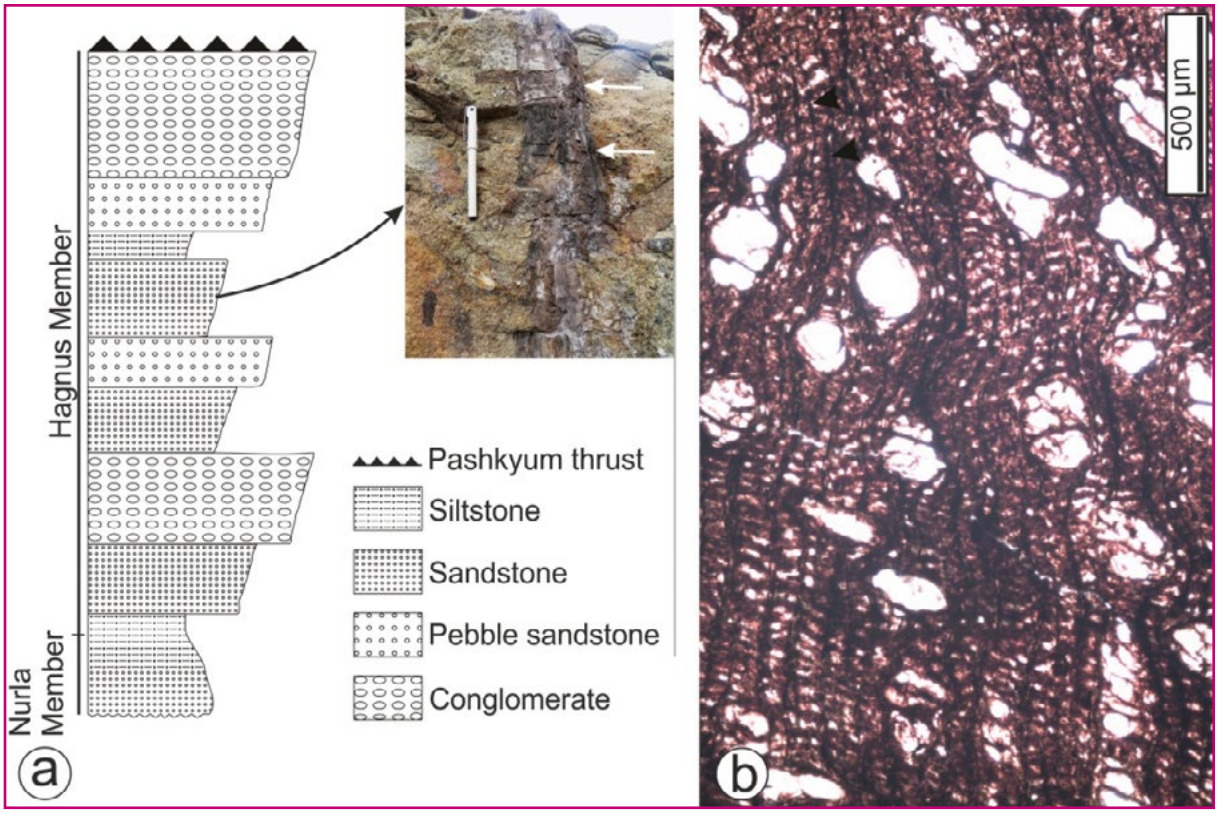


Fig. 8 – (a) Showing the litholog and fossil wood-bearing horizon, (b) Transverse section of the fossil wood Ebenoxylon siwalicus showing anatomical details.

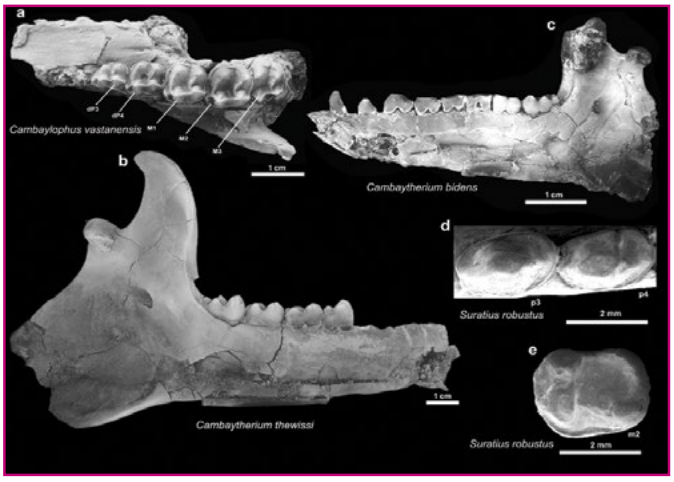


Fig. 9 - Glimpse of a few ~54.5-million-year-old terrestrial mammals from Cambay Shale, western India (after Kapur et al., 2022)

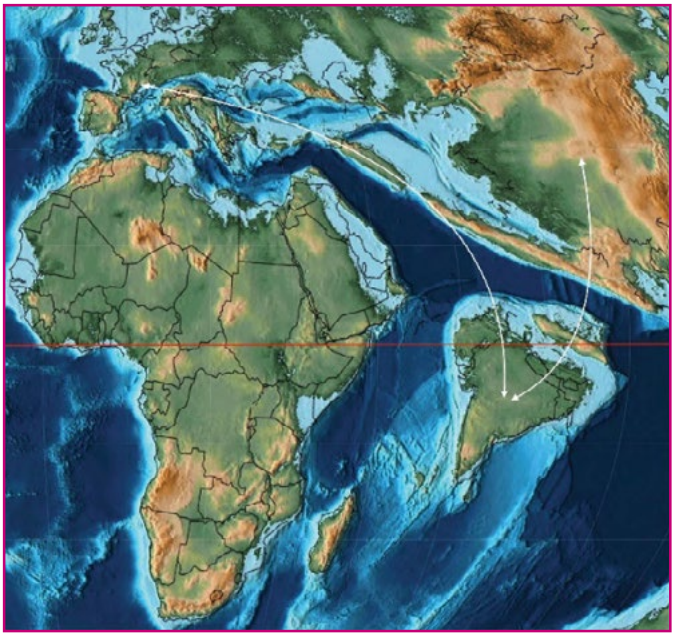


Fig. 10 - Palaeobiogeographic reconstruction around Palaeocene-Eocene Boundary (~55 Ma) showing the directions (white arrows) of faunal exchanges between India and Asia/ Europe (after Kapur et al., 2022).

Araucariaceae and Podocarpaceae as the major conifers contributed into these sediments (Fig. 11). The occupancy of these southern conifers in this area also points to its existence as refugia among the angiosperms.

Neogene plant fossil records from the Indus Basin sedimentary rocks (IBSR), deposited in the Indus Tsangpo Suture Zone (ITSZ), are sparse and important in understanding the evolution of climate and plant diversity in the Trans-Himalaya. Plant fossils described from the Karit Formation suggest a warm and humid Trans-Himalaya during the late Miocene, which is in contrast to the present cool and dry climate in the Trans-Himalaya.

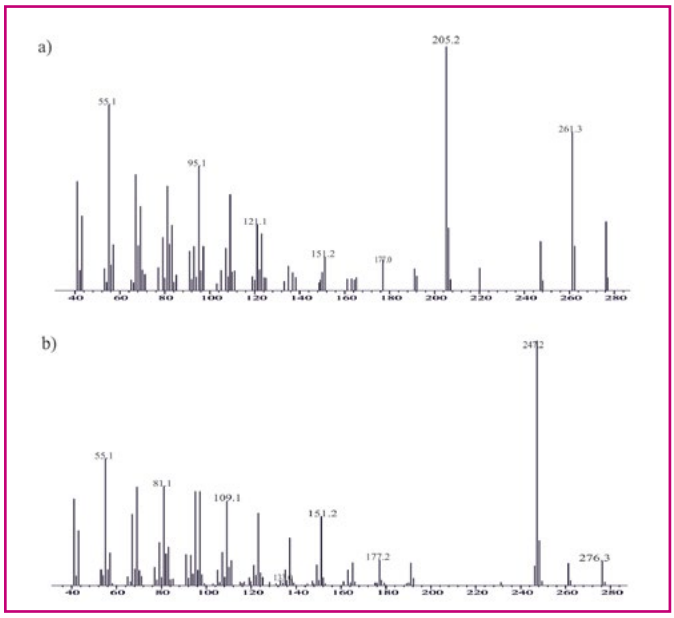


Fig. 11 – (a) Tricyclic diterpenoid, which is also distinct for extant A. Nemrosa and A. Cunninghamii, (b) Rosane: Compound from both Podocarpic and Araucarian precursors.

A reconnaissance field work was undertaken for palaeontological investigations of the Middle Siwalik sedimentary sequences of northwest Himalaya (Fig. 12). The preliminary palaeontological investigation revealed presence of a rich assemblage of cyprinids fishes mainly represented by isolated dental elements. Overall, the late Miocene cyprinid assemblage from the Middle Siwalik sediments of NW Himalaya indicates prevalence of a freshwater palaeoenvironment.

The interplay between tectonic exhumation, climate, atmospheric CO_2 and continental erosion and weathering is crucial to understand the mechanism that forced Cenozoic global cooling. However, long-term silicate weathering records are poorly constrained in the Himalayan belts during the late Cenozoic Era. Our preliminary data of clay mineral assemblages shows an increase in smectite and a decrease in kaolinite content close to 7 Ma that is suggestive of reduced precipitation but increase in seasonality in the catchment of the Himalayan Foreland Basin (Fig. 13).

Claystone samples from the Lumpy Clay Member of Maniyara Fort Formation exposed along Berwali River near Bermoti Village, Kachchh were analyzed for micropalaeontological study and several moderately preserved nummulitid foraminifera, corals, coralline algae, bryozoans and gastropods were recorded (Fig. 14). Based on the presence of marker foraminifer *Nummulites vascus*, the studied section has been dated as early Oligocene (Rupelian). The study also suggests that corallines were dominated by lithophylloid and geniculate (articulated) forms indicative of a warm and shallow-marine depositional palaeoenvironment.

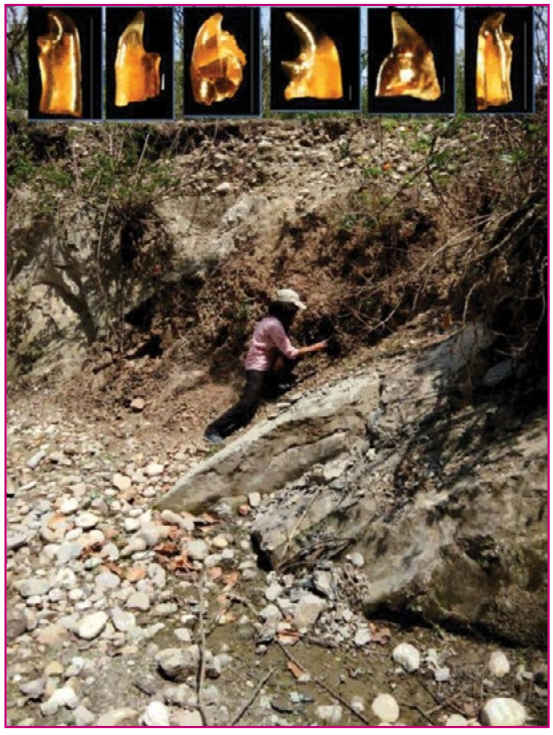


Fig. 12 - Field photograph showing cyprinids teeth and fossil horizons in Siwalik.

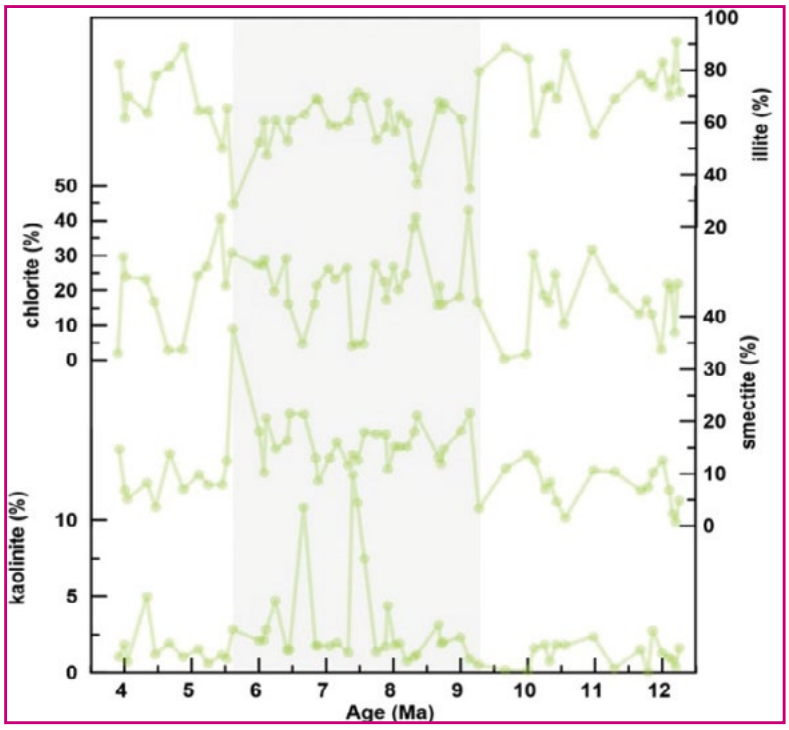


Fig. 13 - Clay mineral assemblages from Kathgodam section.

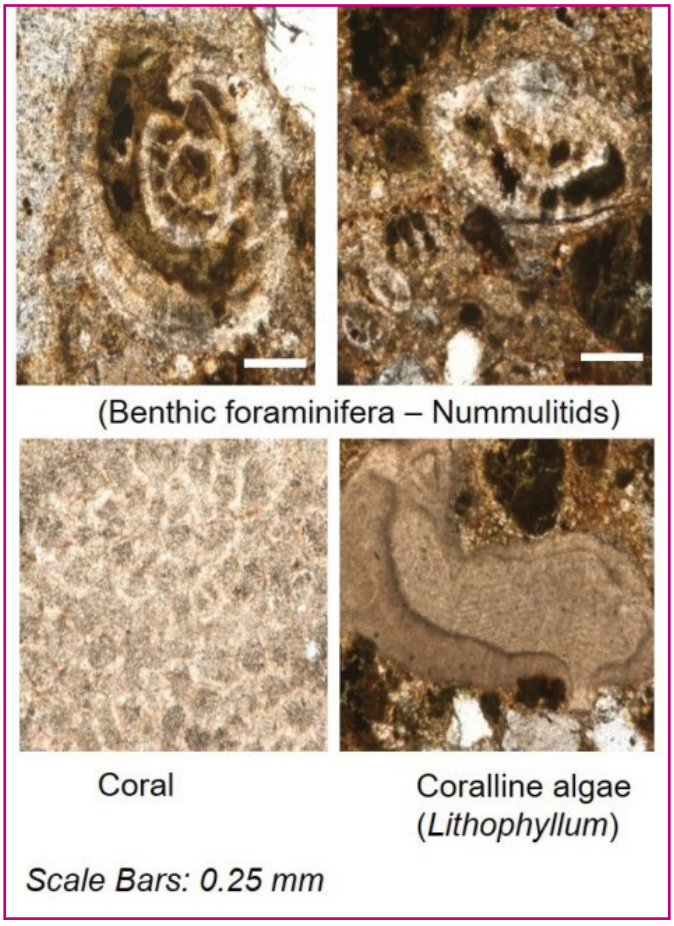


Fig. 14 - Photographs of the thin section showcasing nummulitid foraminifera.

PROJECT OUTCOME

In SCI (Science Citation Index) Journals

1. Bhatia H, Srivastava G, Mishra SR, Barman P, Su Tao, Mehrotra RC & Tripathi SC 2021. Warm and humid Trans-Himalaya during the late Miocene: plant fossil evidence. Palaeoworld. DOI: 10.1016/j.palwor.2021.10.003. **(IF: 2.717)**
2. Farooqui A, Singh H, Prasad M & Singh VK 2021. Morphometry and morphology of Testate amoebae from the Miocene sub-Himalayan zone of Darjeeling, India. Himalayan Geology 42(1): 137-154. **(IF: 1.311)**
3. Kapur VV, Carolin N & Bajpai S 2022. Early Palaeogene mammal faunas of India: a review of recent advances with implications for the timing of initial India-Asia contact. Himalayan Geology 43 (1B): 337-356. **(IF: 1.311)**
4. Mishra S, Singh SP, Arif M, Singh AK, Srivastava G, Ramesh BR & Prasad V 2022. Late Maastrichtian vegetation and palaeoclimate: Palynological inferences from the Deccan Volcanic Province of India. Cretaceous Research 105126. https://doi.org/10.1016/j.cretres.2021.105126. **(IF: 2.432)**
5. Prasanna K, Ghosh P, Eagle RA, Tripati A, Kapur VV, Feeney RF, Fosu BR & Mishra D 2021. Temperature estimates of lower Miocene (Burdigalian) coastal water of southern India using a revised otolith "clumped" isotope Palaeothermometer. Geochemistry, Geophysics, Geosystems 22, e2020GC009601. DOI: 10.1029/2020GC009601. **(IF: 4.48)**
6. Shukla A, Srivastava R, Mehrotra RC & Chandra K 2021. First Record of *Lagerstroemia* (family Lythraceae) wood from the Deccan Intertrappean beds of India. Journal of the Geological Society of India 97(9): 1028-1032. **(IF: 1.466)**
7. Singh H, Agnihotri P & Sharma J 2022. Amber flora and fauna from early Eocene Vastan Lignite Mine Cambay Basin, Gujarat: Ecological diversity and environmental significance. Journal of Geological Society of India 98: 661-668. **(IF: 1.466)**
8. Singh H, Judd W, Samant B, Agnihotri P, Grimaldi D & Manchester S 2021. Flowers of Apocynaceae in amber from the early Eocene of India. American Journal of Botany 108(5): 1-10. DOI:10.1002/ajb2.1651. **(IF: 3.325)**
9. Singh VP, Singh BD, Mathews RP, Mendhe VA, Agnihotri P, Mishra S, Radhwani M, Dutta S, Subramanian KA, Singh A & Singh H 2021. Petrographical-geochemical characteristics and floral-faunal compositions of the Valia Lignite deposits from Cambay Basin (Gujarat), western India. International Journal of Coal Geology 248: 103866. **(IF: 6.3)**.
10. Wood HM, Singh H & Grimaldi DA 2021. Another Laurasian connection in the Early Eocene of India: Myrmecarchaea spiders (Araneae, Archaeidae). ZooKeys. 1071: 49-61. **(IF: 1.546)**.

Refereed Non-SCI Journals

1. Bhatia H, Srivastava G & Mehrotra RC 2021. Late Oligocene climate and floristic diversity of Assam, northeast India. Palaeobotanist 69: 73–92.

General Articles/Reports/Database Published

1. Kapur VV, Kumar K, Pranav JP, Ghosh AK, Chakraborty A, Sharma A, Chauhan G & Thakkar MG 2021. Alpheids from the early Miocene (Aquitanian) Khari Nadi Formation, Kutch Basin, western India: associated chemical [EDS (Multispot and Mapping) and XRF] data. Mendeley Data, V1. DOI: 10.17632/fyt8783th6.1.

Publications other than the Project Work

1. Adhikari P, Bhatia H, Khatri DB, Srivastava G, Uhl D, Mehrotra RC & Paudayal KN 2022. Plant fossils from the Middle Siwalik of eastern Nepal and their climatic and phytogeographic significance. Palaeobiodiversity and Palaeoenvironments. DOI: 10.1007/s12549-022-00523-5 **(IF: 1.736)**.
2. 2. Aggarwal N, Mathews RP, Ansari AH, Thakur B & Agrawal S 2022. A combined palynofacies, isotopic and biomarker studies on palaeoenvironmental reconstruction of the Permian strata of the Godavari Valley Coalfield, south India. Journal of Palaeogeography. DOI: 10.1016/j.jop.2021.07.001 **(IF: 2.789).**
3. Arif M & Misra S 2021 Rock magnetism of ejected basaltic boulders from Lonar Crater, India: Implications for the existence of a short-lived impact-generated weak magnetic field. Meteoritics & Planetary Science 56(4): 794-808. **(IF: 2.89)**
4. Bansal M, Morley RJ, Nagaraju S, Dutta S, Mishra AK, Selveraj J, Kumar S, Niyolia D, Harish SM, Abdelrahim OB, Hasan SE, Ramesh BR,

Dayanandan S, Morley HP, Ashton PS & Prasad V 2022. Southeast Asian Dipterocarp origin and diversification driven by Africa-India floristic interchange. Science. 375(6579): 455−460. DOI.: 10.1126/science.abk2177 **(IF**: **63.714)**.

5. Bhatia H, Srivastava G, Adhikari P, Tao S, Utescher T, Paudayal KN & Mehrotra RC 2022. Asian monsoon and vegetation shift: evidence from the Siwalik succession of India. Geological Magazine. DOI: 10.1017/S0016756822000243 **(IF: 2.656)**.
6. Kumar D, Ghosh S, Tiwari B, Varma AK, Mathews RP & Chetia R 2021. Palaeocene-Eocene organic sedimentary archives of Bikaner-Nagaur Basin, Rajasthan, India: An integrated revelation from biogeochemical and elemental proxies. International Journal of Coal Geology 247, 103848.DOI: 10.1016/j.coal.2021.103848 **(IF: 6.3)**.
7. Patel R, Goswami S, Aggarwal A & Mathews RP 2021. Lower Gondwana megaflora, palynoflora and biomarkers from Jagannath Colliery, Talcher Basin, Odisha, India and its biostratigraphic significance. Geological Journal 57: 986-1004. DOI:10.1002/gj.4318 **(IF: 2.128)**.
8. Patel R, Goswami S, Aggarwal A & Mathews RP 2021. Palaeofloristics of Lower Gondwana exposure in Hingula area, Talcher Basin, Odisha, India: An inclusive study on biomarkers, megafloral and palynofloral assemblages. Historical Biology DOI:10.1080/08912963.2021.1986039 **(IF: 1.942)**.
9. 9. Singh A, Deori N, Pandey DK, Shekhawat RS & Verma P 2021. Biostratigraphic implications of the calcareous nannofossils from the Spiti Formation at Langza, Spiti Valley. In: Banerjee S & Sarkar S (Editors) - Mesozoic stratigraphy of India, Society of Earth Scientists Series, Springer International Publishing, Springer Nature Switzerland AG : 429–442. DOI: 10.1007/978-3-030-71370-6_15.
10. Singh VP, Singh BD, Mathews RP, Mendhe VA, Agnihotri P, Mishra S, Radhwani M, Dutta S, Subramanian KA & Singh H 2021. Petro-geochemical characteristics and floral-faunal composition of Valia Lignite deposits of Cambay Basin (western India), in relation with palaeoenvironment, palaeoecology, depositional settings and hydrocarbon generation potential. International Journal of Coal Geology 248, 103866. DOI: 10.1016/j.coal.2021.103866 **(IF: 6.3)**.
11. Singhla G, Ali S, Singh BP, Bhargava ON, Morrison S, Kaur R, Sati M & Stopden S 2022. Geochemical evidence for the provenance, tectonic settings and depositional environment during the Cambrian Series 2-Wuliuan (Miaolingian) from the Kunzam La Formation in the Sumna Valley, Spiti, NW Himalaya. Journal of Earth System Sciences **(IF: 1.912)**.
12. Song A, Liu J, Liang SQ, Do TV, Nguyen HB, Deng WBD, Jia LB, Rio CD, Srivastava G, Feng Z, Zhou ZK, Huang J & Su T 2021. Leaf fossils of *Sabalites* (Arecaceae) from the Oligocene of northern Vietnam and their Palaeoclimatic implications. Plant Diversity. DOI: 10.1016/j.pld.2021.08.003 **(IF: 3.359)**.
13. Umamaheswaran R, Dutta S, Singh H & Kumar S 2021. Pyrolysis-GCxGC-TOFMS as a tool for distinguishing the macromolecular structure of nitrogen-bearing animal biopolymers in fossil tissues. Journal of Analytical and Applied Pyrolysis 161, 105362 **(IF: 6.437)**.

SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

SP 3.1: Biostratigraphy of Kerala Basin based on palynology and calcareous nannofossils: implications on palaeovegetation and palaeoclimate (Sponsored by DST, New Delhi, Project No. EMR/2016/005983).

Investigator(s): Poonam Verma (PI), Abha Singh (Co-PI), Yogesh Pal Singh (SRF)

An integrated biostratigraphy based on dinocysts and calcareous nannofossils from the Quilon Formation (Kerala) indicates that the investigated Channa-Kodi succession was deposited during the early Miocene (middle Burdigalian, ~19-17.5 Ma). The recovered dinocyst assemblage consists of diverse taxa namely *Cleistosphaeridium*, *Polysphaeridium*, *Lingulodinium*, *Homotryblium* and *Spiniferites* indicative of inner to outer neritic shallow marine depositional palaeoenvironment. The abundance of autotrophic, thermophilic taxa suggests relatively high surface water temperatures and high nutrient availability. An increase in the relative abundances of outer neritic dinocyst taxa such as *Spiniferites*, *Hystrichokolpoma* and *Achomosphaera* in the upper part of the succession suggests a change towards more open marine conditions due to marine ingression. The interpreted marine ingression along the south-western Indian Coast probably corresponds to the initial small pulses of transgression at the onset of the long-term global sea-level maximum related to the Mid-Miocene Climatic Optimum (MMCO) (Fig. SP 3.1).

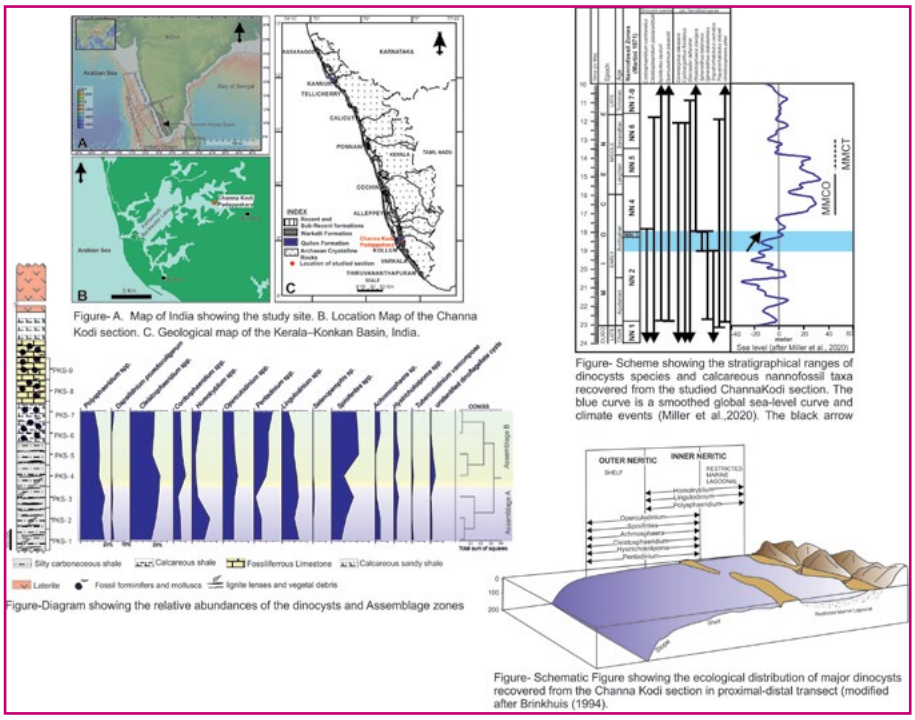


Fig. SP 3.1 - Location map, stratigraphic ranges, relative abundances and ecological distribution of the recovered dinocysts from the Channa Kodi section, Kerala.

SP 3.2: Palaeodietary habit(s) in deep time, linkages to producer taxa, and palaeoenvironmental inferences utilizing Mesozoic-Cenozoic fossilized faecal matter (coprolites) from India (Sponsored by SERB, New Delhi as part of Core Research Grant (CRG); Project No. CRG/2019/002204).

Investigator(s): Vivesh Vir Kapur (PI), Kamlesh Kumar (Co-PI1), P Morthekai (Co-PI2), Ramanand Sagar (JRF)

This project aims to elucidate the contents of Mesozoic-Cenozoic coprolites to infer the diet of producer taxa, to establish associations between coprolites and their producer(s) in a morphometric and statistical framework and to understand the deep-time prey-predator relationship(s) in varied environments (Fig. SP 3.2).

SP 3.3: Appraisal of the Neogene vegetation shift and climate change in northern India, based on plant megafossils (Sponsored by SERB, New Delhi as part of Core Research Grant (CRG); Project No. CRG/2019/002461).

Investigator(s): Gaurav Srivastava (PI), R C Mehrotra (Co-PI)

We have analyzed the floristic diversity of Lower (Middle Miocene) and Middle (Late Miocene–Pliocene) Siwalik of Darjeeling, West Bengal. We have quantified the climate of Lower and Middle Siwalik of this area

Fig. SP 3.2 - Digital photographs showcasing the external views of recently recovered cm-sized coprolite specimen from the Neogene of Kutch (=Kachchh) region, western India. Scale bar equals 1 cm for all. Note: constrictions (blue arrow), ribbings (green arrow).

using the Co-existence Approach. The floristic analysis indicates that Lower Siwalik forests were dominated by wet evergreen taxa, whereas deciduous ones became more dominant during the Middle Siwalik (Fig. SP 3.3). The quantified reconstructed climate data indicate a decrease in winter temperature and precipitation during the wettest months in the Middle Siwalik. The vegetation shift occurred most likely due to a decrease in rainfall during the wettest months, i.e. summer monsoon season.

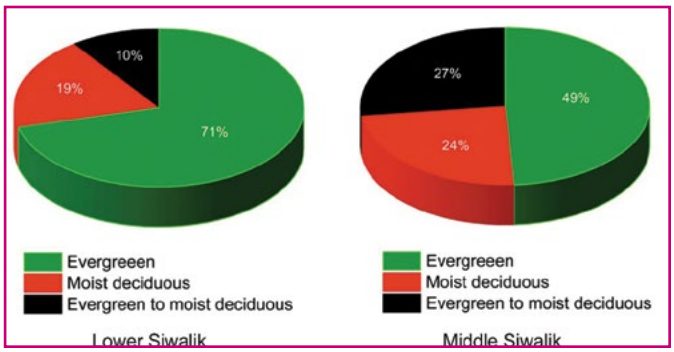


Fig. SP 3.3 - Pie diagram showing the forest types during the deposition of the Lower and Middle Siwalik sediments of Darjeeling, West Bengal.

SP 3.4: Reconstruction of Palaeobathymetric variations and Palaeogeographic maps of south Cambay Basin during middle to late Eocene (Sponsored by ONGC-RGL, Vadodara).

Investigator(s): Vandana Prasad (PI), Poonam Verma (Co-PI), Abha Singh (Co-PI), Prem Raj Uddandam (Co-PI), Suman Sarkar (Co-PI), Shreya Mishra (Co-PI)

A collaborative project entitled "Reconstruction of Palaeobathymetric variations and Palaeogeographic maps of south Cambay Basin during middle to late Eocene Cambay Basin" is formulated and implemented between ONGC, RGL, Vadodara and BSIP. A visit was paid to RGL-Vadodara during 4-8 October, 2021 to discuss the project and to the decide work plan.

OTHER ACADEMIC WORKS

Research papers presented

1. **Srivastava Gaurav** - Monsoon and vegetation shift during the Neogene: evidence from the Siwalik flora of eastern Himalaya. NECLIME Conference, Germany (online), 19–22 April, 2021.
2. **Bhatia Harshita** - Advent of monsoonal climate and evolution of evergreen forest in South Asia: evidence from Oligocene flora of India, NECLIME Conference, Germany (online), 19–22 April, 2021.
3. **Bhatia Harshita** - Fossil wood of *Cordia* L. from the Tipam Sandstone Formation of northeastern India. NECLIME International Conference "Neogene Climate Evolution in Asia", Online, 7-9 September, 2021.
4. **Mathews RP, Chetia R & Singh VP** - Organic geochemical and petrographical characteristics of Jalipa Lignite of Barmer Basin, Rajasthan, India. International Committee for Coal and Organic Petrology, 72nd Annual Meeting, Prague, Czech Republic, Online, 19th – 25th September, 2021.
5. **Mathews RP, Singh VP, Chetia R, Singh BD, Singh A & Mendhe VA** - Organic petrographic and geochemical characterization of Neyveli Lignite Deposits (Cauvery Basin), Tamil Nadu, India: Insights into the Source Flora, Depositional Environment and Hydrocarbon Generation Potential. NECLIME, 7-9 September, 2021.
6. **Domning DP, Bajpai S & Kapur VV** - Biotic evolution and biogeography during the Neogene in South Asia: Sirenians and Seagrasses. NECLIME International Conference "Neogene Climate Evolution in Asia", Online, 7-9 September, 2021. Abstract: Page nos. 25-26.
7. **Sagar R, Kapur VV, Kumar K, Morthekai P, Sharma A, Chauhan G & Thakkar MG** - Preliminary data on coprolites from the Neogene (Miocene: Aquitanian–Burdigalian) Khari Nadi and Chassra formations, Kutch Basin, western India. NECLIME International Conference "Neogene Climate Evolution in Asia", Online, 7-9 September, 2021. Abstract: Page nos. 43-44.
8. **Chandra K, Shukla A, Mehrotra RC & Singh AK** - Palaeotropical diversity of western Rajasthan during the Palaeogene: insight from the plant megafossil records. XLIV All India Botanical Conference of the Indian Botanical Society. 18-20 October, 2021 Abstract: Page nos. 122-123.
9. **Bhandari Ansuya** - Remarkable Miocene vertebrate fossils from Kutch, western India. NECLIME International Conference "Neogene Climate Evolution in Asia", Online, 7-9 September, 2021. Abstract: Page no. 28.
10. **Ali Sajid, Hathorne Ed & Frank Martin** - Miocene to recent chemical weathering in the Himalaya inferred from the stable Li-isotopes. Goldschmidth (online), 4-9 July, 2021. Abstract: Page no. 7615.

Deputation to Conferences/Seminars/ Workshops (both online and offline)

Anumeha Shukla

- XLIV All India Botanical Conference of the Indian Botanical Society held at the Department of Botany (UGC-CAS) Jai Narain Vyas University, Jodhpur (October 18-20, 2021).

Deputation to Training/Study Visits

Poonam Verma

- Training on applied biostratigraphy (online) by Ingeoexpert, London, 29th March to 10th May, 2021.
- Training on Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act 2013, (online) by National Productivity Council, Ministry of Commerce and Industry, Govt. of India, 21st and 22nd December, 2021.

Mohammad Arif

- Training imparted to Ms. Isha Singh, Geology Department, Lucknow University for completion of her MSc Dissertation on the topic "Palaeogeographic reconstruction of Indian subcontinent: clues from palaeomagnetism of lava flows within Palaeoproterozoic Vempalle Formation, Cuddapah Supergroup, south India" during March-June, 2021.

Sarvendra Pratap Singh

- 5th National Geo-Research Scholars Meet (NGRSM) 2021 on "Earth Sciences for Sustainable Development" organized by Wadia Institute of Himalayan Geology, Dehradun during July 22-23, 2021.
- E-training on "Refresher Course on Igneous, Sedimentary and Metamorphic Petrology" conducted by Regional Training Division, Eastern Region, Geological Survey of India Training Institute, Kolkata during June 21-28, 2021.
- On-line short graduate course GSA597-Special topics in Applied Geology on "Anisotropy of Magnetic Susceptibility (AMS) and its applications" conducted by Instituto Oceanográfico, Universidade de São Paulo, Brazil during September 6-15, 2021.

Lectures delivered

Poonam Verma

- Palaeocene-Eocene extreme global warming events: palynological and geochemical signatures, an invited talk at the Geology Department of the K.J. Somaiya College of Science and Commerce, University of Mumbai, Mumbai on the occasion of World Earth Day 2021, 22nd April, 2021.

Vivesh Vir Kapur

- Flavour(s) of Palaeontology at the Birbal Sahni Institute of Palaeosciences, an invited online session on fossils, Seth Anandiram Jaipuria School, Lucknow, 25th January, 2022.

PH.D. PROGRAMMES

Yogesh Pal Singh (2016). Biostratigraphy and palaeoclimate reconstruction of Cenozoic successions of Kerala Basin, under the supervision of **Poonam Verma (BSIP, Lucknow)** and Rameshwar Bali (University of Lucknow, Lucknow), registered with Lucknow University, Lucknow. Status: In progress.

Rimpy Chetia (2018). Organic geochemical and petrographic characterization of lignites from Barsingsar and Jalipa Mines of western Rajasthan, under the supervision of **Runcie Paul Mathews (BSIP, Lucknow)** and P.K. Singh, (Banaras Hindu University, Varanasi), registered with Banaras Hindu University, Varanasi. Status: In-progress.

Sarvendra Pratap Singh (2019). Integrative palynological, magnetostratigraphic, and sedimentological studies of selected Deccan volcano-sedimentary sections of peninsular India: implications for age, palaeoclimate, paleobiogeography and evolutionary history of infra- & intertrappean biotas, under the supervision of **Mohammad Arif (BSIP, Lucknow)** and A.S. Naik (Banaras Hindu University, Varanasi), registered with Banaras Hindu University, Varanasi. Status: In-progress.

Priya Agnihotri (2020). Eocene Arthropods in amber from the Kutch and Cambay Lignites, Gujarat, India: their bearing on palaeoenvironments, under the supervision of **Hukam Singh (BSIP, Lucknow)** and K.A. Subramanian (Zoological Survey of India, Chennai), registered with Academy of Scientific and Innovative Research (AcSIR). Status: In-progress.

Harshita Bhatia (2020). Advent of monsoonal climate and evolution of evergreen forests in South Asia: Evidence from the Oligocene flora of northeast India, under the supervision of **Gaurav Srivastava (BSIP, Lucknow)**, registered with Academy of Scientific and Innovative Research (AcSIR). Status: In progress.

Kajal Chandra (2019). Evolution and diversification of the early Palaeogene Forest during the paleoequatorial position of Rajasthan, under the supervision of **Anumeha Shukla (BSIP, Lucknow)** and Amit Kumar Singh (Lucknow University, Lucknow), registered with University of Lucknow, Lucknow. Status: In-progress.

Sadanand Pathak (2021). Neogene climate evolution vis-à-vis floristic changes in northern India, under the supervision of **Gaurav Srivastava (BSIP, Lucknow)**, registered with Academy of Scientific and Innovative Research (AcSIR). Status:In-progress.

Samiksha Shukla (2021). Evolutionary history of the tropical angiosperms: A case study based on evidence Palaeogene flora from western India, under the supervision of **Anumeha Shukla (BSIP, Lucknow)**, registered with Academy of Scientific and Innovative Research (AcSIR). Status: In-progress.

Mohd Munazir Chauhan (2021).Weathering history of the Himalayan foreland basin sediment since Neogene, under the supervision of **Sajid Ali (BSIP, Lucknow)** and B.P. Singh (Panjab University, Chandigarh), registered with Panjab University Chandigarh). Status: In-progress.

Ramanand Sagar (2022). Mesozoic-Cenozoic vertebrate coprolites from the central and western India: inferences on linkage(s) to producer taxa, palaeodietary habit(s) and palaeoenvironment(s), under the supervision of **Vivesh Vir Kapur (BSIP, Lucknow)** and Kamlesh Kumar (BSIP, Lucknow), registered with Academy of Scientific and Innovative Research (AcSIR). Status: In-progress.

ACCOLADES RECEIVED

- **Hukam Singh:**

  Certificate for Top-cited Article Year 2020-2021 by Wiley for the research article titled "Chemical evidence of preserved collagen in 54-million-year-old fish vertebrae" published in the journal Palaeontology.

- **Vivesh Vir Kapur:**

  Certificate for Top-cited Article Year 2020-2021 by Wiley for the research article titled "Palaeodiet of Miocene producers and depositional environments: Inferences from the first evidence of Microcoprolites from India" published in the journal Acta Geologica Sinica -English Edition.

REPRESENTATION IN COMMITTEES/ BOARD:

Hukam Singh

- Executive Council Member of The Palaeobotanical Society, Lucknow, India.

Vivesh Vir Kapur

- Executive Council Member of The Palaeobotanical Society, Lucknow, India.
- Expert Member to oversee developmental works of the Fossil Park including "*Rajmahal Fossil Museum and Interpretation Centre*" at Mandro, Sahibganj District, Jharkhand.
- Expert Member to oversee developmental and restoration works of the Fossil Park in Khadir, Kachchh District, Gujarat (a Tourism Department, Government of Gujarat initiative) by the Department of Earth and Environmental Science, KSKV Kachchh University, Gujarat.
- Organizing Secretary of the Online International NECLIME Conference titled "Neogene climate evolution and biotic response(s) in south Asia" during 7-9 September, 2021.
- Session Chair for Theme 3 "Climatic Change(s) during the Neogene" during Online International NECLIME Conference titled "Neogene climate evolution and biotic response(s) in south Asia" on 9 September, 2021.

Gaurav Srivastava

- Organizing Secretary of the Online International NECLIME Conference titled "Neogene climate

evolution and biotic response(s) in South Asia" during 7-9 September, 2021.

- Editor of the Bulletin of the Department of Geology, Tribhuvan University, Kathmandu, Nepal.
- Session Chair for Theme 3 "Climatic Change(s) during the Neogene" during Online International NECLIME Conference titled "Neogene climate evolution and biotic response(s) in South Asia" on 9 September, 2021.

Project 4: Ocean and Polar Palaeoclimatic reconstruction during Neogene and Quaternary.

Coordinator: Amit Kumar Ghosh (Scientist F)

Co-coordinator: Pawan Govil (Scientist E)

OBJECTIVES

- *Monsoonal variation during Neogene: Evidences from Andaman Basin.*
- *Palaeoceanographic variations from the western Indian Ocean during the mid-late Miocene: micropalaeontological and geochemical approach.*
- *Climate variability of the Southern Ocean over the Mid-Pleistocene Transition Palaeoceanography reconstruction from the western Indian Ocean during late Quaternary. Late Quaternary palaeoclimate reconstruction from the high latitude (polar: Arctic and Antarctica) using multiproxy data.*

PREAMBLE

Miocene: Recently the Miocene Climatic Optimum (MCO, ~16.9–14.7 Ma), has emerged as a strong candidate to serve as a future climate analogue. The global temperature during the MCO was significantly higher than the present. Broadly, the MCO and a subsequent Antarctic ice-sheet expansion, termed the Middle Miocene Climate Transition (~14.7–13.8 Ma) appear to be associated with relatively small variations (~50–125 ppm) in pCO_2. The uncertainty surrounding the role of CO_2 and the ocean dynamics during the Miocene makes investigating changes in ocean circulation during this period important.

Quaternary: Work depicted the Southern Ocean palaeoceanographic changes during the mid-Pleistocene transition. The present study of longest sea-surface temperatures, sea-ice, diatom productivity, and ice-rafted debris records will be exploring physical and biological mechanisms responsible for climatic changes during the pre- and post-mid-Pleistocene transition and pre- and post-Mid-Brunhes Event. Furthermore, the western Indian Ocean is influenced by a complex system of boundary currents, mainly, Mozambique and Agulhas Current. We reconstruct late Quaternary variations of the surface, thermocline and bottom hydrography by using micropalaeontology, sortable silt, isotopic and elemental concentration of planktic foraminifera.

Antarctica: Lake sediment cores from the East Antarctica show the time limitation of Holocene due to the availability of short sediment cores. Therefore, it is proposed to study long sediment cores to reconstruct climate-driven changes from the lakes and marine sediments over a longer time scale in the eastern Antarctic peripheral region during the Quaternary by using proxies such as sedimentological, geochemical, micropalaeontological, Ancient DNA and biomarker.

Arctic: Previous studies in the Arctic of Svalbard involve glacial geology, stratigraphy, sedimentology and environmental aspects of late Quaternary palaeoclimate. An attempt has thus been made to assess the late Quaternary Palaeoclimate of the Arctic using proxies as dinoflagellates, thecamoebians, diatoms and organic matter study. The geomorphology and sediments of the post glacial marine terraces contain valuable information about relative sea-level change and sea-ice extent.

PERSONNEL INVOLVED

Team Members: Vartika Singh (Scientist D), Abhijit Mazumder (Scientist D), Sunil Kumar Shukla (Scientist D), Manoj MC (Scientist D)

Associate Members: Anupam Sharma (Scientist F), Niraj Rai (Scientist C), Shailesh Agrawal (Scientist D), Santosh K. Pandey (Scientist D), Arif K. Ansari (Scientist D), Gurumurthy (Scientist C).

Research Associate: Arindam Chakraborty.

Research Scholars: Stuti Saxena, Rikee Dey, Lopamudra Roy, Hidayatullah, Brijesh Kumar, Divya Verma, Masud Kawsar, Sneha Mary Mathew, Trishika Seth..

SIGNIFICANT FINDINGS

Monsoonal variation during Neogene: Evidences from Andaman Basin

Correlation of the micropalaeontological data from the offshore and onshore to understand the monsoonal variation in the Neogene, a correlation has been made. The onshore data obtained from the onshore and offshore sequences of the Andaman-Nicobar Basin have been taken into consideration. For the first time, calcareous nannofossils have been recorded from the Tortonian (late Miocene) of Long Island (Fig. 1). Characteristic calcareous nannofossils of the NN8 Zone represented by the index species *Discoaster bellus* and *Spenolithus abies* have been identified (Fig. 2) right from the base of the studied outcrop along with other well preserved calcareous nannofossil taxa (Fig. 3).

The study of pre-Quaternary warm climates using geological records is an important avenue for understanding the environmental changes in our warming future. The south-western Indian Ocean acts as a major source of heat transport for the high latitude warming. The mid-Miocene Climate Optimum (~16.9–14.7 Ma) and a subsequent Antarctic ice-sheet expansion, termed as the Middle Miocene Climate Transition (~14.7–13.8 Ma) appears to be associated with the variation in temperature and pCO_2. Miocene warmth was linked to changes in ocean circulation. Their cause and effect are difficult to establish without a suitable physical framework. It is possible that understanding of physical parameters is missing to explain these climate trends and transitions related to the temperature and pCO_2 changes. The uncertainty surrounding the role of temperature as well as the ocean dynamics during the Miocene makes investigating changes in ocean circulation during this period is important. Therefore, three marine cores were proposed (Fig. 4).

Fig. 1 – Geological map of Long Island showing the study area

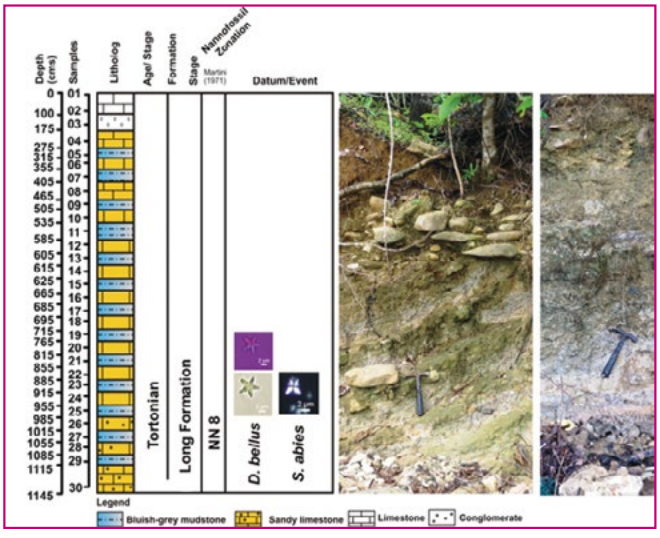


Fig. 2 – Litholog of the outcrop on Long Island and field photograph showing the calcareous nannofissil zone..

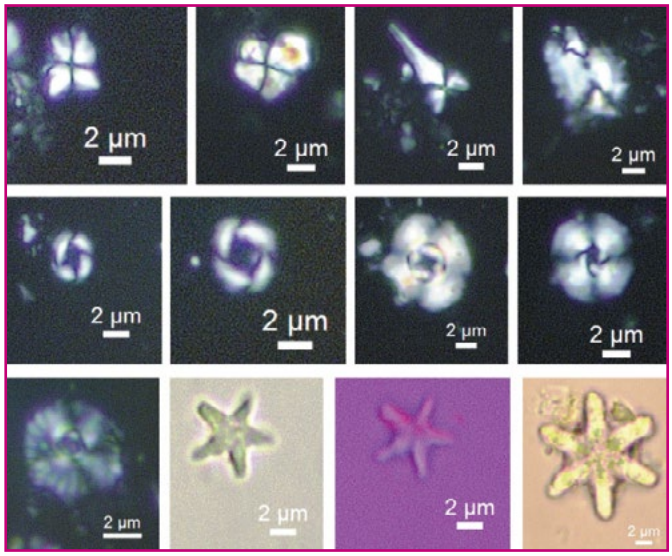


Fig. 3 - Palaeoceanographic variations from the western Indian Ocean during the mid-late Miocene: micropalaeontological and geochemical approach.

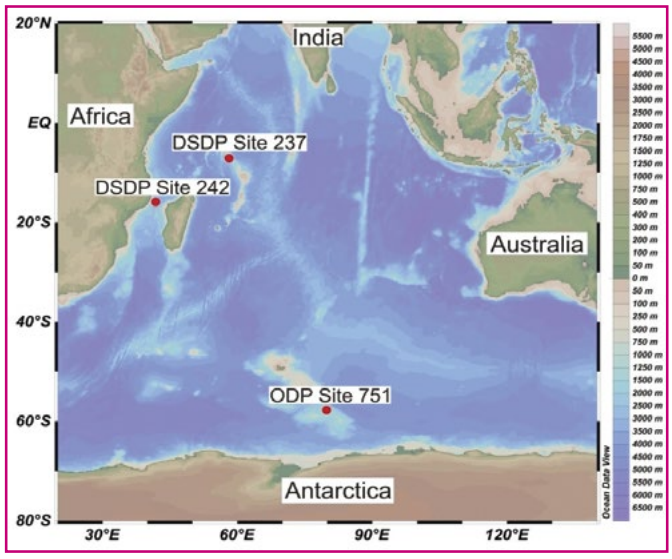


Fig. 4 - Proposed core locations for the marine Miocene sediments.

