Annual Report
2022-23

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, and a great visionary, established the Institute as 'Institute of Palaeobotany' in the year 1946 to establish palaeobotany as a science in itself. He envisaged that palaeobotany as discipline has immense prospects in solving issues of origin and evolution of plant life, other geological issues including exploration of fossil fuels. Initially, the institute laid emphasis on studying the plant fossils across geological time span and their related aspects. However, institute has widened its research dimensions and significantly expanded its mandate in the year 2017, and was renamed as Birbal Sahni Institute of Palaeosciences, accommodating a more holistic approach with reinforced strategies to pursue palaeosciences under one roof and cater enhancing needs of the country amidst global change. 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. 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. BSIP has been continuously exploring and diversifying 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. Understanding the link(s) between climate change and vegetation during the Quaternary Period is also an important part of research at the BSIP. Origin and antiquity of ancient civilizations, human history and subsequent interventions are also being done using ancient DNA analysis. It is pertinent to mention that BSIP is working not only pan-India but also working in the polar regions (Arctic/Antarctic) as well.

It is one of those few premiere research institutes where state of the art facilities are available under one roof to facilitate high end research work. Institute is equipped with TL/OSL dating system, IRMS, ICP-MS, GC-MS, XRF, TFIR systems, for geochemical analyses, Palaeomagnetic Laboratory, Vertebrate Palaeontology and Preparation Laboratory, Ancient DNA laboratories, FE-SEM Laboratory, Confocal Laser and Raman Spectroscopy (CLSM) Laboratory and Industrial Micropalaeontology Laboratory. Institute is also looking forward for upcoming facilities namely Clumped Isotope Laboratory, Amber Analysis Laboratory and a Centre for Promotion of Geoheritage and Geotourism (CPGG) which will soon be functional. In addition, the Museum of the Institute offers a rich repository of fossils and also has a rich collection of literature on palaeosciences.

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 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.

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Published by

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Foreword

It is a matter of immense satisfaction to present the annual report (2022-2023) of the Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow, Uttar Pradesh. The Birbal Sahni Institute of Palaeosciences, Lucknow, is a premier research centre under the Department of Science and Technology, Government of India. The BSIP is a unique institution that is conducting research in a scientific discipline relating to the study of deep time and recent life and climate of our planet. As envisioned by the Founder of the institute, during the early phase the BSIP was generally carrying out research on palaeobotanical (study of fossil plants) and related aspects, apart from applied aspects linked to other associated life forms. However, with the advancement in the state of the art technology and scientific approaches, the institute evolved to pursue interdisciplinary and applied research. Presently, the prime objectives of the research are to understand the origin, evolution of life through time, palaeobiodiversity, palaeoenvironment, past civilization(s), and application of palaeosciences in hydrocarbon exploration. To achieve the desired research objectives, the scientific activities during the year 2022- 2023 have been reformulated and numerous crucial frontline research areas under the umbrella of eleven research themes: Understanding the origin and evolution of various life forms on our planet since 4.6 billion years; Understanding the biotic turnover(s) and abiotic signature(s) in different segments of Earth's history; Biotic assemblage(s), palaeobiogeographic scenario(s) and climatic event(s) during the Cretaceous and Palaeogene time slices; Understanding the Indian Monsoon viz-a-viz Himalayan upliftment; Utilization of biomarkers and coal petrology in hydrocarbon exploration; Dynamics of the Himalaya in terms of vegetation and climate change(s); Quaternary Monsoonal variability and climate change with reference to human evolution and migration; Understanding the Ocean dynamics from the marine records; Archaeobotany and Palaeogenomics; Astrobiology: Life under extreme environments; Establishment of sophisticated instrument(s) and development of analytical technique(s) to enhance research capabilities.

The concerted efforts being carried out by BSIPs scientific staff is reflected in the number and quality of publications in high-impact journals of international repute. Additionally, numerous scientists have received grants in the form of sponsored projects funded by national and international organizations such as DST-SERB, MoES, ONGC, NCPOR, University of Bristol (UK), INQUA, and various state agencies that have helped to generate funds and to conduct research on aspects other than the In-house research projects. Further, BSIP is involved in providing consultancy services to generate funds. The institute's scientists have been actively participating in national and international conferences, workshops, symposia, seminars to enhance the visibility of the scientific endeavours of the organization. In recent years, the BSIP has been actively undertaking initiatives towards promotion of Geoheritage conservation across the country. In this regard, the institute has conceptualized a fossil park at Mandro (District Sahibganj, Jharkhand) as part of a collaboration with the Forest Department, Jharkhand. The Mandro Fossil Park including "Rajmahal Fossil Museum

& Interpretation Centre" was inaugurated by Honourable Chief Minister of Jharkhand (Mr. Hemant Soren) on the 30th June 2022. In addition, BSIP has also provided expertise in the restoration works of fossil wood at Khadir Island (Kutch District, Gujarat). Further, various teams of scientists from BSIP have been actively involved in discussions with central and state government agencies to further the cause of Geoconservation in terms of development of fossils parks. For instance, the Marine Fossil Park (Manendragarh District, Chhattisgarh State), Salkhan Fossil Park (Sonebhadra District, Uttar Pradesh), Bagh Dinosaur National Park (Dhar District, Madhya Pradesh) and Phase-3 Development of Research Center & Dinosaur Fossil Park at Balasinor (Gujarat) to name a few.

BSIP has come a long way since its inception and has made radical changes in its modus operandi. In the financial year 2022-2023, BSIP has signed MoUs with various organizations such as Atomic Minerals Directorate (AMD) for Exploration and Research, (Hyderabad); Indian Institute of Geomagnetism (IIG), Navi Mumbai and Oil India Limited, Assam. Further, ongoing MoUs with Geological Survey of India (GSI) and Oil and Natural Gas Corporation (ONGC) and other premier institutions are assisting in knowledge sharing while solving the core research objectives apart from generating financial support. In addition, a joint BSIP-AcSIR Ph.D. program being run at the institute has been beneficial for both research scholars and supervising scientists of the organization.

In lines with the expanded research mandate, the construction of a multi-storey building of the institute is under way. The construction is aptly timed and shall benefit the BSIPs fraternity in terms of setting up of new state-of-the-art laboratories at its premises in the near future while accommodating an increasing number of scientists and research students. As the institute has adopted an integrated and a multi-disciplinary approach, thus, to fulfill its aims and objectives, several analytical facilities are in the process of development. For instance, the institute has placed the procurement order for the state-of-the-art Micro-Computed Tomography (Micro-CT) equipment as part of developing a Micro-CT National facility at BSIP to help in 3D reconstruction of fossil and geological samples. Once established it will be a cost-effective method for data archiving, data sharing and for public outreach. The institute has also placed an order for procurement of an IRMS and a Gas bench Peripheral as an effort to augment its existing analytical facility. In addition, the institute is in the process of development of a state-of-the-art Laboratory for the Coal Quality Assessment to cater to the hydrocarbon industry.

Collective efforts of scientific, technical, and administrative staff 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 2022-2023. 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 (GB) of the Institute and Research Advisory Council (RAC) for 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 the tenure. Hopefully, that with their constant efforts the institute's progress in all facets will continue in the similar manner.

Mahesh G. Thakkar

(Director)

Organizational Highlights

- The institute scientists have published 100 research articles in internationally reputed journals with a calculated average impact factor of 5 per scientist and a total impact factor of 307.72.
- Twenty sponsored projects have been undertaken by the Institute's scientists funded by national and international organizations such as DST-SERB, MoES, ONGC, NCPOR, University of Bristol (UK), INQUA, and various state agencies.
- As per the Govt. of India's Swachhata Action Plan 2022-2023, a fortnightly celebration of Swachhata Pakhwada with series of events such as Swachhata Pledge, Quiz Competition, Plantation Programme, and cleanliness drive were conducted from 01st – 15th May, 2022 at BSIP.
- Under the Govt. of India's "Har Ghar Tiranga" Programme a series of events such as Oral lecture, Poem recitation '*Kavita path*' were organized at BSIP on the 14th June, 2022.
- As part of the institute's Geoheritage conservation efforts, the BSIP conceptualized a fossil park at Mandro (District Sahibganj, Jharkhand) as part of a collaboration with the Forest Department, Jharkhand. The Mandro Fossil Park including "*Rajmahal Fossil Museum & Interpretation Centre*" was inaugurated by Honourable Chief Minister of Jharkhand (Mr. Hemant Soren) on the 30th June, 2022.
- On the Foundation Day (10th September, 2022) of the Institute, the first issue of a Hindi magazine "पुराविज्ञान स्मारिका" was released.
- As part of Institute's outreach programme, more than hundred students from numerous schools/colleges/ universities in Lucknow and adjoining areas visited BSIP's Museum and various state-of-the-art laboratory facilities.
- As per the directives of the Ministry of Women and Child Development, Govt. of India, various events were organized on the theme "Awareness program for Women empowerment and Security"from 25th November to 10th December, 2022 in the BSIPs premises.
- A High-End Workshop (KARYASHALA) on "Disaster and Climate-Resilient Pathways: Adaptation, Mitigation and Sustainable Development" as part of the SERB-Accelerate Vigyan Scheme was organized at BSIP from 07th to 13thDecember, 2022.
- The 7th PAMC-Geosciences meeting of the Ministry of Earth Sciences (MoES) was held from 23rd to 24th February, 2023 at BSIP.
- The institute has placed an order for state-of-the-art Micro-Computed Tomography (Micro-CT) equipment as part of developing a Micro-CT National facility at BSIP to help in 3D reconstruction of fossil and geological samples. Once established it will be a cost-effective method for data archiving, data sharing and for public outreach.
- The institute has also ordered an IRMS and a Gas bench Peripheral as an effort to augment its existing analytical facility.
- The institute is in the process of development of a state-of-the-art Laboratory for the Coal Quality Assessment to cater to the hydrocarbon industry.
- The construction of the multi-storey building of the institute is under way, and is aptly timed, in line with the expanded research mandate of the BSIP.

Research Highlights

- Shale and Limestone samples from Rohtasgarh (Madhya Pradesh) were analysed to assess their hydrocarbon potential. The organic richness, kerogen type, and thermal maturity of Rohtasgarh limestone in the study area signify poor to fair hydrocarbon generation potential.

- A study delineated the Permian eustatic changes across the Gondwana for better inter-regional correlations and palaeogeographic reconstructions. It presented a palaeodepositional model, emphasizing a diverse floral assemblage during the lower Barakar Formation, leading to thick coal seams in the Rajhara Colliery. The data revealed a transition from freshwater environment at the top (RDB-1) to a slightly freshwater-brackish environment below. The study confirms dense forests and swampy vegetation during the deposition of the Barakar Formation with a subsequent marine incursion.

- A study on the Ordovician calcareous siltstones of Takche Formation, Spiti region of Tethyan Himalaya, India, identified non-calcified marine macroalgae, brachiopods, gastropods, tentaculitoids, and few trace fossils. The study represents the first diversified macroalgal records from the Ordovician strata in the Tethyan realm of the Indian subcontinent.

- First report of source-specific terpenoid biomarkers from Bikaner-Nagaur Basin, western India. A significant chemotaxonomic marker for *Araucaria* is also reported which provided clues to conifer elements in the Indian Paleogene rainforests.

- A study analyzed early Paleogene lignite from western Rajasthan, previously believed to be dominated by angiosperms. The study demonstrated a significant role of gymnosperms in the formation of peat evidenced by tracheidal pits, mega-spores, and specific biomarker compounds. Some analysis speculated the occurrence of wild fires in the depositional setting.

- *Ficus* fossils recovered from the early Paleogene in India emphasized the Indian Plate's role in the early diversification of this plant genus. The study suggested its major proliferation between the Paleocene and Miocene.

- Legumes are the important food crops and understanding their survival in globally warm future climate is crucial. A legume fruit from ~56 million years old sediments of Meghalaya was unearthed. This finding is important in understanding the evolutionary ecology of legumes when Earth was much warmer and CO_2 concentration was >1000 ppm than present.

- The oldest record of alpheid shrimps in Asia traced back to the Miocene by ~22 million years. The co-occurring microbiota record consisted of a variety of fish, and a diverse assemblage of ostracods. Chemical analysis of the sediments suggests a shallow marine environment. The investigation provided the oldest fossil evidence on the co-occurrence of *Alpheus* and gobiids (based on otoliths) that strongly advocated that the mutualistic association within these animal groups had developed by the Aquitanian.

- The oxygen-isotope analysis of Miocene bivalves from the Quilon Formation, southwest India revealed regular $\delta^{18}O$ cycles indicating seasonal temperature and monsoonal shifts. The $\delta^{18}O$ values suggested distinct wet and dry seasons. A mixing model showed ~70–80% freshwater discharge in the dry season. The data clearly indicated the presence of a monsoon system in the southwest of India during the Miocene.

- The Asian monsoon shows a weaker trend during the Little Ice Age (LIA) and relatively stronger during the Medieval Climate Anomaly (MCA). The tree-ring isotopic data shows that monsoon activity has decreased in the Indian Himalayan Region (IHR) during the last several decades whereas mean annual precipitation has increased in Tibet.

- Multi-proxy evidence supports the idea that a regional sea level fall at Lothal (ancient Harappan dockyard of coastal Gujarat) might have adversely impacted ancient maritime Harappan trade and contributed to the declining/decentralizing Indus Civilization during the end part of its mature phase.

- A study analyzed the start and growth of agricultural practices in varied regions of India using palynological data. It suggested agriculture began around 9000 yr BP in central India, 8500 to 5300 yr BP in the Himalayas, 13,000 yr BP in the Ganga Plain and 12,450 and 10,810 yr BP in Northeast India.

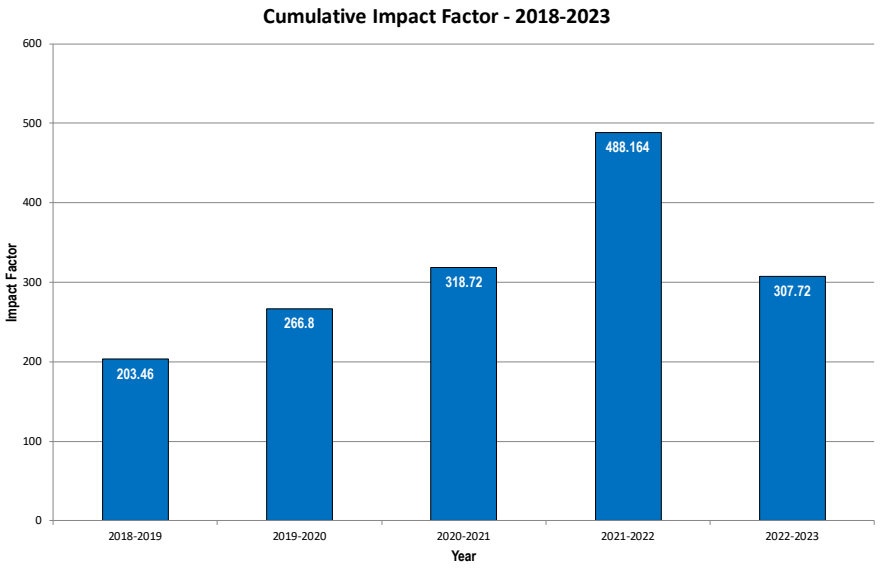
- Using species distribution modelling, the past, present and future distributions of two key mangrove species in Indian Coastal wetlands were assessed. Projections show a decrease in total mangrove habitat by 2050 and 20270 due to climate change, with species moving inland. This highlights the need for species-specific restoration plans to address climate change impacts on these crucial species in India.

- A study evaluated the importance and threats to the Quaternary Karewa Group sediments in the Kashmir Valley and deposits in the Ladakh Trans-Himalaya, emphasizing their potential as geotourism sites and sources of palaeoclimatic data related to Himalayan tectonics. The article specifically examined several Quaternary geosites in Jammu and Kashmir (J & K) and Ladakh, emphasizing their significance and current vulnerabilities.

- Researchers analyzed the mitochondrial DNA of 999 individuals from various Nepali ethnic groups to uncover their maternal ancestry. The study revealed that the majority of these populations have maternal origins from lowland populations rather than highlanders. This research filled gaps regarding Nepal's historical demographic events, suggesting that carriers of certain mitochondrial lineages might have migrated into Nepal via Southeast Tibet approximately 3.8 to 6 thousand years ago.

- A climatic study of the Bengal region spanning the last ~10,200 years revealed variations in the Indian Summer Monsoon (ISM) patterns. From ~10.2-5.6 ka, the region experienced strong ISM rains, which weakened around 4.3 ka. A resurgence occurred between ~3.7 and 2.1 ka before transitioning to a drier phase. The ISM became strong again from 0.2–0.1 ka. Comparisons with existing data suggest Holocene ISM variability over the Bay of Bengal is consistent on a millennia scale, but fine-scale differences may arise from varied proxy responses and dating uncertainties.

- A tree-ring study in the Kumaon-Garhwal Himalaya (KGH) presented a 508-year record (1508-2015 CE) of summer drought variability using stable oxygen isotopes (δ^{18}OTR). Recent drought patterns resemble early historic drought intensities. There is a noticeable decline in the strength of the Indian Summer Monsoon over the KGH's high altitudes.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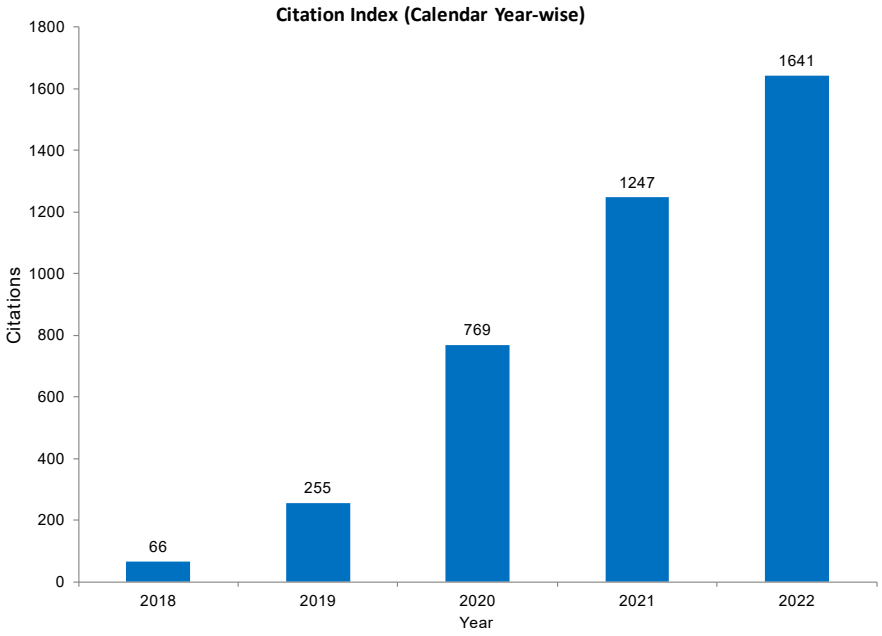
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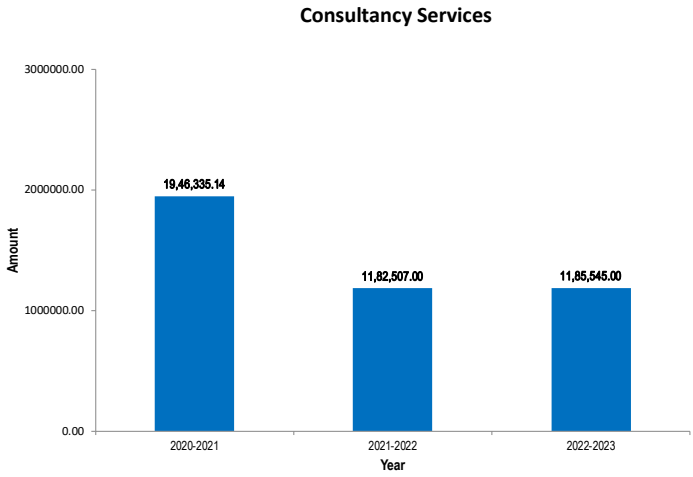
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2021-2022
2022-2023
Year

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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

SEDIMENTOLOGY / STRATIGRAPHY

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

LUMINESCENCE DATING

CONFOCAL LASER SCANNING MICROSCOPY WITH RAMAN SPECTROSCOPY

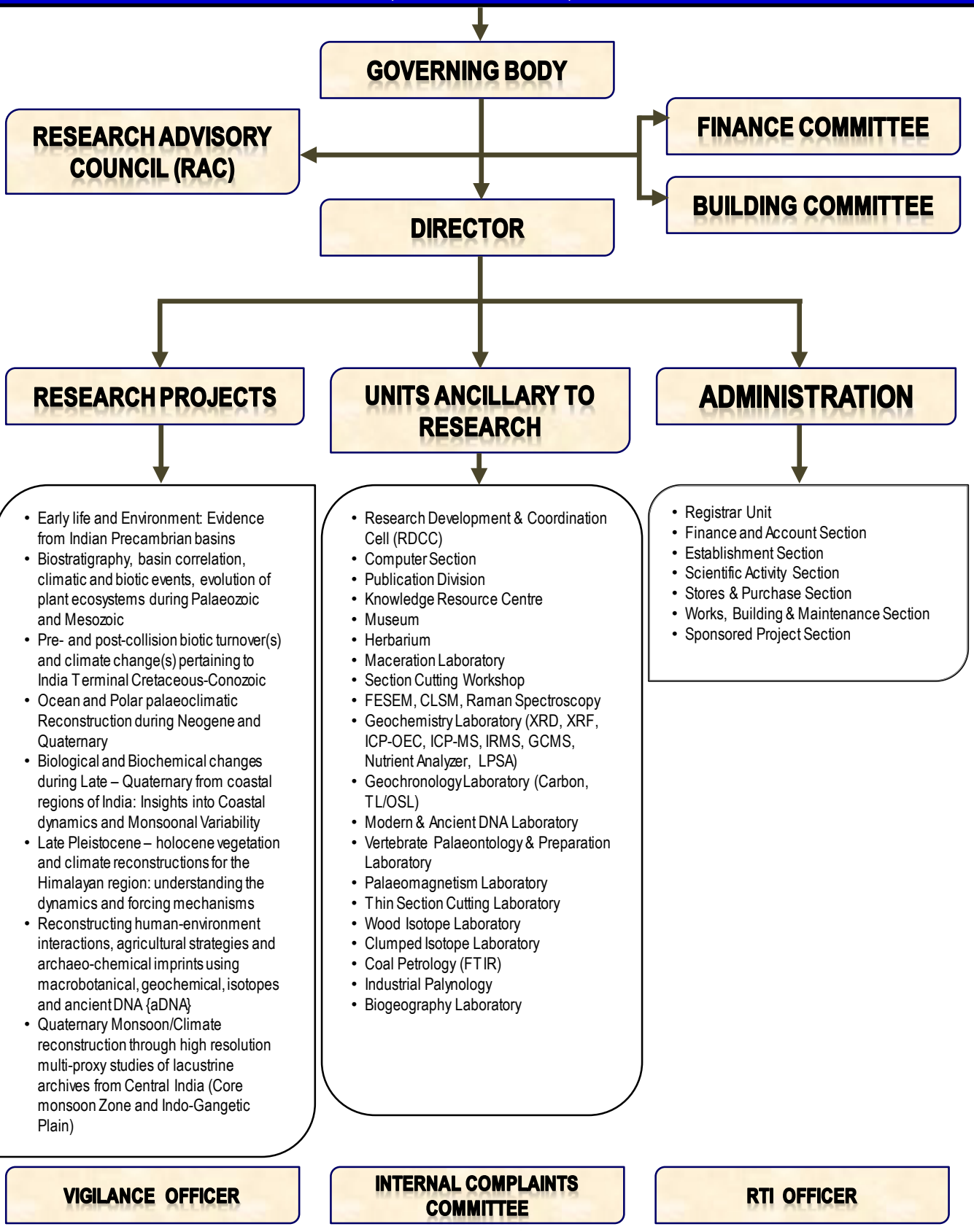
FIELD EMISSION SCANNING ELECTRON MICROSCOPY

ORGANIZATIONAL STRUCTURE

Department of Science and Technology (DST)

Birbal Sahni Institute of Palaeosciences (BSIP)

(Autonomous Institute)



RESEARCH

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

Coordinator: Mukund Sharma (Scientist G) (upto 31/12/2022)
Veeru Kant Singh (Scientist E) (w.e.f. 01/01/2023)

Co-coordinator: Veeru Kant Singh (Scientist E) (upto 31/12/2022)
Santosh K. Pandey (Scientist D) (w.e.f. 01/01/2023)

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

Under the Precambrian palaeobiology the key questions, viz. origins and evolution of early life, as well as the appearance of eukaryotes, multicellular organisms, and their development into complex metaphytes and metazoan forms, are studied in the Indian Precambrian successions. Archaean age (4000-2500) stromatolites are recorded from the Dharwar Craton of India. The antiquity of microscopic and megascopic fossils remains are investigated from the sediments of the Raipur Group of Chhattisgarh and Bhander Group of the Vindhyan Supergroup of central India. The Ediacaran Complex Acanthomorphic Palynoflora (ECAP), which is 635–538 million years old, is investigated from the Lesser Himalaya. Studies on the evolution of oxygen during the Proterozoic (2500-538 million years before present) and its role in eukaryotic diversification through robust geochemical studies (Trace Elements, REE, TOC and carbon isotope and where possible, sulphur isotope) have been carried out. Sediments of the Cuddapah and Vindhyan Supergroup are investigated to understand how oxygen evolved during the Proterozoic and its involvement in eukaryotic evolution. Additional studies on the hydro-geochemistry of the three different Trans-Himalayan hot spring sites in the Ladakh region have also been performed to understand the distribution of major cations, anions, and trace elements to understand the life forms and associated biogeochemical processes in the extreme environment from the Modern analogues.

PERSONNEL INVOLVED

Team Members: A.H. Ansari (Scientist D), Yogmaya Shukla (Scientist C), Arvind K. Singh (Scientist C), Gurumurthy G.P. (Scientist C)
Technical Support Member: Shivalee Srivastava (TA 'B') & Archana Sonker (TA 'A')
Research Associate: Shamim Ahmad (up to August 2022), Bandana Shukla
Research Scholars: Abhinav Jain, Divya Singh, Yogesh Kumar, Kumail Ahmad and Faizan Ahmad Khan.

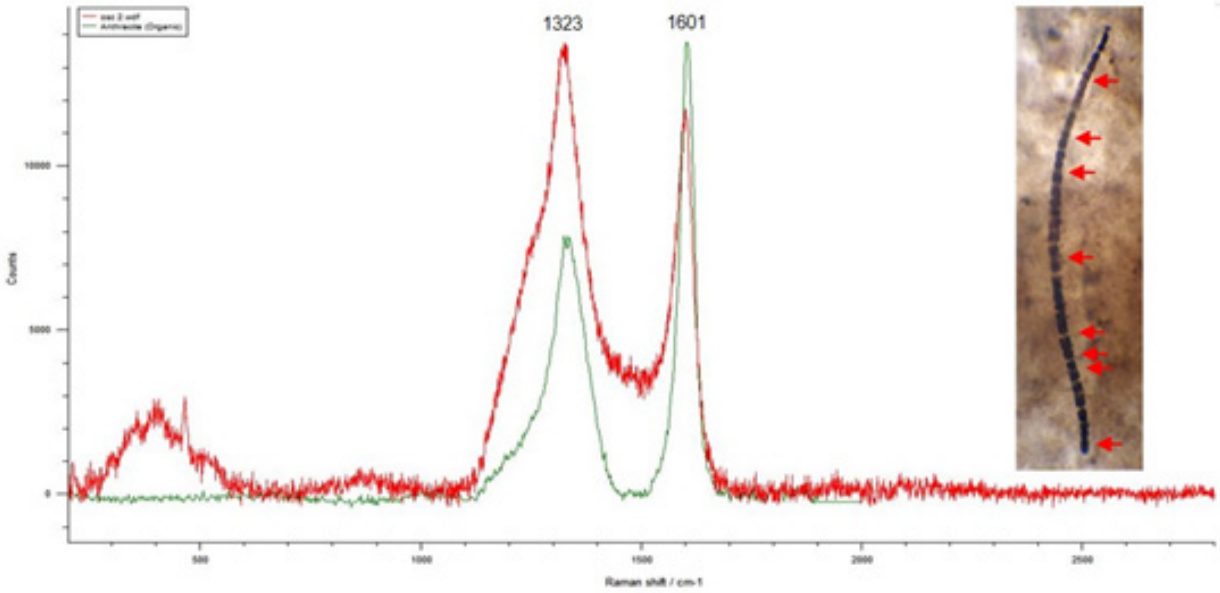


Fig. 1 - Micro-Raman spectra of the Saradih Limestone microbiota *Cephalophytarion variable* reflecting the concentration of D (disorder) and G (Graphite) band.

SIGNIFICANT FINDINGS

To understand the chemistry with morphology of microscopic fossils, Laser- Raman Spectroscopy (LRS) was performed on the chert-permineralized microbiota of the Neoproterozoic Raipur Group, Chhattisgarh Supergroup. Under light microscopy, fossils appeared as arrangements of pyrite framboids. Based on cell arrangements and apices patterns, these fossils are interpreted as *Biocatenoides, Cephalophytarion, Cyanonema, Filiconstrictosus, Heliconema, Oscillatoriopsis* and *Veteronostocale* belonging to Oscillatoriaceae and Nostocaceae family of Cyanobacteria. Kerogenous characterization of cell walls through LRS demonstrates that cells are made up of carbonaceous material (anthracite, D band = 1334 cm-1 and G band = 1601 cm-1) (Fig. 1). Further the Raman Index of Preservation (RIP) value of the fossils is comparable to the Neoproterozoic Skillogalee Dolomite (~770 Ma). Such characterization is a new addition to the growing knowledge on microfossils.

Dickinsonia tenuis, an important Ediacaran fossil, described from the Maihar Sandstone by Retallack *et al.* (2021) was re-investigated in the field to ascertain the biogenicity. Field observations, outcrop features and laboratory analyses [X-Ray Diffraction (XRD), Raman Spectroscopy] do not support the biogenicity and syngenecity of reported fossil (Fig. 2). Based on this reinvestigation, the inferences drawn about the age of the Maihar Sandstone and the palaeogeographic position of India by Retallack *et al.* (2021) are therefore considered invalid. In fact, Indian *Dickinsonia* specimen described by Retallack *et al.* (2021) is a left-over impression of a *fallen beehive* which is further proved by the detailed Raman Spectroscopy and X-Ray Diffraction (XRD) analyses (Fig. 3).

To understand the redox conditions of Palaeoproterozoic Ocean as recorded in the Vempalle and Tadpatri formations, lower Cuddapah Basin, Peninsular India was investigated. The Chemical Index of Alteration (CIA) values of sediments suggest moderate chemical weathering for the Gulcheru Quartzites, Vempalle and Tadpatri formations. Further the present study demonstrates that the sediments are predominantly derived from the felsic sources with subordinate contribution from mafic sources. The Vempalle and Tadpatri formations sedimentation occurred under anoxic depositional conditions (Fig. 4).

A total of ten (10) lithofacies were shown to exist within the Vempalle Formation based on sedimentological study done in the field and laboratory data that revealed an inner-outer mixed siliciclastic-carbonate ramp setting with sporadic influence from tidal and storm currents. Additionally, four types of stromatolitic facies namely; (a) Stratifera/crinkled laminite type, (b) Columnar (Cylindrical, Branched or Conical) type, (c) Domal/cabbage headed type, (d) Spherical or elliptical type, have been identified, within carbonate unit of Vempalle Succession. The association of these stromatolitic facies types indicate their deposition in a shallow carbonate platform setup with depositional condition varying from subtidal, intertidal and supratidal zones (Fig. 5).

New locality of least altered, well-developed, and preserved Neoarchaean stromatolites (organosedimentary structures) from the Joldhal Formation (=Aleshpur Formation) exposed near Shanti Sagara Lake (Sulekere), Davangere

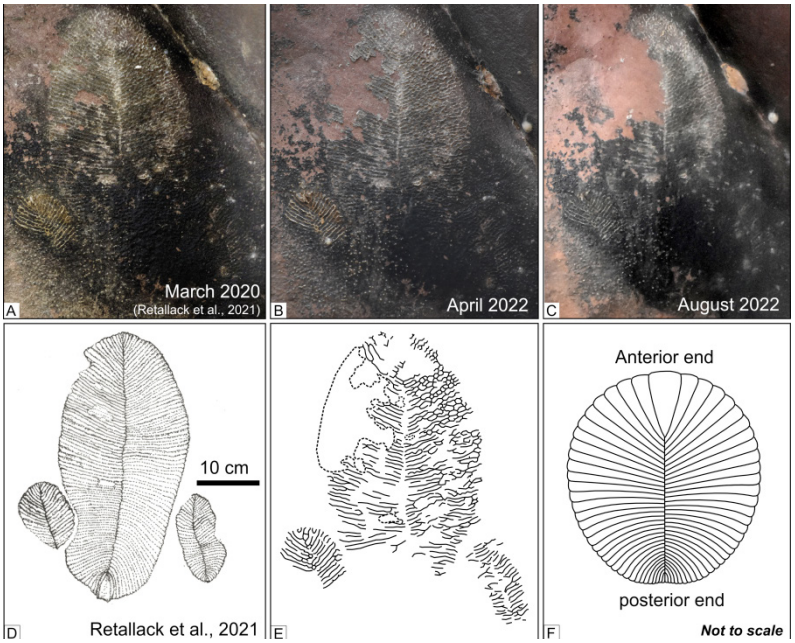


Fig. 2 - (A) *Dickinsonia* by Retallack *et al.* (2021): March 2020; (B) photograph: 10th April 2022 (beeswax eroded from the left side); (C) Same re-photographed: 22nd August 2022); (D) Reconstruction of '*Dickinsonia*': Retallack *et al.* (2021); (E) Reconstruction of '*Dickinsonia*': Pandey *et al.* (2023); (F) Original sketch of '*Dickinsonia*' (Ivantsov & Zakrevskaya, 2022).

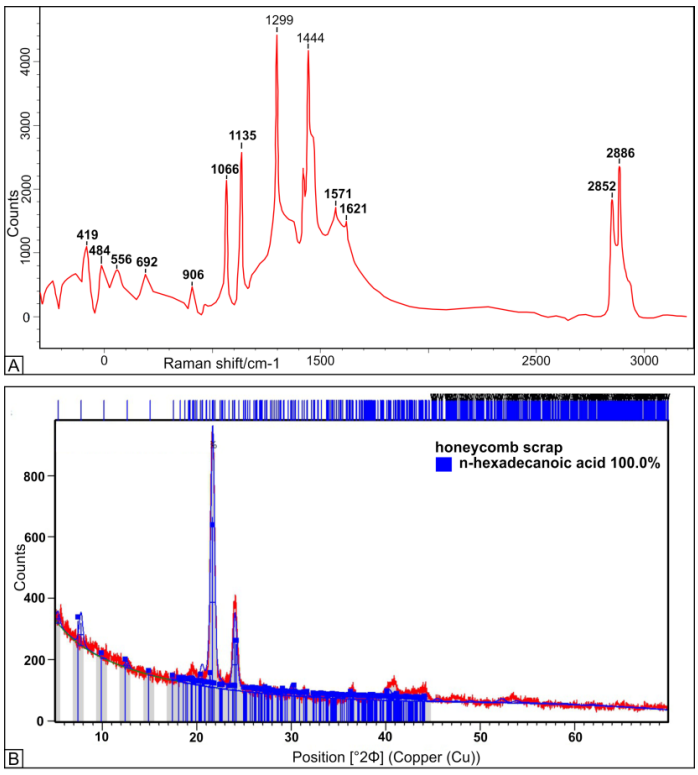


Fig. 3 - (A) Micro-Raman spectra of the waxy material reflecting the concentration of beeswax and related spectra; (B) X-Ray diffractograms for beeswax possess hexadecenoic acid (Palmitic acid).

District, Karnataka has been recorded. Stromatolite hosting carbonate rocks belong to the part of the Archaean age Shimoga Schist Belt of the Dharwar Supergroup (3000-2600 Ma) of India (Fig. 6).

Studies on the hydro-geochemistry of the three different Trans-Himalayan hot spring sites in the Ladakh region have been performed to understand the distribution of major cations, anions and trace elements. The result reveals that magmatic fluid inputs were principally responsible for controlling the high concentrations of B, Na, Cl, K, and W in the hot spring waters. B and W are frequently

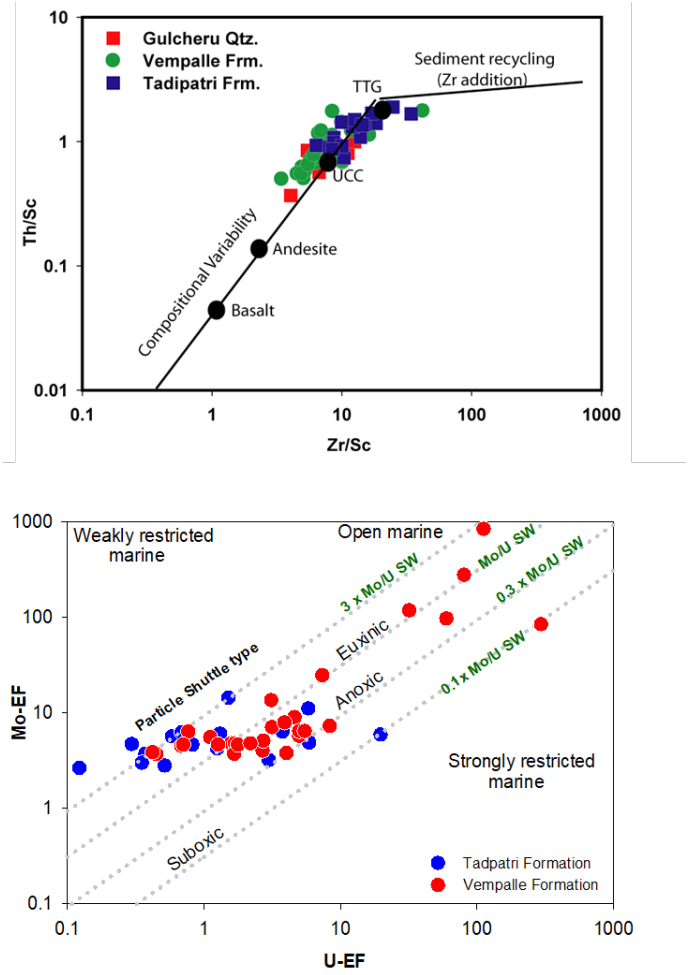


Fig. 4 - (a) Th/Sc vs. Zr/Sc (McLennan *et al.*, 1993) shows minimal influence of heavy minerals. (b) U_{EF} vs. Mo_{EF} for Vempalle and Tadpatri Shale samples discriminating the redox environments. Note the sequestration of U than Mo in the Vempalle and Tadpatri sediments indicating rapid removal and restricted supply of Mo.

found concentrated in high-temperature geothermal waters connected to the formation of mafic to felsic arc magma due to subduction. However, information on where these elements come from and how they are transported from such hydrothermal systems is scanty and unclear. The Trans-Himalaya presents a unique opportunity to examine how continental collision generates the high B and W contents in geothermal fluids because it is the only active continental collision location in the world. Additionally, the highest Cl and B concentrations for the Trans-Himalayan hotspring waters were found in this study.

PROJECT OUTCOME

Publications in SCI (Science Citation Index) Journals

1. Ansari AH 2023. Detection of organic matter on Mars, results from various Mars missions, challenges, and future strategy: A review. Frontiers in Astronomy and Space Sciences 10: 30. doi: 10.3389/fspas.2023.1075052 (IF - 4.055).
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: 72-82 (IF - 3.271).
3. Ashutosh A, Samal AK, Singh VK, Sharma M & Srivastava RK 2022. Geochemistry and Petrogenesis of Mesoproterozoic mafic intrusive rocks from the Singhora and Chandarpur groups, eastern Chhattisgarh Basin, Bastar Craton: Possible implication for the time of sedimentation. Journal of the Geological Society of India 98: 1486-1496 (IF - 1.466).
4. Bhan U, Boruah A, Maurya DS, Rai SK, Goswami L & Singh VK 2022. Mineralogy, organic richness and macerated microbial studies of the Rohtasgarh Shales in the Vindhyan Basin, India: Implications for gas generation potential. Journal of the Geological Society of India 98: 567-575 (IF - 1.466).
5. Colleps C, McKenzie N, Beek P, Guenthner W, Sharma M, Nordsvan A & Stockli D 2022. Assessing the long-term low-temperature thermal evolution

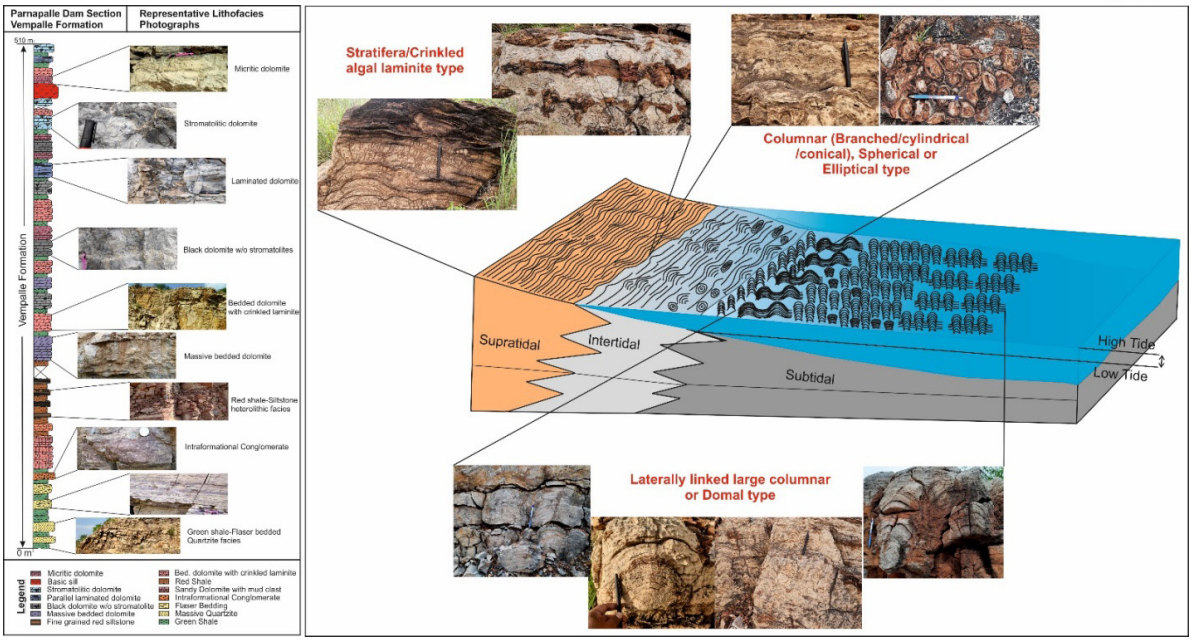


Fig. 5 - Facies litholog showing total of ten lithofacies in Vempalle Formation on the left and schematic block diagram depicting depositional model and distribution of various stromatolitic facies on Vempalle carbonate platform.

of the central Indian Bundelkhand craton with a complex apatite and zircon (U-Th)/He dataset. American Journal of Science 322: 1089-1123 (IF-5.620).

6. Kumar Y, Sharma M & Goswami S 2022. Possible Ediacaran discs from the Paniam Quartzite, Kurnool Group, south India. Current Science 122: 885-887 (IF – 1.169).
7. Pandey SK, Ahmad S & Sharma M 2023. *Dickinsonia tenuis* reported by Retallack *et al.* 2021 is not a fossil, instead an impression of an extant 'fallen beehive'. Journal of the Geological Society of India 99: 311-316 (IF - 1.466).
8. Singh VK & Sharma M 2022. New material of Carbonaceous compressions from the ~1.5 Ga Singhora Group, Chhattisgarh Supergroup, India, and their Interpretation as Benthic Algae. Frontiers in Earth Science 10. DOI: 10.3389/feart.2022.825430 (IF – 3.661).

Book Chapters/Memoirs/Bulletins

1. Gurumurthy GP, Tripti M, Balakrishna K, Riotte J, Audry S & Udayashankar HN 2023. Geochemical characterization of suspended sediments in the Nethravati Estuary, Southwest Coast of India: Insights to redox processess, metal sorption and pollution aspect. *In:* Coasts, Estuaries and Lakes: Implications for Sustainable Development. Jayaraju N, Sreenivasulu G, Madakka M & Manjulatha M (Editors) - Springer Nature. DOI: - https://doi.org/10.1007/978-3-031-21644-2_7.

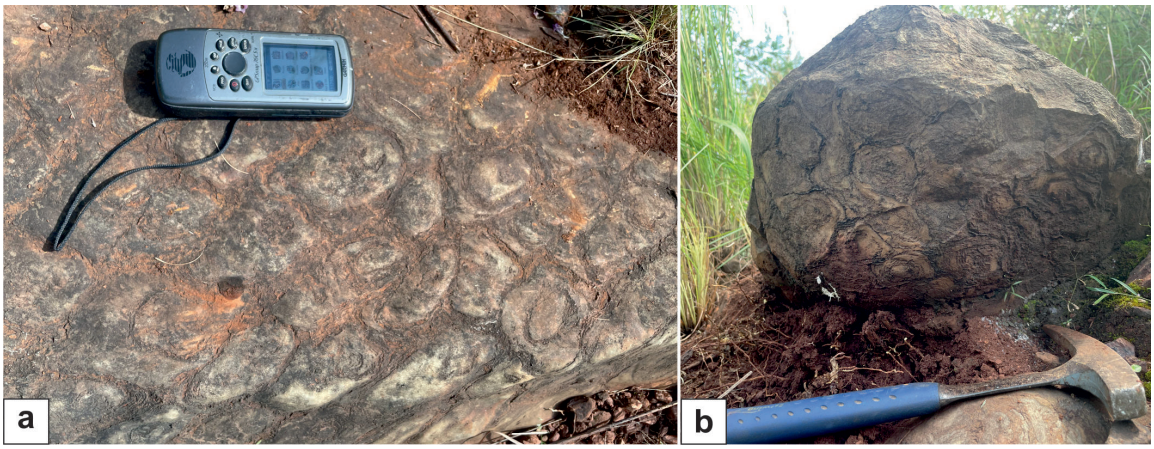


Fig. 6 - Archaean (>2.6 Ga) stromatolites from the Aleshpur Formation, Shimoga Schist Belt, Dharwar Craton, India.

PH.D. PROGRAMME

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: Awarded (January 2023)

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: Submitted (February 2023)

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, Karnatka. Status: Ongoing.

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: Ongoing.

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: Ongoing.

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: Ongoing. *

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: Ongoing.

Faizan Ahmed Khan (2022). Geochemical evolution of Earth's hydrospheric environment during the Neoarchaean and Paleoproterozoic Era: Evidences from Dharwar Craton, under the Supervision of **Gurumurthy GP (BSIP)**, Academy of Scientific and Innovative Research (AcSIR), Ghaziabad. Status: Ongoing.

Kumail Ahmad (2022). Sedimentological and geochemical evolution of argillaceous and carbonate successions from Cuddapah Basin, under the supervision of **Dr Arvind K Singh (BSIP)** registered with Academy of Scientific and Innovative Research (AcSIR). Status: Ongoing.

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 (up to 31/12/2022), Veeru Kant Singh, S.K. Pandey, A.H. Ansari, Arvind K. Singh, Bandana Shukla & Yogesh Kumar

A set of 256 samples of SK-A well, provided by the Oil and Natural Gas Corporation Limited (ONGC) was processed and analyzed. Palaeobiological investigations, viz. scanning, photodocumentation, identification of extracted organic matter is in progress using high-resolution optical microscope. Additionally, we conducted a field work in parts of Rajasthan and Madhya Pradesh for the collections of outcrop samples. Palaeobiological investigations on the outcrop samples are under progress.

SP 1.2: **Ediacaran Complex Acanthomorph Palynoflora (ECAP) based biostratigraphy of the Krol Belt of the Lesser Himalaya, Northern India: Significance for global correlation** (Sponsored by 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 Lesser Himalaya to understand

the origin, antiquity, affinity, evolution, diversification, and potential refinement of biostratigraphic zonation during the Ediacaran Period. Petrographic thin sections of silicified black cherts of the Krol-A Formation of the Pachmunda Syncline exposed in Solan Valley of the Himachal Pradesh have been studied using transmitted light microscope. Microscopic observations of chert resulted excellent preservation of Early Ediacaran Complex Acanthomorphs Palynoflora (ECAP). Photo documentation, Taxonomic identification and their interpretations are under progress.

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.

The study investigates the environmental magnetic and geochemical records preserved in the deep marine sediments of the northeastern Arabian Sea to elucidate the erosion history of the western Himalayas and its link with the prevailing hydroclimatic conditions since the late Miocene. The results reveal that the hydroclimatic conditions were predominantly arid during the late Miocene, except humid intervals from 6.1 Ma to 5.6 Ma. The humid climate conditions in the Indus River Basin returned during the mid-Pliocene which continued to the Pleistocene with an intense chemical weathering regime from 1.9 Ma to 1.2 Ma. The dominant sediment source to the northeastern Arabian Sea at Site U1457 during the late Miocene and the Pliocene was the Indus River, while during the Pleistocene mixed sediments brought by the Indus River and the Peninsular Indian rivers were observed. The sediment contribution from chemically less altered mafic source (the Deccan basalts) increased between 1.2 Ma and 0.2 Ma, possibly linked to weak Indian Summer Monsoon. The summer monsoon wind strength and associated shift in the Inter-Tropical Convergence Zone (ITCZ) influenced the dominant sediment provenance at Site U1457 of the Laxmi Basin.

SP 1.4: **Biomolecules preservation in modern and relict Ladakh hotspring deposits, with implications for finding life on Mars** (Sponsored by SERB, New Delhi; No: CRG/2022/000460 w.e.f. 23.02.2023).

Investigator: A.H. Ansari

This project aims to investigate the Trans-Himalayan geothermal sites of the Ladakh region which are lying at an altitude ranging between 3000 to 4400 m above mean sea level. These hot springs in Ladakh are considered unique sites for astrobiological research because of their high elevation, cold desert environment, high UV exposure, lower surface boiling temperature, which collectively simulate a more similar environment currently existing on Mars. These characteristics are particularly fascinating for studying the numerous factors that may impact the formation and diagenetic evolution of hotspring deposits, as well as the preservation of organics.

CP 1.1: **Veeru Kant Singh** [& Ankur Ashutosh, Amiya Kumar Samal & Rajesh Kumar Srivastava, Banaras Hindu University, Varanasi]

Mesoproterozoic mafic intrusions in intrusive rocks exposed in the Singhora and Chandarpur Group of rocks in the eastern part of the Chhattisgarh Basin, their petrological and geochemical characteristics to understand the nature and genesis and likely implication on the time of sedimentation. They chiefly consist of clinopyroxene and plagioclase and show ophitic texture. Geochemically, they are sub-alkaline basalt to basaltic andesite and strongly supports cogenetic nature of mafic intrusives from both the groups. Further, geochemical analysis supports an SZLM (subduction zone-modified lithospheric mantle) source for these mafic intrusions. Low CaO/MgO (1.20-1.64), intermediate FeO/MnO (45.71-71.80), positive PX (1.10-5.89), and high values of FC3MS (0.58-1.35) and FCKANTMS (0.59-0.93) explicitly support derivation of the primary melt from an olivine-poor and pyroxene-rich (pyroxenite type) source. The observed geochemical characteristics and published age data on these mafic intrusions indicate that sediments of both the stratigraphic units are older than ca. 1.42 Ga.

CP 1.2: **Arvind K. Singh** [& Anju Saxena, Srikanta Murthy, SSK Pillai, BSIP]

Process based sedimentology of Talchir and Barakar formations exposed at Manendragarh and Kuju sections, Damodar Valley for palaeoenvironmental analysis. Very fine to fine-grained, olive-green shale with intermittent storm sand beds having gutters are observed directly over Archaean gneissic basement at Manendragarh whereas a total of six lithofacies have been identified at Kuju section from lower Barakar Formation. A cyclic fining upward character with concave up lenticular channel deposit comprising conglomeratic unit at base and shaly top has been observed suggesting low sinuous channel fill deposit for these sediments.

CP 1.3: Arvind K. Singh [& Mohd. Arif, BSIP]

The composite intertrappean deposit comprising three intervening intertrappean beds within four basaltic lava flows, exposed at Gujri-Dugni Village near Dhamnod, MP, was studied for their sedimentary attributes in order to infer palaeoenvironmental and palaeoclimatic information. Out of three intertrappean units, five microfacies have been identified namely, (a) fossiliferous argillaceous limestone; (b) silty carbonaceous mud with fossils; (c) Limy fossiliferous shale; (d) nodular calcrete layer; and (e) carbonaceous mud. Under microscopic observation the lowermost microfacies has yielded fossils and bioclasts of bivalves (molluscs) whereas limy fossiliferous shale exhibits presence of ostracods and charophytes. Considering the sedimentary attributes of lithounits and fossil occurrence it is suggested that these three intertrappean units were deposited in a palustrine/ lacustrine environment.

CP 1.4 Gurumurthy GP [& Jyoti Srivastava BSIP, Lucknow]

An integrated biotic (palynological analysis) and abiotic proxy (sediment chemistry, clay mineral assemblages and grain size end member (EM) analysis) records in a chronologically constrained sedimentary sequence from the southeastern part of the Mahanadi River Delta have been used to reconstruct the hydroclimate for the past 2600 years. The Mahanadi Delta sediments are primarily derived from felsic rock source possibly derived from granites or granulites. The dominance of herbaceous taxa, high aridity index and deposition of fine grain (EM1) sediment possibly suggest a relatively cold and dry climate in the study region during ~2600–2100 cal yr BP which corresponds to the Iron Age Cold Period (IACP). Presence of diverse mangrove and tree taxa, deposition of coarser sediment (EM3) and relatively high abundance of secondary clay minerals possibly indicate high precipitation associated with the Roman Warm Period (RWP, ~2100–1800 cal yr BP). A decline in mangroves indicates a relatively drier climate which coincides with the Dark Age Cold Period (DACP). High moisture index and wet phase coincide with the onset of the Medieval Climatic Anomaly (MCA).

CP 1.5 Gurumurthy GP [& Jyoti Srivastava, BSIP, Lucknow and K Balakrishna, Manipal Institute of Technology, Manipal]

Carried out a study to understand the chemistry suspended particulate matter (SPM) from the estuarine region of Nethravati River, southwest India. The SPM content and its metal concentrations in the Nethravati Estuary showed strong seasonal and spatial variability. The Fe–Mn oxyhydroxides formed the important carriers of metals in the estuarine region; however, it depends on the seasonality. The heavy metals displayed higher concentrations at a low Fe/Mn ratio in the estuary, which suggest a dominant role of Mn-oxyhydroxides as the metal carrier phase. Thus, the geochemical assessment of SPM in the Nethravati Estuary demonstrates redox cycling of metals coupled with adsorption–desorption of heavy metals onto the metal oxyhydroxides. Higher concentrations of heavy metals were observed in the estuarine bed sediments than in the suspended sediments.

CP 1.6 Gurumurthy GP [& Tripti Muguli, National Centre for Earth System Studies, Trivandrum]

Investigated sources of precipitation moisture for the Indian Monsoon and the local environmental mechanisms controlling its distribution over the Southwest Coast of India. Stable isotope ratios of rainwater with space and time over Southwest, India provide evidences of microclimate impact on water sources in tropical rainforest of India. Isotopic amount effect over the humid tropical coast of India is demonstrated. Isotopic reversal of continental and elevation effects is evident in small humid basins. Fingerprinted critical water reserve in humid tropics through isotope systematics.

OTHER ACADEMIC WORKS

Research Papers Presented

- **Alam M, Tripti M, Gurumurthy GP, Sohrin Y, Tsujisaka M, Singh AD, Takano S & Verma K** - Reconstruction of the late Miocene redox condition in the Eastern Arabian Sea at IODP Site U1457 of Laxmi Basin using stable isotopes of molybdenum and tungsten. Goldschmidt 2022 held at Honululu, Hawai, USA, 2022.
- **Singh AK** - Palaeoenvironmental implications of Palaeogene succession of Jaisalmer Basin, western Rajasthan, India in the National Conference on 'Current Understanding from Indian Sedimentary Basins and Road ahead' and 38th Convention of Indian Association of Sedimentologists, University of Delhi, Delhi, December 09–11, 2022.

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

A.H. Ansari

- Brainstorming Meeting on the topic "Integrating Molecular Biology and Geosciences in India" organised by Department of Earth Sciences & Department of Biosciences and Bioengineering, Indian Institute of Technology, Roorkee from Feb

17-19, 2023; Venue: GNEC-IIT Roorkee, NCR.

Veeru Kant Singh & Yogmaya Shukla

- Field Workshop on "Zawar Metallurgical National Geological Monuments and Jhamarkotra Phosphatic Stromatolite National Geological Monument" at Udaipur, Rajasthan from March 03-04, 2023.

S.K. Pandey

- Indian Energy Exhibition held at Bangalore International Exhibition Center, Bangaluru from February 6-8, 2023.

S.K. Pandey & Arvind K. Singh

- Organizing Secretary for the Field Workshop on "Zawar Metallurgical National Geological Monuments and Jhamarkotra Phosphatic Stromatolite National Geological Monument" held at Udaipur, Rajasthan from March 03-04, 2023.