Climate variability of the Southern Ocean over the Mid-Pleistocene Transition

To understand the role of the Southern Ocean in global climate change, a sediment core from the Indian sector of the Southern Ocean was analyzed for sortable silt (SS), ice rafted debris (IRD), and diatoms. The SS data shows a glacial-interglacial pattern for the past ~610 ka (Fig. 5). The increased mean SS values were found particularly during the interglacials, which indicate strengthened bottom-current activity. The quantitative sea-surface temperature (SST) data was reconstructed using diatoms also indicates a glacial-interglacial pattern in the two sediment cores of the sub-Antarctic region for the past 350 ka and 450 ka (Fig. 6). The millennial-scale SST variability was linked to the summer insolation and atmospheric carbon dioxide concentration.

Palaeoceanography reconstruction from the western Indian Ocean during late Quaternary

The present work is focused on proxy-based studies for better understanding of long-term Ocean circulation and monsoon variability from the western Indian Ocean marine sediment cores (Fig. 7A). The western equatorial Indian Ocean sediment core (VM29-045) shows the planktonic foraminifera assemblages (Fig. 7B). The low relative abundance of mixed layer species and high relative abundance of thermocline species at these two depth intervals (364-280 and 128-68 cm) indicates a thin mixed layer and shallower thermocline in the western equatorial Indian Ocean due to negative IOD conditions (Fig. 8A). On the other hand, towards the top of the core, relative abundance of the mixed layer and thermocline layer species shows an increasing and decreasing trend, respectively. It indicates a thick mixed layer and deeper thermocline due to positive IOD conditions. The Agulhas Plateau study (U1475) results describe the increase

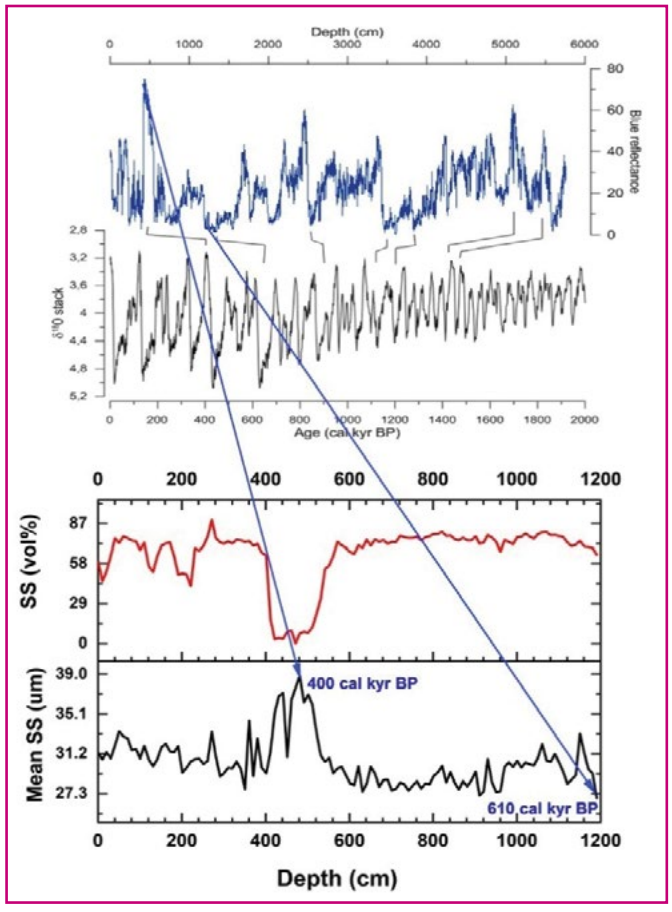


Fig. 5 - Mean sortable silt (SS) and SS % downcore variations in MD19-3576 core. The age tuning has been done by comparing the SS record with the shipboard Blue reflectance and $\delta^{18}O$ stack.

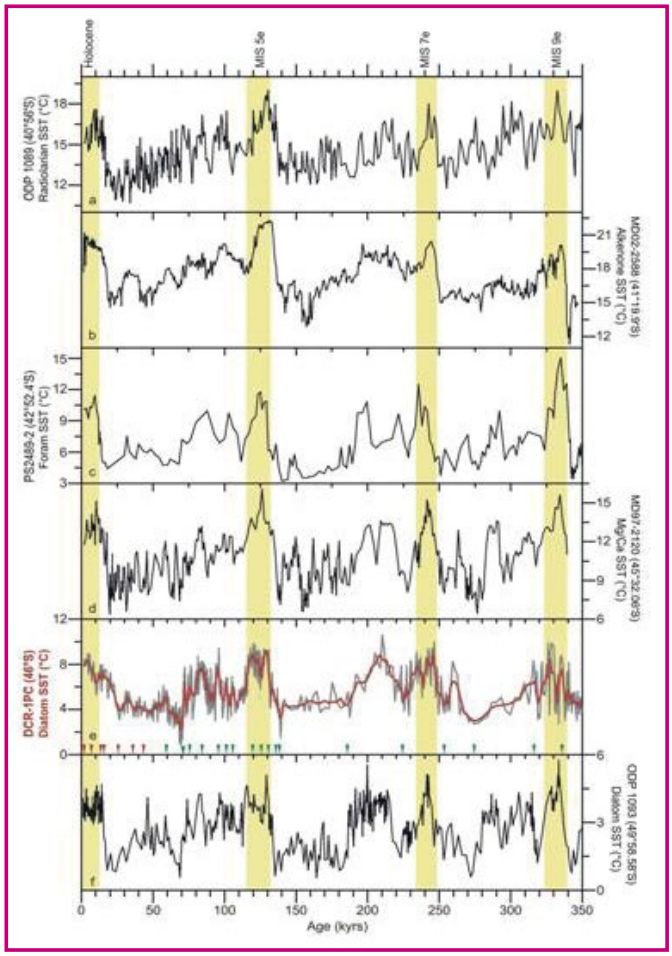


Fig. 6 - Diatom-based sea-surface temperature (SST) of DCR-1PC core for the past 350 ka with the different interglacial periods highlighted in yellow. The SST data was compared with previous SST records from the Southern Ocean.

in relative abundance of *G. bulloides* during MIS-2, the middle part of MIS-3 and MIS 5 suggests high productivity during these periods, and increase in relative abundance of *G. truncatulinoides* during MIS-1, 3 and 5 are suggesting deeper thermocline (Fig. 8B).

Late Quaternary palaeoclimate reconstruction from the high latitude (polar: Arctic and Antarctica) using multiproxy data

The Pleistocene Palaeoenvironmental studies and biotic signatures of recent warming in High Arctic Svalbard - The microfossil record of the sedimentary sequences based on foraminifera and molluscs assemblage was used for Palaeoenvironmental reconstruction of the late Quaternary (Fig. 9). Limited biotic signatures hampered the identification of glaciation and deglaciation events. This shortcoming could only be addressed by a detailed study of all preserved microfossils of the terrestrial sequence exposed at different locations. Arctic amplification is leading to profound changes in the environmental and climatic conditions and is severely impacting the High Arctic ecosystems. The biotic remains of recent warming are being compared with the preserved remains of late Pleistocene.

Antarctica - Study of diatom and sand percentage from the lake sediment core samples taken from the Larsemann Hills provides a brief account of the palaeoenvironmental/ palaeoclimatic changes taken place in and around the study area. The presence of diatom with high sand percentage in the upper half (0-22 cm) and vice versa in lower half (22-40 cm) in core (Fig. 10). Comparatively high productivity, due to less precipitation causing no ice cover on the lake sequence in the upper half and vice versa in lower half can be inferred. Thus, lake area must have experienced a glacial period previously, followed by an interglacial period which extended till Present.

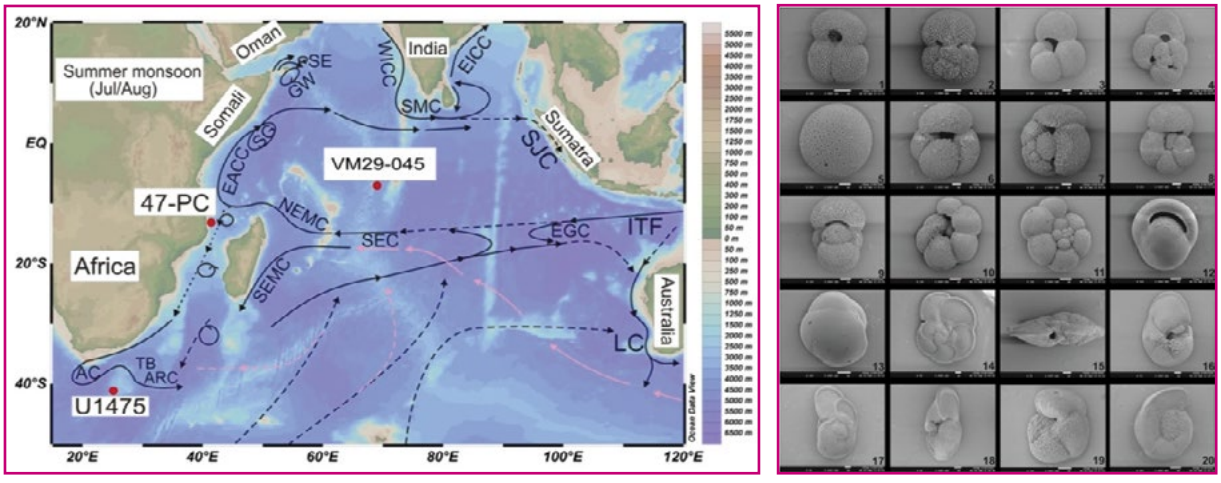


Fig. 7 – (A) Core locations from the western Indian Ocean; (B) Surface and subsurface Planktic foraminifera species of the core VM29-045. Globigerinoides ruber (1, 2), Globigerinoides sacculifer (3, 4), Orbulina universa (5), Globigerinoides conglobatus (6, 7), Globigerinella siphonifera (8, 9), Neogloboquadrina dutertrei (10, 11), Pulleniatina obliquiloculata (12, 13), Globorotalia menardii (14, 15), Globorotalia tumida (16-18), Globorotalia truncatulinoides (19, 20) [scale =100 µm].

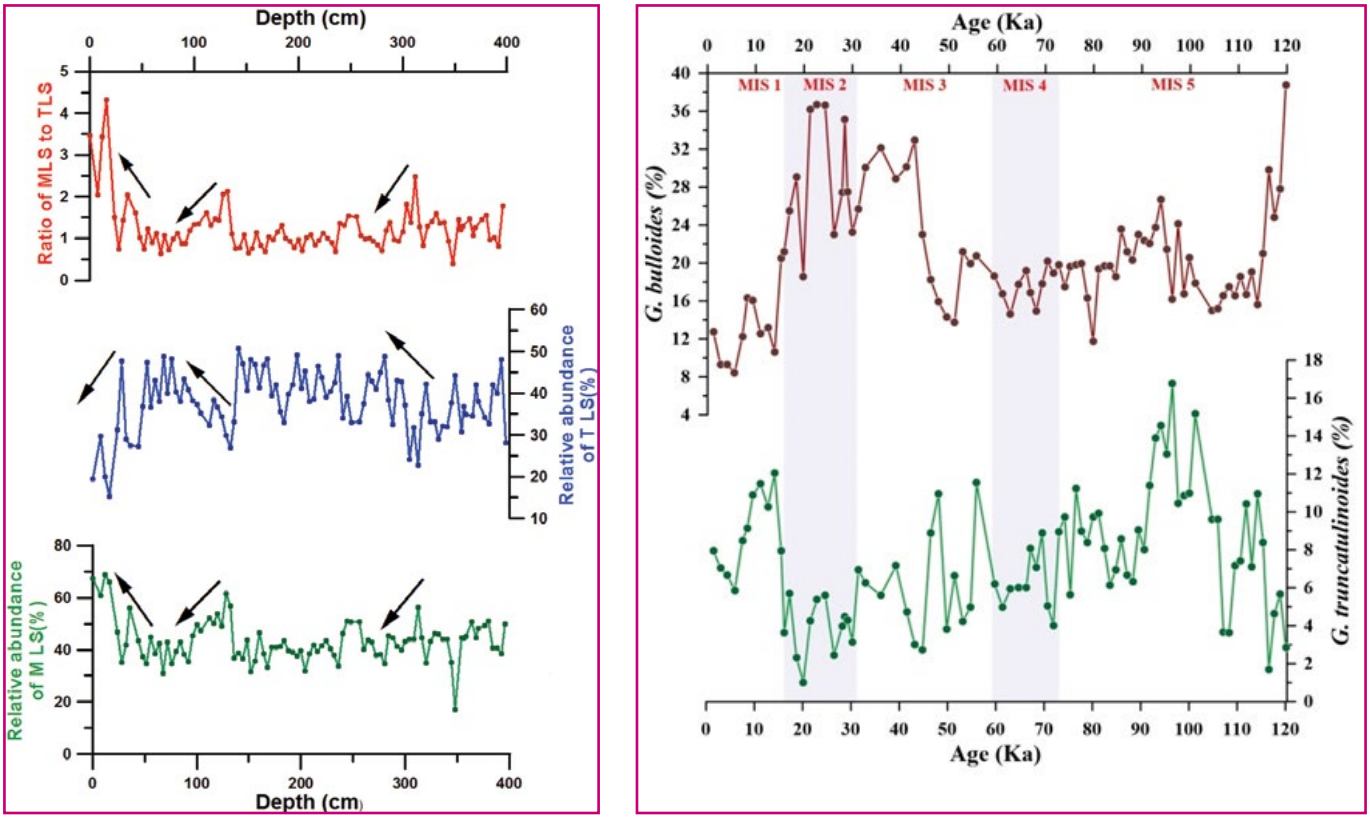


*Fig. 8 – **(A)** Variation of mixed layer (Globigerinoides ruber, G. sacculifer and G. conglobatus) and thermocline dweller species (Neogloboquadrina dutertrei, Globorotalia menardii and G. tumida) of the core VM29-045 up to 400 cm depth.(B) Variation in relative abundance of G. bulloides (mixed layer species) and G. truncatulinoides (thermocline species) of the core U1475.*

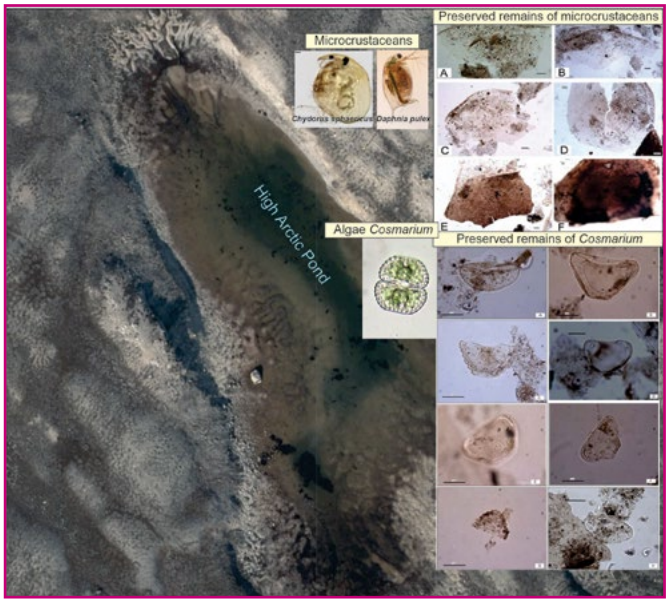


Fig. 9 - Study of preserved biotic remains from a High Arctic pond in Svalbard, Norway.

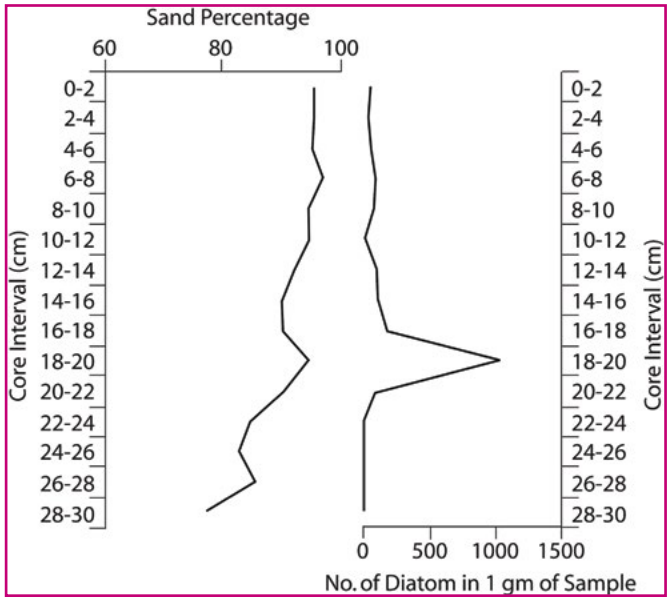


Fig. 10 - Number of total diatoms from the McLeod Island lake core.

PROJECT OUTCOME:

Publications in SCI (Science Citation Index) Journals:

1. Saxena S, Chakraborty A, Galović I, Roy L & Ghosh AK 2022. New insights into the earliest occurrence, possible evolutionary lineage, palaeogeography and palaeoclimatic implications of Nicklithusamplificus: Evidence from Adriatic Sea, Indian Ocean and Paratethys. Marine Micropalaeontology172: 102111. **(IF: 2.102)**
2. Roy L, Ghosh AK, Bhaumik AK, Chakraborty A, Sensarma S, Dey R & Saxena S 2022. Diatom assemblages from the Tortonian of northeast Indian Ocean (NGHP-01-17A): correlation with significant radiolarian and calcareous nannofossil events. Micropalaeontology 68(1): 51-84. **(IF: 1.942)**
3. Chakraborty A, Ghosh AK & Saxena S 2021. Neogene calcareous nannofossil biostratigraphy of the northern Indian Ocean: Implications for palaeoceanography and palaeoecology. Palaeogeography, Palaeoclimatology, Palaeoecology 571: 110583. **(IF: 3.565)**
4. Chakraborty A & Ghosh AK 2021. Early Pliocene low primary productivity: Evidence from Car Nicobar Island, northern Indian Ocean. Journal of the Geological Society of India 97(8): 893-89.9 **(IF: 1.289)**
5. Dey R, Ghosh AK, Bhaumik AK, Chakraborty A, Saxena S & Roy L 2021. Late Pliocene to early Pleistocene planktonic foraminifera from northern Indian Ocean (Andaman and Nicobar Islands): Interpretation on cooling event and ocean upwelling. Journal of Foraminiferal Research 51(3): 115-138. **(IF: 1.582)**
6. Chakraborty A, Ghosh AK, McCartney K, Saxena S, Dey R & Roy L 2021. Early Pliocene calcareous and siliceous microfossils of the Sawai Bay Formation, Car Nicobar Island, northern Indian Ocean. Acta Geologica Polonica 71(2): 175-198. **(IF: 1.289)**
7. Shukla SK, Crosta X & Ikehara M 2021. Sea surface temperatures in the Indian Sub-Antarctic Southern Ocean for the last four interglacial periods. Geophysical Research Letters 48: e2020GL090994. https://doi.org/10.1029/2020GL090994. **(IF: 5.576)**
8. Govil P, Mazumder A, Agrawal S, Azharuddin S, Mishra R, Khan H, Kumar B & Verma D 2022. Abrupt changes in the southwest monsoon during Mid-Late Holocene in the western Bay of Bengal. Journal of Asian Earth Sciences 227: 105100. **(IF: 3.374)**

Refereed Non-SCI Journals

1. Singh V & Barinova S 2021. Cladocera from the sediment of high Arctic Lake in Svalbard (Norway). Transylvanian Review of Systematical and Ecological Research "The Wetlands Diversity" 23(2): 13-20.
2. Singh V & Barinova S 2022. Palynological analysis of surface sediments in a High Arctic pond, revealing desmids as indicators of wetlands and climate change. Transylvanian Review of Systematical and Ecological Research "The Wetlands Diversity" 24(1): 1-16.

Book Chapters/Memoirs/Bulletins

1. Govil P & Mazumder P 2022. A review of the Palaeoclimatic studies from lake sediments of Schirmacher Oasis, East Antarctica. *In:* Khare Neloy (Editor) - Assessing the Antarctic Environment from a climate change perspective pp: 107-126.

Publication Other than the Project Work

1. Ghosh AK, Chatterjee R, Kar R & Pramanik S 2021. Radiation of flora in the early Triassic succeeding the end Permian crisis: Evidence from the Gondwana sediments of Tatapani-Ramkola Coalfield of Peninsular India. Mesozoic Stratigraphy in India (Springer Nature Switzerland) https://doi.org/10.1007/978-3-030-71370-6_3.
2. Pramanik S, Keshri JP, Kar R & Ghosh AK 2021. Megaspores of heterosporous lycopsid affinity from the late Permian of Chhattisgarh, central India and their evolutionary significance. Journal of Botanical Society of Bengal 75(2): 1-16.
3. Srivastava J, Manoj MC, Manjunatha BR, Yoganandan V, Jose J, Balakrishna K, Kumar AN & Ahmed A 2022. Delineation of terrestrial and marine productivity in the Southwestern Continental margin of India. Journal of Asian Earth Sciences 230: 105203. https://doi.org/10.1016/j.jseaes.2022.105203. **(IF: 3.374)**
4. Anoop S, Manoj MC, Kawsar M, Sivadas SK & Beevi MR 2022. Spatio-temporal distribution of heavy metals in sediments of Biyyam Backwater, Kerala, southwest India: its environmental implications. Environmental Nanotechnology, Monitoring & Management. https://doi.org/10.1016/j.enmm.2022.100662. **(IF: 5.647)**

5. Manoj MC, Thakur B & Uddandam PR 2021. Controls on rare earth elements distribution over the past 2000 years from Kerala Coast, southwest India. Environmental Forensics. http://dx.doi.org/10.1080/15275922.2021.1940383. **(IF: 1.88)**

6. Chaddha AS, Mathews RP, Kumar K, Ali SN, Phartiyal B, Manoj MC & Sharma A 2021. Caves as interim-refugia: chemical signatures of human habitation under extreme environments of Ladakh, NW India. Journal of Archaeological Science: Reports 63, 102799. https://doi.org/10.1016/j.jasrep.2021.102799. **(IF: 1.63)**

7. Azharuddin S, Govil P, Singh AD, Mishra R & Agrawal S 2022. Mid-Holocene intensification of the oxygen minimum zone in the northeastern Arabian Sea. Journal of Asian Earth Sciences 227: 105094. **(IF: 3.374)**

8. Azharuddin S, Govil P, Thomas BC, Shekhar M, Gavin LF & Mishra R 2022. Abrupt upwelling and CO_2 outgassing episodes in the north-eastern Arabian Sea since mid-Holocene. Scientific Reports 12(1): 1-12. **(IF: 4.996)**

SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

SP 4.1: Diatom and silicoflagellate biostratigraphy and their implications on palaeoclimate from early Palaeocene to Oligocene of Site U1553, South Pacific Ocean (Sponsored by (IODP Exp. 378), Project No. NCPOR/IODP/E.3947/2021)

Investigators: Amit K. Ghosh (PI); Arindam Chakraborty (Co-PI) & Viswadeep Rout (Project assistant)

To establish early Palaeocene to Oligocene diatom and silicoflagellate biostratigraphy and to evaluate the diversity and evolution of siliceous microfossils during Palaeocene/Eocene and Eocene/Oligocene transitions an in-depth micropalaeontological analysis has been carried out from Site U1553 drilled during Expedition 378 located in the south of New Zealand at Campbell Plateau, South Pacific Ocean. From hole B of the site early Eocene and early to late Oligocene diatoms have been recovered represented by some index species, viz. *Rocella schradari* and *Rocella gelida.* Other characteristic species recognized in the diatom assemblages are *Actinoptychus senarius, Coscinodiscus marginatus, C. radiates, C. rex, Diploneis crabro, Paralia crenulata, P. sulcata, Rocella gelida, Xanthiopyxis oblongata,* etc. (Fig. SP 4.1a). The significant silicoflagellate species are represented by *Bachmannocena apiculata apiculata, Corbisema triacantha mediana, Corbisema apiculate, Distephanus speculum pentagonus, Distephanus speculum speculum, Distephanus crux, Distephanus longispinus, Naviculopsis biapiculata,* etc. (Fig SP 4.1b).

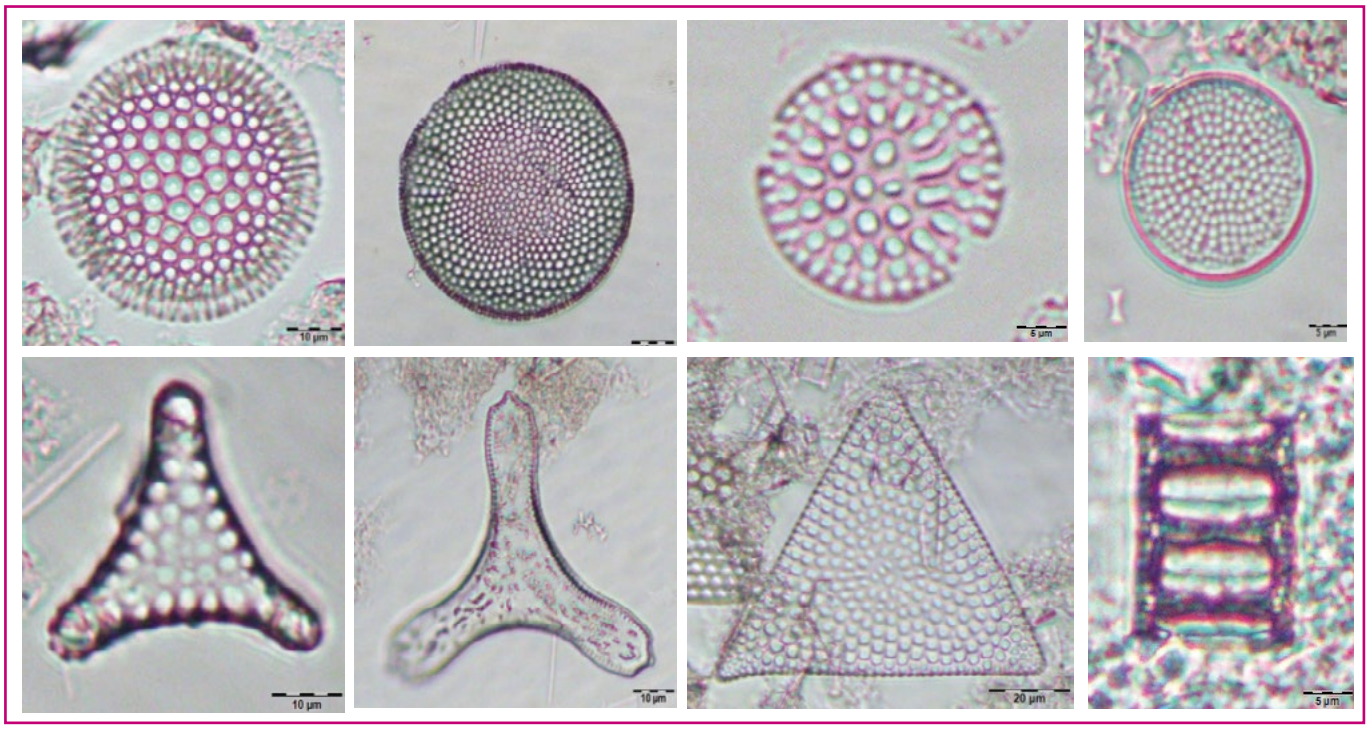


Fig. SP 4.1a - Significant Eocene - Oligocene diatom taxa from Site U1553 of IODP Expedition 378

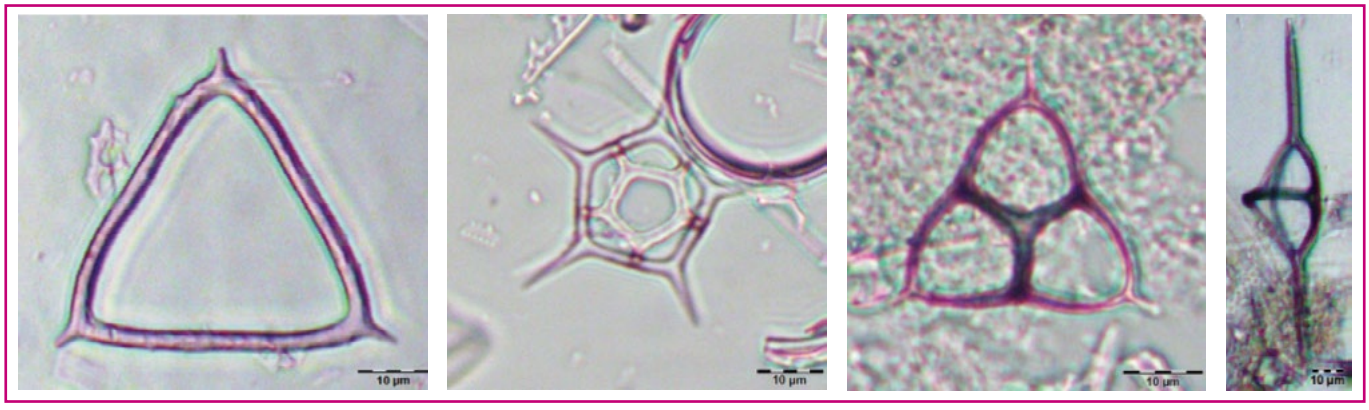


Fig. SP 4.1b - Significant Eocene - Oligocene silicoflagellate taxa from Site U1553 of IODP Expedition 378.

SP 4.2: Investigation on phytoplankton diversity and geochemistry of the Miocene-Pliocene Sequence from the Andaman and Nicobar Islands: Its significance in past climate reconstruction (Project No. DST-INSPIRE-IF170181).

Investigators: Stuti Saxena, DST-INSPIRE, SRF and Amit K. Ghosh (Scientist F), Mentor

The study has been carried out on the nannofossil assemblage from the Sitapur Village Section located on Neil Island. Based on the recovered index calcareous nannofossils, *viz. Discoaster berggrenii* and *D. surculus* (Fig SP-4.2a), the base of the section is assigned to ~8.20 Ma. The presence of characteristic marker calcareous nannofossil assigns this section to NN11 Zone (Martini, 1971) and CNM16 (Backman *et al*., 2012) (Fig SP 4.2b). Other Calcareous nannofossils in the assemblage includes *Calsidiscus leptoporus*, *C. macintyrei*, *Discoaster bergenii*, *D. berggrenii*, *D. brouweri*, *D. quinqueramus*, *D. surculus*, *D. variabilis*, *Helicosphaera carteri*, *H. intermedia*, *Pontosphaera discopra*, *P. multipora*, *Reticulofenestra haqii*, *R. minuta*, *Sphenolithus abies*, *S. moriformis*, *Umbilicosphaera jafari* and *U. rotula*.

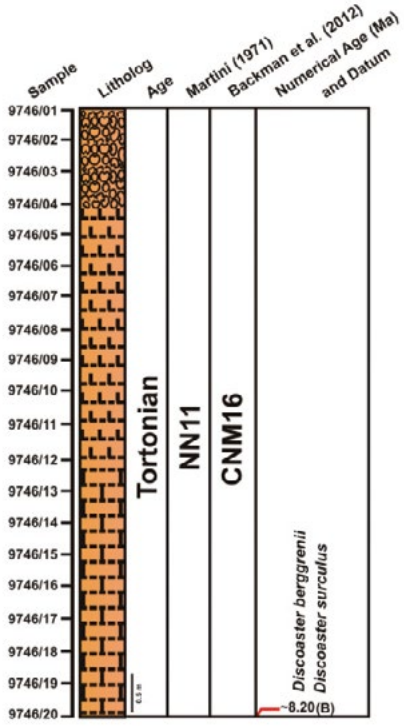


Fig SP 4.2b - Age determination and zone assignment on basis of recovered calcareous nannofossils.

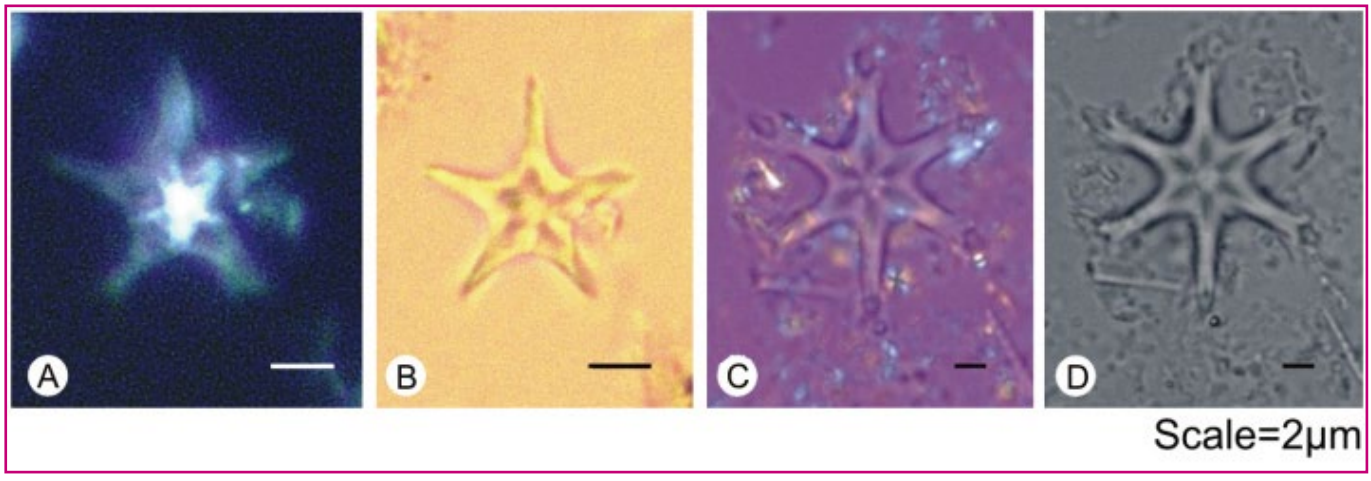


Fig SP 4.2a - A-B. Discoaster berggrenii, C-D. D. surculus.

SP 4.3: Reconstruction of Miocene to Pleistocene palaeoclimate derived from the studies of silicified and calcified microfossils from Andaman and Nicobar Islands (Project No. DST-INSPIRE-IF170761).

Investigators: Rikee Dey, DST-INSPIRE, SRF and Amit K. Ghosh (Scientist F), Mentor

One hundred nineteen taxa belonging to 71 species have been identified from a comprehensive analysis on the radiolarians from the outcrops of Havelock Island; out of which four species namely, *Eucecryphalus histricosus* [Fig. SP 4.3 (A)], *Hexacontium pachydermum* [Fig. SP 4.3. (B)], *Larcopyle pylomaticus* [Fig. SP-4.3 (C)], and *Stylodictya tenuispina* [Fig. SP 4.3 (D)] been recorded for the first time from the northeastern part of the Indian Ocean. The cumulative relative age has been estimated as <17.03 Ma to 13.60/13.63 Ma for the three sections based on the FO and LO of the index radiolarian species. The Nassellaria–Spumellaria ratio indicates that the deposition took place into some extent a deep–water setting to marginal sea. The Water Depth Ecology index (WADE) suggests a corresponding shift towards higher values that implies lower export productivity. Substantial dominance of warm–water species of radiolarians indicates that the possible effect of the MCO event continued till 13.60/13.63 Ma.

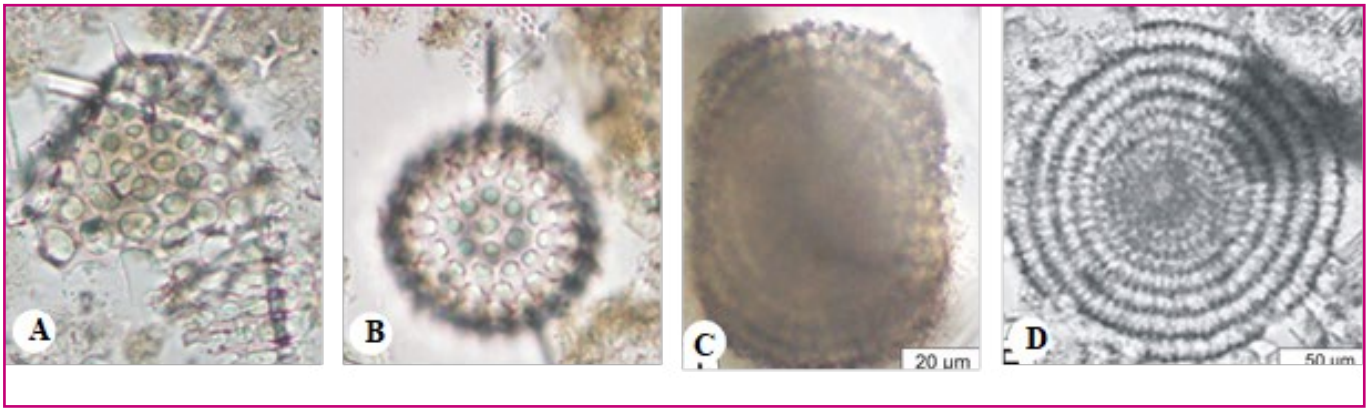


Fig. SP 4.3 - (A) - *Eucecryphalus histricosus, (B) Hexacontium pachydermum, (C) Larcopyle pylomaticus and (D) Stylodictya tenuispina.*

SP 4.4: Late Miocene to Pleistocene palaeoclimate reconstruction based on high-resolution biotic proxies coupled with geochemical analysis from the sediment cores of northeast Indian Ocean (Project No. DST-INSPIRE-IF180254).

Investigators: Lopamudra Roy, DST-INSPIRE, SRF and Amit K. Ghosh (Scientist F), Mentor

Calcareous nannofossil events have been identified from ~320 mbsf to the top of the core, i.e. 0.03 mbsf. The relative age for the studied sequence has been calibrated as >7.39 Ma - <0.43 Ma (Fig. SP 4.4) based on the occurrence FO and LO of index calcareous nannofossils taxa. Significant index calcareous nannofossil taxa are represented by *Pseudoemiliania lacunose, Gephyrocapsa oceanic, Discoaster pentaradiatus, Reticulofenestra pseudoumbilicus, Ceratolithus cristatus, Discoaster quinqueramus, Nikilithus amplificus* and *Amaurolithus primus.* Other dominant calcareous nannofossils taxa are *Reticulofenestra haqii, R. minuta, Pontosphaera multipora, P. discopora, Sphenolithus moriformis, Helicosphaera carteri, Calcidiscus macintyrei,* etc. As derived from the age-depth model based on the significant events (FO, LO) of calcareous nannofossils, it has been estimated that the sedimentation rate was ~50 m/Ma during Messinian to Tarantian in the northeast Indian Ocean.

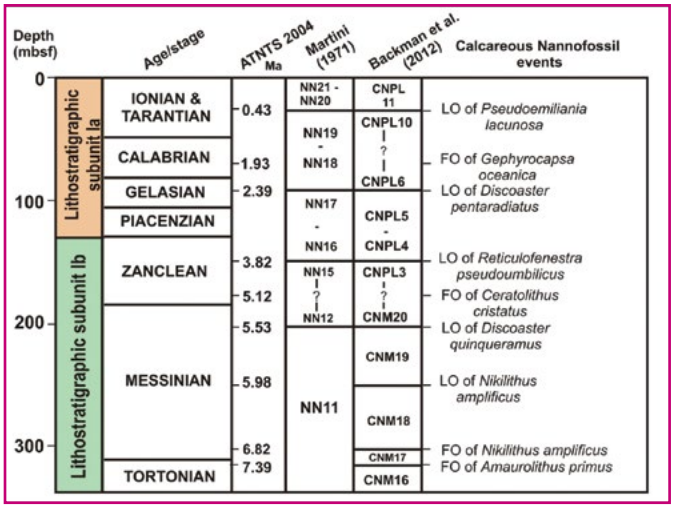


Fig. SP 4.4 - Lithological features of the core (after Collett et al., 2012) and a columnar section showing depth and relative age based on calcareous nannofossils biostratigraphy (Neogene chronostratigraphic scale is after Lourens et al., 2004).

SP 4.5: Climate evolution of the Indian sector of the Southern Ocean over the Late Quaternary. Sponsored by NCPOR; Project No. NCPOR/2019/PACER-POP/ES-04)

Investigators: Sunil Kumar Shukla (BSIP, Lucknow), Rahul Mohan (NCPOR, Goa) and Ms. Trishika Seth (JRF, BSIP)

Quantitative sea-surface temperature (SST) and sea ice presence data were reconstructed using diatoms by applying transfer functions. The reconstructed SST was cooler during the last glacial period and started rising at ~17 ka. Both deglacial and the early Holocene periods were demonstrated with the warmer SST when complete absence of sea ice was found. Such warm SSTs during the deglacial and early Holocene periods could be attributed to the increased solar insolation and atmospheric carbon dioxide (Fig. SP 4.5).

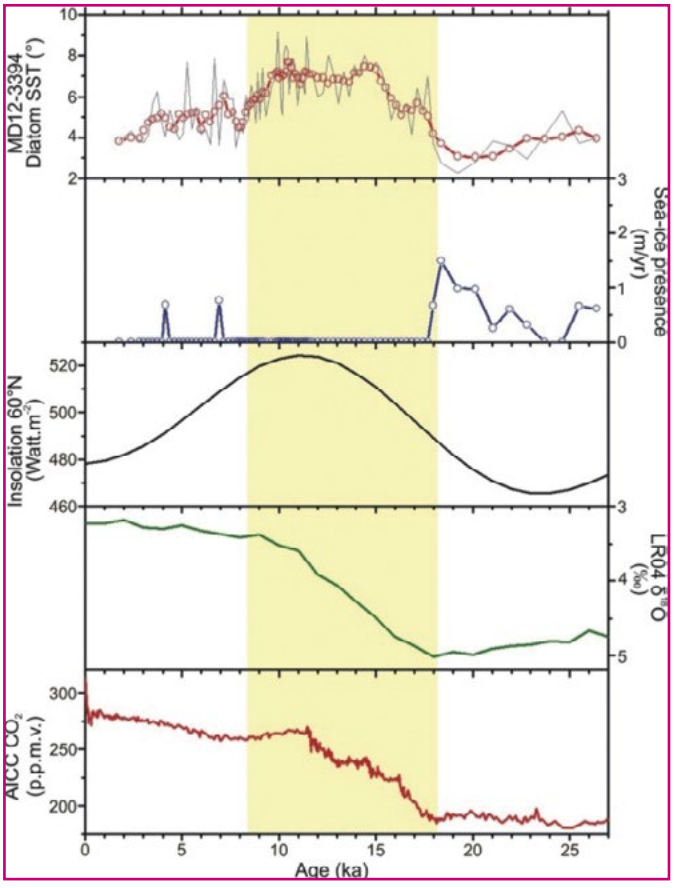


Fig. SP 4.5 - Quantitative sea-surface temperature (topmost red curve) and sea ice presence (blue curve) data were reconstructed through diatoms using a sediment core from the Indian sector of the Southern Ocean for the past ~26 ka. Both SST and sea ice presence data were correlated with the previously published climatic records. The highlighted yellow shading shows warmer SST and the complete absence of sea ice during the deglacial and the early Holocene periods.

OTHER ACADEMIC WORKS

Research Papers Presented

1. Ghosh AK, Roy L, Saxena S, Chakraborty A, Sensarma S & Bhaumik AK 2021. Signature of high productivity during Tortonian: evidence from biosiliceous microfossils from northeast Indian Ocean. Online International NECLIME Conference on "Neogene Climate Evolution and Biotic Response(s) in South Asia", 7-9 September, 2021, organized by Birbal Sahni Institute of Palaeosciences, Lucknow.
2. Chakraborty A & Ghosh AK 2021. Neogene Sea surface temperature derived from calcareous nannofossils of northeast Indian Ocean. Online International NECLIME Conference on "Neogene Climate Evolution and Biotic Response(s) in South Asia", 7-9 September, 2021, organized by Birbal Sahni Institute of Palaeosciences, Lucknow.
3. Dey R, Ghosh AK & Bhaumik AK 2021. WADE ratio of radiolarians: A tool for interpretation on the palaeoecology of Neogene sediments from Andaman and Nicobar Basin, Online International NECLIME Conference on "Neogene Climate Evolution and Biotic Response(s) in South Asia", 7-9 September, 2021, organized by Birbal Sahni Institute of Palaeosciences, Lucknow.
4. Dey R, Ghosh AK, Bhaumik AK 2021. Impact of Radiolarians on Neil Island of Andaman and Nicobar Basin, northeast Indian Ocean, The Micropalaeontological Society Annual Conference, 2021, Prague on 18th -19th November, 2021, Czech Republic.
5. Saxena S, Chakraborty A & Ghosh AK 2021. Late Miocene calcareous nannofossils from Neil Island, northeast India Ocean. The Micropalaeontological Society Annual Conference, Prague, 18th-19th November, 2021.
6. Roy L, Ghosh AK, Chakraborty A, Bhaumik AK, Sensarma S, Saxena S & Dey R 2021. High biosiliceous productivity during the Tortonian - a case study of diatom assemblages from offshore and onshore sediments of the northeast Indian Ocean. Online International Diatom Symposium, 23rd – 25th August, 2021.
7. Roy L, Ghosh AK, Bhaumik AK & Sensarma S 2021. Calcareous nannofossil events and sedimentation rate during Tortonian from northeast Indian Ocean. Online International NECLIME Conference on

'Neogene Climate Evolution and Biotic Response(s), South Asia, 7th-9th September, 2021.

8. Roy L, Ghosh AK, Bhaumik AK & Sensarma S 2021. Late Miocene to Pleistocene calcareous nannofossil events from northeast Indian Ocean. TMS Annual Conference 2021, Prague, Czech Republic, 18th and 19th November, 2021.
9. Kumar B & Govil P 2022. A review and preliminary study on Indian Ocean dipole variability and its impact. Online International Conference "Association of Quaternary Research (AOQR)", organized by Birbal Sahni Institute of Palaeosciences, Lucknow.
10. Verma D & Govil P 2022. Palaeo-productivity variation based on Planktic Foraminifera record from Agulhas Plateau IODP Site U1475. Online International Conference "Association of Quaternary Research (AOQR)", organized by Birbal Sahni Institute of Palaeosciences, Lucknow.
11. Khan H, Govil P, Panchang P, Agrawal S & Kumar P 2022. Southwest monsoon response to surface hydrographic variations in western Arabian Sea through the last 172 kyr". Online International Conference "Association of Quaternary Research (AOQR)", organized by Birbal Sahni Institute of Palaeosciences, Lucknow.

Deputation to Conferences/Seminars/ Workshops (both online and offline)

Amit K. Ghosh, Arindam Chakraborty, Rikee Dey & Lopamudra Roy

- Neogene Climate Evolution and Biotic Response(s) in South Asia, 7-9 September, 2021, organized by Birbal Sahni Institute of Palaeosciences, Lucknow.

Pawan Govil

- Deputed to participate in India International Science Festival Mega Science, Technology & Industry Expo 2021 at Goa for erecting/display a Museum stall of BSIP during 10th to 13th December, 2021.

Arindam Chakraborty, Stuti Saxena, Rikee Dey & Lopamudra Roy

- The Micropalaeontological Society Annual Conference, Prague, 18th-19th November, 2021.

Arindam Chakraborty & Rikee Dey

- One day Workshop on the "International Mangrove Day" held on 26th July, 2021, Birbal Sahni Institute of Palaeosciences, Lucknow.

Arindam Chakraborty & Lopamudra Roy

- Online International Diatom Symposium (IDS-2021) Yamagata, Japan, 23rd-25thAugust, 2021.

Arindam Chakraborty

- NECLIME Early career scientists' network first online workshop held on 8thOctober, 2021.

Arindam Chakraborty, Stuti Saxena, Rikee Dey & Lopamudra Roy

- NECLIME-Early Career Research Workshop, (15th to 16th March, 2022).

Stuti Saxena

- International Training on "Manuscript drafting and fundamentals of Thesis writing" (TOT- 01st to 27th July, 2021), organized by Eudoxia Research Centre, registered under Ministry of Corporate Affairs, Government of India.
- Faculty Development Program (FDP) on "Intellectual Property Rights" (20th-25th September, 2021), organized by REST Society for Research International (RSRI).
- Distinguished Lecture Series 2021-22 on "Biodiversity and its conservation" (27th September, 2021), organized by Department of Botany, Government College, Bichhua, Chhindwara, MP.
- Webinar on "Career Path of Life Science Aspirants" (04th October, 2021), organized by Dwaraka Doss Goverdhan Doss Vaishnav College, Chennai.

Training/Study Visits

- Arindam Chakraborty - Applied Biostratigraphy (50 hours/6 weeks training) conducted by Ingeoexpert, Madrid from 29.03.2021 to 09.05.2021.
- Rikee Dey & Lopamudra Roy - e-Training on "Refresher Training on Concepts of Quaternary Mapping" conducted by RTD, CR, GSITI, Nagpur from 31.05.2021 to 04.06.2021.
- Rikee Dey & Lopamudra Roy - e-Training on"Critical and Strategic Minerals" conducted by RTD, CR, Nagpur from 27.09.2021 to 01.10.2021.

Lectures delivered

Amit K. Ghosh

- Taxonomic and taphonomic issues with special reference to plant macrofossils. NECLIME - Early Career Research Workshop, Virtual Mode (15th to 16th March, 2022).

- Floral radiation and diversity during the age of reptiles. 8th Dr M.N. Bose Memorial Lecture, BSIP, Lucknow (9th March, 2022).

Manoj M.C.

- Palaeoceanography- Lessons for a future world. Department of Chemistry, St. Paul's College, Kalamassery, July 2021.
- Decoding the dynamics of soil erosion and hydroclimatic signals using End Member Modelling Analysis on southwest Indian lakes. IQC-2022: An International Conference, January 2022 (Online).
- Reconstructing dynamics of Northern and Southern sourced bottom waters using sortable silt records in the lower Bengal Fan during last 200 ka. IQC-2022: An International Conference, January 2022 (Online).
- A multi-proxy sedimentary record of last 2.6 ka climate and vegetation from the Mahanadi River Delta, East Coast of India. IQC-2022: An International Conference, January 2022 (Online).

PH.D. PROGRAMMES

Rikee Dey (2017). Reconstruction of Miocene to Pleistocene palaeoclimate derived from the studies of silicified and calcified microfossils from Andaman and Nicobar Islands, under the supervision of **Amit K. Ghosh (BSIP)** and Ajoy Kumar Bhaumik (IIT-ISM), Status: ongoing.

Stuti Saxena (2018). Investigation on phytoplankton diversity and geochemistry of the Miocene-Pliocene Sequence from the Andaman and Nicobar Islands: Its significance in past climate reconstruction, under the supervision of **Amit K. Ghosh (BSIP)** and J. P. Keshri (University of Burdwan), Status: Ph. D. thesis submitted.

Lopamudra Roy (2019). Reconstruction of late Miocene to Pleistocene palaeoclimate using micropalaeontology and geochemical analysis from the sediment core of northeast Indian Ocean, under the supervision of **Amit K. Ghosh (BSIP)** and Sarajit Sensarma (University of Lucknow), Status: ongoing.

Hidayatullah Khan (2020). Reconstruction of Palaeoceanography of tropical Indian Ocean since Marine Isotopic Stages 5, under the supervision of **Pawan Govil (BSIP)** and Rajani Panchang (Pune Univeristy), Status: Ongoing

Brijesh Kumar (2020). Late Quaternary palaeoceanographic reconstructions from the equatorial Indian Ocean: emphasis on Indian Ocean dipole, under the supervision of **Pawan Govil (BSIP),** AcSIR - Academy of Scientific & Innovative Research. Status: Ongoing

Divya Verma (2021). High resolution reconstruction of Palaeoceanography and Palaeoclimatology of south-west Indian Ocean during Late Quaternary, under the supervision of **Pawan Govil (BSIP),** AcSIR - Academy of Scientific & Innovative Research. Status: Ongoing

Masud Kawsar (2020). The Bengal Fan evolution through Neogene and Quaternary: Implication for deep ocean circulation, productivity, and monsoonal shifts, under the supervision of **Manoj M.C. (BSIP)** and Michael E. Weber (University of Bonn, Germany), AcSIR - Academy of Scientific & Innovative Research. Status: Ongoing.

Sneha Mary Mathew (2020). Palaeocene–Eocene records of palaeohydrological and palaeoenvironmental changes from the lignite fields of Rajasthan, India, under the supervision of **Manoj M.C. (BSIP, Lucknow)** and **Shailesh Agrawal (BSIP, Lucknow)**, AcSIR - Academy of Scientific & Innovative Research (In- progress)

Trishika Seth (2022). Oceanographic changes of the Indian sector of the Southern Ocean since the Mid-Pleistocene transition, under the supervision of **Sunil Kumar Shukla (BSIP, Lucknow)**, AcSIR - Academy of Scientific & Innovative Research. Status: Ongoing.

ACCOLADES RECEIVED

Vartika Singh

- Visiting Scientist Fellowship of the Polish Academy of Sciences, Poland in the year 2021.

Representation in Committees/ Board:

Pawan Govil

- Appointed as a Secretary of "The Palaeobotanical Society" on 01st January, 2022.
- Nodal Officer and Convener of the web portal committee for science indicators of public-funded R & D institutions, Principal Scientific Advisor to Govt. of India invited BSIP to participate to explain and demonstrate the instrument and online platform for all subsequent activities. The committee provided and uploaded the answers of 62 questionnaires for the last three financial years of BSIP in 2021.
- Member in the AcSIR (CSIR affiliated deemed University) Committee to look after all the matters pertaining to the Ph.D. registration of BSIP research scholars/student and scientist guideship from the AcSIR.

Project 5: Biological and Biogeochemical changes during Late - Quaternary from Coastal regions of India: Insights into Coastal Dynamics and Monsoonal Variability.

Coordinator: Anjum Farooqui (Scientist F)

Co-Coordinator: Rajesh Agnihotri (Scientist F)

OBJECTIVES

- *To assess palaeoproductivity, palaeovegetation and relative sea-level changes using biotic– abiotic interactions.*
- *To assess variability in governing factor(s) for SW & NE monsoonal strength and coastal ecology.*
- *To evaluate relative roles of continental versus marine factors in governing climatic cycles/ transitional periods.*
- *To delineate controls of climate-tectonic forces on fluvio-marine processes with respect to sea level fluctuations/changes in palaeogulf settings.*

PREAMBLE

The coastal core project was framed to understand the biogeochemical processes that are linked to the biosphere, atmosphere, and hydrosphere. The coastal sediments are the major archives to understand the regional as well as global phenomenon occurring in the climate. All aquatic realms, whether from inland or along the coastal areas, are suffering adverse changes due to the increased industrial and population growth over the recent decades. Rapid changes in the climate, extreme rainfall, and anthropogenic pressures are the major factors that lead to change in coastal ecology. Coastal sediments provide high-resolution ecological alteration in carbon sequestration, sea ingression/ regression. Elements such as, Carbon, Nitrogen, Sulfur, and Phosphorus (C, N, S and P) are the important parameters to understand the biogenic productivity and coastal ecosystems. Deeper understandings into natural and anthropogenically perturbed biogeochemical cycles of biogenic elements are essential for the risk assessment, scenario development, and also to control the mitigation effects of climate change. The integration of the stable isotopes of C, N, S, and the biotic proxies such as, pollen, diatoms, palynofacies, and phytoliths are confirmatory signatures of the past ecological changes, which affect the geochemistry and biodiversity. The combination of proposed proxies allowed us to investigate the complex biogeochemical changes in the present as well as past sediments records. The investigation aimed to provide fruitful insights for today's imbalanced and unmanaged wetland ecosystem and coastal fringe regimes, which can work as a key factor for the climate change scenario.

PERSONNEL INVOLVED

Team Members: Biswajeet Thakur (Scientist E), Shilpa Pandey (Scientist D), P. Morthekai (Scientist D), Niteshkumar Khonde (Scientist C), Sanjay Kumar Singh Gahlaud (Scientist B)

Associate Members: Abhijit Mazumdar (Scientist D), Arif H. Ansari (Scientist D),

Research Scholars: Pooja Tiwari, Anand Rajoriya

SIGNIFICANT FINDINGS:

Multi-proxy study of Vettaikaraniruppu (VKI core), Tamil Nadu

Coastal areas harbour large population, amidst anthropogenic climate change. Sea level ingressions and intrusion of seawater in ground waters are likely to impact East Coast of India at large. To gauge upcoming pressures on coastal ecology, a high-resolution sedimentary record (~25 m long core) from the Kaveri Delta, Tamil Nadu was investigated comprising various biotic and biogenetical tracers for capturing natural environmental variability pattern. Various biotic (pollen and palynofacies), abiotic [sediment texture indices, C, N, and S alongwith their stable isotopes ($\delta^{13}C_{TC}$, $\delta^{13}C_{TOC}$, $\delta^{15}N$, $\delta^{34}S$) with a suite of major elements] reveal the presence of anoxic seawater at the core site. Overall a conspicuous transgressive phase of seawaters could be inferred between ~9-6 ka as observed in multi-proxy dataset (Fig. 1).

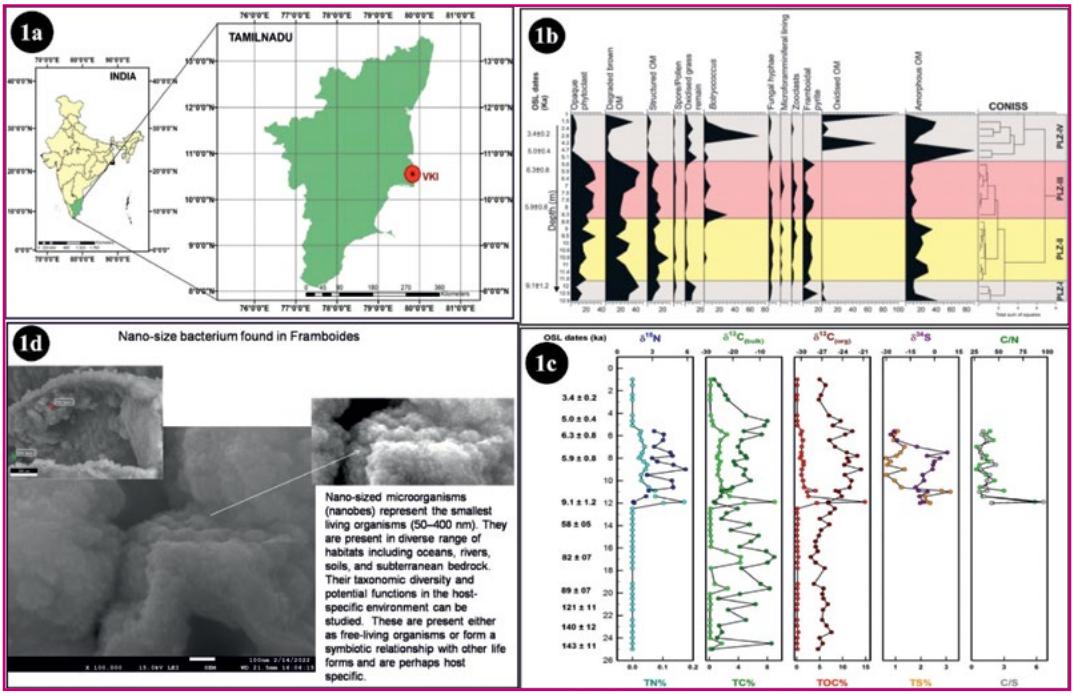


Fig. 1 - (a) Location map of the VKI core from Tamil Nadu, (b) Palynofacies distribution of VKI core, (c) Stable Isotope of CNS and C/N of VKI core, (d) SEM image showing nano-sized micro-organisms from VKI core

Palaeoenvironmental reconstruction from the Great Rann of Kachchh, western India

From the Great Rann of Kachchh Basin, three sediment cores of ~42 m, 37 m, and 32 m were sub-sampled and lithostratigraphy of the same was completed. Along with this, sediment grain size studies were performed. The results showed several coarsening and fining upward sequences in all the studied core sections denoting the significant depositional environmental changes (Fig. 2) of marine transgression/regression/s from this region through the Holocene. Multi-proxy data generation is ongoing, which will help deciphering the palaeoenvironmental conditions.

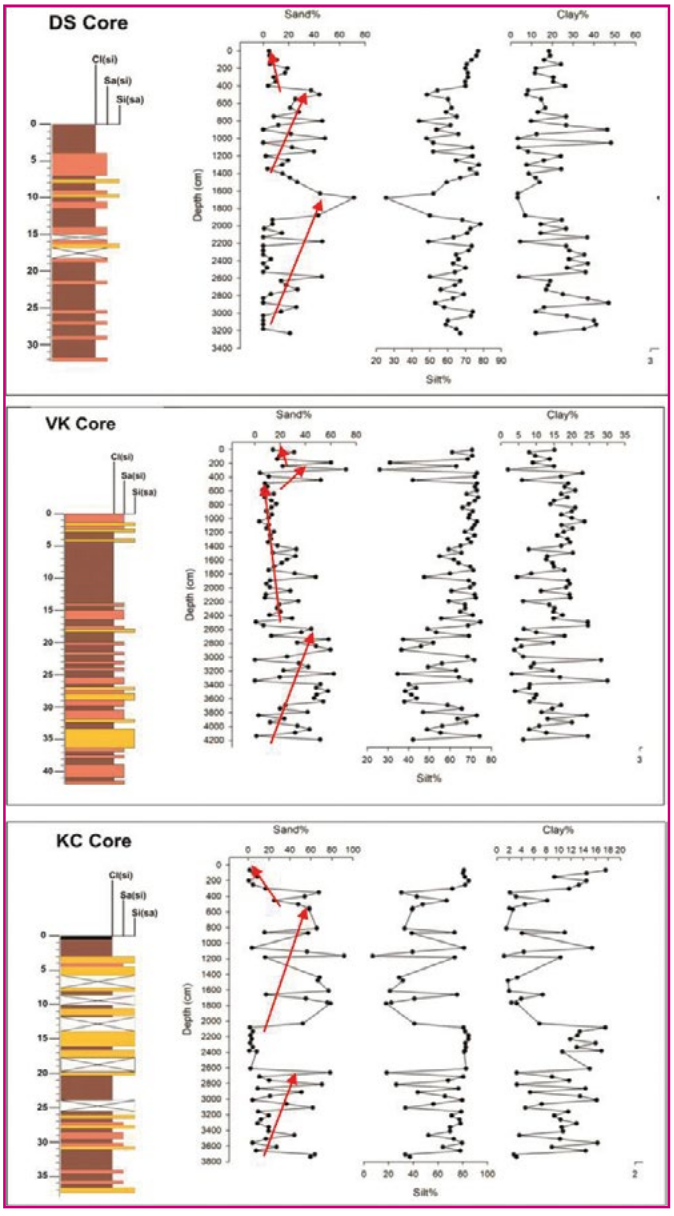


Fig. 2 - Figure showing the lithologs of the retrieved sediment cores from the western GRK Basin. Graphs showing the grain size variability with depth. Several fining upward-coarsening upward cycles are marked.

Filling of Korkai bay by Thamirabarani River by 600 yrs ago

The absence of foraminifera since 750 years ago, the high flux of coarser grain into the bay (EM4/EM1), and a high pulse of magnetic susceptibility collectively suggest the southern river (Thamirabarani) silted the bay by 1450 CE (OSL dates) (Fig. 3). This observation is supported by the global sea level curve and the reconstructed east coast sea level, and the local climate controlled by the north-east monsoon ($\delta^{13}C_{SOM}$).

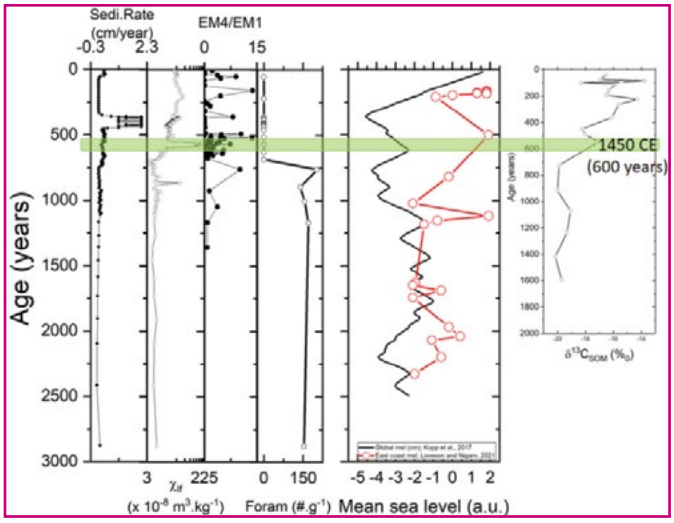


Fig. 3 - Magnetic susceptibility and OSL chronology of Thamirabarani, East Coast of India.

PROJECT OUTCOME:

Publications in SCI (Science Citation Index) Journals

1. Farooqui A, Agnihotri R, Khan S, Gahlaud SKS & Sharief MU 2021. Temporal variability in Carbon and Nitrogen stable isotopes of *Strobilanthes kunthianus* leaf: Its photosynthetic efficacy and water-use efficiency in a warming climate. Journal of Earth System Science 130(4): 1-14. DOI 10.1007/s12040-021-01737-5. **(IF: 1.912)**
2. Agnihotri R, Farooqui A, Khonde N, Mathews RP, Sharma S, Gahlaud SKS, Manjul SK Manjul A & Sawlani R 2021. Microscopic, biochemical and stable isotopic investigation of seven multi-nutritional food-balls from Indus archaeological site, Rajasthan (India). Journal of Archaeological Science: Reports 37, 102917 DOI 10.1016/j.jasrep.2021.102917. **(IF: 1.63)**
3. Gaur AS, Sundaresh Agnihotri R, Maurya P, Jayakumar S & Thorat BR 2021. Time and causes

of submergence of ancient temple structures off Mahabalipuram, East Coast of India. Indian Journal of Geomarine Sciences 50: 658-665. **(IF: 0.553)**

4. Kumar A, Maurya DM, Khonde N, Phartiyal B, Arif M, Giosan L & Chamyal LS 2021. Holocene palaeoenvironmental changes in the marginal marine basin of Great Rann of Kachchh, western India: Insights from sedimentological and mineral magnetic studies on a ~60 m long core. Quaternary International 599: 138-147. DOI 10.1016/j.quaint.2021.02.039. **(IF: 2.454)**

Publication Other than the Project Work

1. Khan S, Farooqui A, Shukla UK, Grøsfjeld K, Knies J & Prasad V 2021. Late Pliocene continental climate and vegetation variability in the Arctic-Atlantic gateway region prior to the intensification of Northern Hemisphere glaciations. Palaeogeography, Palaeoclimatology, Palaeoecology 586 (2022): 110746. DOI 10.1016/j.palaeo.2021.110746. **(IF: 3.565)**
2. Farooqui A, Singh H, Prasad M & Singh VK 2021. Morphometry and morphology of Testate amoebae from the Miocene sub Himalayan zone of Darjeeling, India. Himalayan Geology 42(1): 1-10. **(IF: 1.311)**
3. Basumatary SK, Gogoi R, Tripathi S, Ghosh R, Pokharia AK, McDonand HG, Sherpa N, Van Esperen EN, Agnihotri R, Chhetri G, Saikia K & Pandey A 2021. Red Panda feces from Eastern Himalaya as a modern analogue for palaeodietary and palaeoecological analyses. Scientific Reports 11(1): 1-14. DOI 10.1038/s41598-021-97850-y. **(IF: 4.996)**
4. Tripathi S, Basumatary SK, Pandey A, Khan S, Tewari P & Thakur B 2021. Palaeoecological changes from 580 to 1220 CE from the Indo-Burma region: A biotic assessment from the Barak Valley of Assam, northeast India. Catena 206: 105487. DOI 10.1016/j.catena.2021.105487. **(IF: 6.367)**
5. Quamar MF, Tiwari P & Thakur B 2021. The modern pollen–vegetation relationship in Jammu, India: a comparative appraisal. Acta Palaeobotanica 61(1): 1-19. DOI 10.35535/acpa-2021-0001. **(IF: 0.69)**
6. Quamar F, Thakur B, Singh VK & Pandey SK 2021. Pollen heteromorphism in *Schleichera* Lour. (Sapindaceae), observed in surface soil samples from central India. Acta Palaeobotanica 61(1): 32-41. DOI 10.35535/acpa-2021-0003. **(IF: 0.69)**
7. Aggarwal N, Mathews RP, Ansari AH, Thakur B & Agrawal S 2022. Palaeoenvironmental reconstruction for the Permian (lower Gondwana) succession of the Godavari Valley Coalfield in southern India based on a combined palynofacies, carbon isotope, and biomarker study. Journal of Palaeogeography, https://doi.org/10.1016/j.jop.2021.07.001. **(IF: 2.789)**

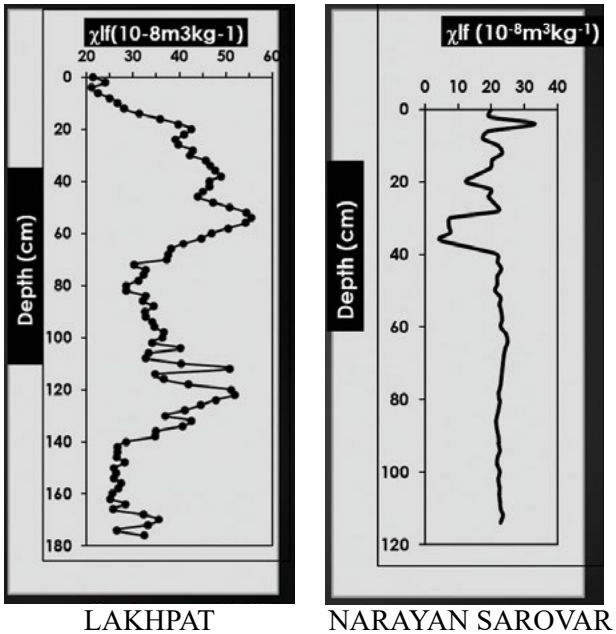
SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

SP 5.1: Land-sea interactions along coastal wetlands of Gujarat, western India: mangroves response to climate and sea-level changes during the Holocene (Sponsored by SERB, New Delhi; Project No: EMR/2017/004795).

Investigators: Shilpa Pandey (BSIP, Lucknow) & Prof. Mahesh G. Thakkar (K.S.K.V. Kachchh University, Bhuj, Kachchh)

Magnetic Susceptibility Studies - Magnetic susceptibility of 178 sub-surface sediment samples of Lakhpat and Narayan Sarovar were analysed to understand the palaeo-monsoonal rainfall variations in the studied regions (Fig SP 5.1).

Coastal dunes: Morphology, sedimentology and Chronology - The stabilized parabolic coastal dunes are found overlying in the relict mudflats and some on the beveled Tertiary bed rock in the Narayan Sarovar and Lakki regions, Gulf of Kachchh. Similar dune system found to occur a few km inside the Kori mouth from



LAKHPAT NARAYAN SAROVAR

Fig. SP 5.1 - Magnetic susceptibility study sub-surface sediment samples of Lakhpat and Narayan Sarovar.

Pinjor Pir to almost 15 km inside up to Chher Nani where they are incised by the tidal creeks, which again follow the hard rock substratum of Tertiary Period. A total of 8 samples from various sandy horizons of the Narayan Sarovar and Lakki stabilized dunes section were collected and their morphology, sedimentology and chronometry were studied to understand the role of relative sea level changes and climate change in the growth of coastal dunes and also to ascertain the causes of shift in the nature of sedimentation (from sand dominated to clay dominated).

SP 5.2: Reconstruction of Holocene vegetation climate and sea-level fluctuation from the Mahanadi Delta, Odisha, East Coast of India: A multi proxy approach (Sponsored by (MoES), New Delhi; Project No. MoES/CCR/Paleo-2/2019).

Investigators: Shilpa Pandey (BSIP, Lucknow); Pratap Mohanty (Berhampur University, Odisha); Pankaj Kumar (IUAC, New Delhi) & Rajani Panchang (SPPU, Pune)

A ~2 m sediment profile was collected using dug trench from the Astrang area, Mahanadi Delta, Odisha. A total of 67 samples were collected at an interval of 3 cm each. Lithologically, it represented silt and clay. *Bruguiera, Ceriops, Avicennia, Acanthus* dominated area with other mangrove species such as, *Sonneratia* and *Excoecaria* and *Aegialitis rotundifolia*. Around 67 sub-surface sediment samples were analyzed for palynological study that yielded 30 taxa represented with 15 families and 11 genera. Overall the frequency of occurrence reveals that the highest abundance was shown by *Sonneratia* and *Excoecaria agallocha* throughout the core. On the other hand, pollen taxa such as *Acanthus*, *Avicennia marina*, *Bruguiera gymnorrhiza*, *Xylocarpus granatum*, *Heritiera*, *Nypafruiticans*, Poaceae, *Suaeda*, and *Phoenix paludosa* were abundant in the restricted stratigraphic sequences. *Acrostichum aureum*, the only mangrove fern, was abundant in the upper part of the core.

CP 5.1: Anjum Farooqui, Rajesh Agnihotri [& Pitamber Pati, IIT Roorkee]

Collaborating with Prof. Pitamber Pati IIT Roorkee and associates (Chinmay Das & Soumya Dhal) for generating biotic (pollen taxa) and stable carbon isotopic data in a well dated sediment core spaning Holocene from Chilka Lagoon (Odisha) for understanding 10Be/9Be derive denudation rates in realm of climate variability and/or sea level change.

CP 5.2: Shilpa Pandey [& Rabindra Sahoo, NCCR, Chennai]

Collaborated with Rabindra Sahoo, Scientist, National Centre for Coastal Research (NCCR), Chennai for multi-proxy studies on surface and sub-surface sediment samples from the West Coast of India.

OTHER ACADEMIC WORKS

Research Papers Presented

1. Katange Kishor, Singh Gursewak & Khonde Niteshkumar - Sediment characteristics and clay mineral assemblage of modern Kori Creek sediments, Kachchh Basin, western India. 1st Indian Quaternary Congress (IQC) 2022 Virtual Conference hosted by Association of Quaternary Researchers (AOQR), India held during 19-22 January, 2022.
2. Singh Gursewak, Katange Kishor, Khonde Niteshkumar & Singh AD – Foraminiferal content and sedimentological studies on the modern Kori Creek sediments from Great Rann of Kachchh, western India. XXVIII Indian Colloquium on Micropalaeontology and Stratigraphy (ICMS), held between 15-17th February 2022, organised by Department of Environmental Sciences, Savitribai Phule Pune University, Pune, INDIA. 17: 17 (ICMS-SPPU 2022/17).
3. Tiwari Pooja, Thakur Biswajeet, Manoj MC, Mazumder Abhijit, Gahlaud Sanjay KS, Agnihotri Rajesh, Agarwal Shailesh & Srivastava Purnima - Role of natural/ anthropogenic influence in ecological deterioration of Southwest Coastal Kerala using multi-proxy study. 1st Indian Quaternary Congress (IQC) 2022 Virtual Conference hosted by Association of Quaternary Researchers (AOQR), India held during 19-22 January, 2022.

Lectures delivered

Rajesh Agnihotri

- Delivered invited lecture on "Radiocarbon dating and decoded history of past ecology, environment and agriculture through usage of stable Carbon and Nitrogen isotopes for Vadnagar archaeological settlements (spanning last ~2500 years)", on e-platform of Vadnagar Workshop being organized by Archaeological Survey of India (Vadodara circle) India on 6th July 2021.
- Delivered invited lecture on "Radiocarbon dating from conventional to AMS methods: Impacts on Indian Archaeological Sciences" on e-platform of a Bhishma School of Indic Studies, Pune, India on 26th November, 2021.

Shilpa Pandey

- Delivered Talk on "Driving factors for the degradation of mangroves in the past: A case study from the Chilika lagoon, Odisha" presented in an International Mangrove Day Workshop (online) at the BSIP, on 26th July, 2021.

Niteshkumar Khonde

- Delivered talk on, "Coastal Wetlands As Recorders of Climate Change and Sea Level Rise: Implications for Future Sustainability" in virtual international event – "iLEAPS World Wetland Day-2022, A South Asian perspective"organised by the iLEAPS (Integrated Land-Ecosystem Atmosphere Process Studies), South Asian Chapter on the occasion of World Wetland Day on 2nd **February, 2022.**

Ph.D. PROGRAMMES

Salman Khan (2016). Pliocene-Pleistocene changes in vegetation, climate and sedimentation in Middle and High Latitudes, under the supervision of **Anjum Farooqui (BSIP, Lucknow)** & Uma Kant Shukla, BHU, registered with Banaras Hindu University, Varanasi. Status: In-progress

Sanjay Kumar Singh Gahlaud (2018). Geochemical and stable isotopic characterization of sediments from Arabian Sea: Implications to Nitrogen and Sulfur biogeochemical cycling of Late Pleistocene – Holocene, under the supervision of **Rajesh Agnihotri (BSIP, Lucknow)** and Bindhyachal Pandey, registered with the Department of Geology, Banaras Hindu University. Status: In-progress

Nikhil Patel (2018). Geochronology and isotopic investigation of geoarchaeological remains from different archaeological sites of India implications to human environment relationship, under supervision of **Rajesh Agnihotri (BSIP, Lucknow)** and Alok Kumar (BHU), Varanasi, registered with Banaras Hindu University Varanasi. Status: In-progress

Pooja Tiwari (2018). Holocene climate and environment reconstruction from southwest coastal settings of Kerala using multi-proxy studies, under the supervision of **Biswajeet Thakur (BSIP, Lucknow)** and Purnima Srivastava, Geology, Lucknow University, Lucknow, registered with Lucknow University, Lucknow. Status: In-progress.

Kishor V Katange (2020). Geochemical and isotopic investigations on the high-frequency sedimentation in the Great Rann of Kachchh Basin, western India, under the supervision of **Niteshkumar Khonde (BSIP, Lucknow)**, registered with AcSIR, New Delhi. Status: In-progress.

Gursewak Singh (2021). Palaeoclimatic and palaeoenvironment studies on coastal sediments from western continental margin of India, under the supervision of **Niteshkumar Khonde (BSIP, Lucknow)**, registered with AcSIR, New Delhi. Status: In-progress**.**

Anand Rajoriya (2022). Sediments biogeochemistry with special focus on Carbon, Nitrogen, Sulfur, and Phosphorus cycling at present and in the past (late Quaternary Period) in aquatic realms of India, under supervision of **Rajesh Agnihotri (BSIP, Lucknow)** and **Biswajeet Thakur (BSIP, Lucknow)** registered with AcSIR, New Delhi. Status: In-progress

ACCOLADES RECEIVED

Shilpa Pandey

- Convened a National webinar on "International Mangrove Day 2021" (as Convener) on 26th July 2021 at the BSIP, Lucknow.
- Convened a National webinar on "Mangroves and Disaster Risk Reduction" on 25th March, 2022 in collaboration with National Institute of Disaster Risk Management, New Delhi and Birbal Sahni Institute of Palaeosciences, Lucknow.
- Invited as "Expert Panel Member" in an International Conference on "Mangrove Research in Indian sub-continent: Recent advances, knowledge gaps and future perspectives" organized by the Centre for International Forestry Research (CIFOR), Indonesia and Wildlife Institute of India (WII), Dehradun.

- Invited as Moderator in a National Conference on "Disaster Risk Reduction and Resilience: Policies and Management" jointly organized by BBAU, Lucknow and NIDM, New Delhi during 07-09 March, 2022.

Representation in Committees/Board

Anjum Farooqui

- Fellow Founder 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, BSIP, Lucknow
- Member co-ordinator INQUA HaBcom

Rajesh Agnihotri

- Fellow of Earth Science Society India
- Fellow of Indian Geophysical Union, Hyderabad, India

Biswajeet Thakur

- Co-editor of the online open access journal EarthScienceIndia.info

Shilpa Pandey

- Elected as Executive Member of Mangrove Society of India, Goa.

Project 6: Late Pleistocene - Holocene vegetation and climate reconstructions for the Himalayan Region: understanding the Dynamics and forcing Mechanisms.

Coordinator: Ratan Kar (Scientist E) **Co- coordinator:** S.K. Basumatary (Scientist E)

OBJECTIVES

- *To reconstruct the vegetational changes, tree-line dynamics, glacial sensitivities and abrupt hydroclimatic events during Late Pleistocene–Holocene.*
- *To understand the driver(s) for Holocene vegetation and climate, based on modern proxy–climate analogues.*
- *To trace the inception and impact of anthropogenic activities.*
- *To structure spatio-temporal climate reconstructions using tree-ring data of multiple taxa.*

PREAMBLE

The present climate is changing at an unprecedented rate and the mountainous regions are more susceptible to these changes compared to other regions under the same latitudinal belt. The Holocene Epoch (the last 11,700 years) is marked by the rapid climatic events when significant variability both in temperature and hydrological regimes occurred (e.g., 8.2 ka event, Holocene Climate Optimum, 4.2 ka event, Medieval Warm Period, Little Ice Age, etc.). The high-altitude Himalayan regions are the exceptional repository of past climatic changes as the signatures of climate variability are well preserved in these relatively pristine environments. The great Himalayan range is unique due to its climatic, topographic, geological, and altitudinal variations. The Western Himalaya is affected by both the Indian Summer Monsoon (ISM) and Western Disturbances (WDs). The Eastern Himalaya and the Northeastern region, on the other hand, receive precipitation only from the ISM and therefore represented with relatively more humid conditions.

In order to understand the trends of climatic changes and their impact on highly vulnerable region, i.e. Himalaya, long term records beyond the instrumental period are necessary. The quest of this thrust area is to understand the Holocene climatic phases in the Himalaya and Northeastern region at the decadal to centennial scales using biological proxies (pollen, tree-rings, and phytoliths) (Fig. 1). The inception and the impact of anthropogenic activities in such ecologically sensitive regions would also be investigated. Besides this, the teleconnections with the mid- or high-latitude regions would also be explored.

Although a large number of palaeoclimatic records are now available from the Himalayan region, the underlying forcing mechanisms in most of the studies are yet to be explored. An understanding of forcing mechanisms and their impact on the past ecosystems will strengthen our knowledge for simulating palaeoclimatic models and possibly help obtaining insights about the future climate variability and its impact on the Indian subcontinent.

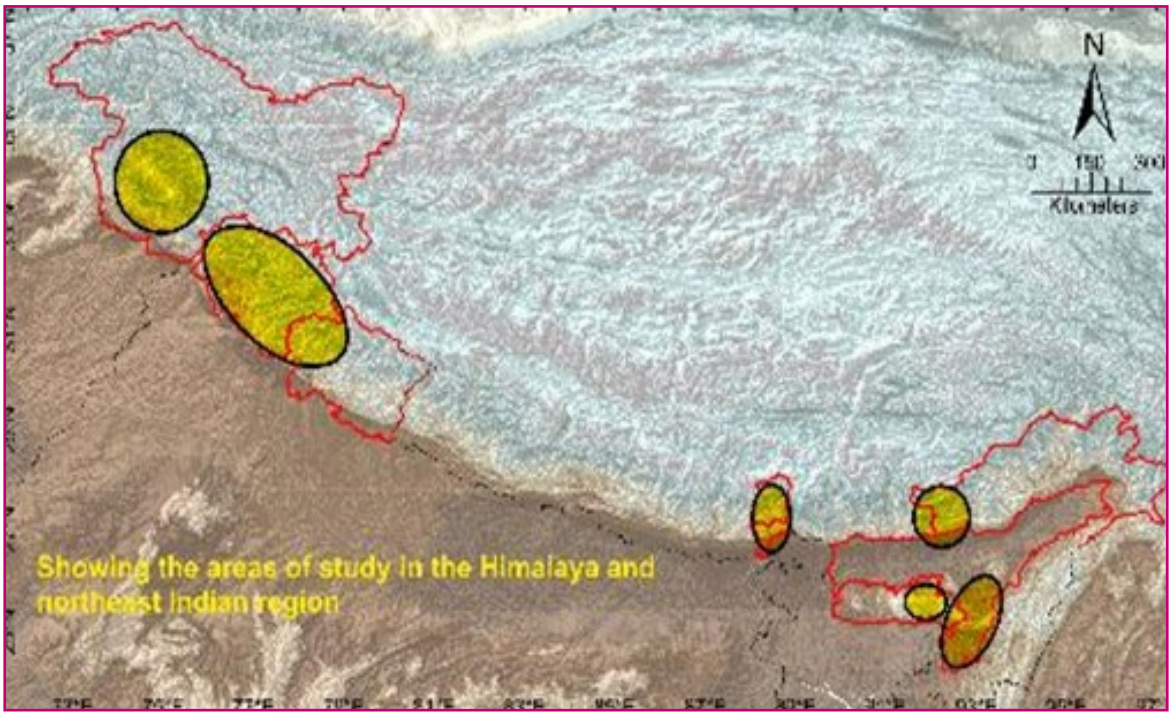


Fig.1 - Map showing the areas of study in the Himalaya and northeast Indian region.

PERSONNEL INVOLVED

Team Members: Santosh K. Shah (Scientist E), K.G. Misra (Scientist E), Ruby Ghosh (Scientist D), Swati Tripathi (Scientist D); S Nawaz Ali (Scientist D)

Associate Member: Parminder Singh Ranhotra (Scientist D)

Technical Support Members: Rajaram Verma (TA B)

Research Scholars: Kajal Singh, Nidhi Tomar, Arya Pandey, Amit K. Mishra, Lamginsang Thomte, Deeksha, Korobi Saikia, Ravi Shankar Maurya, Sadhana Vishwakarma, Prachita Arora

SIGNIFICANT FINDINGS

The pollen composition, non-pollen palynomorphs (NPPs), and stable carbon isotope data ($\delta^{13}C$ values) using the surface sediments from the proglacial deposits (outwash plain and the two levels of kame-terraces) of the Chorabari Glacier, Kedarnath, were studied to generate the modern biotic analogue for the reconstruction of vegetation-based past climatic conditions from the alpine region of the Western Himalaya (Fig. 2). The pollen–vegetation relation is incompatible (non-linear) with the present vegetation, as the pollen assemblages are marked by the prolific over-representation of the extra-local pollen, especially *Pinus*, over the local herbaceous taxa (Fig. 3). The pollen records have also revealed the anthropogenic activities in the form of degradation of tree-line and over-grazing by the domesticated animals. The NPPs reflect the prevalence of grazers in the present times, and would be useful in tracing the advent and intensification of grazing in the region.

Fig. 2 - Downstream view of the study area showing the U-shaped Glacial Valley and the Kedarnath township.

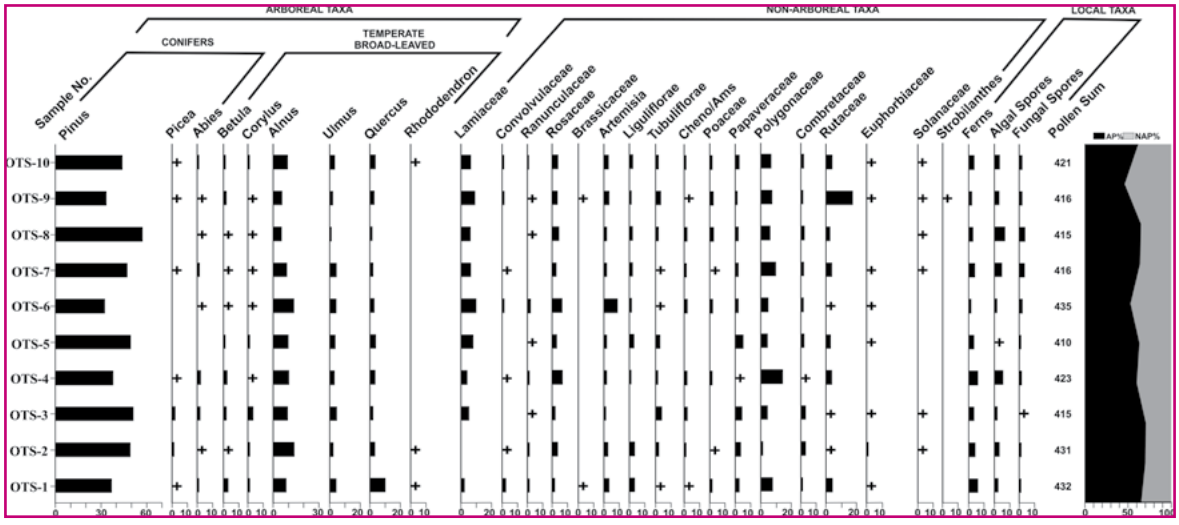


Fig. 3 - Pollen diagram showing the frequency distribution of pollen-spores from the outwash plain of the Chorabari Glacier.

Pollen and non-pollen palynomorphs were studied from the Meghalaya using a total number of 70 surface soil samples from the different vegetation types and land-use, namely, evergreen forest, *Schima* forest, *Pine* forest, Grassland, and cropland. The palynology data displayed a close relationship between the modern pollen deposition and the current vegetation in the studied region. The evergreen alongwith *Nepenthes* and *Impatiens* pollen taxa in the pollen assemblage from the studied samples are indicative of the high rainfall activity in the region. Presence of *Nepenthes* and *Pandanus* pollen in the Grassland are suggestive of the anthropogenic activities in the region (Fig. 4).

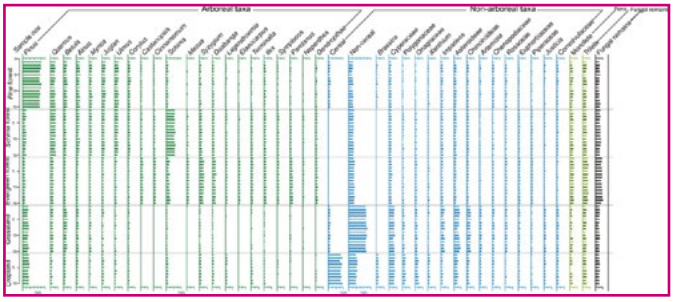


Fig. 4 - Pollen spectra from the different vegetation types of Meghalaya.

Chemical processing for pollen and non-pollen palynomorphs analyses of a 1.6 meter (32 samples) long road cutting section procured from the Mawsynram and Shillong road of Meghalaya was studied for reconstructing the past vegetation and climate in relation to the rainfall activity in the region. Three palaeovegetation zones and associated climatic changes have been recognized based on the abundances of major arboreal and non-arboreal pollen taxa among the palynoassemblages.

15 modern bat guano samples were collected from the Mawsynram Cave of East Khasi Hills were analyzed for pollen assemblage. The pollen data reflected the local vegetation, which is reliable and counter part of the surface soil samples in the region.

Based on the regional tree-ring dataset of multiple coniferous taxa (Fir, Deodar and Spruce), a 508-year (1508-2015 CE) long drought (PDSI) reconstruction for June-August has been done for the Kumaon-Garhwal Himalaya. This reconstruction has added reliable database to assess the long-term hydroclimatic variability of the region, especially, the recent decreasing trends (Fig. 5).

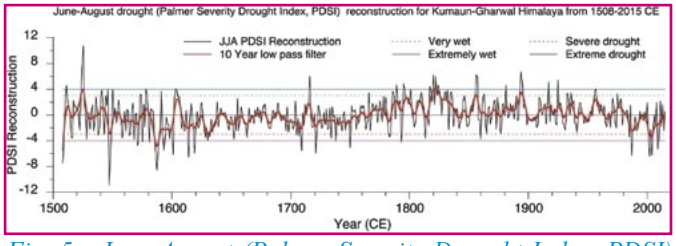


Fig. 5 - June-August (Palmer Severity Drought Index, PDSI) reconstruction for Kumaon-Garhwal Himalaya from 1508-2015 CE.

Based on the tree-ring chronology of Khasi pine, winter-spring (January to April) soil-moisture based drought variability over the West Karbi Anglong region, Assam, northeast India, was reconstructed from 1868 to 2018 CE. This soil moisture reconstruction adds additional input towards the agricultural planning and management in the northeast region of India (Fig. 6).

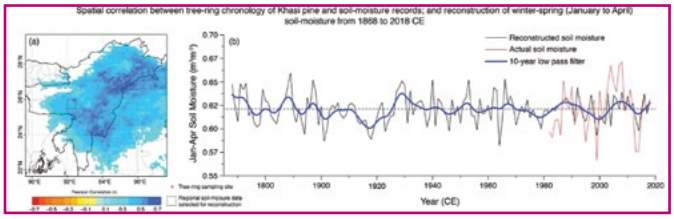


Fig. 6 - Spatial correlation between tree-ring chronology of Khasi pine and soil moisture records; and reconstruction of winter-spring (January to April) soil-moisture from 1868 to 2018 CE.

To assess if the 'bilobate' type (a grass phytolith morphotype found to occur in most of the members of the 12 sub-families of Poaceae) shows any morphometric variability with changes in temperate-rainfall regimes, a study has been undertaken by comparing grasses and surface soils from the eastern Himalaya and peripheral Bengal Basin regions. Three morphometric size categories of bilobate types are recognized, i.e. small (< 15 µm), medium (15−25 µm), and large (> 25 µm) (Fig. 7). Both large and medium bilobates are abundant in the sites with higher rainfall and low temperature. Conversely, small bilobates are dominant in the sites with comparatively low rainfall and high temperature. Therefore, it may be inferred that the size variability of the bilobate morphotypes is jointly driven by the temperature and soil moisture availability. This study has implications in reconstructing the past climatic conditions of wide geographic regions covering both the plains and mountains using fossil phytolith assemblages.

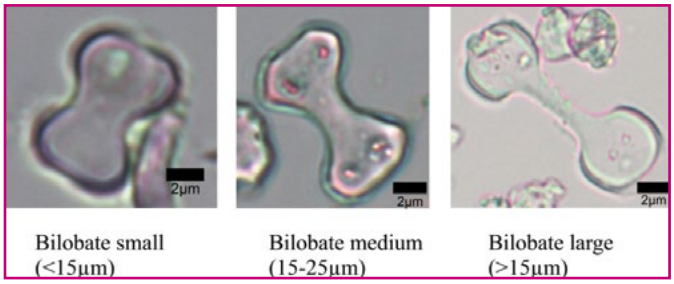


Fig. 7 - Different size categories of bilobates from grasses and surface soil samples from the eastern Himalaya and Bengal Basin.

Using well-replicated Himalayan cedar data, robust drought (SPI) reconstruction for the annual year (SPI12-May) extending back to AD 1613 for Jammu & Kashmir was developed. The SPI record revealed relatively long-

term wet conditions in the early part of the reconstruction from 1613-1760s, whereas the presence of high-magnitude droughts in the later part from the late 18th Century to the present (1760s-2017). The study revealed that the droughts in the later part of the reconstruction persist for the longer duration and occur more frequently compared to the wet episodes. However, droughts occurred for short period and remained close to the mean value of SPI in the earlier part (Fig. 8).

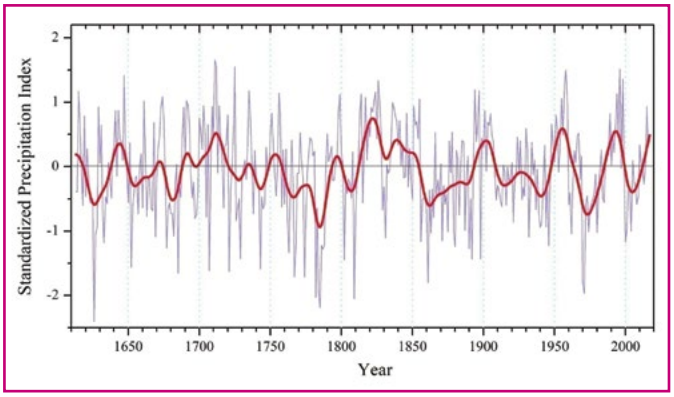


Fig. 8 - Standardized Precipitation Index (SPI12-May) reconstruction using a network of moisture-stressed Himalayan cedar chronologies from Kishtwar, Jammu & Kashmir. The thick smoothline superimposed over the reconstruction is 20-year low pass filter to show variations overlonger time scale.

Reconstruction of the late Holocene hydroclimatic events from the summer monsoon dominant Bhagirathi region of the western Himalaya revealed weak summer monsoon phases corresponding to globally identified dry 4.2 ka and Little Ice Age (1500 to 1850 CE) climate events. The hydroclimatic changes also resulted to vegetation change, such as increase in the growth of dry steppe taxa and changes in the anthropogenic cultivation activities adapting the climatic variations.

The modern pollen dispersal analysis along the temperate to subalpine vegetation zones in Rukti Valley, Kinnaur, Himachal Pradesh showed the dominance of tree pollen taxa (mainly *Pinus, Cedrus, Picea, Betula, Alnus, Quercus*). The pollen assemblage also represented the pollen of presently ongoing cultivation such as cereals (Poaceae), beans (*Fagopyrum* and other Polygonaceae), apple, apricot (Rosaceae), Akhrot (*Juglans*), etc. by the local population. Moreover, the high frequency of micro-charcoal in the sediments from subalpine altitudes reflects the ongoing fire wood burning activities for the survival at upper altitudes. This study will help assessing the magnitude of anthropogenic activities in the past.

The Barak Valley of Assam (under the Indo-Burma biodiversity hotspot) experienced a less warm and humid climate with relatively less seasonality from 1220 CE onwards, due to a reduction in monsoon precipitation. Increased farming activities (human settlement) resulted in the subtle decrease in the tropical mixed deciduous elements which is paralleled by a tremendous increase of secondary forest elements (shrubs), such as *Melastoma* and Oleaceae documenting a loss of biodiversity in the previously pristine region. The MAT (16–28◦C) and MAP (380–1700 mm) is reduced relative to the preceding MCA peak phase (940 to 1220 CE) (Fig. 9). This rasping climatic period to some extend is within the range of LIA, and is attributed to the enhanced anthropogenic activities. The rise in ecologically tolerant diatom species (*Ulnaria ulna*, *Pinnularia* sp., and *Gomphonema* sp.) for the last 1220 CE support the palynological inferences and suggests increased anthropogenic activities in and around the Chatla Lake as indicated by the evidence for eutrophication (Fig. 10). The rise in the diatom *Amphora* also suggests a fouling environment in the lake and can be indicative of increased heavy metal contamination in the surrounding areas of Barak Valley.

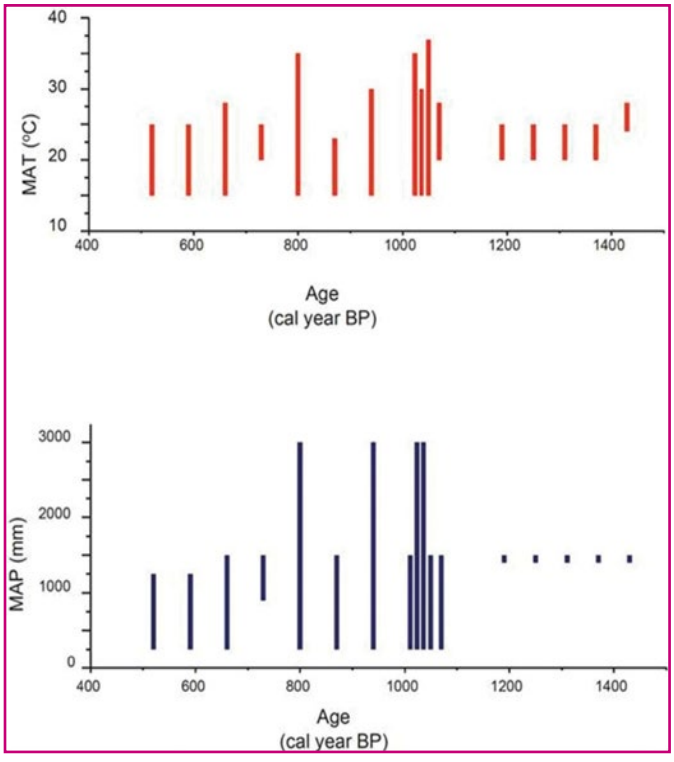


Fig. 9 - Climatic tolerance estimates for mean annual temperature (MAT) and precipitation (MAP) for sediment samples of Barak Valley, Assam.