Training/Study Visits

Arvind K. Singh

- National Workshop on Chronological imparted summer training to Ms. Shradha Singh, M.Sc. (Tech.) Applied Geology, Department of Applied Geology, Indian Institute of Technology (Indian School of Mines), Dhanbad, Jharkhand on the topic entitled 'Grain size analysis, petrography and process-based facies analysis of Proterozoic sediments: Insights on diagenesis and palaeoenvironment' during July 2022.
- Imparted training to Ms. Asha Chaudhary, M.Sc. Geology, Department of Geology, University of Lucknow, Uttar Pradesh, on the topic entitled 'Facies analysis and petrography of Paleogene sequences of Jaisalmer Basin' during Sept-Nov., 2022.

Arvind K. Singh & Gurumurthy G.P.

- National Workshop on 'Chronological Systematics and their applications in Earth Sciences' held at Geochronology Group, IUAC from April 19–21, 2022 (online).

Lectures delivered

Gurumurthy G.P.

- *Ocean oxygen- past and present*. at Departmental Seminar at Department of Geology, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, 13th May, 2022 (invited seminar) .

CONSULTANCY/ TECHNICAL SUPPORT RENDERED

Mukund Sharma & Veeru Kant Singh

Confocal Laser Scanning Microscopy (CLSM) – RAMAN Spectroscopy Lab

Dr. Kratika Singh, Integral University, Lucknow, INR 5900
Dr. Niharika Pandey, Integral University, Lucknow, INR 5900
Dr. Aisha Begum, Career Dental College, Lucknow, INR 23600
Dr. Prachi Jha, KGMU, Lucknow, INR 17700

Gurumurthy G.P.

ICP-MS and ICP-OES Lab, Stable Isotope analysis, INR 50,000.

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
- Chief Editor, Journal of the Palaeontological Society of India, Lucknow (2022-2023).
- 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.
- Fellow, 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
- Fellow, The Society of Earth Scientists, India
- Fellow, The Geological Society of India

S.K. Pandey

- Life Member, The Indian Science Congress Associations (ISCA)
- Life Member, The Palaeontological Society of India, Lucknow (PSI)

Yogmaya Shukla

- Life Member, The Indian Science Congress Associations (ISCA)
- Life Member, The Palaeontological Society of India (PSI)
- Voting Member, The Sub-commission on Pre-Cryogenian Stratigraphy –International Commission of Stratigraphy (continuing)

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.
- Life Member, Indian Association of Sedimentologists, Aligarh Muslim University, Aligarh.

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

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

OBJECTIVES:

- *To resolve the biostratigraphic issues in the Palaeozoic and Mesozoic sequences.*

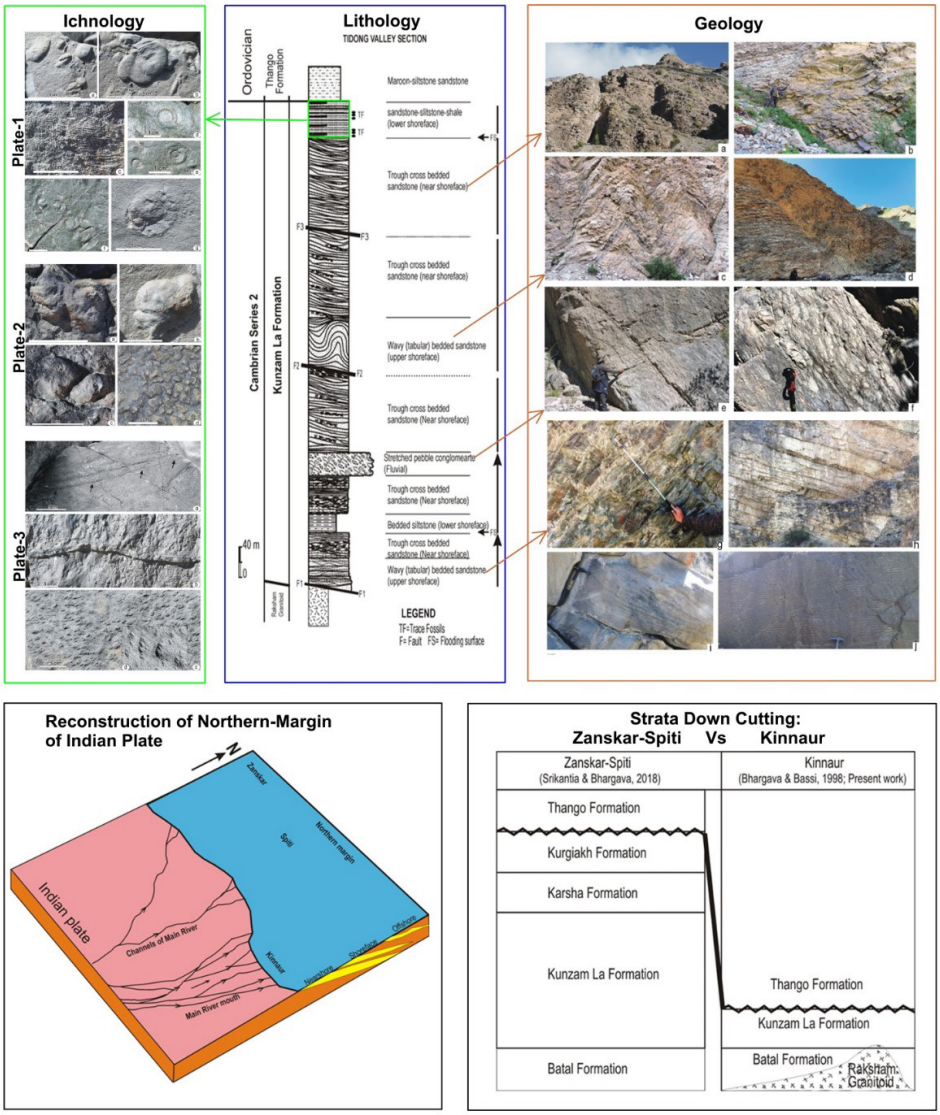


Fig. 1 - Integrated ichnological and sedimentological studies of the Cambrian of Tidong Valley led reconstruction of the northern margin of the Indian Plate and its correlation with the Zanskar–Spiti region.

- *To assess and delineate the events of biotic crisis and establish sequence biostratigraphic framework.*
- *Evolution of plant ecosystem with special emphasis on radiation of seed plants and phylogenetic studies to trace the early Angiosperms evolution in Indian context.*
- *To assess the hydrocarbon generation potential of Gondwana sediments.*

PREAMBLE:

The research work of Gondwana Palaeobiology Group deals with deep time sediments encompassing Cambrian to Early Cretaceous time period (~100 to 545 Ma old). One aspect of the research work mainly focuses on understanding the explosion of life during the Cambrian and evolution and subsequent radiation of terrestrial plants, evidences for which are stored in the early Palaeozoic rocks of Tethyan realm particularly in Himachal Pradesh. Another major focus is on the study of 'Gondwana' successions (300-100 Ma, named after the 'Gond Tribe' of Madhya Pradesh), which are the major store house of coal deposits of country and are exclusively distributed in Damodar, Rajmahal, Son-Mahanadi, Satpura and Wardha-Godavari basins along with some parts of extra peninsular region. 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. Contemporaneous sequences are known from most of the Southern Hemisphere continents suggesting former amalgamation of these landmasses. The research activities mainly aim to resolve issues related to biostratigraphy, palaeoclimate and hydrocarbon exploration with integration of microfossils and macrofossils assemblages, along with sedimentological and geochemical parameters.

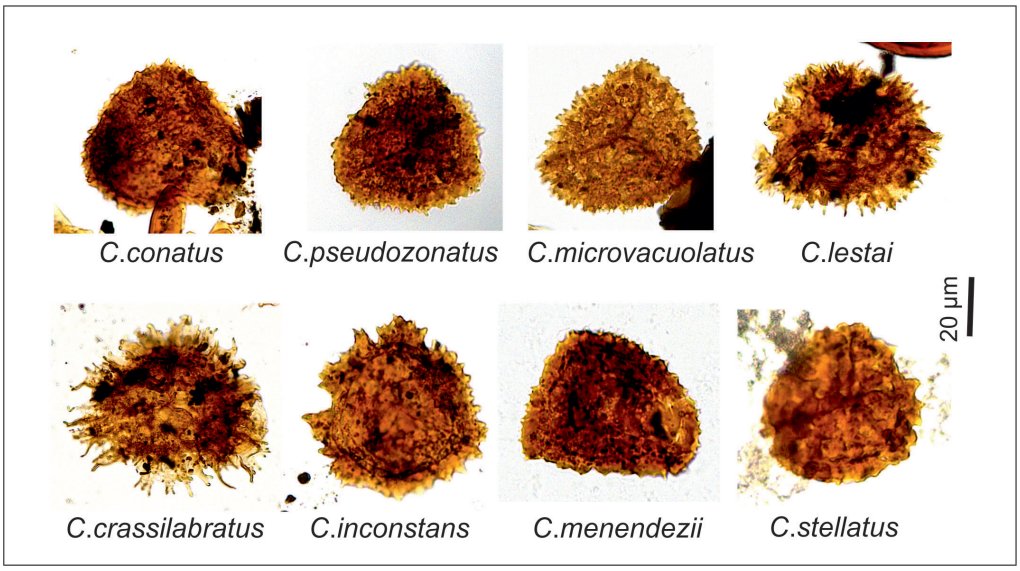


Fig. 2 - Species of *Cristatisporites* recorded for the first time in the Talchir sediments of Wardha Basin, Maharashtra State, central India.

Emphasis is also being made to understand the evolution of flowering plants. The research findings contribute towards the understanding of the geochronological framework of Gondwana regions, origin, and evolution of land plants during the Palaeozoic 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.

PERSONNEL INVOLVED

Team Members: K. Pauline Sabina (Scientist E), S.Suresh K. Pillai (Scientist E), Deepa Agnihotri (Scientist E), 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: Runcie Paul Mathews (Scientist D), Gurumurthy G.P. (Scientist C)

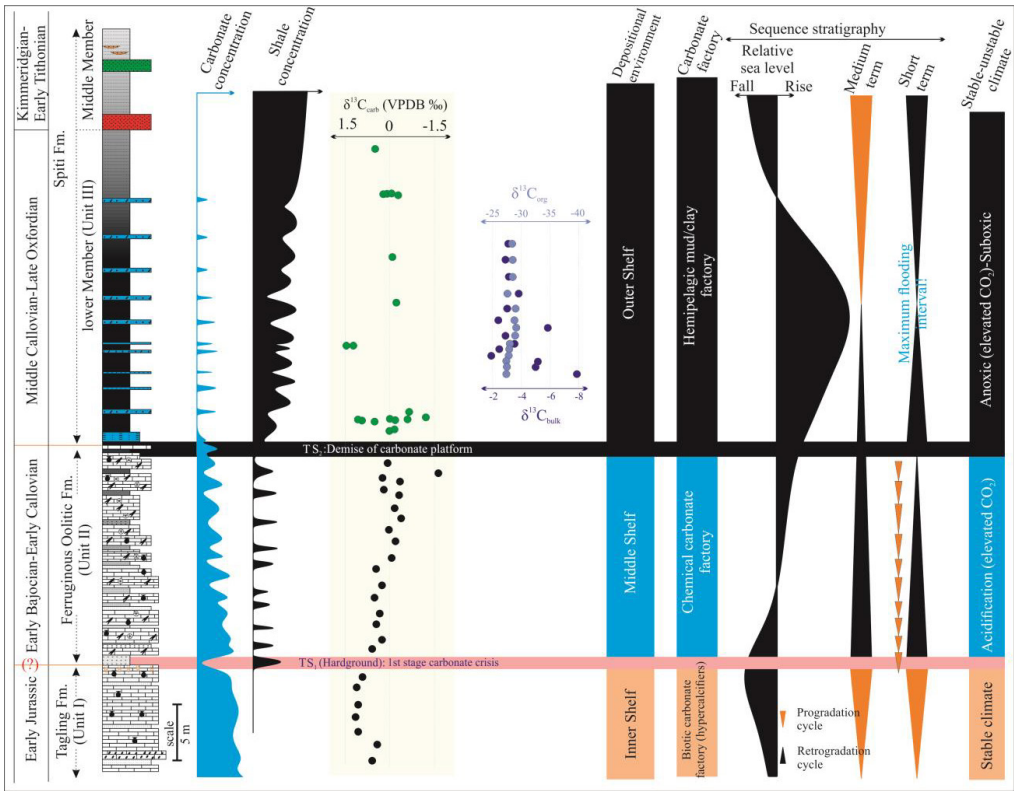


Fig. 3 - Summary of climatic-environment crisis and change of carbonate production observed in Spiti Himalaya, deposited in Southern Hemisphere of Tethys.

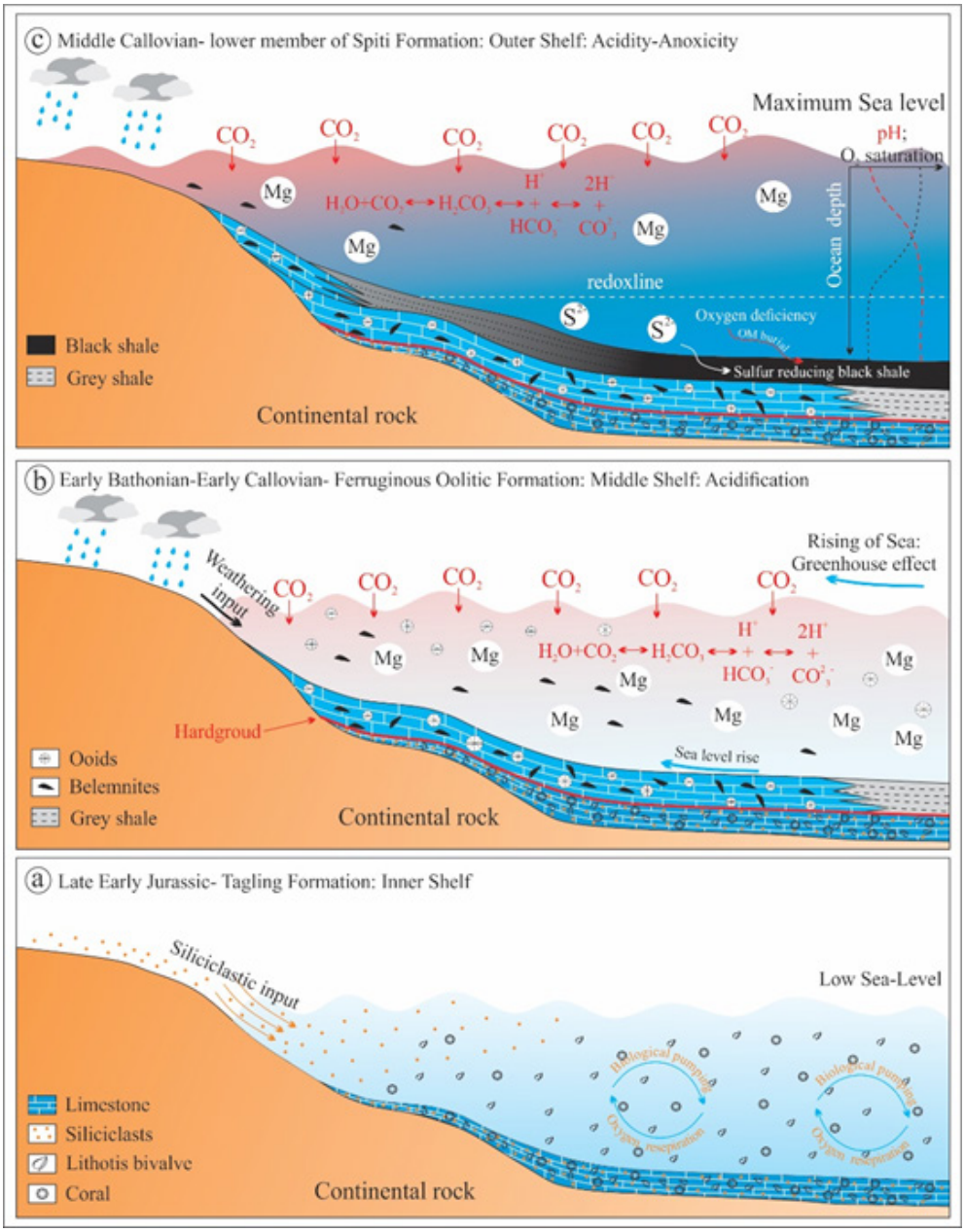


Fig. 4 - Schematic representation of carbonate platform shutdown in Spiti Himalaya, in the sediment succession from Tagling Formation to Spiti Formation.

Technical Support Member: Ms. Shivalee Srivastava (Technical Assistant B)
Research Associate: Saurabh Gautam
Research Scholars: Raj Kumar, Suyash Gupta, Alok Mishra, Deveshwar P. Mishra, Nazim Deori, Suraj Kumar, Ayushi Mishra

SIGNIFICANT FINDINGS

Integrated ichnological and sedimentological studies of the Cambrian of Tidong Valley, Kinnaur has been carried out and trace fossil assemblage of *Bergaueria perata*, *B. hemispherica*, *Bergaueria* sp., *Dimorphichnus obliquus*, *Monocraterioni* sp., *Psammichnites gigas circularis, Psammichnites gigas gigas* along with arthropod scratch marks (Fig. 1: Ichnology Pls 1-3), are for the first time, recorded from the Cambrian Kunzam La Formation exposed in the Tidong Valley. These fossils confirmed the *Psammichnites gigas gigas* sub-Ichno zone in the formation belonging to the latest part of Cambrian Series 2, Stage 4, immediately below the rocks of the Ordovician Thango Formation. The ichnological findings on integration with the sedimentological data (Fig. 1: Lithology) suggested a shallow-marine, near shore to upper shore face environment of deposition for the formation, where a main river system met the northern margin of Indian Plate during the investigated Cambrian time. A regional correlation of the strata showed a direct evidence of down-cutting in the Cambrian strata from NW (Zanskar-Spiti region) to the Tidong Valley (Kinnaur

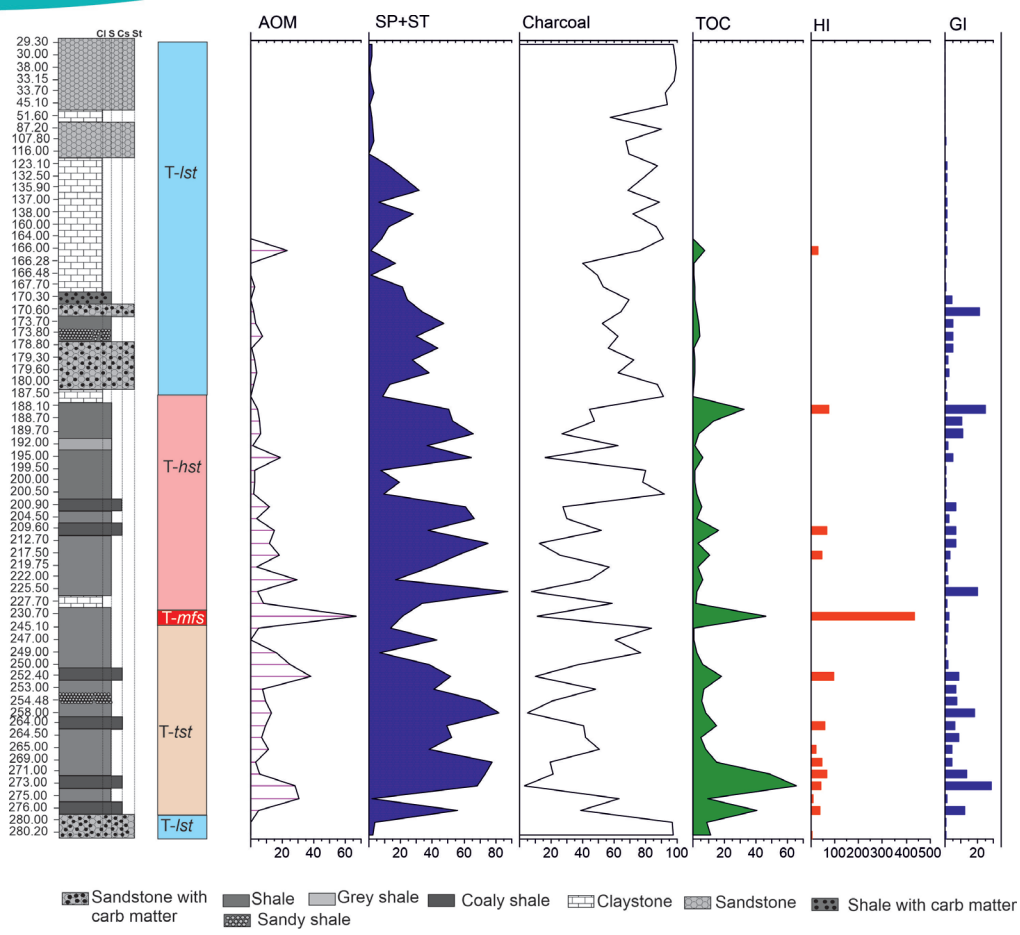


Fig. 5 - Palynofacies and geochemical analysis in Permian Succession of Godavari Valley Coalfield.

region) during the Cambrian-Ordovician interval.

In the Indian Gondwana sequences, hitherto only two species of *Jayantisporites* have been recognized, viz. *J. Conatus* Lele & Makada 1972 and *J. Pseudozonatus* Lele & Makada 1972. And based on their morphological similarities shared with the genus *Cristatisporites* (Potonié & Kremp, 1954) Butterworth *et al.*, 1964, a new combination *Cristatisporites conatus* is proposed. This has facilitated in recognition of several species of *Cristatisporites* for the first time from the Talchir sediments of Wardha Basin, which are reported from co-eval Pan Gondwana sediments. This contributes additional feasibility to global correlation and records their palaeobiogeographic distribution even in this part of Gondwana. The following species are recorded here- *Cristatisporites conatus, C. pseudozonatus, C. microvacuolatus, C. lestai, C. crassilabratus, C. inconstans, C. menendezii* and *C. Stellatus* (Fig. 2).

To assess the climatic-environmental stressor, sedimentological and geochemical studies were carried out from an extinct carbonate platform of Early-Middle Jurassic Spiti-Himalayan sequence, deposited in the Southern Hemisphere of the Tethys, India. The studied sequence records two-phase carbonate crisis: biocalcification (Tagling Formation) to hypoxic black shale (lower member of Spiti Formation) through chemical precipitation (Ferruginous Oolitic Formation). The carbonate crisis is associated with sea-level rise as well as palaeoceanographic change from inner to outer shelf linked to environment stressor. The negative carbon isotope excursion (CIE), related to oolitic rocks and black shales, suggests carbonate saturation drop, followed by a calcification overshoot. The increasing atmospheric CO_2 acidifies the ocean and precipitates ooidal limestone to revive the alkalinity of ocean. The CO_2 injection and change of redoxcline with sea-level rise cause anoxia in the outer shelf, while acidification continues in the inner shelf (Fig. 3). The biostratigraphy of the studied sequence corresponds to a local impact in the Aalenian-Bajocian and Middle Callovian.

The demise of carbonate platform is due to number of factors, including siliciclastic poisoning, sea-level rise or fall, pH, oxygen saturation (anoxicity), where each of the factor is directly or indirectly controlled by climate and provide crucial information on Early earth and predict the future on anthropogenic impact. The Jurassic Spiti Himalaya records such a demise of carbonate platform in the sediment sequence Tagling Formation (TF) to Spiti Formation (SF) in-between Ferruginous Oolitic Formation

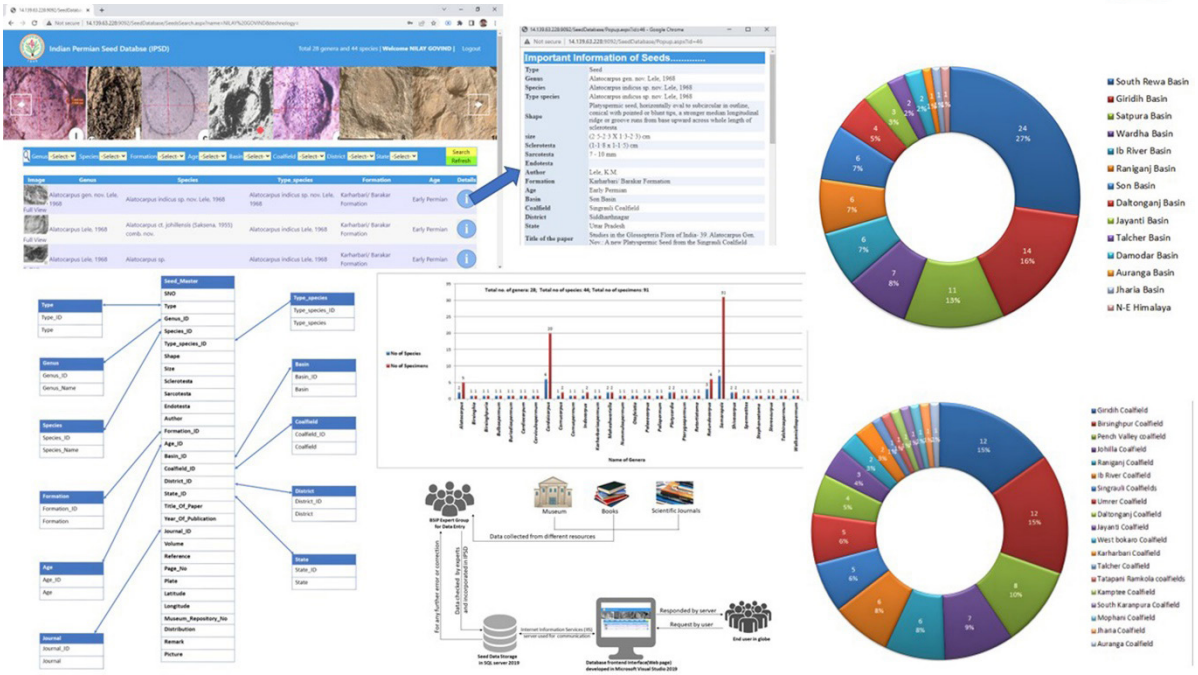


Fig. 6 - Indian Permian Seed Database (IPSD) software from Lower Gondwana sequences.

(FOF). The distribution of facies in the investigated succession suggests that TF was deposited there and that it transitioned gradationally to the middle shelf carbonate-shale alternation with sea level rise. The middle shelf is pushed out to the outer shelf by the procedure. The siliciclastic input in TF provides enough nutrient supply to proliferate the biogenic productivity and form a biotic platform. The sea-level rise due to elevated CO_2 forms hardground at top of TF and creates a chemical carbonate depositional system. CO_2 exchange between ocean and atmosphere acidified the system, and deposited the oolitic carbonate in alternation with shale (siliciclastic deposition) (Fig. 4). In the influence of this elevated atmospheric CO_2 (green-house effect), sea-level continuously rose and developed anoxic environment. The anoxicity, deposited depth below carbon compensation depth (CCD) ultimately led to the demise the carbonate platform.

Preliminary investigation of the terrestrial sediments of the Godavari Valley Coalfield, south India has been applied in the low-resolution sequence biostratigraphy through palynofacies and geochemical analysis. Collected samples belong to the Barakar and Lower Kamthi/Raniganj formations of the Permian age. Some new terminologies have been coined in these terrestrial sediments (Fig. 5):

- High Stand System Tract (HST) in the terrestrial sequence has been termed as T-hst similarly for Low Stand System Tract (LST) it is T-lst. Similarly, the Maximum Flooding Surface (MFS) and Transgressive System Tract (TST) are termed as T-mfs and T-tst respectively.
- Based on Amorphous Organic Matter (AOM), Hydrogen Index (HI), Pyrozable Carbon (PC) and Gelification Index (GI) one and half cycles have been recognized.
- In the first cycle, T-mfs has been marked based on high and fluorescent AOM, highest value of HI and PC, indicative of anoxic conditions suitable for organic richness and preservation. Thus, T-mfs has been found to be an excellent source rock for hydrocarbon generation.

Fossil seeds play a key role in the study as they are widely described from different sediments or formations and their diversity and abundance in the Permian age. The Indian Permian Seed Database (IPSD) software will be an information system for ensuring storing, safety, accessibility and recovery of the details of Indian Permian seed records in a selective manner. The current database includes 28 genera and 44 species of compressed seed described from Lower Gondwana (Permian) with all details for young researchers. The software provides an option of addition, deletion, modification and search facility. The search also includes different options (single or combination). It is a quick and organised way to look for seeds, especially on a data grid for information about seeds that have already been published in the same or different sediments. It provides morphotaxonomical characters, distribution and photo documentation of seeds. The software increases accuracy through computer-assisted identification of seeds. Hence, reducing and curtailing the unnecessary information while describing a new species with inadequate earlier knowledge (Fig. 6).

Miofloral and fossil charcoal analyses of the Permian

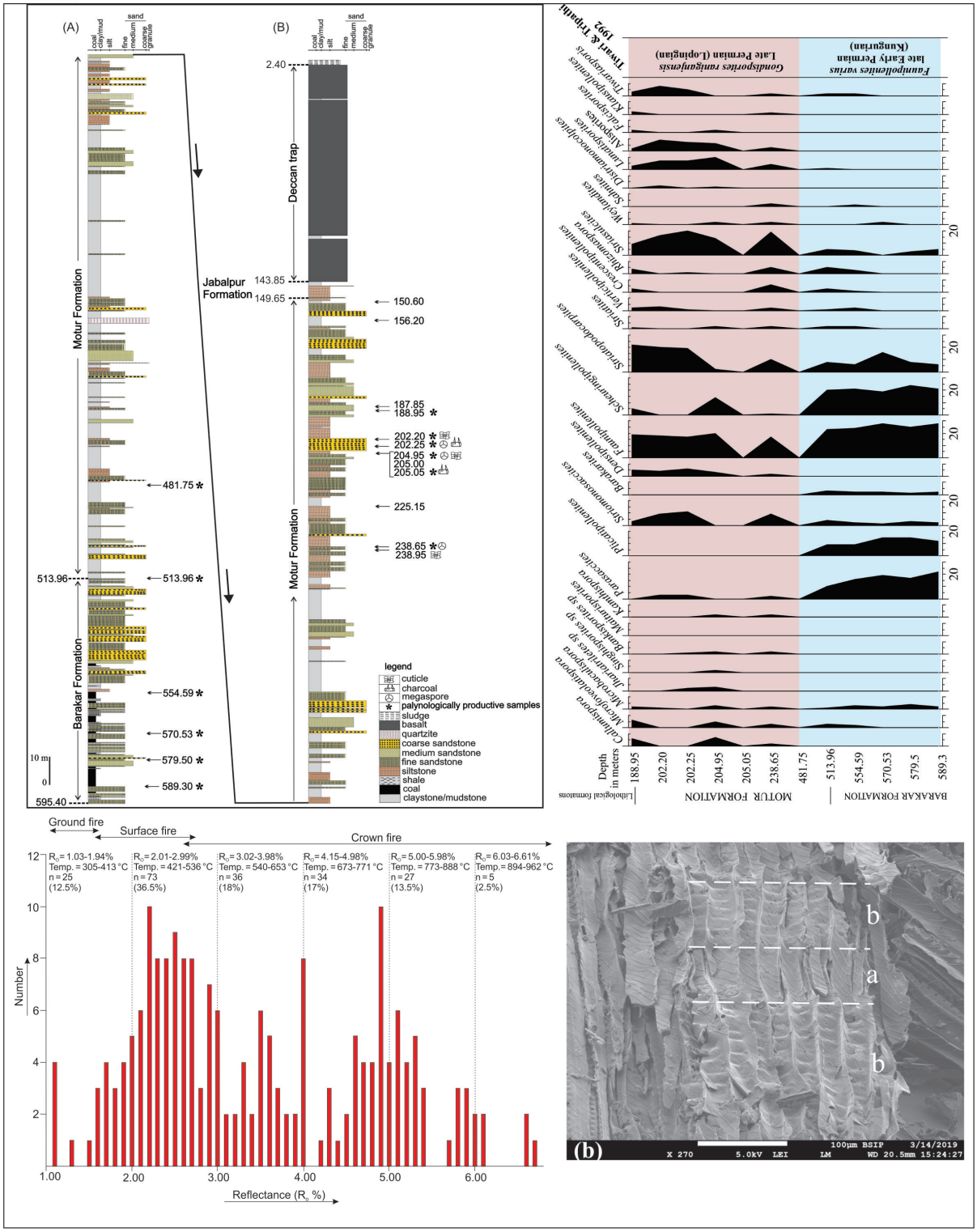


Fig. 7 - Litholog of the borecore PKK-2B, Satpura Gondwana Basin showing sample positions, along with frequency distribution chart of recovered palynomorphs in the borecore. Histogram of cumulative fusinite reflectance values shows calculated combustion temperatures and reconstructed fire types. FESEM image of a fragment of charcoal specimen.

deposits of Barakar and Motur formations from core PKK-2B, located in the Pench-Valley Coalfield, Satpura Basin (India) were carried out to assess the floral diversity, evidence for palaeo-wildfire and age. Two distinct palynoassemblages have been identified, viz. *Faunipollenites varius* palyno-assemblage and *Gondisporites raniganjensis* palyno-assemblage and dated as Kungurian (late Early Permian) and Lopingian (Late Permian) in age respectively. These assemblages show dominance of pollen attributable to Glossopteridales followed by Cordaitales and Coniferales. The occurrence of charcoal at two levels in the sedimentary sequence indicates the occurrence of repeated wildfires in the surrounding area. The macroscopic charcoal fragments

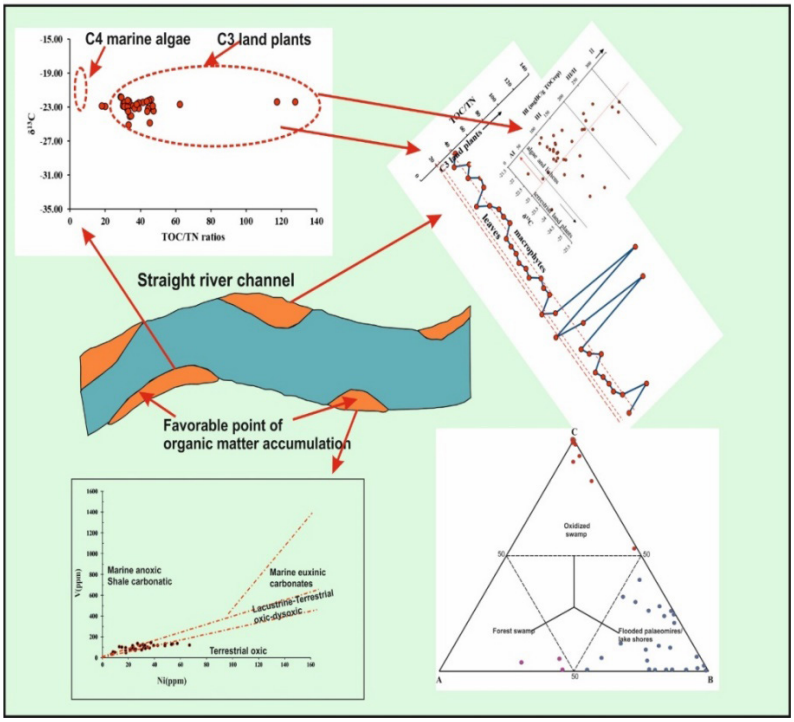


Fig. 8 - Pictorial representation showing palaeoenvironmental conditions impacts on the hydrocarbon generation potential of the shale samples from the Lower Permian, Barakar Formation.

exhibit anatomical features of gymnospermous wood affinity (Fig. 7). Large sized charcoal fragments mostly exhibit rounded edges suggesting an allochthonous origin. Furthermore, the fusinite reflectance of the studied charcoal/inertinite fragments suggests that their temperature of formation was in the range of~ 305-962°C. This indicates the occurrences of high-temperature crown fires, together with medium- and low-temperature surface- and ground fires respectively.

Geochemical and palynological studies were carried out on the L. Permian shales from the Auranga Basin to infer its palaeoenvironmental conditions behind the source rock evaluation. Based on the present study following inferences have been drawn:-

- The wide distribution of TOC $\delta^{13}C$ (3.11 to 54.89 wt%) exhibits the fluviatile deposition under shallow water setting with periodic meandering swampy conditions for reed marsh vegetation along with bacterial activity. The present amorphous organic matter is a degraded part of terrestrial humic matter.
- The fluviatile facies are predominated by the terrestrial C3 plants as $\delta^{13}C$ and $\delta^{15}N$ varies from -25.05 to -21.76‰ and -2.98 to + 2.55‰ respectively. The wide variations of $\delta^{13}C$ show the input of macrophytes and leaves as the terrestrial material deposited at these locations. Moreover, the depleted $\delta^{15}N$ in the samples confirms the cyano-bacterial activities in the deposited organic matter.
- Palynofacies and geochemical palaeoproxies converge to the flooded palaeomire of suboxic-oxic distal fresh water settings under semi-arid to semi-humid climatic condition.

The selective low fractionation and in-situ weathering indication through rare earth elements distributions are responsible for controlling the organic richness in the sediments.

Investigations were carried out on the megafossils collected from the road cutting section exposed in Kakadbhit (23°16′16″: 69°21′46″) which is about 40 km north-west of Bhuj, Gujarat. Floristic studies have helped to identify some new plant taxa, namely *Fredlindiya* Anderson & Anderson 2003, *Williamsonia rugosa* McLoughlin *et al.*, 2018. These new taxa belong to class bennettopsida. The recovered new taxa reveal their resemblance with the Australian bennettopsid taxa (middle Triassic to early Cretaceous). However, based on the morphological characters of the reproductive structures, McLoughlin (2018) claims that Australian bennettopsid species are endemic. The resemblance of early Cretaceous Indian taxa with those of middle Triassic, middle Jurassic and early Cretaceous Australian taxa shows not only the close association of both Gondwanaland countries but also long ranging (Triassic to Cretaceous) migration of these taxa.

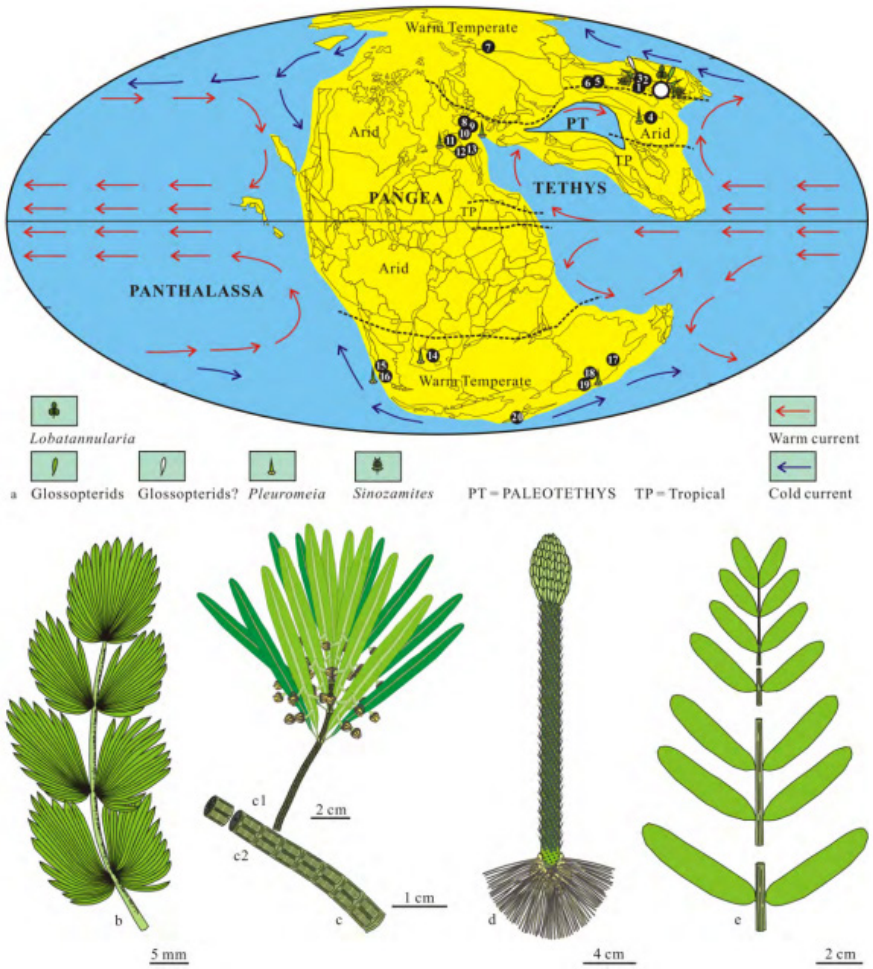


Fig. CP 2.1 - Middle Triassic palaeomap, showing the area of Benxi (white circle) developing the Linjia flora, mainly composed of *Lobatannularia, Sinoglossa, Pleuromeia* and *Sinozamites*, influenced by the warm and cold currents in the climatic zone of warm temperate (For detailed description see Zhang *et al.*, 2022, Global Geology).

PROJECT OUTCOME:

Publications

In SCI (Science Citation Index) Journal

1. Gautam S, Mendhe VA, Murthy S, Mishra DP & Mishra VK 2022. Palynoassemblages and depositional environment of the subsurface Permian sediments in Raniganj Coalfield, Damodar Basin, West Bengal, India. Journal of Earth System Science 131: 224 (IF-1.912).
2. Kumar R, Aggarwal N, Das Neelam, Pandey B & Kumar K 2022. Palaeoenvironmental reconstruction based on palynofacies analysis of the Early to Middle Jurassic of the Lathi Formation, Jaisalmer Basin, India. The Journal of the Palaeontological Society of India 67(2): 262–273 (IF: 0.652).
3. Mishra DK, Hackley PC, Jubb AM, Sanders MM, Agrawal S & Varma AK 2022. Maturation study of vitrinite in carbonaceous shales and coals: Insights from hydrous pyrolysis. International Journal of Coal Geology 259: 104044, https://doi.org/10.1016/j.coal.2022.104044 (IF- 6.3).
4. Murthy S, Uhl D, Jasper A, Sarate OS & Mishra DP 2022. New evidence for Palaeo-wildfire in the Early Permian (Artinskian) of Gondwana from Wardha Valley Coalfield, India. Journal of Geological Society of India 98: 395-401 (IF-1.466).
5. Pillai SSK, Manoj MC, Mathews RP, Murthy S, Sharma A, Sahoo M, Saxena A, Pradhan S & Kumar S 2023. Lower Permian Gondwana sequence of Rajhara (Daltonganj Coalfield), Damodar Basin, India: Floristic and geochemical records and their implications on marine ingressions and depositional environment. Environmental Geochemistry and Health, https://doi.org/10.1007/s10653-023-01517-8 (IF: 4.898).

Refereed Non-SCI Journals

1. Mathews RP, Aggarwal N, Mishra D, Singh VP, Rahi IC, Chetia R & Sahu SK 2022. Report of the 73rd Annual Meeting & Symposium of the International Committee for Coal & Organic Petrology (ICCP 2022). Journal of Palaeosciences 71: 235-238.

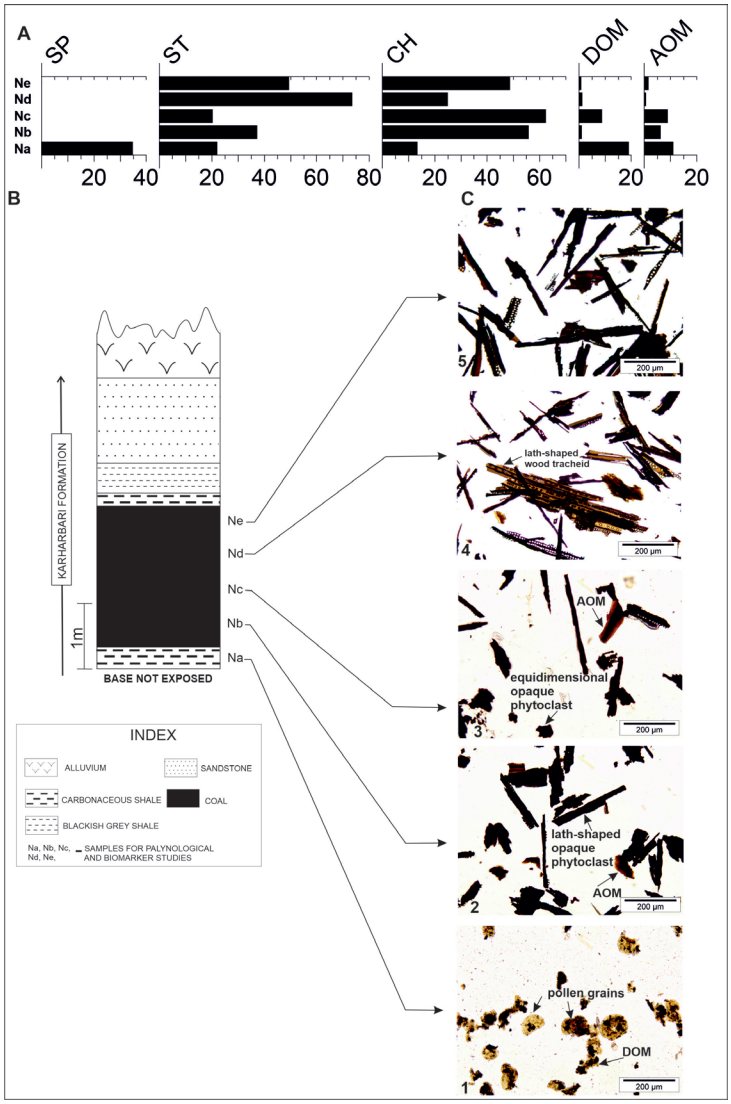


Fig. CP 2.3 - (A) Percentage of the various types of the organic matter particles in studied samples, SP = spore-pollen, ST = structured phytoclasts, CH = opaque phytoclasts, DOM = Degraded Organic Matter, AOM = Amorphous Organic Matter. (B) Position of the collected samples in the lithocolumn. (C) Different forms of the recovered palynofacies 1. Dominance of palynomorphs along with DOM in sample no. Na, 2. Predominance of lath-shaped opaque phytoclasts along with AOM in sample no. Nb, 3. Occurrence of lath-shaped phytoclasts along with AOM in sample no. Nc, 4. Predominated of the occurrence of lath-shaped structured phytoclasts in sample no. Nd, 5. Dominance of lath-shaped phytoclasts in Sample no. Ne).

2. Saxena A, Gupta S, Pillai SSK, Murthy S, Agnihotri D, Khangar R, Savita C & Khan M 2022. Late Permian macrofloral remains from the Bijori Formation, Satpura Gondwana Basin and their biostratigraphic implications. Geophytology 51(1 & 2): 41–58.
3. Zhang Y, Zheng S, Singh KJ, Wang Y, Zhang S & Saxena A 2022. Glossopterids survived end-Permian mass extinction in North Hemisphere. Global Geology, DOI: 10.3969/j.issn.1673-9736.2022.04.02.

Book Chapters / Memoirs / Bulletins

1. Singh YP, Verma P & Singh A 2022. Palynofloral diversity during Mid-Miocene warming in Kerala Basin, South-Western India: Palaeoclimatic implications. *In:* Phartiyal B, Mohan R, Chakraborty S, Dutta V & Gupta AK (Editors) - Climate change and environmental impacts: Past, present and future perspective. Society of Earth Scientists Series, Springer, pp. 47-61.

General Articles / Reports / Database Published

1. Das N, Pandey S & Bhandari A 2023. Workshop on biodiversity conservation for Women Scientist/ Technologists. The Journal of the Geological Society of India 99(2023): 293–294.
2. Tripathi S, Pandey A, Saxena A, Das N *et al.* 2022. 28th Indian Colloquium on Micropalaeontology and Stratigraphy. Journal of Palaeosciences 71(2022): 117–120.

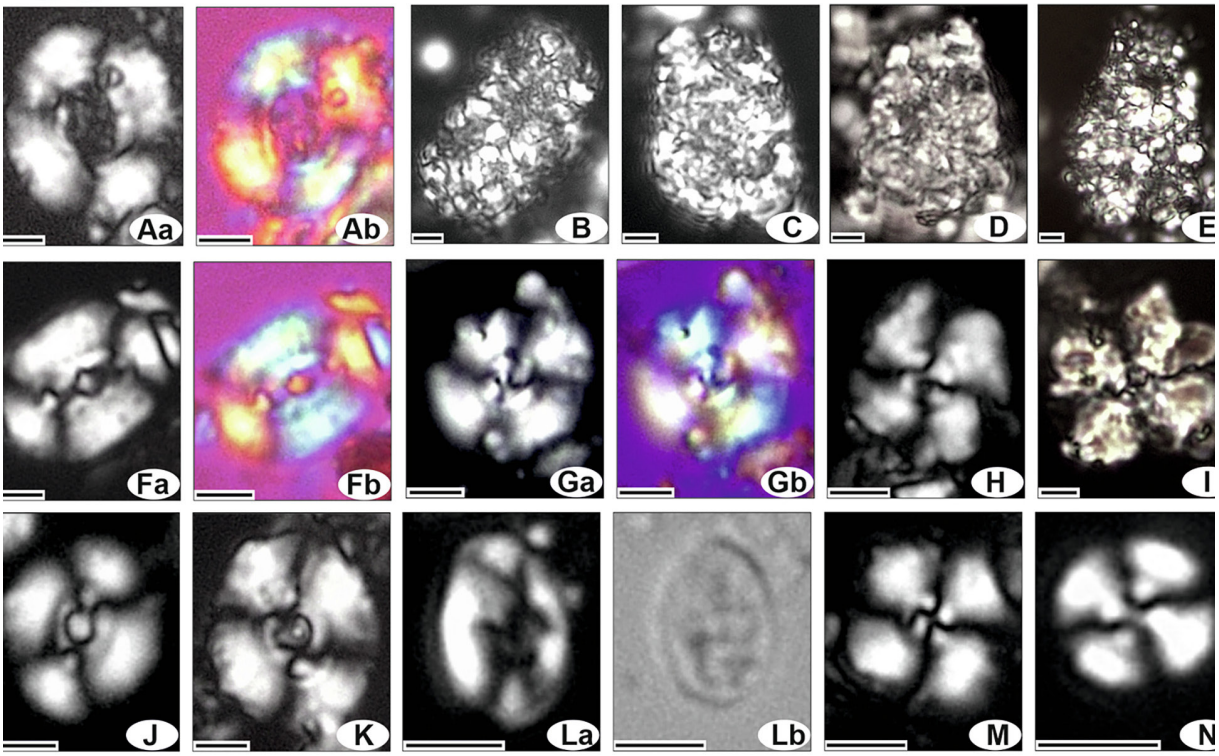


Fig. CP 2.4 - Nannofossil assemblage from two samples of Kurar section, samples 6 and 9. (Aa, Ab) *Heleneachiastia* Worsley, 1971, sample 6. (B–E) *Faviconus multicolumnatus* Bralower in Bralower *et al.*, 1989, sample 6 (B, C) and sample 9 (D, E). (Fa, Fb, J, K) *Watznaueria britannica* (Stradner, 1963) Reinhardt, 1964, sample 6 (J, K) and sample 9 (Fa, Fb). (Ga, Gb, H, I) *Watznaueria manivitiae* Bukry, 1973, sample 6 (Ga, Gb) and sample 9 (H, I). (La, Lb) *Zeugrhabdotus noeliae* Rood *et al.*, 1971, sample 6. (M, N) *Watznaueria barnesiae* (Black in Black & Barnes, 1959) Perch-Nielsen, 1968, sample 6. Scale bar = 2 mm.

Publications as an outcome of Sponsored Projects

1. Mishra DP, Singh VP, Saxena A, Uhl D, Murthy S, Pandey B & Kumar R 2022. Palaeoecology and depositional setting of an Early Permian (Artinskian) mire based on a multi-proxy study at the Jagannath coal mine (Talcher Coalfield), Mahanadi Basin, India. Palaeogeography, Palaeoclimatology, Palaeoecology. https:// doi.org/10.1016/j.palaeo.2022.111124 (IF: 3.565).
2. Shabbar H, Saxena A, Tinn O, Gupta S & Singh KJ 2022. Non-calcified siphonous warm-water marine macroalgae from the Ordovician strata of Spiti, Tethys Himalaya, India. Palaeoworld (IF: 2.717).

Publications other than the Project Work

1. Aggarwal N, Patel R & Goswami S 2022. Palaeoclimate, Palaeoecology and Palaeovegetation in and around Nandira Colliery, Talcher Basin, Odisha, India during Early Permian: Inferences for Typical Karharbari palynofloral and palynofacies analysis. Journal of the Geological Society of India 98: 1244-1252. https://doi.org/10.1007/s12594-022-2159-y (IF 1.466).
2. DiPasquo M, Kavali PS, Iannuzzi R, Lopez S & Grader G 2022. The palynological catalogue of the lower Permian (Asselian-?Artinskian) Copacabana Formation at Apillapampa, Cochabamba, olivia and palaeobiogeographic approaches. Boletin de la Asociacion Latinoamericana de Paleobotanica Palynologia n.22, p.699-754.

SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

SP 2.1: **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 (completed on 25.06.2022)].

Investigators: Srikanta Murthy (PI) & Deveshwar Prakash Mishra (SRF)

The analysis of petrography, palynofacies, charcoal and plant fossils for the coal-bearing Jagannath section

PH.D. PROGRAMME

Anand Prakash (2016). Palaeobiodiversity of coal forming flora of western apart of the Son-Mahanadi Basin: depositional, petrological and palaeoecological 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.

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: Submitted in January 2023.

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)**, J.M. Patel, RR 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 Talchir Coalfield, Mahanadi Basin, Odisha, India, under the supervision of **Srikanta Murthy (BSIP)** and Bindhyachal Pandey (BHU), registered with Department of Geology, Banaras Hindu University, Varanasi. Status: In progress**.**

Suraj Kumar (2022). Phases and Pathway of marine incursion and vegetation dynamics of Gondwana sediments from eastern India: Biological and Geochemical perspectives, under the supervision of **S. Suresh Kumar Pillai (BSIP)** and **Runcie Paul Mathews (BSIP)** registered with AcSIR (Academy of Scientific and Innovative Research). Status: In progress.

in the Talcher Coalfield, Mahanadi Basin, India, to improve understanding of the age, palaeoecology and depositional setting of this palaeo-mire. Palynology is indicative of the *Scheuringipollenites barakarensis* assemblage, suggesting an Early Permian (Artinskian) age. The age of the studied section is inferred based on correlation with coeval assemblages across Gondwana. Palynoassemblages have more similarity with those of Africa than South America. Petrographic indices suggest that peat-forming vegetation accumulated mainly in telmatic settings under ombrotrophic-mesotrophic (intermittent fluctuating) hydrological conditions. Palynofacies suggest that the deposition of organic matter (by high energy fluvio-deltaic agents) took place in an oxic to occasionally dysoxic setting. Megaflora comprise a low diversity assemblage dominated by Equisetales (*Schizoneura* and *Paracalamites*), with less common Glossopteridales (*Glossopteris* and *Gangamopteris*) and Filicales (*Dichotomopteris*) indicative of dense arborescent vegetation. Numerous fossil macrocharcoal fragments indicate the repeated occurrence of wildfires in the catchment area. The high abundance of pyrogenic inertinites in Permian coals of Gondwana may indicate a high-fire phase of Earth history linked to elevated atmosphere oxygen level, and our current study further substantiates this idea demonstrating the occurrence of fire, not only in seasonally dry ecosystems but also in peat forming ecosystems under humid conditions. Our multiproxy study is significant for understanding Permian peat-forming ecosystems and environments and provides a robust age assessment based on inter and intra-basinal correlations of coeval sequences across the Gondwana.

SP 2.2: **Revaluation of late Paleozoic spores and pollen from Indian Gondwana sequences to resolve gaps in global correlation and palaeobiogeography** [Sponsored by MoES, No. MoES/P.O.(Geo211/2019), w.e.f. October 2022].

Investigators: Pauline Sabina Kavali (PI), Runcie Paul Mathews (Co-PI) & Ayushi Mishra (JRF, MoES)

Carried out first field work in Damodar Basin. Chemical

processing of the samples and observation of slides are in progress.

CP 2.1: **Anju Saxena** [& Prof. Zhang, NIGPAS, Chinese Academy of Sciences, China PR]

Worked on the aspect of Glossopteris flora. Genus *Glossopteris* is the most significant representative fossil of the Gondwanan Supercontinent in the Paleozoic. It has been regarded as an important clade of Angiophytes on the basis of its reproductive organ related to Angiosperms. Since Brongniart erected *Glossopteris* in 1928, reliable Glossopterids attached by fertile organs were only collected from the Permian Gondwanaland. A new element of Glossoptetids, *Sinoglossasunii* gen et sp. nov., with attached female organs from the Middle Triassic Linjia Formation in Benxi, Northeast China was found (Fig. 9). This demonstrates that Glossoptetids not only distributed in Southern Hemisphere, but also in Northern Hemisphere, and successfully survived the end-Permian mass extinction in Northern Hemisphere. The distinguished environment in Northeast China influenced by both warm and cold currents, probably resulted in the Paleozoic relic elements, such as Glossopterids associated with *Lobatannularia* successfully survived the end-Permian mass extinction.

CP 2.2: **Anju Saxena** [& Late Rajesh Agnihotri]

Inter-institutional collaborative work for a multidisciplinary study on the sediments of Lahuradewa Lake which were studied for robust chronology and understanding the anthropogenic activities and its bearing on agricultural evidences. This lacustrine profile provided evidences for the earliest rice cultivation in central Ganga plains at ~8.3 ka BP using depth profiles of phytoliths and paddy field diatoms. These dataset were coupled with $\delta^{13}C_{TOC}$, $\delta^{15}N$ and $\delta^{34}S$ data along with 6 AMS dates and provided four distinct phases of agricultural activities during Holocene.