A potentially dangerous moraine-dammed pro-glacial lake in the Bhilangna Valley, Central Himalaya, India, which has been expanding at an alarming rate during the last two decades, has been explored. We attempted to determine the potential trigger and modeled the worst-case outburst scenario, as well as its impact on downstream valley populations and infrastructure. Two breaching scenarios have been generated: (1) overtopping, and (2) piping, which might be produced by ice calving into the lake or avalanches, and a maximum probable discharge amount of 4377 cumec has been predicted. The discharge can inundate an area of ~19 km^2 along the river channel with a mean water depth of ~38 m, and an average velocity of ~16 m/s. The GLOF generated catastrophic hyper-concentrated flow and its far-reaching consequences on life, property and infrastructure are the foremost concern throughout the high mountain areas (Fig. 11).

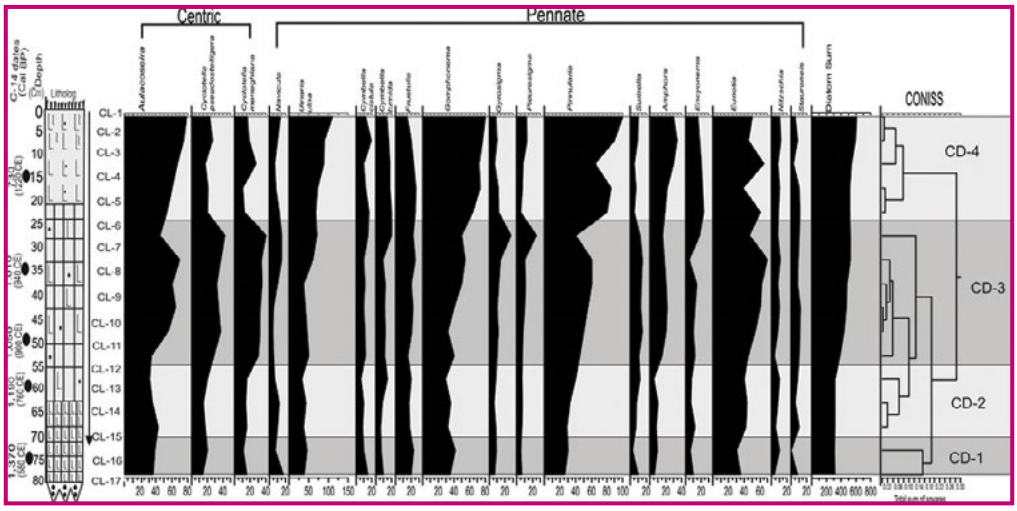


Fig. 10 - Diatom frequency diagram from the Cachar District, Barak Valley of Assam.

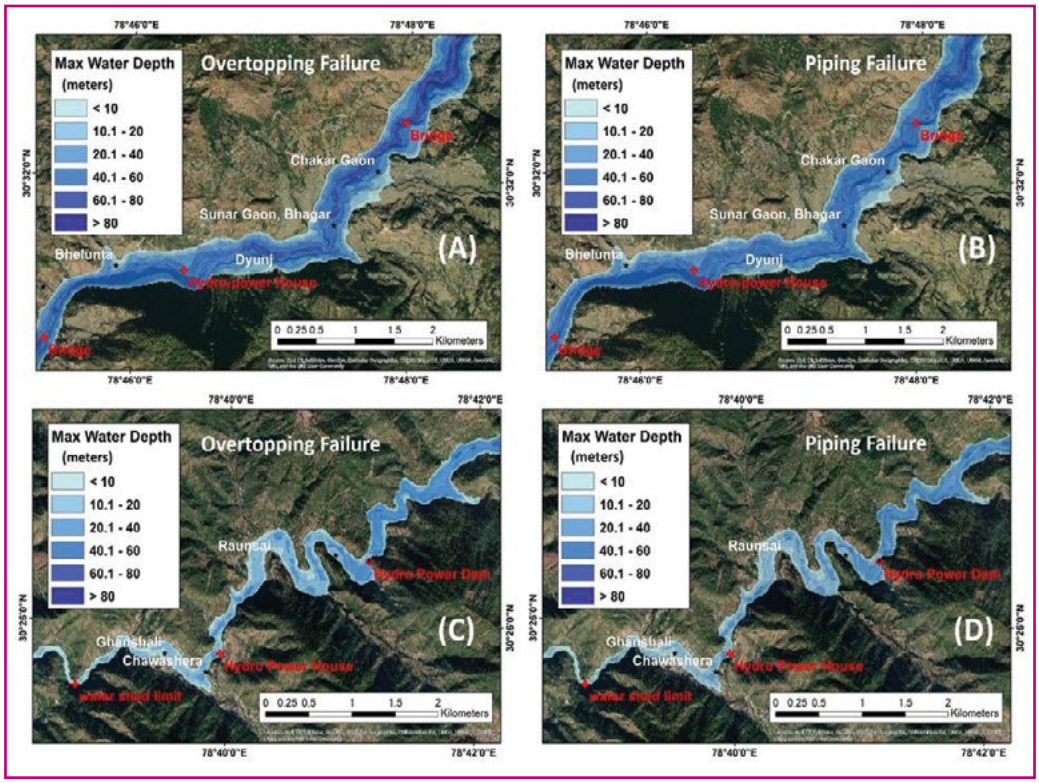


Fig. 11 - Innundation characteristics (max. water depth) at two major settlement and hydropower locations within the watershed.

PROJECT OUTCOME:

Publications in SCI (Science Citation Index) Journals

1. Kar R, Mishra K, Quamar MF, Mohanty RB, Agarwal S, Tripathi S & Mishra AK 2022. A high-altitude calibration set of modern biotic proxies from the Western Himalaya, India: pollen–vegetation relation, anthropogenic and palaeoclimatic implications. Catena 211: 106011. doi.org/10.1016/j.catena.2021.106011. **(IF: 6.367)**
2. Basumatary SK & Tripathi S 2021. Is Bat Guano a potential pollen trap? A comparative assessment from conventional soil and moss substrates from Eraaning Cave of Meghalaya, India. Review of Palaeobotany & Palynology 295: 104539. Doi.org/10.1016/jrevalbo.2021.104539. **(IF: 2.493)**
3. Basumatary SK, Gogoi R, Tripathi S, Ghosh R, Pokharia AK, McDonald HG, Sherpa N, van Asperen EN, Agnihotri R, Chhetri G, Saikia K & Pandey A 2021. Red Panda feces from Eastern Himalaya as a modern analogue for palaeodietary and palaeoecological analyses. Scientific Reports, doi.org/10.1038/s41598-021-97850-y. **(IF: 4.996)**
4. Roy I, Ranhotra PS, Shekhar M, Bhattacharyya A, Ghosh R & Sharma YK 2021. Modern pollen-vegetation relationships along the vegetation gradient in the Bhagirathi Valley, Western Himalaya, India. Journal of Geological Society of India 97: 571-578. doi: 10.1007/s12594-021-1732-0. **(IF: 1.466)**
5. Thomte L, Shah SK, Mehrotra N, Bhagabati AK & Saikia A 2022. Influence of climate on multiple tree-ring parameters of *Pinus kesiya* from Manipur, Northeast India. Dendrochronologia 71: 125906. https://doi.org/10.1016/j.dendro.2021.125906. **(IF: 3.071)**
6. Upadhyay KK, Shah SK, Roy A & Tripathi SK 2021. Dendroclimatology of teak indicates prevailing climatic conditions of tropical moist forests in India. Ecological Indicators 129: 107888. https://doi.org/10.1016/j.ecolind.2021.107888. **(IF: 6.263)**
7. Misra KG, Singh V, Yadava AK, Misra S, Maurya RS & Vishwakarma S 2021. Himalayan blue pine deduced precipitation record from cold arid Lahaul-Spiti, Himachal Pradesh, India. Frontiers in Earth Sciences, 9, https://doi.org/10.3389/feart.2021.645959. **(IF: 3.661)**
8. Singh V, Misra KG, Singh AD & Yadav RR 2022. Increasing incidence of droughts since later part of Little Ice Age over north-western Himalaya, India. Journal of Geophysical Research: Atmospheres, 127, e2021JD036052. https://doi.org/10.1029/2021JD036052. **(IF: 5.217)**
9. Roy I, Ranhotra PS, Tomar N, Shekhar M, Agrawal S, Bhattacharyya A, Kumar P, Patil SK & Sharma R 2022. Reconstruction of the late Holocene climate variability from the summer monsoon dominated Bhagirathi Valley, Western Himalaya. Journal of Asian Earth Sciences 227: doi.org/10.1016/j.jseaes.2022.105080 **(IF: 3.374)**.
10. Tripathi S, Basumatary SK, Pandey A, Khan S, Tewari P & Thakur B 2021. Palaeoecological changes from 580 to 1220 CE from the Indo-Burma region: A biotic assessment from the Barak Valley of Assam, northeast India. Catena 206: 105487. https://doi.org/10.1016/j.catena.2021.105487 **(IF: 6.367)**.
11. Ali SN, Singh P, Arora P, Bisht P & Morthekai P 2022. Luminescence dating of late Pleistocene glacial and glacio-fluvial sediments in the Central Himalaya, India. Quaternary Science Reviews, 284: doi.org/10.1016/j.quascirev.2022.107464. **(IF: 4.456)**
12. Pandey VK, Kumar R, Singh R, Kumar R, Rai SC, Singh RP, Tripathi AK, Soni VK, Ali SN, Tamang D & Latief SU 2022. Catastrophic ice-debris flow in the Rishiganga River, Chamoli, Uttarakhand (India). Geomatics, Natural Hazards and Risk, 13(1): 289-309. doi.org/10.1080/19475705.2021.2023661. **(IF: 3.922)**
13. Khan MAR, Singh S, Pandey P, Bhardwaj A, Ali SN, Chaturvedi V & Ray PKC 2021. Modelling permafrost distribution in Western Himalaya using remote sensing and field observations. Remote Sensing 13(21): 4403. doi.org/10.3390/rs13214403. **(IF: 5.349)**

Refereed Non-SCI Journals

1. Basumatary SK, Tripathi S & Bera SK 2021. Early Holocene pollen record of vegetation and climate history in response to the monsoonal activity in East Garo Hills, Meghalaya, India. The Palaeobotanist 69: 51-61.
2. Pandey P, Chauhan P, Ray PKC, Sharma P, Chattoraj SL, Sharma R, Nainwal HC, Ali SN & Singh R 2021. Glacial lakes of Uttarakhand (Atlas). Published by

Indian Institute of Remote Sensing, Indian Space Research Organization, Dehradun, India: p. 95. (ATLAS)

Book Chapters/Memoirs/Bulletins

1. Kar R, Mishra AK, Mazumder A, Patil SC, Mishra K, Ranhotra PS, Mohanty RB & Singh K 2021. Deciphering the changing climate and environment around NyÅlesund, Svalbard, since the Last Glacial Maximum: a multi-proxy approach. *In*: *Understanding Present and Past Arctic Environments* (Elsevier): 49-78.
2. Shah SK, Mehrotra M, Gaire NP, Thomte L, Sharma B, Pandey U & Katel O 2022. Potential utility of Himalayan tree-ring $\delta^{18}O$ to reveal spatial patterns of past drought variability – It's assessments and implications. *In*: Kumaran KPN & Padmalal D (Editors) - Holocene Climate Change and Environment, Elsevier: 265-292. https://doi.org/10.1016/B978-0-323-90085-0.00003-6
3. Singh V, Misra KG, Yadava AK & Yadav RR 2021. Application of tree rings in understanding long-term variability in river discharge of high Himalayas, India. *In:* Kumaran N & Padamlal D (Editors) - Holocene Climate Change and Environment: 247-261. Published by Elsevier. DOI: https://doi.org/10.1016/B978-0-323-90085-0.00018-8.
4. Roy I, Tomar N, Singh A, Shekhar M, Ranhotra PS, Bhattacharyya A & Sharma YK 2022. Hydroclimatic and glacial variabilities in the Himalayan and Tibetan regions since Last Glacial Maxima: A Synthesis. *In*: Seema Rani & Rajesh Kumar (Editors) - Climate Change Impacts, Responses and Sustainability in the Indian Himalaya, Springer Nature: 73-102.
5. Shekhar M, Ranhotra PS, Bhattacharyya A, Singh A, Dhyani R & Singh S 2022. Tree-ring-based hydrological records reconstructions of the Himalayan rivers: Challenges and opportunities. *In*: Seema Rani & Rajesh Kumar (Editors) - Climate Change Impacts, Responses and Sustainability in the Indian Himalaya, Springer Nature: 47-72.
6. Ranhotra PS, Shekhar M, Roy I & Bhattacharyya A 2022. Holocene climate and glacial extents in the Gangotri Valley, Garhwal Himalaya, India: A Review. *In*: Seema Rani & Rajesh Kumar (Editors) - Climate Change Impacts, Responses and Sustainability in the Indian Himalaya, Springer Nature: 125-142.
7. Arora P, Ali SN & Morthekai P 2021. Exploring methodological approaches for climate perception studies in Himalaya. *In*: Climate Change - Impacts, Responses and Sustainability in the Indian Himalaya" Publisher-Springer Nature Switzerland AG, Gewerbestrasse 11: 6330 Cham, Switzerland.
8. Arora P, Ali SN & Morthekai P 2021. Climate variability and its causal mechanisms over the northeastern Indian Himalaya in Book "Climate Change - Impacts, Responses and Sustainability in the Indian Himalaya" Publisher-Springer Nature Switzerland.

Publication other than the Project Work

1. Quamar MF, Kar R & Thakur B 2021. Vegetation response to Indian Summer Monsoon variability during the Late Holocene from the central Indian Core Monsoon Zone. The Holocene 31(7): 1197–1211. DOI: 10.1177/09596836211003191 **(IF: 3.092)**.
2. Demina AV, Belokopytova LV, Zhirnova DF, Mehrotra N, Shah SK, Babushkina EA & Vaganov EA 2022. Degree of connectivity in reconstructed precipitation dynamics and extremes for semi arid regions across South Siberia. Dendrochronologia 71: 125903. https://doi.org/10.1016/j.dendro.2021.125903 **(IF: 3.071).**
3. Kumar M, Saikia K, Agrawal S, Ghosh R, Ali SN, Arif M, Singh DS, Sharma A, Phartiyal B & Bajpai S 2022. Climatic control on the C3 and C4 plant abundance during the late Pleistocene–Holocene in the northern Gangetic Plain, India. Palaeogeography, Palaeoclimatology, Palaeoecology 591: 110890. doi.org/10.1016/j.palaeo.2022.110890 **(IF: 3.565)**.
4. Naskar M, Ghosh R, Das S, Paruya DK, Saradar B, Yadava MG & Bera S 2021. Grass phytoliths in surface sediments of the Sunderbans, India and their implications in reconstructing past deltaic environmental changes. The Holocene 09596836211041736, doi.org/10.1177/09596836211041736 **(IF: 3.092)**.
5. Naskar M, Blinnikov M, Ghosh R, Das S, Paruya DK, Majumdar S & Bera S 2021. A diagnostic phytolith morphotype found in *Porteresia coarctata* (Roxb.) Tateoka indicates coastal swampy mangrove environments: A case study from the Indian east coast. *Floras* 282: 151884. doi.org/10.1016/j.flora.2021.151884 **(IF: 2.22)**.
6. Saikia K, Paruya DK, Ghosh R & Bera S 2021. Phytolith assemblages of *Shorea robusta* Gaertn. (Sal) from West Bengal part of the Bengal Basin,

India and their implications in palaeoclimate reconstructions. Botany Letters, 1–13. doi.org/10.1080/23818107.2021.1960602 **(IF: 1.566)**.

7. Biswas R, Karmakar M, Biswas O, Mukherjee B, Paruya DK, Ghosh R & Bera S 2021. Phytolith spectra of some Panicoideae grasses from the Western Ghats region of Maharashtra, India. Journal of Botanical Society of Bengal 79(1): 1–9.
8. Dhyani R, Shekhar M, Joshi R, Bhattacharyya A, Ranhotra PS, Pal AK, Thakur S & Nandi SK 2021. Reconstruction of pre-monsoon relative humidity since 1800 C.E. based on tree-ring data of *Pinus roxburghii* Sarg. (chir–pine) from Pithoragarh, Western Himalaya. Quaternary International:doi.org/10.1016/j.quaint.2021.04.026 **(IF: 2.454)**.
9. Ali SN & Shukla S 2021. The Himalayan red lake. Association of Quaternary Researchers (AOQR) 3 (3): 5-6.
10. Farooqui S, Shah AP, Maurya DM, Archna G, Ali SN & Sharma A 2021. Texture, mineralogy and geochemistry of late Quaternary sediments of the Mahi River Basin, western India: Implications to climate and tectonics. Applied Geochemistry 134: 105088. Doi.org/10.101016/j.apgeochem. **(IF: 3.841)**
11. Ali SN & Shukla AD 2021. An Exigency for Ice Core studies to determine Spatio-temporal variability in moisture sources and impact of Black Carbon–Mineral Aerosols on the Himalayan Glaciers. Journal of Atmospheric Science Research 4(3): 61-63. **(IF: 3.184)**

SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

SP 6.1: Vegetation dynamics, climate change and anthropogenic impact during the Holocene from Chopta-Tungnath region, Western Himalaya, India (Sponsored by CSIR-UGC NET Fellowship, UGC Grant No. 19/06/2016(i) EU-V-205247; w.e.f. 05/06/2017).

Investigators: Amit K. Mishra SRF-UGC & Ratan Kar (Mentor)

The pollen–vegetation relation shows a correlation on the basis of changes in the vegetation along the altitudinal transect (2700 to 3800 m). However, it is marked by the over-representation of extra-local *Pinus* pollen in both the surface and subsurface palynological assemblages. Among the broad-leaved taxa, *Quercus*, which is one of the dominant elements in the present vegetation, is properly represented in the pollen-rain and fossil assemblages. On the other hand, *Rhododendron,* though abundantly present in the extant vegetation, is under-represented in the pollen records, which is mainly because of its low pollen productivity (Fig. SP 6.1a). Good percentage of coprophilous fungi in the pollen records is due to the presence of grazers in the area. The modern pollen data on cultural pollen and non-pollen palynomorps, especially the coprophilous fungi, would also help to interpret the inception and intensification of anthropogenic activities in this Higher Himalayan region (Fig. SP 6.1b).

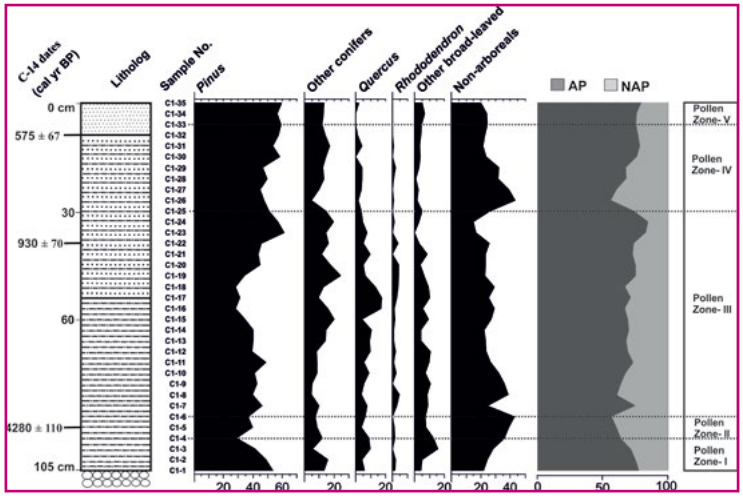


Fig. SP 6.1a - Pollen diagram showing the frequency distribution of major pant groups from a Late Holocene subsurface profile, Chopta-Tungnath region, Western Himalaya, Uttarakhand.

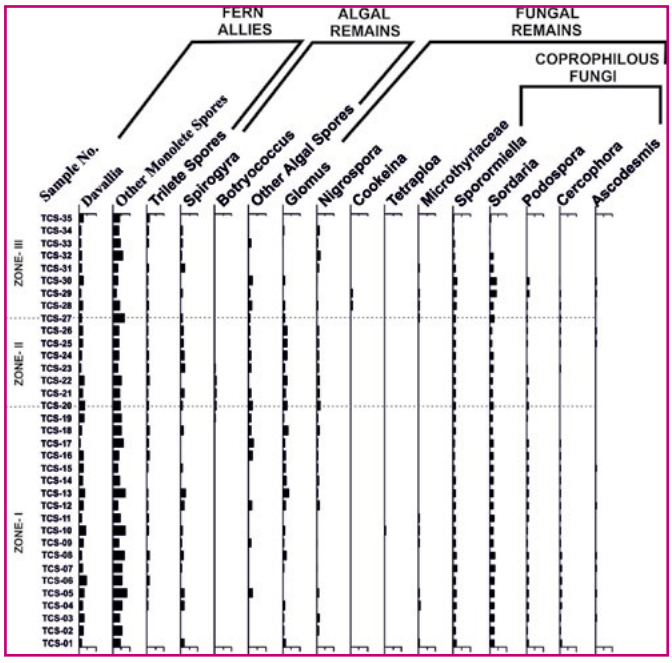


Fig. SP 6.1b - Frequency distribution of the non-pollen palynomorphs (NPPs) recovered from the surface samples along an altitudinal transect (2700 to 3800 m), Chopta-Tungnath region, Western Himalaya, Uttarakhand.

SP 6.2: 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 (SRF-UGC) & Ratan Kar (Mentor)

A multi-proxy approach involving palynology, quartz grain micro-texture, and magnetic susceptibility was applied on the sub-surface sediments of a trench near the Kolhamna Lagoon, Ny- Alesund, Svalbard, having a chronology of ca. 19000 yr BP. Due to paucity of palynomorphs in the subsurface sediments, vegetation-based palaeoclimatic reconstructions were not possible. Nonetheless, pollen-spores from the surface sediments, though scarce, helped in establishing the pollen–vegetation relation, which may be used for the reference in future palynological studies from this region. After the culmination of the LGM, during late Pleistocene (19130 to 10860 cal yr B.P.), a warming phase is observed with evidence of glacial retreat. The Early Holocene Period (10860 to 8100 cal yr B.P.) is marked by continuous warming. During Middle to Late Holocene (8100 cal yr B.P. to the Present), a general fluvio-glacial environment in and around the study area is observed, with glacial melt-water streams criss-crossing the strandflat and flowing into the fjord (Fig. 6.2a, b).

Fig. SP 6.2a - (A) The Kolhamna Lagoon and the location of the trench, (B) The trenching site with the Kolhamna Lagoon and Kongsfjord in the background, (C) Dug trench for subsurface sampling.

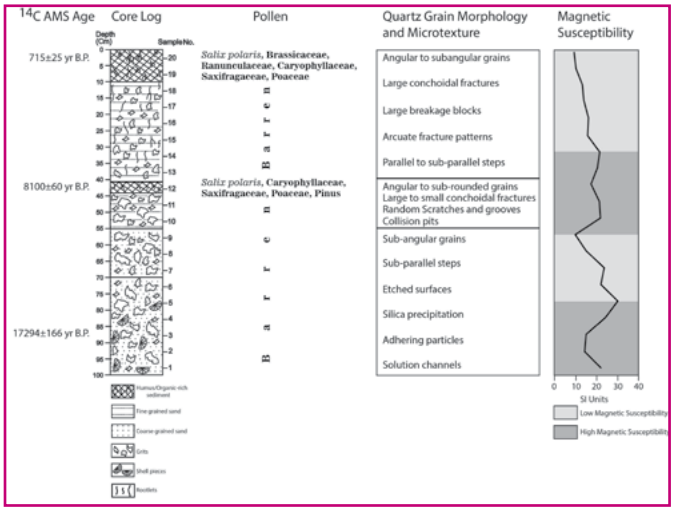


Fig. SP 6.2b - Litholog of the trench showing the samples and 14C AMS dates, along with pollen, quartz grain microtexture and magnetic susceptibility data.

SP 6.3: Quantifying the Holocene monsoonal variability using modern vegetation-climate relationships in the western margin of the Bengal Basin, India: development of transfer functions (Sponsored by SERB-DST, Project No. EMR/2016/005209 dt. 28.05.2018)

Investigators: Ruby Ghosh, BSIP, Lucknow, Shailesh Agrawal BSIP, Lucknow & Subir Bera, Department of Botany, University of Calcutta.

A total of 243 modern plant specimens including (162 dicots and 81 monocots) were studied from the two different forest regimes (i.e., dry and moist deciduous forests) along the rainfall gradient of the western margin of Bengal Basin (BB). From the study of 76 grasses, a total of 22 morphotypes have been retrieved. For non-

grass plant specimens (167 species), a total of 29 different morphotypes have been retrieved. In the dry deciduous forests, SADDLE are highest in abundance followed by CROSS and BILOBATE (small and medium) (Fig. SP 6.3a). While in the moist deciduous forests, the BILOBATE (medium) are higher in frequency than SADDLE and CROSS (Fig. SP 6.3b). Similar was the case of non-grass morphotypes, therefore, it is clear that in the dry deciduous forests EPIDERMAL POLYGONAL and BLOCKY are more abundant among the plants (Fig. SP 6.3c). However, SPHEROID ORNATE and EPIDERMAL SINUATE are more abundant in moist deciduous forests (Fig. SP 6.3d). From the above study, it can be inferred that both the grass and non-grass phytoliths have potential in distinguishing two different forest types across the rainfall gradient of the Bengal Basin.

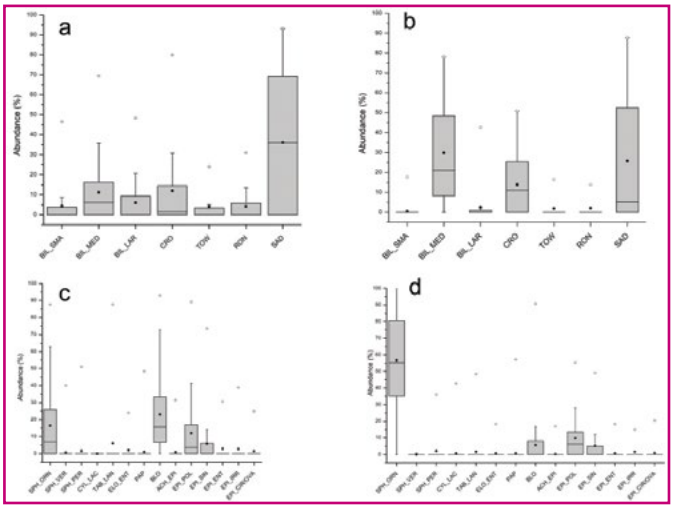


Fig. SP 6.3 - 2 Box plots showing the variations of grass and non-grass phytolith morphotypes in dry (a, c) and moist (b, d) deciduous forest of the Bengal Basin.

SP 6.4: Tree growth response of selected tree species of timber line to climate variability across the Indian Himalayan (Sponsored by MoEF & CC under NMHS program; No. 1886/XII-86/2016; 01.04.2016 to 30-09-2021).

Investigators: Parminder Singh Ranhotra (PI); Amalava Bhattacharyya (Co-PI) and Ayushi Singh (JPF).

Stand structure of *Abies spectabilis* (Himalayan fir) from the tree-line ecotone in the westerly dominant Kashmir region of Western Himalaya revealed mixed age and girth class within the tree-line ecotone. A good number of fir trees are found older than 200 years in transects. The fir forest showed subsequent densification during 19th and 20th Century with the commencement of warming conditions after the cool little ice age (LIA) phase. The fir growth to climate relation studies from the region is important to analyze the response of Himalayan conifers to recent warming trends for better evaluation of changes in forest health and interaction between vegetation and atmospheric conditions.

SP 6.5: Modelling and mapping of forest age distribution in the Alpine Himalayan region using dendrochronology and remote-sensing approach (Sponsored by SAC-ISRO, Ahmedabad. No. SAC/EPSA/BPSG/ALPINE/SHRESTI/ 09/2019; w.e.f. May 2019).

Investigators: Parminder Singh Ranhotra (PI) and Nidhi Tomar (JRF).

Developed the 60 year (1960–2019 CE) tree-ring cellulose oxygen isotope ($\delta^{18}O$) chronology of *Abies spectabilis* (Himalayan fir) from Triyuginarayan, Kedarnath area and growth behaviour of fir to climate was studied. The fir trees forming the tree-line ecotone at subalpine altitudes (3200 to 3400 masl) in this summer monsoon-dominated area are sensitive to temperature, soil-moisture and snow-cover of late winter and spring months. The rising temperature trend could result spring season and pre-monsoon drought conditions influencing the growth dynamics of fir in the region.

SP 6.6: Climate induced Holocene vegetation response and anthropogenic impact in Majuli Island of Assam, northeast India based on multiproxy records (Sponsored by SERB DST, New Delhi; No. SB/WEA-06/2019 (Women Excellence Award-2019), w.e.f. 23.05.2019).

Investigator: Swati Tripathi

The palynological study was carried out to delineate climatic gradient for the Majuli Island (world largest river island) of Assam. The pollen assemblage from 31 sediment samples comprised of 36 pollen taxa, which was statistically analyzed using Co-Existence Approach. A relatively warm and humid climatic condition was evident through marker pollen/NPPs (like *Lagerstroemia, Syzygium*, Sapotaceae, *Delitchia, Valsaria, Ustilago* and *Neorhabdocoela*) during 4099 to 2272 cal. yrs. BP. However, during 2272 to 1088 cal yrs BP, relatively less warm and humid climate was witnessed due to the decline in arboreal and aquatic pollen taxa, corresponding to the Dark Ages Cold Period (DACP) (Fig. SP 6.6).

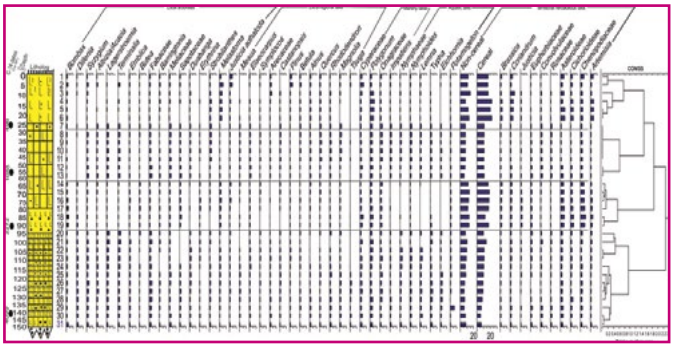


Fig. SP 6.6 - Pollen frequency diagram from the Majuli Island of Assam, northeast India.

CP-6.1: S.K. Basumatary [& Navneet Singh, Zoological Survey of India, Kolkata, West Bengal]

A palynological study on the 40 numbers of moths samples procured from the Arunachal Pradesh and Sikkim was undertaken to understand the pollen adherence in relation to the pollination and current vegetation and climate in the region. The study reveals that the moth species are directly depend on the local and regional vegetation as evident through the presence of adherence pollen with their proboscis and other body parts (Manuscript prepared).

CP 6.2: SK Shah, BSIP [Narayan P. Gaire, Tribhuvan University, Nepal; Ze-Xin Fan, XTBG, China]

First multi-centennial spring- to early-summer season (March–July) streamflow reconstruction for the Kamali River in the Central Himalaya, Nepal by using moisture-sensitive tree ring-width chronologies of multiple tree species was developed. This study found an increasing frequency of extreme events during the recent decades. The study showed the importance of long-term streamflow records towards the water management, agriculture, and energy sector (Fig. CP 6.2).

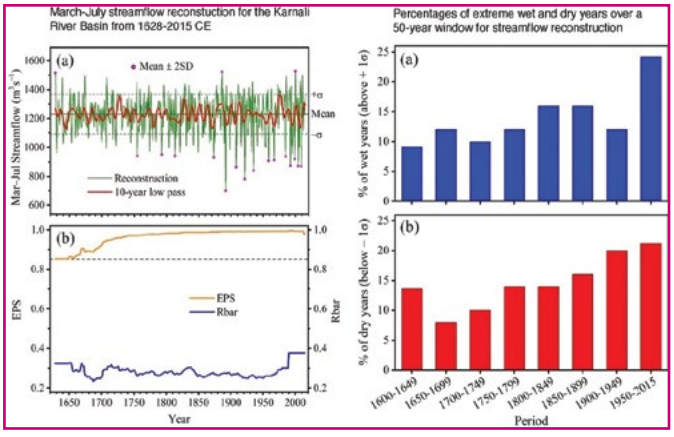


Fig. CP 6.2 - March-July streamflow reconstruction for the Kamali River Basin from 1628-2015 CE.

CP 6.3: Ruby Ghosh, BSIP, Lucknow [With Shailesh Agrawal, Scientist-D, BSIP]

Records of stable carbon isotopes ($\delta^{13}C$ values), TOC/TN, magnetic susceptibility (χlf), palynology, and phytoliths for a late Quaternary lacustrine archive from the northern Gangetic Plain, India are combined to determine the primary driver(s) of past C3/C4 plant variability. The study reveals nine climate-driven shifts in vegetation over the last 15.2 ka and provides a comprehensive picture of the evolution of the lake sequence. This study shows that before shifting to a C4-dominated vegetation during the early-Greenlandian to early- Northgrippian, C3 plants used to dominate the northern Gangetic Plain throughout the late-Pleistocene Period and also infers that temperature and rainfall jointly influenced the diversity and distribution of C4 plants in the northern Gangetic Plain.

CP 6.4: Swati Tripathi, Anjum Farooqui, Arya Pandey [& Arti Garg, A.N. Shukla (BSI, Allahabad)]

The pollen micro-morphometry of popular arboreal taxa of sub-family Caesalpinioideae comprising eight species of *Bauhinia* including one natural hybrid, *B. blakeana* Dunn., two species of *Cassia*, three species of *Senna* and and two species of *Caesalpinia* have been undertaken from the Gangetic Plain of central India using Light Microscope (LM) and Field Emission Scanning Electron Microscope (FESEM). All the fifteen species were clustered using hierarchical cluster analysis (HCA) based on their differences in observed pollen characteristics using average linkage method (Fig. CP 6.4). This examination could furnish the utility of selected morphological features of pollen grains of these species for taxonomic characterization, palaeoecological, phylogenetic implications, and correlation with other species growing around the world (MS communicated).

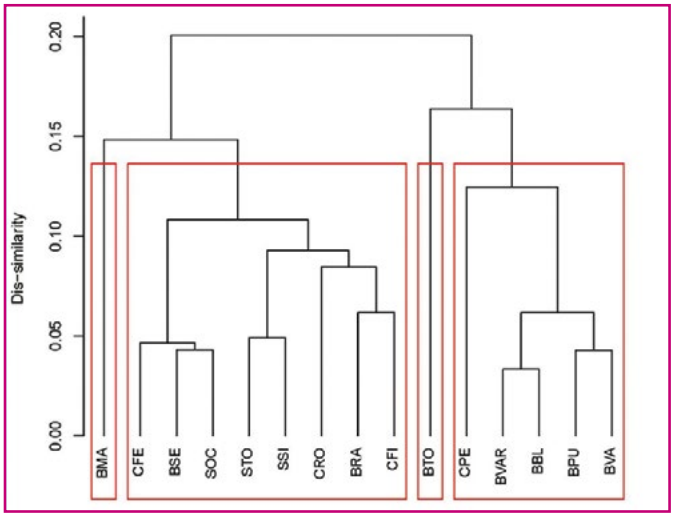


Fig. CP 6.4 - Results of hierarchical cluster analysis (HCA) are presented as dendrogram. There are two clusters and two unique taxa (BTO and BMA).

OTHER ACADEMIC WORKS

Research Papers Presented

1. **Ghosh Ruby, Saikia K, Biswas O, Agrawal S, Morthekai P, Arif M, Phartiyal B, Sharma A, Singh N, Paruya DK & Bera S 2022**. Evolution of the Indian Summer Monsoon in the Bengal region during the past ~ 10 ka and coupled shifts in a lacustrine ecosystem. 1st Quaternary Congress: Virtual Conference on "Integrative Quaternary Sciences for Societal Service " held on 19-21, January, 2022.
2. **Saikia K, Paruya DK, Kabeer A, Ghosh R & Bera S 2022** - Phytoliths in modern plants from dry and moist deciduous forests of the western margin of Bengal Basin and its implications in palaeovegetation reconstructions. 1st Quaternary Congress: Virtual Conference on "Integrative Quaternary Sciences for Societal Service" held on 19-21, January, 2022.
3. **David B, Ranhotra PS, Bräuning A, Shekhar M, Singh A, Tomar N & Singh CP 2021 -** Tree-line dynamics of *Abies spectabilis* in the summer monsoon dominant region of Western Himalaya. *In:* Edvardsson J, Chen TT, Gunnarson B, Hansson A & Linderholm HW (Editors) - *Book of Abstracts*. TRACE 2021 Conference, 16-17 June 2021, Lund, Sweden. p. 47.
4. **Tripathi S & Basumatary SK 2022 -** Modern pollen representation of the vegetation from the Meghalayan Cave of India: A comparative assessment of bat guano from conventional soil and moss substrates. 1stIndian Quaternary Congress-2022 (International Virtual Conference), BSIP, January 19th-21st, 2022 (Abstract: 18).
5. **Basumatary SK, Tripathi S, Pokharia AK & Gogoi R 2022** - Plant remains (micro and macrofossils) from soil sediment in and around Archaeological site: implications for palaeovegetation, climate-culture and rituals relationship. Int. Colloq., on Importance, Sacred Landscape and Value-Based Management of the AhomMoidams of Charaideo in Assam (India), Directorate of Archaeology, Govt. of Assam, Sivsagar, March 10th-12th, 2022 (Abstract: 26).

Deputation to Conferences/Seminars/ Workshops (both online and offline)

Ruby Ghosh, K Saikia, O Biswas, S Agrawal, P Morthekai, M Arif, B Phartiyal, A Sharma, N Singh, DK Paruya & S Bera

- Evolution of the Indian Summer Monsoon in the Bengal region during the past ~ 10 ka and coupled shifts in a lacustrine ecosystem. 1st Indian Quaternary Congress: Virtual Conference on "Integrative Quaternary Sciences for Societal Service " held on 19-21, January, 2022.

KG Misra

- Participated in the "Workshop on International mangrove day" held on virtual platform organized by Birbal Sahni Institute of Palaeosciences, Lucknow on July 26, 2021.
- Attended an online training-cum-conference on "Disaster Risk Reduction and resilience: Policies and Management" organized by the Department of Geology, BBAU, Lucknow and NIDM, New Delhi from March 7-9, 2022.

Swati Tripathi

- Participated in the 1stIndian Quaternary Congress-2022 (International Virtual Conference) at Birbal Sahni Institute of Palaeosciences, Lucknow during January 19th-21st, 2022.

Training/Study Visits

KG Misra

- Attended online training on "Disaster Management of floods due to Climate Change" organized by Amity University Campuses and NIDM, New Delhi from March 22-24, 2022.

Lectures delivered

Ratan Kar

- Basics of Quaternary palynology, in GSI training programme, Lucknow-Delivered a lecture on "Statistical tools for modern and sub-surface data" in the National Online Training Programme on Quaternary Palynology organized by Association of Quaternary Researchers (AOQR) jointly with Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow during 22–24, February 2021.

Sadhan K. Basumatary

- Delivered a lecture on topic "Earth Ecology: past and present" on June, 21st, 2021 at Arya Vidyapeeth College, Guwahati, Assam.

PH.D. PROGRAMMES

Amit K. Mishra (2018). Tree-line shifts, climate change, anthropogenic impact during the Holocene from Chopta-Tungnath region, Garhwal Himalaya, India, under the supervision of **Ratan Kar (BSIP, Lucknow)** and UK Shukla (BHU), registered with Banaras Hindu University, Varanasi. Status: Ongoing.

Kajal Singh (2018). Study of the Late Pliestocene-Holocene climatic and environmental changes around Ny-Alesund, Svalbard, under the supervision of **Ratan Kar (BSIP, Lucknow)** and Ashwani Raju (BHU), registered with Banaras Hindu University, Varanasi. Status: Ongoing.

Lamginsang Thomte (2018). Climate signals from multiple tree-ring parameter of *Pinus kesiya* from Northeast India, under the supervision of **Santosh K. Shah (BSIP, Lucknow)** and AK Bhagabati (Gauhati University), registered with Gauhati University, Guwahati. Status: Ongoing.

Deeksha (2021). Tree-ring analysis of teak from Central India, under the supervision of **Santosh K. Shah (BSIP, Lucknow)** and Munendra Singh, (Lucknow University), registered with Lucknow University, Lucknow. Status: Ongoing.

Korobi Saikia (2020). Holocene climate variability and its impact on the C3/C4 plant communities in the western margin of the Bengal Basin: phytolith based evidences, under the supervision of **Ruby Ghosh, BSIP,** Subir Bera, C.U., Angela A. Bruch, Senckenberg Research Institute, Germany, registered with Academy of Scientific and Innovative Research AcSIR New Delhi, India. Status: Ongoing.

Ravi Shankar Maurya (2020). Tree-ring based climate reconstruction from Himachal Pradesh, Western Himalaya and its association with glacial dynamics, under the supervision of **K.G. Misra (BSIP, Lucknow)**, registered with AcSIR, New Delhi. Status: Ongoing.

Sadhana Vishwakarma (2020). Development of multi-century long climate records using tree-rings from Uttarakhand, India. Under the supervision of **K.G. Misra (BSIP)** & Nandita Ghosal, BHU, registered with Banaras Hindu University, Varanasi. Status: Ongoing.

Ipsita Roy (2014). Climate and Glacial History during Late Quaternary from the Dokriani Bamak Glacier, Western Himalaya, under the supervision of **Parminder Singh Ranhotra (BSIP, Lucknow)** and Y.K. Sharma (Lucknow University), registered with Botany Department, Lucknow University, Lucknow. Status: Awarded.

Nidhi Tomar (2021). Late Quaternary vegetation and hydroclimatic variabilities in the Himachal region of Western Himalaya, under the supervision of **Parminder Singh Ranhotra (BSIP, Lucknow)**, registered with Academy of Scientific and Innovative Research (AcSIR), New Delhi, India. Status: Ongoing.

Arya Pandey (2020). Climate-induced Holocene vegetation response and anthropogenic impact in upper Brahmaputra Valley of Assam, northeast India: signatures of global climatic events, under the supervision of **Swati Tripathi, (BSIP, Lucknow)** and Hema Singh (BHU), registered with Department of Botany, Banaras Hindu University. Status: Ongoing.

Naushi Aneez (2017). A study on geoenvironmental status of Kukrail Reserve Forest, Lucknow, Uttar Pradesh with special reference to its soil properties, under the supervision of **Swati Tripathi (BSIP, Lucknow)** and Ajay Kumar Arya (Lucknow University), registered with Department of Geology, Lucknow University. Status: Ongoing.

Jyotsna Dubey (2016). Late Quaternary glacial chronology, palaeoclimatic reconstruction and their climatic implications in the Thangu Valley, Sikkim Himalaya, India, under the supervision of **S. Nawaz Ali (BSIP, Lucknow)**, registered with BHU Varanasi. Status: Awarded.

Prachita Arora (2020). Timing, extent, and sensitivity of the glaciers to the Late Quaternary climate variability in the Higher Sikkim Himalaya, under the supervision of **S. Nawaz Ali (BSIP)**, registered with Academy of Scientific and Innovative Research (AcSIR), New Delhi, India. Status: Ongoing.

ACCOLADES RECEIVED

S. Nawaz Ali

- Geological Society of India S.S. Merh Award-2021

Representation in Committees/ Board:

Ratan Kar

- Member, State Level Expert Appraisal Committee (SEAC), Ministry of Environment, Forest and Climate Change.

S.K. Basumatary

- Member, Editorial Board, Bio-Science Letters (an e-journal of Bodoland University, Assam, India).
- Member -Editorial Board, Journal - Geophytology (Palaeobotanical Society of India)

Santosh K. Shah

- Guest Editor, Frontiers in Forests and Global Change for research topic 'Determinants of Temporal Variation in Growth Rate in Tropical Forest Trees'
- Guest Associated Editor, Frontiers in Earth Science
- President, Asian Dendrochronological Association (ADA)
- Treasurer, Association of Quaternary Researchers (AOQR)

Ruby Ghosh

- Assessment Committee Member for the assessment of Lab Attendant (2) in CSIR-Central Drug Research Institute, Lucknow on 26.11.21

Parminder Singh Ranhotra

- Editorial Board, Journal - Geophytology (Palaeobotanical Society of India)

Swati Tripathi

- Member, Editorial Board, Journal of Palaeosciences.

Project 7: Reconstructing Human-Environment Interactions, Agricultural Strategies and Archaeo-Chemical imprints using Macrobotanical, Geochemical, Isotopes and Ancient Dna (aDNA)

Coordinator: Anil K. Pokharia (Scientist E) **Co-coordinator:** Rajesh Agnihotri (Scientist F)

Objectives:

- *To understand the early agricultural management, and cropping strategies/intensity during Prehistoric and Historic times.*
- *Characterise the paradigm-shift/transitions in lifestyles, with adoption of farming, and emergence of new technologies such as metal-working (Chalcolithic) and writing (Early Historic onwards).*
- *To assess impact(s) of geological climatic episodes (e.g. 4.2 ka BP the initiation of Meghalayan Era, MWP (~900-1450 AD), LIA (~1500-1850 AD), MW (1850 AD onwards) on human habitations.*
- *To understand the past population dynamics, domestication strategies and adaptation of human population using state of the art ancient and modern genomics.*

PREAMBLE

The first component of Archaeobotany Group deals with macro- and microbotanical remains as plant remains from archaeological sites provides ample information on the plant-based subsistence economy, and the existing environment during the time of its occupation. The north-western India holds immense potential for reconstructing subsistence model, palaeoecology, and palaeoclimate based on macro- and micro-botanical remains from the archaeological archives. Preliminary investigations at Tigrana have enriched our understanding on culture-subsistence-climate relationship during prehistoric times in the semi-arid region of the north-western India.

The second component Archaeochemistry deals with radiocarbon dating (both conventional radiometric and AMS dating, stable isotopic measurements of bio-archaeological samples (both botanical as well as zoological), and geochemistry of habitational sediments recovered from the archaeological sites. The study has demonstrated utility of chemical and isotopic data of bio-archaeological samples (charred grains, bones, teeth, cloth, rope pieces, food residues left in pots, etc.). Using these parameters, we have been working

on key archaeological sites such as Vadnagar, Sinauli, etc. Investigations carried out from these together with Lahuradeva Lake sediments provided information about the past human diets, ecology, climate, land use patterns, and biogeochemistry of freshwater lacustrine system of the Central Ganga Plain.

Under third component, we are using state-of-the-art ancient genomics and stable isotope approach to understand the past population dynamics, adaptation, and mixing events. We are also attempting to develop novel statistical approach to reconstruct the human population history, Agro-Pastoralism events, and migrations against the different environmental pressures.

PERSONNEL INVOLVED

Team Member: Niraj Rai (Sci. D)

Technical Support: Nandita Tiwari (Tech. Officer A)

Research Associate: Deepika Tripathi

Research Scholars: Himani Patel; Nikhil Patel (SRF)

Dr. Anil K. Pokharia

Dr. Rajesh Agnihotri

Nandita Tiwari

Deepika Tripathi

SIGNIFICANT FINDINGS

Archaeobotany:

Macro-botanical remains have revealed double-cropping pattern based on winter and summer season crops. So far, evidence of cereals, pulses and weeds has been reported. The direct (AMS) dates of barley grains (2400-2200 BC) authenticate the mature phase of Indus Civilization at the Tigrana archaeological site. Few sediment samples from the archaeological deposit were also processed for micro-botanical remains (phytolith), and work is in progress.

Archaeo-chemistry and Geochronology:

We have been working on Vadnagar archaeological site since 2017-18 for providing scientific chronologies and palaeo-ecology of the habitational areas near Sharmistha Lake. Chronologies of two trenches, namely, Amba Ghat and Darbargarh, were obtained using three C-14 and five OSL dates. Entire cultural sequence spanned between 2nd Century BCE to 6th Century CE. Obtained results were published in International Journal of Archaeological Science: Reports. The excavation of Vadnagar archaeological site was continued and various bio-archaeological samples (bone-teeth) from the extended areas of Amba Ghat region in the northern side of Sharmistha Lake were retrieved and studied. In the latest excavation phase, following noteworthy observations were made: (i) a long fault with significant amount of sand indicating a plausible seismic activity /or major subsidence in the region thereafter (ii) burial layer of auspicious monks of 10th Century in excavated trench near *Anaj Godam*. Multi-proxy analysis along with AMS dating of bio-archaeological samples is underway.

Fig. 1 - a. Map showing study site along with Indus/Harappan sites in north-west India studied for archaeobotanical records; b. Panoramic view of Tigrana site showing field excavation camp on the site; c. Aerial view of trench lay out plan for excavation; d. Potsherd showing painted floral motifs possibly paddy plant; e. Potsherd showing painted floral motifs possibly 'peepal' (Ficus religiosa); f. Terracotta wheels; g. Bone points; h. Faience bangles.

Fig. 2 - Showing aforesaid seismic activity and collected bio-archaeological samples.

Another significant finding came from investigating Lahuradewa Lake sediment from the Central Ganga Plain. The lake provided evidences for the earliest rice cultivation in Central Ganga Plain at ~8.3 ka BP. Chronology of the lake profile was earlier constrained by six conventional radiometric ^{14}C dates. To refine chronology and to deduce biogeochemical changes in the lake vicinity, we conducted radiocarbon dating of six samples (using AMS method) from the different strata and measured total organic carbon (TOC). Nitrogen (N) and sulfur (S) contents and their stable isotopes ($d^{13}C_{TOC}$, $d^{15}N$ and $d^{34}S$) in twenty-eight (28) sedimentary layers were also examined. All six AMS ^{14}C ages were found to be in excellent agreement with earlier reported radiometric ^{14}C dates (as shown in the Fig. 3). The pre-agricultural phase (black organic muddy sediment between 2.3 to 2.8 m; peat zone) was found to have stored significantly higher organic matter (TOC and N contents were ~28% and ~2%, respectively) due to development of *Botrycoccus* algae in the lake. Such algal growths in wetlands promote large amount of carbon sequestration (absorbing greenhouse CO_2 gas), and this stored carbon rich material acts as a fuel after maturation. These insights can play vital roles in efforts to minimizing carbon footprint of India by AD 2070.

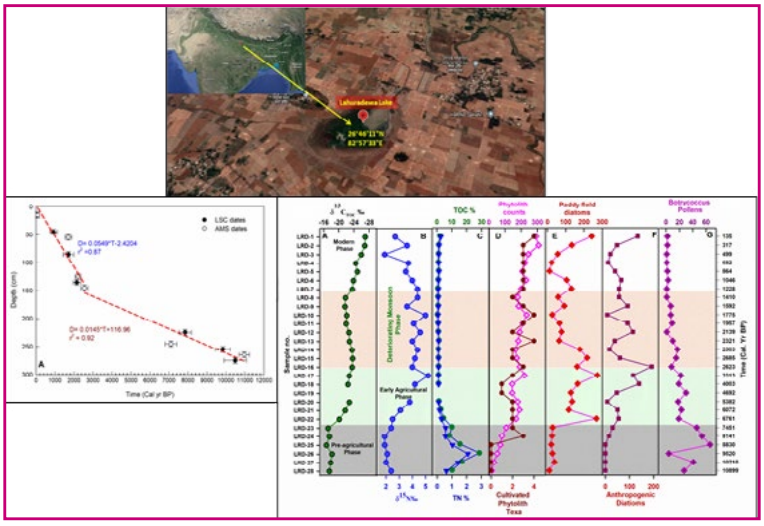


Fig. 3 - In the above figures, map showing the study area the Lahuradewa Lake (U.P.). Depth vs time plot shows the AMS and LSC radiocarbon dates of soil organic matter of lacustrine sediments in Lahuradeva Lake. The depth profiles of stable isotopes ($\delta^{13}C_{TOC}$, $\delta^{15}N$ and $\delta^{34}S$), TOC and TN contents represented from panels A-C. Phytolith counts (Total and cultivated), Paddy field / anthropogenic diatoms and Botrycoccus algae pollen counts shown in the Figure were adopted from earlier published works (Saxena et al., 2006, 2013; Thakur et al., 2020; Chauhan et al., 2009).

Archaeogenomics:

The discovery of human remains and artifacts from the past is akin to chancing upon a goldmine. It presents an opportunity to understand the past with some degree of certainty and clarity. The human remains bring new knowledge concerning the biological, cultural, historical, and geographical realities of man in the bygone era. We significantly worked on an archaeological site located in Ajnala, Punjab, and successfully revealed the anthropological answers related to origin and genetic affinities of the human skeletal remains abandoned in a well. It was documented the capture, imprisonment, and eventual killings of 282 Indian soldiers of the 26th Native Bengal Infantry regiment of the British Indian army. In May 1857, the Indian soldiers revolted against the colonial ordeal and killed by Britishers and their bodies were dumped in the nearby disused well. Sociopolitical sensitivity of the incident and the emergent sanitary concerns were cited as the most immediate reasons for their disposal in the well at Ajnala. Unfortunately, the book reference did not receive the attention it deserved from the state authorities. However, in February 2014, some local amateur archaeologists and curiosity seekers took it on their own to unearth the said, reported remains. They did not employ any scientific excavation technique for their exhumation from the well sediments, and in the process, the brittle skeletal remains were severely damaged, fragmented, and commingled. In 2014, 157 years after the Sepoy Mutiny of 1857 to pinpoint their area of origin, we have successfully isolated DNA from cementum-rich material of 50 good-quality random teeth samples and analyzed mt-DNA haplogroups (Fig. 4). In addition to that, we analyzed 85 individuals for oxygen isotopes ($\delta^{18}O$ values). The mt-DNA haplogroup distribution and clustering pattern rejected the local ancestry and indicated their genetic link with the populations living east of Punjab (Fig. 5). In addition, the oxygen isotope analysis ($\delta^{18}O$ values) from archaeological skeletal remains corroborated the molecular data and suggested the closest possible geographical affinity of these skeletal remains toward the eastern part of India, largely covering the Gangetic Plain region. The data generated from this study are expected to expand our understanding of the ancestry and population affinity of martyr soldiers.

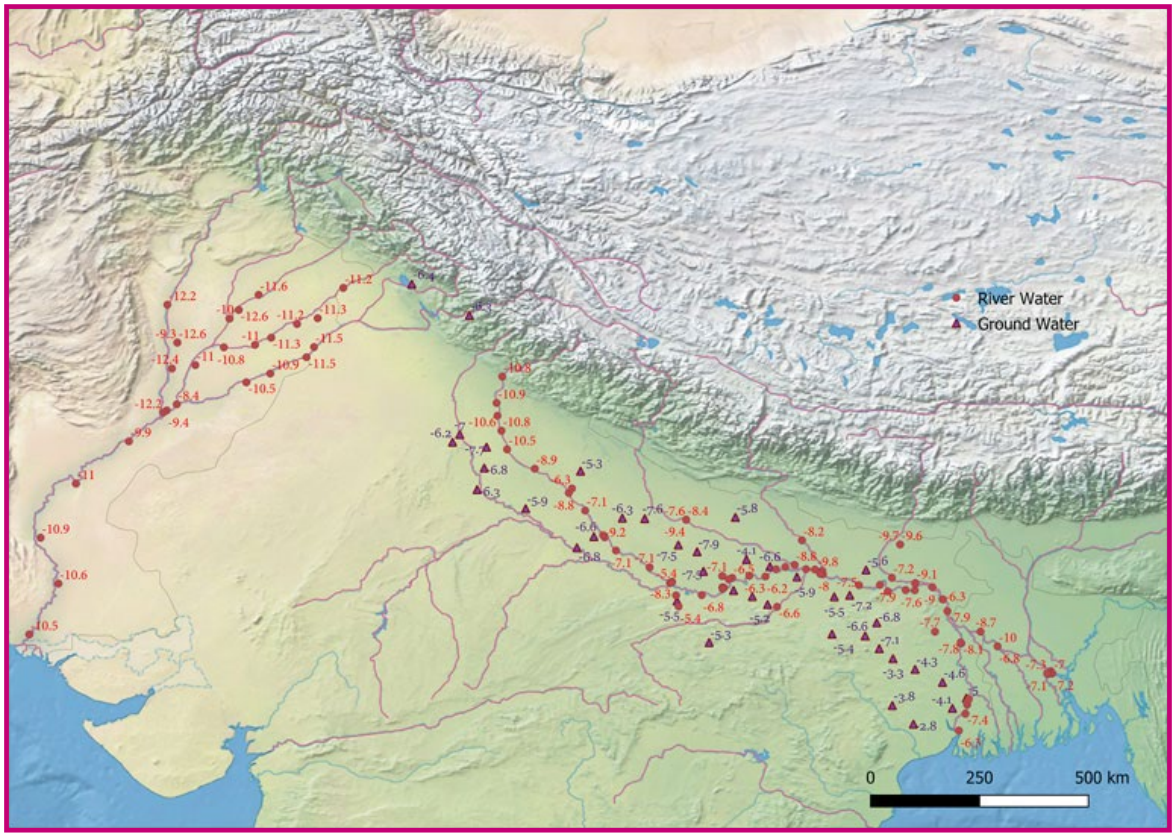


Fig. 4 - Map showing the spatial distribution of oxygen isotope ratio of Ganga and Indus River system (circles) and oxygen isotope ratios in groundwater (triangles).

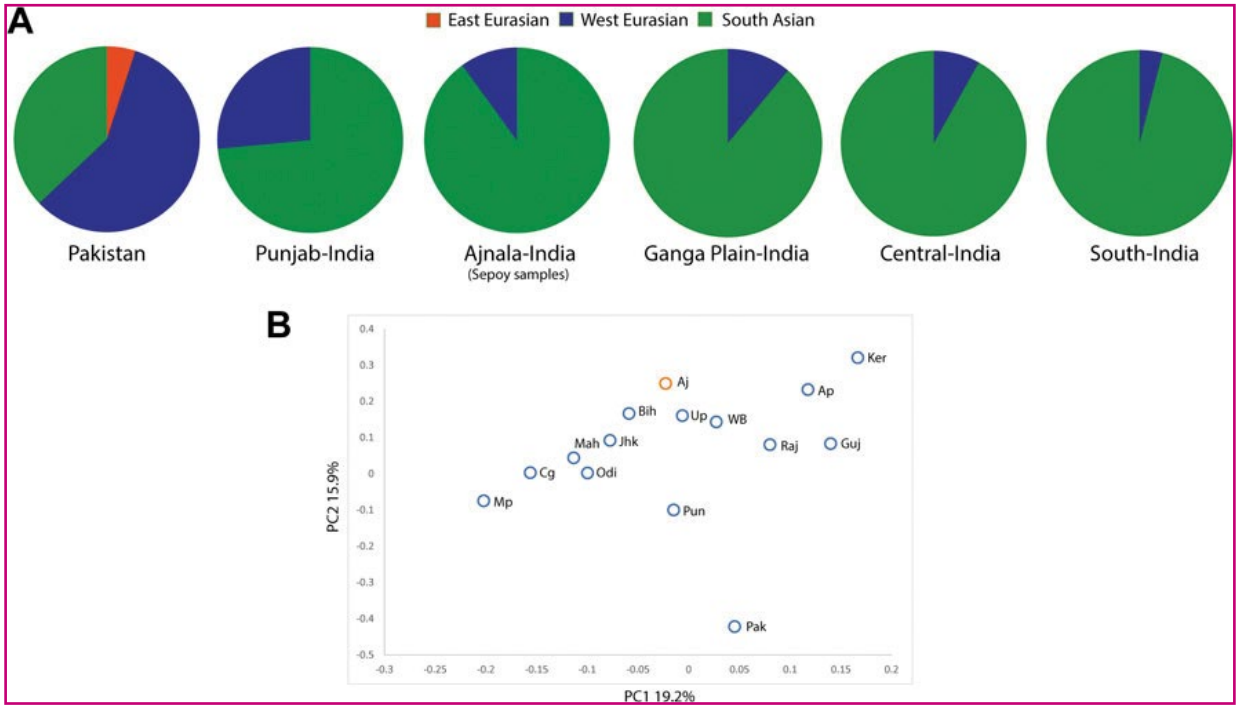


Fig. 5 - Pie chart showing the proportion of the East Eurasian, West Eurasian, and South Asian genetic ancestries among the studied group (Ajnala, India), with respect to their adjacent geographical regions. South Asian haplogroups: M2-M6, M18, M25, M30-M67, N5, R5-R8, R30-R32, and U2a,b; West Eurasian haplogroups: HV, H, J, K, R0, R1, R2, U1-U5, U7, U8, U9, W, and X; East Eurasian haplogroups: A-G, M7-M12, R22, and N9. (B) Principal component analysis (PCA) on maternal haplogroups of South Asian populations, showing the affinity of sepoy samples with South Asian populations. Pak, Pakistan; Pun, Punjab India; Aj, Ajnala (sepoy samples); Raj, Rajasthan; Guj, Gujarat; Mah, Maharashtra; Up, Uttar Pradesh; Bih, Bihar; Jhk, Jharkhand; WB, West Bengal; Mp, Madhya Pradesh; Cg, Chhattisgarh; Odi, Odisha; Ap, Andhra Pradesh; Ker, Kerala.

PROJECT OUTCOME

Publication in SCI (Science Citation Index) Journals

1. Gaur AS, Agnihotri R, Maurya P, Jaykumar S & Thorat BR 2021. Time and causes of submergence of ancient temple structures off Mahabalipuram, East Coast of India. Indian Journal of Geo-marine Sciences 50: 658-665 **(IF: 0.496).**
2. Agnihotri R, Patel N, Srivastava P, Ambekar A, Arif M, Kumar A, Phartiyal B & Kumar A 2021. A new chronology based on OSL and radiocarbon dating for the archaeological settlements of Vadnagar (western India) along with magnetic and isotopic imprints of cultural sediments. Journal of Archaeological Science: Reports, 38 doi:103045. 10.1016/j. jasrep.2021.103045 **(IF: 1.63).**
3. Kumar L, Farias K, Prakash S, Mishra A, Mustak MS, Rai N & Thangaraj K **2021**. Dissecting the genetic history of the Roman Catholic populations of West Coast India. *Human Genetics*, nature springer, 140, 10 :1487-1498. Doi:10.1007/s00439-021-02346-4 **(IF: 5.881).**
4. Mahajan S, Sathe V, Rai N, Agrawal S & Chakraborty S 2022. Human tooth enamel carbon and oxygen stable isotope dataset from chalcolithic Inamgaon (India), Data in brief. Vol 40, doi:10.1016/j. dib.2021.107711 **(IF: 1.133).**
5. Patel H, Pokharia AK, Nihildas N, Rai N & Sinha RP 2021. Rithi Ranjana: reconstructing crop economy based on archaeobotanical evidence and radiocarbon dates from an Early Iron Age site in Vidarbha region, Maharashtra, India. Current Science 120 (11): 1728-1739 **(IF: 1.169).**
6. Pokharia AK, Sharma S, Rawat YS, Srivastava A, Bhushan D & Pande P 2021. Rice, beans and pulses at Vadnagar: an early historical site with a Buddhist Monastery in Gujarat, western India. Geobios 64:77-99. doi.org/10.1016/j.geobios.2020.12.002 **(IF: 2.115).**
7. Sehrawat JS, Agrawal S, Sankhyan D, Singh M, Kumar S, Prakash S, Rajpal R, Chaubey G, Thangaraj K & Rai N 2022. Pinpointing the geographic origin of 165-year-old human skeletal remains found in

Punjab, India: Evidence from Mitochondrial DNA and Stable Isotope analysis, frontiers in genetics. DOI:10.3389/fgene.2022.813934 **(IF: 4.772).**

Refereed Non-SCI Journals

1. Nihildas N, Pokharia AK & Patel H 2021. Rice production in the Early Iron Age of Vidarbha: Archaeological and Archaeobotanical evidences from Rithi Rajana, Maharashtra. Man and Environment XLVI (1): 92-100.
2. Pokharia AK, Trivedi A, Tripathi D, Srivastava C, Tewari DP, Menon J, Varma S, Srivastava A & Vaishali 2021. Palaeodiet, Palaeoecology and Palaeoenvironment during 1200 BCE-300 CE in the Ganga Plain: A palaeoethnobotanical and palynological approach. The Palaeobotanist 69: 1-25.
3. Ritchey Melissa M, Sun Y, Matuzeviciute GM, Shoda S, Pokharia AK, Spate M, Tang L, Song J, Li H, Dong G, Vaiglova P, Frachetti M & Liu X 2022. The wind that shakes the barley: the role of East Asian cuisines on barley grain size. World Archaeology. DOI: 10.1080/00438243.2022.2030792
4. Spate M, Yatoo MA, Shen H, Pokharia AK, Shah Mohammad A & Betts A 2022. Cereal size, AMS and charcoal data from phase 1 of the Kashmir Prehistory Project. Journal of Archaeological Science: Reports, https://doi.org/ 10.1016/ j.jasrep. 2022. 103369.

Book Chapters/Memoirs/Bulletins

1. Srivastava A & Pokharia AK 2021. Antiquity of *Datura* L. in India. *In:* Shirvalkar P & Prasad E (Editors) - Culture, Tradition and Continuity (Disquisitions in Honour of Prof. Vasant Shinde), Vol. II, pp. 317-328. B.R. Publishing Corporation, Delhi.

Publication other than the Project Work

1. Basumatary SK, Gogoi R, Tripathi S, Ghosh R, Pokharia AK, McDonald HG, Sherpa N, Eline N, van Asperen *et al*. 2021. Red Panda feces from Eastern Himalaya as a modern analogue for palaeodietary and palaeoecological analyses. Scientific Reports, 11:18312doi.org/10.1038/s41598-021-97850-y **(IF: 4.996).**
2. Farooqui A, Pillai SK, Agnihotri D, Khan S, Tewari R, Shukla SK, Ali S, Trivedi A, Pandita SK, Kumar K, Bhat GD & Agnihotri R 2021. Impact of climate on the evolution of vegetation in tectonically active Karewa Basin, Kashmir Himalayas**.** Journal of Earth System Science 130: 93. https://doi.org/10.1007/s12040-021-01586-2. **(IF: 1.912).**
3. Lasagna E, Ceccobelli S, Cardinali I, Perini F, Bhadra U, Thangaraj K, Dababani RC, Rai N, Sarti FM, Lancioni H & Ige AO 2020. Mitochondrial diversity of Yoruba and Fulani chickens: A biodiversity reservoir in Nigeria. Poult Sci. 99(6): 2852-2860. doi:10.1016/j.psj.2019.12.066 **(IF: 4.014).**
4. Maharana P, Agnihotri R & Dimri AP 2021. Changing Indian monsoon rainfall patterns under the recent warming period 2001–2018. Climate Dynamics: 1-13, DOI: https://doi.org/10.1007/s00382-021-05823-8 **(IF: 4.901).**
5. Phartiyal B, Singh R, Nag D, Sharma A, Agnihotri R, Prasad V, Yao T, Yao P, Karthick B, Joshi P, Gahlaud SKS & Thakur B 2021. Reconstructing climate variability during the last four millennia from Trans-Himalaya (Ladakh-Karakorum, India) using multiple proxies, Palaeogeography, Palaeoclimatology, Palaeoecology 562: 110142 **(IF: 3.565).**
6. Trivedi A, Bhattacharyya R, Ghosh A, Saha ND, Biswas DR, Mahapatra P, Verma S, Shahi DK, Khan SA, Bhatia A, Agnihotri R & Sharma C 2021. 60 years of fertilization and liming impacts on soil organic carbon stabilization in a sub-tropical Alfisol, Environmental Science and Pollution Research: 1-16 **(IF: 5.19).**

SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

CP 7.1: Himani Patel, Anil K. Pokharia Niraj Rai & [Shantanu Vaidya from Deccan College, Pune] - Archaeobotanical samples from Nagardhan archaeological site in Vidharba region, Maharashtra were analyzed in collaboration with Deccan College, Pune and State Archaeology Department, Nagpur, Maharashtra. A total of 3,922 plant remains were recovered including cultivated crops, weeds, and wild taxa. The plant based subsistence economy is characterized by cereals, viz. *Hordeum vulgare*, *Triticum aestivum*, *Triticum sphaerococcum*, *Oryza sativa*; leguminous crops *Pisum arvense*, *Lens culinaris*, *Cicer arietinum*, *Lathyrus sativus*, *Vigna radiata*, *Lablab purpureus*, *Macrotyloma uniflorum;* minor cereals (millets) like *Sorghum bicolor*, *Paspalum scrobiculatum*, *Panicum miliaceum*, *Pennisetum*

glaucum, *Bracharia* sp., *Setaria* sp. Besides, oilseed and fibrous crops such as *Linum usitatissimum* and *Gossypium* sp. have also been recorded.

CP 7.2: Nikhil Patel, Rajesh Agnihotri, Ravi Bhushan & [Prof. Ravi Bhushan and Vineet Goswami, PRL Ahmedabad] - Collaborating with Ravi Bhushan and Vineet Goswami from PRL Ahmadabad for measuring ^{14}C activities in processed graphite powders at BSIP's Radiocarbon dating and Isotope characterization laboratory and measuring Sr isotopic composition in bio-archaeological remains (bones and teeth from human burials).

CP 7.3: Rajesh Agnihotri & [Anil K. Pokharia and Himani Patel] - Collaborating for generating stable isotopic data (C and N) of habitational sediments and macrobotanical remains from Vadnagar archaeological site.

CP 7.4: Rajesh Agnihotri, Niraj Rai & [Abhijit Ambekar, ASI, Baroda and Siddarth Prizomwala, ISR, Gujarat] - Collaborating for ascertaining chronologies of archaeological section which revealed evidences of past seismic activity / subsidence in the vicinity of Vadnagar archaeological site, north Gujarat.

CP 7.5: Niraj Rai, Dr Anil K. Pokharia and Dr Rajesh Agnihotri for AMS dating and archaeogenomics, also collaborating with Prof. Kumarasamy Thangaraj, Prof. Vasant Shinde, Prof. Gyaneshwer Chaubey, Prof. Maanasa Raghavan and Prof. David Reich to develop different ancient DNA protocol and co-operation in genomic data analysis.

OTHER ACADEMIC WORK

Research Papers presented

- **Niraj Rai** - Paper presented in one-day seminar organized by Archaeological Survey of India, Vadodara Circle, Gujarat entitled "*Reconstructing genetic history of Vadnagar, Gujarat using ancient DNA analysis* on June 06, 2021.

Lectures delivered

Rajesh Agnihotri

- Radiocarbon dating and decoded history of past ecology, environment and agriculture through usage of stable Carbon and Nitrogen isotopes for Vadnagar archaeological settlements (spanning last ~2500 years), invited lecture given on e-platform of Vadnagar Workshop being organized by Archaeological Survey of India (Vadodara circle) India on 6th July 2021.
- Radiocarbon dating and its importance in Indian Archaeological Sciences, invited lecture given on e-platform of a Bhishma School of Indic Studies, Pune, India on 26th November 2021.

Niraj Rai

- Delivered Keynote talk in an International Conference GenoPro-2021 organized by Invertis University, Bareilly on October 08, 2021. Titled of the talk was- *Reconstructing human population history of South Asia using ancient genomics.*
- Delivered invited talk in a three-day International Workshop on *Mt-DNA analysis of challenging samples in DNA forensics* organized by DBT- Centre for DNA Fingerprinting and Diagnostics, Hyderabad on December 17, 2021. Title of the talk was- *"Mitochondrial DNA analysis from complicated forensic specimens".*
- Delivered invited talk on complex genetic make-up of South Asians organized by Department of Anthropology, Panjab University on March 11, 2022. Title of the talk was- "*Reconstructing the peopling of old world South Asia: from modern to ancient genomes*".

PH.D. PROGRAMMES

Shalini Sharma (2017). Exploring plant-food resources, vegetation and climate of Indus (Harappan) and subsequent cultures in north-western India, under the supervision of **Anil K. Pokharia (BSIP, Lucknow)** and P.C. Pandey, Kumaun University, registered with Kumaun University, Nainital. Status: Awarded.

Nikhil Patel (2018). Geochronology and Isotopic investigations of geo-archaeological remains from different Archaeological sites of India: Implications to human-environment relationship, under the supervision of **Rajesh Agnihotri (BSIP, Lucknow)** and Alok Kumar (BHU), registered with Banaras Hindu University, Varanasi. Status: Ongoing.

Himani Patel (2018). Early farming in prehistoric India: New insights into agronomy, genetics and subsistence strategies in North-Western and Central India, under the supervision of **Niraj Rai (BSIP, Lucknow)** and R.P Sinha (BHU), registered with Banaras Hindu University, Varanasi. Status: Ongoing.

Sachin Kumar (2020). Palaeogenomics and Stable Isotope Approach to reconstruct the Early Ahom peopling in the North East of India, under the supervision of **Niraj Rai (BSIP, Lucknow)** and Maanasa Raghavan (The University of Chicago), registered with Academy of Scientific and Innovative Research (AcSIR), New Delhi. Status: Ongoing.

Richa (2020). The peopling of old-world South Asia: From Modern to Ancient genome, under the supervision of **Niraj Rai (BSIP, Lucknow)** and Maanasa Raghavan (The University of Chicago), registered with Academy of Scientific and Innovative Research (AcSIR), New Delhi. Status: Ongoing.

Aparna Dwivedi (2021). Reconstructing Neolithic and Megalithic Populations of South Asia using Ancient DNA and Stable Isotope Analysis, under the supervision of **Niraj Rai (BSIP, Lucknow)**, registered with Academy of Scientific and Innovative Research (AcSIR), New Delhi. Status: Ongoing

Project 8: Quaternary Monsoon / Climate reconstruction through High-Resolution – Multi-Proxy studies of Lacustrine Archives from Central India (Core Monsoon Zone and Indo-Gangetic Plain)

Coordinator - Anupam Sharma (Scientist F)

Co-coordinator - Binita Phartiyal (Scientist E)

OBJECTIVES

- *To reconstruct the palaeoclimate and hydroclimate variability during the late Quaternary using multi-proxy records & spatio-temporal mapping of abrupt and extreme climate events.*
- *To access chronological lag and disparity in long term records and ascertain the causal mechanisms of climate vs. Vegetation.*
- *To study climate-culture interaction in this region & social response variables.*
- *Palaeoclimate modelling.*
- *Creation of awareness and outreach for dissemination of knowledge to society.*

PREAMBLE

India is an agriculture base country and our entire socio-economic activities are governed by the monsoon; however, our understanding towards this important subject is still inadequate. It is true that for last several decades we are trying to understand the complex system of Indian Summer Monsoon, its characteristics, driving forces, teleconnections, etc. but the relatively short instrumental records of the temperature, precipitation, and humidity are posing challenge before us. To overcome this, proxy records, both biotic and abiotic are very useful and have the capacity to provide information for last several thousands of years of the monsoon behaviour. Quaternary sediments are the best archive for recording the signatures of multiple proxies. In continental setting, lakes act as the closed system and therefore record the signatures in continuous fashion. Because of the logistic restrictions and otherwise, long sediment cores from the centre of the lakes could not be raised earlier and therefore the institute launched a flagship programme named Quaternary Lake Drilling Programme (QLDP) with a

goal to reconstruct the palaeoclimate and hydroclimate variability through the lake sediments of the central India in the first phase of the program. Additionally, all the facilities required in the study are available in the institute and same methodologies will be applied by same set of personnel, so as to minimize the inter-laboratory biases in the data.

In order to understand the past records, preparation of modern analogues is mandatory. Therefore, in last one year of the program several filed visits have been conducted and samples are analysed and the preparation of analogues is in process. Parallely, the necessary administrative formalities for outsourcing the lake drilling were also completed and M/s Horizon Geoservices India Pvt. Ltd is awarded the tender to carry out the drilling of selected lakes for retrieving the sediment cores. Once the cores are received, multiproxy studies will be conducted to track the palaeorecords in chronological order of the Late Quaternary Period, which not only improve our understanding of the monsoon but the data will also help the climate modellers for future projections of the monsoon.

PERSONNEL

Core Team Members - Anupam Sharma (Scientist F), Binita Phartiyal (Scientist E), Anjali Trivedi (Scientist D), P S Ranhotra (Scientist D), Shailesh Agrawal (Scientist D), Kamlesh Kumar (Scientist D), Md. Firoze Quamar (Scientist D), Jyoti Srivastava (Scientist D), P. Morthekai (Scientist D), Prasanna K (Scientist C), Trina Bose (Scientist C), Mayank Shekhar (Scientist B) & Anurag Kumar (Scientist B)

Associate Members - Anjum Farooqui (Scientist F), Rajesh Agnihotri (Scientist F), Sadhan K Basumatary (Scientist E), Biswajeet Thakur (Scientist E), Santosh K. Shah (Scientist E), Ruby Ghosh (Scientist D), Swati Tripathi (Scientist D), S.N. Ali (Scientist D), Shilpa Pandey (Scientist D), Manoj MC (Scientist D), Runci Paul Mathews (Scientist C), Niteshkumar Khonde (Scientist C), Md. Arif (Scientist C)

Research Associates - Sandhya Mishra

Research Scholars - Arvind Tewari, Md Ikram, Nazakat Ali, Nagendra Prasad

SIGNIFICANT FINDINGS

The relationship between pollen and their depositional ecosystem across ISM transitional zones from northwest India.

Pollen, Isotope, geomagnetism, grain size together with geochemical studies of the ISM transitional zone in Northwest India harbouring mixed C_3-C_4 dominated vegetation in eastern Rajasthan and C_4 dominated in western Haryana and Uttar Pradesh (Fig 1). it is also certified that the degree and diversity in pollen composition along the transect from east to west ISM boundary were controlled by the intensity of the summer monsoon. The degree of human impact from eastern Rajasthan to western Haryana and UP is moreover remarkable.

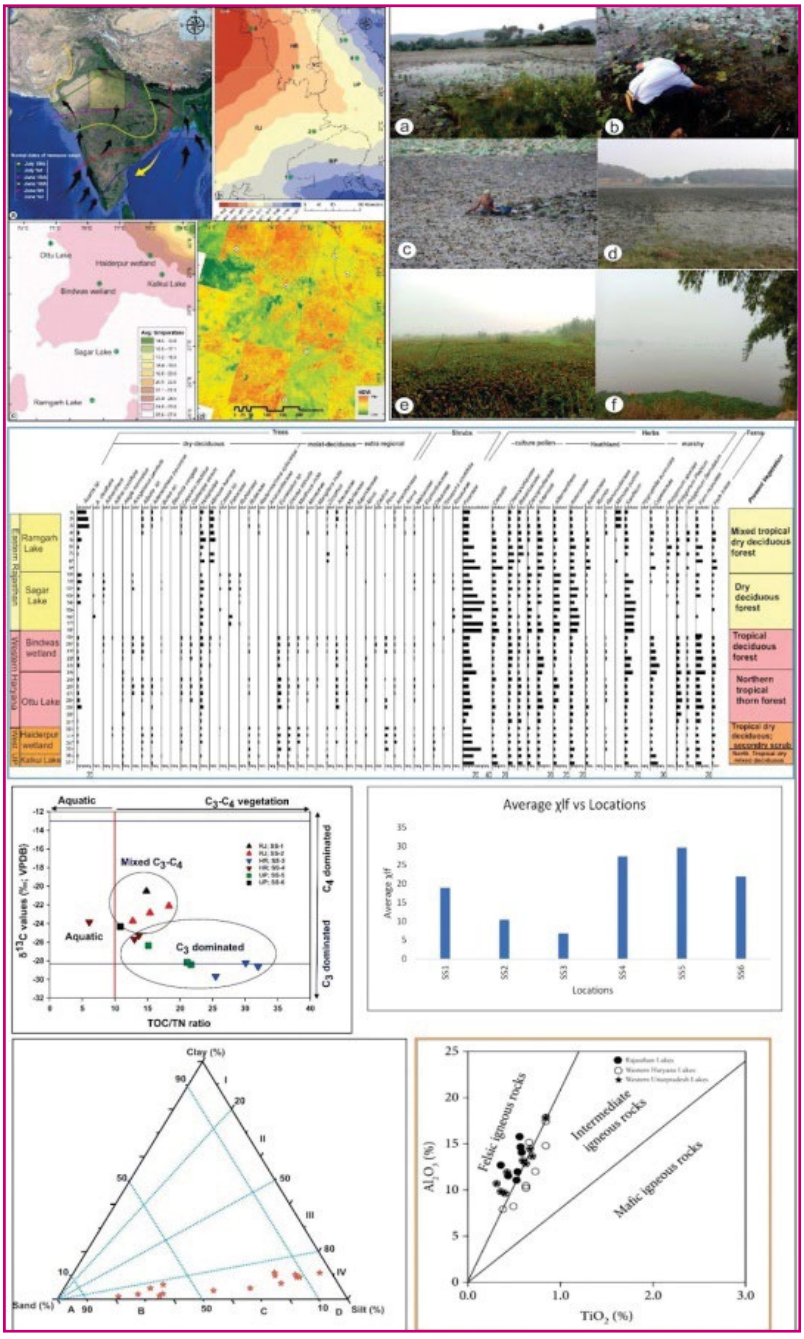


Fig. 1 - Modern analogue reconstruction from the transitional climatic zone (Indian Summer Monsoon) of western India showing the study area, average temperature and precipitation, vegetation, field photographs and the recovered pollen frequencies. The graphs show the stable carbon isotope ratios, mineral magnetic susceptibility, grain size and major oxide concentrations respectively.

Pollen frequency spectra from the Ghaghara-Gandak and Ganga-Ghaghara interfluves of Central Ganga Plain.

To assess how reliably multiproxy evidence can distinguish different ecological and depositional sub-environments (such as lacustrine and fluvial deposits; agricultural and forest land), a modern surface training dataset combining biotic and abiotic proxies (i.e. modern pollen precipitation, phytolith, diatom, stable carbon and nitrogen isotope, geochemical, grain size and environmental magnetic parameters) have been prepared from the two interfluves of the Central Ganga Plain (CGP). The biotic record in Ghaghara-Gandak interfluve is more productive than in the Ganga-Ghaghara interfluves (Fig. 2). The pollen data comprising *Acacia, Madhuca, Butea, Bombax, Bauhinia,* and *Syzygium* reflect the mixed deciduous forest under a warm and humid climate in response to rainfall variations in the region.

Though phytolith data can distinguish between different ecological and depositional environments still, a little ambiguity especially in river and cropland samples may be attributed to the redundancy and multiplicity of the phytolith morphs in different plant families (Fig. 3).

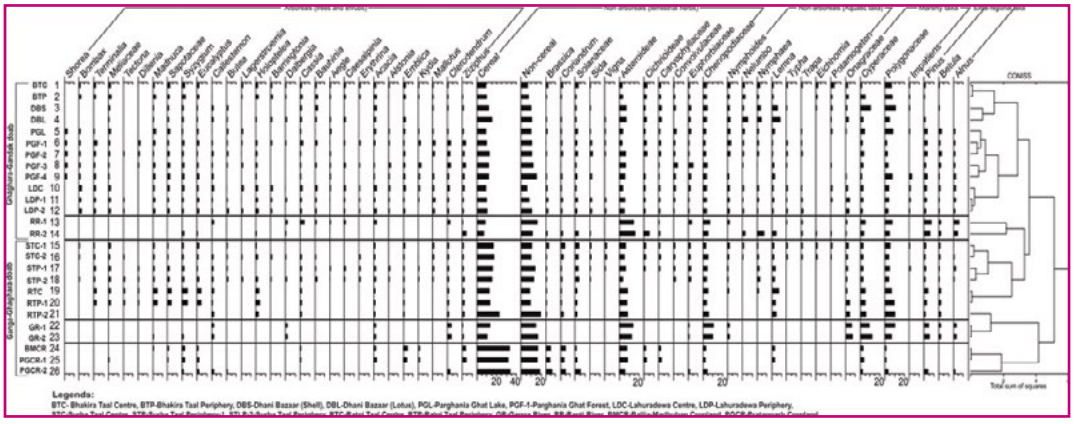


Fig. 2 - Pollen frequency diagram of the Ghaghara-Gandak and Ganga-Ghaghara interfluves of Central Ganga Plain.

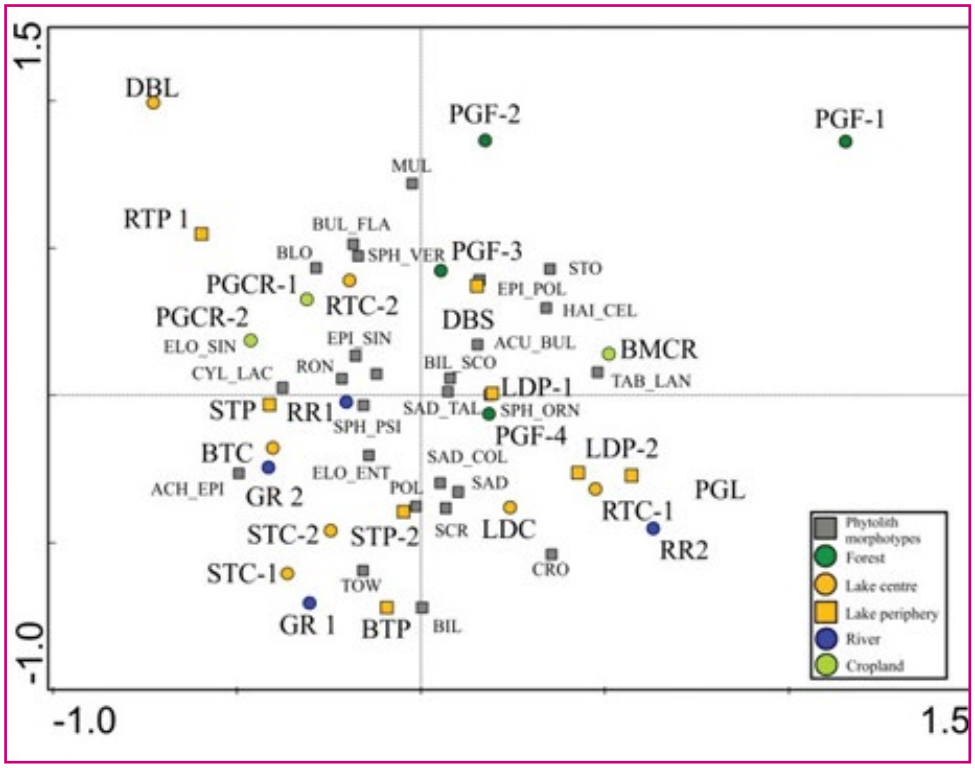


Fig. 3 - PCA ordination plot showing inter-relationships of phytolith morphs and surface samples collected from different depositional settings under Ghaghara-Gandak and Ganga-Ghaghara interfluves and the magnetic susceptibility data.

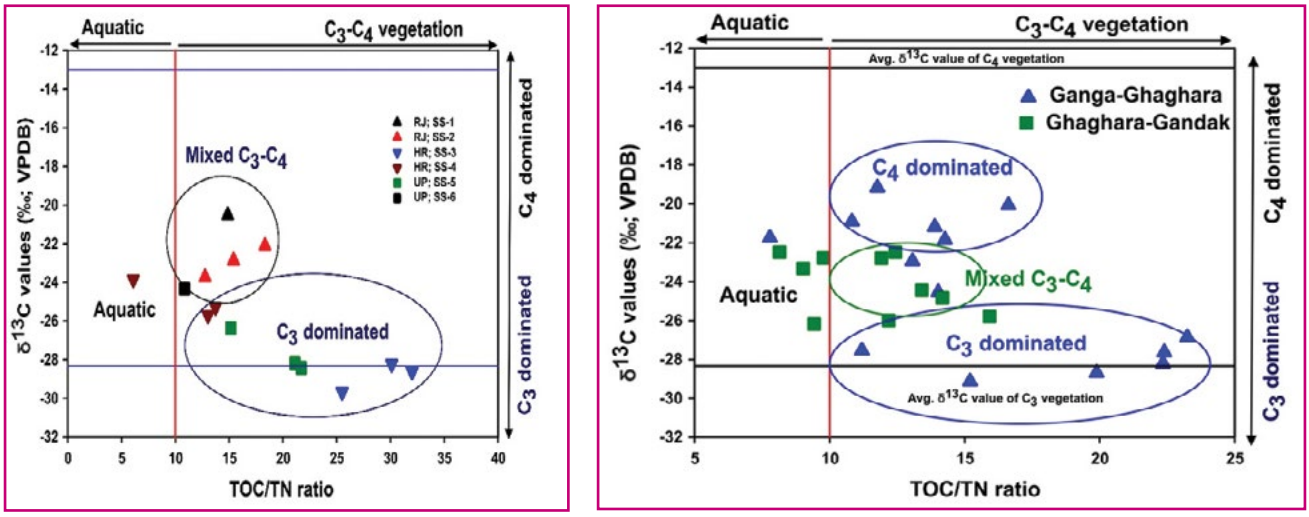


Fig. 4 - (a) Isotope study harbour mixed C3-C4 vegetation in the eastern Rajasthan and C3 dominated in western Haryana and Uttar Pradesh, (b) The relatively higher δ13C values along with high TOC/TN values in the sediments suggest a mixed C3-C4 source of vegetation in the CGP. The phytolith assemblage and stable carbon isotopic values complement each other.

The sediment samples collected from the Ganga Riverbed show high values of magnetic susceptibility compared to lake sediments, most probably due to multiple inputs from the catchment of varied lithology. The relatively higher $\delta^{13}C$ values along with high TOC/TN values in the sediments suggest a mixed C_3-C_4 source of vegetation in the CGP (Fig. 4). Thus, the generated multiproxy data from the CGP are very much required because it could serve as background information for the Quaternary palaeoecological reconstruction in the deep lake cores.

Phytolith study of the Ghaghra-Gandak and Ganga-Ghaghra interfluves of the Central Ganga Plain.

Twenty-six surface soil/sediment samples collected from different depositional environments from the Ghaghra-Gandak and Ganga-Ghaghra interfluves were subjected to phytolith analysis to assess the efficacy of the phytoliths (Fig. 5) and stable carbon isotopic analysis in distinguishing different sub-environments. The samples from the forested areas show the dominance of woody morphotypes and $d^{13}C$ values vary between -27.6 to -29.1‰. The samples collected from the lakes show the dominance of SADDLE, BILOBATE and CROSS suggesting the prevalence of warm-moist and warm-dry loving grasses in the local vegetation. Here, the $d^{13}C$ values range between -20.1 to -21.7‰. The samples collected from the floodplains of both the doab regions show the isotopic values ranging between -20.9 and -26.1‰ and dominance of grass phytoliths such as SADDLE, BILOBATE, and CROSS and the non-grass morphotypes such as SPHEROID ORNATE, ACHENE EPIDERMIS, TABULAR LANCEOLATE, etc. The samples collected from the cropland have shown the isotopic value ranging between -24.8 to -26‰. The study infers that the stable carbon isotopic values complement the phytolith assemblages retrieved from different depositional settings and have potential for palaeoclimate reconstructions.

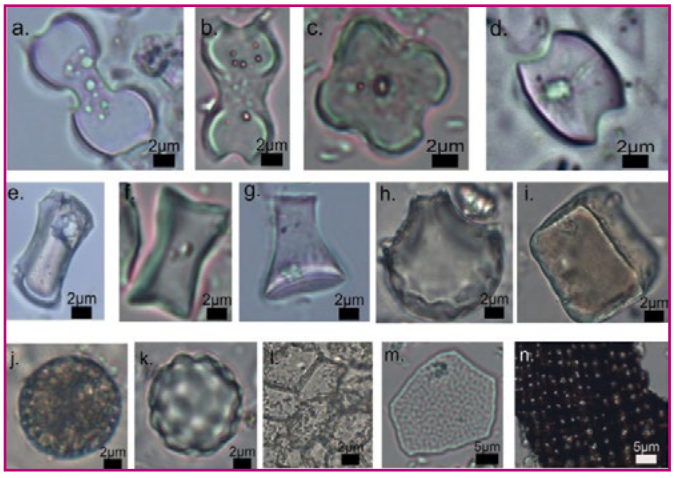


Fig. 5 - Showing different phytolith types recovered from surface soils/sediments from the Ghaghra-Gandak and Ganga-Ghaghra interfluves of the Central Ganga Plain. a. Bilobate; b. Bilobate Scooped; c. Cross; d. Saddle; e. Tall Saddle; f. Collapsed Saddle; g. Rondel; h. Bulliform Flabellate; i. Blocky; j. Spheroid Ornate; k. Spheroid Verrucate; l. Epidermal Polygonal; m. Scrobiculate; n. Achene Epidermis.

Studies in the Central Indian core monsoon zone (CMZ).

The multiproxy study, comprising pollen and diatom (biotic proxies), as well as grain size, magnetic susceptibility, and geochemistry (abiotic components), was undertaken on the modern soil samples, collected from the states of Chhattisgarh and Madhya Pradesh, central Indian core monsoon zone (CMZ), wherein the weathered materials of the Palaeocene Cretaceous extrusive rocks and sedimentary rocks of the Late Triassic to Upper Carboniferous are underlying the soil cover. The study revealed that the overall pollen and diatom preservation is comparatively good at areas where the Palaeocene Cretaceous extrusive rocks are found except for the areas of human settlements, whereas the preservation of pollen and diatom was comparatively poor at areas where sedimentary rocks of the Late Triassic to the Upper Carboniferous are found. The most plausible reason for this difference is the availability of nutrients which are supplied more abundantly by the easily weatherable Deccan basalt rocks compared to their sedimentary counterpart.

Using proxy data and vegetation modelling to predict past, current, and future distributional shift of *Butea monosperma*, a marker of land degradation in India.

Extensive deviations in spatio-temporal social and environmental dynamics currently alter the health of ecosystems and the services they provide. Detecting the causes that contribute to the distribution of a natural forest species capable of restoring the lost ecosystem function and productivity will aid in determining better food security, livelihoods, and provision of ecosystem goods and services. We modelled the spatial range of *Butea monosperma* under past, i.e. Last Glacial Maximum (LGM), Middle Holocene (MH), current and future (2070) climatic scenarios with MAXENT trained on present-day occurrences. We identified areas of suitable habitats for which the estimation of habitat stability is predicted in all the models at different times. To validate the inferred suitable habitat, we tested the model by the current occurrence and fossil pollen data of *Butea monosperma*. Our distribution models agree with the fossil pollen records for the middle Holocene (4500-7000 yrs BP) and predict the prevalence of *B. monosperma* covering 74.27% of the Indian Subcontinent with maximum habitat stability in western and southwestern India (12.47%). Widespread potential distribution of the plant species during LGM supports the presence of the last remnants of tropical dry deciduous forest in the region. However, a decline in habitat suitability (55.42%) is predicted under current and future climatic scenarios with maximum stability (0.42% - 5.14%) along the Southwestern Ghats in the Southern, Gir Range in the Western, foothills of Siwaliks in the Northern and Khasi-Jaintia hills in the Eastern part of India. Temperature seasonality (39.2%) measured in terms of variable contribution in Maxent model range from 5-30 ˚C and significantly affects the distribution shift of *B. monosperma* along with annual precipitation (15.9%) and annual mean temperature (11.5%) (Fig. 6). Model results provide evidence of habitat reduction and identify the stability hotspots for *Butea monosperma* for its conservation and establishment of land management policies mainly for the dry tropics.

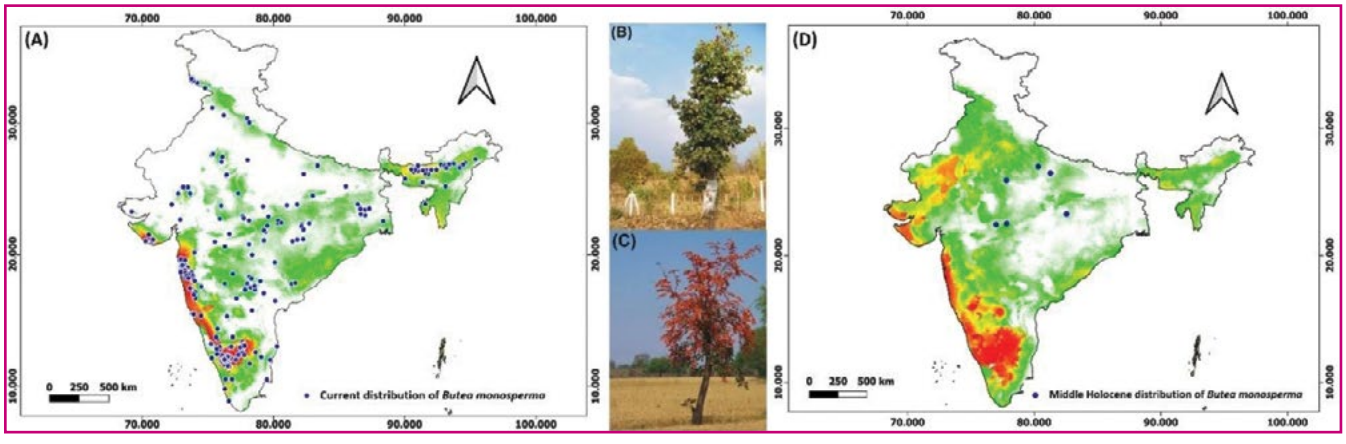


Fig 6 - (A) Current distribution data of Butea monosperma in the Indian Subcontinent based on occurrence records and Species distribution modelling, (B) Surviving B. monosperma on road verges, (C) B. monosperma during spring season, (D) Middle Holocene distribution map of B. monosperma with available fossil pollen data from different localities.

To understand past monsoon dynamics and establish teleconnections with drivers using Dendrochronology and isotope technique.

A field trip was conducted to understand past monsoon dynamics and establish teleconnections with drivers using Dendrochronology and isotope technique. A total of 200 tree ring cores were collected from 100 trees in conserved forests in Maharajganj District of U.P. and surrounding areas. For tree-ring sampling, a latitudinal range of 27°02'38.5"N to 27°23'44.8"N and a longitudinal range of 83°16'42.0"E to 83°40'31.9"E were covered (Fig. 7). The increment borer was used to collect all of the tree-ring core samples from *Tectona grandis*. The chronology was developed from the Manikpur Forest site, which spans 1936 to 2021 C.E. (86 years), and the Madhwalia Chawki Forest region, which spans 1935 to 2021 (87 years). The rest of the samples are being processed for further analysis.

Core Drilling Operation from Kanwar, Begusarai, Bihar.

Together with the Horizon Geosciences company, Mumbai, the project scientists were on the Kanwar Lake site for drilling of the long cores (Fig. 8). Bathymetric and geophysical surveyed were carried out. Cores are being retrieved and sent to BSIP Laboratory.

Fig. 7 - Sampling of tree-ring cores (Tectona grandis) from Maharajganj District, Uttar Pradesh, using an increment borer.

Fig. 8 - Field Photographs of Kanwar Lake at Begusarai, Bihar.

PROJECT OUTCOME

The project is just started and work is under progress. Based on surface samples, a few manuscripts are submitted for publication. However, during the period, scientists working under different projects published numerous papers as given in the following section.