CP 2.3: **Neha Aggarwal** [Prof. Shreerup Goswami, Utkal University, Bhubaneswar, Odisha]

Palynofloral study along with palynofacies analysis has been undertaken in Nandira Colliery, Talcher Basin, Odisha, India (Fig. 10). Recovered palynoassemblage is characterized by the dominance of monosaccate pollen grains, viz. *Parasaccites* spp. (25%), *Plicatipollenites* spp. (5%), *Potonieisporites* sp. (1%) and *Diavarisaccus lelei* (1%) along with nonstriate bisaccate *Scheuringipollenites maximus* (35%). The recovered palynoflora shows its affinity towards the Upper Karharbari palynoflora of the early Artinskian age. The carbonaceous shale (Sample Na) is dominated by SP (34.67%) and sub-dominated by ST (22%) along with CH (13.34%), DOM (19%), and AOM (11%). Coal samples (Nb to Ne) are completely devoid of palynomorphs. They are mainly dominated by CH (24.87-62.34%) and ST (20.20-73.38%) with presence of DOM (0.7-8.7%) and AOM (0.4-8.7%). Deposition of the sediments in a lower carbonaceous shale bed (Na) might have occurred in a dysoxic forest swamp in low-energy settings. The coal beds (Nb to Ne) have been deposited in the oxidized swamps in the proximal setting. The predominant occurrence of the opaque phytoclasts associated with the coal sediments may indicate a regular occurrence of palaeofires during the Artinskian.

CP 2.4: **Abha Singh** [& Professor (Dr.) Sreepat Jain, Department of Applied Geology, School of Applied Natural Sciences, Adama Science and Technology University, Adama, Ethiopia]

Worked on sixteen samples from the marl limestone alternations were analysed for calcareous nannofossils from the Kurar section (10°02′39.7″N, 38°13′53.7″E) of the Dejen area. Two samples, 6 and 9, were found to be productive for nannofossils; other samples did not yield any calcareous nannofossils. Sample 6 contains *Heleneachiastia*, *Faviconus multi columnatus*, *Watznaueria britannica*, *Watznaueria manivitiae*, *Watznaueria barnesiae*, and *Zeugrhabdotus noeliae*. Sample 9 contains *Faviconus multi columnatus*, *Watznaueria britannica* and *Watznaueria manivitiae*. In general, both sample assemblages are dominated by the genera *Watznaueria* and *Faviconus*. The assemblage from sample 6 is relatively better preserved whereas for sample 9, the preservation is very poor and most forms have lost their original shape due to dissolution and overgrowth (Fig. CP 2.4). Based on recent studies of calcareous nannofossil biostratigraphy (Casellato, 2010; Casellato & Erba, 2021), the previous calcareous nannofossil record from the Mugher section (Jain & Singh, 2019) is re-evaluated, and the result from present study at the Kurar section, together with previous Tithonian calpionellid (Jain *et al.*, 2022) and ammonite (Jain *et al.*, 2022) records from the region, provides an improved biochronology for the Tithonian interval in Ethiopia.

OTHER ACADEMIC WORKS:

Research Paper Presented

1. **Agarwal N -** Application of palynology in tectonic setting interpretation of coal bearing horizons of Gondwana sequences from India: Case study of

Godavari Coalfield, south India. International Committee for Coal and Organic Petrology, New Delhi, 22nd September, 2022.

2. **Das N** - Recovery of fossil beetle elytron from the Early Cretaceous beds of Jhala Village, Bansa Formation, South Rewa Gondwana Basin, India in the National Conference on "XXVIII Indian Colloquium on Micropaleontology and Stratigraphy", at Department of Environmental Sciences, Pune University, during May 04–06, 2022: 106.
3. **Mishra DK, Aggarwal N, Agrawal S, Govil P, Sharma A, Varma AK & Mendhe VA -** Upshots of stable isotope and rare earth elements for depositional milieu budding for hydrocarbon generation in Permian sediments, India. Abstracts of 38th Annual Meeting of the Society for Organic Petrology; 38th Virtual Conference 12 to 16 September 2022; ISSN 1060-7250.
4. **Mishra DK, Aggarwal N, Varma AK & Mendhe VA -** Fluvial facies depositional milieu potential for hydrocarbon generation in L. Permian shales of Auranga Coalfield from India. Abstracts of the 73rd Annual Meeting & Symposium of the International Committee for Coal & Organic Petrology (ICCP) from September 18-25, 2022 at Vigyan Bhawan & NASC, New Delhi, India, 51.
5. **Saxena A, Gupta S, Shabbar, H, Murthy S, Singh KJ & Bali R -** First record of Late Carboniferous palynoassemblage from Ganmachidam Formation, Spiti Valley: implications to age assessment and extent of Glossopterid elements in Tethyan realm. 28th Indian Colloquium on Micropalaeontology and Stratigraphy-2021 Pune, May 04–06, 2022.

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

Anju Saxena & Neelam Das

- Deputed to attend 28th Indian Colloquium on Micropalaeontology and Stratigraphy-2021, at Department of Environmental Sciences, Savitri Bai Phule University, Pune during May 4-6, 2022.

Anju Saxena & S Suresh Kumar Pillai

- Deputed for 3rd Triennial Congress of Federation of Indian Geosciences Association (FIGA) and Annual Conventions of IGU, PSI and AGM of GSI at Wadia Institute of Himalayan Geology, Dehradun during November 15-19, 2022.

Neelam Das

- Deputed to attend the Training-cum-Workshop on "Biodiversity Conservation" for Women Scientist/ Technologists at Wild Life Institute of India, Dehradun during November 14-18, 2022.

Neha Aggarwal

- Deputed to attend International Committee for Coal and Organic Petrology (ICCP), New Delhi, 22 September, 2022

Deputation to Training/Study Visits:

Ranveer S. Negi

- Attended e-Training on "Effective Writing of Report, Scientific Publications and Presentation Skills in Earth Sciences" held from 11.10.2022 to 13.10.2022" at the Regional Training Division, Geological Survey of India, Central Region, Nagpur.
- Attended Seminar on "Human-Cantered Artificial Intelligence" organised by Stanford University, online via Video Conference on February 22, 2023.

Lecture delivered

Anju Saxena

- Legacy and vision of Prof. Birbal Sahni: Journey from Palaeobotany to Palaeosciences at Department of Botany, University of Lucknow, Lucknow on 13/02/2022.

Deepa Agnihotri

- Administrative Vigilance Course -Department of Science and Technology, New Delhi, June 15-17, 2022.

Divya Kumari Mishra

- Technological properties of the Coal in context to Coal Quality Assessment, on 24.03.2023 at BSIP, Lucknow.

S. Suresh Kumar Pillai

- Geoheritage: A critical appraisal contribution of BSIP in the Development of Fossil Park: Hindi Workshop, BSIP, Lucknow on December 15, 2022.

CONSULTANCY / TECHNICAL SUPPORT RENDERED

S. Suresh Kumar Pillai

- Developed Mandro Fossil Park located in Mandro, a community block in the Sahibganj District of Jharkhand lying in the forested hilly area of Gumri in the Rajmahal Hills of Sahibganj, Pakur, Dhumka, Godda districts, Jharkhand.

Anju Saxena and S. Suresh Kumar Pillai

- A visit to Manendragarh, Chhattisgarh State was made during 19-23 December 2022, in relation to the development of Marine Fossil Park. A detailed work pertaining to the sign boards in simple language about the significance of Manendragarh Marine Fossil Bed and its protection and conservation was carried out.

Divya Kumari Mishra

- Advanced Coal Petro-Geochemical Analytical Facility, Pellet making for organic petrography, Dr. Susheel Kumar, Assistant Professor, Centre for Petroleum Exploration, School of Earth Science and Natural Resource Management, Mizoram University, Aizwal-796004, Mizoram., Rs 11,800/-.

ACCOLADES RECEIVED

Abha Singh

- Invited as Chief Guest in Felicitation Ceremony for the felicitation of class-wise, top-5 students in Half Yearly Examination-2022 at Bal Nikunj Inter College, Sri Nagar Mohibullapur, Lucknow on 22 November, 2022.

REPRESENTATION IN COMMITTEES/BOARD

Anju Saxena

- Member of Executive Council (The Palaeontological Society of India, Lucknow, till 2022).
- Associate Editor, Journal of the Palaeontological Society of India, Lucknow since 2023.
- Co-Editor in the Editorial Board, Geophytology Journal since 2019.
- Co-Editor, open Access journal 'Earth Science India' since 2010.

S. Suresh Kumar Pillai

- Expert in the Botany, Environmental Science & Forestry discipline for 17th USSTC during 10th-12th February, 2023 at Uttarakhand State Council for Science and Technology, Vigyan Dham, Dehradun.

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) 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

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

Indian Plate witnessed large-scale volcanic activity during its northward voyage as a consequence of passing over the Reunion Hotspot and Deccan traps are the remnants of this large-scale volcanic activity. The associated Volcano-Sedimentary Successions (DVSS; infra- and intertrappean) deposits imply intervals of thawing in the volcanic activity and are an important source of ~66 million-year-old fossil biota. To comprehend the timing(s) and the extent of the volcanic activity it is crucial to study the Deccan Volcano-Sedimentary Successions (DVSS) in a chronological framework. Additionally, the biotic turnovers across the Cretaceous–Paleogene (K–Pg) transition can be understood with the help of data on fossil flora and fauna from the DVSS. Further, the palaeontological data from the Paleogene lignite-associated sedimentary successions of western India may help in understanding the origin, early evolution and historical distribution (in a palaeogeographic

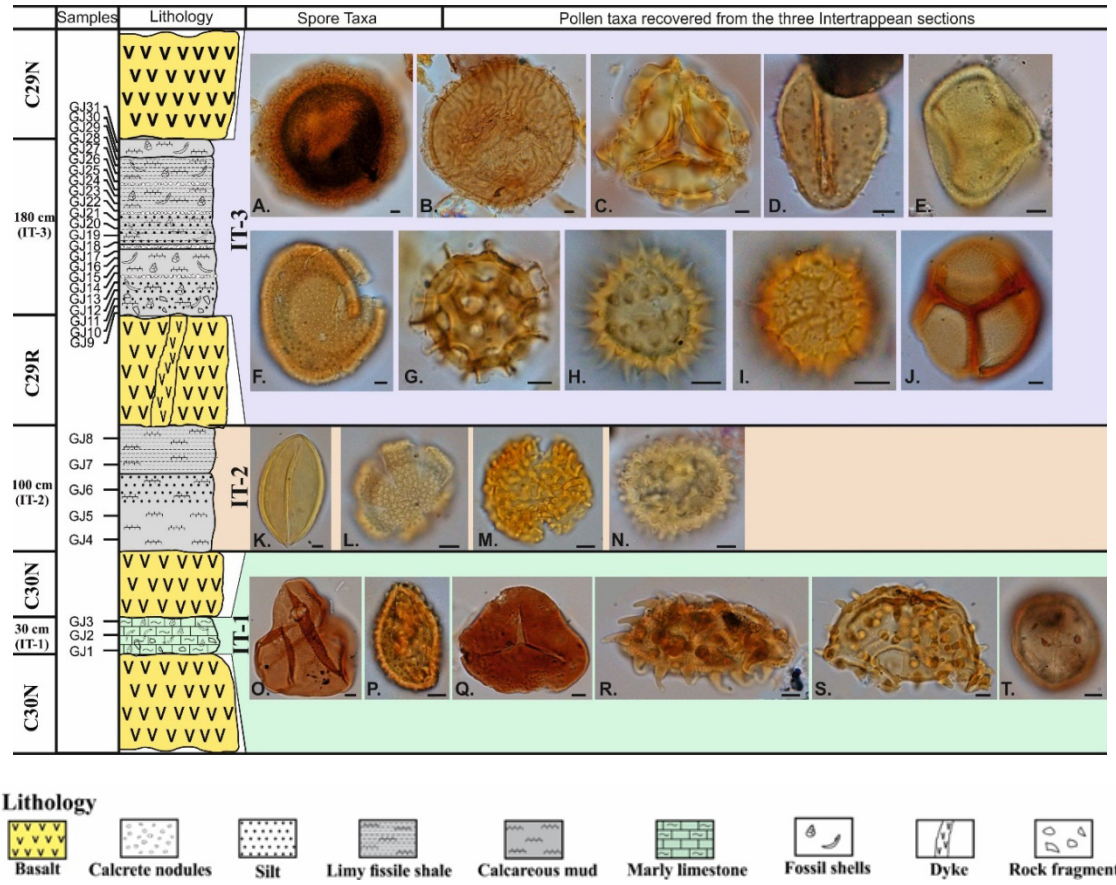


Fig. 1 - Photomicrographs of palynomorphs recovered from the Deccan volcano-sedimentary succession exposed near Gujri-Dugni Village, Dhar, Madhya Pradesh.

framework) of fossil biota. Furthermore, the global climate change events during the Paleogene (e.g., PETM; ~56 Ma) are considered as the important analogues to understand the effect(s) of warming in tropics. Efforts are underway by the Project 3 team members to delineate Paleogene warming events within the lignite associated sedimentary successions of western India. Project 3 team members are also studying the change in the vegetation patterns and faunal diversity and its link(s) to climate change at the end of the Paleogene and during the Neogene intervals.

PERSONNEL INVOLVED

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

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

Technical Support Members: Archana Sonker (Technical Assistant A)

Research Scholars: Priya Agnihotri, Harshita Bhatia, Kajal Chandra, Samiksha Shukla, Pawan Kumar Singh, Sarvendra Pratap Singh, Ramanand Sagar, Sadanand Pathak

SIGNIFICANT FINDINGS

Sedimentary samples collected from the Deccan volcano-sedimentary succession exposed near Gujri-Dugni Village, Dhar (MP) were prepared and analyzed for magnetostratigraphic, palynological and sedimentological studies. The Gujri-Dugni Deccan Intertrappean Succession is unique in its constitution due to the occurrence of three intertrappean deposits (IT-1, IT-2 & IT-3) associated with four Deccan basaltic lava flows in vertical continuous succession. Magnetostratigraphic study of basaltic lava

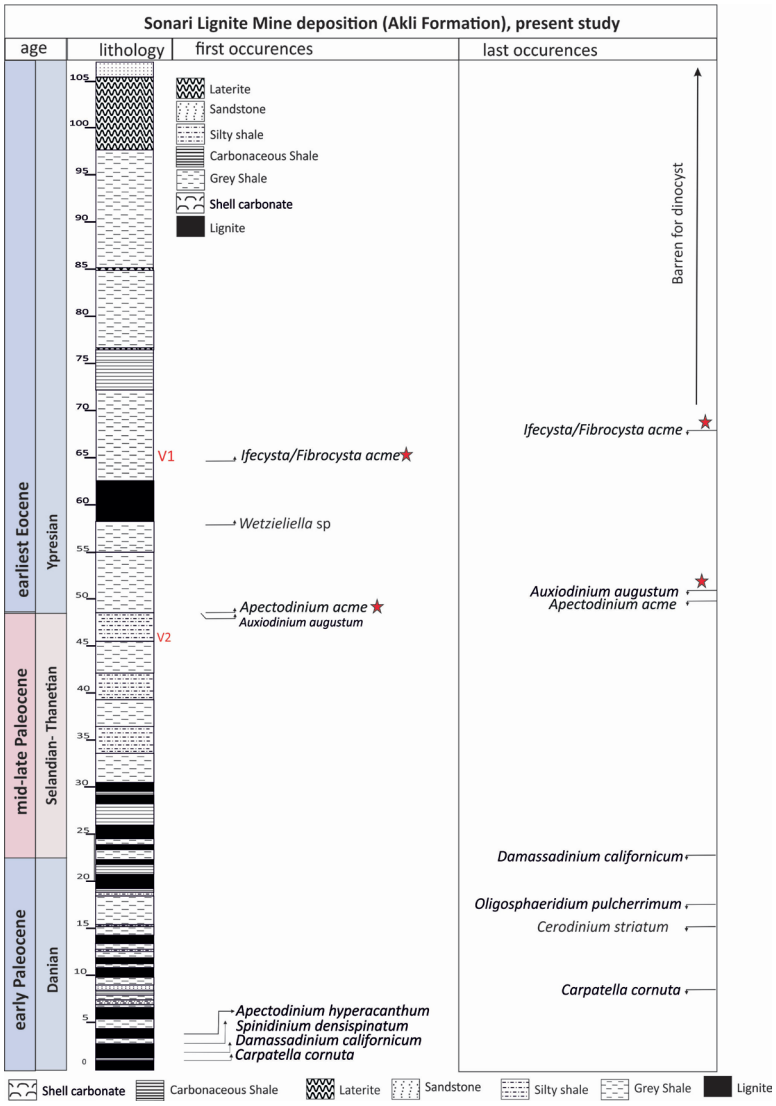


Fig. 2 - Litholog of the Sonari Lignite Mine Succession (Barmer Basin, western India) with dinoflagellate cyst marker levels and age assignment of the studied succession along with vertebrate intervals.

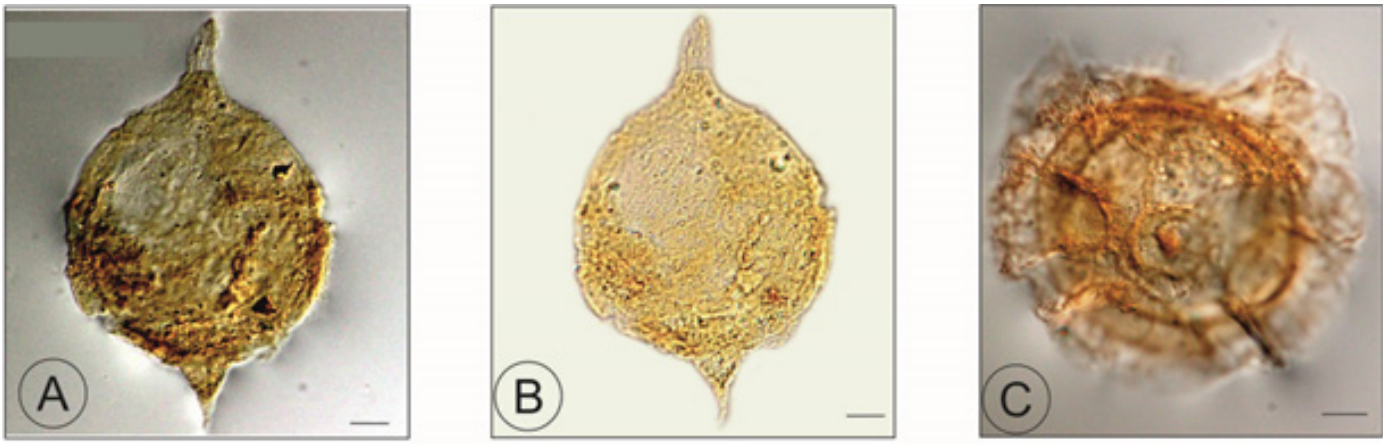


Fig. 3 - Selected dinoflagellate cysts from the Akli Formation, Sonari Lignite Mine, Barmer Basin, western India. The scale bars all indicate 10 µm. England Finder coordinates represent the locations of the specimens on the BSIP slides. (A & B)17133, F28, *Carpatella cornuta*; (C)17134, D26, *Damassadinium californicum*.

flows reveals the presence of all the three C30n-C29r-C29n magnetic polarity sequence representing the significant Deccan volcanic eruption history. Thus, it can be ideally used for palaeovegetational, palaeoecological and palaeoclimatic transition studies concerning to Deccan volcanism. However, unfortunately this succession is palynologically poorly productive (Fig. 1). The Maastrichtian-aged IT-1 (oldest) pollen assemblage consists of tropical humid taxa and IT-2 is almost barren. A climatic transition is observed in the Danian-aged IT-3 palynoassemblage by the high incidence of subtropical to temperate angiosperm taxa. However, this broad palaeovegetational interpretation has been cautiously made due to poor pollen productivity. Sedimentological analysis of the three intertrappean deposits suggest their deposition in a shallow freshwater lacustrine system with low to moderate energy conditions under hot and humid climate.

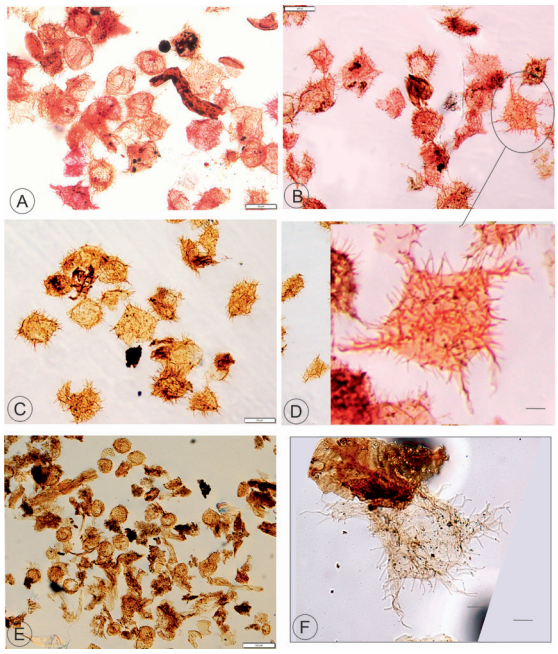


Fig. 4 - Selected dinoflagellate cysts from the Akli Formation, Sonari Lignite Mine, Barmer Basin, western India. The scale bars all indicate 20 µm. England Finder coordinates represent the locations of the specimens on the BSIP slides. (A) 17142, *Apectodinium* acme; (B) 17142a, *Apectodinium* acme; (C) 17142b, *Apectodinium* acme; (D) 17142a, *Apectodinium augustum*; (E) 17142b, *Ifecysta / fibrocysta* acme; (F) 17142b, *Apectodinium augustum.*

A detailed and a diverse record of dinoflagellate cysts from the lignite-associated sedimentary succession (belonging to the Akli Formation) at Sonari Lignite Mine, Barmer Basin, Rajasthan State, western India reveals a Danian to Ypresian age for the investigated succession (Fig. 2) and argues that the deposition of lignitic sequences along India's western margin is not coeval. The occurrence of *Damassadinium californicum* and *Carpatella cornuta* supports a Danian age assignment for the basal part of the studied sedimentary succession at SLM while biostratigraphically significant *Apectodinium* acme (globally linked to the warming event PETM) has also been documented in the investigation from the middle part of the studied succession (Figs 3, 4). First Occurrence of *Wetziella (W.* cf. *stellatum)* species is also registered in the investigation that is indicative of a basal Eocene age for the upper part of the succession at SLM (Fig. 2).

The investigation also identified two vertebrate (dominantly fish-yielding) units within the studied Akli Formation succession. The Ypresian fish genera (mainly represented by dental remains) include *Ginglymostoma, Jaekelotodus, Brachycarcharias, Pycnodus* and *Myliobatis* while the Selandian-Thanetian fish dental remains include *Dasyatis* (Figs 5, 6). A discontinuous distribution of fish fauna during the early Paleogene (based on the temporal and spatial data) within the lignite-associated sedimentary successions of western and north India allowed to infer

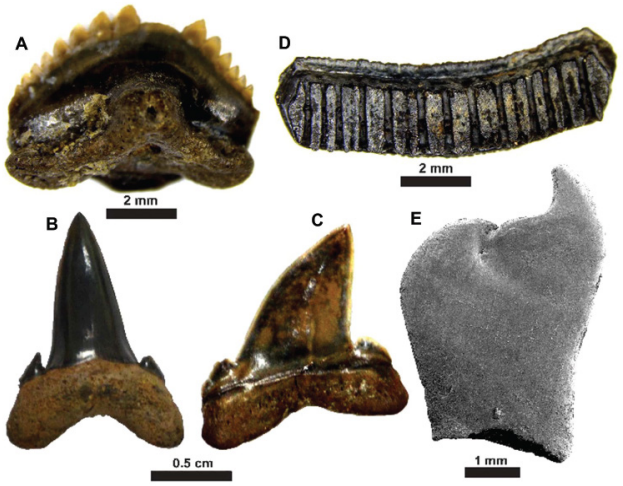


Fig. 5 - Digital photographs and SEM image(s) of the Ypresian fish dental remains from the vertebrate level 1 (V1) Akli Formation at Sonari Lignite Mine, Barmer Basin, Rajasthan, western India. (A) *Ginglymostoma* sp. (isolated lateral tooth, lingual view, specimen no. SNRI/V1/S7: BSIP 42121); (B) *Brachycarcharias* cf. *B. lerichei* (isolated tooth, lingual view, specimen no. SNRI/V1/S3: BSIP 42122); (C) *Jaekelotodus* sp. cf. *J. trigonalis* (isolated tooth, labial view, specimen no. SNRI/V1/S4: BSIP 42123); (D) *Myliobatis* sp. (isolated medial tooth, basal view, specimen no. SNRI/V1/S10: BSIP 42124); (E) SEM image of *Pycnodus* sp. (Isolated tooth, lateral view, specimen no. SNRI/V1/S11: BSIP 42125).

the prevalence of separated realms with variably restricted palaeoenvironmental conditions. Overall, the faunal evidence is indicative of dominantly estuarine to shallow marine conditions with enhanced freshwater influence during the Thanetian as compared to the Danian. The study argues in favour of the earliest appearance of dinoflagellate cyst *Apectodinium* in the near-equatorial region of the Tethys Ocean during the early Paleocene (within Danian).

Wide variability in siliciclastic lithology and dominance of conglomerates in the lower ~40 m of the Khasi Group, south Shillong Plateau depict late Cretaceous tectonic instability in north-eastern India (Fig. 7). Variable fabric pattern within the conglomerates registers spectral variation in flow rheology. Conglomerates are thereby classified in multiple facies- (1) matrix-supported, chaotic, massive, (2) matrix-supported, normally graded, (3) Clast-supported, chaotic, reverse graded and (4) cross-stratified. They indicate a gradual evolution of a hyperconcentrated density flow to a fluidal tractive current. The lensoidal poorly sorted sandstone bodies internally characterized by trough cosets are interpreted as river channel deposits. On the other hand, convex-up compound cross-stratified sandstone bodies are interpreted as mid-channel bars. The heterolithic, finer sandy bodies interspersed with sigmoidal mud layers are inferred as point bars. Reddish shale with sand-filled vertical burrows and with abundant rootlets were deposited on river flood plains.

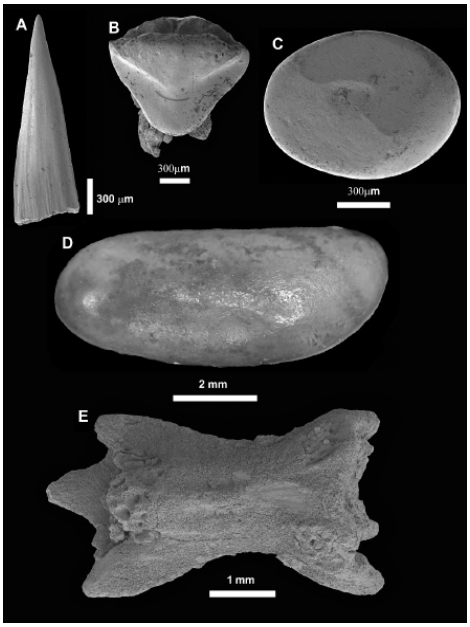


Fig. 6 - SEM photographs of the Selandian-Thanetian vertebrate remains from the vertebrate level 2 (V2) Akli Formation at Sonari Lignite Mine, Barmer Basin, Rajasthan, western India. (A) *Teleost* gen. *et* sp. indet. (isolated tooth, lateral view, specimen no. SNRI/V2/001: BSIP 42126); (B) *Dasyatis* sp. (isolated tooth, occlusal view, specimen no. SNRI/ V2/002: BSIP 42127); (C) *Pycnodus* sp. (isolated ?anterior tooth, occlusal view, specimen no. SNRI/ V2/003: BSIP 42128); (D) *Pycnodus* sp. (isolated medial tooth, occlusal view, specimen no. SNRI/ V2/004: BSIP 42129); (E) Squamata family indet. (isolated vertebra, ventral view, specimen no. SNRI/ V2/005: BSIP 42130).

Eocene amber deposits in India are quite rare and thus, the Cambay amber is quite significant because of its diverse palaeobiota that sustained during the Early Eocene Climate Optimum (EECO; a period when the Earth experienced a significant global temperature increase). The amber palaeobiota is crucial to understand the palaeoecology of the developing tropical broad-leaved Dipterocarpaceae dominated mixed rain forests. In a recent investigation, a new species *Sycorax longistyla* (subfamily Sycoracinae: a subfamily of tiny flies some of which are known to prey on amphibian blood) has been recorded within the Eocene amber collected from the Tadkeshwar Lignite Mine, Cambay Basin, Gujarat State, western India. The occurrence of *S. longistyla* suggests prevalence of sludge-based peat bog spring habitat existed in the early Eocene tropical angiosperm Cambay forest. The fossil species (*S. longistyla*) is distinguished from the extant representatives by possessing an elongate tubular gonocoxite with a large internal lobe; the gonostylus is curved and longer than the gonocoxite and bears a strong apical spine 0.6 times the length of the gonostylus (Fig. 8). Comparison of the drop-shape gonocoxal lobe of *S. longistyla* with the Baltic amber species is a characteristic trait, as well as the comparatively shorter and roundish palpomeres (Fig. 8). Closer relations

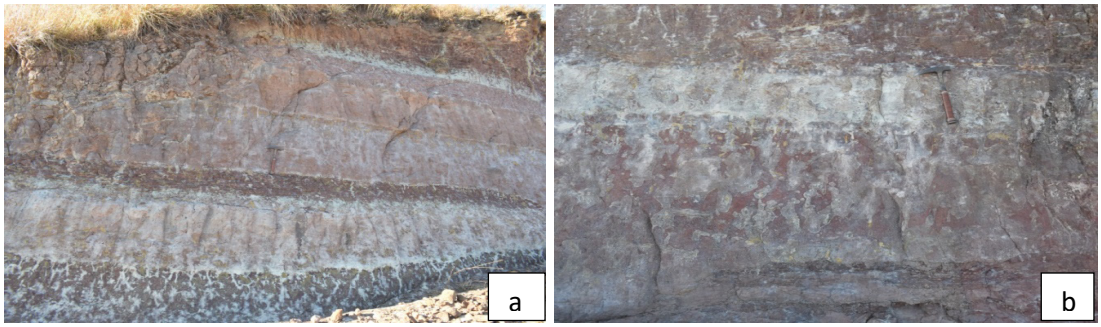


Fig. 7 - Field photographs of the Lower Mahadek Sandstone of the Khasi Group, South Shilong Plateau, Meghalaya. (a) Channel Sandstone bodies in association with floodplain shale, and (b) Close-up view of reddish shale with sand filled vertical burrows and abundant rootlets of flood plain origin.

to other than the extant West-Palearctic and Afrotropical faunas are unlike. In Cambay amber, terrestrial community is abundant and diverse and these field areas are highly potential for palaeobiotic assemblages to improve our understanding in these amber rich sedimentary deposits.

In a separate investigation on amber palaeobiota, the Dolichopodidae described from the Kutch and Cambay amber, *Palaeomedeterus cambayensis* Bickel sp. nov. was described and provisionally assigned to the Peloropeodinae, and is congeneric with European Baltic amber species, suggesting the genus was widespread for a considerable time period in both Europe and India. Two small-sized new monotypic genera are also described, *Gujaratmyia rotunda* Bickel gen. et sp. nov. and *Rajpardia grimaldii* Bickel gen. et sp. nov. Also included are undescribed members of the dolichopodid subfamilies Diaphorinae and Medeterinae, and unplaced species. Based on a specimen of thirty-eight inclusions, the fauna preserved in amber reveals that the family was well-identified by the early Eocene. Adults of many genera are found on tree trunks where they hunt small arthropod prey and search for mates, an association that facilitates their accidental entrapment in sticky resin flows, some of which may be later transformed into amber. As a result, the family is frequently found as inclusions in Cenozoic ambers. By comparison with the two families noted above, the Cambay amber Dolichopodidae comprises thirty-eight specimens, thirty-four of which are assigned to four extant subfamilies, with three genera (two newly described) and three new species, as well as damaged undescribed species (Figs 9-11). The Cambay and Kutch amber deposits are potentially rich and remarkable in terms of yielding a diverse set of palaeoentomological, palaeobotanical, vertebrate and invertebrate palaeontological data.

The lignites and associated sediments from Jalipa Mine, Barmer Basin, Rajasthan in western India were subjected to lipid biomarker studies to understand the evolution and the characteristics of the organic matter (OM) in the basin. Results show a relatively high terrigenous/aquatic ratio (TAR) and the Carbon Preference Index (CPI), suggesting higher plants as the source input. Presence of terpenoids with oleanane and lupane structure dominates the terpenoid concentration and suggests a major angiosperm input. The *n*-alkane distributions, maximizing at *n*-C_{17} and *n*-C_{29}, showed inputs from the algal communities and higher plants. The lignites were characterised by a high abundance of huminite followed by inertinite and liptinite group of macerals. The various petrographical indices suggest that the deposition of the peat-forming flora took place in limno-telmatic environment under rheotrophic hydrological condition. The presence of higher plant terpenoids (diterpenoids, oleanane and lupane structured triterpenoids, etc.) along with algal and bacteria derived

Fig. 8 - *Sycoraxlongistyla* sp. nov. from the lower Eocene amber of Tadkeshwar Lignite Mine, Gujarat State, western India.

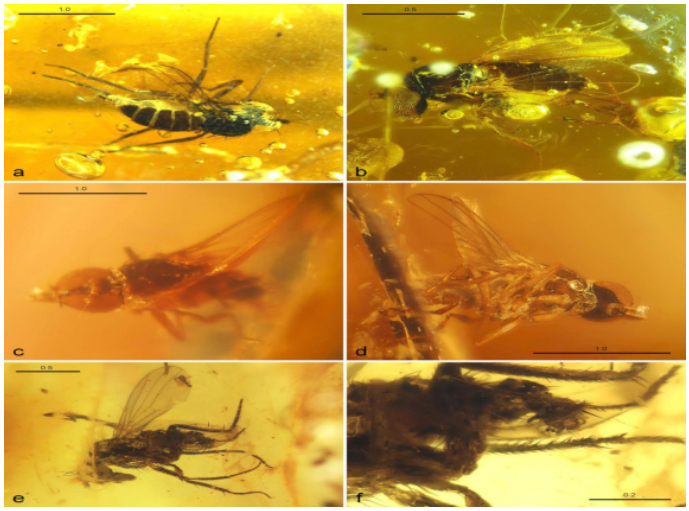


Fig. 9 - Varied morphotaxonomic views of the Dolichopodidae (Diptera).

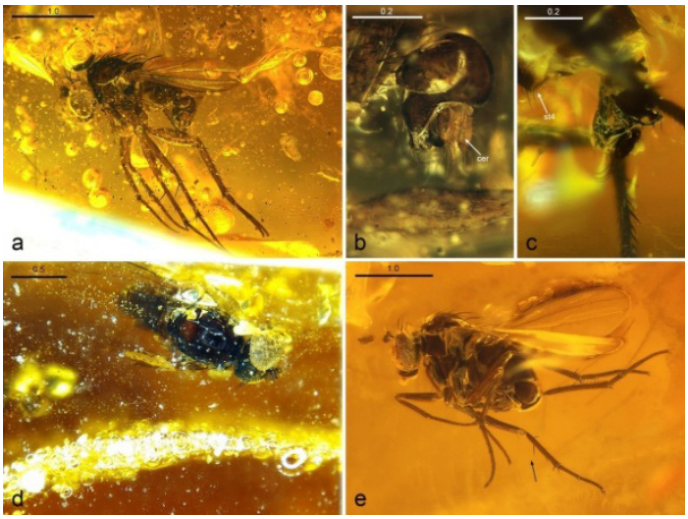


Fig. 10 - Varied morphotaxonomic views of the *Palaeomedeterus cambayensis* sp. nov (Diptera).

Fig. 11 - Varied morphotaxonomic views of the *Gujaratmyia rotunda* sp. nov (Diptera).

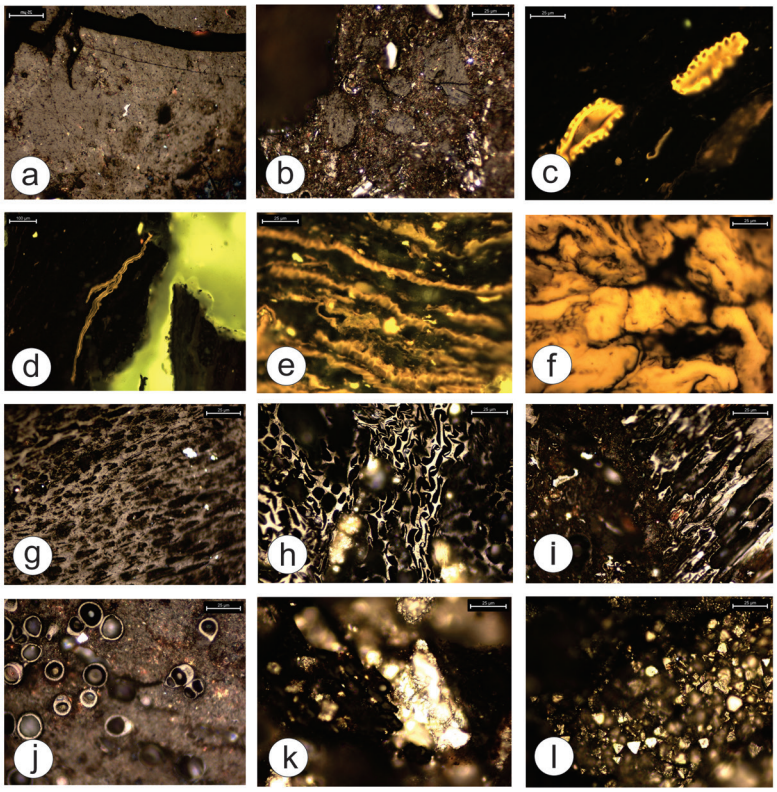


Fig. 12 - Representative photomicrographs of macerals identified in Giral Llignite samples: (a) Ulminite (b) Corpohuminite, Densinite (c-d) Sporinite, (e) Cutinite, (f) Resinite, (g) Semifusinite, (h-i) Fusinite, (j) Funginite (k-l) Pyrite.

hopanoids indicate a mixed floral cover flourishing in a tropical warm climate.

The lignite-bearing sediments from Giral Mine are associated with Akli Formation (Danian-Thanetian), from Barmer Basin, western India. The Barmer Basin is an important depository of Paleogene Lignite and Carbonaceous shales and also a category-I basin. The 'low-rank-C' lignite is chiefly constituted by the huminite group of macerals followed by inertinite and liptinite groups. Amongst huminite, the telohuminite and detrohuminite sub-groups are in co-dominance, signifying that the higher (woody) plants as well as herbaceous (herbs, bushes, etc.) vegetation significantly contributes to the peat. Alternatively, the relatively high content of detrital material (attrinite and densinite) could also reflect the elevated microbial activity, thus promoting the destruction of the plant-tissue framework. Subsequently, the content of the liptinite group is represented by resinite, sporinite, cutinite, and inertoderinite macerals also indicate the higher plant input during the peat accumulation. On the other hand, the raised content of inertinite group of macerals is mainly represented by semifusinite, inertodetrinite, fusinite and funginite macerals which suggests that the peat precursors had experienced intermittent aerial exposure (oxidized conditions) and/or forest fires in the depositional milieu (Fig. 12). Further, the Fourier Transform Infra-Red Spectrometry (FTIR) analysis shows that the lignite spectra are generally prominently characterized by broad OH, aliphatic and aromatic stretching bands. The A-Factor and C-Factor show type-III/II kerogen types which are substantiated by a higher content of huminite and liptinite macerals. The studied lignite samples have moderate to high values of gelification and tissue preservation indices. The extrapolation of these values suggests that limno-telmatic peat-forming flora was accumulated in a back-barrier (mainly) and wet forest swamps. The variation in the values of groundwater index suggests that the hydrological conditions were relatively high and fluctuating (mesotrophic-rheotrophic) during the deposition of peat precursors.

In a separate investigation, shale samples belonging to the Matanomadh Formation (Kutch Basin, western India) were analyzed for organic richness. A few selected samples have shown good presence of vitrinitic and liptinitic and contain alginite (alg), resinite (R), suberinite (Sb), ulminite (U), detrohuminite (Vd), bituminite (Bt) and amorphous organic matter (AOM) (Fig. 13). The presence of framboidal pyrite (Py) is indicative of extreme reducing conditions during the deposition of organic matter. The presence of bituminite and suberinite supports the liquid hydrocarbon generation potentiality of the Matanomadh shales. The exsudatinite is also rarely spotted in two samples (LM31 and LM-45) that hint at liquid hydrocarbons. However, the mineral association is a significant parameter for a source rock

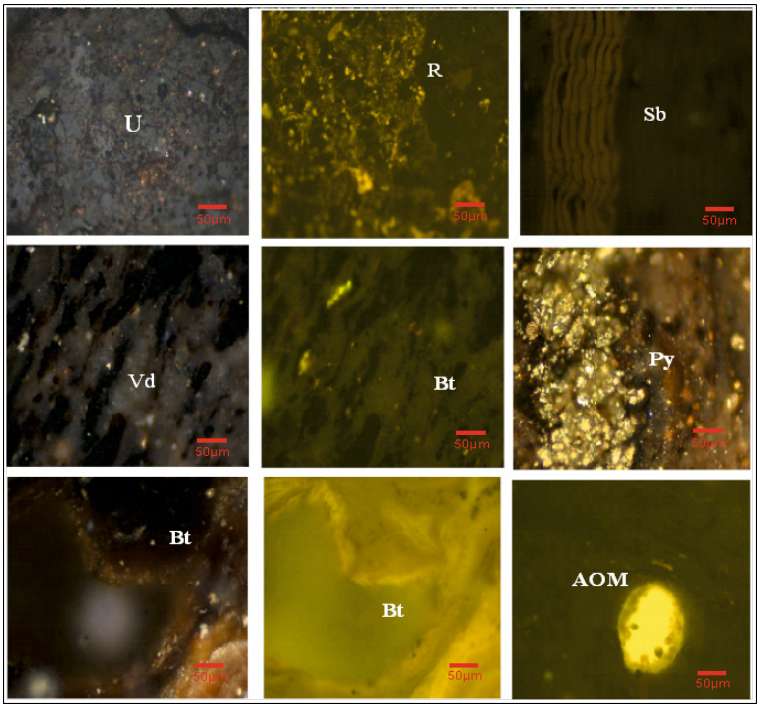


Fig. 13 - Shale samples belonging to the Matanomadh Formation (Kutch Basin, western India) showing good presence of vitrinitic and liptinitic and contain alginite (alg), resinite (R), suberinite (Sb), ulminite (U), detrohuminite (Vd), bituminite (Bt), amorphous organic matter (AOM) and framboidal pyrite (Py).

to expel hydrocarbon generation potential. Thus, further detailed analyses are required to confirm the hydrocarbon generation potentiality of the shales belonging to the Matanomadh Formation.

The integrated records of dinoflagellate cysts and calcareous nannofossils have been used to assign the age of lignitic as well as post lignitic succession of Matanomadh Lignite Mine, Kutch Basin, Gujarat. The dinoflagellate cysts assemblage envisages an age of the interval between lignitic and interbedded shales of Matanomadh Lignite Mine not younger than late Ypresian (early Eocene). The interpreted Ypresian age of lignitic-facies well corroborate with the ages of other lignitic and associated succession of the lignite mines of the Kutch Basin. In addition, calcareous nannofossils suggest a middle Lutetian age (~46-43Ma) for the top non-lignitic marly part of the studied Matanomadh Lignite Mine succession of the Kutch Basin, western India (Fig. 14).

Early Paleogene is considered the warmest period on Earth during the Cenozoic. These warm climates redistributed the habitat of marine and terrestrial biota. Understanding the ecological niche of biota under extremely warm conditions will help in their future conservation. We have discovered two new legume fossils, namely *Leguminocarpum meghalayensis* Bhatia, Srivastava & Mehrotra sp. nov. and *Parvileguminophyllum damalgiriensis* Bhatia, Srivastava & Mehrotra sp. nov. from the late Paleocene sediments of the Tura Formation, Meghalaya (Fig. 15). The reconstructed climate data suggests that fossil legumes were well adapted to a warm seasonal climate with monsoon rainfall.

Woody charcoal is identified from the early Paleogene sediments of the Gurha Lignite Mine (Palana Formation), Bikaner, Rajasthan. These charcoal remains, most of which belong to angiosperms, represent the first verified occurrence of paleo-wildfires in this region during the early Paleogene. The presence of diterpenoid compounds together with the occurrence of (mega) sporinite in the lignite samples also shows the presence of gymnosperm vegetation (conifers). The relatively higher content of these macerals (viz., huminite, inertinite and liptinite) in the studied lignite indicates the regular events of paleofire during the deposition (Fig. 16).

The foliage of three well-preserved figs is described from the early Paleogene succession of the Gurha Mine, Rajasthan, India (Fig. 17). These fossils provide new morphological data that strengthens our understanding of the past occurrences of *Ficus* and, alongside all validly published records of fossil figs, helps to trace the evolutionary history of figs. These data support a Eurasian origin for figs, highlight a pivotal role for the Indian subcontinent during the early phase of fig diversification.

Well-preserved leaflet and pollen comparable to the extant genus *Swietenia* of the Meliaceae from the late Paleocene to the early Eocene sedimentary horizon of the Gurha Lignite Mine, Rajasthan (western India) are described (Fig. 18). These early Paleogene fossils are the oldest known fossil records of the genus *Swietenia* and add a new perspective to its palaeobiogeographic distribution in Southeast Asia during the early Paleogene.

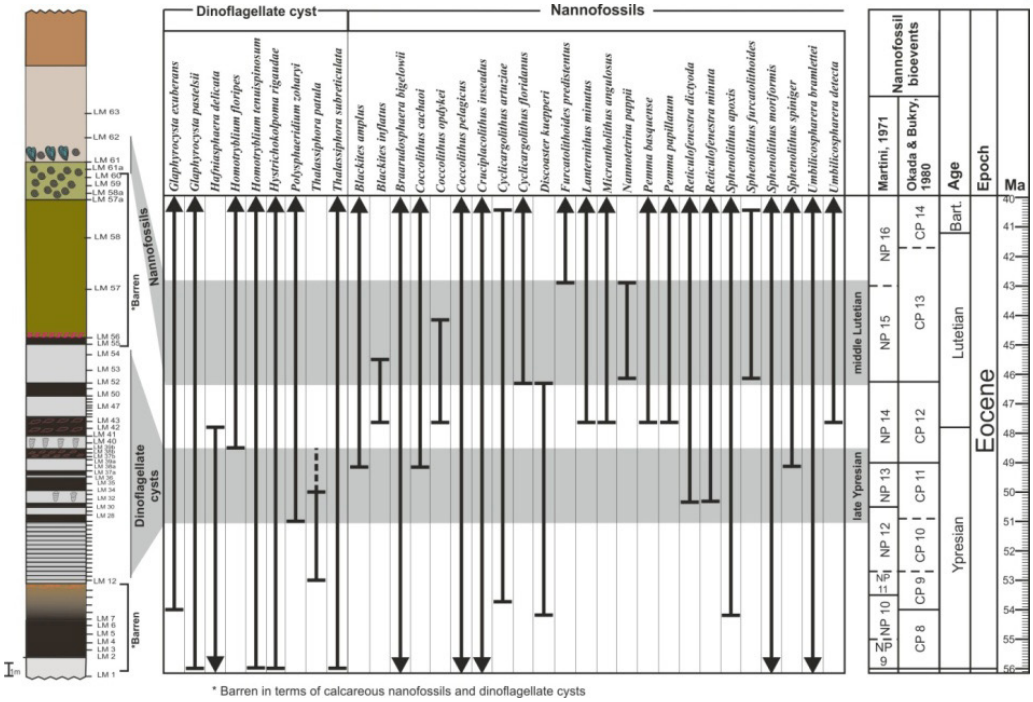


Fig. 14 - Composite representation of the stratigraphical ranges of organic-walled dinoflagellate cyst and calcareous nannofossil species recovered from Matanomadh Lignite Mine succession and their correlation nannoplankton biozonation and chronostratigraphy.

Bulk maceration technique employed on samples from the late Miocene sedimentary units of the Kutch Basin (western India) and coeval Siwalik deposits has resulted in the recovery of numerous cyprinid fish dental remains (Fig. 19). This palaeontological evidence hints at the presence of a freshwater environment.

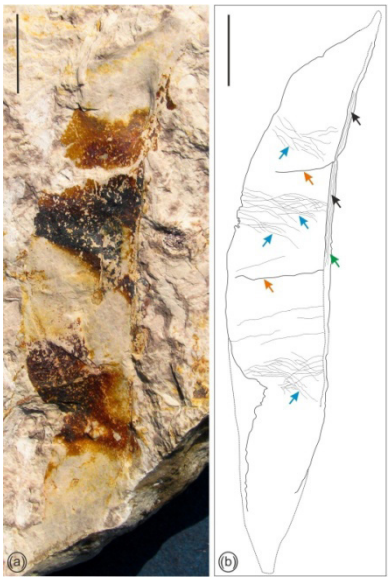


Fig. 15 - (a). *Leguminocarpum meghalayensis* Bhatia, Srivastava & Mehrotra sp. nov. (Bar scale 1 cm). Fossil fruit showing shape, size, valve venation, fracture marks and sutures. (b) Diagram of the fossil fruit showing fascicles of vascular strands (black arrows) preserved on suture with a flange (green arrow), fracture marks (orange arrows) and transverse to slightly oblique striations (sky blue arrows).

In a separate investigation, middle Eocene deposits of Sylhet Limestone of Mikir Hills (northeast India) have yielded vertebrate and invertebrate faunas. The recorded fossil assemblage comprises of dental elements (isolated teeth) belonging to sharks, rays, crocodiles and echinoid spines (Fig. 20). This is the first record of ray and crocodile teeth from the Mikir Hills. Palaeoenvironmental analysis based on the fossil fish assemblage in association with invertebrate (foraminifera) remains and sedimentological observations suggest prevalence of a shallow marine environment ranging from open marine, inner neritic to more proximal coastal settings. Also, the presence of common marine elements (similar faunas) from Kutch, Rajasthan, Himachal Pradesh, Assam (India), New Hampshire, Libya, Iraq, Iran, North Western Sahara (Algeria), Tanzania (East Africa), Italy, Germany, Southern North Sea Basin (Europe) based on previous published works and the present finding testifies to the connection of the Tethys Sea during Lutetian-Bartonian of middle Eocene.

The Quilon Limestone (Kerala Basin) is dominated by foraminifera-green algal skeletal assemblages with abundant soritid *Pseudotaberina malabarica* and various species of calcareous alga *Halimeda* in a float stone facies (Fig. 21) attributed to early Miocene (Burdigalian) based on the presence of *Miogypsina globulina* and *Nephrolepidina sumatrensis*. The Quilon Limestone Assemblage represents a sea grass palaeoenvironment. The micropalaeontological assemblages show close affinity to carbonate associations from Sri Lanka, Java and several Indo-Pacific successions.

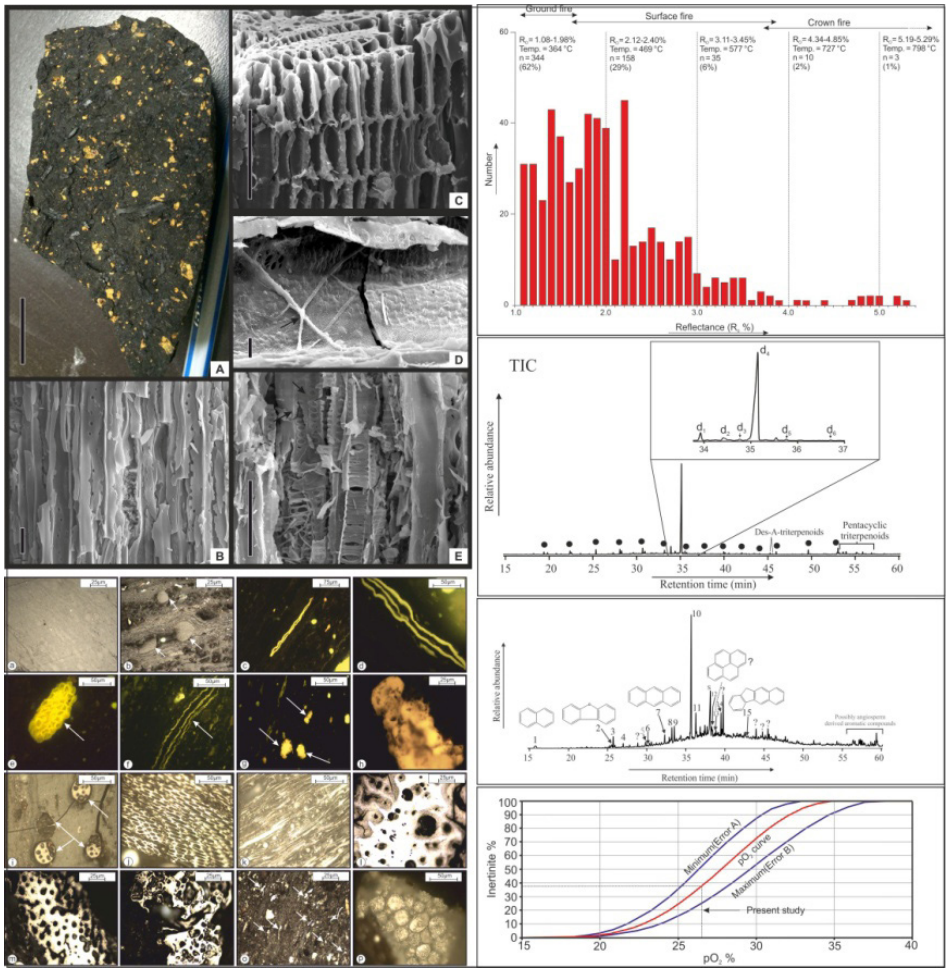


Fig. 16 - Evidences of the paleofire in the early Paleogene, reported from the Gurha Lignite Mine, Bikaner, Rajasthan.

In a separate investigation, both solitary and colonial corals were recorded from the Matanomadh Locality with dominant foliose and massive morphologies (rare branching corals). The meandroid reef corals recorded in the current study are attributed to Oligocene and show close affinity to the modern Indo-Pacific and Mediterranean corals, while they are considerably different from the Carribbean corals thereby showing that the latter were highly isolated forms both ecologically and geographically. On the other hand, the Kutch Basin corals were part of highly diverse Tethyan fauna.

PROJECT OUTCOME

Publications

In SCI (Science Citation Index) Journal

1. Agnihotri P & Singh H 2022. Stratigraphic Harudi signatures at the Umarsar Lignite Mine, Kutch Basin, Gujarat, India. Journal of the Palaeontological Society of India 67(2): 357-362 (IF: 0.8).
2. Alam M, Tripti M, Gurumurthy GP, Arif M, Singh AD, Radhakrishna T, Pandey DK & Verma K 2023. Exploring the erosional history of the western Himalayas and its link to hydroclimatic conditions since the late Miocene: insights from the IODP Site U1457 of Laxmi Basin in the northeastern Arabian Sea. Geological Magazine, Cambridge University Press (IF: 2.656).
3. Bhatia H, Srivastava G & Mehrotra RC 2023. Legumes from the Paleocene sediments of India and their ecological significance. Plant Diversity 45: 199–210 (IF: 3.35).
4. Bickel DJ, Martin J, Agnihotri P & Singh H 2022. Dolichopodidae (Diptera) from the Eocene amber deposits of Cambay and Kutch basins, India. Palaeoentomology 005(5): 475-486 (IF: 1.4).
5. Chandra K, Shukla A, Mehrotra RC, Bansal M & Prasad V 2023. Fossil Mahogany from the Early Paleogene of India. Journal of the Geological Society of India 99(1): 65-72 (IF: 1.4).
6. Chandra K, Spicer RA, Shukla A, Spicer T, Mehrotra RC & Singh AK 2023. Paleogene *Ficus* leaves from India and their implications for fig evolution and diversification. American Journal of Botany 110(3): 216145 (IF: 3.3).
7. Mishra S, Singh SP, Arif M, Singh AK, Srivastava G, Ramesh BR & Prasad V 2022. Late Maastrichtian

Fig. 17 - Fossil leaves of *Ficus* reported from the Gurha Lignite Mine, Bikaner, Rajasthan.

vegetation and palaeoclimate: Palynological inferences from the Deccan Volcanic Province of India. Cretaceous Research 133: 105126 (IF: 2.4).

8. Prasanna K & Kapur VV 2022. Oxygen isotopic studies of a species of *Pitar* (Hyphantosoma) from Quilon Formation, Kerala, Southwest India: Inferences on seasonality during the Miocene (late Burdigalian). Journal of the Geological Society of India 98: 843–850. DOI: 10.1007/s12594-022-2075-1 (IF: 1.6).
9. Shukla A, Jasper A, Uhl D, Mathews R, Singh V, Chandra K, Chetia R, Shukla S & Mehrotra RC 2023. Paleo-wildfire signatures revealing co-occurrence of angiosperm-gymnosperm in the early Paleogene: Evidences from woody charcoal and biomarker analysis from the Gurha Lignite Mine, Rajasthan, India. International Journal of Coal Geology 265: 104164 (IF: 6.3).
10. 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: 1.4).
11. Singh PK, Singh H, Singh SK & Prasad M 2022. Fossil leaf and fruit of the genus *Harpullia* Roxb. from Upper Miocene (Siwalik) sediments in the Sub-Himalayan zone of West Bengal and its biogeographic and palaeoclimatic significance. Journal of the Palaeontological Society of India 67(2): 342-348 (IF: 0.8).
12. Singh YP, Verma P, Singh A & Bali R 2023. Early Miocene (Burdigalian) dinoflagellate cysts from the Kerala Basin, Southwest India: Indicators of Marine Ingression at the Onset of the Mid-Miocene Climate Optimum (MMCO). Journal of the Geological Society of India 99: 357–369. DOI: 10.1007/s12594-023-2318-9 (IF– 1.6).
13. Umamaheswaran R, Dutta S, Singh H & Kumar S 2022. 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: 5.5).
14. Wagner R, Agnihotri P & Singh H 2022. A new species of *Sycorax* (Sycoracinae: Psychodidae) from the Lower Eocene amber of Tadkeshwar, Gujarat, India. Palaeoentomology 005(4): 319-326 (IF: 1.4).

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1. Biswal S, Lokho K, Needham A, Bhandari A, Shukla UK, Whiso K & Prakash K 2022. Record of additional Middle Eocene vertebrate remains from the Mikir Hills, NE India: Implications on palaeoenvironmental and palaeobiogeography. International Journal of Geosciences 13: 609-625.
2. Singh H, Ranjan R, Singh PK & Prasad M 2022. Two new fossil leaf species, *Fissistigma himachalensis* (family: Annonaceae) and *Berberis siwalika* (family: Berberidaceae), from Middle Siwalik of Sarkaghat, Himachal Pradesh, India. Geophytology 52(1 & 2): 57-66.

Book chapter/Memoirs/ Bulletins

1. Bhatia H, Srivastava G & Mehrotra RC 2022. Floristic diversity and climate change in the Siwalik succession. *In:* Phartiyal B, Mohan R, Chakraborty S, Dutta V & Gupta AK (Editors) - Climate change and environmental impacts: Past, present and future perspective. Society of Earth Scientists Series. Springer, Cham. :1–20. https://doi.org/10.1007/978-3-031-13119-6_1.
2. Chandra K, Shukla A & Mehrotra RC 2022. Early Paleogene megaflora of the palaeoequatorial climate: A case study from the Gurha Lignite Mine of Rajasthan, western India. *In:* Phartiyal B, Mohan

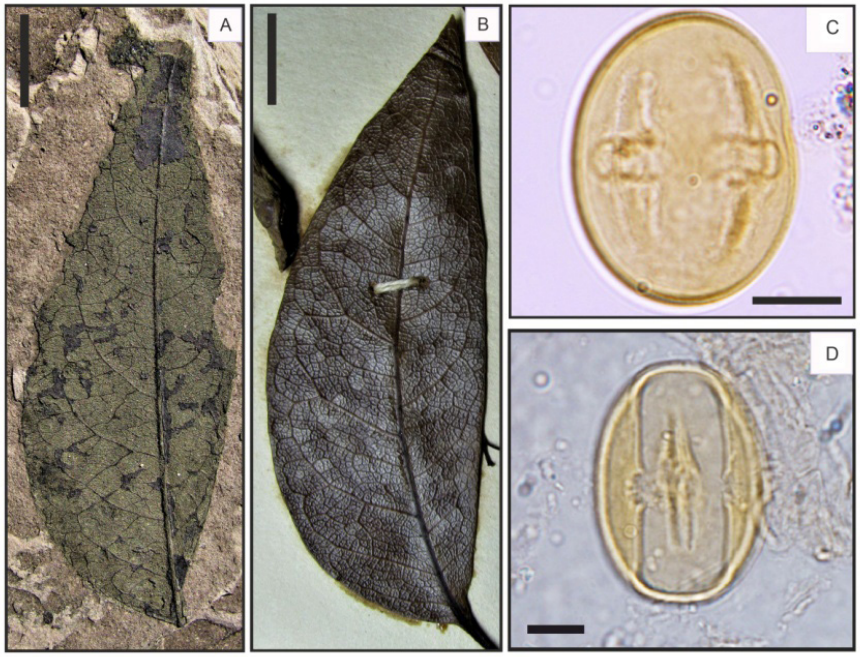

Fig. 18 - Well-preserved leaflet and pollen comparable to the extant genus *Swietenia* of the Meliaceae from the late Paleocene to the early Eocene sedimentary horizon of the Gurha Lignite Mine, Rajasthan.

R, Chakraborty S, Dutta V & Gupta AK (Editors) - Climate change and environmental impacts: Past, present and future perspective. Society of Earth Scientists Series. Springer, Cham. : 21-31. https://doi.org/10.1007/978-3-031-13119-6_2.

3. Kapur VV, García Yelo BA & Thakkar MG 2022. Development of Cenogram Technique over the past six decades with some insights into the varied habitats occupied by diverse mammalian communities across Spain, China, and India transiting the Middle Miocene Climatic Optimum. *In:* Phartiyal B, Mohan R, Chakraborty S, Dutta V & Gupta AK (Editors) - Climate change and environmental impacts: Past, present and future perspective. Society of Earth Scientists Series. Springer, Cham : 33-46. https://doi.org/10.1007/978-3-031-13119-6_3.

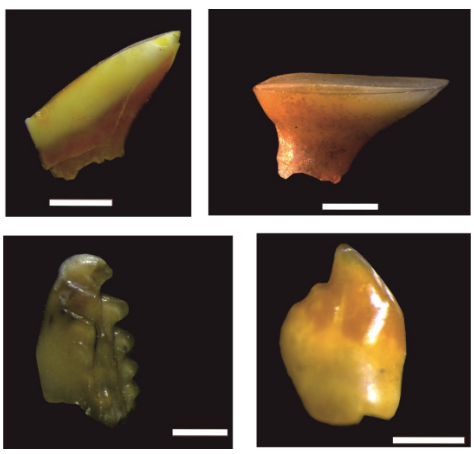

Fig. 19 - Isolated dental remains belonging to Cyprinid fish, late Miocene, Kutch Basin, Gujarat State, western India.

4. Singh YP, Verma P & Singh A 2022. Palynofloral diversity during Mid-Miocene warming in Kerala Basin, south-western India: palaeoclimatic implications. *In:* Phartiyal B, Mohan R, Chakraborty S, Dutta V & Gupta AK (Editors) - Climate change and environmental impacts: Past, present and future perspective. Society of Earth Scientists Series. Springer, Cham: 47-61. https://doi.org/10.1007/978-3-031-13119-6_4.

General Articles/Reports/Database Published

1. Das N, Pandey S & Bhandari A 2023. Workshop on Biodiversity Conservation for Women Scientist/ Technologists. Journal of the Geological Society of India: 99: 293–294.

2. Kapur VV, Sagar R, Kumar K, Chaddha AS, Lourembam RS, Mishra A & Sharma A 2023. Palaeobiological and geochemical aspects of reptilian coprolites from a Maastrichtian Deccan volcano-sedimentary intertrappean deposit of central India. *ESS Open Archive.* DOI: 10.22541/essoar.168167286.66007656/v1.

3. Sagar R, Kapur VV, Kumar K, Morthekai P, Sharma A, Shukla S, Ghosh AK, Chauhan G & Thakkar MG 2022. The first record on CM-sized vertebrate coprolites from the Early-Middle Miocene (Aquitanian-Langhian) Khari Nadi and Chassra formations, Kutch Basin, western India: Palaeobiological significance. DOI: 10.2139/ssrn.4269941.

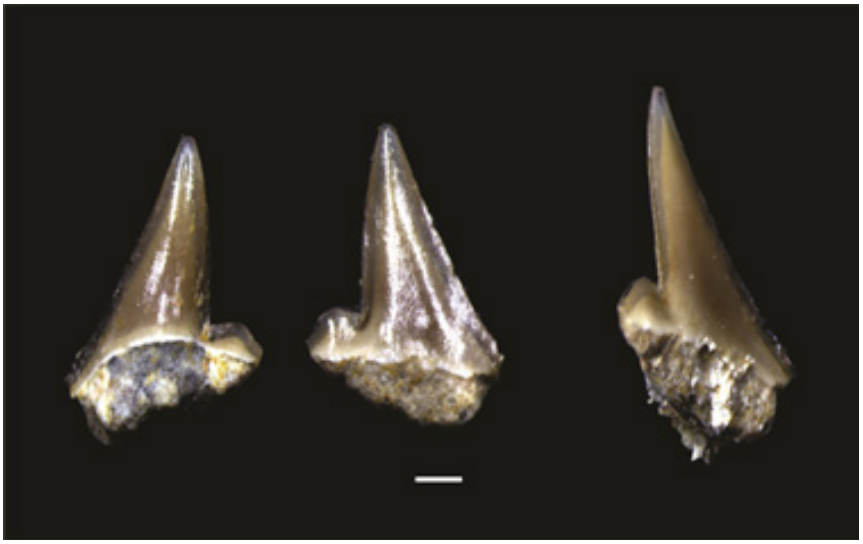

Fig. 20 - Sharks teeth from middle Eocene deposits of Sylhet Limestone of Mikir Hills (northeast India).

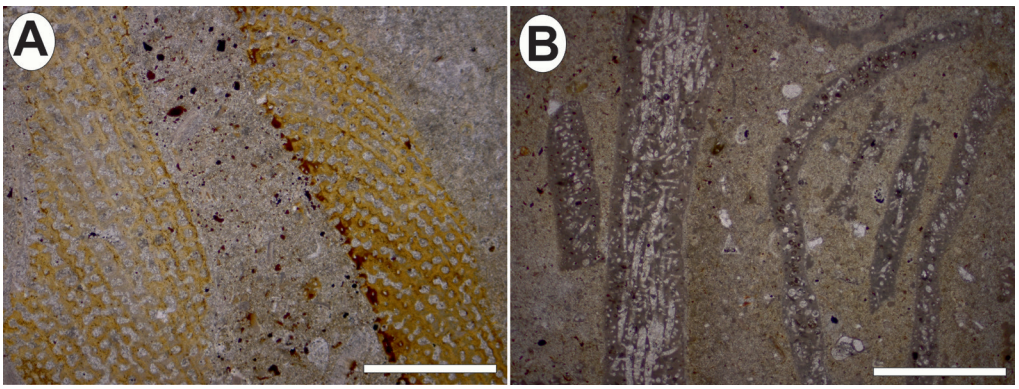

Fig. 21 - Benthic foraminifera-calcareous algae from the early Miocene Quilon Limestone (Kerala Basin): (a) *Pseudotaberina* spp., (b) *Halimeda* spp. All scale bars equal 2 mm.

4. Tripathi S, Pandey A, Saxena A, Das N *et al.* 2022. 28th Indian Colloquium on Micropalaeontology and Stratigraphy. Journal of Palaeosciences 71: 117–120.

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1. Nguyen HB, Huang J, Do TV, Srivastava G, Nguyen HMT, Li S-F, Chen L-L, Nguyen MT, Doan HD, Zhou Z-K, & Su T 2023. Pod fossils of *Albizzia* (Fabaceae: Caesalpinioideae) from the late Miocene of northern Vietnam and their phytogeographical history. Review of Palaeobotany and Palynology 308: 104801 (IF: 2.49).
2. Sarkar S, Cotton LJ, Valdes PJ & Schmidt DN 2022. Shallow water records of the PETM: Novel insights from NE India (Eastern Tethys). Paleoceanography and Paleoclimatology 37: e2021PA004257 (IF: 3.99).
3. Deveciler A, Hadi M, Sarkar S & Sharifi J 2022. First report of *Burdurina selandinica* Sirel (Foraminiferida) and the microfacies analysis of Middle Paleocene limestones in Central Iran. Stratigraphy and Geological Correlation 30(6): 518-534 (IF: 1.244).

SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

SP 3.1: **Palaeodietary habit(s) in deep time, linkages to producer taxa, and palaeoenvironmental inferences utilizing Mesozoic-Cenozoic fossilized faecal matter (coprolites) from India** (Project No. CRG/2019/002204, from January 2020 – ongoing).

Investigators: Vivesh Vir Kapur (PI), Kamlesh Kumar (Co-PI1), P. Morthekai (Co-PI 2), Ramanand Sagar (JRF)

First data on large (cm-sized) coprolites (represented by three morphotypes) from a total of three ossiferous horizons identified within the early Miocene (Aquitanian) Khari Nadi Formation and middle Miocene (Burdigalian-Langhian) Chassra Formation, Kutch Basin, western India was generated (Fig. SP 3.1). The scanning electron

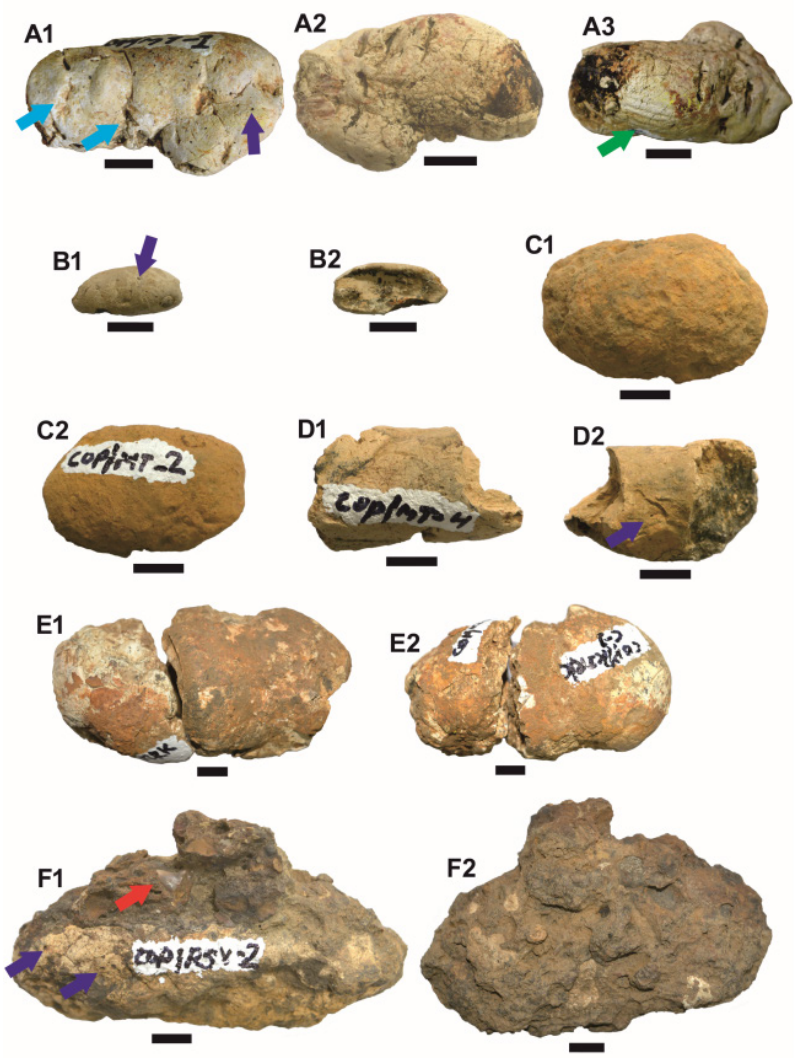


Fig. SP 3.1 - Digital photographs of coprolite specimens recovered from the early-middle Miocene (Aquitanian-Langhian) localities of Matanomadh South, Khirsara, and Palasava, Kutch Basin, western India. A1-A3:Morphotype C1, specimen no. COP/MT-1; B1-B2:Morphotype C2, specimen no. COP/MT-2; C1-C2:Morphotype C3, specimen no. COP/MT-4; D1-D2:Morphotype C3, specimen no. COP/MT-5; E1-E2:Morphotype C3, Specimen no. COP/KIRK-1; F1-F2:Morphotype C3, specimen no. COP/PSV2. Note: constrictions (blue arrow), ribbings/striations (green arrow), burrows (purple arrow), shark tooth (red arrow). Scale bars: 1 cm.

microscopy and geochemical data has confirmed the phosphatic character of the investigated ichnofossils. The dominance of partly digested bone matter and presence of plant remain reflects an omnivorous diet consumed by the producer that were most likely chelonians. Unique is an inclusion of an ultrastructure similar to mammalian dental enamel in a Miocene coprolite from Kutch Basin, western India. Principal Component Analysis based on a dimensional dataset incorporating Mesozoic-Cenozoic coprolites previously recorded within the Indian subcontinent and the coprolites recorded in the investigation support that chelonians are the most likely producers of these ichnofossils. Additional biotic inclusions observed in the investigated coprolites include ostracods (assigned to genera *Paractinocythereis, Hermanites,* and *Propontocypris*), large planispiral benthic foraminifers including the genus *Quinqueloculina*, uniserial and biserial benthic foraminifers belonging to genus *Textularia*, marine calcareous algae genus *Actinoporella*, chrysophytes (resting spores or cysts of planktonic algae), sponge spicules (represented by the morphotypes Acanthoxea and Strongyle), freshwater diatom genus *Aulacoseira*, unidentified fungal remains, and phytoliths. Taken together, the biotic, abiotic (e.g., pyrite) inclusions, geochemical data and associated microbiota suggest that these ichnofossils were deposited in dominantly coastal marine (intertidal) settings linked to a lacustrine/palustrine environment.

SP 3.2: **Appraisal of the Neogene vegetation shift and climate change in northern India, based on plant mega fossils** (Project No. CRG/2019/002461, from January 2020 – ongoing).

Investigators: Gaurav Srivastava (PI), RC Mehrotra (Co-PI)

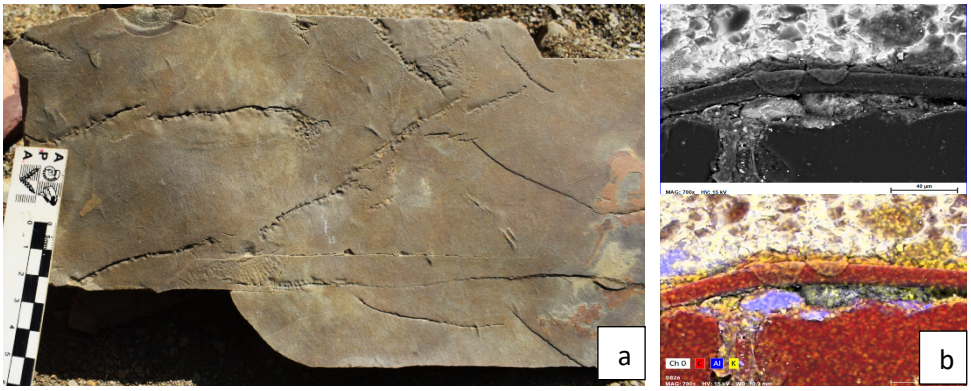


Fig. SP 3.5 - (a) Field photograph and of some suspected behavioural pattern of primitative life recorded from the Sirbu Shale Member of Bhander Formation, Vindhyan Supergroup, India. (b) BSE image and composite elemental map (below) of the tube like structure and the matrix underneath; note that some particles wrap around the tube like structure which are rich in K and Al.

Developing a new calibration file for the quantification of the Cenozoic climate using the plant-based methodology, namely the climate leaf analysis multivariate program (CLAMP). This new calibration file will minimize the error/ uncertainty in the quantification of palaeoclimate using plant fossils.

SP 3.3: **Indian monsoon seasonal dynamics across mid-Pleistocene transition (**Project No. SRG/2022/002129, from 2022 onwards).

Investigators: Prem Raj Uddandam (PI)

The project focuses on deciphering changes in the primary productivity employing dinoflagellate cysts across the mid- Pleistocene, a period. Samples from IODP-355 will be utilized and generated records will be interpreted in terms of changes in the summer and winter monsoon wind and runoff.

SP 3.4: **Reconstruction of Paleobathymetric variations through time from middle to late Eocene and reconstruction of paleogeographic maps of Cambay Basin during middle to late Eocene** (Sponsored by ONGC-RGL, Vadodara).

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

Under the BSIP-ONGC RGL Vadodara project, 5 milestone (of quarterly period) were successfully completed in which 538 well cutting samples from 23 wells (Cambay Basin) were studied for foraminifera, calcareous nannofossil, dinoflagellate cysts and spore-pollen. Based on the integration of foraminifera and dinoflagellate cysts and nannofossil marker fossils data, precise age of the interval samples were assigned and stage boundaries of Lutetian/Bartonian and Bartonian / Priabonian have been demarcated in some wells. In addition, the palaeoenvironmental interpretations of each well have been done on the basis of relative changes in spore-pollen palaeoecological assemblages.

SP 3.5: **Advent of motile life (**Project No. DST/ INSPIRE/04/2017/002038).

Investigator: Adrita Choudhuri (PI)

The Sirbu Shale Member of the Upper Vindhyan Group also preserves some unusual structures. The suspected features are diverse in orientation, numerous in numbers and ridge patterned having positive relief. Close inspection reveals two types of morphological patterns within them- short (<1 cm length) and long ridges (up to 2.5 cm length). Micro-CT scan images reveal the longer ridge variety is of two different kinds –one type is curvy and has overall smooth outer relief while the other is straight and made up of several small rounded beads giving rise to an irregular, segmented outer-relief. However, small and long ridges, both frequently crosscut each other. These features are preserved at the sole of the storm-laid fine sandstone. Re-Os isotope analysis gives depositional age of the host rock ~811 Ma.

OTHER ACADEMIC WORKS

Research papers presented

1. **Agnihotri P, Singh H & Subramanian KA -** Diverse record of spider fossils in Cambay amber from Valia lignites of western India. ICMS-SPPU2022/137. XXVIII Colloquium on Micropalaeontology & Stratigraphy [Abstract, Page 144, Pune University (4-6 May, 2022)].
2. **Chandra K, Shukla A, Mehrotra RC & Singh AK** - Oldest remnants of mahogany (family Meliaceae)

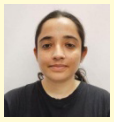
PH.D. PROGRAMME

Yogesh Pal Singh (2016). Biostratigraphy and palaeoclimate reconstruction of Cenozoic successions of Kerala Basin, under the supervision of **Poonam Verma (BSIP)** and Rameshwar Bali (University of Lucknow, Lucknow), registered with Lucknow University, Lucknow. Status: Submitted on 02.01.2023.

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)** 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, palaeobiogeography and evolutionary history of infra- & intertrappean biotas, under the supervision of **Mohammad Arif (BSIP)** and A.S. Naik (Banaras Hindu University, Varanasi), registered with Banaras Hindu University, Varanasi. Status: In-progress.

Priya Agnihotri (2019). Eocene arthropods in amber from the Kutch and Cambay lignites, Gujarat, India: their bearing on palaeoenvironments, under the supervision of **Hukam Singh (BSIP)** 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)**, registered with Academy of Scientific and Innovative Research (AcSIR). Status: In progress.

Kajal Chandra (2019). Evolution and diversification of the early Paleogene forest during the palaeoequatorial position of Rajasthan, under the supervision of **Anumeha Shukla (BSIP)**, 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)**, registered with Academy of Scientific and Innovative Research (AcSIR). Status: In-progress.

Samiksha Shukla (2021). Evolution, diversification, and dispersal history of the pantropical family Phyllanthaceae: Based on the recovered early Paleogene flora from north-western India, under the supervision of **Anumeha Shukla (BSIP)**, 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)** and B.P. Singh (Panjab University, Chandigarh), registered with Panjab University Chandigarh). Status: In-progress.

Ramanand Sagar (2022). Palaeobiological and geochemical aspects of Mesozoic and Cenozoic vertebrate coprolites from central and western India, under the supervision of **Vivesh Vir Kapur and Kamlesh Kumar (BSIP)**, registered with Academy of Scientific and Innovative Research (AcSIR). Status: In-progress.

from the early Paleogene of the Indian subcontinent NECLIME online conference 2022 from 21-25 Nov, 2022.

3. **Choudhuri A, Jambhule D, Sinha S & Srimani S -** Morphological variability of stromatolites and their cyclicity as an indicator of biogenicity- example from a Proterozoic carbonate platform of Vindhyan Supergroup, India. EGU General Assembly 2023.
4. **Mohammad A -** Magnetostratigraphy and Sedimentology of Deccan volcano-sedimentary succession from Malwa sub province, central India (Oral Presentation). 38th Convention of Indian Association of Sedimentologists (IAS-2022) & National Conference on Current Understanding from the Indian Sedimentary Basins and Road Ahead, held at Department of Geology, University of Delhi from 9-11 December, 2022.
5. **Mondal I, Choudhuri A, Koner A & Sarkar S -** Does Mg-enrichment of Precambrian glauconite owe to hydrothermal input? 38th Convention of Indian Association of Sedimentologists (IAS-2022) and National Conference on 'Current Understanding

from the Indian Sedimentary Basins and Road Ahead" (9th-11th December, 2022) in University of Delhi [Abstract, page no. 66].

6. **Srimani S, Koner A, Choudhuri A & Sarkar S -** Distinctive petrography and geochemistry of facies in Kallankuruchi Limestone Formation, Cauvery Basin, India. 38th Convention of Indian Association of Sedimentologists (IAS-2022) and National Conference on 'Current Understanding from the Indian Sedimentary Basins and Road Ahead" (9th-11th December, 2022) in University of Delhi [Abstract, page no. 24].
7. **Srivastava G -** Leaf physiognomy reveals orographic control over the Paleogene Asian monsoon, NECLIME online conference held during November 21-24, 2022.
8. **Srivastava G -** Miocene evolution of modern Indian Summer Monsoon (ISM) and biodiversity hotspots: plant fossil evidence, National Conference on Ecological Restoration and Biodiversity Conservation held in National Botanical Research Institute during September 17-18, 2022.
9. **Singh YP, Verma P, Bhatia H & Srivastava G -** Palaeofloristics and palaeoclimate of the Burdigalian (Early Miocene) tropical region: palynological evidence from Kerala Basin, Southwest India. The 6th International Palaeontological Congress, Khon Kaen, Thailand during 7th to 11th November 2022, p. 236-237.
10. **Kapur VV, Kumar K, Pandya PJ, Ghosh AK, Chakraborty A, Sharma A, Chauhan G & Thakkar MG -** Oldest Asian Record of Snapping Shrimps (Malacostraca: Alpheidae) from the Kutch Basin, western India and Associated Biota: Biostratigraphic, palaeoenvironmental and palaeobiogeographic aspects. The 6th International Palaeontological Congress, Khon Kaen, Thailand during 7th to 11th November, 2022, p. 462.
11. **Sagar R, Kapur VV, Kumar K, Morthekai P, Shukla SK, Ghosh AK, Sharma A, Chauhan G & Thakkar MG -** Miocene (Aquitanian-Burdigalian) cm-sized vertebrate coprolites from the Khari Nadi and Chassra formations, Kutch Basin, western India: chemical nature, biotic inclusion(s) and link(s) to the producer animal. The 6th International Palaeontological Congress, Khon Kaen, Thailand during 7th to 11th November, 2022, p. 132.
12. **Verma P & Singh YP -** Evidences of floral diversity changes in the western Indian palaeo-equatorial region across the early Eocene warming event (ETM2). The NECLIME online conference 2022 during 21st -24th November, 2022, p.34.
13. **Mathews RP -** Petrographical and Geochemical Composition of Lignite and associated sediments from Giral Mine, Rajasthan, western India in 73rd Annual Meeting & Symposium of the ICCP '2022, New Delhi, India. 'International Symposium on Recent Trends on Coal Utilization for Sustainable Development and Energy Security'. September, 18 -25, 2022. New Delhi, India.
14. **Shukla S, Chandra K, Shukla A & Mehrotra RC -** First fossil record of *Eriolaena* (subfamily Dombeyoideae, family Malvaceae) from the early Paleogene of Rajasthan: Insight into its evolutionary history and diversification. NECLIME (Neogene Climate Evolution in Eurasia) online conference 2022.

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

Vivesh Vir Kapur and Poonam Verma

- Deputed to attend the the National Conference and Field Workshop on "*Kachchh paleo-rift Basin: an Ideal tectonic and sedimentary package for Indian Geoheritage*" organized during 11th-14th February, 2023 jointly by KSKV Kachchh University, Bhuj and The Society of Earth Scientists, Lucknow, Uttar Pradesh.

Vivesh Vir Kapur and Anumeha Shukla

- Deputed to attend a Field Workshop on "*Bagh Dinosaur National Park, Dhar District, Madhya Pradesh*" held from 16th to 20th November, 2022 and organized jointly by the Ecotourism Development Board, Department of Forest, Madhya Pradesh and The Society of Earth Scientists, Lucknow, India.

Ansuya Bhandari

- Deputed as Women Scientist and nominated by DST and WII for one week National Programme for Training of Women Scientists and Technologists working in the Government Sector on Biodiversity Conservation' from 14th – 18th November, 2022 at the Wildlife Institute of India, Dehradun (offline).

Runcie P. Mathews and Prem Raj Uddandam

- Deputed to attend a Workshop on *Palynological controls on age, depositional environments & sea level changes from Paleogene sequences of India*. India Energy week, Bangaluru from 6th to 8th January 2023 and also the 73rd Annual Meeting & Symposium of the ICCP, 2022, '*International Symposium on Recent Trends on Coal Utilization for Sustainable Development and Energy Security*' from 18th to 25th September, 2022 at New Delhi, India.

Kajal Chandra

- Deputed to attend a Workshop on "*Starting the*

identification process: Taxonomic and taphonomic issues" organised by NECLIME from 15th-16th March, 2022 and the NECLIME Online Conference from 21st–24thNovember, 2022.

Ansuya Bhandari and Samiksha Shukla

- Participated in the High-End Workshop (Karyashala) "*Disaster and Climate-Resilient Pathways: Adaptation, Mitigation, and Sustainable Development*" sponsored by SERB-DST under the Accelerate Vigyan Scheme, scheduled from 07th to 13th December 2022.

Lectures delivered

Poonam Verma

- Delivered an invited lecture on the topic "Cenozoic palaeopalynology and its applications" on the 15th February 2023 at the Department of Earth and Environmental Science, KSKV Kachchh University, Bhuj.

CONSULTANCY/TECHNICAL SUPPORT RENDERED

Poonam Verma

- Biostratigraphy, palynological studies and palynofacies analysis of OIL samples, Dr. Alok K. Singh, Professor (Geology), Rajiv Gandhi Institute of Petroleum Technology (RGIPT), Amethi, Uttar Pradesh. Rs.2,83,200/-

Vivesh Vir Kapur

- As an Expert Member helped in the conceptualization and the development of the Mandro Fossil Park and Rajmahal Fossil Museum & Interpretation Centre located in Mandro, Sahibganj District, Jharkhand State, India.
- As an Expert Member discussed (in a few online meetings) with the Ministry of Culture officials with regards to the Phase 3 Development of Dinosaur Research Center & Fossil Park at Rayoli, Balasinor, Gujarat.

Runcie Paul Mathews

- FTIR analysis, Ms. Anvesha Kumar, KGMU, Rs. 1700/-
- Coal Maceral analysis, Ms. Priyanka Shukla, CIMFR, Dhanbad. Rs. 5900/-

Divya Kumari Mishra

- Advanced Coal Petro-Geochemical Analytical Facility, Pellet making for organic petrography, Dr. Susheel Kumar, Assistant Professor, Centre for Petroleum Exploration, School of Earth Science and Natural Resource Management, Mizoram University, Aizwal-796004, Mizoram, Rs. 11,800/-.

ACCOLADES RECEIVED

Hukam Singh

- Certificate for Top-Cited Article Year 2021-22 by Proceedings of the National Academy of Sciences for the research article titled "Biogeographic and evolutionary implications of a diverse palaeobiota in amber from the Early Eocene of India" published in the Journal PNAS (USA).

Vivesh Vir Kapur

- Certificate for the Elsevier's SSRN's Top Ten Download List under the category "GeologyRN: Paleoenvironments/Paleoclimatology" for the paper titled "The first record on cm-sized vertebrate coprolites from the early-middle Miocene (Aquitanian-Langhian) Khari Nadi and Chassra formations, Kutch Basin, western India: palaeobiological significance".

Suman Sarkar

- Mani Shanker Shukla Gold Medal from the Palaeontological Society of India for the year 2021.

REPRESENTATION IN COMMITTEES/BOARD

Hukam Singh

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

Gaurav Srivastava

- Editor, Bulletin of the Department of Geology, Tribhuvan University, Kathmandu, Nepal

Vivesh Vir Kapur

- Member of Executive Council: The Palaeobotanical Society, Lucknow, India
- Expert Member: Development of Dinosaur Research Center & Fossil Park at Rayoli, Balasinor, Gujarat
- Expert Member: Conceptualization and Development of the Mandro Fossil Park and Rajmahal Fossil Museum & Interpretation Centre, Mandro, Sahibganj District, Jharkhand State, India.

Adrita Choudhuri

- Associate Editor of the International Biopetrological Society since 2021.

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

Coordinator: Pawan Govil (Scientist E)
Co-coordinator: Vartika Singh (Scientist E)

OBJECTIVES

- *Paleoceanographic 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.*
- *Paleoceanography 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 analog. 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: Few works depicted the Southern Ocean paleoceanographic changes during the mid-Pleistocene transition. The study of longest sea-surface temperatures, sea ice, diatom productivity, and ice-rafted debris records will explore 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 micropaleontology, sortable silt, isotopic and elemental concentrations of planktic foraminifera.

Antarctica: Lake sediment cores from the East Antarctica show the time limitation of the 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 using sedimentological, geochemical, micropaleontological, Ancient DNA, and biomarker.

Arctic: Previous studies in the Arctic of Svalbard involve glacial geology, stratigraphy, sedimentology and environmental aspects at the 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: Pawan Govil (Scientist E), Vartika Singh (Scientist E), Abhijit Mazumder (Scientist D), Sunil Kumar Shukla (Scientist D), Manoj MC (Scientist D)
Associate Members: Anupam Sharma (Scientist G), Niraj Rai (Scientist D), Shailesh Agrawal (Scientist D), Santosh K. Pandey (Scientist D), Arif K. Ansari (Scientist D), Gurumurthy G.P. (Scientist C).
Research Scholars: Hidayatullah, Brijesh Kumar, Divya Verma, Masud Kawsar, Sneha Mary Mathew,

SIGNIFICANT FINDINGS

Paleoceanographic variations from the western Indian Ocean during the mid-late Miocene: a micropaleontological and geochemical approach.

An important way to comprehend the environmental changes humanity will face as the planet warms are through studying pre-Quaternary warm climates using geological records and computer simulations. To understand the ocean circulation, productivity, and climate mechanism in the southwestern Indian Ocean, a total of 272 samples of DSDP core 237 (5 Ma to 25.8 Ma) (Fig. 1) were obtained from the International Ocean Discovery Program, Kochi Centre, Japan. Chronology based on biostratigraphy was established. The age-depth correlation and sedimentary rate were derived during the Miocene Period. The sedimentation rate varies from 22.5 m/Ma to 1.4 m/Ma. The maximum sedimentation rate was noticed during the Mid Miocene Climate Optimum-Mid Miocene Climate Transition (MMCT; 14.7–13.8 Ma) boundary conditions. Further, the core samples are used for different proxy data, such as Sortable Silt, Benthic foraminifera abundance and assemblages, their isotopic investigation, and Dinoflagellate.

Climate variability of the Southern Ocean over the Mid-Pleistocene Transition (Core team member)

The study aimed to understand the role of the Southern Ocean in global climate change. The down-core records of bulk sedimentological parameters, sortable silt ($\overline{SS}$), Ice Rafted Debris (IRD), and diatom productivity were obtained from the Sub-Antarctic zone (SAZ) of the Indian sector of the Southern Ocean (SO) (Fig. 2). The SS was found throughout the core exhibiting a glacial-interglacial pattern, and the distribution of which is primarily unimodal (moderate to well-sorted) or bimodal, with sporadic interjections of a trimodal (less sorted) distribution pattern.

The diatom productivity data was obtained from the SAZ of the Indian sector of the SO, which surprisingly didn't show a distinct glacial-interglacial pattern. The diatom productivity was highest during the Marine Isotope stage (MIS) 6 and MIS4, and lowest during MIS10-MIS8 and MIS3-MIS1, whereas intermediate diatom productivity was found during MIS7 and MIS5 (Fig. 3). Such diatom productivity changes were disconnected from dust flux changes, but might relate to frontal migrations and SO upwelling intensity changes which have both mediated the silica and iron availability for diatoms. Importantly, the data suggest that front migrations were not homogenous in the SO, especially where these fronts interact with bottom topography.

Paleoceanography reconstruction from the western Indian Ocean during the late Quaternary

The present work mainly focuses on proxy-based studies to better understand long-term heat balance differences from

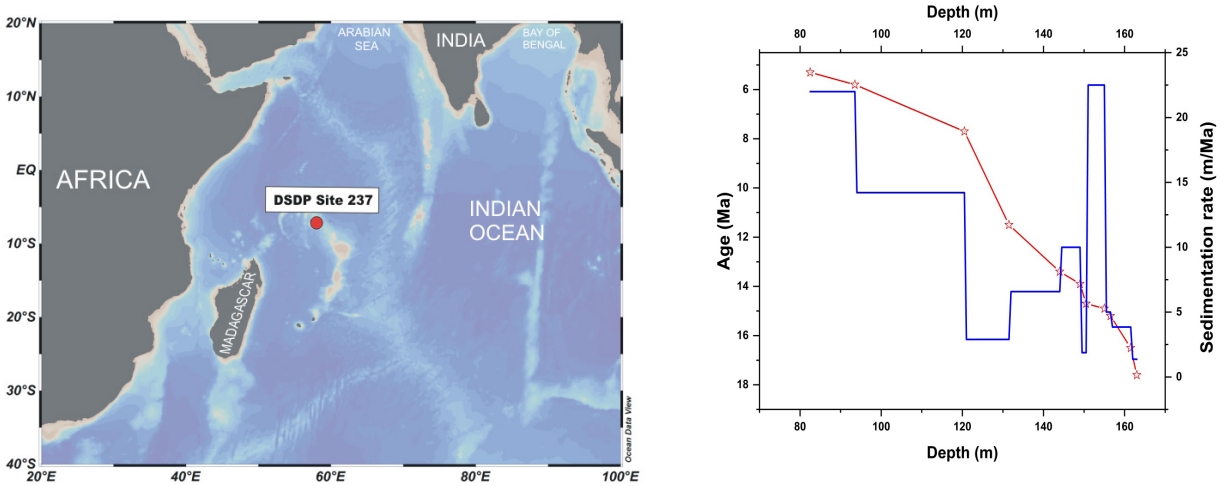


Fig. 1 - The core location of DSDP Leg 24 Site 237, age-depth correlation, and sedimentation rate during Miocene.

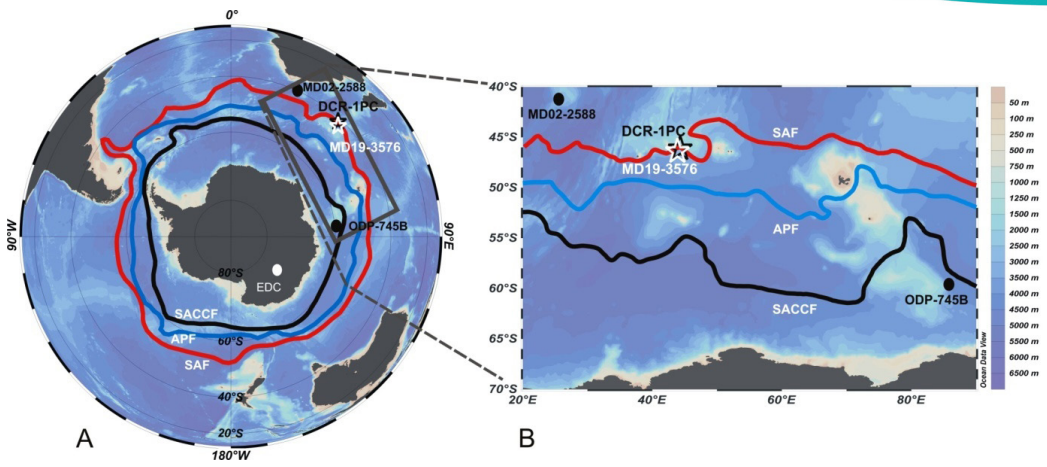


Fig. 2 - The location of the studied cores DCR-1PC (black star) and MD19-3576 (white star) for the palaeoceanographic records in the Sub-Antarctic zone of the Indian sector of the Southern Ocean (A). A close-up map is also shown (B). Locations of published cores are also shown (black circles). Positions of the Sub-Antarctic Front (SAF - red line), Antarctic Polar Front (APF - blue line), and Southern Antarctic Circumpolar Current Front (SACCF – black line) are shown after Park *et al.* (2019).

thermocline depth to mixed layer depth from three marine sediment cores. This ultimately enhances the understanding of Ocean circulation and monsoon variability from the western Indian Ocean marine sediment cores during the late Quaternary (Fig. 4).

First, the core (VM29-045) shows the relative abundance of the mixed layer (thermocline) species had an increasing (decreasing) trend, showing high stratifications and oligotrophic conditions towards the top of the core (Fig. 5).

Second core (47-PC) study from the Mozambique channel documents the decrease in the abundance of planktonic foraminifera species *N. Dutertrei* and concomitant increase in the abundance of *G. ruber* from depth ranges ~170 to 110 cm suggesting the increase in the salinity and low nutrient condition at the surface as well as upper thermocline depth. Other species also have shown remarkable variations in the thermocline and surface mixed layer variations (Fig. 6).

The planktonic foraminifera were grouped into depth stratified surface and thermocline fauna assemblages from the third core of Agulhas Plateau (U1475) to describe the variation in the transitional zone between subantarctic and subtropical water masses and their productivity (Fig. 7).

A total of 235 samples were processed for the textural studies to understand the variations in the bottom water strength during the late Quaternary.

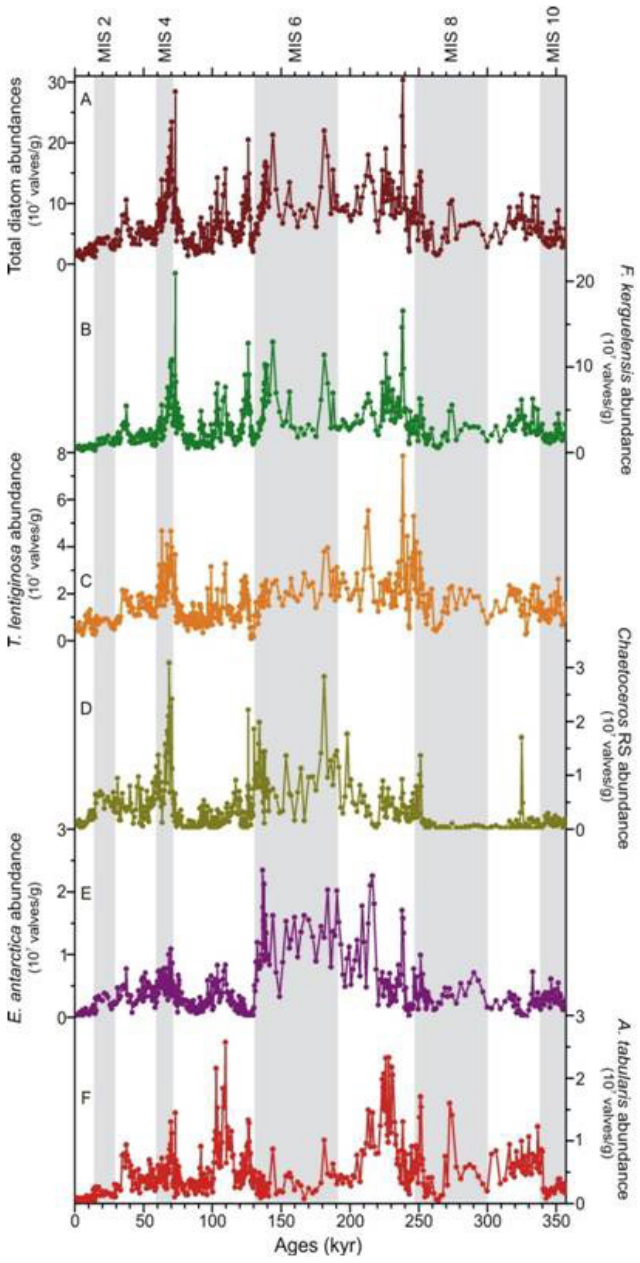


Fig. 3 - Diatom productivity records of core DCR-1PC over the last 357 ka depict total diatom abundances (A), and absolute abundances of the main five diatom taxa, namely, *Fragilariopsis kerguelensis* (B), *Thalassiosira lentiginosa* (C), *Chaetoceros* resting spores (D), *Eucampia antarctica* (E), and *Azpeitia tabularis* (F). The grey-shaded vertical bars show the glacial stages (Marine Isotope Stages 2, 4, 6, 8, and 10).

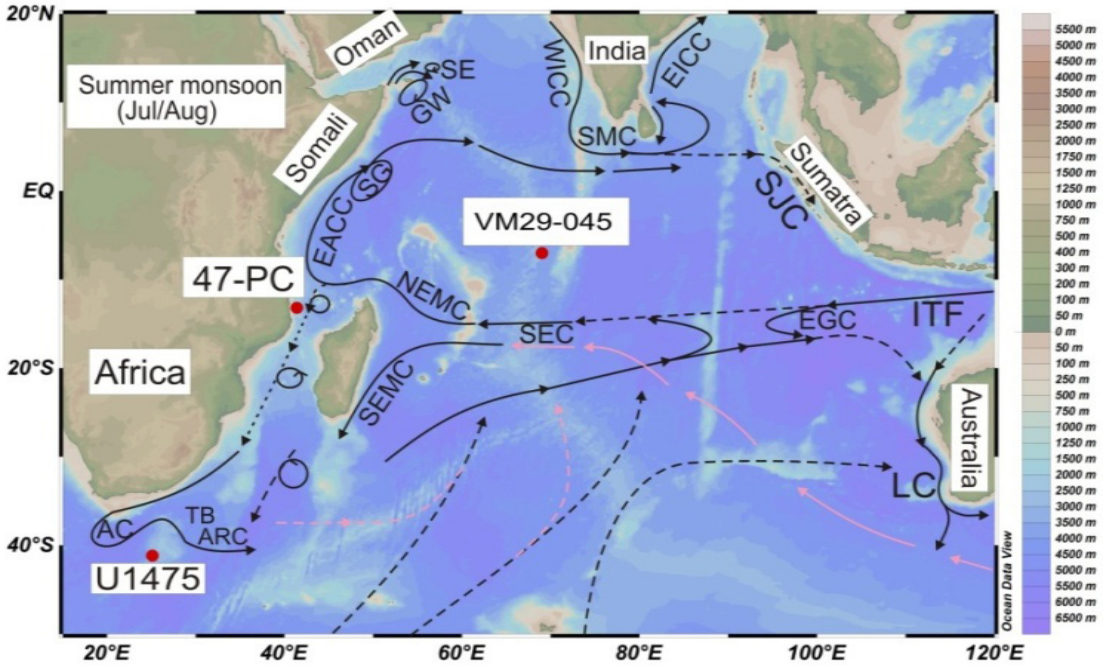


Fig. 4 - Core locations from the western Indian Ocean.

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

High Arctic region: Organic-walled dinoflagellate cysts resist dissolution, unlike calcareous foraminifera, and their assemblages follow biogeographic distributions with distinct latitudinal gradients and serve as important paleoceanography proxy. It is crucial to understand the Last Interglacial climate of the High Arctic Region using a dinoflagellate cyst record constrained by a high-temporal-resolution foraminiferal isotope study covering the interval 136–109 ka (Fig. 8). A very high-resolution record of dinoflagellate cysts and their assemblages will help identify the fine details of the Last Interglacial paleoceanography by applying the known relationships between dinoflagellate cysts and sea surface conditions for the reconstruction of paleoceanographic conditions. The high temporal resolution foraminifera isotope data will provide an accurate time frame to evaluate dinocyst data. Detailed morphological study of benthic diatom assemblage of Svalbard terrestrial sediments (Fig. 8).

Antarctica: The Epishelf (ESL) core from the Schirmacher Oasis has been studied to understand the palaeoenvironmental/palaeoclimatic changes taking place in and around the study area. The grain size variation with Biogenic Silica % (BSi) shows the variation in depositional condition and productivity, which depends on the regional climatic conditions. The higher % of sand indicates more meltwater from surrounding areas and explains the warm conditions in the vicinity. Higher/lower BSi% shows the variation in silica productivity and more nutrient availability to enhance the production of algae and mosses (Fig. 9).

PROJECT OUTCOME

Publications in SCI (Science Citation Index) Journals

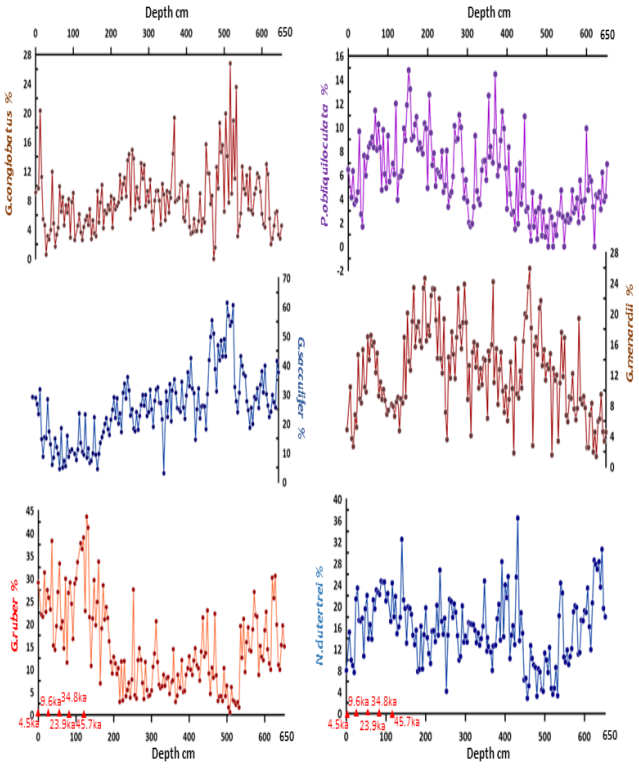


Fig 5 - Variation in the mixed layer (surface) and thermocline planktonic foraminifera species. The red marked arrows show the radiocarbon dates.

1. Crosta X, Kohfeld KE, Bostock HC, Chadwick M, Du Vivier A, Esper O, Etourneau J, Jones J, Leventer A, Müller J, Rhodes RH, Allen CS, Ghadi P, Lamping N, Lange CB, Lawler K-A, Lund D, Marzocchi A, Meissner KJ, Menviel L, Nair A, Patterson M, Pike J, Prebble JG, Riesselman C, Sadatzki H, Sime LC, Shukla SK, Thöle L, Vorrath M-E, Xiao W & Yang J 2022. Antarctic sea ice over the past 130 000 years – Part 1: a review of what proxy records tell us. *Climate of the Past*: 18: 1729-1756. https://doi.org/10.5194/cp-18-1729-2022 (IF-4.498).
2. Shukla SK, Crosta X & Ikehara M 2023. Synergic role of frontal migration and silicic acid concentration in driving diatom productivity in the Indian sector of the Southern Ocean over the past 350 ka. *Marine Micropaleontology* 181: 102245. https://doi.org/10.1016/j.marmicro.2023.102245 (IF- 2.102).

Refereed Non-SCI Journals

1. Ghosh AK 2023. An assumption of the past climate and environment in millennial and centennial scale. Journal of Environmental Biology 44(1): I-II. DOI : http://doi.org/10.22438/jeb/44/1/Editorial.
2. Singh V & Barinova S 2022. Status and scope of Pleistocene palaeoenvironmental studies of Svalbard coastal sediments. *Biodiversity International Journal* 6(1): 1–5. DOI: 10.15406/bij.2022.06.0020.

General Articles/Reports/Database Published

1. Weber ME, Kawsar M & Manoj MC 2022. Sortable silt End member model results for IODP Hole 354-U1452C. *PANAGEA. Data Publisher for Earth & Environmental Science*. https://doi.pangaea.de/10.1594/PANGAEA.949246.

Publications other than the Project Work

1. Agarwal S, Shukla SK, Srivastava P & Sundriyal Y 2023. Peat sequence diatoms from Kedarnath, Central Himalaya, used to reconstruct mid-late Holocene hydroclimatic conditions. *Palaeogeography, Palaeoclimatology, Palaeoecology* 612: 111381. https://doi.org/10.1016/j.palaeo.2022.111381 (IF-3.565).
2. 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: 0.86).
3. Dey R, Ghosh AK, Roy L, Chakraborty A, Bhaumik

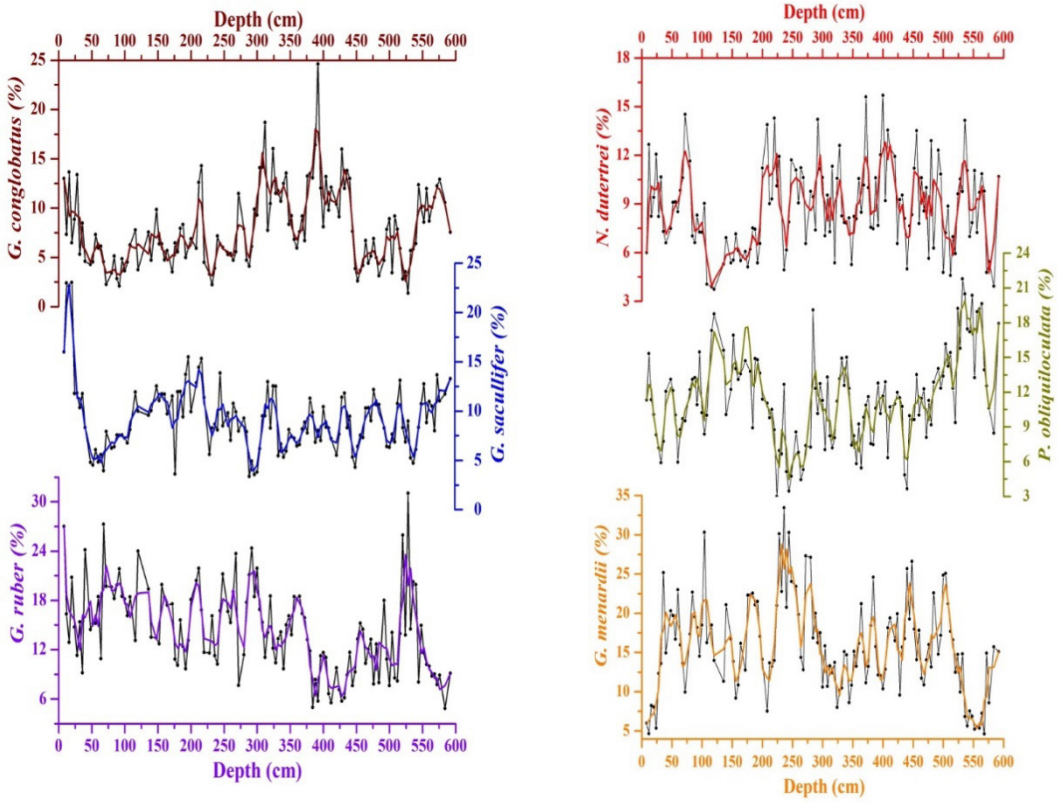


Fig 6 - Variation of the mixed layer (*Globigerinoides ruber*, *G. sacculifer* and *G. conglobatus*) and thermocline dweller species (*Neogloboquadrina dutertrei, Globorotalia menardii* and *G. tumida)* up to 600 cm depth.

AK & Saxena S 2022. Burdigalian-Serravallian radiolarians from Havelock Island, Northeast Indian Ocean and their palaeoecological significance. *Micropalaeontology* 68(4): 345-374. DOI: 10.47894/mpal.68.4.01 (IF: 1.942).

4. Kawsar M, Manoj MC & Weber ME 2022. Reconstructing dynamics of Northern and Southern sourced bottom waters sortable silt records in the lower Bengal Fan during last 200 ka. *Zeitschrift der Deutschen Gesellschaft für Geowissenschaften (ZDGG) (Journal of Applied and Regional Geology)*. https://DOI:10.1127/zdgg/2022/0318 (IF- 1.167).
5. Khan H, Govil P, Panchang R, Kumar P & Agrawal S 2022. Surface hydrographic variations in the western Arabian Sea through the last 172 kyr. *Geo-Marine Letters*, 42: 10. https://doi.org/10.1007/s00367-022-00733-y. (IF: 2.267).
6. McCartney K, Chakraborty A, Ghosh AK, Soeding E and Rout V 2023. Diversity and evolution of late Eocene to late Oligocene silicoflagellates from IODP Expedition 378 Holes U1553A and U1553B, southwest Pacific Ocean. *Marine Micropaleontology* 179: 102215. DOI:10.1016/j.marmicro.2023.102215. (IF: 2.102)
7. 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 System Science* 230: 105203. https://doi.org/10.1016/j.jseaes.2022.105203. (IF: 3.374).

SPONSORED PROJECT (SP) & COLLABORATIVE PROJECT (CP)

SP 4.1: **Climate evolution of the Indian sector of the Southern Ocean over the Late Quaternary** (Sponsored by NCPOR, Goa; Project No. NCPOR/2019/PACER-POP/ES-04).