Research Publication Other than the Project Work

In SCI (Science Citation Index) Journals

1. Raj R, Tripathi JK, Kumar P, Singh SK, Phartiyal B, Sharma A, Sridhar A & Chamyal LS 2021. Palaeoclimatic and sea-level fluctuations from the last deglaciation to late Holocene from western India: Evidence from multiproxy studies. Journal of Asian Earth Science 214: 104777. https://doi.org/10.1016/j.jseaes.2021.104777 **(IF: 3.374).**
2. Subrahmanyam G, Kumar K, Shah AP, Maurya DM, Sharma A, Chamyal LS & Archana G 2021. Geochemical characteristics control potential microbial activity in exposed Late Quaternary alluvial deposits. Pedobiologia - Journal of Soil Ecology 87–88: 150747. doi.org/10.1016/j.pedobi.2021.150747. **(IF: 2.128).**
3. Ghosh R, Shukla UK, Srivastava P & Sharma A 2021. Constraints of lithostratigraphy on the landscape evolution in response to erosion, climate and tectonics in the Marginal Ganga Plain, India. Journal of Asian Earth Sciences 219: 104892. https://doi.org/10.1016/j.jseaes.2021.104892 **(IF: 3.374).**
4. Farooqui S, Shah AP, Maurya DM, Archna G, Ali SN & Sharma A 2021. Texture, mineralogy and geochemistry of late Quaternary sediments of the Mahi River Basin, western India: Implications to climate and tectonics. Applied Geochemistry 134, 105088. doi.org/10.1016/j.apgeochem.2021.105088 **(IF: 3.841).**
5. Jeelani G, Shah RA, Deshpande RD, Dimri AP, Mal S, & Sharma A 2021. Isotopic analysis to quantify the role of the Indian monsoon on water resources of selected river basins in the Himalayas. Hydrological Processes 35(11): e14406. doi.org/10.1002/hyp.1440 **(IF: 3.784).**
6. Tiwari AK, Singh AK, Phartiyal B & Sharma A 2021. Hydrogeochemical characteristics of the Indus River water system, Chemistry and Ecology, DOI: 10.1080/02757540.2021.1999425 **(IF: 2.381).**
7. Kholia N, Kotlia BS, Porinchu D, Bisht K, Sharma A & Jalal P 2021. Sedimentological and grain size characteristics of two lake cores from Himachal Pradesh, India. Indian Journal of Climate Change 7(4): 35-51. doi 10.3233/JCC210024.
8. Halder P, Shukla MK, Kumar K & Sharma A 2021. Mineralogical and geochemical evidence of fluid-rock interaction at the shallow crustal level in Koyna Seismogenic Region, Maharashtra, India: Impact and implications. Acta Geologica Sinica 95: 40–43 **(IF: 3.282)**.
9. Chaddha AS, Sharma A & Singh NK 2021. Clay minerals identification in rock varnish by XRD: A one-step reduction approach. MethodsX 8, 101511. https://doi.org/10.1016/j.mex.2021.101511**(IF: 2.21).**
10. Chaddha AS, Mathews RP, Kumar K, Phartiyal B, Ali SN, Morthekai P & Sharma A 2021. Caves as interim-refugia: chemical signatures of human habitation under extreme environments of Ladakh, NW India. Journal of Archaeological Science: Reports 36: 102799, https://doi.org/10.1016/j.jasrep.2021.102799 **(IF: 1.63).**
11. Joshi P, Phartiyal B & Joshi M 2021. Hydro-climatic variability during the last five thousand years and its impact on human colonization and cultural transition in Ladakh sector, India. Quaternary International 599-600: 45-54 https://doi.org/10.1016/j.quaint.2020.09.053 **(IF: 2.454).**
12. Makwana N, Prizomwala SP, Das A, Phartiyal B, Sodhi A & Vedpathak C 2021. Reconstructing the climate variability during the last 5000 years from the Banni Plains, Kachchh, western India. Frontiers in Earth Science. doi: 10.3389/feart.2021.679689 **(IF: 3.661).**
13. Md. Firoze Quamar 2022. Modern pollen-vegetation relationship from the Rourkela (Sundargarh District), Odisha, India: a preliminary study and a comparative account, Palynology ID. 2050321 DOI:10.1080/01916122.2022.2050321 **(IF: 1.949)**.
14. Nag D, Phartiyal B & Joshi M 2021. Late Quaternary tectono-geomorphic forcing vis-à-vis topographic evolution of Indus catchment, Ladakh, India. Catena https://doi.org/10.1016/j.catena.2020.105103. **(IF: 6.367).**
15. Phartiyal B, Singh R, Nag D, Sharma A, Agnihotri R, Prasad V, Yao T, Yao P, Joshi P, Balasubramanian K, Singh SK & Thakur B 2021. Reconstructing climate variability during the last four millennia from Trans-Himalaya (Ladakh-Karakoram,

India) using multiple proxies. Palaeogeography, Palaeoclimatology, Palaeoecology https://doi.org/10.1016/j.palaeo.2020.110142 **(IF: 3.565).**

16. Phartiyal B, Clarke Jonathan DA & Pandey S 2021. Prospects of Astrogeology and Astrobiology researches in India: Ladakh as an example. Journal of Palaeosciences 70: 326-337. https://jpsonline.co.in/index.php/jop/article/view/24.
17. Phartiyal B, Kapur VV, Nag N & Sharma A. 2021. Spatio-temporal climatic variations during the last five millennia in Ladakh Himalaya (India) and its links to archaeological finding(s) (including coprolites) in a palaeoecological and palaeoenvironmental context: A reappraisal. Quaternary International 599-600: 32-44. https://doi.org/10.1016/j.quaint.2020.11.025. **(IF: 2.454)**
18. Prasanna K, Ghosh P, Eagle RA, Tripati A, Kapur VV, Feeney RF, Benjamin R, Fosu & Mishra D 2021. Temperature estimates of lower Miocene (Burdigalian) coastal water of southern India using a revised otolith "clumped" isotope palaeothermometer. Geochemistry Geophysics Geosystems 22: e2020GC009601. https://doi.org/10.1029/2020GC009601 **(IF: 4.48).**
19. Srivastava J, Manjunatha BR, Balakrishna K, Prajith A, Manjunatha HV, Jose J & Kumar N 2021. Quantitative pollen-based reconstruction of the vegetation diversity in response to the late-Holocene climate change near Karwar, South-west Coast of India. Quaternary International 599–600: 95-106. https://doi.org/10.1016/j.quaint.2021.03.026 **(IF: 2.454).**
20. Srivastava J, Farooqui A, Thakur B & Seth P 2021. Palynomorph distribution in a mangrove ecosystem along environmental and salinity gradient: a tool for palaeoecological reconstruction. Wetlands Ecology and Management 29: 703–717. https://doi.org/10.1007/s11273-021-09803-x **(IF: 2.134).**
21. Srivastava J, Manoj MC, Manjunatha BR, Yoganandan V, Jose J, Balakrishna K, Naveen Kumar A & Ahmed A 2022. Delineation of terrestrial and marine productivity in the southwestern continental margin of India. Journal of Asian Earth Sciences 230: 105-203. https://doi.org/10.1016/j.jseaes.2022.105203 **(IF: 3.374).**
22. Kumar M, Saikia K, Agrawal S, Ghosh R, Ali SN, Arif M, Singh DS, Sharma A, Phartiyal B & Bajpai S 2022. Climatic control on the C3 and C4 plant abundance during the late Pleistocene–Holocene in the northern Gangetic Plain, India. Palaeogeography, Palaeoclimatology, Palaeoecology 591: 110890. doi.org/10.1016/j.palaeo.2022.110890 **(IF: 3.565).**
23. Roy I, Ranhotra PS, Shekhar M, Bhattacharyya A, Ghosh R & Sharma YK 2021. Modern Pollen-vegetation relationships along the vegetation gradient in the Bhagirathi Valley, Western Himalaya, India. Journal of Geological Society of India 97: 571-578. doi: 10.1007/s12594-021-1732-0 **(IF: 1.466).**
24. Dhyani R, Bhattacharyya A, Rawal RS, Joshi R, Shekhar M & Ranhotra PS 2022. Is tree ring chronology of blue pine (*Pinus wallichiana* A. B. Jackson) prospective for summer drought reconstruction in the Western Himalaya? Journal of Asian Earth Sciences 229: doi.org/10.1016/j.jseaes.2022.105142 **(IF: 3.374).**
25. Dhyani R, Joshi R, Ranhotra PS, Shekhar M & Bhattacharyya A 2022. Age dependent growth response of *Cedrus deodara* to climate change in temperate zone of Western Himalaya. Trees, Forests and People 8: doi.org/10.1016/j.tfp.2022.100221 **(IF: 2.39).**

Book Chapters/Memoirs/Bulletins

1. Md. Firoze Quamar 2021. Holocene vegetation and climate change from central India: An updated and a detailed pollen-based review. *In:* Kumaran KPN & Padmalal D (Editors) - Holocene Climate Change and Environment. London: Elsevier.
2. Phartiyal B, Debarati N & Joshi P 2021. Holocene climatic record of Ladakh, Trans-Himalaya. *In:* Kumaran KPN & Padmalal D (Editors) - Holocene Climate Change and Environment, Elsevier: 61-88.
3. Shekhar M, Ranhotra PS, Bhattacharyya A, Singh A, Dhyani R & Singh S 2022. Tree-ring-based hydrological records reconstructions of the Himalayan rivers: Challenges and Opportunities. *In:* Climate Change (pp. 47-72). Springer, Cham. https://doi.org/10.1007/978-3-030-92782-0_3.
4. Singh R, Kumar R, Latief SU & Shekhar M 2022. Recession of Gaglu Glacier, Chandra Basin, Western Indian Himalaya. *In:* Climate Change (pp. 103-123). Springer, Cham. https://doi.org/10.1007/978-3-030-92782-0_5.
5. Trivedi A 2021. Holocene vegetation, climate, and culture in Northeast India: a pollen data–based review. Holocene Climate Change and Environment, Springer, Book Chapter. 611-625.

SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

SP 8.1: Fluid-rock interaction at shallow subsurface level in the upper continental crust and its implications in altering the textural, mineralogical and geochemical characteristics of host rocks (Sponsored by MoES, Govt. of India (MoES/P.O.(Seismo)/1(374)/2019])

Investigators: Anupam Sharma (PI), Kamlesh Kumar (Co-PI 1), Matsyendra Kumar Shukla, BGRL (Co-PI 2) & Piyal Halder (JRF, MoES).

As a part of the International Continental Deep Drilling Program in the Koyna Seismogenic Region, core samples of basement granitoid have been analyzed to delineate the signatures of fluid-rock interaction and its role in triggered seismicity. Zones of alteration have been identified in the basement rock. Mineralogical analyses including XRD, SEM-EDS, and optical microscopic studies reflect precipitation of secondary calcite and the formation of several clay minerals such as Chlorite, illite, etc. as a consequence of fluid-rock interaction (Fig 8.1A & 8.1B). Damage zone mineralogy has been determined which may indicate the role of altered mineralogy on the geophysical anomalies found in the damage zones as proposed by Goswami *et. al.* (2019). Papers have been presented on the significant findings in one National and two International Conferences; one research article has been published in Acta Geologica Sinica.

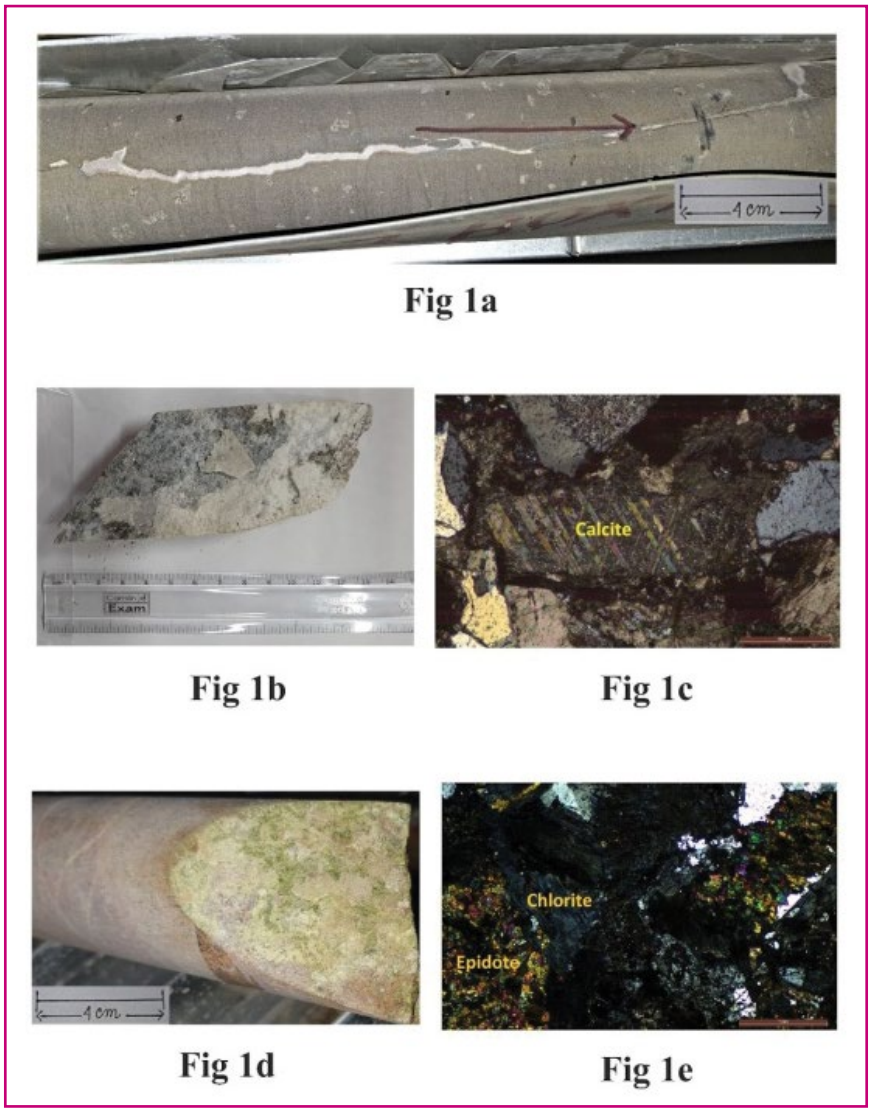


Fig. SP 8.1A - (1a). Mineralized Network of fracture; (1b). Mesoscopic evidence of incipient calcification at around 1153.78 m depth; (1c). Microscopic evidence of the presence of calcite at around 1073.75 m depth; (1d). Greenish tint of Secondary mineralisation at 1027.81 m depth; (1e). Microscopic evidence of occurrences of chlorite and epidote at 1027.81 m depth.

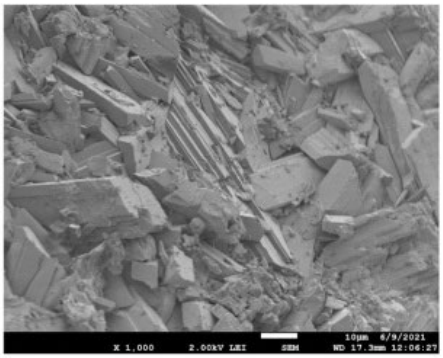


Fig 2a

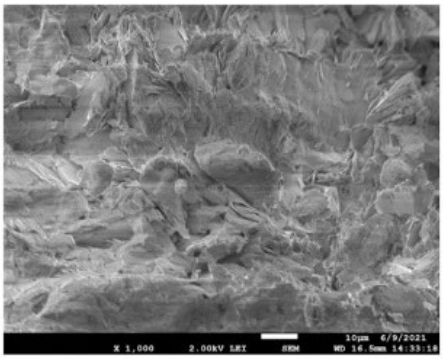


Fig 2b

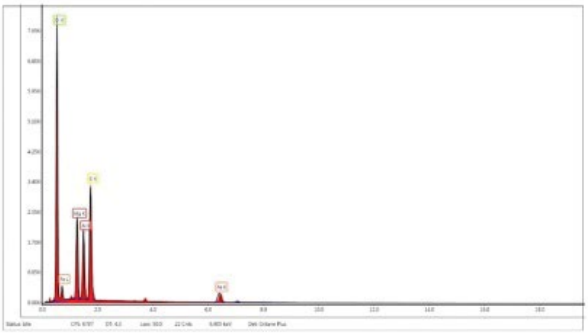


Fig 2c

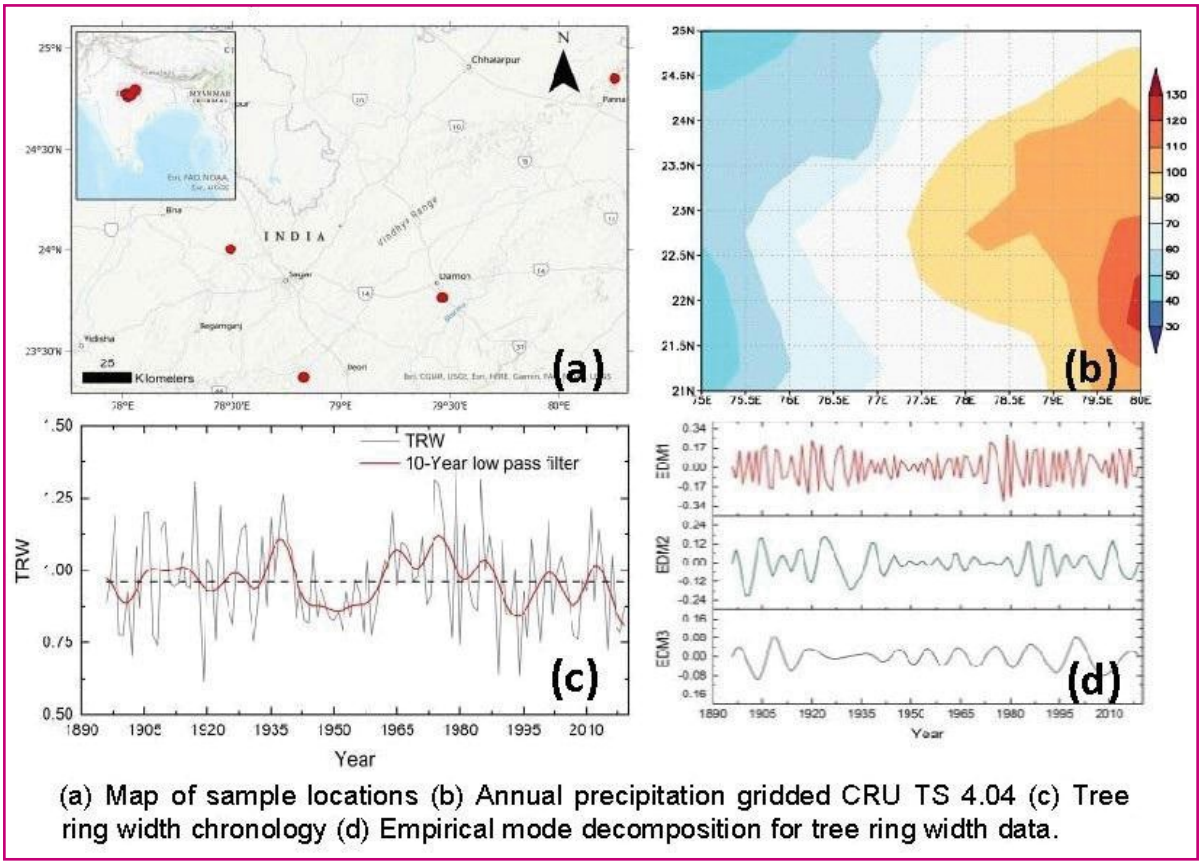
Fig SP 8.1B - (2a) FE-SEM image of calcite (Sample depth-1286.04 m); (2b). FE-SEM image of the greenish tint revealing the presence of Chlorite (Sample depth- 1073.75m); (2c). Corresponding EDAX graph of the same greenish part of the sample of 1073.75 m depth showing occurrences of Mg, Fe, Al along with Si and O.

SP 8.2: Reconstruction of long-term soil moisture evaporation in drought-prone Bundelkhand and Vidarbha regions using tree-ring cellulose isotope data (Sponsored by DST-SERB; SERB Project: ECR/2017/002228).

Investigator: Trina Bose (Scientist C)

For many decades, Bundelkhand and Vidarbha regions are taken as the type examples of agricultural drought, often under media focus for farmer suicides due to crop failure (Gupta *et al*., 2014; Dongre & Deshmukh, 2012). In looking for the cause behind the frequency of droughts in the subcontinent, we are hindered by the lack of long-term soil moisture data. Modelled soil moisture data (1948-2004) from the NOAA [Fan & van den Dool, 2004] is the only such data available but has no long-term validation. Plants primarily source water from the soil, hence its signatures are preserved in tree-ring cellulose isotopic values which can be used to reconstruct soil moisture evaporation [Bose *et al*., 2016]. Application of this method to cellulose isotope datasets of rural trees in Bundelkhand and Vidarbha would lead to reconstructions of long-term agricultural soil evaporation variability. Moreover, comparison with reconstructions from nearby forests should indicate the causes of these regions being repeatedly affected by agricultural droughts.

Tree ring samples were taken from teak trees (*Tectona grandis*) from forests and agricultural sites in four districts in these regions at the end of 2019. These districts were, Nagpur, Sagar, Damoh and Panna covering significant stretches of the Deccan Plateau. The tree ring widths were cross dated and a chronology developed using a standard dendrochronological technique. The timeline spans the years 1896 to 2019 C.E., (124 years). According to a preliminary study covering all districts, the most significant declines in growth happened between 1945- 1970, as well as between 1980 and 2019 CE (Fig. SP 8.2).



(a) Map of sample locations (b) Annual precipitation gridded CRU TS 4.04 (c) Tree ring width chronology (d) Empirical mode decomposition for tree ring width data.

Fig. SP 8.2 - (a) Map of sample locations (b) Annual precipitation gridded CRU TS 4.04 (c) Tree ring width chronology (d) Empirical mode decomposition for tree ring width data.

SP 8.3: Geomorphological evolution and climatic variations in the Hor La Basin, Ladakh Range (Sponsored by DST Kiran Division, New Delhi; Project No. SR/WOS-EA/22/2018).

Investigators: Priyanka Joshi (PI) & Binita Phartiyal (Mentor)

The Hor La (5340 masl) (La=pass), occurs on the eastern margin of the Ladakh Range and is regarded as one of the smallest basin with an area of < 300 km^2. The drainage is controlled by the Indus River and the drainage pattern is sub-dendritic to dendritic. At the Hor La pass the Mahe stream controls the drainage of the basin hence it is named as the Hor-Mahe Basin. The Yaya Tso Lake (6396 m^2), is a pristine glacial lake which is a part of the Hor La-Mahe Basin. The Hor La-Mahe records a palaeoclimatic history since the last ~11700 cal yr which continued till 220 cal yr BP. Cold and arid conditions prevailed in the region due to enhanced glaciations in the region which continued till 7820 cal yr BP. Wetter conditions began to exist in the Hor La after 7.8 ka and continued till 220 cal yr BP with some short spells of moderately cold and much colder periods that existed between 3320 till 1260 cal yr BP as per the different studied physical proxies. The longitudinal profile of the Hor La stream indicates a steep gradient as it originates from the source; the kick indicates a sharp lithological contact with the Indus mollasic sediments and the presence of ISZ. The recession of the glacier at Hor La started quite earlier due to its south-facing and steep slopes, including the higher elevations as well, the glacier started to abandon the valleys and lakes started to form. According to the presence of these lakes, the glacial recession is ~ 760 m (Fig. SP 8.3).

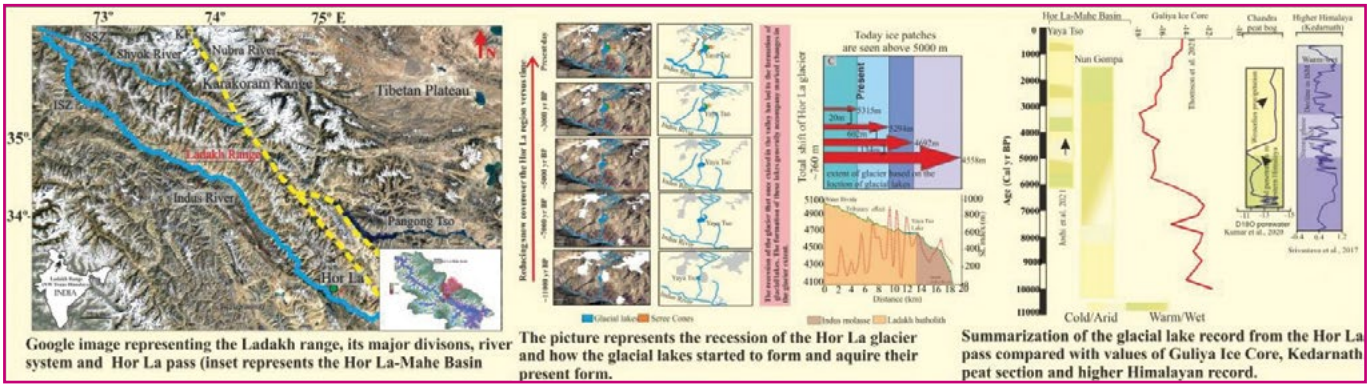
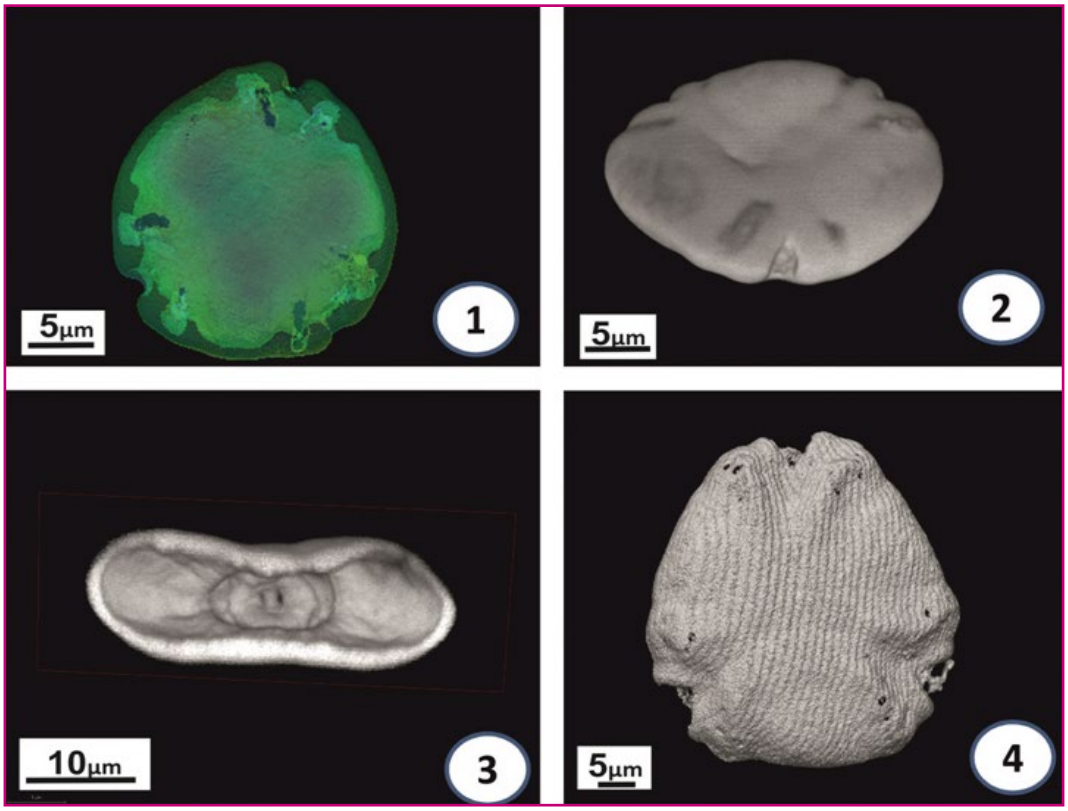


Fig. SP 8.3 – Google image representing the Ladakh Range, it's major divisions, river system and Hor La pass (inset represents the Hor La – Mahe Basin); The picture represents the recession of the Hor La Glacier and how the glacial lakes started to form and acquire their present form; Summarization of the glacier lake record from the Hor La pass compared with the values of the Guliya Ice Core, Kedarnath peat section and higher Himalayan record.

CP 8.1: Swati Tripathi, Anjum Farooqui, Arya Pandey [Arti Garg & A.K. Shukla, BSI, Allahabad].

Pollen micro-morphological studies of the two endangered species of *Rauvolfia* (*R. serpentina* (L.) Benth. ex Kurz and *R. tetraphylla* L.) were performed from the Indo-Gangetic Plain using a light microscope (LM), confocal laser scanning microscope (CLSM) (Pl. CP 8.1) and field emission scanning electron microscope (FESEM). Both the studied species are considered highly medicinal and are regularly used in pharmaceutical industries for drug preparation. Species over exploitation has resulted in their near extinction in the wild and the dwindling population of *R. serpentina* has already resulted in its listing in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This study provides a source of information for systematic and conservation purposes and provides a baseline to facilitate palynological studies of past vegetation and palaeoenvironments.



Pl. CP 8.1 - CLSM micrographs, 1. False colour composite showing the wall thickness of Rauvolfia tetraphylla, 2. Polar view of R. tetraphylla showing ectocolpi and obscure sexine pattern, 3. Cross section of pollen body showing the internal pattern of aperture in R. tetraphylla, 4. The distinct striations on surface of R. serpentina pollen.

CP 8.2: Ensemble modelling approach to predict the past and future climate suitability for two mangrove species along the coastal wetlands of India. [**Jyoti Srivastava** (& Singarasubramanian SR, Department of Earth Sciences, Annamalai University)]

We predicted the potential impact of past (Middle Holocene, ~6000 years), current and future (2050s, 2070s) environmental changes on the two dominant species in the coastal mangrove forest wetlands of India, i.e. *Rhizophora mucronata* (Asiatic mangrove) and *Avicennia officinalis* (Indian mangrove) through an ensemble species distribution modelling approach. Surface elevation was the most important variable (54-67%) for the distribution of both the mangrove species. Additionally, mean diurnal range (Bio2) and minimum temperature of the coldest month (Bio6) contributed to *R. mucronata* distribution whereas precipitation of the coldest quarter (Bio19) and maximum temperature of the warmest month (Bio5) impacted the distribution of *A. officinalis*. High precipitation and high sea-level stand during the middle Holocene led to the maximum range expansion of suitable habitats for the mangrove species which is also validated in the present study by the fossil pollen datasets. Total mangrove habitat in current and future climatic scenarios decreased by 2.6 and 8.5 kyrs. Representative Concentration Pathways (RCPs) for 2050 and 2070 indicate the vulnerability of the species to climate change impacts. Mangrove species are projected to shift their ranges in the future, experiencing a decrease in the amount of suitable coastal area available to them throughout the Indian coastline. Pichavaram, Muthupet, Coringa, Krishna mangroves as well as Konkan-Kerala Coast mangroves are forecasted to see severe decline with a complete loss of stable habitats. However, Sundarbans, Bhitarkanika and Mahanadi mangroves along with Chilika would be conserving both the mangrove species in a low-moderately suitable habitat along the East Coast of India. Our findings will assist in formulating species-specific restoration plans for mangroves in context of climate change in the Indian Subcontinent.

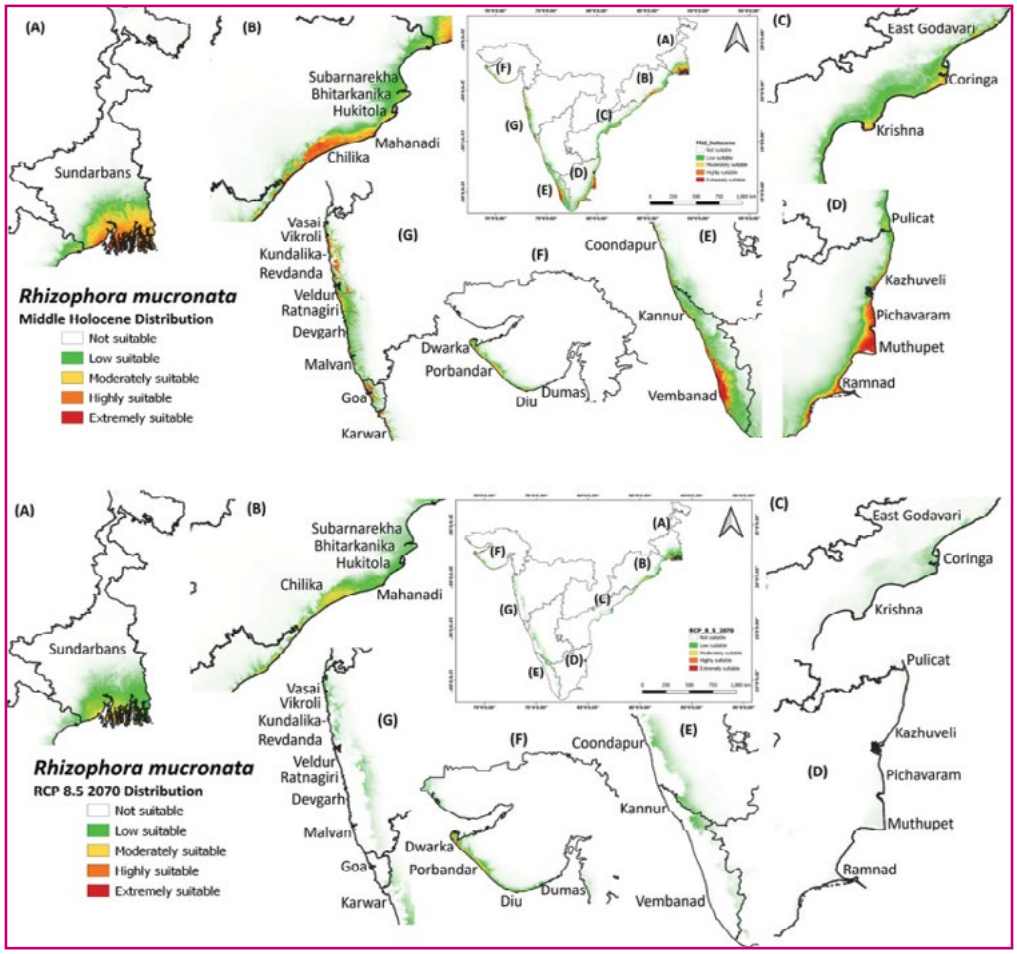


Fig. CP 8.2 - Middle Holocene and future (RCP 8.5 2070) potential distribution of Rhizophora mucronata along (A) Sundarbans, (B) Mahanadi Delta, (C) Godavari and Krishna Delta, (D) Cauvery Delta, (E) Kerala Coast, (F) Gujarat Coast and (G) Maharashtra Coast in India.

Other Academic Works

Anupam Sharma and Amritpal Singh Chaddha

The processes of oxide-hydroxide accumulation at varnish sites are due to iron and manganese oxidizing bacteria which may require clay minerals for additional nutrition. Quantification and identification of clay minerals in this biofilm is needed to understand its formation. Past attempts to analyse the mineralogical composition of rock varnish have led to inconclusive results as varnish is a submicron thin layer composed of a complex mineral matrix. The elimination of non-crystalline cementing groups composed of free iron oxides is a key step in the identification of many types of clay minerals, particularly in soil/sediment mineral studies.

Highlights:

- The Fe-Mn oxide-hydroxide coatings, acting as cementing materials, can be easily removed using a one-step reduction method employing $Na_2S_2O_4$ at 70°C, leading to separation of clay minerals (Fig. 9).
- Our modification helps in the unveiling of clay minerals from a solid substrate and reports the X-ray diffraction peaks, which are elsewise hard to detect and therefore earlier studies are inconclusive.

Jyoti Srivastava

Provided review reports on the following topics, submitted in the journal: *Palynology* for publication by different authors.

- "*Spider web*: *A natural sampler for analysis of airborne pollen-spore spectra from Santiniketan, West Bengal*", submitted to *Palynology* by Oraon *et al*., 2021.
- *Can colpus membrane ornamentation be a reliable taxonomic tool*? *A case study with some rubiaceous taxa from eastern Himalaya*" submitted to *Palynology* by Basak *et al*., 2021.

Prasanna K

- A revised clumped isotope calibration equation for otoliths was established based on the IUPAC parameter set.
- The new calibration equation is validated by quantifying the environmental water $\delta^{18}O$ of modern waters.
- New calibration equation allows for the reconstruction of lower Miocene coastal conditions in southwest India utilizing fossil otoliths (Fig. 10).

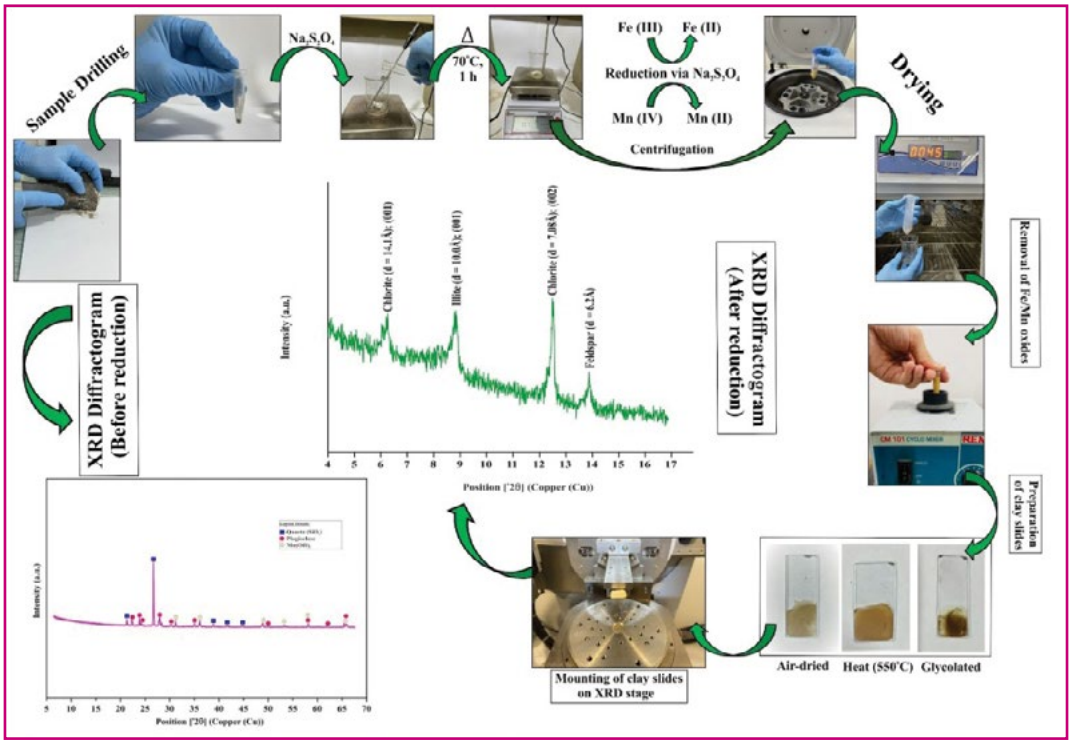


Fig. 9 - Stepwise demonstration of Fe-Mn oxide-hydroxide coatings removal following a one-step reduction method.

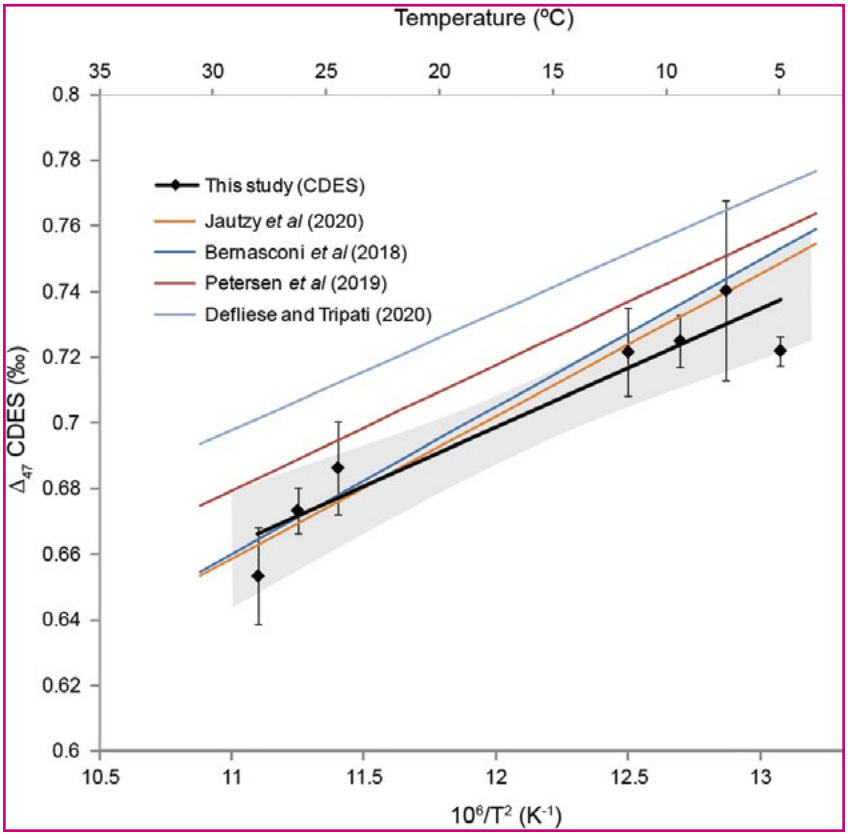


Fig. 10 - Relationship between estimated environmental temperatures at which sampled fishes lived and Δ47 values of CO2 produced by phosphoric acid digestion of fish otoliths (plotted as filled diamond). Two-tailed p-values are calculated using a t-test and the error bars for the offset Δ47 values indicate the 1σ S.E. Other Δ47-temperature equations derived using the IUPAC set of isotopic parameters are shown for comparison. Bernasconi et al. (2018) and Jautzy et al. (2020) at a carbonate reaction temperature of 70°C. Petersen et al. (2019) and Defliese et al. (2015) calibration was replicated and recalculated in Defliese & Tripati (2020), the carbonate reaction temperature was 25°C. The linear regression is calculated here using SigmaPlot (Systat Software, San Jose, CA).

Research Papers presented

1. **1st Indian Quaternary Congress (IQC 2022) organized by Association of Quaternary Researchers (AOQR), 19 – 21 January 2022 on virtual platform –**
   - **Binita Phartiyal, Debarati Nag, Randheer Singh & Priyanka Joshi** - Landscape evolution and climatic variability of Ladakh, NW Trans-Himalaya, India during the Late Quaternary.
   - **Jyoti Srivastava, Pujarini Samal & Pooja Nitin Saraf**. Ensemble modelling approach to predict the past and future climate suitability for two mangrove species along the coastal wetlands of India.
   - **Pooja Nitin Saraf**, **Jyoti Srivastava**, **Bipin Charles, François Munoz & Md. Firoze Quamar**. Using proxy data and vegetation modelling to predict past, current, and future distributional shift of *Butea monosperma*, a therapist for land degradation in India.
   - **Anjali Trivedi & Md. Ikram.** Vegetation, climate change and human impact in Central Ganga Plain during late Holocene Period.
   - **Mayank Shekhar, Trina Bose, Anurag Kumar & Avanish Mishra** - Tree-ring width data from four agricultural drought-prone districts of central India
   - **Trina Bose & Binita Phartiyal** - Hurdles and breakthroughs of integrated palaeoclimate reconstruction: a case study from western India.
2. **Piyal Halder, Anupam Sharma**, **Matsyendra Kumar Shukla & Kamlesh Kumar 2021.** Geochemical analysis of major elements and quantification of weathering in intrabasaltic Deccan red bole from southern Maharashtra. National Seminar on Recent Advances in Geoscience Research in India, University of Delhi, Delhi, 1-2 July, 2021. Abstract Volume pp. 24.

3. **Piyal Halder, Anupam Sharma, Kamlesh Kumar & Matsyendra Kumar Shukla 2021**. Mechanism of fluid rock interaction at shallow crustal level due to anthropogenic activity in Koyna Seismogenic region of Indian Subcontinent. Student Colloquium, Association of Quaternary Researchers, 2-3 July, 2021.
4. **Piyal Halder, Matsyendra Kumar Shukla, Anupam Sharma & Kamlesh Kumar 2021**. Mesoscopic observations of fluid-rock interaction at the pre-Deccan Basement rocks up to 1500 m depth in the Koyna Intraplate Seismogenic Zone of India. Abstract Volume of International Symposium on Geofluids, Hungary. 7-9 July, 2021. Abstract Volume pp. 25.
5. **Piyal Halder, Matsyendra Kumar Shukla, Kamlesh Kumar & Anupam Sharma 2021**. Mineralogical and geochemical evidence of fluid-rock interaction at the shallow crustal level in Koyna Seismogenic Region, Maharashtra, India: Impact and implications. International Symposium on Deep Earth Exploration and Practices (DEEP-2021), Nanjing, China; October 26-31, 2021.
6. **Sagar R, Kapur VV, Kumar K, Morthekai P, Sharma A, Chauhan G & Thakkar MG 2021**. Preliminary data on coprolites from the Neogene (Miocene: Aquitanian–Burdigalian) Khari Nadi and Chassra formations, Kutch Basin, western India. Online NECLIME International Conference "Neogene Climate Evolution in Asia", 7-9 September 2021. Abstract Volume pp. 43-44.

Training/Study Visits (Online/Off-line)

Binita Phartiyal

- ESEP-2021 (Earth and Space Exploration Programme, Ladakh) from 18 July to 3rd August 2021.
- Organizing Secretary of the AOQR-Palynological Training- a National virtual training program organized by AOQR in association with BSIP, from 22-24 February 2021.
- Organied - AOQR Student Colloquium-2021, from 1-2 July 2021.
- **लद्दाख का भूविज्ञान: अतीत और भविष्य की कड़ी** (Ladakh: A Link of Past and Future). Geology with Live History India Channel - [https://www.youtube.com/watch?v=GVCjxsWjvXs].

Lectures delivered

Anupam Sharma

- Geochemistry and its application in reference to Quaternary studies, GSI training, North Region, Lucknow, on 27th July 2021 (online mode).
- BSIP: The home to study Fossils and allied sciences, St. Mary's College (Autonomous), Thoothukudi, Tamil Nadu, on 04 December, 2021 (online mode).

Binita Phartiyal

- Women in field Science: Challenges, International Women's Day, Botany Department, Lucknow University, on 8 March 2021.
- Reimaging role of women in STEM: reference to Earth Science., Kalpana-SHE for STEM Foundation, Vigyanshala, Kalpana Foundation. On 9 May 2021.
- Geology and palaeoclimate of Ladakh-cold arid desert (Focus on geomorphology, sedimentology, neotectonics and climate), GSI training, Central Region, Nagpur, on 1st June 2021.

Firoz Quamar

Basics of pollen morphology and a case study on palaeoclimate from central Indian core monsoon zone (*CMZ*), GSI, Lucknow, India, on 29 November, 2021.

PH.D. PROGRAMMES

Amritpal Singh Chaddha (2019). Geochemical characterization of Rock/desert varnish and its application to electrochemical devices, under the supervision of **Anupam Sharma (BSIP, Lucknow)** and N K Singh (Lucknow University), registered with University of Lucknow. Status: in Progress.

Arvind Tewari (2020). Human-climate relationship in the Central Ganga Plain during the Late Quaternary: A multi-proxy approach. Under supervision of **Binita Phartiyal (BSIP, Lucknow)** and **Ruby Ghosh (BSIP, Lucknow),** registered with AcSIR, New Delhi. Status: in progress.

Harsh Kumar (2019). Role of human-environment interaction in tracing urbanization in different sectors of Ganga Plain. A geochemical approach, under the supervision of **Anupam Sharma (BSIP, Lucknow)**, registered with Academy of Scientific and Innovative Research. Status: in Progress.

Harshita Srivastava (2018). Mineralogical, geochemical and sedimentological aspects of Late Quaternary palaeolake deposits of Ladakh, NW, India, under the supervision of **Anupam Sharma (BSIP, Lucknow)** and U.K. Shukla (Banaras Hindu University), registered with Banaras Hindu University, Status: in progress.

Ishwar Chand Rahi (2019). Geochemical aspects of lignite bearing deposits of Bikaner and Barmer Basins of the western Rajasthan, India, under the supervision of **Anupam Sharma (BSIP, Lucknow)** and A S Naik (Banaras Hindu University), registered with Banaras Hindu University. Status: in Progress.

Md. Ikram (2022). Reconstruction of vegetation succession, climate change and human habitation imprints of lacustrine system in the Ganga Plain during Pleistocene-Holocene Period, under the supervision of **Anjali Trivedi and Shailesh Agarwal (BSIP, Lucknow)**, registered with AcSIR, New Delhi. Status: Ongoing.

Mohan Kumar (2018). Post global Last glacial maximum (gLGM) Indian Summer Monsoon rainfall (ISMR) reconstruction from the northern Ganga plain: forcing factors and implication to C_3-C_4 vegetation change, under the supervision of **Shailesh Agrawal (BSIP, Lucknow)** and DS Singh, (University of Lucknow), registered with University of Lucknow, Status: Ongoing.

Mukesh Yadav (2017). Secondary mineralization in Central Ganga Plain: implications to climate and earth surface processes, under the supervision of **Anupam Sharma (BSIP, Lucknow)** and U.K. Shukla (Banaras Hindu University), registered with Banaras Hindu University, Status: Ongoing.

Nagendra Prasad (2021). Reconstruction of Holocene vegetation dynamics and climate change from the core monsoon zone of India, under the supervision of **Md. Firoze Quamar (BSIP, Lucknow),** registered with Academy of Scientific and Innovative Research (AcSIR). Status: in progress.

Piyal Halder 2021. Mineralogical, geochemical and tectonic aspects of Fluid-rock interaction at shallow subsurface level in the Upper Continental Crust in Koyna Seismogenic Region, Maharashtra, India. Under the supervision of **Anupam Sharma** (Principal Supervisor, **BSIP, Lucknow**), **Kamlesh Kumar** (Co-Supervisor 1, **BSIP, Lucknow**) and Matsyendra Kumar Shukla **(**Co-Supervisor 2, Borehole Geophysics Research Laboratory, MoES), Academy of Scientific and Innovative Research, Ghaziabad, U.P. Status: Ongoing.

Pooja Saraf (2020). Reconstructing middle Holocene climate and vegetation biomes from fossil pollen data and species distribution modelling in Central Ganga Plain, under the supervision of **Jyoti Srivastava (BSIP, Lucknow)** and François Munoz (France), registered with AcSIR, New Delhi. Status: Ongoing.

Prashant Trivedi (2020). Trace element geochemistry of human bones its implication to lithology, dietary habits, geographical location and environmental condition, under the supervision of **Kamlesh Kumar** and **Niraj Rai (BSIP, Lucknow),** registered with Academy of Scientific and Innovative Research. Status: Ongoing.

Priyanka Joshi (2016). Geomorphological evolution and the climatic variations in the ChangLa-Tangste Basin, Ladakh Range, Trans Himalaya, under the supervision of **Binita Phartiyal (BSIP, Lucknow)** and M. Joshi (BHU), registered with Banaras Hindu University, Varanasi. Status: Ongoing.

Pujarini Samal (2018). Progradation of Mahanadi Delta along Southeast Coast of India, under the supervision of **Jyoti Srivastava (BSIP, Lucknow)** and SR Singarasubramanian (Annamali University), registered with Annamalai University, Tamilnadu. Status: Ongoing.

Randheer Singh (2013). Late Quaternary palaeoclimate and morphotectonic evolution of Tangtse Valley, Ladakh, under the supervision of **Binita Phartiyal (BSIP, Lucknow)** and B. Pandey (BHU), registered with Banaras Hindu University, Varanasi. Status: in progress

Shazi Farooqui (2014). Geochemical study of late Quaternary subsurface sediments of lower Mahi River, Gujarat, western India, under the supervision of **Anupam Sharma (BSIP, Lucknow)** and Munenedra Singh (Lucknow University), registered with Lucknow University, Status: Submitted.

Shirish Verma (2020). Sediment characterization and palaeoclimatic history of the Karewa deposits, J & K: a multi-proxy approach, under the supervision of **Binita Phartiyal (BSIP, Lucknow)** and Rakesh Chandra (Ladakh University), registered with AcSIR, New Delhi. Status: Ongoing

Supriya Kumari (2018). Palaeolimnology and geochemistry of Quaternary lake sediments deposits from Lucknow to Begusarai transect of Ganga Plain, under the supervision of **Kamlesh Kumar (BSIP, Lucknow)** and Dhruvsen Singh (Lucknow University), registered with University of Lucknow. Status: Ongoing.

Tarasha Chitkara (2015). Quaternary palaeoclimatic studies using multi-proxy approach around Kurukshetra, Haryana, India, under the supervision of **Anupam Sharma (BSIP, Lucknow)** and O.P. Thakur, (Kurukshetra University), registered with Kurukshetra University. Status: in progress.

Vijay Rathore (2020). Siwalik sediments: an archive to understand co-evolution of Himalayas and monsoon system using sedimentological and geochemical parameters, under the supervision of **Anupam Sharma (BSIP, Lucknow)** and U.K. Shukla (BHU), registered with Banaras Hindu University. Status: in Progress.

Accolades received:

Binita Phartiyal

- Expert Member in Women Scientist Scheme (WOS-A), Department of Science and Technology, New Delhi, 2021-2024.
- Secretary and Founder Member, Association of Quaternary Researchers (AOQR), Lucknow, 2019-2023.
- Listed in World Space Week#WomenInSTEM #WorldSpaceWeek2021, https://twitter.com/astrobiologyin/status/1446161965412327439/, twitter.com, 2021.
- Editor, Journal of Palaeosciences, www.jpsonline.co.in, 2021.
- Mentor and Field Expert, Earth and Space Exploration Programme -2021 (ESEP-2021), Ladakh, July-August 2021.
- Member Advisory Committee- Journal, Geosciences Research (JGSR) (Formerly Gondwana Geological Magazine, https://www.gondwanags.org.in/editorial-team/, 2021.

Representation in Committees/Board:

Anupam Sharma

- Nominated by Geological Survey of India, Lucknow as a Member of the Expert Committee for Sophisticated Analytical Instrument Facility

Ruby Gosh

- Assessment Committee Member for the Assessment of Lab Attendant (2) in CSIR-Central Drug Research Institute, Lucknow on 26.11.21

Jyoti Srivastava

- Member, Conservation Paleobiology Network
- Member, Association of Quaternary Researchers (AOQR)
- Member, Editorial Board, Quaternary Chronicle (under Association of Quaternary Researchers (AOQR)) (Continuing)

Trina Bose

- Member, Association of Quaternary Researchers (AOQR)
- Member, Editorial Board, Quaternary Chronicle (under Association of Quaternary Researchers (AOQR)) (Continuing)

FACILITIES

SCANNING ELECTRON MICROSCOPE

The scanning electron microscopy unit (SEM unit) of the institute is dedicated for providing support for study morphological features and elemental analysis of variety of samples of various disciplines of researches.

The unit is equipped with Field Emission Electron Microscope (FESEM - JEOL 7610F), JEOL Auto fine Sputter Coater, JEOL Carbon Coater and EDAX make peltier cooled EDS spectroscopy detector is attached with FESEM for elemental analysis of the samples. Around 21 scientists of the Institute of different disciplines were investigated their variety of samples for morphological features and elemental analysis using FESEM. The Institute also provides consultancy services to researchers of various universities, academic institutions of India.

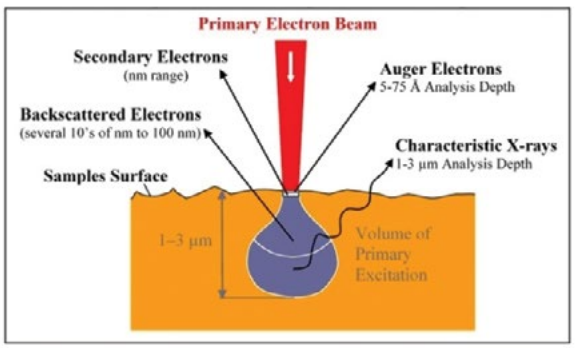
- University of Lucknow, Lucknow (nano materials, powder, sediments)
- Babu Banarasi Das College of Dental Sciences, Lucknow (tooth material)
- University of Allahabad, Prayagraj, UP (powder sample)
- National Research Laboratory for Conservation of Cultural Property, Lucknow (plaster, leaf, metals)
- ICAR-Central Institute for Subtropical Horticulture, Kakori, Lucknow (root samples)
- TERI school of advanced studies, New Delhi (lichen samples)
- BBAU University, Lucknow (powder samples)
- Saraswati Dental College, Lucknow (dental material)
- Shri Shivaji Art, Commerce and Science College, Akola, Maharastra (flower)
- CSIR-NBRI, Lucknow (leaf samples)
- Guru Ghasidas Vishwavidyalaya, Bilaspur, Chhattisgarh (leaf sample)
- P. P. N. College, Mahatma Gandhi Marg, Kanpur (powder sample)

Total consultancy money received around Rs. 225616/= (Two lacs twenty five thousand six hundred sixteen).

CONFOCAL LASER SCANNING MICROSCOPE AND RAMAN SPECTROSCOPY LAB

Raman Spectroscopy facility of the BSIP is extensively used by the scientists of the Institute in determination of organic nature of the crucial and extremely old fossilized material. Confocal Laser Scanning Microscope has proven its importance in generating the 3-D images of fossil material from otherwise 2-D specimens. Three dimensional reconstructions bring out crucial details of the microfossils that are useful in determination of form and functions of the different fossilized organisms. Besides internal usage, the CLSM and Raman Spectroscopic facility is used by other academic institutions. It also helps in generating consultancy funds for the Institute.

Field Emission Scanning Electron Microscope Laboratory

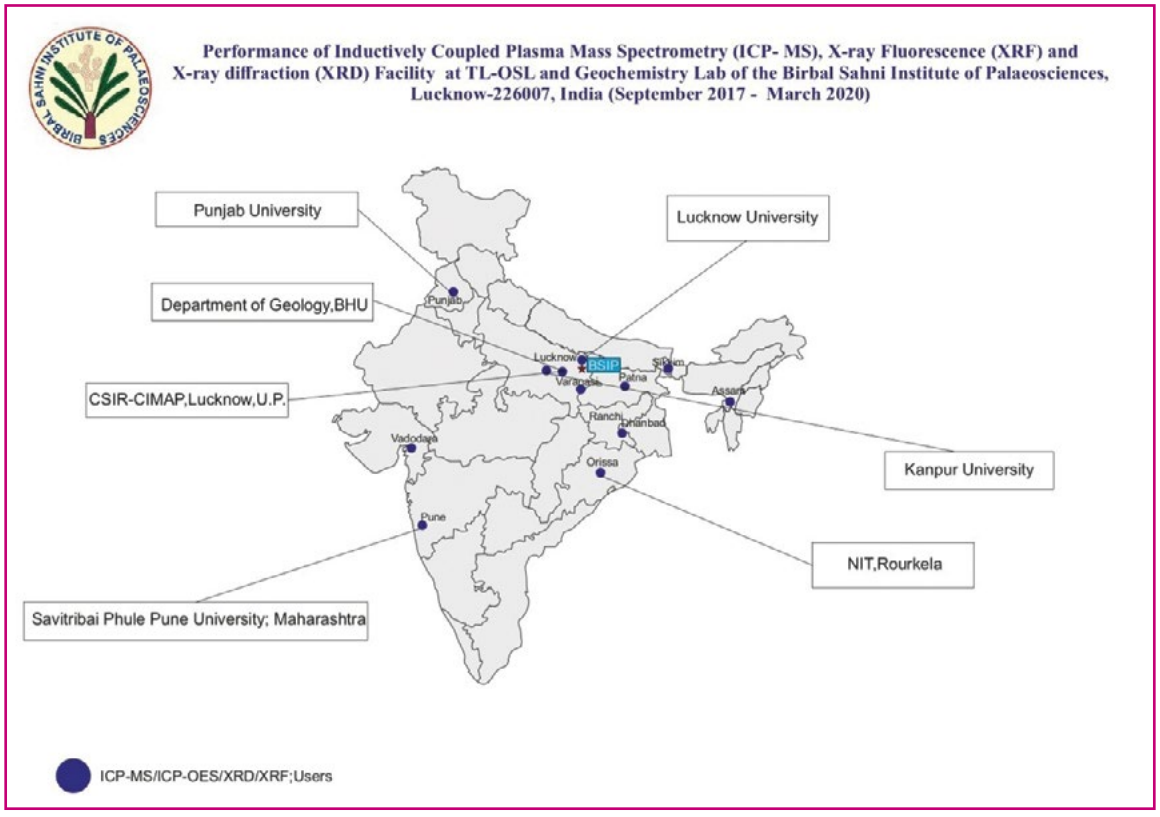


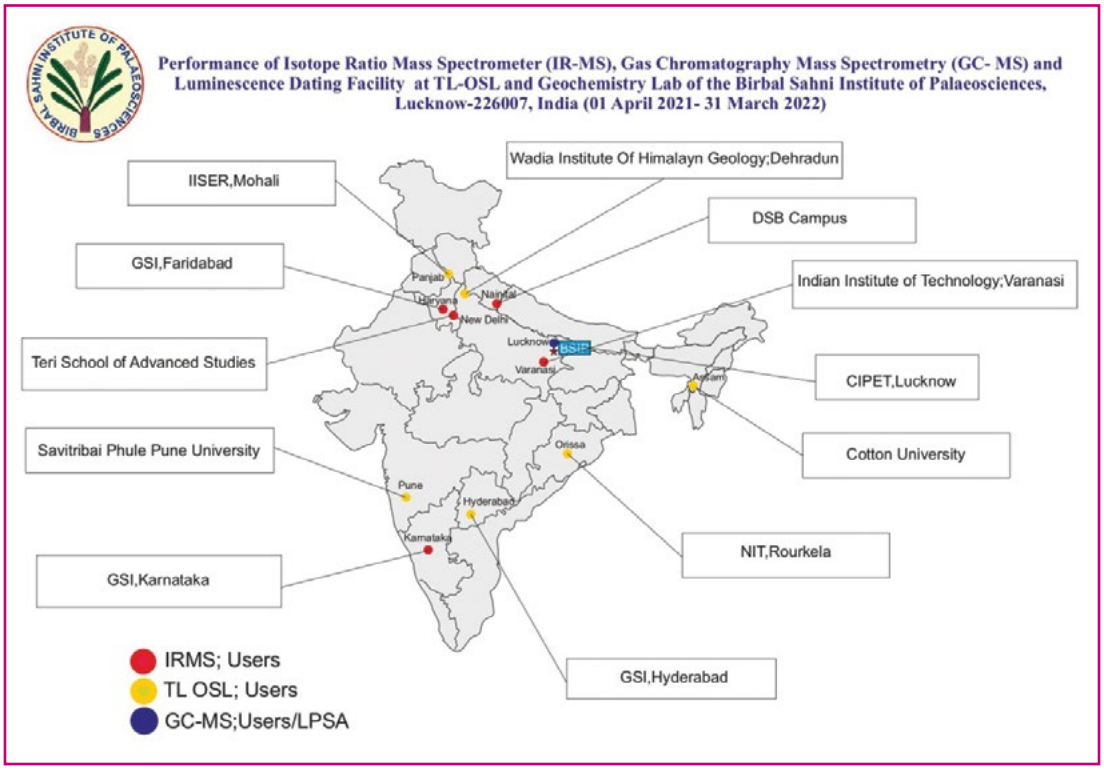
Application: structural and morphological analysis of variety of samples such as Powder, Thin film, Powder pallet, Biological, Geological, Fossils, Nanomaterials, Polymers, Ceramics, Metals, Dental materials, Pharmaceuticals etc

SOPHISTICATED ANALYTICAL FACILITY

The Geochemical and TL/OSL laboratory is equipped with Inductively Coupled Plasma Mass Spectrometer (ICP-MS), Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES), X-ray Diffraction (XRD), X-ray Fluorescence Spectrometer (XRF), Gas Chromatography Mass Spectrometer (GC-MS), Isotope Ratio Mass Spectrometer (IRMS), Nutrient Analyzer (NA), Laser Particle Size Analyzer (LPSA), Thermal Luminescence and Optically Stimulated Luminescence (TL and OSL) Riso Dose Reader and High Performance Germanium Gamma Reader (HPGe). All, these sophisticated state of the art equipments were installed couple of years back. The facility is generating quality data and not only supporting the Institute scientists but also providing consultancy services to the academia and industry. The facility has opened new field of researches and helped Institute to enhance its research output both qualitatively as well as quantitatively. Using the XRD instrument, we have developed a new methodology for identifying clay minerals from solid substrates, and the same is published in the International SCI journal "Methods" by Chaddha *et al.*, 2021.

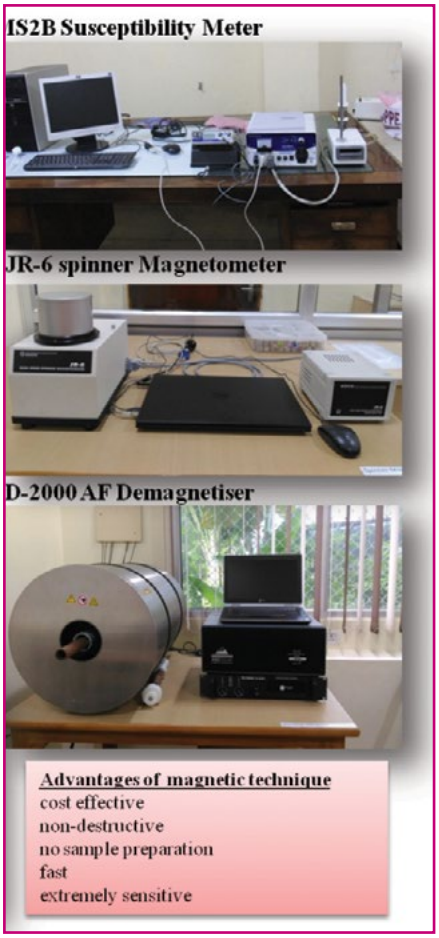
Recently, the facility is enlarged by adding two more IRMS machines, wherein one is dedicated to Biomolecule Isotope studies and the other one for the Clumped Isotopic studies.





PALAEOMAGNETISM LABORATORY, BSIP

The Palaeomagnetism Laboratory of the Institute was established during the year 2016 had been running smoothly throughout 2021. This is a national facility and presently hosts a range of magnetic instruments vizza the Bartington Susceptibility Meter MS2B, JR-6 Spinner Magnetometer (AGICO), Pulse Magnetizer (ASC Scientific), D-2000 AF Demagnetiser (ASC Scientific), TD-48 Thermal Specimen Demagnetiser (ASC Scientific), MFK2-FA Kappabridge alongwith the Bartington Susceptibility Sensors and Pomeroy Rock drill, Dual Blade Rock Saw, Laboratory Lapidary Core Drill etc., for fully characterization of samples for magnetic study purposes. With the addition of new instruments the scope of the PalMag facility becomes multidimensional and during the last few years the laboratory has attracted researchers across the country. During the year 2021-22, a total of 2666 samples were analyzed by 22 different researchers for various aspects. Consultancy services to industries, universities and other stakeholders and helps in resource generation are also given. This Lab also helps Masters and Graduate students for their summer training and dissertation courses.



RADIOCHRONOLOGY AND ISOTOPIC CHARACTERIZATION LABORATORY

The upgraded Radiocarbon dating and Isotope characterization Laboratory of BSIP has two components (a) Conventional Radiometric Radiocarbon dating facility using an offline glass vacuum benzene preparation system, an Elemental Analyzer (EA, EA1112-Thermo®) and an ultra-low-level Liquid Scintillation Counter (Quantulus; Wallac 1220®) and (b) the newly established EA-IRMS-CHS-AGE system. In conventional C-14 dating method, EA is used for pre-quantification and helping the selection suitability of sample's dateable carbon for the benzene preparation. Samples for C-14 dating are received via both ways i.e. through institutional and collaborative scientists via institutional and sponsored projects. The facility also receives external samples for dating from external agencies on payment basis. The method requires relatively large amounts of samples to convert dateable carbon into 1-3 ml of benzene. This needs a thorough checking of sample's goodness its pre-processing (removing any exterior contaminant carbon that can alter required C-14 date of sample). Conventional radiometric C-14 dating is a labour-intensive & time-consuming but a relatively cheaper method (compared to AMS C-14 dating). Benzene preparation involves combustion (or hydrolysis) of the pre-treated organic (inorganic) samples followed by trimerization using appropriate catalysts at different stages. Extracted benzene is cooled off about a week time before taking to counter to settle down shorter liver radioisotopes. 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. Majorly organic-rich sediments, carbonates, wood-charcoal pieces, and peat layers are routinely dated using the shown facility in Fig 1. International reference standard Oxalic Acid II (OX-II) and dry pre-heated Anthracite powder are used as reference standard and blank respectively. (b) The Radiocarbon lab has been up-graded with installation and establishment of an automated graphitization unit (AGE, IONPLUS®) coupled with sample preparatory systems such as dedicated EA (Elementar®), Carbonate Handling System (CHS; IONPLUS®) and an in-line Isotope Ratio Mass-Spectrometer (IRMS) for measuring stable carbon and nitrogen isotopes ($d^{13}C$, $d^{15}N$) for making graphite powder for measuring 14C activity by AMS (Fig 2). AMS 14C measurements require only ~1 mg of solid graphite carbon as an analyte, hence, opened possibility of dating samples which have smaller amounts of carbon. The entire graphite preparation and stable isotopic measurements were thoroughly checked using number of IAEA (International Atomic Energy Agency) supplied reference standards. The new setup is being used for both AMS C-14 sample preparation unit as well as independent EA-IRMS facility of BSIP. Using this new setup, several newer type of samples were dated such as horse and human teeth-enamel, collagen extracted from human burials, wood-cellulose, and charred agricultural grains. This set up thus has enhanced the range of samples that can be dated.

In this year, we have analyzed stable isotopic ratios ($d^{13}C$, $d^{15}N$ and $d^{34}S$) of ~800 samples form terrestrial organic/ marine sediment/ Archaeological samples from In-house projects and several Government Institutes/ Private Industries. We have prepared ~85 graphite of In-house projects and other Government/Private institutes and Industries; Using Conventional Radiocarbon dating method we have dated 42 samples (including standards and blanks).

We have earned consultancy of amount 7,78,680/- INR for the year 2021-2022. Major government clients are from the GSI-Bhubaneswar, GSI-Bhopal, GSI-Bangalore, ICAR-Bhopal, ISR-Gujarat, IIT-Bombay, IIT-Roorkee, Bihar Heritage Development Society. Private Industry's clients are from Airocel technologies Ghaziabad, Pidilite Industries limited Mumbai.

VERTEBRATE PALAEONTOLOGY AND PREPARATION LABORATORY

The "Vertebrate Palaeontology and Preparation Laboratory" (VPPL) of the Institute was established in the year 2018 and has been functioning smoothly with an aim to prepare and study fossil vertebrates, associated micro-fauna, and ichnofossils (e.g., coprolites). The facility is equipped with an electrically powered air-compressor (100% oil-free) unit (with pressure regulators) that help operate the pneumatic air-scribes and a dual tank sand blaster unit. Both the pneumatic air-scribes and the sand blaster unit assist in the preparation of fossil remains. The laboratory is also equipped with an ultrasonic cleaner that is utilized to clean micro-fossils (e.g., dental remains) and a stereoscopic microscope to assist in retrieval of micro-fossils from host matrix. The laboratory is also equipped (in terms of hardware and software) to measure (both manually & digitally), photo-document, and study (both morphometrically and phylogenetically) vertebrate fossils. In addition, the VPPL facility is equipped with an automatic slide scanner for live microscopic study and digitally archive thin sections of fossils and associated ichnofauna. In consideration of health and safety regulations, preparation works are carried out under custom-made dust collector safety box apart from utilization of international standard ear, eye and dust protection.

DENDROCHRONOLOGY

Dendrochronology is the science that deals with the dating and study of the annual growth increments, or tree rings, in woody trees and shrubs.

At BSIP, we are using methods of Dendrochronology in both conifers and broad leaved taxa towards reconstruction of spatio-temporal climate beyond the existing instrumental meteorological data.

In addition, we are also using the technique of Dendrochronology to study glacial fluctuation, tree-line dynamics, fire-scar dating, forest ecology.

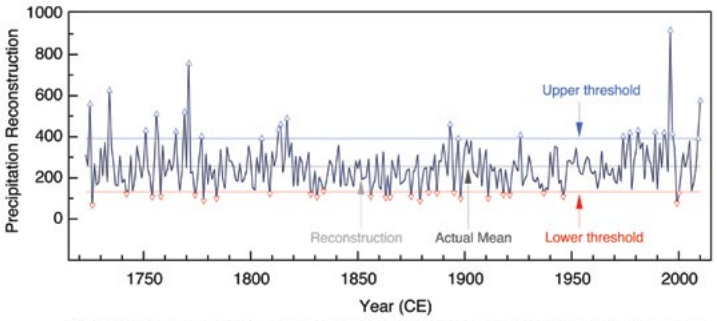
Sensitive sampling site

Sample collection

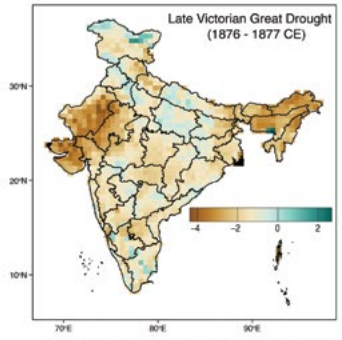
Increment borer with tree core

Sample processing

Sample analysis



Climate (Precipitation) reconstruction showing drought and pluvial



Spatial drought reconstruction

UNITS

Computer Section
Museum
Knowledge Resource Center
Publication

Computer Section

The existing Institutional Domain, i.e. bsip.res.in is working for E-Mail accounts of BSIP staff, units/ sections, and research scholars. All the circular/notices related to the institute are circulated to everyone by same institutional E-mail account. The same e-mail database is now being utilized by the Knowledge Resource Center (KRC) and RDCC of the Institute. The official Facebook and Twitter accounts of the institute have been created and important information with photographs are regularly updated. Video Conferencing System has been installed in the Committee Room for online interview via video conferencing through G-meet, Microsoft team whenever required. The Video Conferencing System facility of the institute is also utilized for various national and international training, workshops and online conferences/ meetings supported by BSIP.

The Computer Section is responsible for maintaining NKN (National Knowledge Network) and internet

connectivity within the institute to provide 24 hours high speed internet facility to all the Institute's employee and research scholars. All the computer systems (number = ~160) are protected from viruses and worms by Anti Virus Program Quick Heal Endpoint Security 6.0 Business edition. The institute is fully covered with Wi-Fi and staff members are using Wi-Fi connectivity on their mobile also. The employee WhatsApp group was also created to circulate official information through admin in addition to the E-mail service. This mobile database and information were also created and maintained by the computer section. Several Wi-fi connectivity points or routers were installed in the newly established laboratories, student facilities and relocated administrative sections in new allotted spaces.

File Tracking System (FTS) has also been successfully implemented. Status of concerning files can be traced to any staff and sections through FTS.

The Institute website is redesigned as per GIGW norms. The Computer Section 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 utility forms are converted into bilingual (Hindi and English) and uploaded in both PDF and Word format.

In addition, web-based payroll and pension packages were also developed. Through which all the employees are receiving their respective pay slips via e-mail. Payroll, Pension packages are also modified as per the requirements of the Account Section. The Computer Section is providing help to the scientists in preparing the multimedia presentations, charts, graphs, litho-log and diagrams for their scientific publications and documentation. Additional support was regularly provided by the computer section for offline lecture series, presentations, and institutional functions in the main auditorium facility.

Museum

Museum of the BSIP plays a vital role to popularize and disseminate the palaeontological knowledge amongst the students and researchers within the country and abroad.

During this period, the exhibits from the Museum were displayed in IISF (India International Science Festival) 2021 which was held at Panaji, Goa, and University of Lucknow. Museum visits were made by students from different schools and colleges of Lucknow on National Science Day. Online glimpses of the Museum were given to students of Madhya Pradesh during Vigyan Manthan Yatra. In addition, some personal visits were also made by the guests/visitors visiting the institute.

Research materials (megafossils and palynological samples) were collected from 140 localities spreading in different parts of the country by the scientists working in Institute's projects as well as on various sponsored projects. Type materials of 24 research papers were also submitted in the Repository during this period.

Museum is continuously striving for outreach activities to disseminate knowledge to students and general public about palaeobotany and research work being carried out at institute, through videos, posters, pamphlet, etc.

Museum Holdings:

Particulars	Addition during 2021-22	Total
Type and Figured Specimens	114	9,584
Type and Figured Slides	256	16,286

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

Projects	Megafossil Specimens	Palynological Samples
Project 1	----------	129
Project 2	----------	231
Project 3	----------	148
Project 4	----------	-----
Project 5	----------	482
Project 6	----------	54
Project 7	----------	62
Project 8	----------	136

Samples deposited in the Repository under Sponsored/ Collaborative Projects:

1. Sponsored Project INT/ RVS/RFBR/P-278 — 274- Samples
2. Sponsored Project SERB N0. EMR/2017/004795- — 740- Samples
3. EMR/2016/006042 — 141- Samples- 16-Specimens
4. AcSIR Ph.D. Work — 1075- Samples
5. Sponsored Project SB/ WEA-06/2019, SERB — 41-Samples
6. Sponsored Project/DST Inspire Faculty Project/ IFA-17EA 562 — 46- Samples
7. ONGC Sponsored Project No. 211.BNGDB.GJ02 — 458- Samples

Institutional Visitors:

1. Shiv Harsh Kisan Post Graduate College, Basti, U.P.
2. Parmanand Ashram, Jhusi, Prayagraj, U.P.
3. Department of Geology, Lucknow University students visited on the occasion of National Science Day.

Knowledge Resource Center

The Knowledge Resource Centre (KRC) is committed in providing the best information services and support to its users and fulfilling its mission to disseminate knowledge.

The current holdings of the library are as under:

Particulars	Additions during 2021-22	Total
Books in English	12	6,409
Journals (bound volumes)	130	17,914
Reprints	-	40,179
Reference Books	-	356
Books in Hindi	36	862
Ph.D. Thesis	22	148
Reports	-	46
Maps & Atlas	-	61
Microfilm/ Fisches	-	294
Compact Disk	-	74

Currently the library is receiving 150 journals (46 through subscription, 54 through NKRC and 50 through exchange). There are 190 registered card holders using the library facilities.

Many other Institutions/ Organizations availed the Library facilities.

In addition, online access of e-journals and databases (viz. Scopus, Web of Science) is available over the Institute's LAN. KRC also provides plagiarism check of manuscripts through iThenticate software, reprography, lamination, weekly current awareness and daily local newspapers for reading.

Publication

Journal

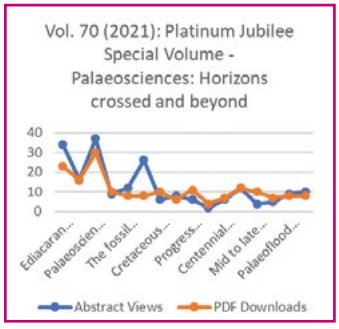
The journal '*The Palaeobotanist*' Volume 69 comprising of 7 research articles and 1 general article was published in 2021.

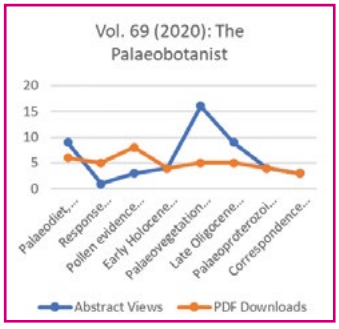
The in-house journal of the Birbal Sahni Institute of Palaeosciences, Lucknow, India and since its inception in the year 1952 many thematic issues, proceeding volumes and important contributions have been published. Over the past two decades, the advancement on the techniques used in Palaeosciences, proxies, software for climate and fossil studies have immensely increased and hence the journal was renamed to the '*Journal of Palaeosciences*' (JPS) in 2021.

The Journal of Palaeosciences is an open-access journal, publishing research papers on palaeoenvironmental, palaeoecological, palaeoclimatic and palaeogeographical

themes, distributed over each of the entire geological time scales right from the Precambrian to the Quaternary (i.e. Recent). The Platinum Jubilee Special Volume 70, entitled **Palaeosciences: Horizons crossed and beyond**, includes 16 invited papers. In order to keep up with the rapid advancement of technology, the Journal of Palaeosciences has switched to an online platform. The journal's website is jpsonline.co.in

Analysis of the journal's accessibility is possible since it is available online and viewed by broader readership. These graphs show the number of times an individual paper has been downloaded or its abstract has been viewed.





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 during the period of 1st April 2020 to 31st March 2021. Besides, conference participation, awards, research papers published/ accepted, training/deputation, Foundation/Founder's Day celebration, reports of different units, annual accounts and related aspects with relevant graphics and photographs were included.

Miscellaneous

Invitation cards for Foundation Day, Founder's Day, Conference and other programmes organised from time to time were printed. Biographical profiles and abstracts of lectures given by eminent speakers on various functions were printed. Correspondence work of the journal was also handled.

Status of Official Language

The Institute continues to pursue the set goals for Official Language implementation. The Institute participated in the meetings of Nagar Rajbhasha Kaaryaanvayan Samiti (Karyaalaya-3) during the year 2021. Scientists and Technical Officers/Employees of the Institute remained active and disseminated science and other outreach activities in Hindi Language through various media platforms.

Hindi Fortnight:

Hindi Fortnight was celebrated during 01-14 September, 2021 in the Institute.

During the fortnight, various competitions namely Hindi Typing (Computer), E-Poster making, Noting, Debate, Essay Writing and Kavi Sammelan were organized, in which staff members participated enthusiastically.

Hindi Workshop/Lectures:

Undermentioned Hindi Workshops and popular lecturers in Hindi (on-line) were organized. The workshops and lectures were followed by lively discussions related to the topics of talks and related terminology.

1. Lecture on "Madhya Bharat ke Upari Ganga kshetra mein Ramsar nam-bhoomi" (Upper Ganga and Ramsar wetlands of Central India) by Dr Aarti Garg on 25.6.2021
2. Workshop on "How to type in Hindi on Computer": by Mr. Y.P. Singh on 18.8.2021
3. Lecture on "Raashtreey Shikshaa Neeti" (New Education Policy) by Prof. Rakesh Chandra, University of Luknow, on 02.9.2021
4. Lecture on "Hamari Bhu-Viraasat" (Our Geoheritage) by Prof. Mukund Sharma on 14.9.2021
5. "Insect and Plant fossils in Early Cretaceous and their relation with Vegetation" by Dr Neelam Das on 21.12.2021
6. A symposium was organized in connection with Aazaadi ka amrit mahotsav –on the occasion of National Girls' Child Day "Vijnan ke kshetra mein career banana hetu Baalikaon ko margdarshan evm protsahan" (Mentoring girl child for career in Science) on 24.01.2022.
7. Lecture on account of International Mother Tongue Day on the topic "Vijnaan ke lok-prasaar men bhashaein" : by Dr Ravi Mishra, National Centre for Polar and Oceanic Research, Goa on 21.02.2022

Miscellaneous:

The computers of the Institute with net facility have access to multi-lingual software. Annual Report of the Institute was published in Hindi also. In addition various posters and outreach activities were done in Hindi to disseminate the knowledge for general public and same are uploaded on the 'Rajbhasha Patal' of Institute's website. Research students of the Institute are also advised to submit their summary of the Ph.D. thesis in Hindi. The task of publishing an In-house Hindi magazine is also being done and first issue of the same will come in September 2022.

Staff

BSIP Personnel

DIRECTOR

Dr (Mrs) Vandana Prasad

SCIENTIST 'G'

Dr Mukund Sharma

SCIENTIST 'F'

1. Dr Rajesh Agnihotri
2. Dr (Mrs) Anjum Farooqui
3. Dr Amit K. Ghosh (retired w.e.f. 28.02.2022)
4. Dr Anupam Sharma

SCIENTIST 'E'

1. Dr Sadhan Kumar Basumatary
2. Dr Pawan Govil
3. Dr Ratan Kar
4. Dr Krishna Gopal Misra (w.e.f. 01.01.2022)
5. Dr Srikanta Murthy
6. Dr (Mrs) Binita Phartiyal
7. Dr S. Suresh Kumar Pillai (w.e.f. 01.07.2021)
8. Dr Anil Kumar Pokharia
9. Dr (Mrs) K. Pauline Sabina (w.e.f. 01.07.2021)
10. Dr (Mrs) Anju Saxena (w.e.f. 01.07.2021)
11. Dr Santosh Kumar Shah
12. Dr Hukam Singh
13. Sri Veeru Kant Singh
14. Dr Biswajeet Thakur

SCIENTIST 'D'

1. Dr (Mrs) Abha
2. Dr (Mrs) Neha Agarwal
3. Dr Shailesh Agarwal
4. Dr (Mrs) Deepa Agnihotri
5. Dr Sheikh Nawaz Ali
6. Dr Arif Hussain Ansari (w.e.f. 01.01.2022)
7. Dr (Ms) Ruby Ghosh
8. Dr Vivesh Vir Kapur
9. Dr Kamlesh Kumar
10. Dr Manoj M.C. (w.e.f. 01.01.2022)
11. Dr Abhijit Mazumder
12. Dr P. Morthekai (w.e.f. 01.07.2021)
13. Dr (Mrs) Neelam
14. Dr (Mrs) Shilpa Pandey
15. Dr Santosh Kumar Pandey (w.e.f. 01.01.2022)
16. Dr Mohd. Firoze Quamar
17. Dr (Mrs) Anumeha Shukla
18. Dr Niraj Rai (w.e.f. 01.07.2021)
19. Dr Parminder Singh Ranhotra
20. Dr Sunil Kumar Shukla (w.e.f. 01.01.2022)
21. Dr (Ms) Vartika Singh
22. Dr Gaurav Srivastava
23. Dr (Mrs) Jyoti Srivastava
24. Dr (Mrs) Swati Tripathi
25. Dr (Mrs) Anjali Trivedi
26. Dr (Mrs) Poonam Verma

SCIENTIST 'C'

1. Dr Sajid Ali (w.e.f. 01.07.2021)
2. Dr Mohammad Arif
3. Dr (Ms) Ansuya Bhandari
4. Dr (Mrs) Trina Bose (w.e.f. 01.01.2022)
5. Dr Gurumurthy G.P. (w.e.f. 01.07.2021)
6. Dr Niteshkumar Narendra Khonde
7. Dr Prasanna K
8. Dr Runcie Paul Mathews
9. Dr (Mrs) Yogmaya Shukla
10. Dr Arvind Kumar Singh

SCIENTIST 'B'

1. Dr (Ms) Adrita Choudhuri (w.e.f. 23.06.2021)
2. Sri Sanjay Kumar Singh Gahlaud (w.e.f. 21.06.2021)
3. Dr Anurag Kumar (w.e.f. 22.06.2021)
4. Sri Sabyasachi Mandal (w.e.f. 23.06.2021)
5. Dr Divya Kumari Mishra (w.e.f. 21.06.2021)
6. Dr (Mrs) Shreya Mishra (w.e.f. 21.06.2021)
7. Dr Ranveer Singh Negi (w.e.f. 20.07.2021)

(The names are in alphabetical order according to "surnames")

8. Dr Suman Sarkar (w.e.f. 23.09.2021)(FN)
9. Dr Mayank Shekhar (w.e.f. 28.10.2021)(FN)
10. Dr Prem Raj Uddandam (w.e.f. 28.06.2021)

TECHNICAL OFFICER 'D'

1. Sri Madhukar Arvind
2. Sri Pavan Singh Katiyar
3. Dr Subodh Kumar
4. Sri Rattan Lal Mehra
5. Sri V.K. Nigam
6. Sri Vinod Kumar Singh (retired w.e.f. 31.01.2022)
7. Sri Yogendra Pratap Singh

TECHNICAL OFFICER 'B'

1. Dr Syed Rashid Ali
2. Sri Digamber Singh Bisht
3. Sri Dhirendra Kumar Pal
4. Sri Dhirendra Sharma
5. Dr Sanjai Kumar Singh

TECHNICAL OFFICER 'A'

1. Sri Sumit Bisht
2. Dr Nilay Govind
3. Sri Ishwar Chandra Rahi
4. Mrs Nandita Tiwari

TECHNICAL ASSISTANT 'E'

1. Sri Amrit Pal Singh Chaddha
2. Sri Prasanta Kumar Das
3. Sri Pawan Kumar
4. Sri Madan Singh Rana
5. Ms Kirti Singh
6. Sri Ajay Kumar Srivastava

TECHNICAL ASSISTANT 'D'

1. Sri Sandeep Kumar Kohri
2. Sri Ishwar Chandra Shukla
3. Sri Jitendra Yadav

TECHNICAL ASSISTANT 'B'

1. Sri J. Baskaran
2. Sri Ashok Kumar Sharma
3. Ms Shivalee Srivastava
4. Sri Ram Ujagar
5. Sri Raja Ram Verma

TECHNICAL ASSISTANT 'A'

1. Ms Archana Sonkar
2. Sri Shailendra Kumar Yadav

REGISTRAR

Sri Sandeep Kumar Shivhare

ACCOUNTS OFFICER

Sri Ashutosh Shukla

PRIVATE SECRETARY

Mrs M. Jagath Janani

SECTION OFFICER

3. Sri N.U. Kannan
4. Sri Mishri lal (w.e.f. 29.12.2021)
5. Mrs Swapna Mazumdar
6. Sri Gopal Singh (w.e.f. 23.06.2021)
7. Sri K.P. Singh

STENOGRAPHER

Sri Murukan Pillai

ASSISTANTS

1. Ms Chitra Chatterjee
2. Sri Shailendra Singh Panwar
3. Sri Rameshwar Prasad
4. Sri Avinash Kumar Srivastava
5. Mrs Renu Srivastava
6. Mrs Manisha Tharu (w.e.f. 09.03.2022)
7. Sri Koshy Thomas

HINDI TRANSLATOR

Sri Ashok Kumar

UPPER DIVISION CLERK

1. Sri Rahul Gupta
2. Ms Anupam Jain
3. Mrs Sudha Kureel
4. Sri Rajesh Kumar Mishra
5. Sri Manoj Singh

LOWER DIVISION CLERK

1. Sri Akshay Kumar (w.e.f. 27.11.2021)
2. Sri Shailesh Kumar

3. Sri Purneshwar Prakash Mishra (w.e.f. 16.12.2021)
4. Mrs Savita Nair (w.e.f. 11.03.2022)
5. Sri Abhishekh Sachan (w.e.f. 21.02.2022)
6. Ms Barsha Shah (w.e.f. 30.12.2021)
7. Sri Abhay Shukla (w.e.f. 16.12.2021)
8. Sri Kshitij Singh (w.e.f. 31.01.2022)
9. Sri Rajat Srivastava (w.e.f. 31.12.2021)
10. Sri Pushkar Verma (w.e.f. 16.12.2021)
11. Mrs Vijaya
12. Sri Karan Yadav

DRIVER 'IV'

1. Sri Devendra Kumar Misra
2. Sri Pushpendra K. Misra

MULTI TASKING STAFF

1. Mrs Bhawana Awasthi
2. Sri R.K. Awasthi
3. Sri K.K. Bajpai (VRS/relived w.e.f. 05.03.2022)
4. Mrs Beena
5. Sri Ram Chander
6. Sri Ram Dheeraj
7. Sri Vishwanath S. Gaikwad
8. Ms Prapti Gupta (w.e.f. 28.03.2022) (FN)
9. Mrs Ram Kali
10. Sri Sanjay Kashyap (w.e.f. 28.03.2022) (FN)
11. Sri Hari Kishan
12. Sri Dhan Bahadur Kunwar
13. Sri Deepak Kumar
14. Sri Indra Kumar
15. Sri Jitendra Kumar (w.e.f. 28.03.2022) (FN)
16. Sri Raj Kumar (resignation/relived w.e.f. 09.12.2021)
17. Sri Ramesh Kumar
18. Sri Sunit Kumar
19. Sri Manish Mishra (w.e.f. 30.03.2022) (FN)
20. Sri Prabhat Mishra (w.e.f. 28.03.2022) (AN)
21. Ms Nandani
22. Sri Kailesh Nath
23. Sri Mani Lal Pal
24. Sri Lavkush Pandey (w.e.f. 28.03.2022) (FN)
25. Sri Puneet Pandey (w.e.f. 31.03.2022) (FN)
26. Sri Mathura Prasad
27. Sri Ravi Shankar
28. Sri Aquil Siddiqui (w.e.f. 28.03.2022) (AN)
29. Sri Ankit Pratap Singh
30. Sri Ram Singh
31. Mrs Sandhya Singh
32. Sri Indra Kumar Yadav
33. Sri Ram Kewal Yadav
34. Sri Shivam Yadav (w.e.f. 28.03.2022) (AN)

BIRBALSAHNIRESEARCHASSOCIATE

1. Sri Shamim Ahmad
2. Dr Arindam Chakraborty (relieved w.e.f. 27.02.2022) (AN)
3. Sri Saurabh Gautam
4. Ms Rupa Ghosh (relieved w.e.f. 29.10.2021)
5. Dr (Mrs) Shreya Mishra (relieved w.e.f. 21.06.2021)
6. Dr (Ms) Debarati Nag
7. Dr (Mrs) Sandhya Sharma
8. Shri Mayank Shekhar (relieved w.e.f. 28.10.2021)
9. Dr (Mrs) Deepika Tripathi (relieved w.e.f. 27.02.2022) (AN)

BIRBAL SAHNI RESEARCH SCHOLAR

1. Ms Priya Agnihotri
2. Ms Prachita Arora
3. Ms Harshita Bhatia
4. Ms Kajal Chandra
5. Ms Rimpy Chetia (tenure completed on 06.08.2021)
6. Ms Supriya Kumari
7. Sri Subhankar Paramanik (relieved w.e.f. 05.07.2021)
8. Ms Shalini Parmar
9. Ms Himani Patel (tenure completed on 21.07.2021)
10. Ms Divya Singh
11. Sri Pawan Kumar Singh
12. Ms Priyanka Singh (tenure completed on 12.08.2021)
13. Ms Harshita Srivastava
14. Ms Pooja Tiwari

APPOINTMENTS

SCIENTIST – 'B'

1. Dr (Ms) Adrita Choudhuri (w.e.f. 23.06.2021) (AN)
2. Sri Sanjay Kumar Singh Gahlaud (w.e.f. 21.06.2021) (AN)
3. Dr Anurag Kumar (w.e.f. 22.06.2021) (AN)
4. Sri Sabyasachi Mandal (w.e.f. 23.06.2021) (AN)
5. Dr (Mrs) Divya Kumari Mishra (w.e.f. 21.06.2021) (AN)
6. Dr (Mrs) Shreya Mishra (w.e.f. 21.06.2021) (AN)
7. Dr Ranveer Singh Negi (w.e.f. 20.07.2021) (AN)
8. Dr Suman Sarkar (w.e.f. 23.09.2021(FN)
9. Dr Mayank Shekhar (w.e.f. 28.10.2021) (FN)
10. Dr Prem Raj Uddandam (w.e.f. 28.06.2021) (FN)

LOWER DIVISION CLERK

1. Sri Akshay Kumar (w.e.f. 27.12.2021)
2. Sri Purneshwar Prakash Mishra (w.e.f. 16.12.2021)
3. Mrs Savita Nair (w.e.f. 11.03.2022)
4. Sri Abhishek Sachan (w.e.f. 21.02.2022) (AN)
5. Ms Barsha Shah (w.e.f. 30.12.2021)
6. Sri Abhay Shukla (w.e.f. 16.12.2021)
7. Sri Kshitij Singh (w.e.f. 31.01.2022)
8. Sri Rajat Srivastava (w.e.f. 31.12.2021)
9. Sri Pushkar Verma (w.e.f. 16.12.2021)

MTS

1. Ms Prapti Gupta (w.e.f. 28.03.2022) (FN)
2. Sri Sanjay Kashyap (w.e.f. 28.03.2022) (FN)
3. Sri Jitendra Kumar (w.e.f. 28.03.2022) (FN)
4. Sri Manish Mishra (w.e.f. 30.03.2022) (FN)
5. Sri Prabhat Mishra (w.e.f. 28.03.2022) (AN)
6. Sri Lavkush Pandey (w.e.f. 28.03.2022) (FN)
7. Sri Puneet Pandey (w.e.f. 31.03.2022) (FN)
8. Sri Aquil Siddiqui (w.e.f. 28.03.2022) (AN)
9. Sri Shivam Yadav (w.e.f. 28.03.2022) (AN)

PROMOTIONS

SCIENTIFIC STAFF

1. Dr Niraj Rai Scientist-D (w.e.f. 01.07.2021)
2. Dr Sajid Ali, Scientist-C (w.e.f. 01.07.2021)
3. Dr Arif Husain Ansari, Scientist-D (w.e.f. 01.01.2022)
4. Dr (Mrs) Trina Bose, Scientist-C (w.e.f. 01.01.2022)
5. Dr Gurumurthy G.P. Scientist-C (w.e.f. 01.07.2021)
6. Dr Manoj M.C., Scientist-D (w.e.f. 01.01.2022)
7. Dr P. Morthekai, Scientist-D (w.e.f. 01.07.2021)
8. Dr K.G. Mishra, Scientist-E (w.e.f. 01.01.2022)
9. Dr Santosh Kumar Pandey, Scientist-D (w.e.f. 01.01.2022)
10. Dr S Suresh K. Pillai, Scientist-E (w.e.f. 01.07.2021)
11. Dr (Mrs) K. Pauline Sabina, Scientist-E (w.e.f. 01.07.2021)
12. 1Dr (Mrs) Anju Saxena, Scientist-E (w.e.f. 01.07.2021)
13. Dr Sunil Kumar Shukla, Scientist-D (w.e.f. 01.01.2022)

ADMINISTRATIVE STAFF

1. Sri Mishri Lal, Section Officer (w.e.f. 29.12.2021)
2. Sri Gopal Singh, Section Officer (w.e.f. 23.06.2021)
3. Mrs Manisha Tharu, Assistant (w.e.f. 09.03.2022)

RESIGNATION / RELIEVED

1. Dr Arindam Chakraborty, BSRA (w.e.f. 27.02.2022) (AN)
2. Dr Rupa Ghosh, BSRA (w.e.f. 29.10.2021) (AN)
3. Sri Raj Kumar, MTS-II (w.e.f. 09.12.2021)
4. Dr (Mrs) Shreya Mishra, BSRA (w.e.f. 21.06.2021) (FN)
5. Sri Subhankar Paramanik BSRS (w.e.f. 05.07.2021)
6. Dr Mayank Shekhar, BSRA (w.e.f. 28.10.2021)
7. Dr (Mrs) Deepika Tripathi, BSRA (w.e.f. 27.02.2022)

SUPERANNUATION

1. Sri V.K. Singh (retired w.e.f. 31.01.2022)
2. Dr Amit Ghosh (retired w.e.f. 28.02.2022)
3. Sri K.K. Bajpai (VRS w.e.f. 05.03.2022)

OBITUARY

1. Dr H.A. Khan, Ex-Scientist on 14.04.2021
2. Dr Anil Chandra, Ex-Scientist-F on 16.04.2021
3. Dr S.K.M. Tripathi, Ex-Scientist-F on 23.04.2021
4. Mrs V. Nirmala Nair, Ex-Section Officer on 24.04.2021
5. Dr K.S. Saraswat, Ex- Scientist-F on 23.10.2021
6. Sri Chandra Pal, Ex-Technical Officer 'D' on 28.02.2022
7. Dr G.K.B. Navale, Ex-Dy Director (SG) on 14.03.2022

OTHER SCIENTIFIC STAFF & PROJECT / RESEARCH SCHOLARS

SRA- POOL SCIENTIST

1. Dr Akhilesh Kumar Yadava, CSIR

NPDF

1. Dr Vikram Pratap Singh

WOMAN SCIENTIST

1. Ms Priyanka Joshi, DST-SERB
2. Dr Nivedita Mehrotra, DST-SERB

SPONSORED PROJECT

RESEARCH ASSOCIATE

1. Dr Bandana Shukla, ONGC

SENIOR RESEARCH FELLOW

1. Ms Debika Deori, DST-SERB
2. Sri Suyash Gupta, DST-SERB
3. Ms Korobi Saikia, DST-SERB
4. Sri Yogesh Pal Singh, DST-SERB

JUNIOR RESEARCH FELLOW

1. Sri Alok Kumar Mishra, DST-SERB
2. Sri Raj Kumar, DST-SERB
3. Sri Sadanand Pathak, DST-SERB
4. Sri Deveshwar Prakash Mishra, DST-SERB
5. Sri Ramanand Sagar, DST-SERB
6. Sri Yogesh Kumar, ONGC
7. Sri Piyal Haldar, MOES
8. Ms Vartika Singh, MOES
9. Ms Nidhi Tomar, SAC-ISRO
10. Ms Ayushi Singh, NHMS
11. Sri Adarsh Mishra, NCPOR
12. Sri Mahboob Alam, NCAOR
13. Sri Masud Kawsur, NCAOR
14. Ms Trishika Seth, NCPOR

PROJECT ASSISTANT

1. Sri Ashish Kumar Mishra, ONGC
2. Sri Raj Kumar, ONGC
3. Sri Sachin Kumar, DST-SERB
4. Sri Vishwadeep Rout, NCPOR

TECHNICAL ASSISTANT

1. Sri Sachin Kumar Dhiman, ONGC
2. Sri Sumit Kumar, ONGC

SELF SUPPORTED Ph.D.