Investigators: Sunil Kumar Shukla (BSIP, Lucknow), Rahul Mohan (NCPOR, Goa)

The study includes the reconstruction of paleoceanographic inferences from the Antarctic zone of the Indian sector of the Southern Ocean during the recent Glacial-Interglacial Period. The diatom productivity data show high productivity during the Deglacial and the Holocene periods, whereas lower diatom productivity was found during the Glacial Period (26-18 ka B.P.). Such variations in the diatom productivity suggest that frontal migration may have resulted in the increased nutrient supply during the Deglacial and the Holocene periods.

SP 4.2: **Diatom and silicoflagellate biostratigraphy and their implications on palaeoclimate from early Paleocene to Oligocene of Site U1553, South Pacific Ocean** (Sponsored by IODP Exp. 378; Project No. NCPOR/IODP/E.3947/2021; w.e.f. 01.04.2022 to 11.07.2022)

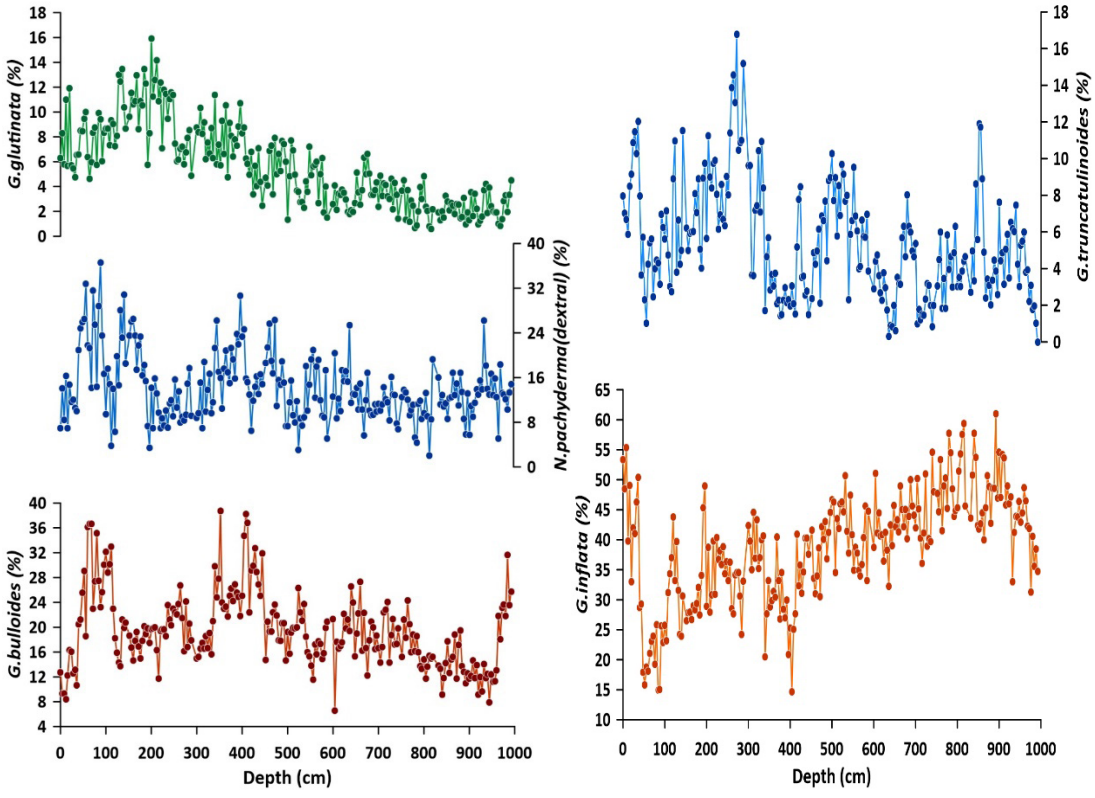
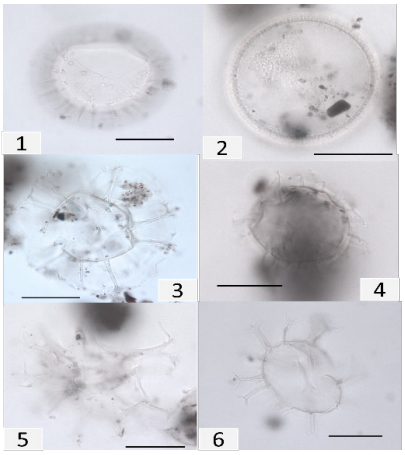


Fig. 7 - Variation in the relative abundance of mixed layer species and thermocline species.



Recovered dinoflagellate cysts
1. *Operculodinium centrocarpum;*
2. *Bitectatodinium tepikiense;*
3. *Nematosphaeropsis labyrinthus;*
4. *Pentapharsodinium dalei;*
5. *Spiniferites membranaceus;*
6. *Spiniferites ramosus*

Scale bar -20 µm

Fig. 8 - Study of preserved biotic remains from a High-Arctic pond in Svalbard, Norway.

Investigators: Amit K. Ghosh (PI) and Arindam Chakraborty (Co-PI), Vishwadeep Rout (Project Assistant)

A study of the South Pacific Ocean sediments from IODP Expedition 378, Site U1553, reveals late Eocene to late Oligocene diatoms and silicoflagellates. The early Oligocene sediments record abundant, well-preserved diatoms but diatoms are rare in the early Oligocene sediments (Fig. SP 4.2a). The presence index diatom species *Rocella schaderi* and *Rocella vigilans* characterize the early Oligocene and late Oligocene sediments. The dominance of *Pyxilla* sp. denotes late Eocene age. During the Eocene diatom abundance reduced and the late Eocene diatoms are dominated by lightly silicified centric diatoms such as *Asterolampra*, *Azpeitia*, *Cestodiscus* and *Coscinodiscus.* This indicates the middle-high latitude cooling and increased surface water mixing. Nineteen late Eocene to late Oligocene silicoflagellate species have been recorded from the site. The late Eocene includes *Corbisema tajmahalii* n. sp. (Fig. SP 4.2b). This study has found the first known *Bachmannocena* double skeleton. Silicoflagellate skeletal abundance declines after the Eocene-Oligocene boundary.

SP 4.3: Investigation on phytoplankton diversity and geochemistry of the Miocene-Pliocene sequence from the Andaman and Nicobar Islands: Their significance in past climate reconstruction [(Project No. DST-INSPIRE - IF170181); w.e.f. 01.04.2022 to 04.11.2022].

Investigators: Stuti Saxena, DST-INSPIRE, SRF & Amit K. Ghosh (Emeritus Scientist-CSIR), Mentor

Silicoflagellate abundance, their significance in palaeoenvironment have been studied in detail from the outcrop of Sitapur Village situated near the East Coast of Neil Island. Based on the index calcareous nannofossils species the section is assignable to the Tortonian-Messinian age. The base of the section is not older than ~8.30 Ma owing to the presence of *Discoaster quinqueramus* and *Discoaster berggrenii* while the top of the section is estimated at ~5.12 Ma based on the presence of *Amaurolithus primus* (Fig. SP 4.3a). The recovered silicoflagellate assemblage (Fig. SP 4.3b) belongs to *Dictyocha extensa* Zone. Two main silicoflagellate genera were observed: *Stephanocha* sp. and *Dictyocha* sp. It is well established that *Dictyocha*

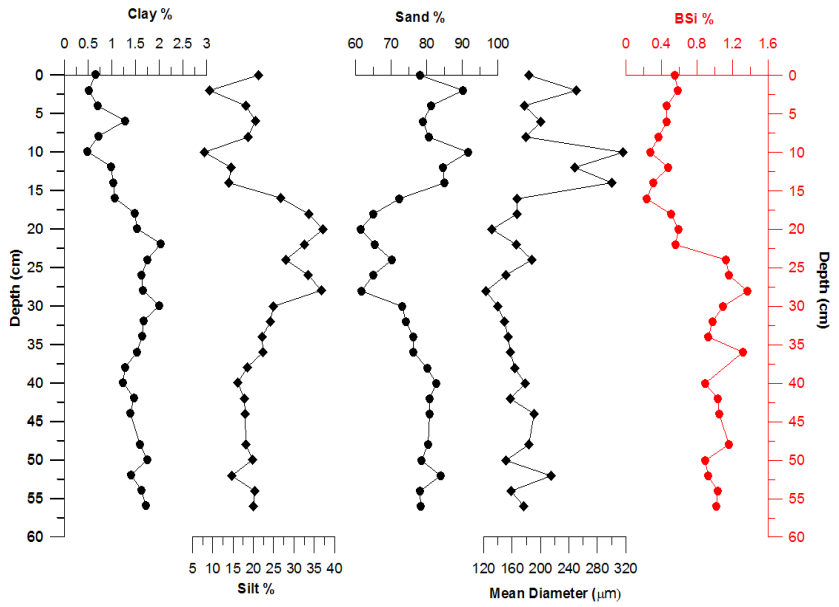


Fig. 9 - Depth vs grain size and BSi % data from ESL core of Schirmacher Oasis (East Antarctica).

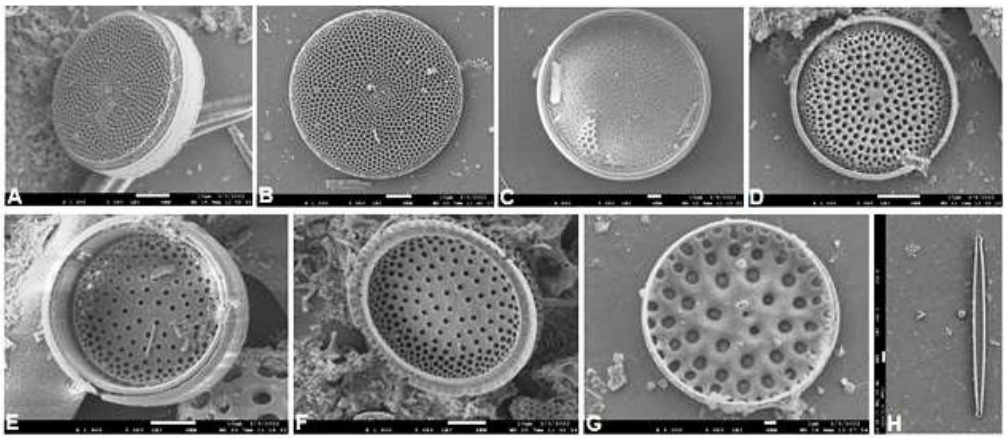


Fig. SP 4.2a - Significant diatoms from U1553. (A-B) *Azpeitia nodulifera*, (C) *Coscinodiscus* sp. (D) *Coscinodiscus superbus*, (E-F) *Cestodiscus robustus*, (G) *Rocella gelida* var. *schraderi*, (H) *Synedra jouseana*.

prefers warmer water while *Stephanocha* prefers cooler environment. *Dictyocha*/*Stephanocha* ratio was estimated that indicated dominance of *Dictyocha* over *Stephanocha*. This signifies prevalence of warmer climatic conditions during Tortonian-Messinian. Ph.D. thesis was submitted in February 2022 and has been awarded on November 04th, 2022 by the University of Burdwan, West Bengal.

SP 4.4: **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); (01.04.2022 to 22.08.2022)].

Investigators: Rikee Dey, DST-INSPIRE, SRF & Amit K. Ghosh (Emeritus Scientist-CSIR), Mentor

The Ph. D. thesis has been compiled based on the studies of silicified and calcified microfossils, e.g. radiolarians, planktonic foraminifera, etc. from the Miocene to Pleistocene outcrops of Havelock, Neil, Little Andaman and Car Nicobar Island to develop a high-resolution multiple microfossil biochronology. A synergistic approach was employed based on the evidences of microfossils coupled with the geochemical signatures for accurate interpretation of palaeocology, palaeoclimate, depositional environment and overall palaeoceanography that may be useful as a benchmark to predict future climatic changes.

An in-depth study on the bioevents based on radiolarians and the dataset obtained from the diversity analysis and Water Depth Ecology (WADE) index provides a clear picture of the environment during the middle Miocene to early Pliocene. Based on the study on planktonic foraminifera from the Pliocene-Pleistocene sequence has been demarcated in the Plio–Pleistocene boundary (Fig. SP 4.4). An event of ocean upwelling has been identified based on the index planktonic foraminiferal taxa from the late Pliocene to early Pleistocene of the northern Indian Ocean that also correlates with the palaeoceanographic records known from other upwelling regions of the world. Based on the study of the Miocene to Pleistocene sequences of the Andaman-Nicobar Basin, the precise age of the sediments has been determined and significant climatic events have been identified. The Ph. D. thesis was submitted on August 26, 2022, and awarded on January 16, 2023, by IIT-ISM (Dhanbad).

SP 4.5: **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 & Amit K. Ghosh (Emeritus Scientist-CSIR), Mentor

Twenty-two silicoflagellate taxa belonging to five genera, e.g. *Bachmannocena, Dictyocha, Distephanopsis, Parameseocena* and *Stephanocha* have been identified from the sediment core (NGHP-01-17A) ranging from the

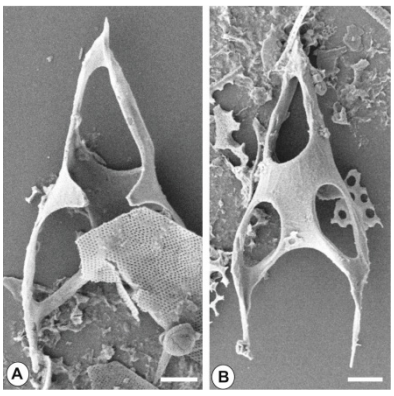


Fig. SP 4.2b - A new species *Corbisema tajmahalii* n. sp. from U1553. (A) Abapical view. (B) Apical view.

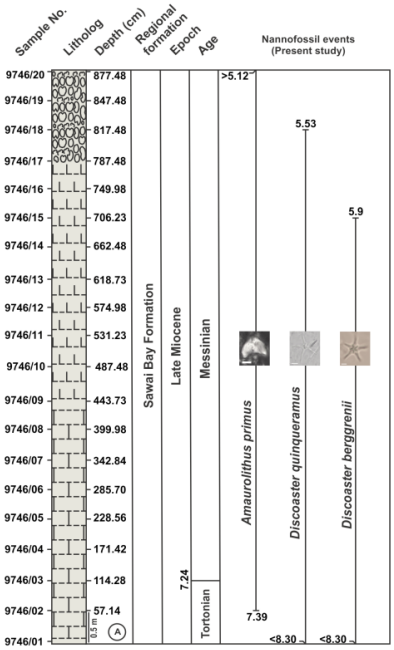


Fig. SP 4.3a – Age of the outcrop based on calcareous nannofossils.

depth interval 684.09 mbsf to 316.55 mbsf. Based on the analysis of index calcareous nannofossils and radiolarian events, late Miocene (Tortonian) age (9.86–7.39 Ma) has been assigned for this section of the core (Fig. SP 4.5). Two Partial Range zones namely *Dictyocha varia* and *Dictyocha extensa* and one Subzone, i.e. *Bachmannocena elliptica* have been proposed. It has been envisaged in the present study that the transition of *D. varia* to *D. extensa* took place within the Tortonian. Relative abundances of the two genera, *Dictyocha* and *Stephanocha* have been determined to estimate palaeotemperature. There was substantial dominance of *Dictyocha* over *Stephanocha* throughout the studied sequence. This implies the prevalence of a warmer climate during the Tortonian (9.86-7.39 Ma) with a cooling peak in the *Bachmannocena elliptica* Subzone during 8.104–8.088 Ma corresponding with the nutrient rich condition.

SP 4.6: Neogene climate change vis-à-vis major climatic events: a quantitative reconstruction from northeast Indian Ocean [(CSIR Emeritus Project No. ES2021Y8027) [21(1143)/22/EMR-II); 06.06.2022 to 31.03.2023].

Investigator: Amit K. Ghosh (Emeritus Scientist-CSIR)

Rhodolith-forming non-geniculate coralline recorded from the Long Formation, exposed in four different outcrops on Little Andaman Island (Hut Bay) in the northeast Indian Ocean are represented by species of *Sporolithon, Mesophyllum, Lithothamnion, Phymatolithon, Lithoporella, Spongites, Neogoniolithon* and *Lithophyllum*. The algal assemblages also include geniculate corallines

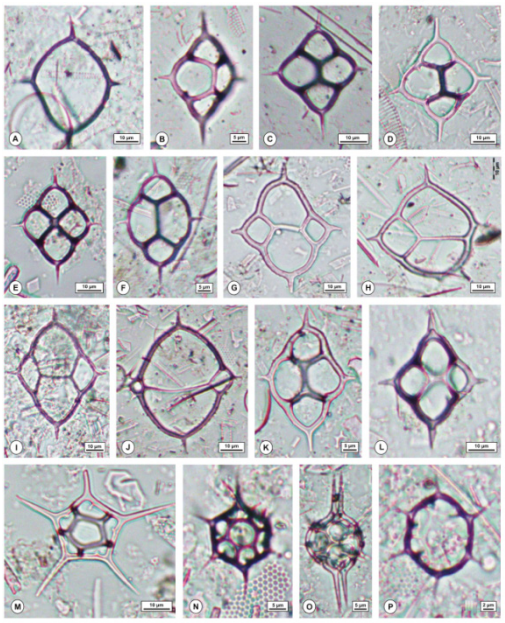


Fig. SP 4.3b – Silicoflagellate taxa.

belonging to the genera *Amphiroa* and *Corallina*. The four outcrops are dominated by bioclastic wackestone and packstone composed of coralline red algae, benthic and planktonic foraminifers, echinoid spines and unidentified coral fragments. Most of the rhodolith morphotypes are box work in nature with concentric to laminar internal structures that designate moderate energy settings (Fig. SP 4.6). The rhodolith-forming coralline red algae, the growth forms and taphonomic features in non-geniculate corallines and the characteristic benthic foraminifers are indicative of a moderate to marginally high energy environment. The study indicates that carbonate production was considerably high during the Serravallian of the tropical northeast Indian Ocean. Geochemical analysis was done on the samples from only one outcrop containing both planktonic and benthic foraminifers embedded within the rock matrix and calcium carbonates were extracted from the foraminiferal tests. Stable isotopic ratios ($\delta^{13}C$ and $\delta^{18}O$ values) were measured by Continuous Flow Isotope Ratio Mass Spectrometer (CFIRMS; MAT 253). Furthermore, the TOC and $\delta^{13}C_{TOC}$ have been measured from the same samples. The isotopic analysis provides an indication that the sedimentation during the Serravallian took place in the shallower part of the ocean in the proximity of hydrocarbon seepage.

CP 1: Sunil K. Shukla [& Yaspal Sundriyal, HNB Garhwal University]

A collaborative research work was performed with Prof. Yaspal Sundriyal, HNB Garhwal University, Srinagar, Uttarakhand. This research carried out diatom analyses from a peat sequence of Kedarnath, Central Himalaya. Using the diatom assemblage, a semi-quantitative water table was inferred for the mid-late Holocene Period.

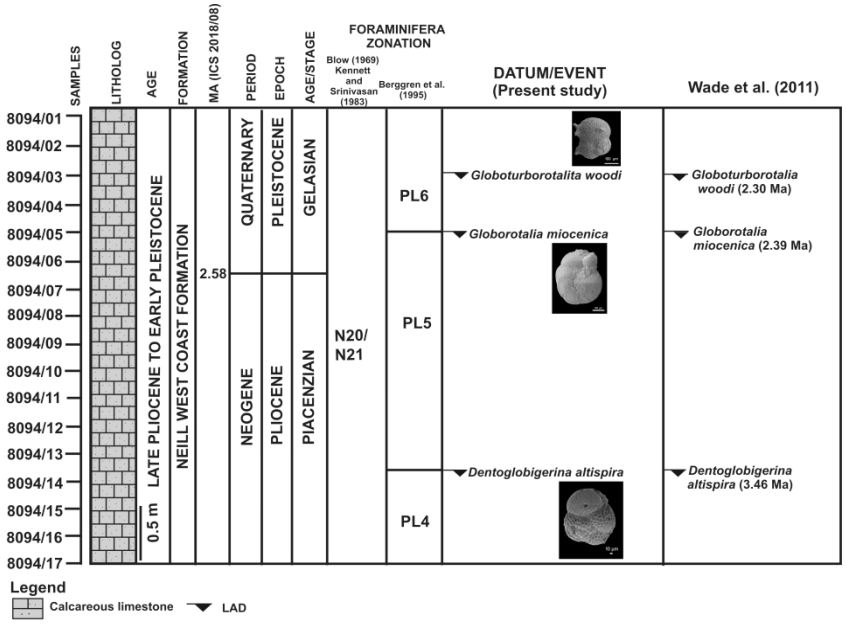


Fig. SP 4.4 - Columnar section from the West Coast of Neil Island showing the litholog, sampling horizons and relative age based on marker planktonic foraminifera (LAD) that has been correlated with Wade *et al.* (2011).

The study demonstrates a positive correlation of diatom abundances with the Indian Summer Monsoon (ISM), whereas a negative correlation with the westerlies. The low to negligible abundances of diatoms during the recent past indicate drier conditions in Kedarnath, Central Himalaya. Thus, the in-situ monitoring of the Indian peat sequences is urgently needed.

CP 4.2: Manoj MC, P Morthekai [& Kannan J Prakash (GSI)]

Geochemical and geochronological studies of Toba volcanic ash bearing sediments in Keala, India. The sediment samples collected from the core samples of different layers containing Toba ash and Ferricrete from different parts of Kerala have been processed for the geochemical analysis.

OTHER ACADEMIC WORKS

Research Papers Presented

1. **Ghosh AK, Roy L, Dey R & Chakraborty A -** Benthic calcareous algal diversity during middle Miocene to Pleistocene sequences in the northeast Indian Ocean: their significance in deciphering depositional environment. International Conference on Neogene Climate Evolution in Eurasia (NECLIME) (Online), November 21-24, 2022.

2. **Ghosh AK** - Keynote Address - Climate changes since the last 23 million years: evidences from the fossilized marine phytoplankton of Andaman and Nicobar Islands. International Conference on Advances in Plants, Microbes and Agricultural Sciences, 02-04 March, 2023: 2.

3. **Kawsar M, Manoj MC & Weber ME -** 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) .

4. **Khan H, Govil P, Panchang R, Kumar P & Agrawal S -** Surface and subsurface hydrographic variation from the western Arabian Sea during the late Quaternary. 28th Indian Colloquium on Micropaleontology and Stratigraphy (ICMS) during 4-6 May, 2022.

5. **Khan H, Govil P, Panchang R, Kumar P & Agrawal S -** Evidence of glacial warming and monsoon-induced productivity changes in the surface mixed and thermocline layers from the western Arabian Sea during the late Quaternary. AGU Fall Meeting online during 12-16 December, 2022.

6. **Kumar B & Govil P -** The Indian Ocean Dipole variability in the western equatorial Indian Ocean: Evidence from the planktic foraminiferal record. 28th Indian Colloquium on Micropaleontology and Stratigraphy (ICMS) during 4-6 May, 2022.

7. **Kumar S, Singh VP, Mathews RP, Murthy S, Pillai SSK & Manoj MC -** Organic petrographic and palaeofloristic composition: Implications on

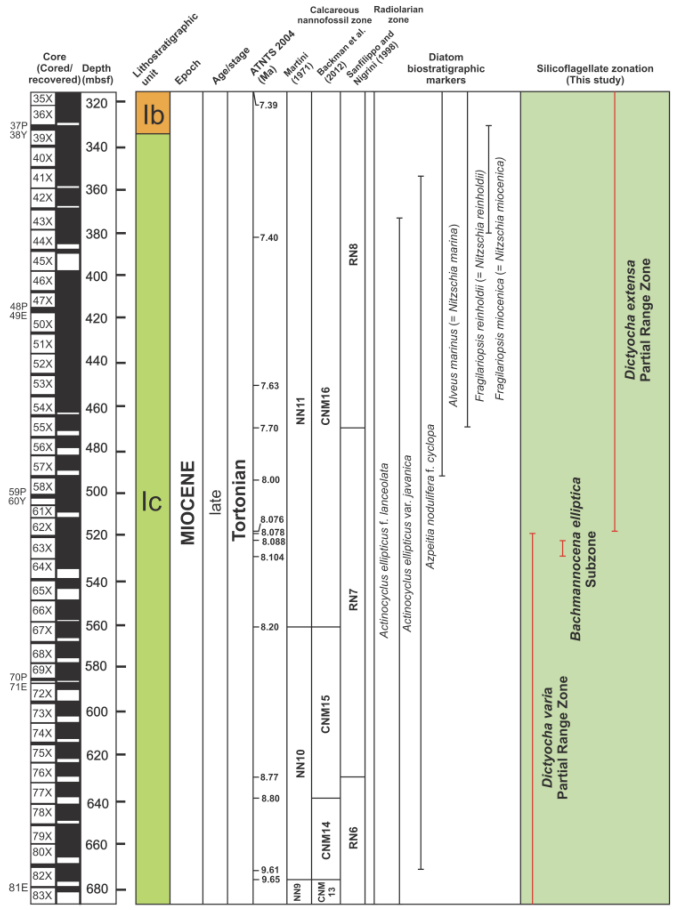


Fig. SP 4.5 - Columnar section showing depth and relative age based on silicoflagellate biostratigraphy (Neogene chronostratigraphic scale is after Lourens *et al.*, 2004 and integrated biostratigraphy of diatoms, radiolarians and calcareous nannofossils after Roy *et al.*, 2022).

the environment and depositional settings from Ashoka Mine, North Karanpura, Damodar Basin, India. 73rd Annual Meeting and Symposium of the International Committee for Coal & Organic Petrology (ICCP-2022) at New Delhi, India, September, 2022.

8. **Kumar S, Singh VP, Mathews RP, Murthy S, Pillai SSK & Manoj MC** - Paleofloristic and petrographic characteristics of the Ashoka coal-bearing succession of North Karanpura Basin, India. GEOYOUTH 11th All India Students Symposium on Geology by Department of Geology Mohanlal Sukhadia University, Udaipur, Februar,y 2022.

9. **Manoj MC & Kawsar M** - 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).

10. **Roy L, Ghosh AK, Bhaumik AK & Sensarma S** - Tortonian radiolarian events from Northeast Indian Ocean (NGHP-01-17A). International Conference on Neogene Climate Evolution in Eurasia (NECLIME) (Online), November 21-24, 2022.

11. **Samal P, Singarasubramanian SR, Srivastava J, Kawsar M, Manoj, MC Gurumurthy GP, Chauhan Md. M, Ali S, Alam M & Sharma AA** - 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).

12. **Saxena S & Ghosh AK** - Tortonian-Messinian calcareous nannofossils and silicoflagellates from the northern Indian Ocean. International Conference on Neogene Climate Evolution in Eurasia (NECLIME) (Online), November 21-24, 2022.

13. **Verma D & Govil P** - Late quaternary oceanographic and climatic variations based on the planktic foraminiferal record at IODP U1475, southwest Indian Ocean. presented at the 28th Indian Colloquium on Micropaleontology and Stratigraphy (ICMS) during 4-6 May, 2022: 25.

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

Singh V, Head MJ & Radmacher W

- Last Interglacial paleoceanography at ODP Site 986 on the Svalbard margin, Fram Strait, based on dinoflagellate cysts. 14th International Conference on Paleoceanography, Bergen, Norway, 29 August-02 September, 2022.

W. Radmacher, Vartika Singh & M. Head

- Paleoceanography of the subpolar North Atlantic ODP Site 984 for the Last Interglacial (Late Pleistocene): preliminary results based on dinoflagellate cysts. 14th International Conference on Paleoceanography, Bergen, Norway, 29 August-02 September, 2022.

Amit K. Ghosh, Stuti Saxena & Lopamudra Roy

- International Conference on Neogene Climate Evolution in Eurasia (NECLIME) (Online), 21st-24th November 2022.

Amit K. Ghosh

- International Conference on Advances in Plants, Microbes and Agricultural Sciences, organized

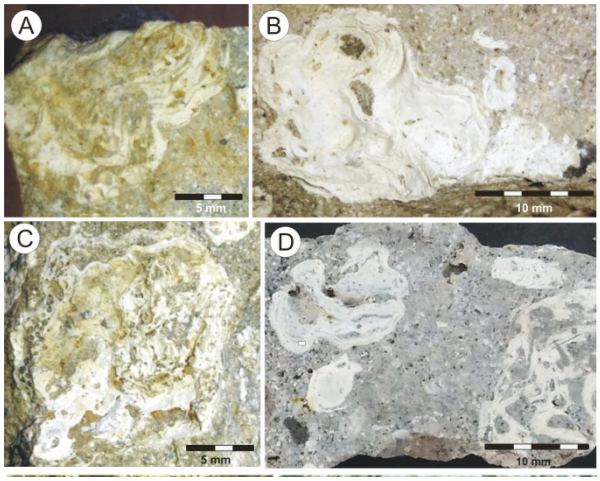


Fig. SP 4.6 – (A–D) Polished surface of the sliced rock samples showing boxwork laminar concentric rhodoliths.

by DST (FIST) and UGC-SAP assisted DRS, Department of Botany, University of North Bengal, Sponsored by DBT and DST-SERB (Govt. of India), 02nd-04th March, 2023.

Lectures delivered

Pawan Govil

- Understanding the Indian monsoon with proxy records from the Northern Indian Ocean. Online Monsoon Series Talk worldwide, Online from BSIP, Lucknow, 31st August, 2022.

Vartika Singh

- Nearing a topic/area, AcSIR Course Work, BSIP, 28th August, 2022
- Evolutionary Ecology, AcSIR Course Work, BSIP 7th October, 2022

A.K. Ghosh

- Climate changes since the last 23 million years: evidences from the fossilized marine phytoplankton of Andaman and Nicobar Islands. International Conference on Advances in Plants, Microbes and Agricultural Sciences (02nd-04th March, 2023), organized by DST (FIST) and UGC-SAP assisted DRS, Department of Botany, University of North Bengal, Sponsored by DBT and DST-SERB (Govt. of India) during March 02-04, 2023 (Keynote Address).

Stuti Saxena

- Tortonian-Messinian calcareous nannofossils and silicoflagellates from the northern Indian Ocean. International Conference on Neogene Climate Evolution in Eurasia (NECLIME) (Online), 21st-24th November, 2022.

Lopamudra Roy

- Tortonian radiolarian events from Northeast Indian Ocean (NGHP-01-17A). Online International Conference on 'Neogene Climate Evolution and Biotic Response(s), NECLIME, South Asia, 21st-24th November, 2022.

CONSULTANCY/TECHNICAL SUPPORT RENDERED

Pawan Govil (Geochemistry Lab)

- A number of samples on ICP-MS in the laboratory have been analyzed. Samples are largely of soil and sediments collected from terrestrial realms, including glacier, fluvial and lacustrine nature. Besides routinely used international standard protocols, efforts are made to develop protocols for tough samples. The Lab received samples from different parts of the country on a consultancy basis. Institute generated approximately Rs. 3,00,000/- through the Consultancy. Besides Consultancy, In-House project samples were also analyzed and provided the data to the concerned lab/scientist.

REPRESENTATION IN COMMITTEES/BOARD

Pawan Govil

- Secretary of "The Palaeobotanical Society" from 2022 to the present.
- Convener of the Store and Purchase section, BSIP, Lucknow.
- Member, Building & Electrical Maintenance (BEMC) Committee.

Manoj MC

- Membership Association of Quaternary Researchers (AOQR)
- Member, Editorial Board, Quaternary Chronicle [under Association of Quaternary Researchers (AOQR)] (Continuing).
- Member, Supervising Committee for functioning of AcSIR Ph.D. Programme from 2020-2023 (OM No. BSIP/2020-21/L-269 dated 15/07/2020).

PH.D. PROGRAMME

Amulya Saxena 2016. Phytodiversity and climate fluctuation in and around wildlife sanctuaries of Assam since late Holocene: A geological and palynological aspects, under the supervision of **Abhijit Mazumder (BSIP)** and Dhruv Sen Singh (LU) registered with Lucknow University. Status: Submitted.

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: Awarded (16.01.2023).

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: Awarded (04.11.1022).

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 University), Academy of Scientific & Innovative Research (AcSIR) 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)**; Academy of Scientific & Innovative Research (AcSIR). Status: Ongoing.

Divya Verma (2020). High resolution reconstruction of paleoceanography and paleoclimatology of the south-west Indian Ocean during Late Quaternary, under the supervision of **Pawan Govil (BSIP)**; Academy of Scientific & Innovative Research (AcSIR). 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 MC (BSIP)** and Micheal E Weber, the University of Bonn, Bonn, Germany, Academy of Scientific & Innovative Research (AcSIR). Status: Ongoing.

Sneha Mary Mathew (2020). Paleocene–Eocene records of palaeohydrological and palaeoenvironmental changes from the lignite fields of Rajasthan, India, under the supervision of **Manoj MC and Shailesh Agrawal (BSIP),** Academy of Scientific & Innovative Research (AcSIR). Status: Ongoing.

Amit K. Ghosh (Emeritus Scientist)

- Member of the Advisory Board of the Journal of Environmental Biology.
- Member, National Advisory Committee, XXVIII Indian Colloquium on Micropalaeontology & Stratigraphy (ICMS-2022) during 4-6 May, 2022 organized by Savitribai Phule Pune University, Pune.
- Member, Advisory Committee, International Conference on Advances in Plants, Microbes and Agricultural Sciences (02nd-04th March, 2023), Organized by DST (FIST) and UGC-SAP assisted DRS, Department of Botany, University of North Bengal, Sponsored by DBT and DST-SERB (Govt. of India) during March 02-04, 2023.

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) (upto 31.12.2022)
Biswajeet Thakur (Scientist E) (w.e.f. 01.01.2023)

Co-Coordinator: Rajesh Agnihotri (Scientist F) (upto 17.01.2023)
Shilpa Pandey (Scientist D) (w.e.f. 18.01.2023)

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

Understanding the biogeochemical interaction between the earth's atmosphere and ocean is the goal of the coastal core project. The largest archives of the local and global climatic phenomena are found in coastal sediments. In recent decades, there has been an increase in industrial and population growth, which has had a negative impact on all aquatic environments, whether they are found inland or along the shore. The primary causes of change in coastal ecology are anthropogenic pressures, excessive rainfall, and rapid climate change. High resolution biological changes in carbon sequestration and sea ingression/regression are provided by coastal sediments. In order to comprehend biogenic productivity and coastal ecosystems, it is vital to understand elements, like carbon, nitrogen, sulphur and phosphorus (C, N, S and P). For risk assessment, scenario planning, and management of the consequences of climate change mitigation, a deeper understanding of the biogeochemical cycles of biogenic materials that are both naturally occurring and anthropogenically disrupted is crucial. The biotic (pollen/ spore, diatoms, palynofacies) and abiotic (major traces, rare earth elements, grain size) are one of the major tracers of the past climatic and ecological changes that may have influenced the geochemical and biodiversity in coastal settings. Combining these proxies would enable us to examine complex biological and biogeochemical changes in both older and contemporary sediment records. The investigation would definitely play a significant role in the scenario of climate change as it can offer the necessary and productive parameters for today's unbalanced and unmanaged coastal ecosystem.

PERSONNEL INVOLVED

Team Members: P. Morthekai (Scientist D), Niteshkumar Khonde (Scientist C), Sanjay Kumar Singh Gahlaud (Scientist B)
Associate Members: Abhijit Mazumder (Scientist E), Arif H. Ansari (Scientist D)
Research Scholars: Salman Khan, Nikhil Patel, Pooja Tiwari, Kishor V Katange, Gursewak Singh, Anand

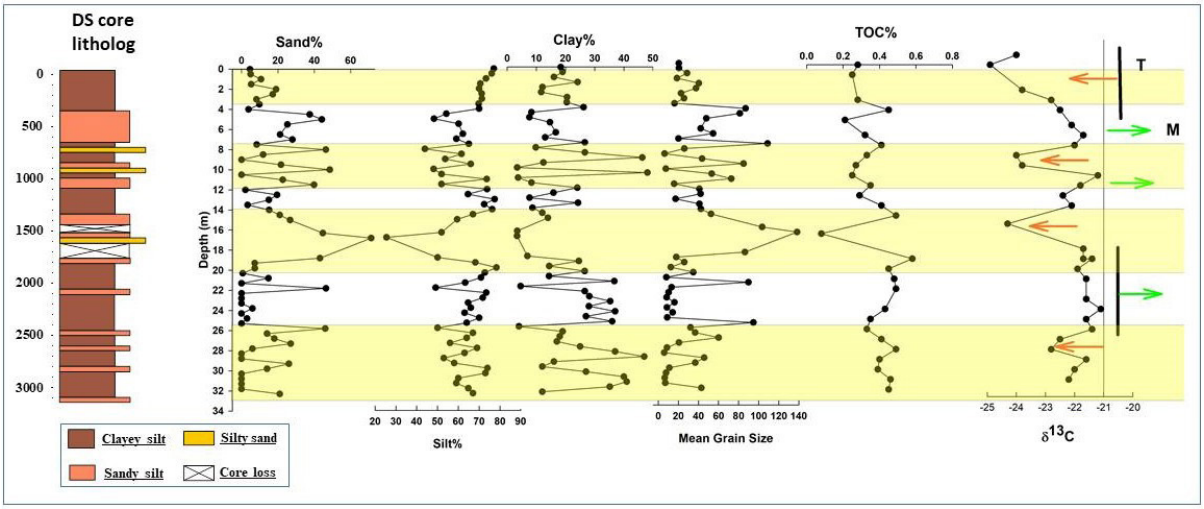


Fig. 1 - Litholog of DS core (~32 m) raised from the Bet Zone of Great Rann of Kachchh(GRK) Basin, western India. Temporal changes in grain size variations, TOC and $\delta^{13}C$ indicating the land-marine interaction changes in the Bet Zone.

Rajoriya, Nazakat Ali, Shivansh Saxena, Vartika Singh, Vinai K Tiwari, Alka Rani

SIGNIFICANT FINDINGS

Kachchh window: The DS core (~32 m) raised from Bet Zone of Great Rann of Kachchh (GRK) Basin was analyzed for particle size analysis shows several coarsening and fining upward sequences. The TOC content and $\delta^{13}C$ of the downcore section shows numerous phases of enhanced marine (green arrows) and terrestrial source for organic matter (red arrows) during the deposition of these sediments from mid-late Holocene to recent (Fig. 1). The chemical weathering and mineralogical indices show moderate to low chemical weathering under sub-humid paleoclimatic conditions, while higher physical weathering processes under the semi-arid conditions is observed in the upper core section (Fig. 2).

The study of Edathua core from Kerala shows different fluvial and marine phases during the Holocene as evidenced from the ~9 m core based on palynofacies and sediment texture (Figs 3, 4). The depositional environment mainly represented marginal dysoxic-anoxic, proximal suboxic-anoxic and mud-dominated oxic region as witnessed from the association of different phytoclasts, palynomorphs and amorphous organic matter distribution. To decode the biotic-abiotic interaction, modern analogue was prepared from the surface sediments of the Kondagai and Sambai, Tamilnadu coastal regions using multi-proxy data.

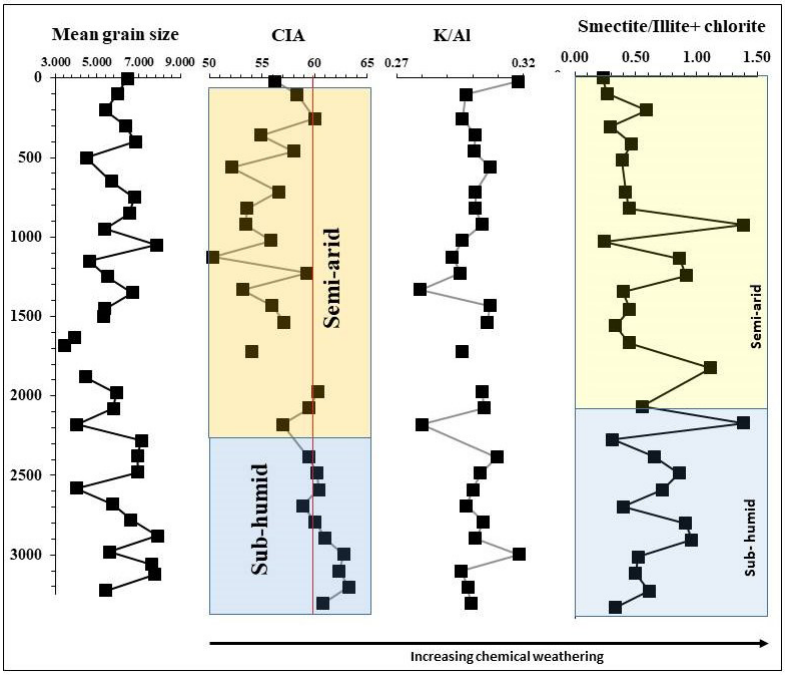


Fig. 2 - Downcore variations in the mean grain size, geochemical and clay mineralogical ratio as weathering indices in DS core (~32 m) raised from the Bet Zone of Great Rann of Kachchh (GRK) Basin, western India.

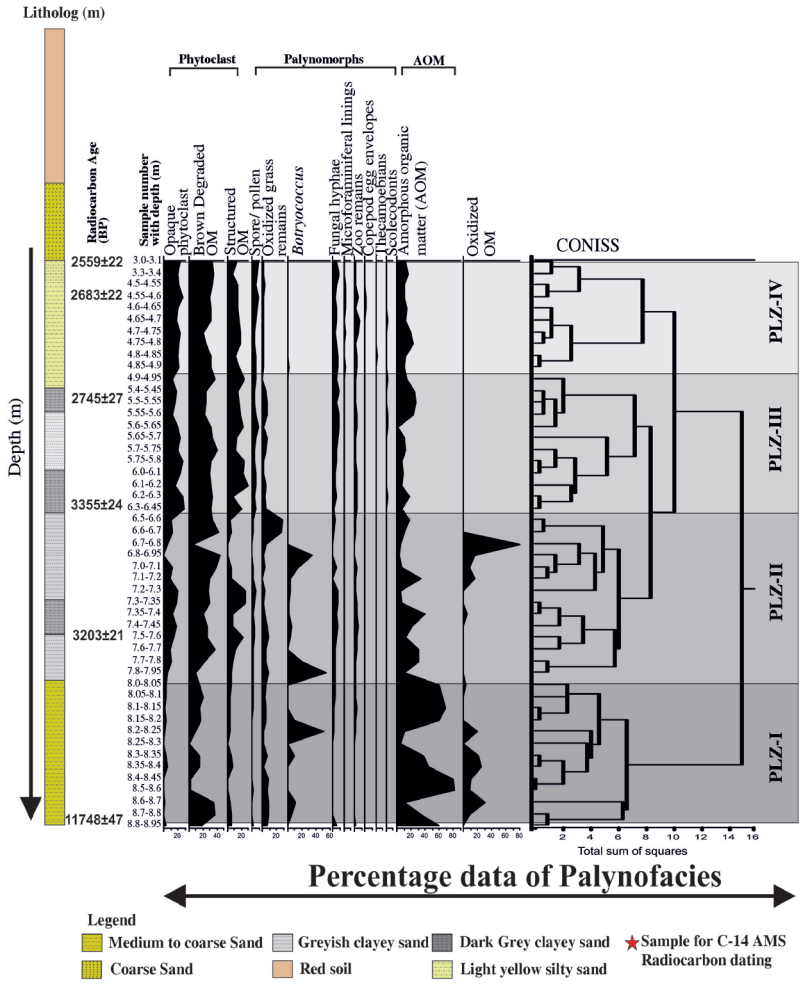


Fig. 3 - The zone distribution chart of palynofacies from the Edathua core, Kerala depicting the sedimentary organic matter.

PROJECT OUTCOME

Publications in SCI (Science Citation Index) Journals

1. Morthekai P, Tiwari P, Murari MK, Singh P, Thakur B, Manoj MC, Ali SN, Singh VK, Kumar K, Rai J, Dubey N & Srivastava P 2022. Further investigations towards luminescence dating of diatoms. *Radiation Measurements* 156: 106803 (IF: 1.743).

Publication other than the Project Work

1. Patel N, Trivedi P, Agnihotri R, Rai N, Sathe S, Bhushan R, Khonde N & Kumar A 2022. New Chronology for Megalithic burials in Vidarbha (central India): Insights into contemporary hydro-climate and food habits. Radiocarbon https://doi.org/10.1017/RDC.2022.47 (IF: 6.324).
2. Sharma S, Sati SP, Basaviaha N, Pandey **S**, Sundriyal YP, Rana N, Singh P, Pradhan S, Shukla AD, Bhushan R, Bhatt R & Juyal N 2022. Mid to late Holocene climate variability, forest fires and floods entwined with human occupation in the upper Ganga catchment, India. *Quaternary Science Reviews* 293: 107725 (IF: 4.456).
3. Sagwal S, Sengupta D, Kumar A, Dutt S, Srivastava P, Agnihotri R, Gahlaud SKS, Sarathi JP, Shivam A & Bhushan R 2022. Late-Holocene wildfire record from the Stagmo peat section, Leh Valley, NW Himalaya. *The Holocene* https://doi.org/10.1177/09596836231157066 (IF: 3.092).
4. Kumar K, Sharma A, Srivastava P & Thakur B 2022. Implications for catchment weathering, provenance and climatic records from a late Pleistocene to present sedimentary sequence in Gujarat, India. *Quaternary Research*: 1–18. https://doi.org/10.1017/qua.2022.39 (IF: 2.797).
5. Patel N, Gahluad SKS, Saxena A, Thakur B, Bharti N, Dabhi AKJ, Bhushan R & Agnihotri R 2022. Revised chronology and stable isotopic (Carbon and Nitrogen) characterization of Lahuradewa Lake sediment (Ganga-Plain, India): Insights into biogeochemistry leading to peat formation in the lake. *Journal of the Palaeontological Society of India* 67(1): 113-125 (IF: 0.652).

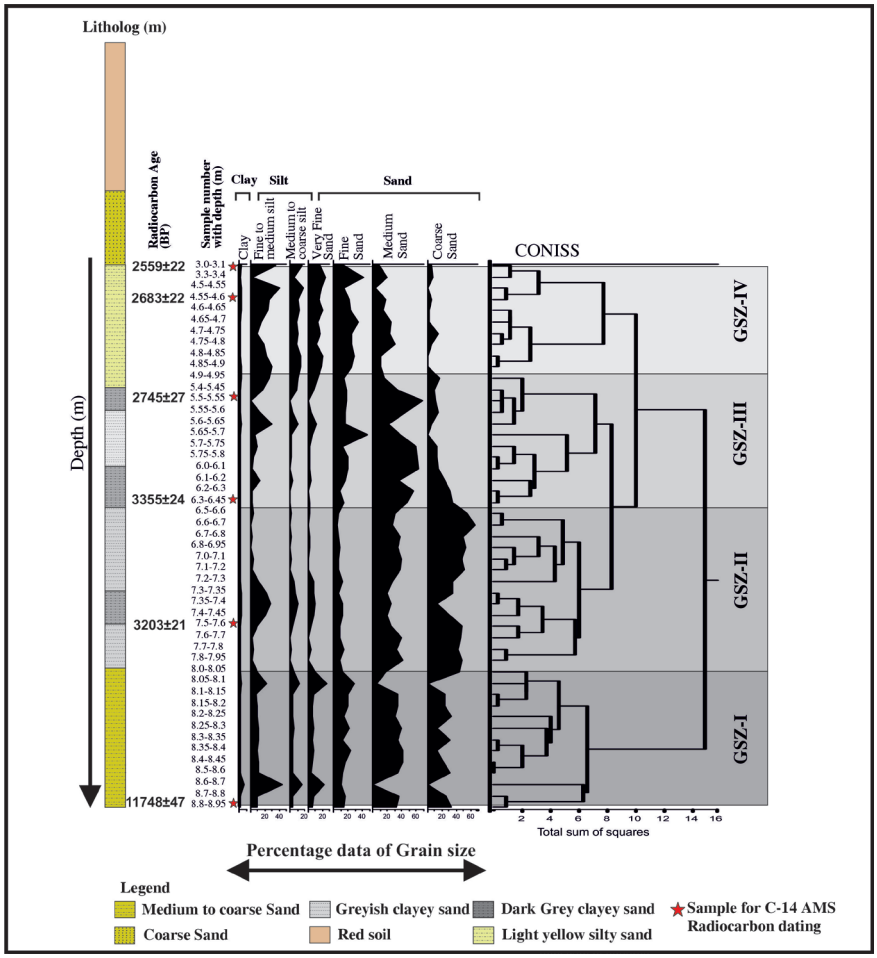


Fig. 4 - Grain size distribution of the Edathua core, Kerala showing textural association.

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 (Completed)].

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

Modern pollen rain studies and sub-surface palynological studies are completed from Pirotan Island, Jodiya, Balachadi and other coastal sites of Saurashtra, Gujarat.

High diversity of molluscans has been recovered from a sediment core collected from the Gulf of Kachchh, Gujarat at different depths. The collected samples have been sent for AMS dating to fix the chronology. In addition, taxonomy and stable isotopic studies of the molluscs are in progress to reconstruct the palaeoecological history of the microbenthic fauna since Holocene and also to understand large-scale environmental processes led to long-term changes in species composition and diversity of molluscans assemblages.

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

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

Palynological and sedimentological studies of recent sediments from offshore Odisha Coast were carried out to assess the distribution of palynomorphs viz-a-viz

lithofacies in the study area. Various and well-preserved marine and freshwater palynomorphs consisting of dinoflagellate cysts, tintinnomorphs, microforaminiferal linings, thecamoebians, in addition to inputs from the terrestrial vegetation (pollen grains and spores), were found in recent sediments of the Odisha Coast. The palynological studies from the Astrang area and other coastal areas of the Mahanadi Delta, Odisha completed and the manuscript is in progress.

CP 5.1: **Anjum Farooqui, Rajesh Agnihotri, SKS Gahlaud** [& 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 spanning Holocene from Chilka Lagoon (Orissa) for understanding 10Be/9Be derive denudation rates in realm of climate variability and/or sea level change.

CP 5.2: **Niteshkumar Khonde** [& Liviu Giosan, Woods Hole Oceanographic Institution, USA]

Investigating on Inorganic geochemical proxies, mineralogical compositions on the sediment cores collected from Okavango Delta, Botswana by Prof. Liviu Giosan.

CP 5.3: **Shilpa Pandey** [& Prof. Anil K. Gupta, IIT, Kharagpur]

Collaborated with Prof. Anil K. Gupta, Department of Geology and Geophysics, IIT, Kharagpur for palynological studies to reconstruct vegetation, climate and to investigate impact of environment on subtropical and temperate plant communities during Holocene.

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.
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), February 15-17, 2022, organised by Department of Environmental Sciences, Savitribai Phule Pune University, Pune, INDIA.
3. **Tiwari Pooja, Singh Veeru Kant, Ansari AH, Ahmad Shamim, Thakur Biswajeet & Sharma Mukund** - High altitude extermophilic diatoms of Panamik and Puga Hotspring of Ladakh, India. National Georesearch Scholars Meet, June, 7-10, 2022 hosted by University of Ladakh.
4. **Morthekai, P, Ali Sheikh Nawaz, Khonde Niteshkumar, Singh Priyanka, Saikia Korobi, Tiwari Pooja, Kawsar Masud, Ghosh Ruby, Arif Mohammad, Gahlaud Sanjay KS, Balasubramanian Karthick, Thakur Biswajeet & Manoj MC** - Lowering sea-level and siltation jointly caused abandonment of Korkai Port (India): inference from a multi-proxy palaeoenvironmental record. XXI INQUA Congress 2023.
5. **Sridhar Alpa, Tiwari Pooja, Thakur Biswajeet, Goswami Vineet, Bhushan Ravi, Maurya Deepak & Chamyal LS** - A 2 ka history of floodplain accretion and palaeohydrological change from the ISM dominated semi-arid alluvial plains, western India: assessing the role of successive flooding events. XXI INQUA Congress 2023.

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

Shilpa Pandey

- Deputed to the National Climate Conclave 2023, Indira Gandhi Pratishthan, Gomti Nagar, Lucknow, April 10-11, 2023.
- Deputed to the 5thNational Convention on Swadeshi Science Movement, AKTU, Lucknow, June 24-26, 2022.
- Deputed to the IODP-India Workshop, NCPOR, Goa, September 22-23, 2022.
- Participated in the India International Science Festival (IISF-2022)-"Artisans Technology Village-Vocal for Local" and Young Scientists and Young Scientist Conference- "Biodiversity, Environment and Climate Change" MANIT, Bhopal, January 21-24, 2023.
- Deputed to the "National Programme for Training of Women Scientists and Technologists working in the Government Sector on Biodiversity Conservation", Wildlife Institute of India, Dehradun, November 14–18, 2022.

PH.D. PROGRAMME

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

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)** and Bindhyachal Pandey (BHU), 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)** and Alok Kumar (BHU), registered with Banaras Hindu University Varanasi. Status: In-progress.

Pooja Tiwari (2019). Holocene climate and environment reconstruction from southwest coastal settings of Kerala using multi-proxy studies, under the supervision of **Biswajeet Thakur (BSIP)** and Purnima Srivastava (LU), registered with Lucknow University, Lucknow. Status: Submitted.

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)**, 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)**, 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 and Biswajeet Thakur (BSIP)** registered with AcSIR, New Delhi. Status: In-progress.

Nazakat Ali (2021). Weathering processes, provenance character and climatic manifestations during the late Quaternary from Central Ganga Plain, India, under the supervision of **Biswajeet Thakur (BSIP)** registered with AcSIR, New Delhi. Status: In-progress.

Shivansh Saxena (2022). Limnology and sedimentary organic matter characterization from Central Ganga Plain and Core Monsoon Zone of India during the late Quaternary, under the supervision of **Biswajeet Thakur (BSIP)** registered with AcSIR, New Delhi. Status: In-progress.

Vartika Singh (2022). Holocene palaeoclimate and relative sea-level changes of the Mahanadi Delta: A multiproxy approach (tentative), under the supervision of **Shilpa Pandey (BSIP)** & Komal Verma (BHU), registered with Banaras Hindu University, Varanasi. Status: In-Progress.

Vinay K Tiwari (2022). Assessment of climate and human impact on Bakhira Bird Sanctuary, a Ramsar site of Uttar Pradesh, under the supervision of **Shilpa Pandey (BSIP)** & Sunita Verma (Department of Botany, Christ Church College, Kanpur) registered with Kanpur University, Kanpur. Status: Ongoing.

Alka Rani (2022). Melissopalynological analysis of natural honeys from forests of Uttar Pradesh, under the supervision of **Shilpa Pandey (BSIP)** & Sunita Verma (Department of Botany, Christ Church College, Kanpur) registered with Kanpur University, Kanpur. Status: In-progress.

Pooja Tiwari, Veeru Kant Singh, AH Ansari, Shamim Ahmad, Biswajeet Thakur and Mukund Sharma

- High altitude extermophilic diatoms of Panamik and Puga Hotspring of Ladakh, India, National Georesearch Scholars Meet, June 7-10, 2022 hosted by University of Ladakh

Training/Study Visits

Shilpa Pandey

- Visited and conducted outreach activities with students of the Maharana Pratap Inter College, Asti, Lucknow on the World Wetland Day, February 02, 2023.

Lectures delivered

Shilpa Pandey

- Career Prospects in Agriculture and Biotechnology, at Sardar Vallabhbhai Patel University of Agricultural and Technology, Meerut on September 12, 2022.
- Biotechnology and Microbiology: A Panacea to combat climate change, at Sri Ram Swaroop Memorial University, Lucknow on September 28, 2022.
- Wetlands of UP and Policy Gaps: Integrated Solutions for Climate Change Mitigation and Sustainable Development. Workshop on Bridging the Climate Change Research and Policy Gap for Enhanced Local Climate Action in Uttar Pradesh, at Department of Environment, Forest & Climate Change, Government of Uttar Pradesh on December 29, 2022.
- Relevance of Palaeosciences research in Climate Change Era. Climate Action Now (CAN) Workshop, at IIT, Gandhinagar, Gujarat on January 29, 2023.
- Mangroves and Sustainable Coastal Tourism. Short Term Course on "Coastal Tourism and Environment" organized (Online) by UGC-Human Resource Development Centre, Goa University on March 9, 2023.
- Significance of Wetlands in changing Climate, at Maharana Pratap Inter College, Asti, Lucknow on the World Wetland Day on February 2, 2023.

ACCOLADES RECEIVED

Shilpa Pandey

- External Examiner of B.Sc. (Hons) 4th Semester Practical Viva-Voce at Babasaheb Bhimrao Ambedkar University, Lucknow on May 25, 2022.
- External Examiner for Viva-Voce, M.Sc, Sardar Vallabhbhai Patel University of Agricultural and Technology, Meerut, September 11-12, 2022.
- External Examiner of B.Sc. Practical Viva Voce at Babasaheb Bhimrao Ambedkar University, Lucknow on 24th March, 2023.
- Resource Person on Short Term Course on "Coastal Tourism and Environment" from 08.03.2023 to 14.03.2023 (Online) organized by UGC-Human Resource Development Centre, Goa University.
- Panel Member on National Science Day 2023 organized by IGNOU, Bhopal.
- Guest Speaker on Climate Action Now Workshop held at the IIT, Gandhinagar during 27-31 January, 2023.
- Event Organizer of the High-End Workshop (*Karyashala*) on "Disaster and Climate Resilient Pathways: Adaptation, Mitigation and Sustainable Development" under Accelerate Vigyan Scheme by SERB, New Delhi, December 7-13, 2022.

REPRESENTATION IN COMMITTEES/BOARD

Biswajeet Thakur

- Life Member, Palaeobotanical Society (since 2013)
- Life Member, Society of Earth Scientists (since 2013)
- Life Member, Earth Science India, Lucknow (since 2010)
- Executive Council Member, Palaeontological Society of India (since 2014)

Shilpa Pandey

- Life Member, Mangrove Society of India, Goa
- Life Member, Asia Hub Representative for C-Peat Group (since July 2022)
- Life Member, Society of Environmental Sustainability
- Member, International Organization of Palaeobotany
- Associate Professor in the Faculty of Biological Sciences, Academy of Science and Innovative Research (AcSIR), August, 2022

Project 6: Late Pleistocene-Holocene vegetation and climate reconstructions for the Himalayan region: understanding the dynamics and forcing mechanisms.

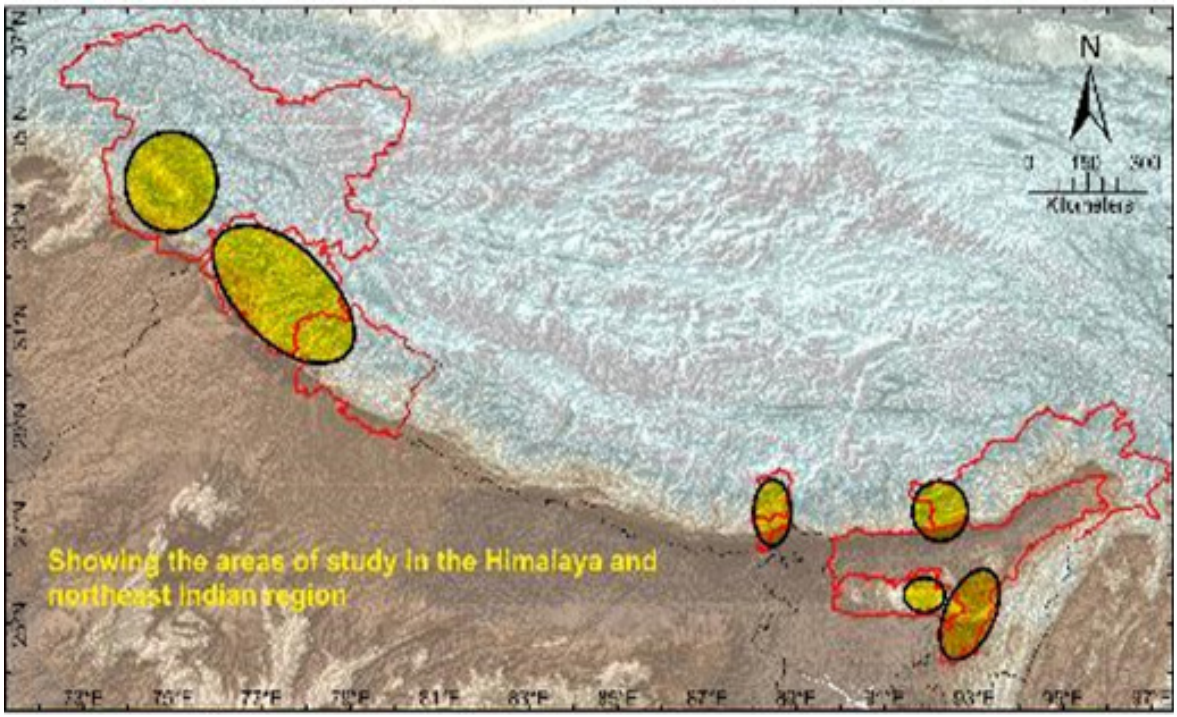
Coordinator: Ratan Kar (Scientist F)
Co-coordinator: S.K. Basumatary (Scientist E)

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 (IPCC 2018) and the mountainous regions are more



susceptible to these changes as compared to other regions under the same latitudinal belt. The Holocene Epoch (last 11,700 years) is marked by rapid climatic events (RCCs), where significant variability both in temperature and hydrological regime took place (example: 8.2 ka event, HCO, 4.2 ka event, MWP, LIA, etc.). The Himalaya, especially the high-altitude region, is an exceptional repository of past climatic changes as their signatures are well preserved in a relatively pristine environment. 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 (WD), while the Eastern Himalaya and the Northeastern region, receives precipitation only from the ISM, and is also comparatively more humid. In order to understand the trend of climatic changes and its impact on this highly vulnerable region, long term records beyond the instrumental range are necessary. The quest of this thrust area is to understand the Holocene climatic phases in the Himalaya (and Northeastern region), at decadal to centennial scales, using biological proxy records (pollen, tree-rings, phytoliths). The inception and impact of anthropogenic activities in this ecologically sensitive region is also explored. Besides, the tele-connections with the mid- or high-latitude regions are also investigated. Although, a large number of palaeoclimatic records are now available from the Himalayan region, however, in most of the cases, the underlying forcing mechanisms are yet to be examined. An understanding of the forcing mechanisms and their impact on the past ecosystems will strengthen our knowledge for simulating palaeoclimate models to possibly obtain insights about future climate variability and its impact on the Indian subcontinent.

PERSONNEL INVOLVED

Team Members: Santosh K. Shah (Scientist E), K.G. Misra (Scientist E), Ruby Ghosh (Scientist E), Swati Tripathi (Scientist D), S Nawaz Ali (Scientist D)
Associate Member: Parminder Singh Ranhotra (Scientist E)
Technical Support Member: RajaramVerma (Technical Assistant B)
Research Scholars: Amit K. Mishra, Lamginsang Thomte, Kajal Singh, Nidhi Tomar, Arya Pandey, Deeksha, Korobi Saikia, Ravi Shankar Maurya, Sadhana Vishwakarma, Prachita Arora, Tanveer W. Rahman, Siddhant Vaish

SIGNIFICANT FINDINGS

Palynological analysis of sub-surface sediments from the outwash plain of Hamtah Glacier, Lahaul-Spiti, has brought out the vegetation and climatic changes in the area during the last 1580 years (Fig. 1). The region experienced cold-arid conditions between 1580 and 1330 year BP (AD 370−620), which can be related to the Dark Ages Cold Period (DACP). Thereafter, between 1330 and 950 year BP (AD 620−1000), a comparatively warm and moist phase is seen, marking the Medieval Climatic Anomaly (MCA) in the region. From 950 year BP to the Present (AD 1000 onwards), the region saw a return to cold-arid conditions and the full extent of the Little Ice Age (LIA) is well marked. Over the last 160 years, the Current Warm Period

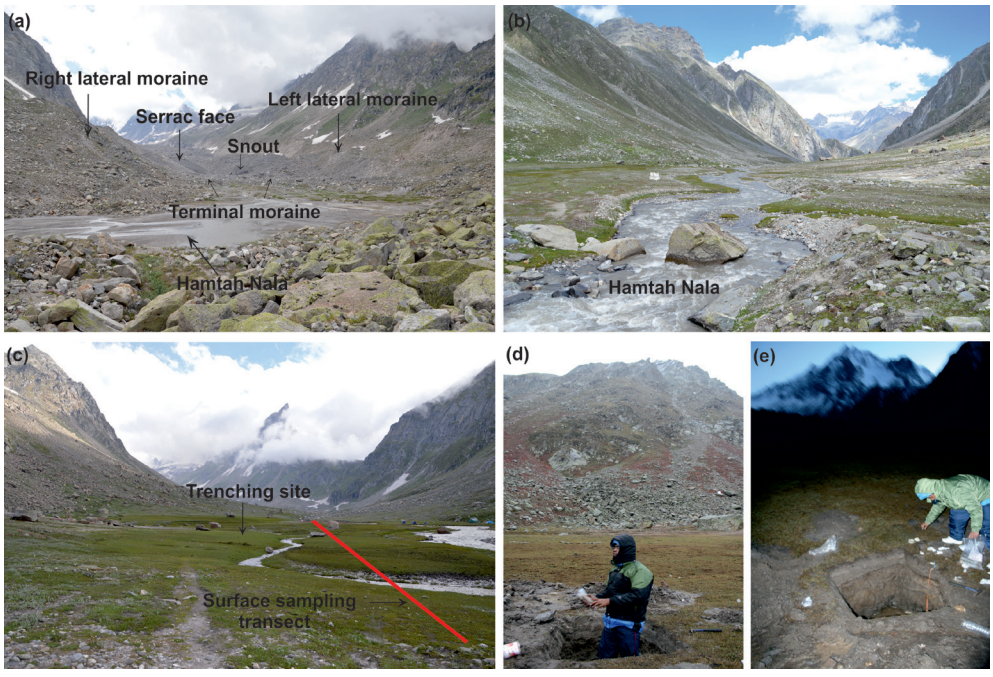


Fig. 1 – (a) Different geomorphic features of the Hamtah Glacier, (b) Downstream view of the outwash plain, (c) Upstream view of the outwash plain, (d−e) Trench for subsurface sampling in the outwash plain.

(CWP) is also discernible. Magnetic susceptibility (χlf) and sediment geochemistry (Weathering Index of Parker) were also attempted to have a multi-proxy approach, and show a general compatibility with the palynological data (Fig. 2).

A comparative analysis has been conducted among modern palynological records from the Western and Eastern Himalaya to understand the drivers for Holocene vegetation and climate based on modern proxy–climate analogues (Fig. 3). Transfer Function would be applied on the palaeo-pollen records to decipher the climatic changes (MAT & MAP) in the Himalayan region during the Holocene.

The tree-ring based oxygen isotope records covering Kumaon-Garhwal Himalaya captured the spatio-temporal distribution of drought and pluvial conditions prevailing in India and the response to the various known feedback mechanisms. The mechanisms such as El Niño southern Oscillation (ENSO) and regional SST patterns have their exogenous influence on the region through their influence on atmospheric circulation causing the variability in the climate scenario was observed. The multi-century summer drought reconstruction over 508 years (1508-2015 CE) highlighted the variation in strength of the Indian Summer Monsoon. The study also indicates that there is a pattern in the strength of the past drought (late 16th to early 17th Century) and the recent drying trends (late 20th to early 21st Century) could possibly lead to more extreme droughts in the future as observed in the past (Fig 4).

Using well replicated annually resolved tree-ring data of Himalayan cedar and Himalayan blue pine together from Lahaul-Spiti, Himachal Pradesh reconstructed 11-month Standardized Precipitation Index of July (SPI11-July) extending back to AD 1437 (Fig 5). The reconstruction showed long drought phase up to the 19th Century with intervening wet episodes. The 20th Century is comparatively wet in comparison to previous centuries. In the reconstruction 1626 being the driest annual year followed by 1554, 1705, 1971, 2008 and 1785. Dry and pluvial phases during the reconstruction are comparable with other hydrological records present from the westerly influenced western Himalayan region. The long-term drought reconstruction developed from the semi-arid Lahul-Spiti region is very important to identify its effects on crop productivity over the region.

The stable carbon isotope ($\delta^{13}C$) analysis of the surface sediments along the 500-4300 masl transact in Uttarakhand region showed dominance of drought tolerant C4 type vegetation above 3000 masl. Temperature rises and thin soil conditions could be the reason supporting C4 vegetation at the upper temperate and sub-alpine zones.

132 years (1890-2021 CE) tree-ring width chronology (TRWC) of *Cedrus deodara* (cedar or deodar) from Uttarkashi, Uttarakhand, showed significant positive correlation with precipitation and PDSI (Palmer drought severity index) for spring/summer season (March-June). Spring month's soil-moisture remains an important factor during the early growing season of deodar. The good

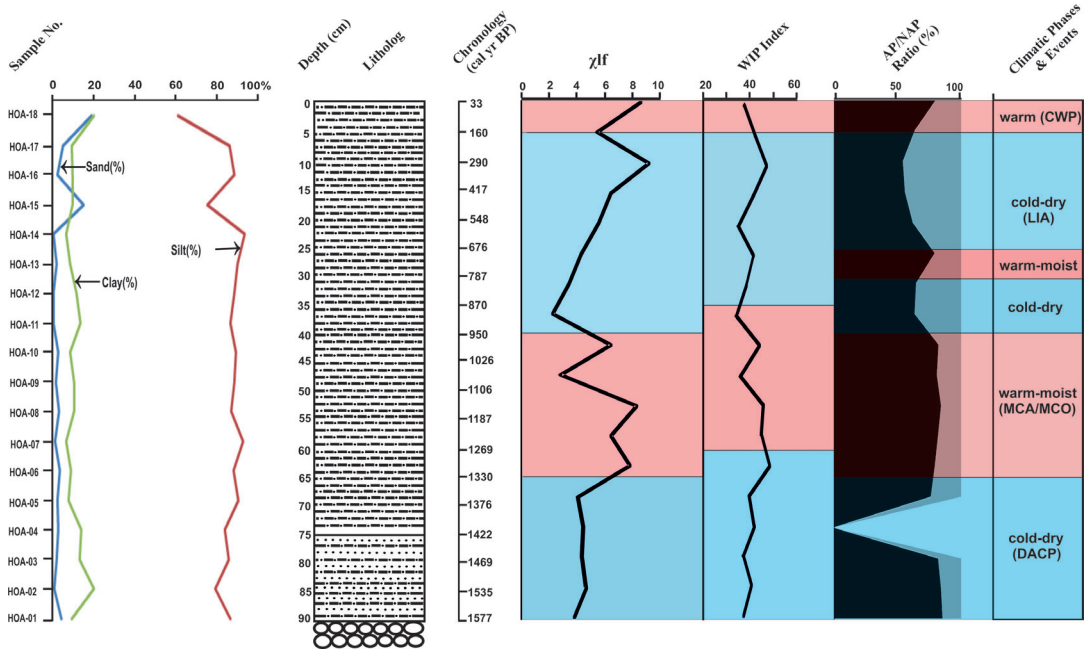


Fig. 2 - Summary diagram showing the results of different proxies and the climatic phases from Hamtah Glacier, Lahaul-Spiti, H.P. (χlf: magnetic susceptibility, WIP: Weathering Index of Parker, AP/NAP: arboreal pollen / non-arboreal pollen ratio, DACP: Dark Ages Cold Period, MCA/MCO: Medieval Climatic Anomaly/Medieval Climatic Optimum, LIA: Little Ice Age, CWP: Current Warm Period).

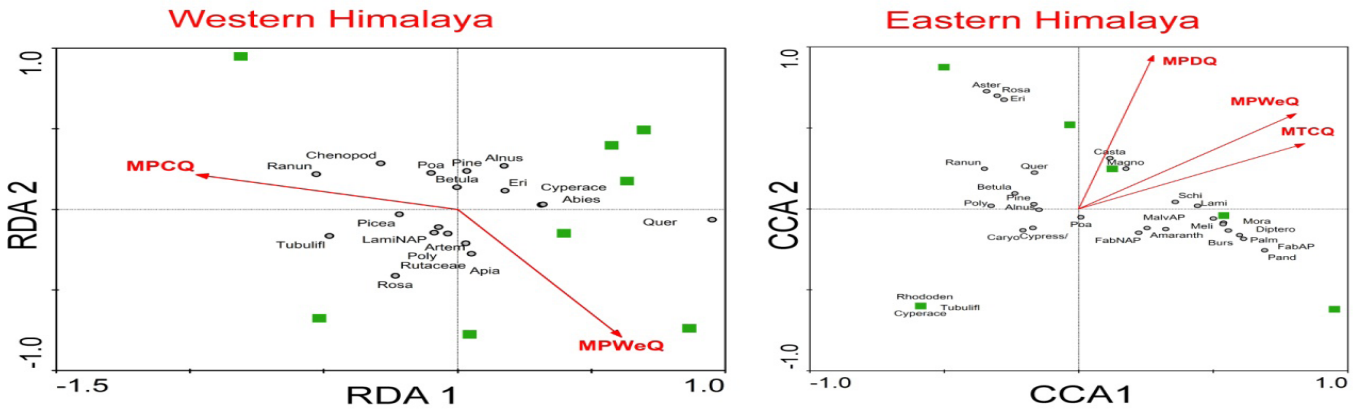


Fig. 3 - Direct gradient analysis plots for the Western and Eastern Himalaya samples.

(poor) soil-moisture conditions during March-June could be favourable (unfavourable) for deodar growth in the temperate zones of Himalaya.

373 years (1643-2016 CE) of April-June (AMJ) self-calibrated Palmer drought severity index (scPDSI) reconstruction for south Kashmir region revealed 1650-1816 CE as wet phase, indicating the influence of Little Ice Age (LIA) over the region. Post-LIA (1817-2016 CE) had prominent dry episodes. North Atlantic Oscillation (NAO) dominantly modulated the winter/spring precipitation over Kashmir during LIA. During 1980-2016 CE, Pacific decadal oscillation (PDO) remains critical in modulating the summer monsoon and teleconnected winter-westerlies, possibly due to significant temperature rise and sea surface warming of Indian-Pacific and Arabian waters.

Palynological analysis of the 45 surface soil samples collected from the different vegetation types (evergreen, mixed deciduous and Sal Forest) of Garo Hills of Meghalaya (Fig. 6). The evergreen forest is characterized by the *Mesua-Schima-Castanonpsis-Elaeocarpus* assemblages in the

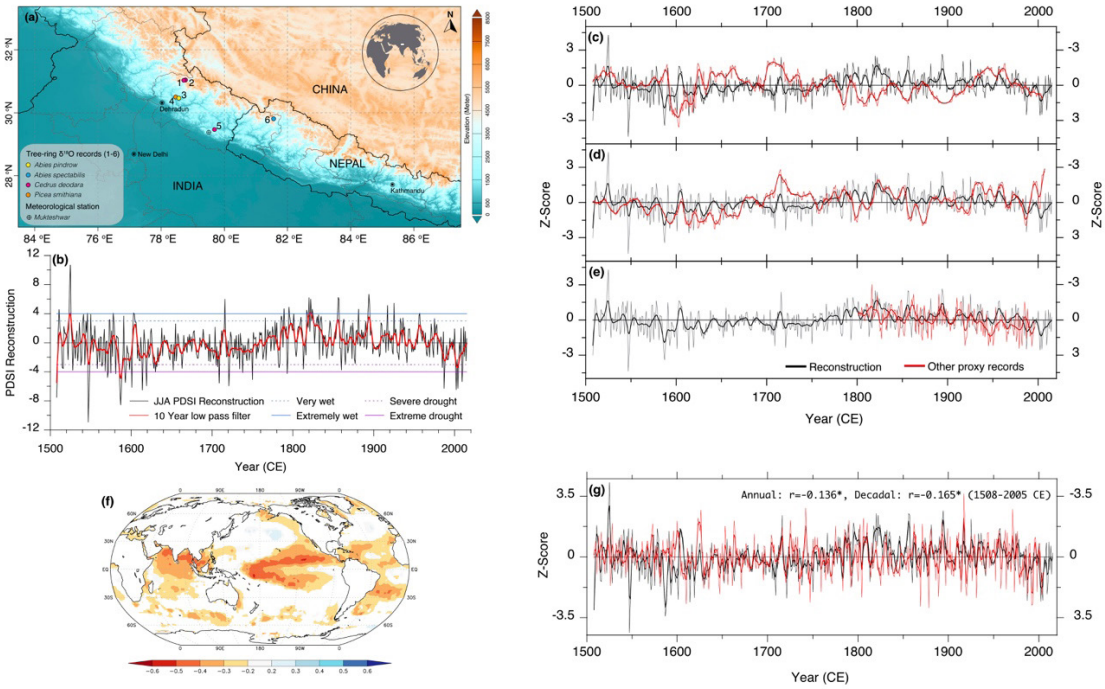


Fig. 4 – (a) Map showing sites of tree-ring stable oxygen isotope ($\delta^{18}O$) records and location of the meteorological station, (b) JJA-PDSI reconstruction from 1508 to 2015 CE, (c-e) The temporal comparison of JJA-PDSI reconstruction with (c) speleothem based $\delta^{18}O$ records from Sahiya cave, Western Himalaya, (d) speleothem based $\delta^{18}O$ records from Jhumar-Dandak cave, core monsoon region of India and (e) ice core based $\delta^{18}O$ record of Dasuopu, (f) Spatial field correlation between reconstructed JJA-PDSI with global sea surface temperature records of HadISST1 and (g) The temporal comparison of JJA-PDSI reconstruction with ENSO index reconstructions.

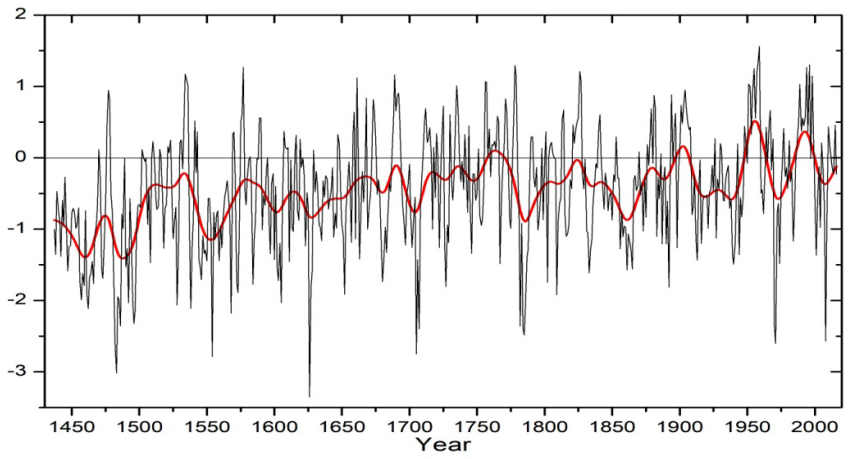


Fig. 5 - Standardized Precipitation Index (SPI11-July) reconstruction from Lahaul-Spiti, Himachal Pradesh. The thick smooth line superimposed over the reconstruction is 50-year low pass filter to show variations over the longer time scale.

pollen assemblages. The evergreen taxa along with ferns and fungal spores in the pollen assemblages are indicative of the warm and humid climatic condition in the region. The mixed deciduous forest is marked, *Dillenia-Salmalia-Albizia-Terminalia* assemblage and recorded within the ranges of 40-45% in the pollen assemblages. The regular presence of *Duabanga*, *Syzygium* and *Lagerstroemia* in the pollen assemblages is indicative of the perennial water system in response to the high rainfall activity in the region. The *Shorea robusta* forest is characterized by the presence of 15-20% pollen in the pollen assemblages, however, the other associates namely, *Dillenia*, *Syzygium*, Arecaceae and *Terminalia* are also continuously represented in the pollen assemblages. Regular recovery of Arecaceae, *Impatiens* and Piperaceae pollen in the pollen assemblages is observed and indicative of the high monsoonal activity in the region. A comparative study has been completed on the bat guano samples from the Siju, Eraaning and Pipulbari caves of Garo Hills. Study reveals that, the bat guano samples are exactly reflected the regional vegetation and could be precisely utilized for the palaeovegetation and climate reconstruction in the Garo Hills of Meghalaya.

Modern pollen dataset of 30 surface soil and sediment samples from the forested, cropland, wetland and river sites of the Karimganj District in south Assam has been analyzed, to comprehend the connection between the recent pollen assemblage and the vegetation patterns in the Barak Valley (Fig. 7). The presence of Euphorbiaceae, Convolvulaceae, Acanthaceae, Moraceae, *Barringtonia* and *Syzygium* inferred high monsoonal activity in and around the region. A sturdy relationship between local herbaceous vegetation and pollen was observed.

Recurring pollen clumping was highly significant and suggests their native genesis and entomophilous nature. The steady occurrence of cereal pollen (avg. 18.67%) along with other cultural pollen taxa like Brassicaceae, *Coriandrum* and Solanaceae illustrate intense agricultural activity around the valley areas. A distinct signal of winter dryness is undeniably evident in the forest margin and open-land pollen assemblage, especially observed through *Ziziphus, Melastoma, Xanthium,* and Asteroideae. According to PCA score plot, three pollen cluster separations, (1) crop-land and open-land, (2) forest center and forest margin and (3) wetland and river margin were observed, which is quite concurrent with the present vegetation set-up. The pollen dataset's presentation was standardized using Box-plot analysis, which was based on a five-number summary (Fig. 8).

First systematic and comprehensive assessment of the impact of climate change on the glacier and glacial lake of the Kadu Nala Valley, Lahaul Himalaya, India. In line with regional and global trends, the satellite data and future model projections show a warmer and wetter climate with significant implications for high-mountain glacier cover and glacial lake expansion. All four future model simulations project changes in precipitation and temperature, as well as their effects on glacier area change and glacial lake expansion. Furthermore, despite an increase in precipitation overall, it is the increase in temperature and associated decrease in winter snow cover that will accelerate glacier loss/melting and significantly increase lake area and volume in the future. Because of the expected glacier lake expansion over the next decade, this lake is vulnerable to glacial outburst floods. Such GLOFs events cause deaths, as well as destruction and damage to settlements, public infrastructure, hydroelectric facilities, etc. In order to implement adaptation and mitigation measures in high mountain areas, regular monitoring of such glacial lakes, forecasting, and modelling of the potential GLOF are necessary (Figs 9, 10).

Fig. 6 - A view of *Shorea robusta* (Sal) forest in Garo Hills, Meghalaya.

PROJECT OUTCOME

Publications in SCI (Science Citation Index) Journals

1. Mishra AK, Mohanty RB, Ghosh R, Mishra K, Shukla UK & Kar R 2022. Modern pollen–vegetation relationships along an altitudinal transect in the Western-Higher Himalaya, India: palaeoclimatic and anthropogenic implications. The Holocene doi. org/10.1177/09596836221096006 (IF: 3.092).
2. Shah SK, Berkelhammer M, Li Q, Mehrotra N, Thomte L, Shell R, Pandey U, Gaire NP, Kathayat G & Sinha A 2023. Regional tree-ring oxygen isotope deduced summer monsoon drought variability for Kumaun-Garhwal Himalaya. Quaternary Science Reviews 301: 107927. https://doi.org/10.1016/j.quascirev.2022.107927 (IF: 4.456).
3. Thomte L, Shah SK, Mehrotra N, Saikia A & Bhagabati AK 2023. Dendrochronology in the tropics using tree-rings of *Pinus kesiya*. Dendrochronologia 78: 126070. https://doi.org/10.1016/j.dendro.2023.126070 (IF: 3.071).
4. Gaire NP, Shah SK, Sharma B, Mehrotra N, Thapa UK, Zan ZX, Aryal PC & Bhuju DR 2023. Spatial minimum temperature reconstruction over the last three centuries for eastern Nepal Himalaya based on tree rings of *Larix griffithiana*. Theoretical and Applied Climatology https://doi.org/10.1007/s00704-023-04432-1 (IF: 3.410).
5. Thomte L, Bhagabati AK & Shah SK 2022. Soil moisture-based winter-spring drought variability over West Karbi Anglong region, Assam, Northeast India using tree-rings of *Pinus kesiya*. Environmental Challenges 7: 100512. https://doi.org/10.1016/j.envc.2022.100512 (IF: 2.57).
6. Tripathi S, Garg A, Shukla AN, Farooqui A, Pandey A, Tripathi T & Singh VK 2022. Pollen micro-morphometry of two endangered species of *Rauvolfia* L. (Apocynaceae) from the Indo-Gangetic Plains of Central India using LM, CLSM and FESEM. Palynology (Taylor & Francis) 46(4): 2072966. https://doi.org/10.1080/01916122.2022.2072966 (IF: 1.949).
7. Ghosh R, Saikia K, Biswas O, Agrawal S, Morthekai P, Arif M, Phartiyal B, Sharma A, Singh N, Paruya DK, Maharana P, Shekhar M & Bera S 2023. Last 10 millennial history of Indian Summer Monsoon in the Bengal region – a multi-proxy reconstruction from a lacustrine archive. Palaeogeography, Palaeoclimatology, Palaeoecology 609: 111308 (IF: 3.565).
8. Pokharia AK, Basumatary SK, Thakur B, Tripathi S, McDonald HG, Tripathi D, Tiwari P, Van Asperen E, Spate M, Chauhan G, Thakkar MG, Srivastava A & Agarwal S 2022. Multiproxy analysis on Indian wild ass (*Equus hemionus khur*) dung from Little Rann of western India and its implications for the palaeoecology and archaeology of arid regions. Review of Palaeobotany & Palynology 304: 104700. https://doi.org/10.1016/j.revpalbo.2022.104700 (IF: 2.493).
9. Ali SN, Pandey P, Singh P, Mishra S, Shekhar M, Misra KG & Morthekai P 2023. Intimidating evidences of climate change from the higher Himalaya: A case study from Lahaul, Himachal Pradesh, India. Journal of the Indian Society of Remote Sensing : 1-14 (IF: 1.894).
10. Ali SN & Pandey P 2023. Crucial, but not systematically investigated: Rock glaciers, the concealed water reservoirs of the Himalayas: An opinion. Journal of Atmospheric Science Research 6(2): 33-41 (IF: 5.965).
11. Roy I, Tomar N, Ranhotra PS & Sanwal J 2022. Proxy response heterogeneity to the Indian Monsoon during Last Millennium in the Himalayan region. Frontiers in Ecology and Evolution 10: 778825. doi: 10.3389/fevo.2022.778825 (IF: 4.496).
12. Chinthala BD, Grießinger J, Ranhotra PS, Tomar N, Singh CP & Bräuning A 2022. Tree-ring oxygen isotope variations in subalpine firs from the Western

Fig. 7 - Field photographs in Karimganj District, Assam, (1) Tropical moist deciduous forest inside Patharia Hill Reserve Forest; (2) Tree fern, *Cyathea gigantea* growing inside Patharia Hill Reserve Forest; (3) Son wetland (dried area); (4) A Shrub, *Melastomamala bathricum* growing luxuriantly at the forest margin; (5) Collection of surface soil from the Kushiara River margin, Karimganj District, Indo-Bangladesh border; (6) Kushiara River flowing through Indo-Bangladesh border.

Himalaya capture spring season temperature signals. Forests 13: 437. doi.org/10.3390/f13030437 (IF: 3.282).

13. Singh V, Misra KG, Yadav RR, Yadava AK, Vishwakarma S & Maurya RS 2022. High-elevation tree-ring record of 263-year summer temperature for a cold-arid region in the Western Himalaya, India. Dendrochronologia 73. https://doi.org/10.1016/j.dendro.2022.125956 (IF: 3.071).
14. Singh V, Misra KG, Yadava AK & Yadav RR 2022. Sub-alpine Himalayan birch in cold arid Lahaul-Spiti: a proxy of winter/early spring minimum temperature. Current Science 123: 22-25 (IF: 1.169).

Refereed Non-SCI Journals

1. Garg A, Tripathi S, Farooqui A, Shukla A & Pandey A 2022. Palynological remarks on the taxonomic status of *Ludwigia octovalvis* sub sp. *sessiliflora* (Micheli) P.H. - Raven: LM and FESEM studies. *Tropical Plant Research* 8(3): 203–209. https://doi.org/10.22271/tpr.2021.v8.i3.025.

Book Chapters/Memoirs/Bulletins

1. David B, Singh A, Shekhar M, Tomar N, Phulara M, Yadav A, Pandey P, Ranhotra PS, Bhattacharyya A, Joshi R & Singh CP 2023. Age-girth stand structure of Himalayan fir and Growth-NDVI relationship in the treeline transects of western Himalaya: An

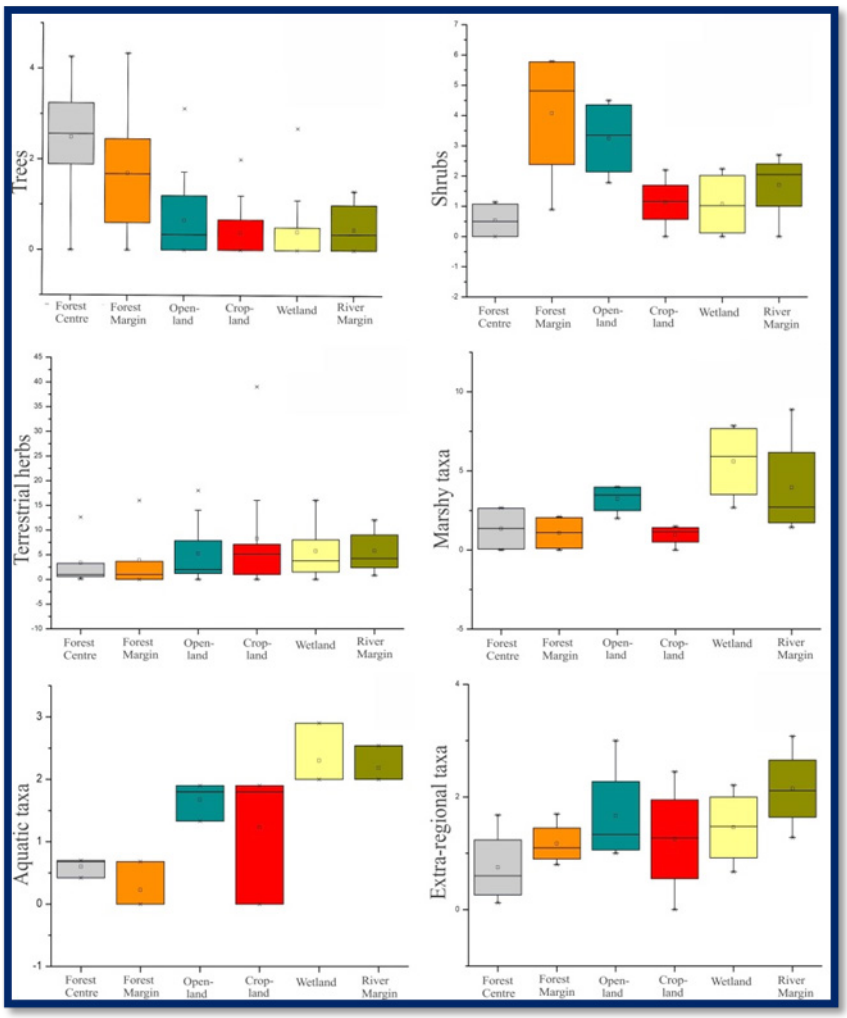


Fig. 8 - Box plots showing distribution of arboreal, non-arboreal and extra-regional taxa in Karimganj District, Barak Valley based on the modern pollen precipitation.

ecological perspective. *In:* Singh SP, Reshi Zafar & Joshi Rajesh (Editors) - Ecology of Himalayan Timberline Ecotone, Springer Nature 455-482.

2. Pandey A, Tripathi S & Basumatary SK 2023. Non-pollen palynomorphs from the Late-Holocene sediments of Majuli Island, Assam (Indo-Burma region): Implications to palaeoenvironmental studies. *In:* Phartiyal B, Mohan R, Chakraborty S, Dutta V & Gupta AK (Editors) - Climate Change and Environmental Impacts: Past, Present, and Future Perspective. Society of Earth Scientists Series. Springer, Cham DOI: 10.1007/978-3-031-13119-6_5.
3. Gaire NP, Fan ZX, Chhetri PK, Shah SK, Bhuju DR, Wang J, Sharma B, Peilli S & Dhakal YR 2023. Treeline Dynamics in Nepal Himalaya in a Response to Complexity of Factors. *In:* Singh SP, Reshi ZA & Joshi R (Editors) - Ecology of Himalayan Treeline Ecotone, Springer, Singapore https://doi.org/10.1007/978-981-19-4476-5_22.
4. Deeksha, Mehrotra N, Thomte L & Shah SK 2023. Seasonal and annual rainfall trends in Chhattisgarh, Central India – A study towards understanding hydro-climatic scenario for environmental assessment. *In:* Jain R (Editor) - Global Environmental Challenges Management & Sustainable Development. Pratush Publisher, New Delhi: 48-66.
5. Misra S, Sharma A, Maurya RS & Misra KG 2022. Wetlands as potential zones to understand spatio-temporal plant-human-climate interactions: a review on palynological perspective from western and eastern Himalaya. *In:* Pandey M, Pandey PC, Ray Y, Arora A, Jawak SD & Shukla UK (Editors) - Advances in Remote Sensing Technology and the Three Poles (Wiley publisher): 340-350.

General Articles/Reports/Database Published

1. Tripathi S, Pandey A, Saxena A, Das N, Bhandari A, Roy I, Joshi P, Singh SP, Singh G, Tomar N, Agnihotri P & Mishra DP 2022. 28th Indian Colloquium on Micropalaeontology and Stratigraphy. Journal

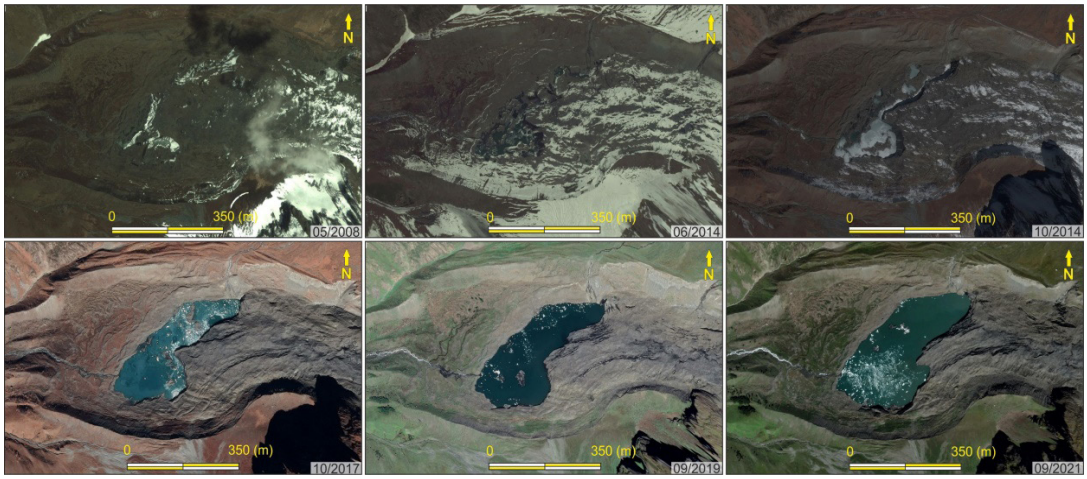


Fig. 9- Satellite data showing the lake expansion since 2008.

of Palaeosciences 71: 117-120. DOI: 10.54991/jop.2022.999.

2. Tripathi S 2022. Bat Guano substrates: a tool for developing modern pollen analogue in Meghalaya. *Quaternary Chronicle Newsletter* 4(1): 8, Association of Quaternary Researchers.
3. Pandey A & Tripathi S 2022. Non-pollen palynomorphs (NPPs): a tool for palaeoecological interpretation. Quaternary Chronicle Newsletter 4(2): 4, Association of Quaternary Researchers.
4. त्रिपाठी स्वाति & पाण्डेय आर्या 2022. मजुली द्वीप (दुनिया का सबसे बड़ा नदी द्वीप): पुरा-जलवायु और पुरा-बाढ़ पुनर्निर्माण के लिए संभावित संग्रह. पुराविज्ञान स्मारिका अंक 1: 36-37.
5. मौर्य रविशंकर, मिश्र केजी एवं विश्वकर्मा साधना 2022. वृक्ष-वलय (ट्री-रिंग): पृथ्वी की बदलती जलवायु का विश्लेषण. पुराविज्ञान स्मारिका पत्रिका, अंक 1.

Publications other than the Project Work

1. Quamar MF & Kar R 2022. Agricultural practices in India during the Holocene: a pollen view point and

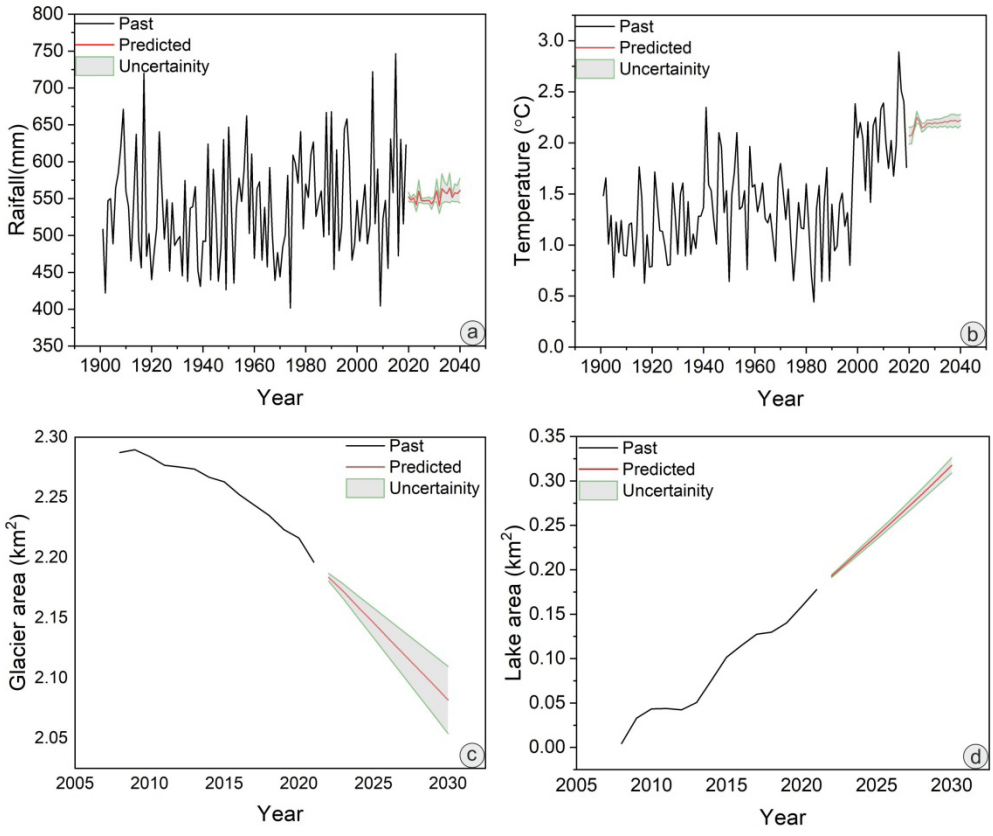


Fig. 10 - Forecasting of glacier lake area and glacier area from the year 2022 to 2040 using modelling methods (a) simple exponential smoothing (SES) (b) manual ARIMA (c) generalized regression neural network (GRNN) (d) Bayesian based ARIMA method.

a critical appraisal. The Holocene 32: 1340–1357. doi.org/10.1177/095968362211142 (IF: 3.092).
2. Mehrotra N, Shah SK, Basavaiah & Kar R 2022. Middle to Late Holocene climate, vegetation and sea-level changes in NW Tripura, northeast India, based on palynological and mineral magnetic evidence. Journal of Paleolimnology. doi.org/10.1007/s10933-022-00249-6 (IF: 2.265).
3. Gaire NP, Zaw Z, Fan ZX, Bräuning A, Sharma B, Dhakal YR, Timilsena R, Shah SK & Bhuju DR 2022. Increasing extreme events in the central Himalaya revealed from a tree-ring based multi-century streamflow reconstruction of Karnali River Basin. Journal of Hydrology 610: 127801. https://doi.org/10.1016/j.jhydrol.2022.127801 (IF: 6.708).

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** [CSIR-UGC NET Fellowship UGC Grant/19/06/2016(i) EU-V-205247, up to 04.06.2022]

Investigators: Ratan Kar (PI) and Amit K. Mishra (SRF)

Multi-proxy palaeoclimatic studies were undertaken from the two sub-surface profiles in the Chopta-Tungnath region, Garhwal, Uttarakhand (105 cm, 5070 year BP to Present and 150 cm, 11810 year BP to present). On the basis of multiproxy data and ^{14}C dating, the climatic changes of the study area, during the last 11810 year BP, have been divided into six climatic phases. The palaeopalynological records from the region have not only recorded the past climatic and vegetation changes but also identified the impact of anthropogenic activities. Thesis was submitted and Ph.D. has been awarded (Fig. SP 6.1).

SP 6.2: **Holocene palaeovegetation and climate changes in relation to the palaeoflood episodes in central Brahmaputra Valley of Assam, India based on multiproxy analysis** [Sponsored by SERB-DST; Project No. SERB-DST-EEQ-2021/000846, w.e.f. 10.03.2022).

Investigators: Sadhan K Basumatary (PI) and Siddhant Vaish (JRF)

Sixty surface soil and moss cushion samples from the Kaziranga National Park procured from the different vegetation types (Evergreen, mixed deciduous, openland, Grassland and wetland) have been studied. The overall pollen assemblages displayed a good relationship between modern pollen and vegetation in the national park. The abundance of fungal spores especially coprophilous fungal spores, namely *Sporormiella*, *Saccobolus*, *Sordaria* and *Ascodesmis* in the pollen assemblages suggestive of the presence of herbivores in the national park. However, a

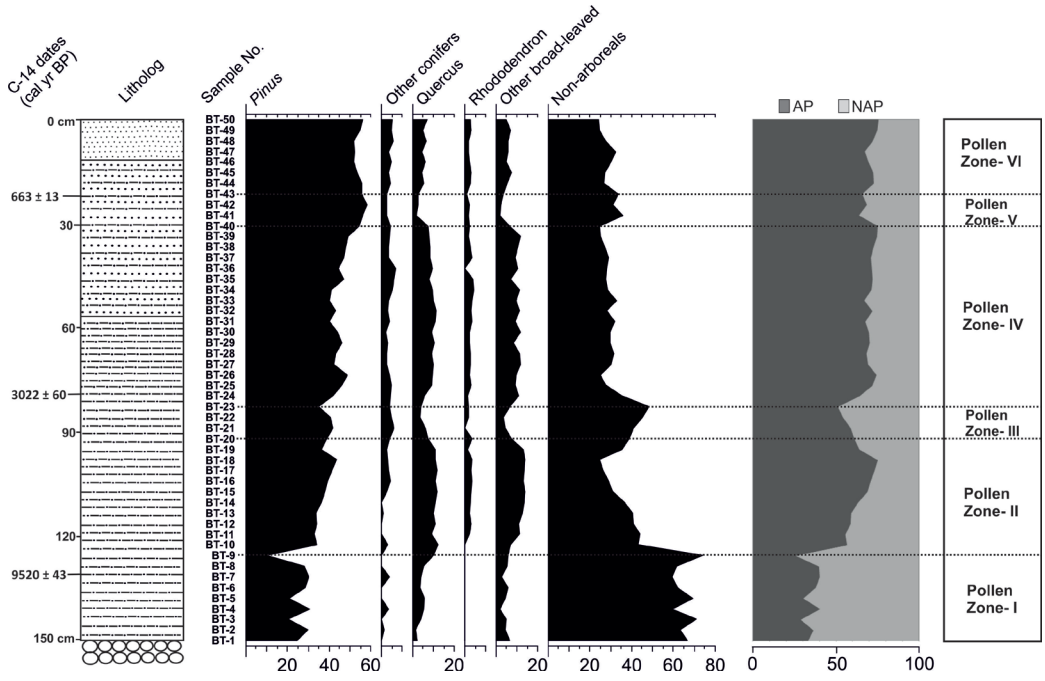


Fig. SP 6.1 - Pollen diagram of fossil pollen assemblages showing the major groups of taxa from a trench having a chronology of ca. 11.5 kyr BP, in the Chopta-Tungnath region.

Fig. SP 6.2 - A view of Kaziranga National Park, Assam.

site-by-site variation has been observed of the preservation of the fungal spores especially the coprophilous fungal spores in the park. This generated data will be helpful for the reconstruction of the palaeoecology and palaeoherbivory analysis in the region and to correlate in global level.

SP 6.3: **Investigation of xylogenesis from alpine and high altitude Himalayas to analyse climate change and its consequences on extreme ecological environments** (Sponsored by SERB-DST, Project No. SCP/2022/000706, w.e.f. 15.03.2023)

Investigator: K.G. Misra

Project work has been initiated, literature survey is in progress and planning of field excursion is being done.

SP 6.4: **Modelling and mapping of forest age distribution in the Alpine Himalayan region using dendrochronology and remote-sensing approach** (Sponsored by SAC-ISRO, Ahmedabad. Project No. SAC/EPSA/BPSG/ALPINE/SHRESTI/ 09/2019; w.e.f. May 2019).

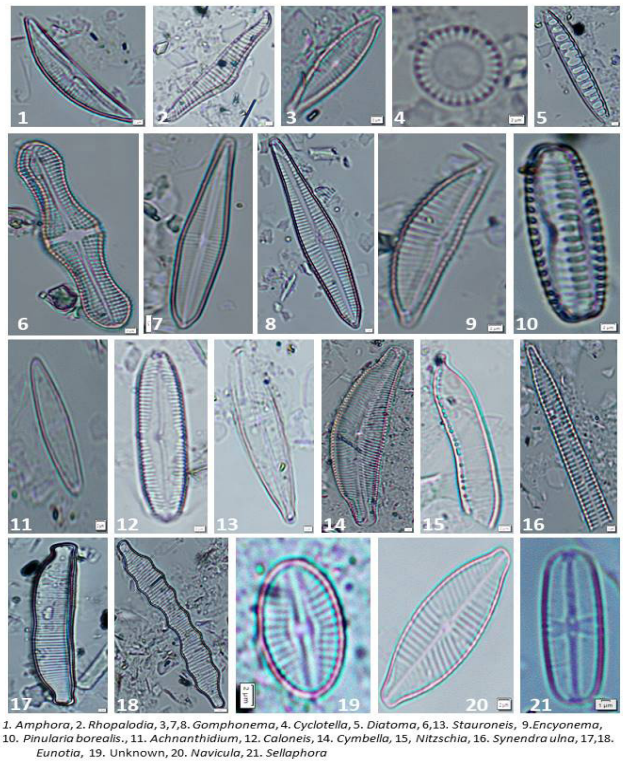
Investigators: Parminder Singh Ranhotra (PI) and Nidhi Tomar (SRF)

Investigated the stand structure (age, girth and height) and tree-line dynamics of the *Abies pindrow* (Himalayan fir) for the last 360 years at the Gulmarg, J & K, western Himalaya. The fir reached its present upper growth limit of ~3500 amsl by the mid-20th Century with the average shift rate of ~1.79 meter per year in 360 years. The highest advancement rate (~5 m/yr) of fir was calculated during 17th Century CE, corresponding to wet Little Ice Age phase. This was followed by subsequent decline in advancement rate (~1 m/yr) probably relating to the climate warming.

SP 6.5: **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

During 310 BCE to 870 CE (2260-1080 cal. BP), gradual conversion of mixed deciduous forest to open-dry vegetation was witnessed in the Majuli Island of Assam as evidence by the decline in moist tree cover under relatively less warm and humid climate, corresponding to the Migration Period Cooling (MPC). During 870 to 1520 CE, the average values of maximum MAP were the highest recorded (≈2750 mm) which was concurrent with the global MCA. Since the last 1520 CE (430 cal. BP), striking dipping in MAT (13-22ºC) and MAP (500-1092 mm) range was observed. Inclination in cultural pollen taxa, like cereal, non-cereal, *Brassica* and *Coriandrum* indicates anthropogenic activities, followed by the scarce occurrence of tree pollen. Moreover, the occurrences



1. Amphora, 2. Rhopalodia, 3,7,8. Gomphonema, 4. Cyclotella, 5. Diatoma, 6,13. Stauroneis, 9.Encyonema, 10. Pinularia borealis., 11. Achnanthidium, 12. Caloneis, 14. Cymbella, 15, Nitzschia, 16. Synendra ulna, 17,18. Eunotia, 19. Unknown, 20. Navicula, 21. Sellaphora

Fig SP 6.5 - Diatom assemblage from the Majuli Island of Assam, northeast India.

of pennate and centric diatoms are also observed in the Majuli (upper Assam) sediments.

CP 6.1: **SK Shah** [& Narayan P. Gaire, (Tribhuvan University, Nepal)]

Reconstructed summer (June-September) minimum spatial temperature for eastern Nepal over the past 288 years (1733-2020 CE), using a total tree-ring width chronology of Himalayan Larch (*Larix griffithiana*) from Kanchanjunga Conservation Area (KCA). This increasing warming trend appears to be unprecedented in the context of the past 288 years. A short (2.5 years) and multidecadal (35, 43, 71 and 100 years) cyclicity in the reconstructed data has been observed which suggests possible atmospheric teleconnection with the broader circulation system of Atlantic Multidecadal Oscillation (AMO).

CP 6.2: **Anil K. Pokharia, Sadhan K. Basumatary, Biswajeet Thakur, Swati Tripathi, Deepika Tripathi, Pooja Tiwari and Shailesh Agrawal** [& H. Gregory McDonald (Bureau of Land Management, Colorado State Office, U.S.A.); Eline Van Asperen (School of History, Classics and Archaeology, Newcastle University, U.K.); Michael Spate (Department of Archaeology, The University of Sydney, Australia); Gaurav Chauhan; Mahesh G. Thakkar (Department of Earth and Environmental Science, KSKV Kachchh University, Bhuj, Gujarat); Alka Srivastava (Department of Botany, DG College, Kanpur)].

Collaboration on dietary habits of wild ass. The dung of the Indian wild ass was analyzed using biotic and abiotic proxies to determine its dietary habits in relation to the plant diversity and ecology in the arid region of western India. The presence of both micro and macrobotanical remains of Poaceae, Chenopodiaceae, and Fabaceae indicates that they are the primary food plants of the wild ass. The continuous recovery of arboreal pollen taxa, chiefly *Prosopis, Acacia*, and *Ephedra* is indicative of dry thorny forest under semi-arid to arid conditions which display the existing vegetation and climate in the region.

CP 6.3: **Swati Tripathi and Arya Pandey** [& A.K. Shukla, Brijesh Kumar & Arti Garg (BSI, Allahabad)]

Collaboration on the aspect of diverse fern species of genus *Adiantum*. The genus *Adiantum* L. commonly known as "Maiden Hair Fern" is the most diverse fern found in tropical and subtropical regions of the world. The detailed investigation of spore morphology of 21 species of genus *Adiantum* growing in the Indian sub-continent has been studied using LM and FESEM.

OTHER ACADEMIC WORKS

Research Papers Presented

1. **Misra KG, Singh V, Singh AD & Yadav RR** - Tree-ring inferred drought records from Jammu & Kashmir, India. India International Science Festival (IISF) 2022 on Marching towards Amrit Kall with Science Technology & Innovation, held at MANIT, Bhopal, January 21-24, 2023.
2. **David B, Ranhotra PS, Grießinger J & Bräuning A** - Growth behaviour assessment of subalpine fir in relation to climate and glacial variability from Kashmir, northwest Himalaya. Book of Abstracts. TRACE 2022 Conference, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany, June 16-17, 2022.
3. **Ranhotra PS, Roy I, Tomar N, Shekhar M, David B & Bhattacharyya A** - Vegetation change and Tree-line dynamics in relation to Climate during post-LGM to Holocene in the western Himalaya. Abstract volume, 3rd International BDCC-2023, IIT-Kharagpur, TS-V:01K: 140.
4. **Tomar N, Roy I, Ranhotra PS & Shekhar M** - Modern pollen-vegetation relationships as analogues to reconstruct the past climate and landcover changes: Study from Western Himalaya.

Abstract Volume, 3rd International BDCC-2023, IIT-Kharagpur, TS-V:23R: 161.

5. **Tripathi S, Basumatary SK, Pandey A, Khan S, Tiwari P & Thakur B -** Climatic alterations during the Medieval Climatic Anomaly (MCA) from the Indo-Burma region: a quantitative biotic assessment from the Barak Valley Assam, northeast India. XXVIII Indian Colloquium on Micropalaeontology & Stratigraphy, Department of Environmental Science, SPP University, Pune, May 4-6, 2022: 8.
6. **Pandey A, Tripathi S, Basumatary SK & Singh H -** Non-pollen palynomorph preservation from the sediments of Majuli Island (Indo-Burma region): Implications in palaeoenvironmental studies. XXVIII Indian Colloquium on Micropalaeontology & Stratigraphy, Department of Environmental Science, SPP University, Pune, May 4-6, 2022: 62.

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

KG Misra

- Participated in the Young Scientist Conference (YSC) under the umbrella of "India International Science Festival (IISF)" held at Maulana Azad National Institute of Technology (MANIT), Bhopal organized by Ministry of Earth Sciences, Ministry of Science & Technology and Vijnana Bharati, January 21-24, 2023.

PS Ranhotra

- Participated in 3rd International Workshop on "Biodiversity and Climate Change- Sustainable Development Perspective", held at the Center for Ocean, River, Atmosphere and Land Sciences (CORAL), IIT Kharagpur, February 16-19, 2023.

Swati Tripathi

- Participated in the XXVIII Indian Colloquium on "Micropalaeontology & Stratigraphy" held at Department of Environmental Science, SPP University, Pune, May 4-6, 2022.

Training/Study Visits

Ratan Kar

- Supervised M.Sc. dissertation of Ms Deepshikha Dutta, Geology Department, Lucknow University on the topic "Use of Stable Isotopes ($\delta^{13}C/\delta^{15}N$) for climatic interpretations."