(DST-INSPIRE, CSIR, UGC)

SENIOR RESEARCH FELLOW

1. Ms Ipsita Roy, DST-INSPIRE
2. Sri Prashant Mohan Trivedi, DST-INSPIRE
3. Sri Ravi Shankar Maurya, DST-INSPIRE
4. Sri Harsh Kumar, CSIR
5. Ms Mahi Bansal, CSIR
6. Sri Mohan Kumar, CSIR
7. Sri Mukesh Yadav, CSIR
8. Sri Amit Kumar Mishra, UGC
9. Ms Kajal Singh, UGC
10. Sri Mukesh Yadav, UGC
11. Sri Nikhil Patel, UGC

JUNIOR RESEARCH FELLOW

1. Sri Mohd. Arif Ansari, DST-INSPIRE
2. Ms Deeksha, DST-INSPIRE
3. Ms Arya Pandey, DST-INSPIRE
4. Sri Hidayatullah, DST-INSPIRE
5. Sri Kishore Katange, DST-INSPIRE
6. Ms Lopamudra Roy, DST-INSPIRE
7. Ms Pooja Saraf, DST-INSPIRE
8. Ms Rikee Dey, DST-INSPIRE
9. Ms Sneha Mary Mathews, DST-INSPIRE
10. Ms Stuti Saxena, DST-INSPIRE
11. Sri. Vijay Kumar Rathaur, DST-INSPIRE
12. Sri Gursewak Singh, CSIR
13. Sri Mohd Ikram, CSIR
14. Sri Md. Munazir Chauhan, CSIR
15. Sri Nagendra Prasad, CSIR
16. Sri Sanjay Kumar Singh Gahlaud, CSIR
17. Sri Sarvendra Pratap Singh, CSIR
18. Sri Shirish Verma, CSIR
19. Ms Aparna Dwivedi, UGC
20. Sri Arvind Tiwari, UGC
21. Sri Brijesh Kumar, UGC
22. Ms Divya Verma, UGC
23. Sri Lamgingsang Thomte, UGC
24. Sri Nazakat Ali, UGC
25. Ms Richa, UGC
26. Ms Sadhana Vishwakarma, UGC

Events during 2021-2022

Death Anniversary of Prof. Birbal Sahni, 10 April 2021

The floral tribute was offered to Prof. Birbal Sahni on his Death Anniversary on his Samadhi at the Institute premises on 10th April, 2021 by scientific, technical and administrative staff of the institute.

World Environment Day, 05 June 2021

World Environment Day was celebrated on June 05, 2021. The day is also known as Eco Day or Environment Day. The theme of the year was Ecosystem Restoration and Pakistan was the global host of the day.

An academic lecture was delivered by Dr Rajesh Agnihotri, Scientist 'F', BSIP on the topic entitled "***Changing Indian monsoon rainfall patterns amidst recent global warming in last -100 years***" on the occasion of World Environment Day-2021 via online platform (Google Meet). All Scientists, Research Scholars / sponsored Project members and staff members of the Institute attended the lecture.

International Mangrove Day, 26 July 2021

One day Workshop on "International Mangrove Day" was organized by BSIP Lucknow and Mangrove Society of India, Goa on July 26, 2021 via online platform.

Independence Day, 15 August 2021

Flag hoisting ceremony was organized on the auspicious occasion of the 75thIndependence Day (15th August 2021). Dr Vandana Prasad (Director, BSIP) emphasized the importance of freedom in every domain and the price paid by freedom fighters in her deliberation. She encouraged all the scientific, technical, and administrative staff to work hard towards bringing geosciences at the centre stage of sustainable development. The event was attended by all the staff members of the Institute following COVID-19 guidelines.

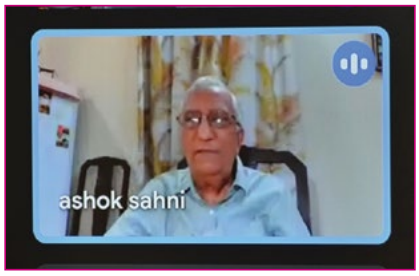
Swachhta Pledge

With regards to the Swachhta Action Plan (SAP) 2020-2021, Dr Kamlesh Kumar (Nodal Officer, SAP, BSIP) organized a 'Swachhta Pledge' event on 15th August 2021, which was recited by all scientific, technical, and administrative staff members of the Institute to spread awareness towards maintaining cleanliness of our surroundings.

Governing Body Meeting, 27 August 2021

Members of the Governing Body (GB), BSIP, Lucknow having deliberation during a meeting held on the 27th August 2021 in the institute.

Lecture series on the occasion of Platinum Jubilee celebration of the Institute, 03 September 2021



A lecture series was organized on the occasion of BSIPs Platinum Jubilee Celebration (as part of the 'Azadi Ka Amrit Mahotsav' in the year 2021. The first lecture was delivered by Professor Ashok Sahni (Scientist Emeritus, Panjab University, Chandigarh) entitled "Prof. Birbal Sahni and his scientific journey" on the 3rd September, 2021.

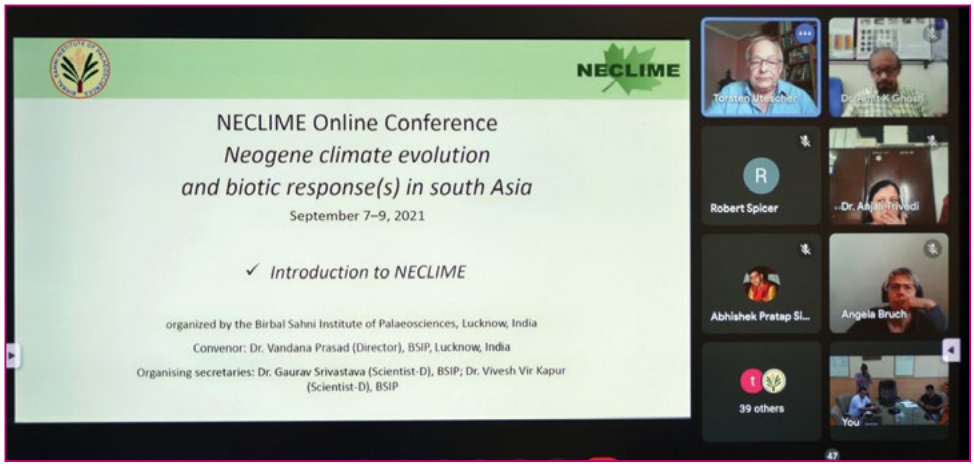
The second lecture was delivered by Professor Arunabh Ghosh (Harvard University, USA) entitled "Birbal Sahni and Hsu Jen - connected histories of science across India and China" on the 8th October, 2021.

Both the lectures were delivered via virtual (online) platform.

Hindi Pakhwara, 1-14 September 2021

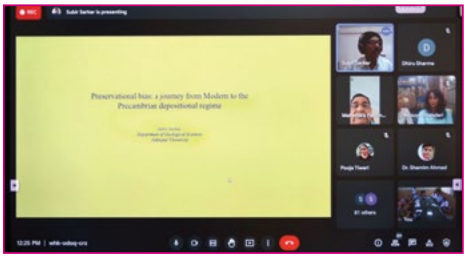
BSIP celebrated 'Hindi Pakhwada' from 1st to 14th September, 2021. The event was inaugurated by Dr Vandana Prasad (Director, BSIP, Lucknow). Professor Rakesh Chandra (University of Lucknow, Lucknow) delivered a lecture on "नई शिक्षा नीति" (New Education Policy) on 1st September, 2021. During this period, various competitions like Hindi Typing (computer), Debate, Noting, Poster Competition, Essay Writing, and Kavi-Sammelan were organized via online platform. Professor Mukund Sharma (Scientist-G, BSIP) delivered a lecture in Hindi on the topic "हमारी भू-विरासत: वर्तमान दशा और दिशा" on 14th September, 2021. All scientific staff members including, research scholars, technical, and administrative personnel of the institute participated in various events with enthusiasm.

International Conference on Neogene Climate Evolution and Biotic Response(s) in South Asia (Virtual Mode), 07-09 September 2021



An International Conference on "Neogene Climate Evolution and Biotic Response(s) in South Asia" was organized by BSIP and NECLIME during 7th to 9th September, 2021 via virtual (online) platform.

Foundation Day Celebration, 10 September 2021

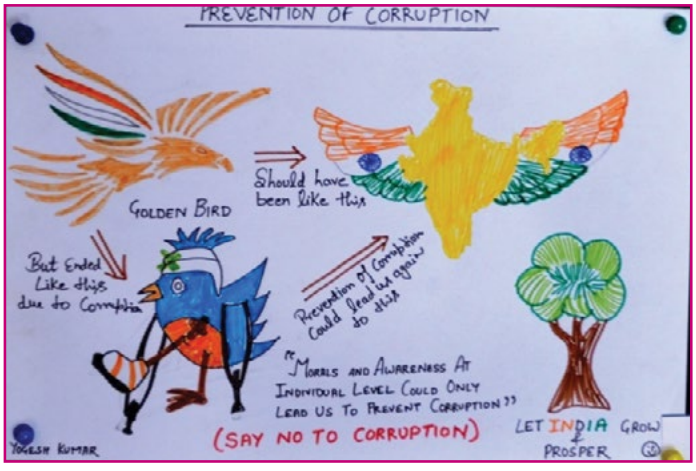


BSIP celebrated 75th Foundation Day on the 10th September, 2021 by offering floral tributes to Late Prof. Birbal Sahni. Floral tributes were offered by Dr Vandana Prasad (Director, BSIP) along with other scientific, technical, and administrative staff members of the Institute. On this occasion Prof. Subir Sarkar (Department of Geological Sciences, Jadavpur University, Kolkata) delivered the Foundation Day Lecture (via virtual platform) entitled "Preservational bias: a journey from Modern to the Precambrian depositional regime". The event was chaired by Dr Vandana Prasad (Director, BSIP). All the scientific staff including research scholars attended the lecture.

Vigilance Awareness Week
26 October to 01 November 2021

Vigilance Awareness Week-2021 was observed during October 26–November 01, 2021. About 175 staff members including Director, scientists, students, technical and administrative staff members took the integrity pledge in English and Hindi both on October 26, 2021. A poster competition on the topic "Prevention of corruption" and an Essay writing competition on the topic "Promotion of vigilance and consciousness" were organized within the Institute during the week. Winner of both the competitions received the prizes and certificates from Prof. Sandeep Verma, Secretary SERB, New Delhi on the occasion of Founder's Day of the Institute.

Poster Competition (As part of Vigilance Awareness Week)
26 October to 01 November 2021



A poster competition on the topic "Prevention of corruption" was organized as part of Vigilance Awareness Week-2021 during October 26–November 01, 2021 within the Institute. Winners of the Poster Comptetion were awarded prizes and certificates from Prof. Sandeep Verma, Secretary SERB, New Delhi on the occasion of Founder's Day of the Institute.

Founder's Day Celebration, 14 November 2021

BSIP celebrated Founder's Day on the 14th November, 2021. Dr M. Ravichandran [Secretary, Ministry of Earth Science (MoES) and Department of Science and Technology (DST)] was the chief guest of the function. Dr Vandana Prasad (Director, BSIP) took the audience down memory lane of the legacy and contributions of Late Prof. Birbal Sahni. She also highlighted the research achievements and research mandates of BSIP. Prof. Sandeep Verma (Secretary, SERB-DST) delivered the 51st Prof. Birbal Sahni Memorial Lecture entitled "Science Technology Innovation Policy (STIP)-2020: Policy and Process." The Annual Report (2020-2021) and a documentary film showcasing seventy-five years of Institute's achievements were also released on the occasion of Founder's Day as well as part of Platinum Jubilee celebrations. The event was attended by all the scientists, technical staff, and research scholars of the Institute via both offline and online modes.

Internal Complaint Committee (ICC), BSIP Awareness Lecture December 9, 2021

The BSIP Internal Complaint Committee organized an awareness talk on the "Sexual Harassment of Women at Workplace Prohibition and Redressal Act, 2013" in order to achieve gender parity and sensitization. Ms. Anchal Gupta (Advocate, High Court, Lucknow) delivered an online talk on the 9th December, 2021. The lecture was attended by all of the Institute's scientific, technical, and administrative personnel.

Dr Venkatachala Memorial Lecture, 03 January 2022

On the occasion of 89th Birth Anniversary of Former Director Late Dr B. S. Venkatachala, BSIP organized the 9th B. S. Venkatachala Memorial Lecture on the 3rd January, 2022. At this event, Prof. Mukund Sharma (Scientist -'G', BSIP), delivered a lecture entitled "Precambrian Palaeobiology: A Journey through Early Life". The event was attended by institute's scientists, research scholars, technical, and administrative staff.

Republic Day, 26 January 2022

BSIP celebrated the 73rd Republic Day by hoisting the National Flag and singing the National Anthem on its campus. Because of the rapid increase in Covid cases, the flag hoisting was restricted to a smaller group that included only the Director BSIP, Registrar, Project Coordinators/Co-coordinators, senior technical officers, and a few support staff following Covid protocols.

Research Advisory Committee (RAC) Meeting 02-04 March 2022

Members of the Research Advisory Council (RAC), BSIP, Lucknow had deliberation during meetings held from 2nd to 4th March 2022 in the Institute.

8th Dr M.N. Bose Memorial Lecture, 09 March 2022

Dr Amit K. Ghosh (Retired Scientist) of Birbal Sahni Institute of Palaeosciences, Lucknow delivered the 8th Dr M. N. Bose Memorial Lecture on "Floral radiation and diversity during age of reptiles" in the Institute's Auditorium. The lecture was attended by Institute's scientists, technical officers, and research scholars.

Governing Body Meeting, 22 March 2022

Members of the Governing Body (GB), BSIP, Lucknow having deliberation during a meeting held on the 22nd March 2022 in the Institute.

Inauguration of Laboratories, 22 March 2022

Birbal Sahni Institute of Palaeosciences, Lucknow is continuously enhancing its technical capabilities and academic prowess towards newer avenues of Geosciences and bio-geosciences. In this regard, Prof. Nitin Karmalkar, Chairman, Governing body and Prof. L. S. Chamyal, Chairman, Research Advisory Council of the Institute inaugurated three new 'state of the art' scientific research laboratories at its campus. Clumped Isotope Laboratory will be used for reconstruction and accurate quantification of key climate parameters (such as temperature) in the past. This is one of the most sophisticated and advanced tool in palaeoclimate reconstruction. In addition to this, new Industrial Micropalaeontology Laboratory, FTIR (Fourier Transform Infra-Red) spectroscopy and ICP-AES laboratories were also inaugurated in the Institute. These instruments are capable of analyzing both inorganic and organic samples coming from wide array of geological fields comprising coal, petroleum, rocks and other energy related fields.

Fourier Transform Infrared Spectroscopy Laboratory (FTIR)

Clumped Isotope Laboratory

Industrial Micropalaeontology new Laboratory

Building Construction Site Visit, 22 March 2022

Working Group of Association of Quaternary Researchers (AOQR) (2021-2022)

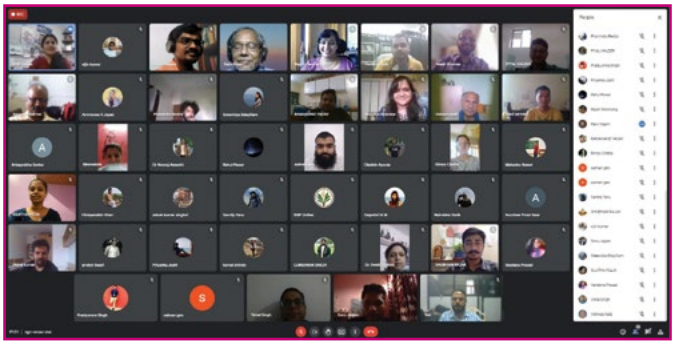
National Online Quiz on Geoarchaeology (09 May 2021)

On 9th May, 2021, the HUCLIMQAT working group of the Association of Quaternary Researchers (AOQR) successfully held an online quiz. The quiz covered the questions about the recent archaeological studies as well as a wide range of geoarchaeological methodologies. Out of 185 participants that registered for the event, 89 participants across the country successfully completed

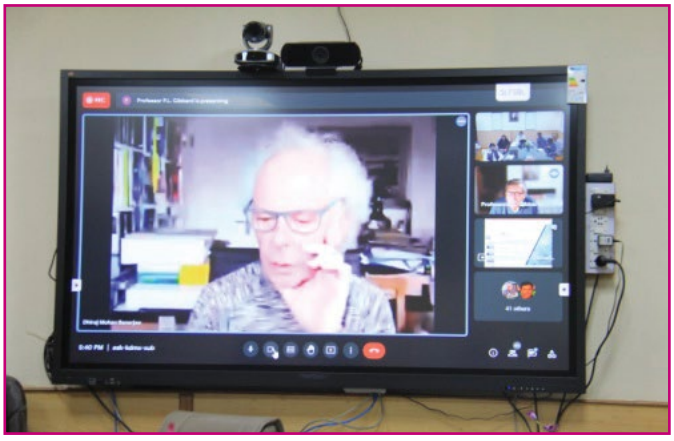
the quiz. Participants from 18 states/UT and various disciplines such as Geology, Archaeology, Geography, Environmental Science, etc. and of UG, PG, M.Phil and PhD levels have taken the quiz. Out of 89, the participants who achieved a score of more than 35%, received a certificate of merit, while the top 10 ranked participants received rank certificates.

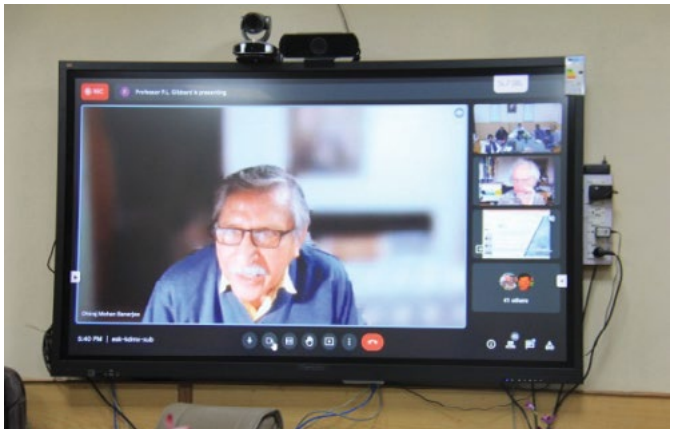
Students Colloquium (02-03 July 2021)

The Association of Quaternary Researchers (AOQR) organized a six-hour online colloquium during 02-03 July, 2021. Post graduate students and Quaternary Sciences research scholars presented their findings to a wide range of early career researchers, expert panellists, and faculty members. There were five (5) sessions with seventeen (17) talks covering various themes of Quaternary research. For focused and constructive debates, each session included a session chair and an exclusive peer scholar rapporteur for each talk. The sessions were followed by a general discussion and overview, providing a good platform for young Quaternary researchers to showcase their work and create engaging collaborations.



2nd Foundation Day Function, AOQR (12 December 2021)



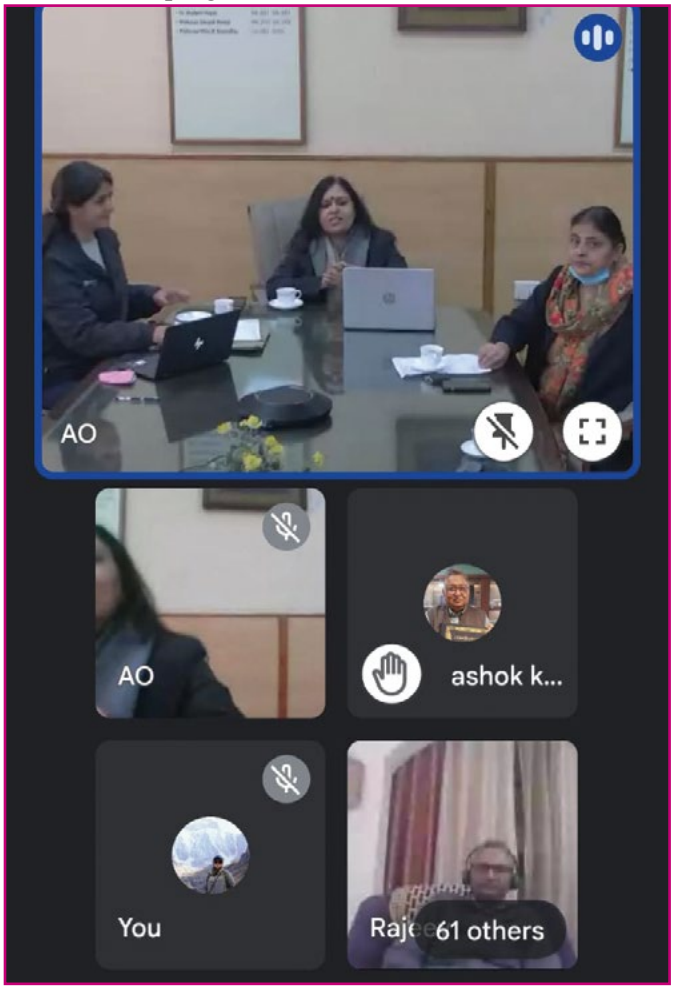


The Association of Quaternary Researchers (AOQR) celebrated its second 'Foundation Day' on the 12th December, 2021. The chief guest of the function was Prof. Philip Gibbard (Scott Polar Research Institute, University of Cambridge, UK) who delivered the foundation day talk entitled "The Anthropocene: an event, not a division of geological time". The event was presided by Prof. D. M. Banerjee (Chairman, INSA-INQUA Committee) and welcome address was delivered by Dr Binita Phartiyal (Secretary, AOQR). The event was attended by professors, scientists, technical staff, and research scholars from various institutes across India.

1st Indian Quaternary Congress (IQC) (19-21 January 2022)

The Association of Quaternary Researchers (AOQR), India hosted the 1st Indian Quaternary Congress (IQC) via virtual mode during 19th-21st January, 2022. The focal theme of the congress was Integrative Quaternary Sciences for Societal Service. The three-days congress began with a presidential address by Dr Vandana Prasad (Director, BSIP and the President of the AOQR society). The congress featured papers from 266 researchers from India working on various aspects of the Quaternary sciences.

The papers were classified into sessions on Climate: Past, Present and Future; Earth Surface Processes in Quaternary; Oceans in Quaternary; Humans in Quaternary; Fossil records from Quaternary and Quaternary landscape evolution having 3 keynote talks, 42 oral and 49 poster presentations. The congress encompassed all significant aspects of the Quaternary Period, both terrestrial and marine. IQC 2022 provided a single forum for India's Quaternary community to present and discuss its newer results, as well as establish a larger interdisciplinary collaborative programme.



AOQR Newsletter- Quaternary Chronicles

(https://www.aoqr.org/publication.aspx#)

Three issues of the Quaternary Chronicles-a quarterly newsletter published online

April 2021(Volume 3(1))

August 2021 (Volume 3(2)

December 2021 (Volume3(3)

OUTREACH PROGRAMME

As the nation celebrates 75 years of Independence, the Birbal Sahni Institute of Palaeosciences (BSIP) is grateful for the funding provided to its research by the Government of India's Department of Science and Technology. In a year that marks 75 years of Independence, the Institute celebrates its 75th Jubilee on 10th September. The BSIP, founded in 1946, has carved a niche in the field of palaeobotany and the study of plant fossils to track the evolution of plant life on earth. The new mandate has expanded BSIP's capabilities in conducting interdisciplinary research in the field of Palaeosciences.

The 'Azadi Ka Amrit Mahotsav' gives BSIP an opportunity to celebrate the nation's 75 years of journey through various outreach activities.

The future of India rests on the shoulders of its 65% young population who will be responsible for steering the country towards the path of sustainable development. BSIP strives to engage closely with its younger research community to weave them into the Institute's activities and research work. The 'Azadi Ka Amrit Mahotsav' gives us an opportunity to initiate youth centric activities that will enable the voices of the younger community to be heard and encouraged. With the world grappling with the COVID-19 crisis- celebrations may be curtailed; however, the spirit of brotherhood and nation-building continues to remain strong. BSIP joins the nation in marking this important milestone 'Azadi Ka Amrit Mahotsav' of our shared history.

Development of Fossil Park at Mandro, Jharkhand

The Mandro Fossil Park is located at Mandro, a community

block in the Sahibganj District of Jharkhand amidst the forested hilly area of Gurmi in the Rajmahal Hills. This region has been considered a gold mine for plant fossils dating back to the early Cretaceous Period. Scientists hold an opinion that the Rajmahal Hills region may have been a home to early angiosperms (or flowering plants), thus, any significant fossil find from this region could lead to critical understanding of plant evolution on the planet. The geological discoveries that this region promises makes large-scale preservation efforts essential. A team of BSIP scientists (Dr Suresh Kumar Pillai, Scientist - 'E' and Dr Vivesh V. Kapur, Scientist - 'D') during 9-13 March, 2022 through their scientific contributions [as part of an MoU with the Forest Department (Jharkhand)] have helped conceptualization of a Fossil Park at Mandro including a Museum and Interpretation Centre within the Fossil Park. The Mandro Fossil Park will help bring to light the rich geological history that was cosily nestled in the Rajmahal Hills of Jharkhand and which now warrants adequate coverage as a national geographical heritage site. The Fossil Park is being developed by the Forest Department, Jharkhand.

Visit of BSIP scientists to Manendragarh, Chhattisgarh for development of Marine Fossil Park.

A team of BSIP scientists (Dr S. Suresh Kumar Pillai, Dr Adrita Choudhuri and Mr Sabyasachi Mandal) visited Manendragarh area of Koriya District, Chhattisgarh for development of Marine Fossil Park during August 4–7, 2021 in collaboration with Chhattisgarh Biodiversity Board and Forest Department of Chhattisgarh.

Marine Fossil Park, Manendragarh area of Koriya District, Chhattisgarh

Marine fossils recovered from the overlain sediments

An outreach program was carried out at a local government school (Uchya Madhyamik Vidyalaya, Majhlaul-3) near the Kawar Lake. Class 7 to 10 students were briefed about science and shown different types of rocks, fossils and were briefed about the works we carry out at BSIP and the work we plan to do at Kawar Lake. Students were also taught about reduce reuse and recycling plastic as the area is also coming under the bane of plastic use.

Reservation 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.

Accounts

SINGH AGARWAL & ASSOCIATES

Chartered Accountants

ICAI Firm Registration No.:004702C
HO:30, Ashok Marg, 1st Floor, Corpn Bank Bldg, Near Gomti Bridge, Lucknow-226001
Ph.(0522)4060801/9415002846/9415039253/9335087588,
Email:mukesh.saa@gmail.com, amit.saa@gmail.com; agrawal.mukesh.kumar@icai.org:

AUDIT 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 2022 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 over all financial statement presentation. We believe that our audit provides are as on able 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 there on, 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 2022, 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.

7. Report on Other Legal and Regulatory Requirements

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 (ICAQ) Partner

Membership No- 073355

UDIN: **22073355ASILJZ7423**

Place : Lucknow

Date: 13.09.2022

ANNEXURE-'A'

(Annexed to and forming part of the Audit Report for the year ended 31st March 2022)

COMMENTS / AUDIT OBSERVATIONS ON ACCOUNTS OF 'BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES' - LUCKNOW

DEFICIENCIES IN PROCUREMENT PROCESS

1. A sum of Rs. 2269.81 lacs is advance to M/s National Projects Construction Corporation Limited as on 31st of March 2022 for construction of building of BSIP. The work was awarded on the basis of tender invited for the purpose. Following discrepancies were noticed in the procurement process:

   Technical qualification conditions (Total estimated award value Rs. 90 Crores):

   For bidder to be technically qualified, the bidder was required to submit the documents in support of completed similar projects of 80% of value of work or 2 similar projects of 60% value in the last 10 years.

   M/s NPCC Limited had submitted a work certificate issued by Directorate General, Assam Rifles for completing "various" works during FY 2012-13 to FY 2017-18 for Rs. 1148.57 Crores. Details/ Documents of any specific work was not obtained as the bidder was required to submit documents of 1(one) work of 80% value of estimated award value (i.e. Rs. 72.00 crores) or 2 works of 60% value of estimated award value (i.e. 54.00 crores each).

   In the reply to the draft audit report submitted by management, it was stated that the value of work done as per certificate issued by Directorate General, Assam Rifles is more than 16 times the desired amount of work and was considered for qualification criteria.

   The certificate issued by Directorate General, Assam Rifles was in respect of various works during the period and in absence of any appropriate document, it cannot be confirmed that there was a single work of required award value. Hence, M/s NPCC Limited was though technically qualified for the contract but it may have effect on the technical points awarded to M/s NPCC Limited.

2. Various construction work was done by inviting quotations from limited parties. It was noticed that selection of parties from whom quotations has been invited is not adequate. In "Renovation of Stock Room", 5 firms had quoted the price wherein 2 parties out of 5 are related parties (M/s Gupta Constructions & M/s Aditya Enterprises). The Contact numbers mentioned on their quotations were same (9415002836/9305635643). Further, GST registration certificate is not demanded to ensure that the parties are registered under GST.

3. Various contract work was done by M/s Siddhi Vinayak Enterprises but they are not registered under GST as work contractor. They are registered as Trader- Wholesaller/ Distributor and dealing in Stationery Items, Cooking Appliances, Machinery, Plant or Equipment, Vegetables.

   LOANS & ADVANCES:

4. The internal control over loans and advances is not adequate and needs strengthening. There should be a process of periodic reconciliation of advances and follow up for outstanding advances. The outstanding advance of Mr. Rajesh Mishra (Staff of accounts Deptt) remained outstanding in Bank reconciliation statement for around a year. This was done by Rajesh Mishra himself who was handling cash book maintenance also; Even though interest on delayed deposit has been reportedly recovered after our draft observations but internal/dual control over advance to staff & cash/bank book maintenance needs strengthening;

5. Advances (capital head) unsettled and pending for recovery/adjustment as on 31.03.2022 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
M/s Alliance Book Suppliers, Delhi	2014-15	200883.89
M/s Spem A/c	Several years	55324.00
M/s Comco Inc UK	2020-21	1079442.46

6. A sum of Rs. 266690/- 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 NIL. The difference of Rs. 266690/- 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 .

7. Register of staff Advance is not updated and reconciled with financial accounts on regular basis. As on 31st March 2022, a sum of Rs. 2215918.45 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
Mr. K P. Singh	2018-19	132640.00
Mrs. Kirti Singh	2017-18 to 2020-21	3150.00

BANK RECONCILIATION STATAEMENT:

8. In Bank reconciliation statement as on 31st of March 2022, Credit without advice amounting to Rs. 5495047/- which includes Rs. 2115608/- for more than 3 months are lying. The details of these entries to be identified and appropriate action to be taken.

   Further, there were various entries of "Consultancy receipts" which were received in cash but recorded as bank receipts and remained outstanding in Bank reconciliation statement for more than a year which is clearly misappropriation of the Institute Fund. The amount was actually deposited in March 2022 by Mr Rajesh Mishra (staff). This misappropriation was done by Mr Rajesh Mishra who himself had recorded this entry wrongly in the accounts and kept cash with him intentionally;

   Even though, as reported by the management, amount with interest has since been recovered & non-cash transaction process has also been implemented after our submission of draft report but the same needs to be continuously & strengthened to avoid such kind of instances;

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.

OTHER ISSUES:

10. A sum of Rs. 1,71,40,067/- was received on account of COVID Fund Grant. Controlling record for purchase of consumables items at lab level is not properly maintained. In absence of any controlling record, correctness of expenses booked under this head cannot be ensured A total of Rs. 8942914/- was spent on COVID expenses and balance Rs. 8197153/ is outstanding with BSIP. Appropriate action to be taken by the Institute for refund of balance amount.

11. The Institute is preparing accounts on accrual basis of accounting. However, establishment expenses are accounted for on March to Feb. Provision for expenses for the month of March 2022 of Rs. 269.52 lacs were not done.

12. Grant is being sanctioned by the DST under three difference heads- General, Salary and Capital Creation and intra-head utilization of grant is subject to approval/ ratification by the governing body/ DST.
13. GST invoice not being issued for all output supply including consultancy receipts, rent from IOB, tender fees, etc.

For: Singh Agarwal & Associates
Chartered Accountants

Mukesh Kumar Agarwal
FCA. DISA (ICAQ) Partner
Membership No- 073355
UDIN: **22073355ASILJZ7423**

Place: Lucknow
Date: 13-Sep-2022

ACTION TAKEN FOR AUDIT REPORT FOR THE FY 2021-22

S. No.	Audit Observations	Action Taken by the Institute
1.	A sum of Rs. 2269.81 lacs is advance to M/s National Projects Construction Corporation Limited as on 31st of March 2022 for construction of building of BSIP. The work was awarded on the basis of tender invited for the purpose. Following discrepancies were noticed in the procurement process: **<u>Technical qualification conditions (Total estimated award value Rs. 90 Crores) :</u>** For bidder to be technically qualified, the bidder was required to submit the documents in support of completed similar projects of 80% of value of work or 2 similar projects of 60% value in the last 10 years. M/s NPCC Limited had submitted a work certificate issued by Directorate General, Assam Rifles for completing "various" works during FY 2012-13 to FY 2017-18 for Rs. 1148.57 Crores. Details/ Documents of any specific work was not obtained as the bidder was required to submit documents of 1 (one) work of 80% value of estimated award value (i.e. Rs. 72.00 crores) or 2 works of 60% value of estimated award value (i.e. 54.00 crores each). In the reply to the draft audit report submitted by management, it was stated that the value of work done as per certificate issued by Directorate General, Assam Rifles is more than 16 times the desired amount of work and was considered for qualification criteria. The certificate issued by Directorate General, Assam Rifles was in respect of various works during the period and in absence of any appropriate document, it cannot be confirmed that there was a single work of required award value. Hence, M/s NPCC Limited was though technically qualified for the contract but it may have effect on the technical points awarded to M/s NPCC Limited.	The high powered evaluation committee, on the basis of the certificate No. VIII.11014/Engr-2018/Wks Dated 12.9.2018 issued by Directorate General, Assam Rifles considered the deposit work as an completed project and awarded the marks accordingly. Further, M/s. NPCC Ltd. was technically qualified even after excluding the experience certificate referred above and it is confirmed that there is no change in the status of lowest evaluated tender.
2.	Various construction work was done by inviting quotations from limited parties. It was noticed that selection of parties from whom quotations has been invited is not adequate. In "Renovation of Stock Room", 5 firms had quoted the price wherein 2 parties out of 5 are related parties (M/s. Gupta Constructions & M/s Aditya Enterprises). The Contact numbers mentioned on their quotations were same (9415002836/9305635643). Further, GST registration certificate is not demanded to ensure that the parties are registered under GST.	The work was not awarded to M/s. Gupta Constructions or M/s. Aditya Enterprises. Most of the firms had mentioned the GST number in their quotations. However, the audit observations are noted for compliance.
3.	Various contract work was done by M/s. Siddhi Vinayak Enterprises but they are not registered under GST as work contractor. They are registered as Trader- Wholesaller/ Distributor and dealing in Stationery Items, Cooking Appliances, Machinery, Plant or Equipment, Vegetables.	Noted for compliance.

(Ashutosh Shukla)
Accounts Officer

(Sandeep Kumar Shivhare)
Registrar

(Dr. Vandana Prasad)
Director

<table>
<tr><th>S. No.</th><th>Audit Observations</th><th>Action Taken by the Institute</th></tr>
<tr><td>4.</td><td>LOANS & ADVANCES:
The internal control over loans and advances is not adequate and needs strengthening. There should be a process of periodic reconciliation of advances and follow up for outstanding advances. The outstanding advance of Mr. Rajesh Mishra (Staff of accounts Dept.) remained outstanding in Bank reconciliation statement for around a year. This was done by Rajesh Mishra himself who was handling cash book maintenance also; Even though interest on delayed deposit has been reportedly recovered after our draft observations but internal/dual control over advance to staff & cash/bank book maintenance needs strengthening;</td><td>All corrective measures had been taken for settlement of outstanding advances/amount. All the payments and receipts to the Institute are being routed through PFMS and in-house developed dedicated payment portal of the Indian Overseas Bank respectively.</td></tr>
<tr><td>5.</td><td>Advances (capital head) unsettled and pending for recovery/ adjustment as on 31.03.2022 under different heads, since long, are to be properly taken care of at the Institute level for early adjustment thereof Details of which are as under:
<table>
<tr><th>PARTICULARS</th><th>YEAR</th><th>AMOUNT</th></tr>
<tr><td>M/s Alliance Book Suppliers, Delhi</td><td>2014-15</td><td>200883.89</td></tr>
<tr><td>M/s Spem A/c</td><td>Several years</td><td>55324.00</td></tr>
<tr><td>M/s Comco Inc UK</td><td>2020-21</td><td>1079442.46</td></tr>
</table></td><td>The amount of Rs. 2,00,883.89 of M/s. Alliance Book Suppliers has already been submitted for consideration of Governing Body.
The M/s. SPEM Ltd. is being taken in current year for adjustment.
M/s. Comco Inc. UK is already settled during Current Financial Year 2022-23 vide voucher No. 53 dated 30.8.2022.</td></tr>
<tr><td>6.</td><td>A sum of Rs. 266690/- 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 NIL. The difference of Rs. 266690/- 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.</td><td>All efforts are being made for early settlement of outstanding advances.</td></tr>
<tr><td>7.</td><td>Register of staff Advance is not updated and reconciled with financial accounts on regular basis. As on 31st March 2022, a sum of Rs. 2215918.45 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:
<table>
<tr><th>NAME OF PERSON/ STAFF</th><th>PENDING SINCE</th><th>AMOUNT</th></tr>
<tr><td>Mr. K. P. Singh</td><td>2018-19</td><td>132640.00</td></tr>
<tr><td>Mrs. Kriti Singh</td><td>2017-18 to 2020-21</td><td>3150.00</td></tr>
</table></td><td>The adjustment of advance of Mr. K. P. Singh has already been submitted in the office and is under consideration for settlement.
The several advance pertains to advance payment of Group Insurance Scheme of Mrs. Kirti Singh was not attending the office and her salary bill of for several month are yet to be paid. The amount will be settled on the payment of salary to her.</td></tr>
</table>

(Ashutosh Shukla)
Accounts Officer

(Sandeep Kumar Shivhare)
Registrar

(Dr. Vandana Prasad)
Director

S. No.	Audit Observations	Action Taken by the Institute
8.	**BANK RECONCILIATION STATAEMENT:** In Bank reconciliation statement as on 31st of March 2022, Credit without advice amounting to Rs. 5495047/- which includes Rs. 21156081/- for more than 3 months are lying. The details of these entries to be identified and appropriate action to be taken. Further, there were various entries of "Consultancy receipts" which were received in cash but recorded as bank receipts and remained outstanding in Bank reconciliation statement for more than a year which is clearly misappropriation of the Institute Fund. The amount was actually deposited in March 2022 by Mr. Rajesh Mishra (staff). This misappropriation was done by Mr. Rajesh Mishra who himself had recorded this entry wrongly in the accounts and kept cash with him intentionally; Even though, as reported by the management, amount with interest has since been recovered & non-cash transaction process has also been implemented after our submission of draft report but the same needs to be continuously & strengthened to avoid such kind of instances;	Out of Rs. 54,95,047/- a sum of Rs. 22,15,918.45 has already reconciled as on 31.7.2022 and taken in the Institute account. The rest of amount is being settled. All corrective measures had been taken for settlement of outstanding advances/amount. All the payments and receipts to the Institute are being routed through PFMS and in-house developed dedicated payment portal of the Indian Overseas Bank respectively.
9.	**STORES AND WORKS & BUILDING:** 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.	Necessary directives has already issued to the concerned functionaries for taking corrective steps.
10.	**OTHER ISSUES:** A sum of Rs. 1,71,40,067/- was received on account of COVID Fund Grant. Controlling record for purchase of consumables items at lab level is not properly maintained. In absence of any controlling record, correctness of expenses booked under this head cannot be ensured. A total of Rs. 8942914/- was spent on COVID expenses and balance Rs. 81971531/- is outstanding with BSIP. Appropriate action to be taken by the Institute for refund of balance amount.	The Institute is already taken up the issue with concerned State Government authorities. The issue is further being taken on priority.
11.	The Institute is preparing accounts on accrual basis of accounting. However, establishment expenses are accounted for on March to Feb. Provision for expenses for the month of March 2022 of Rs. 269.52 lacs were not done.	The Institute will try to implement accrual system during current financial year.
12.	Grant is being sanctioned by the DST under three different heads- General, Salary and Capital Creation and intra-head utilization of grant is subject to approval/ratification by the governing body/ DST.	There is no any intra-head utilization of grant during FY 2021-22. Hence there is no need for approval/ratification by the Governing Body/ DST.
13.	GST invoice not being issued for all output supply including consultancy receipts, rent from IOB, tender fees, etc.	The invoice is already issued for all receipt of consultancy project. As far as GST invoice for rental and tender fees is concern it will be issued for current FY.

(Ashutosh Shukla)
Accounts Officer

(Sandeep Kumar Shivhare)
Registrar

(Dr. Vandana Prasad)
Director

BALANCE SHEET AS AT 31.03.2022

(Amount - Rs.)

Particulars	Schedule No.	Current Year 31.03.2022	Previous Year 31.03.2021
CORPUS/CAPITAL FUND AND LIABILITIES			
CORPUS/CAPITAL FUND	1	710,656,644.15	701,852,965.46
RESERVES ANS SURPLUS	2	73,210,903.00	73,210,903.00
EARMARKED/ENDOWMENT FUNDS	3	769,105,386.63	591,922,268.33
SECURED LOANS AND BORROWINGS	4	-	-
UNSECURED LOANS AND BORROWINGS	5	-	-
DEFERRED CREDIT LIABILITIES	6	-	-
CURRENT LIABILITIES AND PROVISIONS	7	43,896,316.84	68,330,256.00
TOTAL		**1,596,869,250.62**	**1,435,316,392.79**
ASSETS			
FIXED ASSETS	8	251,264,025.69	219,332,307.92
INVESTMENTS-FROM EARMARKED/ENDOWMENT FUNDS	9	769,105,386.63	591,922,268.33
INVESTMENTS-OTHERS	10	123,918,709.00	150,521,600.00
CURRENT ASSETS,LOANS,ADVANCES ETC.	11	452,581,129.30	473,540,216.54
MISCELLANEOUS EXPENDITURE		-	-
(to the extent not written off or adjusted)			
TOTAL		**1,596,869,250.62**	**1,435,316,392.79**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

For: Singh Agarwal & Associates
Chartered Accountants

Mukesh Kumar Agarwal
FCA. DISA (ICAQ) Partner
Membership No- 073355
UDIN: **22073355ASILJZ7423**

(Ashutosh Shukla)
Accounts Officer

(Sandeep Kumar Shivhare)
Registrar

(Dr. Vandana Prasad)
Director

Place: Lucknow
Date: 13-Sep-2022

INCOME AND EXPENDITURE ACCOUNT FOR THE PERIOD/ YEAR ENDED 31.03.2022

(Amount - Rs.)

Particulars	Schedule	Current Year 2021-22	Previous Year 2020-21
INCOME			
Income from Sales/Services	12	1,182,507.00	637,222.14
Grants/subsidies (OB, Deposit A/C and Transfer from Cap. Fund)	13	572,500,000.00	530,900,000.00
Fees/Subscriptions	14	-	-
Income from Investments (Income on Invest. From earmarked/endow. Funds transferred to Funds)	15	47,067,305.00	69,720,605.08
Income from Royalty, Publication, etc.	16	-	-
Interest Earned	17	412,878.00	606,062.00
Other Income/Adjustments	18	5,069,870.00	3,715,809.32
Increase/ (decrease) in stock of Finished goods and works-in-progress	19	-	-
TOTAL(A)		**626,232,560.00**	**605,579,698.54**
EXPENDITURE			
Establishment Expenses	20	305,844,133.00	254,450,301.00
Other Administrative Expenses etc.	21	90,782,280.48	80,927,957.00
Expenditure on Grants,Subsidies etc.	22	-	-
Interest	23	-	-
Depreciation (Net Total at the year-end-corresponding to Schedule 8)		42,132,271.83	36,645,766.14
TOTAL (B)		**438,758,685.31**	**372,024,024.14**
Balance being excess of Income over Expenditure(A-B)		**187,473,874.69**	**233,555,674.40**
Transfer to Reserve Fund		-	40,000,000.00
Interest on GPF Fund transferred to GPF Fund		4,595,755.00	10,603,943.00
Interest on Institute Account refundable to DST		14,912,875.00	7,309,124.08
Interest on Pension Fund Trf to Pension Fund		24,097,103.00	40,230,196.00
Interest on Buding Fund FD trf to Building Fund		-	8,195,620.00
Interest on Donated Fund FD trf to Donated Fund		64,463.00	154,198.00
Transfer to/from General Reserve to Pension Fund		135,000,000.00	73,430,263.00
BALANCE BEING SURPLUS/DEFICIT CARRIED TO CORPUS/ CAPITAL FUND		**8,803,678.69**	**53,632,330.32**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

For: Singh Agarwal & Associates
Chartered Accountants

Mukesh Kumar Agarwal
FCA. DISA (ICAQ) Partner
Membership No- 073355
UDIN: **22073355ASILJZ7423**

(Ashutosh Shukla)
Accounts Officer

(Sandeep Kumar Shivhare)
Registrar

(Dr. Vandana Prasad)
Director

Place: Lucknow
Date: 13-Sep-2022

Receipt and Payment for the Period/ year ended 31.03.2022

Receipt	Current Year 2021-22	Previous Year 2020-21	Payment	Current Year 2021-22	Previous Year 2020-21
I. Opening Balances			I) Expenses		
a) Cash in hand	-		a) Establishment Expenses(Corresponding to Schedule 20)	305,844,133.00	254,450,301.70
b) Bank Balances		-	b) Administrative Expenses(Corresponding to Schedule 21)	90,782,280.48	80,927,957.00
i) In current accounts					
ii) In deposit accounts	423,072,825.32	390,553,712.23	II) Payments made against funds for various projects	21,878,525.85	30,871,795.14
iii) Endowment deposits			(Name of the fund or project should be shown along with		
iv) TDS on other grant	64,599.00	399,920.00	the particulars of payments made for each project)		
II. Grants Received			III) Investments and deposits made		
a) From Government of India	572,500,000.00	530,900,000.00	a) Out of Earmarked/Endowment funds	32,089,967.00	54,061,663.00
b) From State Government			b) Out of Own Funds (Investments-Others)		
c) From other sources(details)			IV. Expenditure on Fixed Assets & Capital Work-in-Progress		
(Grant for capital & revenue exp.	-		a) Purchase of Fixed Assets	74,063,989.60	39,274,640.08
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	32,089,967.00	54,061,663.00	b) To the State Government		
b) Own Funds (Utilized)			c) To other providers of funds		
IV. Interest Received			VI. Finance Charges (Interest)	53,368,085.00	-
a) On Bank deposits	14,912,875.00	15,504,744.08	VII. Other Payments (Specify)		
b) Loans, Advances etc.	412,878.00	606,062.00	i) Advances to Staff	246,497.00	331,973.00
i) Sale proceeds of Publications	-	-	ii) Earnest Money Refunded	-	-
ii) Miscellaneous Income	5,069,870.00	3,715,809.32	iii) Advances to Parties	249,214,973.80	46,251,367.22
iii) Sale of Services (Consultancy)	1,182,507.00	637,222.14	iv) Pension Fund	135,000,000.00	73,430,263.00
iv) Group Insurance			v) Transfer to reserve & surplus	(40,000,000.00)	40,000,000.00
VI. Amount Borrowed	-		VIII. Closing Balances	-	-
VII. Any other receipts (give details)	2,080,544.02	(4,039,818.76)	a) Cash in hand	-	-
			b) Bank Balances	-	-
Transfer from Reserve Fund	-	-	i) In current accounts	-	-
Net Receipt from Project	26,856,817.67	26,941,847.77	ii) In deposit accounts	-	-
		-	iii) Saving account	202,965,211.54	423,072,825.32
I) Recovery of Advances	46,583,340.22	21,256,222.68	iv)Endowment deposit account	-	-
ii) Earnest Money Deposit	787,340.00	2,200,000.00	v)TDS on other grant	159,899.96	64,599.00
iii) FDR Matured		-		-	-
TOTAL	**1,125,613,563.23**	**1,042,737,384.46**	**TOTAL**	**1,125,613,563.23**	**1,042,737,384.46**

For: Singh Agarwal & Associates
Chartered Accountants

Mukesh Kumar Agarwal
FCA. DISA (ICAQ) Partner
Membership No- 073355
UDIN: **22073355ASILJZ7423**

Place: Lucknow
Date: 13-Sep-2022

(Ashutosh Shukla)
Accounts Officer

(Sandeep Kumar Shivhare)
Registrar

(Dr. Vandana Prasad)
Director

Marine Fossil Park at Manendragarh, Surguja District, Chhattisgarh

Mandro Fossil Park at Mandro, Sahibganj District, Jharkhand

ISBN 0972-2726

Skill India
कौशल भारत-कुशल भारत

Digital India
Power To Empower

स्वच्छ भारत
एक कदम स्वच्छता की ओर