Sadhan K Basumatary

- Supervised Internship of one M.Sc. Student from

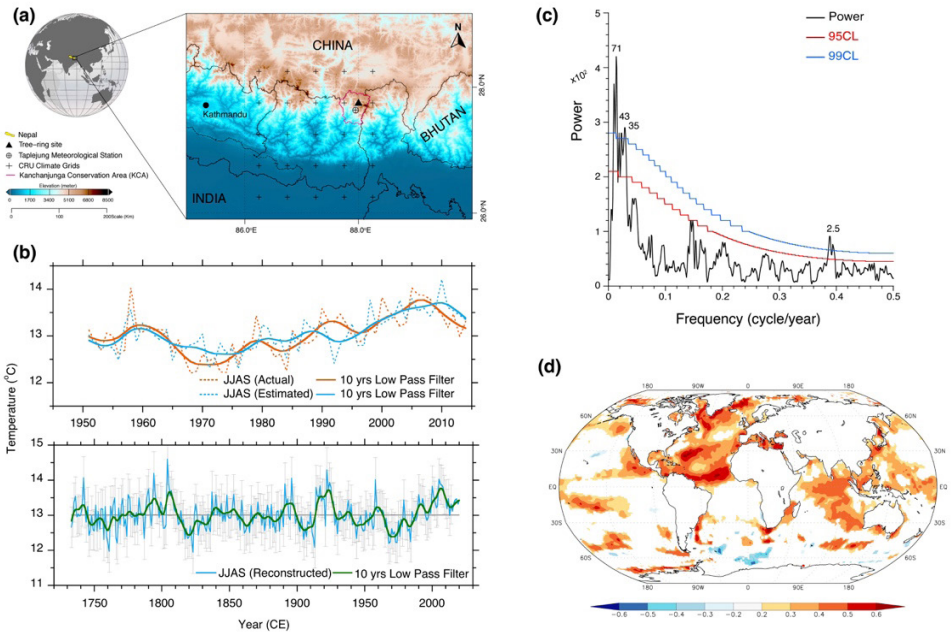


Fig. CP 6.1 - (a) Map showing the locations of tree-ring site of *Larix griffithiana*, meteorological station and grid climate data locations, (b) Actual and estimated June-September minimum temperature for 1951-2014 (upper panel) and reconstructed June-September minimum temperature from 1733 to 2020 CE (lower panel), (c) Multi-tapered power spectral of the reconstructed temperature and (d) Spatial correlation between reconstructed temperature and global sea surface temperature (HadISST1).

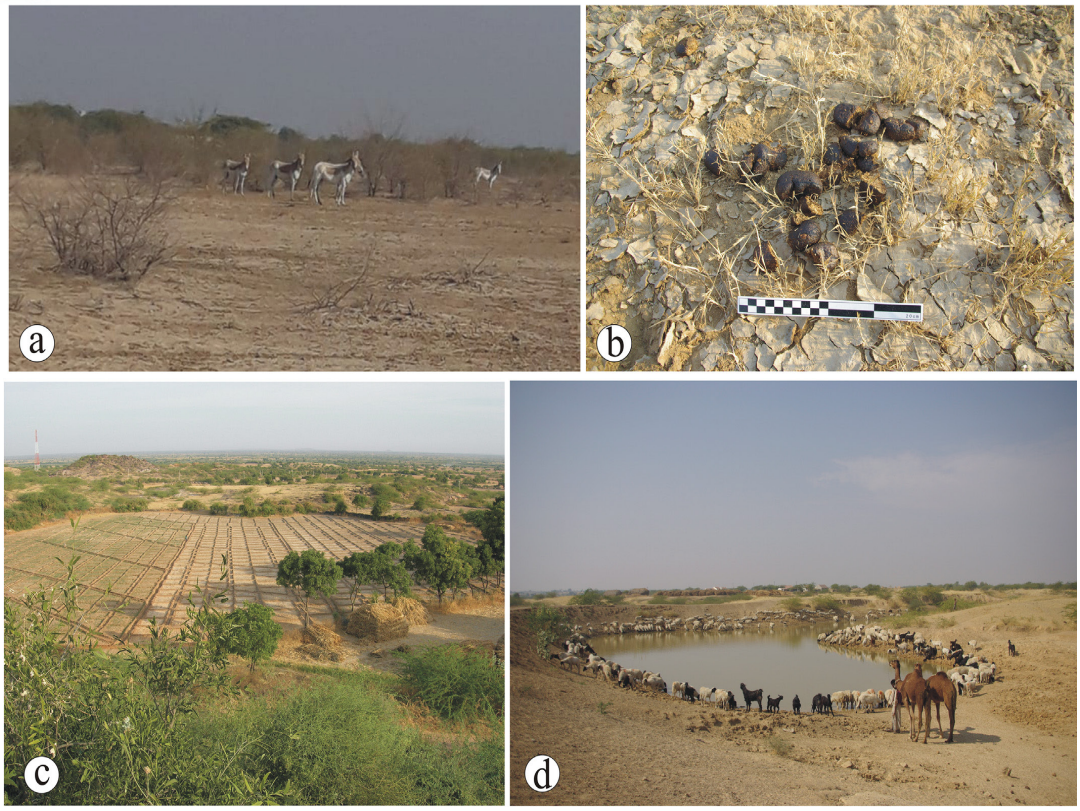


Fig. CP 6.2 – (a) Close up of *Equus hemionus khur* in its natural habitat, (b) A midden dung of *E. hemionus khur*, (c) Practices of crop cultivation by the local people in and around the Little Rann of Katchch, (d) A view of domesticated animals during drinking water time in and around the study areas.

Pondicherry University, in collaboration with Dr. Binita Phartiyal, on the topic "Use of physical and biotic proxies for defining the sediment characteristics and vegetation of Ganga Plain surface sediments".

SK Shah

- Wiley Advanced Webinar Series: Session 1: Everything you wanted to know about data science, Online, August 24, 2022.
- Wiley Advanced Webinar Series: Session 2: Master data analysis and visualizations using R, Online, August 31, 2022.
- Wiley Advanced Webinar Series: Session 3: Ace statistical thinking for research, Online, September 7, 2022.

Swati Tripathi

- Training imparted to Ms. Suman Kumari, (M.Sc. Geology; Hansraj College, University of Delhi) on topic entitled 'Palynological response deduced through spatially distinct surface samples to reconstruct palaeoecology and palaeoclimate of the Barak Valley, Assam, northeast India' under 'Summer Research Fellowship Programme'of Indian Academy of Sciences, Bangalore (June-August, 2022).
- Training imparted to Mr. Rajeev Ranjan on topic entitled 'Pollen morphometric analysis of arboreal and non-arboreal taxa from Lucknow District, Uttar Pradesh using LM: Implications to systematics and palaeoecology' for M.Sc. dissertation (Geology), Department of Geology, School of Earth & Environmental Sciences, Baba Saheb Bhimrao Ambedkar University, Lucknow (April-June, 2022).

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

- Vegetation dynamics, climate reconstruction and anthropogenic impact during the Holocene,

PH.D. PROGRAMME

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)** and UK Shukla (BHU), registered with Banaras Hindu University, Varanasi. Status: Awarded.

Kajal Singh (2018). Study of the Late Pliestocene-Holocene climatic and environmental changes around Ny-Alesund, Svalbard, under the supervision of **Ratan Kar (BSIP)** 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)** and AK Bhagabati (Gauhati University), registered with Gauhati University, Guwahati. Status: Awarded.

Deeksha (2021). Tree-ring analysis of teak from Central India, under the supervision of **Santosh K. Shah (BSIP)** 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 (CU) & 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)**, 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)** & Prof. Nandita Ghosal, BHU, registered with Banaras Hindu University, Varanasi. Status: Ongoing.

Nidhi Tomar (2021). Late Quaternary vegetation and hydroclimatic variabilities in the Himachal region of Western Himalaya, under the supervision of **Parminder Singh Ranhotra (BSIP)**, 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)** 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)** and Ajay Kumar Arya (Lucknow University), registered with Department of Geology, Lucknow University. Status: (Submitted in July, 2022).

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.

Pushpendra Pandey (2022). Analyzing the extreme climatic events in the Western Himalaya using tree-rings, under the supervision of **P S Ranhotra (BSIP)**, Academy of Scientific and Innovative Research (AcSIR), New Delhi, India. Status: Ongoing.

Siddhant Vaish 2022. Holocene climate changes based on geobiological proxies and geomorphological investigations in parts of Central Brahmaputra Valley of Assam, India, under the supervision of **Sadhan K. Basumatary (BSIP)** and Ajay Kumar Arya (Lucknow University, Lucknow). Status: Ongoing.

Tanveer W Rahman (2022). Evaluation of climatic indices and past climate reconstruction using tree-rings of *Abies* spp. from the Himalaya region, under the supervision of **Santosh K. Shah (BSIP)** and Anup Saikia, Geography Department, Gauhati University, Assam. Status: Ongoing.

Western Himalaya: Palynological implications. 1st Prof. Sunirmal Chanda Memorial Lecture at East Himalayan Society for Spermatophyte Taxonomy (EHSST) on 3rd November, 2022.

- Basics of Quaternary Palynology. LEM International School & Symposium, Amravati on 23rd March, 2023.

Swati Tripathi

- Delivered an invited Lecture entitled 'Climate induced vegetation alterations in the Barak Valley of Assam during late Holocene' in LEM International School & Symposium on 21st March, 2023.

PS Ranhotra

- Delivered lecture on "Palaeobotany and Climate Change: Applications and relevance to Society" on group level at Space Applications Center (SAC-ISRO), Ahmedabad, on 27th December, 2022.

- Invited Key note lecture on "Vegetation change and tree-line dynamics in relation to climate during post-LGM to Holocene in the Western Himalaya", and session chair in the 3rd International Workshop on Biodiversity and Climate Change- Sustainable Development Perspective, at IIT Kharagpur during February 16-19, 2023.

- Lectures delivered on "Principles, Material and Methods of Dendrochronology", and "Applications of Dendrochronology: Ecological perspective", and session chair in the International School and Symposium-2023 on Landuse-landcover mapping and modelling using pollen and isotopic data in different ecological regions of the monsoon (LEM), in western Vidarbha, Maharashtra, India during March 13-26, 2023.

CONSULTANCY/ TECHNICAL SUPPORT RENDERED

Santosh K Shah

- Quaternary Training on Dendrochronology: Basic Dendrochronology and its application in climate reconstruction to Mr. Veer Singh Gautam, Scientist-B, Institute of Wood Science and Technology, Bangaluru (Rs 2000/-).
- Quaternary Training on Dendrochronology: Basic Dendrochronology and its application in climate reconstruction to Dr. M. Sujatha, Chief Technical Officer, Scientist-B, Institute of Wood Science and Technology, Bangaluru (Rs 2000/-).

ACCOLADES RECEIVED

Swati Tripathi

- Best Poster Award for the paper entitled 'Non-pollen palynomorph preservation from the sediments of Majuli Island (Indo-Burma region): Implications in palaeoenvironmental studies' in XXVIII Indian Colloquium on Micropalaeontology & Stratigraphy SPP University, Pune during May 4th-6th, 2022.
- नगर राजभाषा कार्यान्वयन समिति ने दिसम्बर 26, 2022 को छमाही हिंदी बैठक में बीएसआईपी की राजभाषा पत्रिका 'पुराविज्ञान स्मारिका' (सह-संपादक) को प्रोत्साहन पुरस्कार से सम्मानित किया।

REPRESENTATION IN COMMITTEES/BOARD

Ratan Kar

- Member, State Level Expert Appraisal Committee (SEAC), Ministry of Environment, Forest and Climate Change
- Member (co-opted), Project Monitoring Committee, Core Research Grant, Earth Sciences, SERB, New Delhi

Sadhan K. Basumatary

- Member, Editorial Board, Bio-Science Letters, Bodoland University, Assam, India

Santosh K. Shah

- Guest Associate Editor, Frontiers in Earth Science since 2016
- Treasurer, Association of Quaternary Researchers (AOQR) [2019-2023]

Parminder Singh Ranhotra

- Member, Editorial Board, Geophytology Journal, since 2022

Swati Tripathi

- Member, Editorial Board, Journal of Palaeosciences, since 2020
- सह-संपादक, 'पुराविज्ञान स्मारिका' अंक 1 (2022), संस्थान की राजभाषा पत्रिका।

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

Coordinator: Rajesh Agnihotri (Scientist F)
Co-coordinator: Anil K Pokharia (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 macrobotanical remains from Indus site Tigrana (Lat. 28°53′25.9′′ N, Long. 76°08′ 08.8′′E), in semi-arid tropics of the north-western India of the subcontinent for reconstructing subsistence model, palaeoecology, and palaeo-climate from the archaeological archives. The investigations at Tigrana have enriched our understanding on cropping pattern and ecological conditions around settlement site during proto-historic times. Tigrana archaeological site in Bhiwani District, Haryana, is considered one of the important sites in the upper Saraswati Basin, which is located on the southern periphery of the alluvial plain. It's location between the Indo-Gangetic plains and the Thar Desert of Rajasthan make it quite distinctive. The second component using Paleogenomics, aiming to develop and fully apply ancient DNA (aDNA) analysis to the rich history and culture of South Asia and the surrounding region in order to understand past population dynamics, migrations and mixing events. The new data from Pattanam ancient port city of southern India (Kerala) directly links the active trade connections of South Asia with the Mediterranean region almost 2400 years ago.

PERSONNEL INVOLVED

Team Member: Niraj Rai (Scientist D)
Technical Support: Nandita Tiwari (Technical Officer A)

Fig. 1 - (Top) - Turquoise glazed pottery which belongs to West Asian and South Arabian ceramics, (Bottom) - Human skeletal remains dating back to first century BCE (specimen IDs REG. NO. 336)

SIGNIFICANT FINDINGS

Further analyses of floated samples have revealed that the settlers exploited both winter and summer seasons for field crops. Evidence of cereals, pulses, oeliferous and fibre crops along with weeds and wild taxa have been reported. The direct dates (AMS, Table 1) of grains authenticate the mature and late phase of Harappan/Indus civilization at the Tigrana archaeological site.

Under the research theme of Archaeogenomics, we are aiming to develop and fully apply ancient DNA (aDNA) analysis to the rich history and culture of South Asia and the surrounding region, through strong archaeological collaboration coupled with an institutional network of domestic lab and analysis capacity. By focusing on ancient genomics as a methodological approach, we are leading research into the origins and relationships of humans, animals and pathogens in the region. By working with archaeologists and archaeological scientists we are revealing an integrated and pioneering understanding the human past, as well as changing environments and disease. Ancient DNA has transformed our understanding of human history in temperate Eurasia and the Americas. The revolution is only beginning to arrive in the tropics of South and Southeast Asia due to the challenges posed by faster DNA degradation and a lack of local resources. However, we have been successful with many important archaeological sites, e.g. Pattanam has been a site of immense archaeological and historical importance for several years and excavations over the years unconcealed human bones, storage jars, a gold ornament, glass and stone beads, utilitarian objects made of stone, copper and pottery shreds (Fig. 1). Our ancient DNA research work has recently clarified the local ancestry and West Eurasian ancestry at the Pattanam ancient port city of Kerala. Cultural assemblage found after archaeological excavations indicate a vast 'urban' settlement. The excavations suggest that the site was first occupied by the indigenous "Megalithic" (Iron Age) people, followed by Roman contact in the Early Historic Period. Almost no prehistoric genetic data was available so far from southern India, our newly published work from Pattanam ancient port city of Kerala directly links the active trading link of South Asia with the Mediterranean almost 2400 years ago. We have analyzed ancient DNA from a prehistoric archaeological site- “Pattanam” on the West Coast of Malabar and found unique imprint of West

S. No.	Sample	Lab ID	Radiocarbon Age BP	Cal BP (2σ range)	Cal BC (2 σ)
1.	TRN/ZA1/140-170	IUACD#21C3590	3790 ± 32	4290-4010	2341-2061
2.	TRN/ZA1/190-204	IUACD#21C3591	3845 ± 32	4405-4151	2456-2202
3.	TRN/ZA1/235-243	IUACD#21C3592	3836 ± 37	4405-4100	2456-2151
4.	TRN/YD4/205-215	DeA-34879	3869 ± 25	4409-4230	2460-2282
5.	TRN/YD4/218-243	DeA-34880	3875 ± 27	4412-4230	2463-2283

Table 1- Radiocarbon dates of *Hordeum vulgare* (barley) from Tigrana archaeological sites.

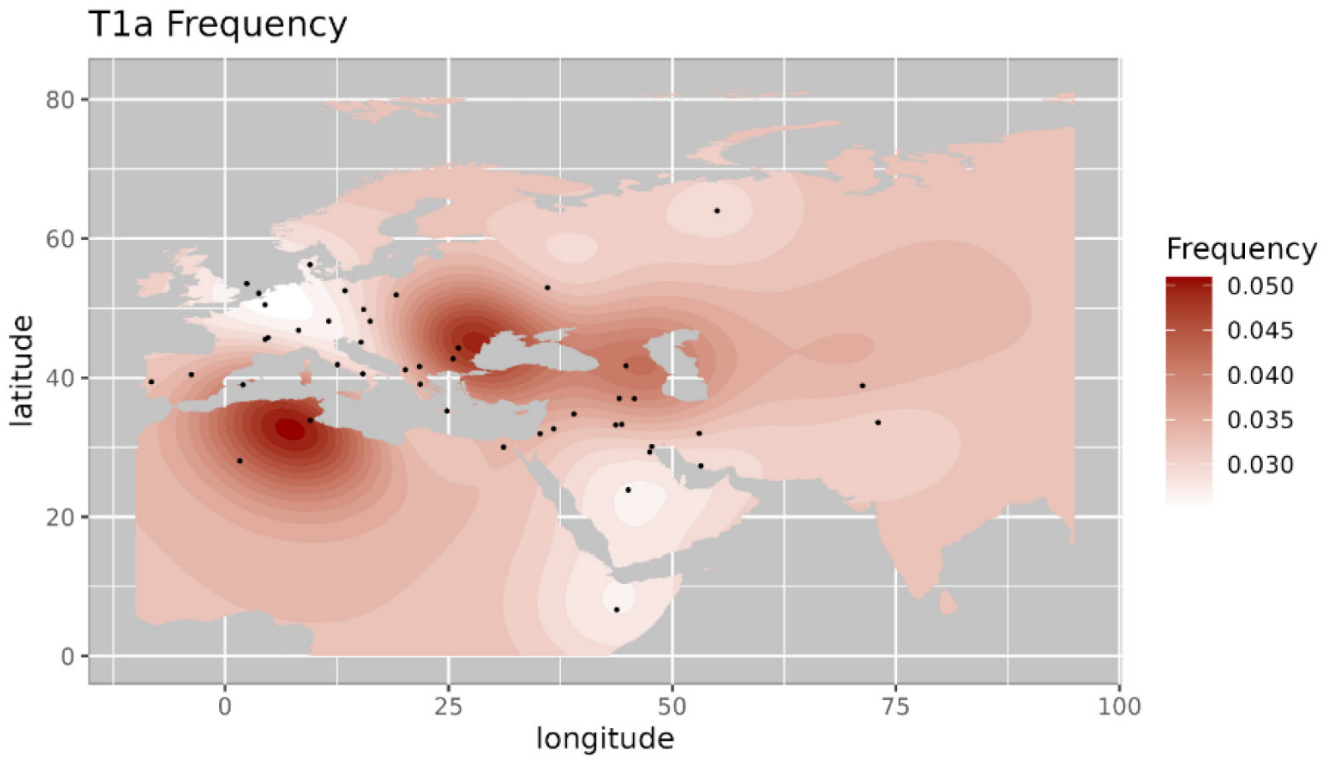


Fig. 2 - Iso-frequency map of mitochondrial DNA haplogroup T1a inferred from the worldwide frequency distribution. Sampling locations are represented by black dots in the plotting area. The geospatial patter indicates that T1a is highly prevalent in Balkan, Caucasus, and Southern Europe, with minor occurrence in the near East.

Eurasian and Mediterranean signatures (Fig. 2) in the human skeletal remains which confirms the continuous inflow of traders and multicultural mixing in ancient south India"

PROJECT OUTCOME

Publications in SCI (Science Citation Index) Journals

1. Tripathi D, Pokharia AK, Parmar N, Kumar P, Srivastava A & Sharma R 2022. Tigrana: Insights on the Indus excavations in the palaeo-Saraswati Basin, Bhiwani District, Haryana. Current Science 120(10): 1126-1128 (IF: 1.169).
2. Ahlawat B, Kumar L, Cherian PJ, Sehrawat JS, Rai N & Thangaraj K 2023. Deciphering the West Eurasian Genetic Footprints in Ancient South India. Genes 14: 963. https://doi.org/10.3390/genes14050963 (IF: 4.141).
3. 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 40: 107711. 10.1016/j.dib.2021.107711 (IF: 0.131).
4. Patel N, Trivedi P, Agnihotri R, Rai N, Sathe V, Khonde N & Kumar A 2022. New chronology for megalithic burials in vidarbha (central india): insights into contemporary hydro-climate and food habits. *Radiocarbon* 64(5): 1075-1091. https://doi.org/10.1017/RDC.2022.47. (IF: 6.324).
5. Basnet R, Rai N, Tamang R, Awasthi NP, Pradhan I, Parajuli P & Thangaraj K 2022. The matrilineal ancestry of Nepali populations. Human Genetics: 1-14. https://doi.org/10.1007/s00439-022-02488-z (IF: 5.881).
6. Sehrawat JS, Agrawal S, Sankhyan D, Singh M, Kumar S, Prakash S & 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 13. https://doi.org/10.3389/fgene.2022.813934 (IF: 4.772).
7. Fernando AS, Wanninayaka A, Dewage D, Karunanayake EH, Rai N, Somadeva R, Tennekoon RH & Ranasinghe R 2023. The mitochondrial genomes of two Pre-historic Hunter Gatherers in Sri Lanka. Journal of Human Genetics 68: 103–105. https://doi.org/10.1038/s10038-022-01099-w (IF: 3.767).
8. Dalal V, Pasupuleti N, Chaubey G, Rai N & Shinde V 2023. Advancements and challenges in Ancient DNA Research: Bridging the Global North–South Divide. Genes 14: 479. https://doi.org/10.3390/genes14020479 (IF: 4.141).

PH.D. PROGRAMME

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)** 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)** 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)** 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)**, registered with Academy of Scientific and Innovative Research (AcSIR), New Delhi. Status: Ongoing

Refereed Non-SCI Journals

1. Sharma S, Pokharia AK, Kumar A, Srivastava A & Yadav R 2022. *Carthamus* L.: Origin, distribution and its archaeological records in India. Journal of Palaeosciences 71(2): 177-186.

Publications other than the Project Work

1. Kumar A, Nizamuddin S, Rai N, Roy B, Kashyap M, Gupta G & Kaushik A 2022. Common variant c.-22+ 155C> T of BDNF as a genetic risk factor of opium addiction. Human Gene 34: 201111. https://doi.org/10.1016/j.humgen.2022.201111.
2. Mohit, Sharma I, Sharma V, Kumar S, Rastogi G, Dutt P, Shrivastava A, Rai N & Chand P 2022. Empirical assessment of allele frequencies of genome wide association study variants associated with obstructive sleep apnea. American Journal of Translational Research 14(5): 3464. PMC9185076 (IF: 3.94).
3. Srivastava P, Sanyal P, Bhattacharya S, Mishra PK, Dutta S, Chakravarti R, Rai N, Navani N, Ambili A, Karanth KP, Joshi J, Singh S & Sadasivan SK 2023. A need to integrate metagenomics and metabolomics in geosciences and develop the deep-time digital earth-biome database of India. Current Science 124(1): 26-37. 10.18520/cs/v124/i1/26-37 (IF: 1.169).
4. Gupta G, Deval R, Rai N, Nizamuddin S, Upadhyay S, Pasupuleti N & Rao VR 2022. Genome-wide association study for suicide in high–risk isolated historical population from North East India. Journal of Affective Disorders Reports 8: 100327. https://doi.org/10.1016/j.jadr.2022.100327 (IF:1.1).

OTHER ACADEMIC WORKS

Research Papers presented

1. **Niraj Rai –** Archaeo-genetics: "Revisiting the past" at 1st Indian Botanical Congress held at Kolkata during 23-24 March, 2023

2. **Niraj Rai –** "Reconstructing the peopling of Old-World South Asia" at ADNAT International Conference held at BHU, Varanasi during 10-12 March, 2023

Lectures delivered

Niraj Rai

- Revisiting the Genetic Histories of South Asia. An expert resource person talk organized by Sangam Talks on January 10, 2023.
- Expert Lecture to National Forensic Workshop organized by National Forensic Science University, Delhi on January 11, 2023.
- Reconstructing the peopling of old- world South Asia from Modern to Ancient Genome. Online talk organized by Max Planck Institute of Geoanthropology, Germany on January 25, 2023.
- Revisiting the Genetic Histories of Our Past, organized by Kerala Genome Data Centre, Govt. of Kerala on 14th March, 2023.

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 G)
Co-coordinator: Binita Phartiyal (Scientist F)

OBJECTIVES

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

PREAMBLE

India, being an agricultural country, is largely dependent on the monsoon for its agricultural productivity, economy and societal benefits. The Indian Summer Monsoon (ISM) or Southwest Summer Monsoon (SWM) is responsible for ~80% of the annual precipitation during the months of June to September. Furthermore, the potential impact of the ISM variations includes droughts and floods over India. However, our knowledge regarding the spatio-temporal ISM rainfall (ISMR) variability is limited, underdeveloped and poor owing to the lack of continuous, high-resolution long-term proxy records from the ISM domain. In this backdrop, this project is designed to contribute new information to the existing knowledge on Indian lake records, as well as to extend our knowledge of the ISMR variability beyond the instrumental and historical records.

Lacustrine sediments respond directly to the regional precipitation changes and are robust storehouse for multiple proxy archives. Long sediment cores from the centre of the lakes could not be raised so far due to the logistic restrictions and other technical issues; therefore the institute has launched a flagship programme as the Quaternary Lake Drilling Programme (QLDP) with a goal to reconstruct the palaeoclimate and hydroclimate variability through the lake sediments of Indo-Gangetic Plain, central Indian Core Monsoon Zone and also from the western India.

Having modern analogue is inevitable to understand the past changes (especially vegetation, climate, monsoonal behaviour); therefore, several field excursions have been conducted for the last two years and a few research papers are published. Efforts are underway to gather long sediment cores for conducting multi-proxy studies, which will not only improve our understanding of the ISMR variability and spatio temporal behaviour, but also aid climate modellers to the prediction of future monsoon behaviour.

PERSONNEL

Core Team Members–Anjali Trivedi (Scientist E), P.S. Ranhotra (Scientist E), Kamlesh Kumar (Scientist D), Shailesh Agarwal (Scientist D), Jyoti Srivastava (Scientist D), Md. Firoze Quamar (Scientist D), Paulramasamy Morthekai (Scientist D), Prasanna K (Scientist C), Trina Bose (Scientist C), Anurag Kumar (Scientist B), Mayank Shekhar (Scientist B)

Fig. 1- Sampling at the Buka Lake, Korba District, Chhattisgarh, central Indian CMZ.

Associate Memebrs– Sadhan Kumar Basumatary (Scientist E), Biswajeet Thakur (Scientist E), Santosh K, Shah (Scientist E), Swati Tripathi (Scientist D), Shilpa Pandey (Scientist D), Sheikh Nawaz Ali (Scientist D), Manoj M.C. (Scientist D), Runci Paul Mathews (Scientist D), Niteshkumar Khonde (Scientist C), Mohammad Arif (Scientist C)

Research Scholars– Arvind Tewari, Md Ikram, Nazakat Ali, Nagendra Prasad, Mohammad Javed, Manisha MT

SIGNIFICANT FINDINGS

Vegetation dynamics and contemporary climate (change) from the central Indian CMZ and also from the Indo-Gangetic Plain

Pollen analysis of a 120 cm long lacustrine sediment profile from the Buka Lake, Korba District (Chhattisgarh) demonstrated a varying set of palyno-assemblages which indicate open forest vegetation, mixed tropical deciduous forest and dense mixed tropical deciduous forest around the landscape of the study area under cool and dry climate (reduced monsoon rainfall), warm and humid climate (increased monsoon rainfall) and warm and more humid climate (intensified monsoon) (Fig. 1). The temporal explanation of the study, as well as its regional and global contextualization will be made with the availability of dates, which are awaited.

Biotic-abiotic interaction from the Indo-Gangetic Plain

A modern analogue dataset from the surface soil and sediment samples based on biotic and abiotic proxy records from different depositional settings (lake beds, river beds, forest floors, and crop lands) across the two interfluves of the Central Ganga Plain, i.e. Ghaghara-Gandak and Ganga-Ghaghara interfluves was prepared (Fig. 2). This modern comprehensive dataset will provide background information for the Late Quaternary palaeo-ecological reconstruction from the CGP along with the practices for the preservation and conservation of the endangered biodiversity. The occurrence of non-pollen palynomorphs (NPPs) especially fungal spores and biodegraded pollen in the soil samples along with the anthropogenic indicator diatoms, like *Gomphonema* and *Ulnariaulna* indicates the continuous deterioration of the lake and river health of the CGP.

Palynological estimation of 95 modern surface soil/ sediment samples collected from the CGP under the grid strategy reveals the over-dominance of non-arboreal taxa over arboreal taxa. The grasses including cereal and non-cereal taxa along with other cultural pollen taxa (*Brassica, Coriandrum* and Solanaceae) are frequently observed (Fig. 3).

Modern surface analogue dataset with the help of stable carbon and nitrogen isotopes of organic matter was also generated from the Ghaghara-Gandak and Ganga-Ghaghara interfluves of the Central Ganga Plain (CGP) to determine the extent to which the stable isotope ratio can distinguish different types of depositional sub-environments (lacustrine and fluvial deposits; cropland and forestland).

Modern surface sediment dataset to understand the modern proxy-environment inter relationships and its use for proxy-based palaeoenvironmental reconstructions

Magnetic susceptibility had been recorded for the gridded samples and showed the higher susceptibility values are concentrated in the northern and southern part (effect of the Ghaghara, Gandak and Ganga rivers) (Fig. 4a-b). The

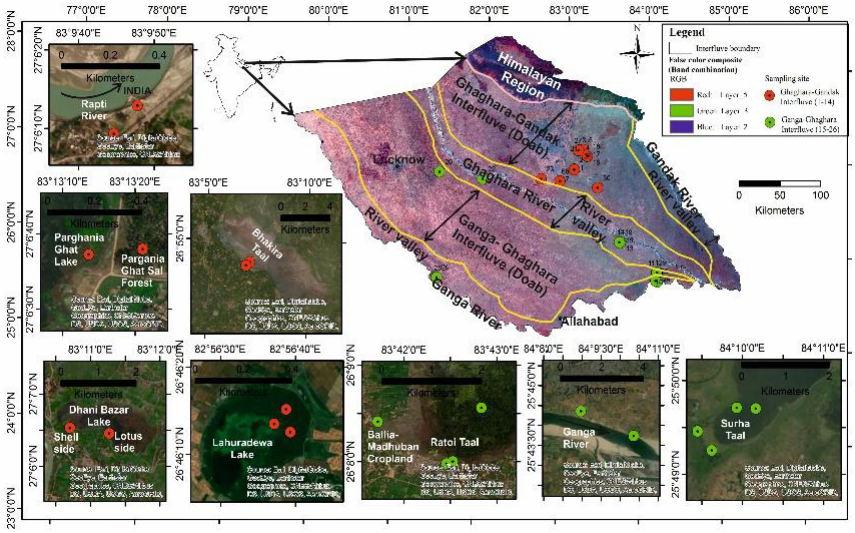


Fig. 2 - Map showing the study areas in Ghaghara-Gandak and Ganga-Ghaghara interfluves.

interfluves areas show low susceptibility values. Work is in progress (abiotic and biotic proxies are being conducted).

Ecological niche modelling to project past, present and future distributional shift of black ebony tree (*Diospyros melanoxylon* Roxb.)

This endemic plant of India and Sri Lanka is also known as the breadwinner tree of India due to its various commercial and ethnomedicinal uses. Detecting the environmental factors that direct its distribution shift will aid in analysing its habitat suitability in future climatic conditions. Ensemble species distribution modelling approach was used to predict distributions under present, past (Last Glacial Maximum, ~22,000 yrs BP; Middle Holocene ~6000 yrs BP), and future climate change scenarios (RCP 2.6 and 8.5 for 2050s and 2070s). Annual mean temperature (28.7%), in terms of variable contribution significantly affects the distribution of *D. melanoxylon*. The present study exhibited that *D. melanoxylon* has the most favourable habitats in western, southern and central India regions (Fig. 5). Model-based species distribution for the period of LGM and MH complemented with fossil pollen data indicates that the species had a well-established niche during the past with its widespread distribution during the LGM time. By 2050s and 2070s (RCP 8.5), there would be an increase in the low suitable habitats for *Diospyros melanoxylon* with an estimated reduction in extremely suitable habitats from the present distribution by 4.41% and 4.58%, respectively (Fig. 6). These results provide useful information for establishing conservation strategies to restore this species of high economic and ecological importance.

Rising winter temperatures influencing the wheat yield in the Indo-Gangetic Plains might indicate a range of impacts on crop patterns

Wheat is a major grain crop in the Gangetic Plain and, therefore, crucial to the food security of this densely populated region. Apart from the soil quality and spatial diversity, the yield of wheat is primarily controlled by the variation in climate parameters line temperature, sunshine hours, rainfall and the regional availability of moisture. We assessed the linkage of past wheat yield with palaeoclimate from five districts of the U.P and recorded a positive and statistically significant correlation between wheat yield and the previous year's winter mean temperature. The yield of wheat shows a significant positive relationship with both air temperature and sea surface temperature (SST) during the winter months in and around India and over the seas regulating the winter climate. This indicates that winter temperature may have a direct role in modulating the yield of wheat in the Gangetic Plain.

Development of tree-ring width chronology and the stable isotope time series in environmental biomolecules, especially the carbon and oxygen isotopes of cellulose from tree rings and other plant materials

The tree-ring width chronologies from Laxmipur and Pharenda Forest Ranges in Maharajganj, Uttar Pradesh (Fig. 7), span 1928-2021 CE, and provide valuable insights into the growth patterns of trees over time in this ancient region.

In a separate study, carbon isotopic data of tree rings of the teak tree (*Tectona grandis* L.f.) collected from four

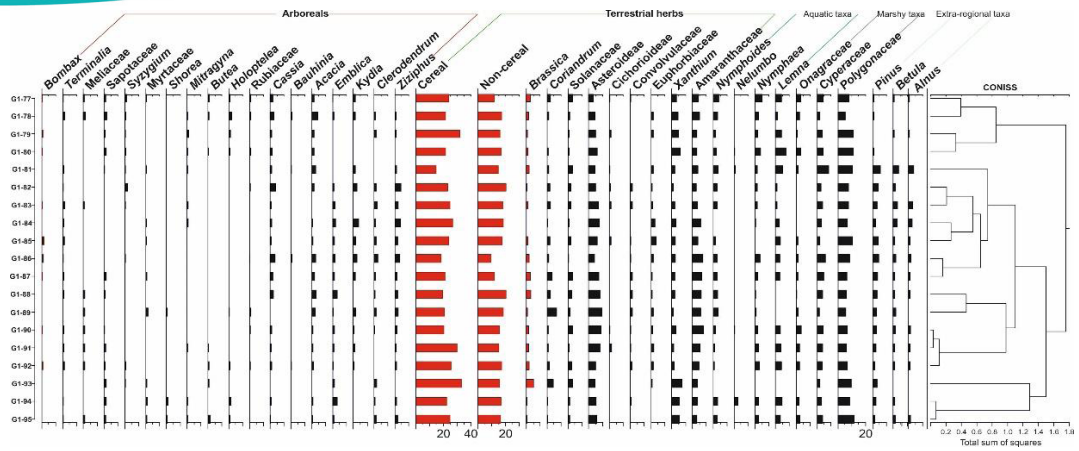


Fig. 3 - Pollen frequency spectra of 19 modern soil/sediment samples collected from gridded location in the CGP.

forested sites of drought-prone areas in central India shows decreasing isotopic trend in the $\delta^{13}C$ values of the extracted cellulose which is synchronous with that of the $\delta^{13}C$ of atmospheric CO_2 (Fig. 8).

Characterization of vegetation signature encoded in the modern lake sediments of western India

The study area covers the semi humid and arid areas of western Uttar Pradesh, eastern Haryana, and Rajasthan. The study is focusing on reconstructing the comprehensive modern analogue using stable carbon isotope signature of the lake sediments which will form the baseline data for palaeoclimatic/environmental reconstructions. Stable carbon isotope data indicating the dominance of C3 plants in relatively humid areas and C4 plants in semi-arid areas suggest climatic control on the relative abundance of C3-C4 plants.

Geochemical characterization of modern lake sediments of western India

The bulk chemistry of surface sediments is mainly controlled by the grain size where increased sand fraction is reflected in the increased SiO_2 values. In the ternary A-CN-K plot (Fig. 9a) all the samples lie on the A-CN line where the Rajasthan lake samples cluster above UCC whereas Haryana and Uttar Pradesh samples lie in a very wide range. In addition, the scatter plot between Al_2O_3 vs TiO_2 shows that all samples lie between felsic to intermediate igneous rocks- composition (Fig. 9b).

PROJECT OUTCOME

In SCI (Science Citation Index) Journals

1. Tripathi S, Thakur B, Sharma A, Phartiyal B, Basumatary SK, Ghosh R, Kumar K, Manoj MC, Agrawal S, Farooqui A, Tiwari P, Saikia K, Tiwari A, Pandey A, Ali Nazakat, Agnihotri R, Prasanna K, Morthekai P, Ranhotra PS, Pandey S & Bose T 2023. Modern biotic and abiotic analogues from the surface soil of Ganga-Ghaghara-Gandak interfluves of the Central Ganga Plain (CGP), India: Implications for the palaeoecological reconstruction. Catena 224: 106975. https://doi.org/10.1016/j.catena.2023.106975. (IF: 6.36).

Publications other than the Project Work

In SCI (Science Citation Index) Journals

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2. Joshi P, Phartiyal B, Joshi M, Agrawal S & Baghel P 2023. Reconstruction of landscape and climate during last 7000 calyr BP of the largest basin of the Ladakh Range, NW Indian Himalaya. Catena https://doi.org/10.1016/j.catena.2022.106907 (IF: 6.367).
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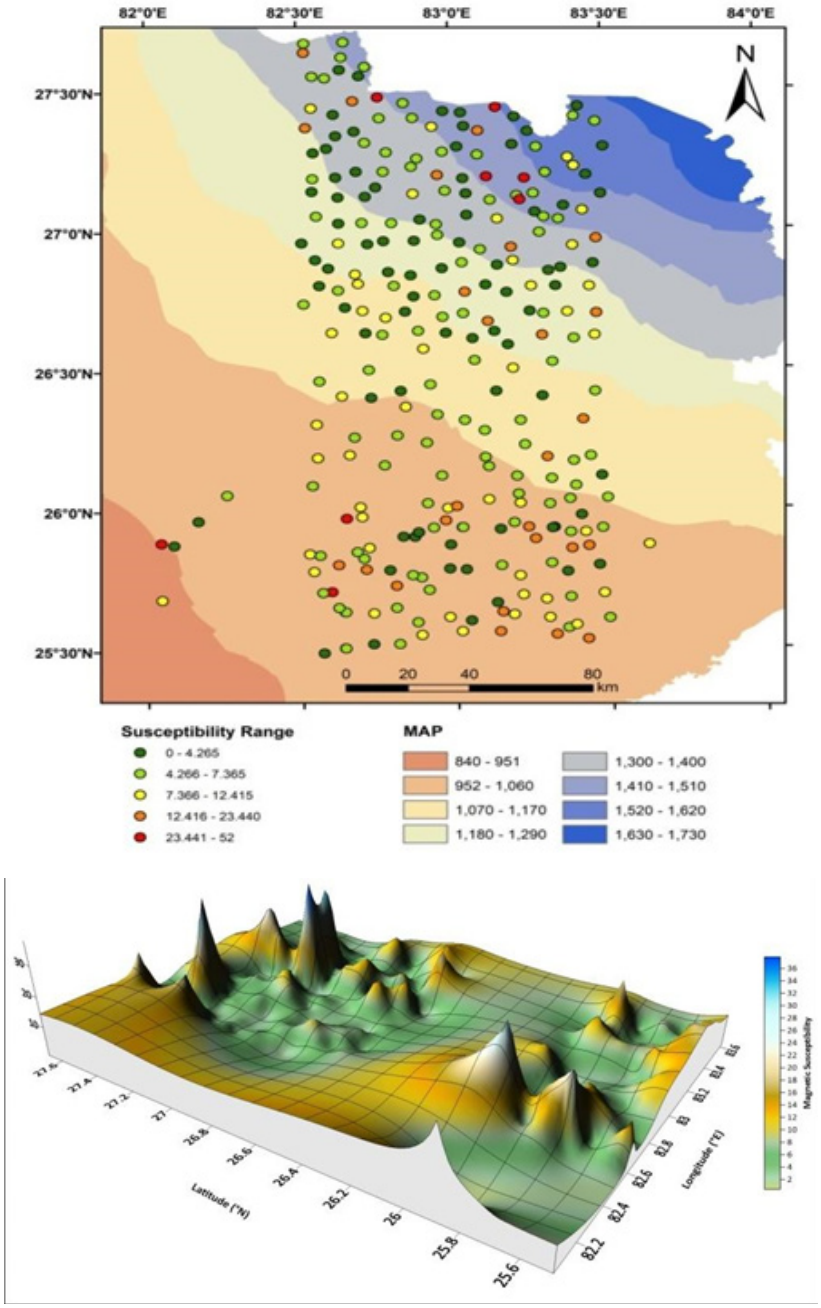

Fig. 4 - (a) Locations of the gridded samples plotted in the precipitation map of CGP, and (b) figure showing the 3D representation of the values of the Magnetic susceptibility from the above locations.

nitrate and Bayesian mixing model. Environmental Research 216: 114744 (IF: 8.431).

6. 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 C_3 and C_4 plant abundance during the late Pleistocene–Holocene in the northern Gangetic Plain, India. Palaeogeography, Palaeoclimatology, Palaeoecology: 110890 (IF: 3.318).
7. Lal DM, Sreekanth GB, Chitra S, Sharma A & Abidi ZJ 2023. Delineating the food web structure in an Indian estuary during tropical winter employing stable isotope signatures and mixing model. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-023-25549-w (IF: 5.19).
8. Morthekai P, Tiwari P, Murari MK, Singh P, Thakur B, Manoj MC, Ali SN, Singh VK, Kumar K, Rai J, Dubey H & Srivastava P 2022. Further investigations towards luminescence dating of diatoms. Radiation Measurements 156: 106803. https://doi.org/10.1016/j.radmeas.2022.106803 (IF: 1.743).
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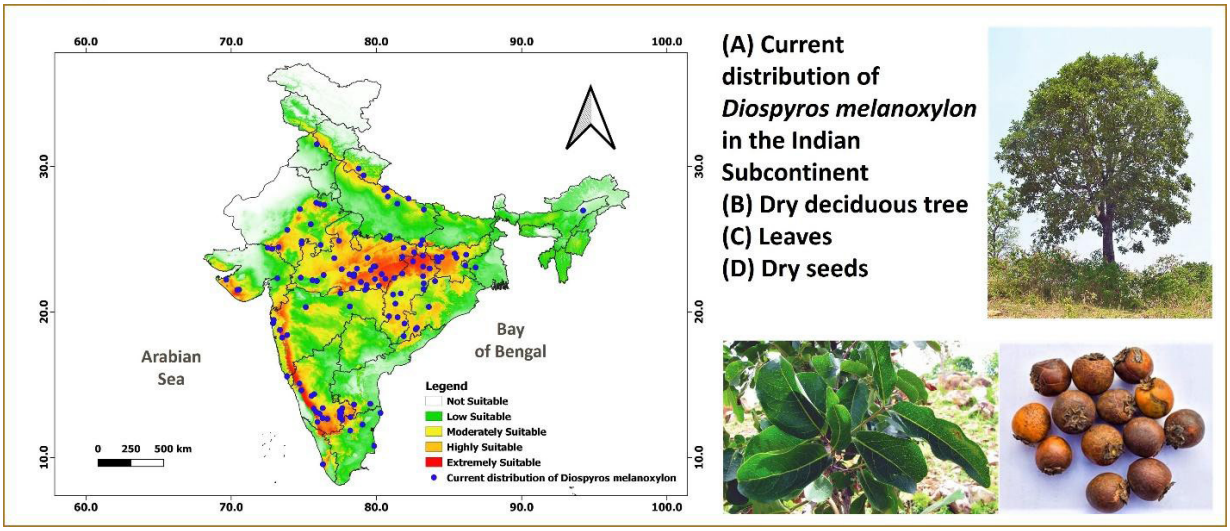

Fig. 5 - Present distribution data of *Diospyros melanoxylon* in the Indian Subcontinent based on occurrence datasets and species distribution modelling.

Tanglang La-Gya catchment of River Indus, Ladakh, India. Physical Geography DOI:10.1080/02723646.2021.2022339 (IF: 2.075).

10. Nag D, Phartiyal B, Agrawal S, Kumar P, Sharma R, Kumar K, Sharma A & Joshi M 2023. Westerly-Monsoon variations since the last deglaciation from semi-arid Ladakh region, Trans Himalaya, India. 618, 111515, Palaeogeography, Palaeoclimatology, Palaeoecology https://doi.org/10.1016/j.palaeo.2023.111515. (IF: 3.565)
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14. Quamar MF 2022. Monsoonal climatic reconstruction from central India during the last ca. 3600 calyr: Signatures of global climatic events, based on lacustrine sediment pollen records. Palynology 46(1): 930605.https://doi.org/10.1080/01916122.2021.1930605 (IF: 1.9).
15. Quamar MF, Garg A, Farooqui A, Prasad N, Khan S & Shukla AN 2022. A new pollen aperture in *Schleicheraoleosa* (Lour.) Oken from Madhya Pradesh, central India and its taxonomic and evolutionary significance. International Journal of Plant and Environment 8(2): 133-136 (IF: 2.609).
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18. Samal P, Singarasubramanian SR, Manoj MC, Srivastava J, Dsouza N, Balakrishna K, Chauhan MM, & Ali S 2022. Heavy metal contamination assessment and its associated human health risk evaluation in the Mahanadi River sediments, India. International Journal of Environmental Science and Technology. https://doi.org/10.1007/s13762-022-04630-w (IF: 3.519).
19. Samal P, Singarasubramanian SR, Srivastava J, Kawsar M, Manoj MC, Gurumurthy GP, Chauhan Md M, Ali S, Alam M & Sharma A 2023. A 2600 year -multi-proxy record for climate and vegetation reconstruction along the Mahanadi River Delta, East Coast of India. The Holocene. https://doi.org/10.1177/09596836231163492 (IF- 3.092).
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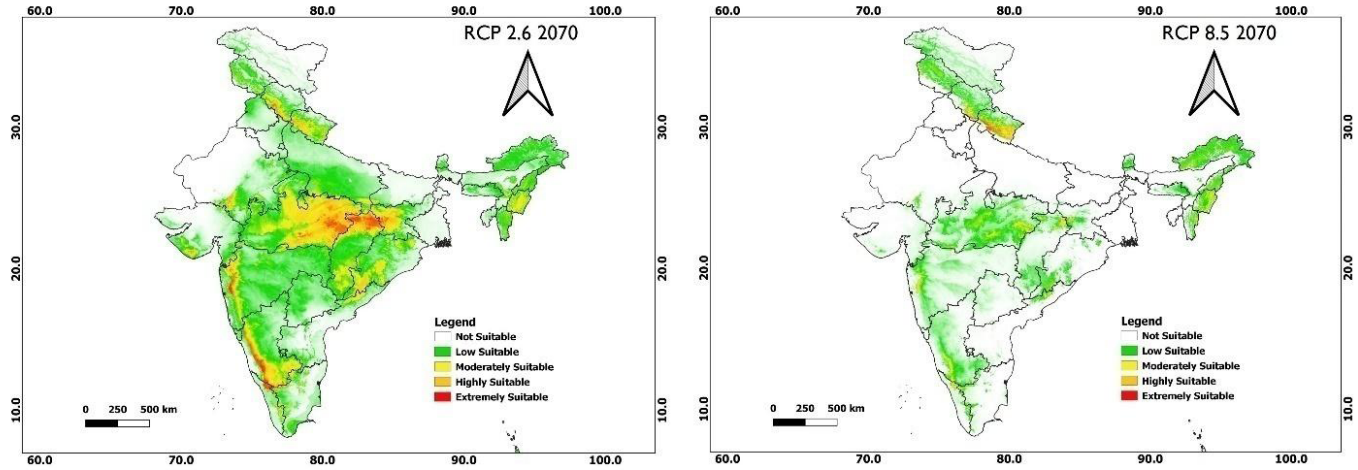

Fig. 6 - Predicted future distribution model of *D. melanoxylon* in 2070s under RCP 2.6 and 8.5.

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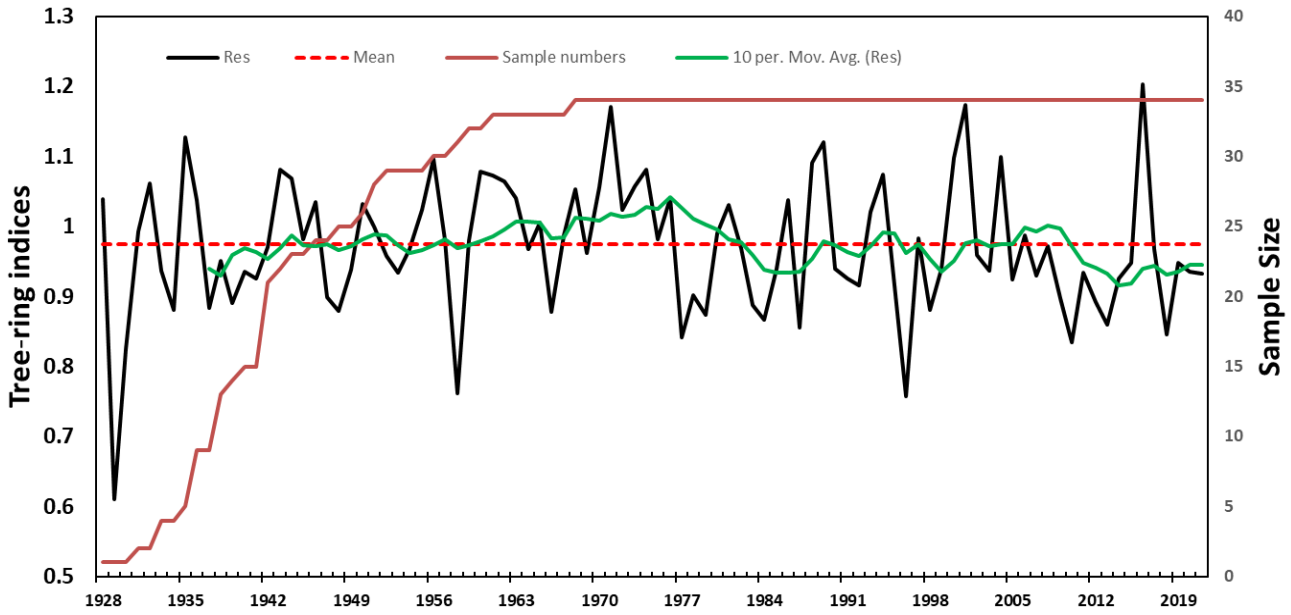

Fig. 7 - Tree ring width chronology of teak from Maharajganj District (U.P.) with sample size (red plot). The red smoothed line indicates a 10 year moving average.

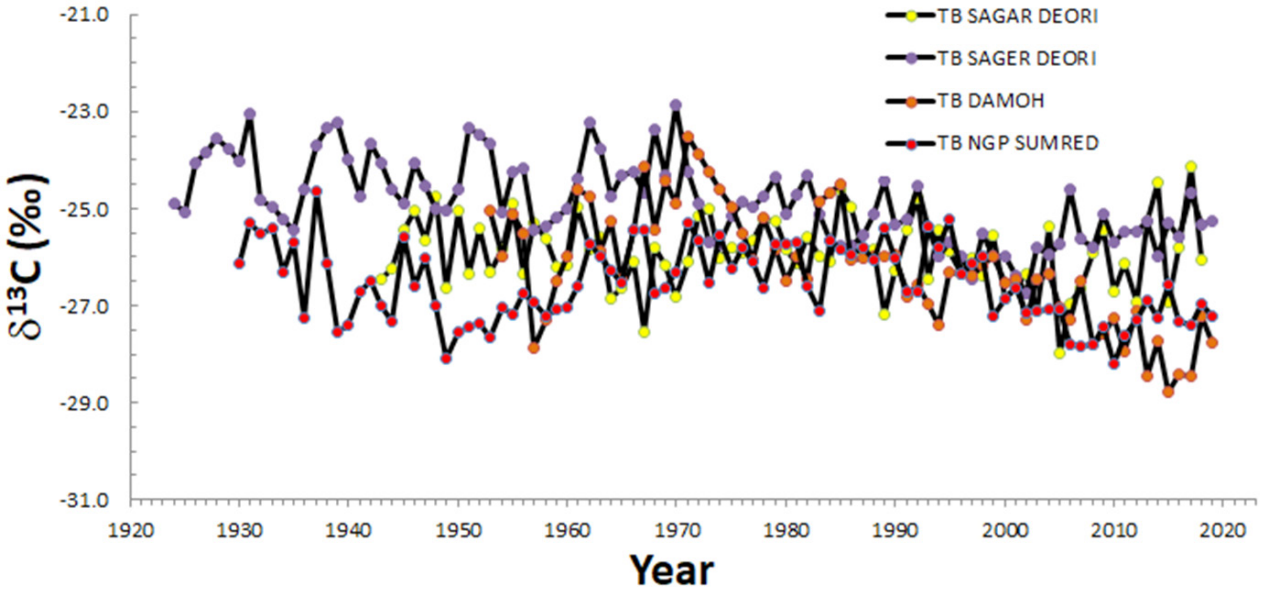

Fig. 8 - Carbon isotopic data of tree rings of the teak tree (*Tectona grandis* L.f.) showing decreasing isotopic trend in the $\delta^{13}C$ values of the extracted cellulose.

230: 105203 (IF: 3.374).

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27. Tripti M, Lambs L, Gurumurthy GP, Moussa I & Balakrishna K 2022. Isotopic fingerprinting of dual monsoon moisture sources, evapotranspiration process and microclimate manifestation over tropical rainforest region, western part of Western Ghats, India. *Journal of Hydrology* 612 (B): 128239. https://doi.org/10.1016/j.jhydrol.2022.128239 (IF: 6.708).

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In Non-SCI Journals (both from Project and other than the Project):

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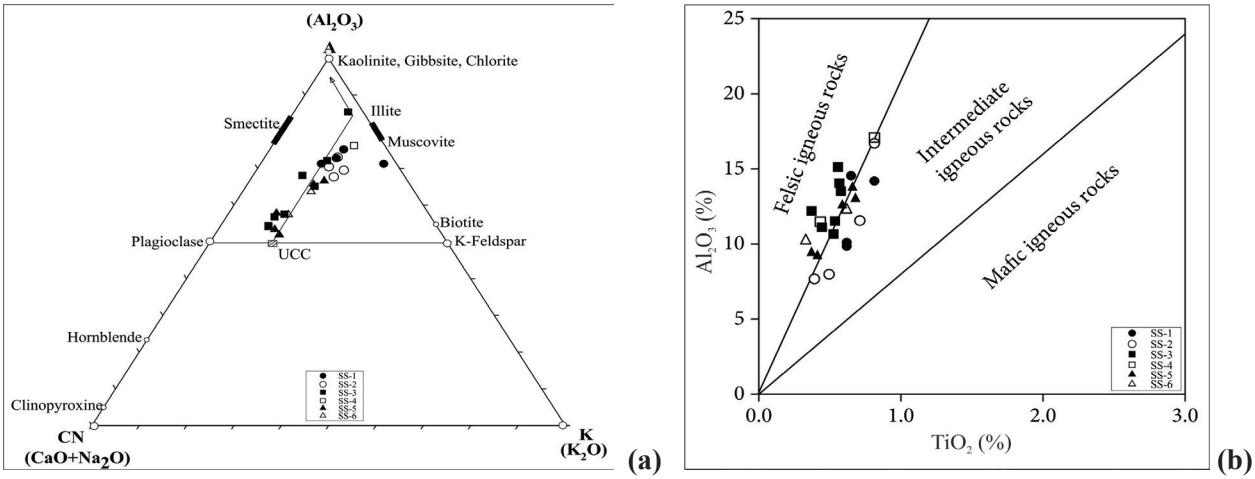

Fig. 9 - **(a)** A-CN-K ternary plot showing that lake sediments are incipiently to moderately weathered, **(b)** Al_2O_3 vs TiO_2 showing felsic to intermediate source of the sediments.

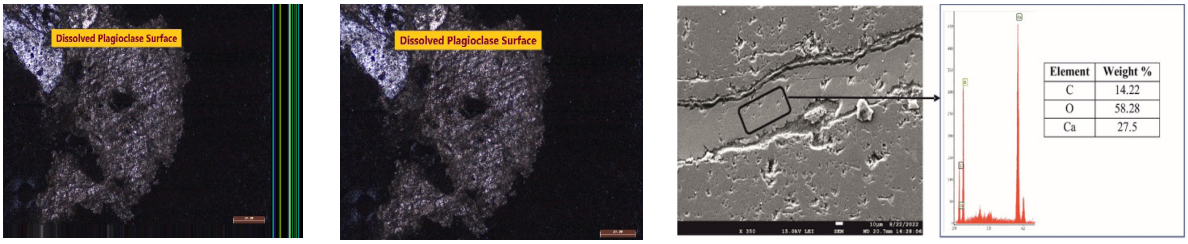

Fig. SP 8.1 - A few selected outcomes of the mineralogical analyses with the aid of Optical Microscopy and FESEM-EDS. **(a)** Photomicrograph of the KBH1_379 sample taken at a depth of 1073 m. showing the biotite remnant found in neoformed chlorite under PPL; **(b)** Photomicrograph of the KBH1_379 sample taken at a depth of 1073 m showing the extremely dissolved plagioclase surface under XPL; **(c)** FESEM image and corresponding EDS data of a wide channel fracture in the thin section of the sample KBH1_381 (1153 m depth). EDS data of the fracture filling material reflects the composition of calcite.

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3. Phartiyal B, Ali N, Sharma A, Agrawal S, Nag D, Tiwari P, Kumar M, Morthekai P, Govil P, Thakur B, Bhushan R, Jena PS & Shivam A 2022. Palaeoclimatic variability during last eight millennia from a morainal lake in Zanskar, northwest Himalaya, India. Journal of Palaeosciences 71(1): 75-88 https://doi.org/10.54991/jop.2022.545.
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5. Tripathi S, Srivastava J, Garg A, Khan S, Farooqui A, Quamar MF, Thakur B, Ranhotra PS, Basumatary SK, Trivedi A, Pandey S, Anupama K, Prasad S & Reghu N 2022. Surface pollen quantification and floristic survey at Shaheed Chandra Shekhar Azad (SCSA) Bird Sanctuary, Central Ganga Plain, India: a pilot study for the palaeoecological implications. Journal of Palaeosciences 71(2): 159–176.
6. Trivedi A, Mishra S & Kanungo AK 2022. Palynological and archaeobotanical investigations at Bhagatrav, Gujarat: A preliminary report. Man and Environment XLVII(2): 23-28.
7. Trivedi A, Srivastava A, Farooqui A, Khan S, Pokharia AK, Ferguson DK & Singh VK 2022. Pollen morphological study in subfamily Papilionoideae using Confocal Laser Scanning Microscopy. Journal of Palaeosciences 71: 123-142.

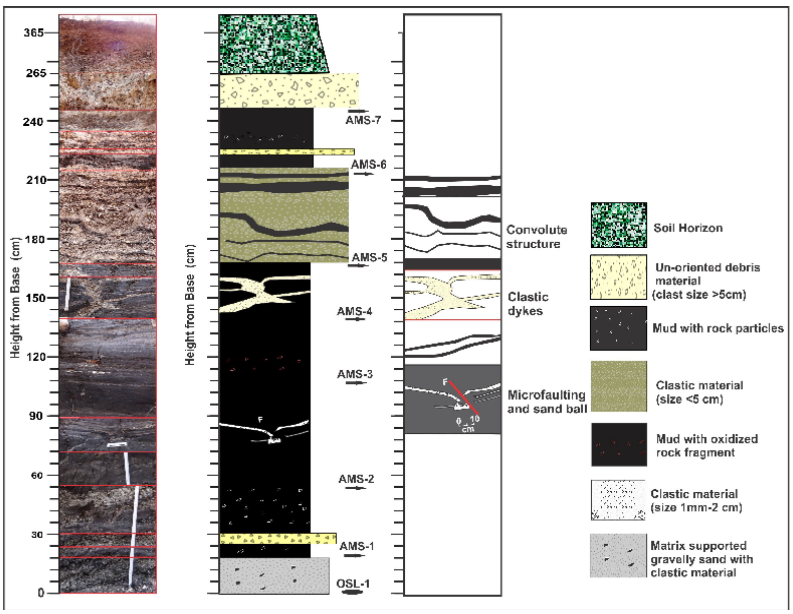


Fig. CP 8.1 - Litholog of the RSP sedimentary profile.

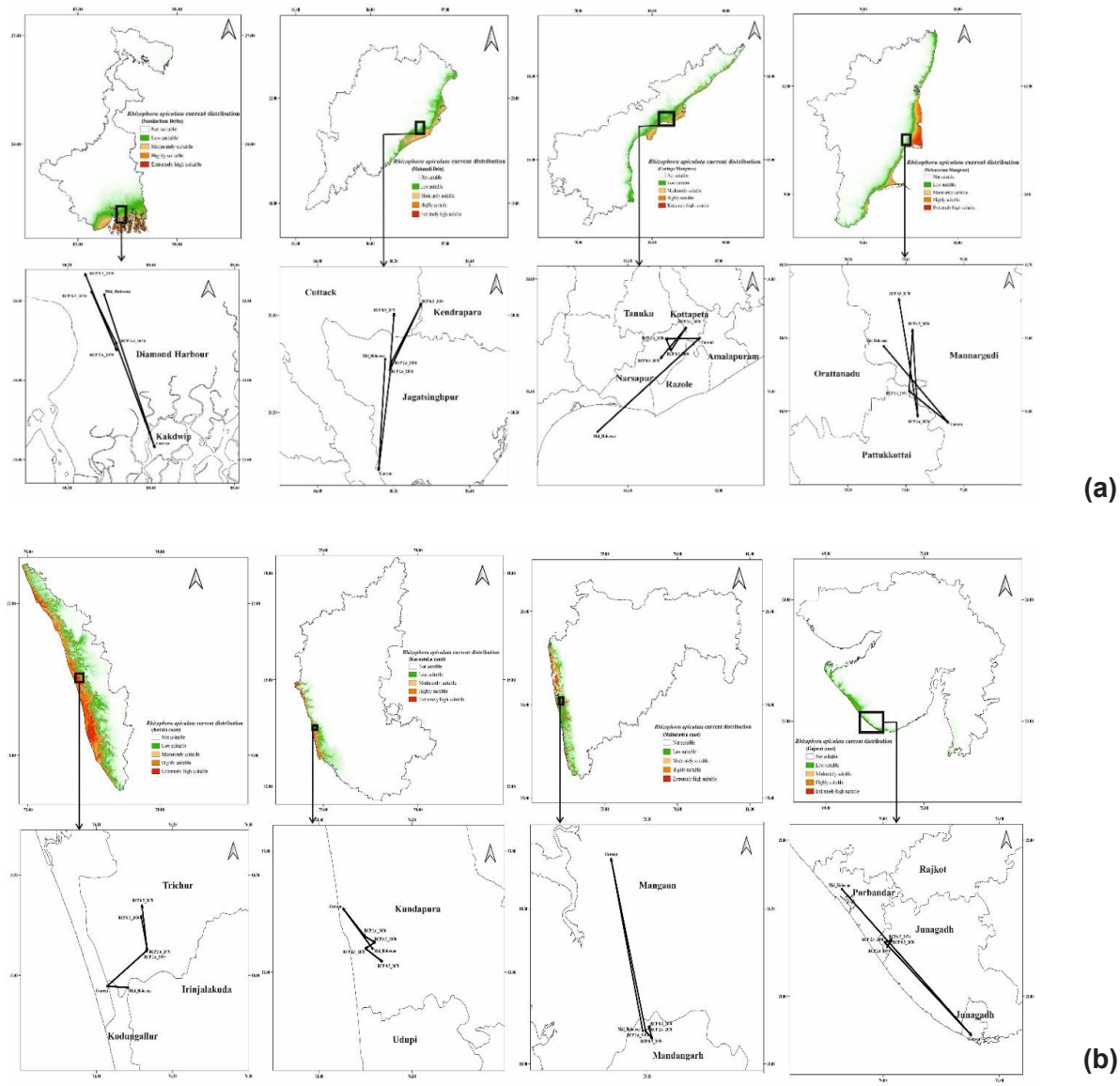


Fig. CP 8.2 - Predicted current distribution and core distributional shift for *Rhizophora apiculata* (a) along the East Coast, and (b) along the West Coast of the Indian subcontinent.

General Articles/Reports/Database Published

1. त्रिपाठी स्वाति एवं फारूकी अंजुम. 2022. लुप्तप्राय राउवोल्फिया पौधे की पराग आकृतिमिति. पुराविज्ञानस्मारिका अंक 1: 38.

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 SAGE-MoES, Govt. of India Project: MoES/P.O.(Seismo)/1(374)/2019)

Investigators: Anupam Sharma, Scientist-G, BSIP, Lucknow (PI), Kamlesh Kumar, Scientist-D, BSIP, Lucknow (Co-PI 1), Matsyendra Kumar Shukla, Scientist-C, BGRL (Co-PI 2), Piyal Halder (JRF)

As a part of the International Continental Deep Drilling Program (ICDP), several boreholes have been drilled up to 3 km depth in the Koyna-Warna Seismogenic Region, Maharashtra India. The core samples of the basement granitoid, underlying the Deccan Trap basalt, have been collected from the MoES-BGRL Core Repository and later analyzed in our laboratory with an objective to delineate the mineralogical and geochemical signatures of fluid-rock interaction and its role in triggered seismicity. Mineralogical analyses with the help of Optical microscopy, FESEM-EDS and XRD have inferred the presence of several secondary minerals like chlorite,

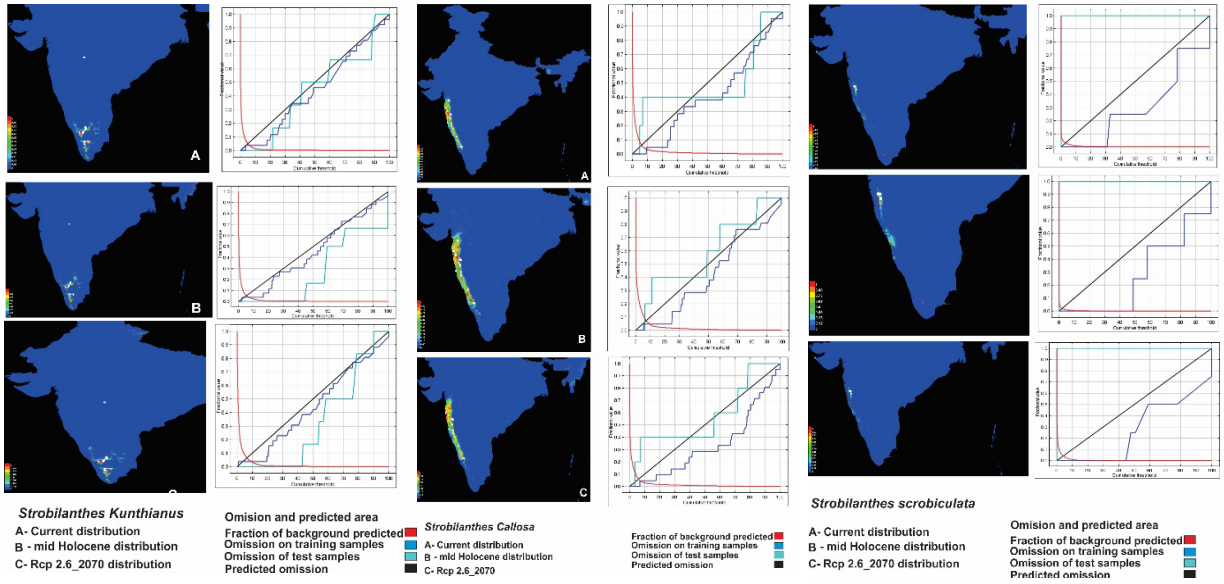


Fig. CP 8.3 - The Current, mid Holocene and Rcp2.6_2070 distribution map of three species of family Acanthaceae, viz. *Strobilanthus* (*kunthianus, scrobiculata* and *callosa*).

epidote, illite, calcite, etc. The presence of chloritic growth over biotite or biotitic remnants within neoformed chlorite, as observed under the optical microscope, has revealed the biotitic origin of chlorite. Besides, the Flow-like appearance of chlorite and kinking within the chlorite grain in a few samples confirms the formation of chlorite as the result of fluid-rock interaction and strain accommodation due to continuous stress build-up. Kinking observed in chlorite indicates the shortening parallel to basal planes in response to the c-axis parallel strain which may have larger implications in seismicity. Geochemical analyses of the samples with the aid of ICP-OES have shown significantly higher concentrations of MgO, Al_2O_3, FeO_t, CaO and, TiO_2 and K_2O (in wt. %) in the majority of the samples reflecting the formation of chlorite, whereas K_2O exhibits contrasting behaviour in the same set of samples supporting the dissolution of biotite. Thus, major oxide data of the altered samples in comparison to the unaltered samples reaffirms the formation of chlorite, epidote, and illite along with the precipitation of calcite confirming the dissolution of biotite as evidenced in the optical microscopy and XRD investigations (Fig. SP 8.1).

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 SERB, Project No. ECR/2017/002228).

Investigator: Trina Bose (Scientist C)

The teak trees (*Tectona grandis* L.f.) rings were collected from forests and agricultural regions close to four forest ranges: Deori and Khurai in the Sagar District, Damoh, and north Panna. The cross-dating of the tree ring widths resulted in the development of a residual chronology covering the period of 124 years from 1896 to 2019 CE. Furthermore, this region experiences a mostly uneven distribution of rainfall, with lesser quantities of monsoonal precipitation occurring in the north (e.g., in Jalaun, Jhansi, Hamirpur, etc.) and higher amounts occurring in the south (e.g., in Chitrakoot, Lalitpur, etc.). However, the tree ring width chronology from agricultural farmland shows a significant increase in growth since 1995 C.E. This may be an effect of India's Green Revolution, which started in the 1990s, on crop management and fertilizer usage. Contrarily, analysis of forest teak tree ring width data reveals that after 1980 CE, the most significant growth declined. Furthermore, we examine the link between climatic indices and tree growth. We discovered a frequency of ~ 2-5 periodicities between 1920 and 1980 in the ring residual chronology, which could indicate an ENSO effect. This study provides a new perspective on the agricultural drought's character and geographic dispersion in central India.

SP 8.3: The Landcover-Landuse of Ecological Regions of the Monsoon (LEM) project, as approved under the Humans & Biosphere Commission (HABCOM) of INQUA, is hosted at the Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow.

Investigators: Trina Bose (Scientist C), Anjali Trivedi (Scientist E)

LEM held its first International School and Symposium (LEM-ISS) from March 13-26, 2023 in western Vidarbha, Maharashtra, India, with the aim to understand Tropical

Fig. a - Various field training sessions organized under LEM - ISS -2023.

Fig. b - Participants and experts of field training sessions organized under LEM - ISS -2023.

Dry Evergreen Forests (Fig. SP 3). The LEM-ISS-2023 is supported by the Department of Forest, Government of Maharashtra; the Science and Engineering Research Board (SERB), Government of India; Ministry of Earth Sciences (MoES), Government of India; and the Association of Quaternary Researchers (AOQR). This school included 23 trainees from India, Nepal, and Sri Lanka, ECRs, and invited experts from India, Sri Lanka, France, Austria, the UK, and the US. Trainees worked in a variety of disciplines, including archaeology, geography, geology, botany, and remote sensing. The school included modelling, practical demonstrations and five days of extensive fieldwork and hands-on field training on collecting surface samples for pollen analysis, surface vegetation mapping, dendrochronology and other proxies for developing modern analogues for palaeoenvironmental reconstruction. This rigorous two-week field school included eight academic sessions, 32 invited talks, 17 keynote talks, and an expert panel discussion. This outdoor school also ran a school outreach programme. The field school ended with a symposium where trainees presented their research and field observations, bridging the gap between emerging and seasoned researchers.

CP 8.1: **Md. Firoze Quamar** [& Anoop K Singh, University of Lucknow]

Reconstruction of vegetation dynamics and contemporary climate (change) during the Holocene from Kumaun Lesser Himalaya: Pollen analysis of a 2.65 m long core (Fig. CP 8.1) from the Rawatsera palaeolake (RSP) of Kumaun Lesser Himalaya revealed mainly showed the dominance of conifers forests around the study area between ~7522 and 7216 calyr BP, ~7216 and 6526 calyr BP, ~6526 and 5987 calyr BP and between ~5987 and 5817 calyr BP; however, broad-leaved forests also demonstrated increasing tendency between ~7522 and 7216 calyr BP in the milieu of cold and dry climates. The

PH.D. PROGRAMME

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

Arvind Tewari (2020). Human-climate relationship in the Central Ganga Plain during the Late Quaternary: A multi-proxy approach, under supervision of **Binita Phartiyal and Ruby Ghosh (BSIP),** 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)**, registered with Academy of Scientific and Innovative Research. Status: in Progress.

Harshita Srivastava (2018). Mineralogical, geochemical and sedimentological aspects of Late Quaternary palaeo lake deposits of Ladakh, NW, India, under the supervision of **Anupam Sharma (BSIP)** and Prof. U.K. Shukla (BHU), 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)** and A.S. Naik (BHU), 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)**, 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 Agarwal (BSIP)** and D.S. Singh, (LU), registered with University of Lucknow, 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)** and U.K. Shukla (BHU), 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),** 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 and Kamlesh Kumar (BSIP)**, registered with 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)** 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),** 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)** and M. Joshi (BHU), registered with Banaras Hindu University, Varanasi. Status: Submitted (2022).

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

Shazi Farooqui (2014). Geochemical study of late Quaternary subsurface sediments of lower Mahi River, Gujarat, western India, under the supervision of **Anupam Sharma (BSIP)** and Munenedra Singh (LU), 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)** 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)** 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)** 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)** and U.K. Shukla (BHU), registered with Banaras Hindu University. Status: in Progress.

Jereem Thampan (2022). Modelling the potential response of natural vegetation to past and future climate change scenarios in Rajasthan, western India, under the supervision of **Jyoti Srivastava (BSIP)** and Mahesh Sankaran, registered under Academy of Scientific & Innovative Research (AcSIR), Ghaziabad. Status: Ongoing.

Holocene Climate Optimum (HCO; 7000–4000 BP) was recorded between ~7522 and 7216 calyr BP. Moreover, the study also revealed that a lake was formed around 7522 calyr BP along the Kulur River, a tributary of Saryu River around the study area and existed till 5817 calyr BP (The research work has been published in the journal *Quaternary*).

CP 8.2: **Jyoti Srivastava** [& Singarasubramanian SR, Department of Earth Sciences, Annamalai University]

Species distribution models to predict the potential niche shift and priority conservation areas for mangroves (*Rhizophora apiculata, R. mucronata*) in response to climate and sea level fluctuations along coastal India: Mangroves are more than just a tree as they are home to thousands of species, carbon absorbers and a natural coastal fortress against floods and storm surges. Hence, conservation planning and decision making for this valuable ecosystem must involve identification of priority conservation areas (PCAs) at species-specific dimensions. In the current study, we adopted an ensemble modelling approach for the distribution of two mangrove species (*Rhizophora apiculata, R. mucronata*) using high-resolution environmental and edaphic datasets, to identify the PCAs for future conservation. We also identified the key environmental variables shaping their distribution and precisely estimated the core distributional shift along the Indian coastline under changing climate scenario (Fig. CP 8.2). The findings revealed that about 5844 km^2 and 7846 km^2 areas were identified as extremely suitable areas, which were distributed along Maharashtra Coast and Kerala Coast for *R. mucronata* and *R. apiculata*, respectively, in the current climate scenario. The highest range expansion of mangrove species occurred during middle Holocene due to high precipitation and sea-level rise and this finding is further supported by fossil pollen evidence. The suitable habitat range for *R. apiculata* is predicted to increase along Kerala Coast under RCP2.6 scenario by 6.90% and 6.93% and under RCP8.5 scenario by 9.33% and 9.90% in the year 2050 and 2070, respectively, whereas the range for *R. mucronata* is getting reduced in the future climate scenario. Overall, our predictions reveal a steady migration of specific mangrove habitat towards land or higher elevations due to relative sea level rise in future. These results would aid in planning a long-term species-specific conservation and management strategy for mangrove ecosystem along coastal India.

CP 8.3: **Anjali Trivedi** [Anjum Farooqui & P. Morthekai, BSIP, Lucknow]

Species Distribution Model (SDM) study: SDMs will help to investigate climatic change, protected areas, invasion and species dispersion risk. Three endangered species of family Acanthaceae, viz. *Strobilanthus* (*kunthianus*, *scrobiculata* and *callosa*), established the association of the occurrence of these species with the bioclimatic variables. Their tolerance limit of temperature and precipitation are, (1) 0 - 20 ºC and 1600 - 2000 mm (*kunthianus*), (2) 19.8-25 ºC and 2200-714 mm (*scrobiculata*), and (3) - 26 - 27.5 ºC and 2400 - 2800 mm (*callosa*). The altitude, Bio-2, -3, -6, -12, -14, -18 and Bio-19 were found significantly controlling the occurrence of these species. The present habitat distribution of *kunthianus* is limited to the southern part of Western Ghats. Whereas the *callosa* species' present day distribution was along the top of Western Ghats from south to north. The *scrobiculatus* was, presently, localized to the northern part of Western Ghats. The distribution of the habitats of these species in the middle Holocene was not much different than the present day one. A similar distribution was observed with the mild radiative forcing value of 2.6 $W.m^{-2}$ in the year 2070 compared to the present-day distribution (Fig. CP 8.3). But the worst-case scenario radiative forcing value of 8.5 $W.m^{-2}$, adversely affected (diminished) the habitat distribution in the Western Ghats and found north-eastern India as moderately suitable habitat.

OTHER ACADEMIC WORKS

Research Papers presented

1. **Quamar MF-** Late Holocene vegetation dynamics and climate change from central India. ICMS 2021, SPPU, Pune, Maharashtra, India during May 4-6, 2022. Abstract Page No. 27.
2. **Saraf PN, Srivastava J, Charles B, Munoz F, Samal P & Quamar MF** - Present, past and future distribution of ebony tree species in India: Integrating ensemble species distribution modelling and fossil pollen data" in 13th Biennial Lake Symposium 2022 (Lake 2022) scheduled from 28-30th December 2022 in Indian Institute of Science, Bangalore.
3. **Shekhar M, Bose T, Kumar A & Mishra A -** Tree-ring width data from four agricultural drought-prone districts of central India. Indian Quaternary Congress-International Virtual Conference during January 19-21, 2022. Abstract Page No. 13.
4. **Bose T & Phartiyal B** - Hurdles and breakthroughs of integrated paleoclimate reconstruction: a case study from western India. Indian Quaternary Congress-International Virtual Conference during January 19-21, 2022. Abstract Page No. 26.
5. **Halder P, Sharma A, Shukla MK & Kumar K -** Mechanisms of secondary mineralization at shallow crustal depths of the Koyna Seismogenic region, Maharashtra, India and its significance. Goldschmidt 2022 Hawaii, USA. 7-17 July, 2022. https://doi.org/10.46427/gold2022.9020
6. **Rahi IC, Sharma A, Ali S, Prasad V & Naik AS** - Palaeocene-Eocene Thermal Maximum continental sediments in the Barmer Basin, Rajasthan, India: A record of enhanced precipitation in South Asia. Goldschmidt 2022. Hawaii, USA. 10-15 July, 2022.
7. **Chetia R, Rahi IC, Mathews RP, Sharma A & Singh PK** - The geochemical documentation of redox conditions in Paleogene lignite deposit of Barsingsar, Bikaner-Nagaur Basin, western India. Goldschmidt 2022. Hawaii, USA. 10-15 July, 2022.

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

Quamar MF

- Late Holocene vegetation dynamics and climate change from central India. ICMS 2021, SPPU, Pune, Maharashtra, India during May 4-6, 2022.

Jyoti Srivastava

- Participated in 13th Biennial Lake Symposium 2022 (Lake 2022) at the Indian Institute of Science, Bangalore during December 28-30, 2022.

Anjali Trivedi and Trina Bose

- As Project Leaders organized International School-cum-Symposia on 'Landuse-landcover mapping and modelling in different Ecological regions of the Monsoon (LEM) International School and Symposium (ISS) – 2023' (Figs a and b) in Vidarbha Region .

Mayank Shekhar and Anurag Kumar

- Deputed by BSIP to attend workshop on building the climate change research and policy gap for enhanced local climate action in Uttar Pradesh. Venue: Hotel Hilton Garden Inn, Gomti Nagar Lucknow. Date 29th December 2022.

Trina Bose, Mayank Shekhar and Anurag Kumar

- Deputed by BSIP as organizers and trainers during Landuse-Landcover of Ecological regions of the Monsoon (LEM) International School and Symposium (ISS) – 2023 from 13th to 26th March, 2023 in western Vidarbha, Maharashtra, India.

Training/Study Visits

Anurag Kumar

Deputed by the Department of Atomic Energy, Nuclear Controls and Planning Wing, Government of India to attend training course on data quality assurance in stable isotope laboratories at the International Atomic Energy Agency, Vienna, Austria during 22-24 November, 2022 at Vienna, Austria.

Lectures delivered

Anupam Sharma

- Delivered a Resource Person lecture in online Refresher Course on Disaster Management entitled *"Earthquake- A way of the mother earth to release stress with a special reference to Reservoir Triggered Seismicity in Koyna, Maharashtra"* on Aug. 08, 2022, at the Department of Geology, Kurukshetra University, Kurukshetra, in collaboration with UGC-Human Resource Development Centre.

- Delivered an invited lecture entitled "*Space and climate: a palaeoclimatic perspective*" in a one-day regional seminar on the theme "*Strategic aspects of disturbances in Akasha Tattva, like weather modification, space warfare, climate migration*" as a part of "Akash for Life" National Space Event hosted by Indian Institute of Geomagnetism, New Panvel, Navi Mumbai, on Nov. 09, 2022.

- Delivered an invited lecture entitled "*Earth and Organic Geochemistry: a proxy to understand the environment*" in the International School and Workshop "LEM-ISS, 2023" funded by the International Union for Quaternary Research (INQUA) under the Humans & Biosphere Commission (HABCOM) in western Vidarbha, Maharashtra, India, on March 22, 2023.

- Delivered an Invited lecture entitled **"***Role of major and trace including rare earth elements in determining the provenance of sediments: a case study from the Mahi River Basin, western India***"** at Indian Institute of Geomagnetism, New Panvel, Navi Mumbai, on March 24, 2023.

Binita Phartiyal

- Participated in Panel discussion of "Scientific Applications within South Asian Archaeology: An integrative platform for research on reconstruction of the past in India", Kohima, Nagaland, December 9-11, 2022.

Jyoti Srivastava

- Classroom session talk delivered on *"Species distribution models to predict the priority conservation areas (PCAs) for mangrove ecosystem"* in "Landuse-landcover mapping and modelling using pollen and isotopic data in different ecological regions of the monsoon" (LEM) project International School and Symposium-2023 during March 13-26, 2023.

S.K. Shah

- Brief information about Dendrochronology and its aspects towards palaeoclimatic study, Department of Forestry, Wildlife & Environmental Science, Guru Ghasidas Vishwavidyalaya Bilaspur, Chhattisgarh, December, 2022.
- Tree-rings and importance of tree-ring studies in Chhattisgarh, FM Radio 90.8 of Bilaspur, Chhattisgarh, December, 2022.

Anurag Kumar

- Delivered a lecture on "*Use of Environmental Isotopes in water resource management: Insights from the Ganga River Basin*" in Uttar Pradesh Ground Water Conference (UPGWC-2023) at Dayal Bagh Resort, Shushant Golf City Amar Shaheed Path, Lucknow, Uttar Pradesh on Feb. 27, 2023.
- Delivered a lecture on "*Organic Geochemistry as a proxy to understand the environment*" during LEM-ISS-2023 on March 22, 2023.

Trina Bose

- Delivered a lecture on "*Environmental Isotopes-Interpretation and Modelling*" during LEM-ISS-2023 on March 22, 2023.
- Delivered a talk on "*Introduction to data integration for Landcover-Landuse studies*" during LEM-ISS-2023 on March 25, 2023.

Mayank Shekhar

- Delivered a lecture on "*Tree-ring-based glacio-hydrological record reconstructions in the Himalayan region: challenges and opportunities*" during LEM-ISS-2023 on March 24, 2023.

Piyal Halder (JRF)

- Delivered a speech on *"Evidence of fluid-rock interaction at the shallow crustal level and its role in triggering seismicity in Koyna Seismogenic Region, Maharashtra, India: Coupling Geochemistry with Geophysics"* in the EGU GMPV Campfires – Geochemistry Edition on Thursday 28th April, 2022

CONSULTANCY / TECHNICAL SUPPORT RENDERED

- Samples were analyzed on XRD, XRF and ICP-MS from Lucknow University, BBAU, Integral University, etc. The total consultancy amount during this financial year was Rs. 306800/- only. Apart from consultancy, other in-house project samples were also analyzed in the geochemistry laboratory.

TRAINING IMPARTED

Md. Firoze Quamar

- Imparted training on the palynology of surface samples from the Baramulla District of Jammu and Kashmir State (India) to Mr. Md. Faisal, M.Sc. (Applied Geology; pursuing), Lucknow University, Lucknow during the months of January to March, 2022, which led to his M. Sc. Dissertation.
- Imparted training on the palynology of surface samples from the Jammu area of the Jammu and Kashmir State (India) to Ms. Sania Khan, M.Sc. (Geology; pursuing), Lucknow University, Lucknow during the months of April to June, 2022, which led to her M. Sc. Dissertation.
- Imparted training on the basics of palynology to Mr. Krishana, a JRF, working on the palynological aspects in central India under Dr. Meghna Agarwala, Ashoka University, Haryana, India during July, 25-August, 10, 2022.

ACCOLADES RECEIVED

Anurag Kumar

- Invited as a Key-note speaker at the National Conference entitled "Uttar Pradesh Ground Water Conference (UPGWC-2023)". He gave his talk on the topic entitled "Sustainable Groundwater Management and Future challenges" on 27th February, 2023 at Dayal Bagh Resort, Shushant Golf City Amar Shaheed Path, Lucknow, Uttar Pradesh.

REPRESENTATION IN COMMITTEES/BOARDS

Binita Phartiyal

- Panel Member, Assessment Panel of 'Gender Advancement for Transforming Institutions' (GATI), DST, New Delhi 2023 onwards.
- Member, Research Advisory Committee, Wadia Institute of Himalayan Geology, Dehradun (2022-24)
- Editor-Journal of Palaeosciences (Formerly The Palaeobotanist) 2020 onwards
- Expert Member of Subject Expert Committee for Women Scientific Scheme-A (constituted for evaluation of research and development in frontier areas of Science and Engineering), Department of Science and Technology, India (2021-24)

PROJECTS AND GRANTS AWARDED

Binita Phartiyal

- The British Academy's Leverhulme Small Grants (SRG22/220841) (2022-23).

Anjali Trivedi

- Landuse-landcover mapping and modelling in different Ecological regions of the Monsoon (LEM) project, as approved under the Humans and Biosphere Commission (HABCOM) of the International Union for Quaternary Research (INQUA), is hosted at the Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow.
- The Conference Grant Awarded by Science and Engineering Research Board (SERB) for The International School-cum-Symposia on Landuse-landcover mapping and modelling in different Ecological regions of the Monsoon.

Piyal Halder (JRF)

- EAG (European Association of Geochemistry) Student Sponsorship of 500 Euro by the European Association of Geochemistry, for European Geosciences Union (EGU) General Assembly, 2023.

FACILITIES

SEM AND EDAX UNIT

Field Emission Scanning Electron Microscopy facility is dedicated to provide the support for researchers of the Institute to study the surface morphological features of their samples up to the nanometer scale which is never possible with optical microcopy. The facility also provides the elemental analysis of their samples during the observation which help them to characterization of their specimen crucially of various disciplines.

The unit is equipped with Field Emission Scanning 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 57 scientists of the Institute of different disciplines were investigated their variety of samples for morphological features and elemental analysis using FESEM. Besides the institute work, FESEM facility also provided to the other researchers of various universities, academic institutions of India as a consultancy services, which helps institute for generating funds.

- University of Lucknow, Lucknow (nano materials, powder, sediments)
- Sam Higglinbottom University of Agriculture Technology and Sciences, Allahabad, U.P. (botanical samples)
- Babu Banarasi Das College of Dental Sciences, Lucknow (tooth materials)
- University of Allahabad, Prayagraj, U.P. (powder samples)
- KGMU, Lucknow (dental material)
- Centre of Advanced Study in Geology, BHU, Varanasi, U.P.
- IFTM University, Moradabad, U.P.
- Govt Girls PG College, Ghazipur, U.P.
- National Research Laboratory for Conservation of Cultural Property, Lucknow (metals)
- BBAU University, Lucknow (powder samples)
- Saraswati Dental College, Lucknow (dental material)
- Guru Ghasidas Vishwavidyalaya, Bilaspur, Chhattisgarh (leaf sample)

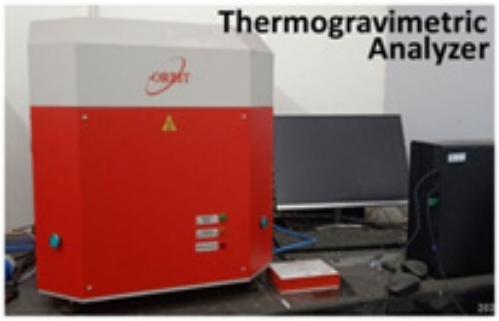
Total consultancy money received around Rs. 4,66,396/= (Four Lakh Sixty Six Thousand Three Hundred Ninety Six)

ADVANCED ORGANIC PETRO-GEOCHEMICAL LABORATORY

Former Fossil Fuel Lab of the Birbal Sahni Institute was renovated and reconstructed as Advanced Organic Petro-Geochemical Laboratory. The new lab was inaugurated by Prof. Nitin R. Karmalkar, Chairman (Governing Body, BSIP) and Vice Chancellor, Savitribai Phule Pune University, Pune on 17th June 2022 in the presence of Prof. L.S. Chamyal, Chairman (RAC, BSIP) and Dr. Vandana Prasad (Director, BSIP). The lab was built to cater the recent requirements in research and fuel sector of the country to support the economy. The lab represents one of the most advanced labs in the country for studying solid fossil fuels such as coal and lignite constituting instrumentation facilities such as Coal Petrographic Microscope with Spectrophotometer, Bomb Calorimeter, Thermogravimetric Analyzer (TGA), Muffle Furnace, Moisture Oven, Humidity Chamber, Automatic Pellet Press, Grinding & Polishing Unit, etc.

One of the most important aspects considering the utilization aspect of the solid fuel is the quality which solely depends on the composition which can be revealed in terms of chemical nature and/or its constituent macerals. Macerals are the basic constituents of coal and can be studied using a dedicated microscope. This decades old facility in BSIP was now re-established with the installation of Advanced Coal Petrographic Microscope with Spectrophotometer. The system can be utilized to study the composition and nature as well as to evaluate the oil/gas generation characteristics and also to study the palaeodepositonal environment. The quality of the fossil fuels profoundly depends on the intrinsic properties including the content of moisture, ash, volatile matter and fixed carbon. These properties are studied using muffle furnace or TGA. Another important aspect is the calorific value which determines the ability of the fuels to generate heat. This can be measured using a Bomb Calorimeter.

The Fourier Transform Infrared Spectrometer (FTIR) laboratory was inaugurated earlier on 22nd March 2022 by Prof. Nitin R. Karmalkar, Chairman. Chemical composition of the coal is a key factor determining the quality which straightaway linked to the maceral and mineral matter composition, in other way the organic and inorganic species. This can be achieved using an FTIR spectrometer. Here in BSIP, the FTIR spectrometer with ATR, K-Br and microscopic accessories makes a facility suited for geological/fossil fuel studies as well as other diverse fields including pharma, biochemistry, dentistry and other subjects.



GEOCHEMICAL AND TL/OSL FACILITY

Samples from the institution as well as those from other national research institutions and universities were analysed with the help of the Sophisticated Analytical Facility. This facility consists of ICP-OES, XRD, XRF, GC-MS, IR-MS, ICP-MS, Particle Size Analyzer, Nutrient Analyzer, Biomolecule and Clumped Isotope Laboratory, and TL/OSL facilities, amongst other things. Aside from that, a novel setup for clumped isotope analysis has been established. Carbonate samples are prepared using a manual vacuum line (Fig. 1) and a rotary pump with an optimal baseline pressure. In an external "Y" tube with orthophosphoric acid kept at 70°C, 4-5 mg of carbonates are reacted. The response time is around 70 minutes. Using a dewar, the freed CO_2 gas and resultant water are frozen during the reaction in a vertical double-coiled, helicoidal glass trap and a "U" trap at distinct phases. By switching to a 'Slush' dewar (ethanol kept at -90°C with the occasional injection of liquid N_2), the CO_2 gas is freed from the water trap, separating water from CO_2. Finally, the pure CO_2 gas is caught in a glass ampoule at liquid N_2 temperature. The clean CO_2 is examined on a Thermo Finnigan MAT 253+ mass spectrometer (Fig. 2) in dual inlet mode against a reference gas with a beam intensity of 10V on mass 44 and total integration duration of 2-3 hours.

Fig. 1 - Manual vacuum line

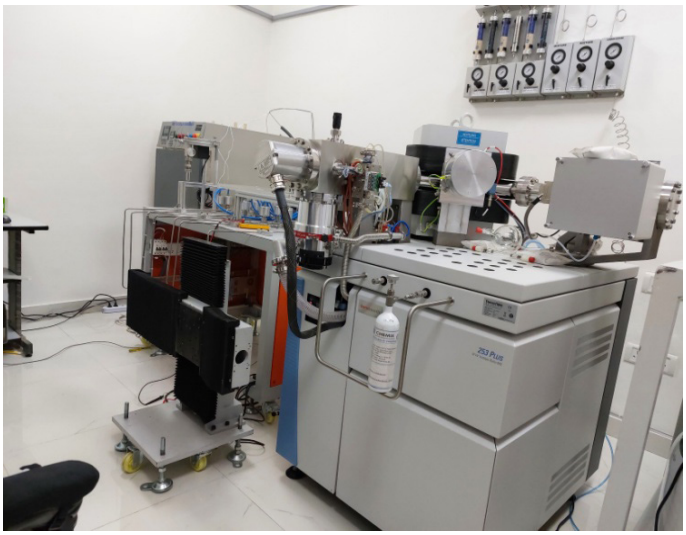


Fig. 2. Thermo Finnigan MAT 253+ mass spectrometer

A compound-specific sample preparation facility (Fig. 3) has also been built. The compound specific isotope analysis laboratory (CSIA-Lab) was founded to answer previous ecological and environmental research questions at the molecular level by analysing the stable isotope composition (Carbon and Hydrogen) of particular compounds isolated from samples. Because it targets the more resistant organic molecules in the samples, the technology has an advantage over standard bulk isotope analysis. A dedicated lab was constructed to set up the CSIA facility, along with the purchase of laboratory necessities such as a hot air oven, furnace, Rotary Evaporator, weighing balance, sonicator, and hot-plate. The samples generated in the CSIA lab will be analysed in the geochemistry laboratory of BSIP Lucknow using an isotope ratio mass spectrometer combined with gas chromatography (GC-IRMS).

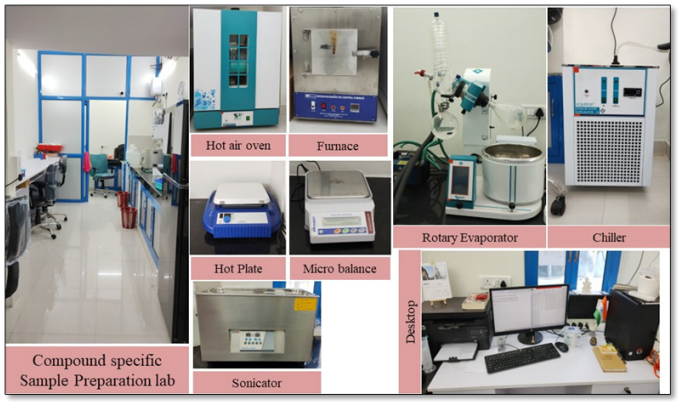


Fig. 3 - Compound-specific sample preparation facility.

VERTEBRATE PALAEONTOLOGY AND PREPARATION LABORATORY

The goal of the institute's "Vertebrate Palaeontology and Preparation Laboratory" (VPPL) is to prepare and research fossil vertebrates, associated microfauna, and ichnofossils (e.g. coprolites). The facility has a dual tank sand blaster unit and an electrically driven air-compressor (100% oil-free) equipped with pressure regulators to aid operate the pneumatic air-scribes. The sand blaster unit and pneumatic air-scribes both help to prepare fossil remnants.

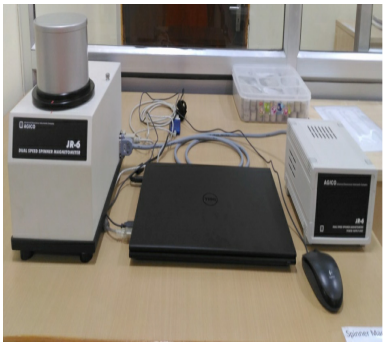
Additionally, the lab is furnished with a stereoscopic microscope to aid in the recovery of microfossils from the host matrix and an ultrasonic cleaner for cleaning fossil remains. The laboratory is also furnished with the necessary computers and software to photograph, and analyse fossilised vertebrates morphometrically and study them phylogenetically. The VPPL facility is also equipped with an automatic slide scanner for microscopic examination as well as digital storage for thin sections for bone histological studies and thin sections of ichnofossils (e.g. coprolites) to study biotic-abiotic inclusions.

In addition to using global standard ear, eye, and dust protection, all preparation works are carried out within custom-built dust collector safety units, in accordance with health and safety requirements.

PALAEOMAGNETISM LABORATORY

Started with a Bartington Susceptibility Meter (MS2B) during the 2016, the Palaeomagnetism Laboratory of the Institute grows to a national facility and at present hosts a range of advanced instruments, viz. JR-6 Spinner Magnetometer, D2000T Alternating Field Demagnetizer, TD-48 Thermal Specimen Demagnetizer, MFK2-FA Kappabridge, IM-10-30 Impulse Magnetizer and the Bartington Susceptibility Sensors (MS2C/2D/2E/2F) for both laboratory and field survey purposes. The laboratory also hosts palaeomagnetic sample preparation instruments of Lapidary Core Drill System & Dual Blade Rock Saw, Pomeroy gasoline-powered field rock drill & its orienting fixture, Brunton compass, etc. During the year 2022, the laboratory analyses a total of 4269 samples of 25 researchers across the country for diverse scientific objectives. The laboratory also provides consultancy services to various industries, universities/research organizations and other stake holders and helps in resource generation. Scientists from the Palaeomagnetic Laboratory also imparted summer training/internship/dissertation work to many B.Sc. and M.Sc. students of several universities.

Bartington Susceptibility Meter (MS2B)



JR-6 Spinner Magnetometer

D2000 Alternating Field Demagnetizer

TD-48 Thermal
Specimen Demagnetizer

MFK2-FA
Kappabridge

IM-10-30 Impulse
Magnetizer

CONFOCAL LASER SCANNING MICROSCOPE AND RAMAN SPECTROSCOPY LABORATORY

Confocal Laser Scanning Microscope (CLSM) has demonstrated its value in creating 3-D pictures of the fossil material from specimens that are typically 2-D. When determining the structure and functions of the many fossilised species, three-dimensional reconstructions reveal important characteristics of the microfossils. The inherent capability of CLSM to optically segment light allows for precise, high-resolution, and high-contrast reconstructions of 3D structures. This is accomplished by capturing a series of images at different depths and subsequently combining them to generate an accurate representation.

Raman Spectroscopy has been instrumental in promoting scientific investigation and analysis. The laboratory has been in the forefront of using cutting-edge equipment and skills to investigate molecular structures, chemical compositions, and material characteristics. The Raman Spectroscopy continues to make a substantial contribution to our knowledge of complex systems and to the facilitation of ground-breaking discoveries by offering accurate molecular fingerprinting and characterisation.

At our institute, 290 specimens have been processed using CLSM and 40 samples have undergone Raman Spectroscopy analysis. Scientists from various disciplines have utilized these techniques to investigate morphological features and perform chemical analysis on their respective samples. The CLSM and Raman Spectroscopy facility not only caters to internal research requirements but also extends its services to external academic institutions, including consultancy services for researchers from various universities and academic institutions across India.

During the 2022-23 period, students and researchers from the following institutions utilized the CLSM and Raman Spectroscopy facility at our institute for their studies:

- Department of Biosciences, Integral University, Lucknow.
- Career Post Graduate Institute of Dental Sciences and Hospital, Lucknow.
- Department of Conservative and Endodontics, King George's Medical University, Lucknow.

These institutions recognized the value of our facility in their respective fields of study, highlighting the broad applicability and interdisciplinary nature of CLSM and Raman Spectroscopy in advancing research across biosciences, dental sciences and medical disciplines.
The total consultancy generated during 2022-2023 amounted to Rs. 53,100/- (Rupees Fifty-Three Thousand One Hundred only).

INDUSTRIAL MICROPALAEONTOLOGY LABORATORY

The Industrial Micropalaeontology Laboratory at the Birbal Sahni Institute of Palaeosciences was inaugurated in January 2022 and is fully dedicated to the analysis of palynological and palaeontological proxies for application in hydrocarbon exploration. Major functions of this facility include precise age determination through biostratigraphy and preparation of 2D depositional palaeoenvironmental models based on the analysis of foraminifera, calcareous nannofossils, dinoflagellate cysts and spore-pollen.

Calculation of Palynological Marine Index (PMI) for deciphering sea level changes, identification of marine flooding surfaces, and the demarcation of palaeoshorelines and preparation of ecological charts are some of the other deliverables from the study of palynological proxies. Study of benthic and planktic foraminifera are an integral component of the laboratory work that have high potential in the reconstruction of shallow-marine to deeper palaeoenvironments and deducing valuable palaeobathymetric data.

The laboratory facilities include several sophisticated microscopes like Leica M205 C stereo microscope, Leica DM3000 LED light microscope and Leica DM2500 polarizing microscope with all the necessary camera attachments. The lab is equipped with other minor instruments such as multiple hot air ovens, distilled water unit, ultrasonicator cleaners and weighing machine. In 2022-23, under the BSIP-ONGC RGL Vadodara project entitled 'Palaeobathymetric variations through time from middle to late Eocene and reconstruction of Palaeogeographic Maps of Cambay Basin', 538 well cutting samples from 23 wells (Cambay Basin) were studied for foraminifera, calcareous nannofossil, dinoflagellate cysts and spore-pollen in the Industrial Micropalaeontology Laboratory being the fulcrum of the project.

UNITS

COMPUTER SECTION
MUSEUM
KNOWLEDGE RESOURCE CENTER
PUBLICATION

COMPUTER SECTION

Institutional E-Mail accounts for BSIP Staff, units/sections and research scholars have on Institute Domain (bsip.res.in). Circular/Notices are circulated to everyone through E-mail and WhatsApp Group. Institute's Facebook page and Twitter accounts have been created and regularly updated with the latest information and photographs. Video Conferencing System is also installed in the Committee Room and online interview, video conferencing through G-meet, Team, etc. are also arranged as and when required.

Computer Section is maintaining NKN (National Knowledge Network) Internet connectivity in the Institute to provide 24 hours high speed Internet facility to the Institute's employees and research scholars. All the Systems (around 170) are protected from viruses and worms by Anti Virus Program (Quick Heal Endpoint Security 6.0 Business edition). Institute is fully covered with Wi-Fi and staff members are using Wi-Fi connectivity on their mobile also. For Network security Sophos - XG-230 firewall is working.

Computer Section is maintaining and updating the Institute's Website (www.bsip.res.in) regularly. The work of redesigning of the Institute's Website has been done as per GIGW norms. Scientists can update their work and achievements on their webpage with more reach in the public. Various utility forms are converted into bilingual and uploaded in PDF and Word format on Institute's Website so that anyone could download and use them. Intranet Website has also been launched for Institute users/ research scholars.

For internal file movement, File Tracking System (FTS) has been successfully implemented. Now the location of the file can be traced anytime from anywhere. In addition, web based payroll, pension packages also developed and modified as per the requirements of the Account Section. Employees are receiving the pay slip through email. Computer Section is providing help to the scientists in preparing the multimedia presentations, charts, graphs, lithologs and diagrams for their scientific publications and documentation. Technical Assistance for Computer is also provided to every staff and units to ease their work.

MUSEUM

Museum plays a vital role to popularize and disseminate the geological knowledge amongst the students, researchers and common people. The Institute's Museum is housed in spacious halls in which the exhibits are arranged and displayed in order to illustrate various aspects of palaeosciences, from a generalized as well as advanced geological point of view. Museum often attends Science festivals, Mela, outreach activities, etc. in different parts of India and also organizes many in-house programmes to promote the scientific knowledge and the awareness about the fossils.

Museum has participated in "Gramodaya Mela" organized by the Deendayal Research Institute, Chitrakoot during October 09-12, 2022. During the period the exhibits from the museum were displayed. The Honorable Minister of Agriculture, Madhya Pradesh Government, Sri Kamal Patel graced the BSIP Stall by his visit and interaction with museum personals about the importance of fossils.

The "3rd Triennial Congress of FIGA", in conjunction with the Annual Conventions of IGU, AEG, AHI, PSI & ISES and AGM of GSI, was held at the Wadia Institute of Himalayan Geology (WIHG), Dehradun during November 16-18, 2022. Museum also participated in the Congress by showcasing its exhibits and fossils. The exhibition stall overwhelmingly received a large number of footfalls with a curiosity to understand more about the diversity of fossils being displayed, ranging in the age from the Precambrian to Quaternary.

The 8th edition of the "India International Science Festival" (IISF-2022) was organized by the Ministry of Science & Technology, the Ministry of Earth Sciences and the Department of Biotechnology, Government of Madhya

Pradesh, in association with the Vijnana Bharati (VIBHA), during January 21-24, 2023 at Bhopal. The Museum also took active participation in the festival and exhibited the various fossils and exhibits. The exhibition was graced by the visit of Dr. S. Chandrasekhar, the Secretary, DST, who interacted with the BSIP team and shown a great enthusiasm towards the fossils being displayed.

Museum has received and indexed various research materials (megafossils and palynological samples) that were collected from around 162 localities spreading in different parts of the country, by the scientists who are working in the Institute's projects as well as on various sponsored projects. Type materials of 30 research papers were also submitted in the repository during the period 2022-23.

Museum has been continuously striving for outreach activities to disseminate knowledge to the students and

general public about palaeosciences and research work being carried out in the institute, through videos, posters, pamphlet, etc. Museum has received a large number of visitors from various colleges and institutions from the state and other parts of India.

Museum Holdings:

Particulars	Addition during 2022-23	Totals
Type and Figured Specimens	142	9,726
Type and Figured Slides	257	16,543

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

Project	Megafossil Specimens	Palynological Samples
Project-1	…	748
Project-2	77	669
Project-3	3,847	443
Project-4	…	…
Project-5	...	112
Project-6	...	148
Project-7	…	54
Project-8	…	302

Institutional Visitors:

1. Feroze Gandhi Post Graduate College, Raebareli U.P.
2. Banda University of Agriculture and Technology, Banda, U.P.
3. Maharaja Bijli Pasi Government Post Graduate College, Ashiyana, Lucknow, U.P.
4. New Standard College of Higher Education, Salethu, Maharajganj, Raebareli, U.P.
5. Sunbeam Women's College Varuna, Varanasi, U.P.
6. Sant Dwarika Post Graduate College, Ambedkar Nagar, U.P.
7. Amity Institute of Biotechnology, Amity University, U.P.
8. Shia Post Graduate College, Lucknow.
9. Navyug Kanya Mahavidyalaya, Rajendra Nagar, Lucknow, U.P.
10. Mahamaya Government Degree College, Mahona, Lucknow, U.P.

Fossil Memento presented to the Distinguished Guests:

1. Dr. Ajay Kumar Sah, Sugar Cane Research Institute
2. Prof. Nitin R. Karmalkar, Chairman Governing Body, BSIP
3. Prof. Ashutosh Sharma, I.I.T Kanpur
4. Dr. Alok Dhawan, Director SGPGI, Lucknow

Specimens / Slides gifted to the Educational Centers:

1. Dr. Subhronil Mondal, Assistant Professor, Department of Earth Sciences, IISER Kolkata, Mohanpur Campus, P.O. Krishi Vishwavidyalaya, District Nadia 741252, West Bengal, India,
2. Dr. Rajeev Singh, Principal Sunbeam Women's College Varuna, 904/1, Central Jail Road, Sikraul, Varanasi 221002, U.P., India
3. Dr. Smita H. Bakshi, I/C Principal, Shrimad Rajchandra Vidyapeeth, Kangvi Road, Karanjveri, Dharampur- 396051, District- Valsad, Gujarat, India

Samples deposited in the repository under Sponsored/ Collaborative Projects:

1.	SERB Sponsored Project No. CRG/2019/002461-	45 Samples
2.	Mo ES. P.O. Seismo/1 (374) 2019	11 Samples
3.	DISHA File no. VDA/WON/REL/GEOLAB/2021/BSRG 21/896052 CSAP out Line Agreement No. 90/0034150	353 Samples
4.	CRG/2019/002461	12 Samples & 102 Specimens
5.	DST. Inspire Faculty Project /IFA- Project/ IFA-17EA 562	14 Samples
6.	ONGC Sponsored Project	1244 Samples
7.	EEQ/2021/000787	36 Samples
8.	ONGC Sponsored Project	125 Samples
9.	Ref No. IV-BSIP/SA/2022-2023/L-883	201 Samples
10.	DST Sponsored Project (No. EEQ-2021/000846-	201 Samples
11.	MoES/P.O. (Geo) 211/2019	367 Samples
12.	EEQ/2021/000787	137 Samples
13.	ACSIR Ph.D. Work	129 Samples & 103 Specimens

KNOWLEDGE RESOURCE CENTRE

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 2022-23	Total
Books in English	10	6,419
Journals (bound volumes)	118	18,032
Reprints	-	40,179
Reference Books	-	356
Books in Hindi	40	902
Ph.D. Thesis	-	148
Reports	-	46
Maps & Atlas	-	61
Microfilm/ Fisches	-	294
Compact Disk	-	74

(Working hours 9.30-18.00 Mon-Fri)

Currently the library is receiving 150 journals (46 through subscription, 54 through NKRC and 50 through exchange). There are 183 registered card holders using the library facilities.

Many other institutions / organizations availed the Library facilities.

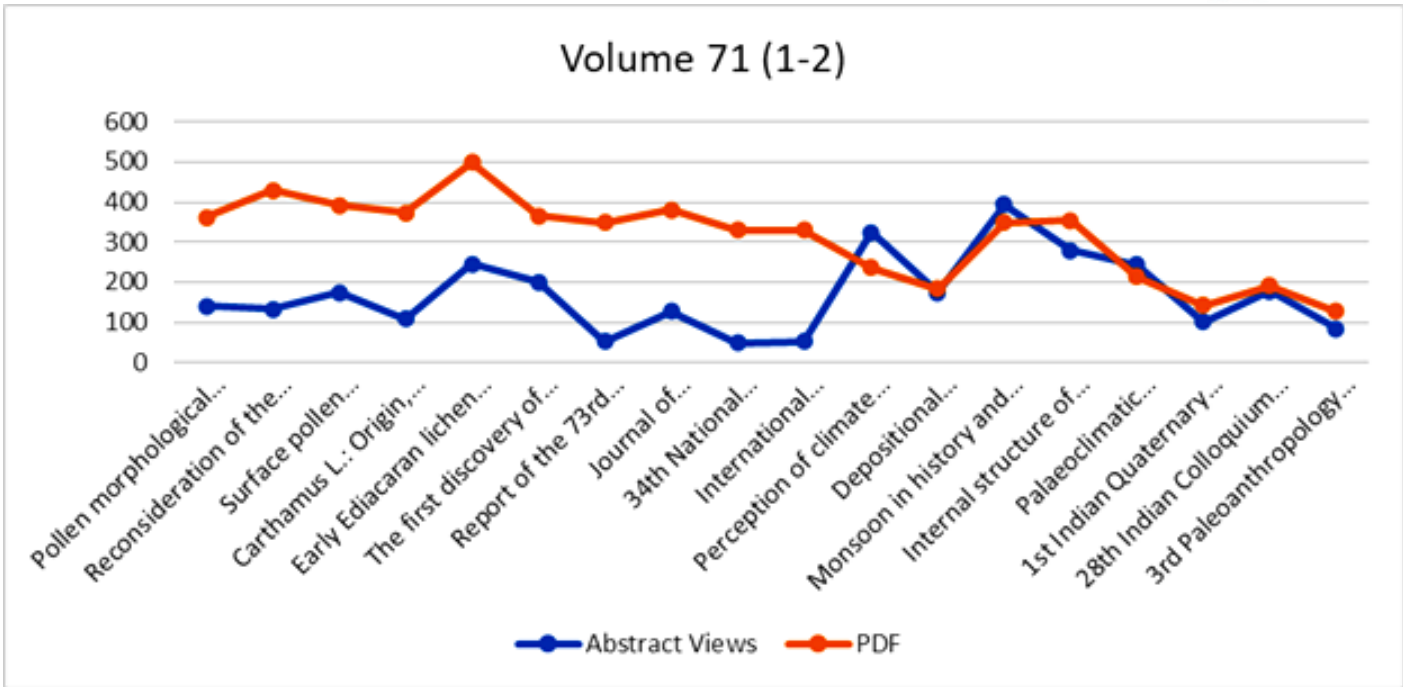
In addition, online access of e-journals and databases (viz. Scopus, Web of Science) is available over the Institute's LAN. KRC also provides plagiarism check of manuscripts through iThenticate software, reprography, weekly current awareness and daily local newspapers for reading.

PUBLICATION

The Journal of Palaeosciences, previously known as The Palaeobotanist, continues to make significant contributions towards disseminating scientific knowledge in the field of earth and life sciences.

The Journal of Palaeosciences is an open-access, online journal that publishes research papers on palaeo-environmental, palaeoecological, palaeoclimatic, and palaeogeographic themes, covering the entire geological time scales from the pre-Cambrian to the Quaternary. In 2022, two issues of Volume 71 were published, containing a total of 11 papers and 6 reports. The journal's website, jpsonline.co.in, to keep pace with the swift technological advancements, the Journal of Palaeosciences has transitioned to a digital platform. An editorial has been published in Vol 71(2) titled "Journal of Palaeosciences: journal of the new era and newer multidisciplinary dimensions" that elucidates the journal's overarching vision and multidisciplinary approach. The editorial underscores the benefits of publishing with the journal and advocates for the adoption of an open access platform.

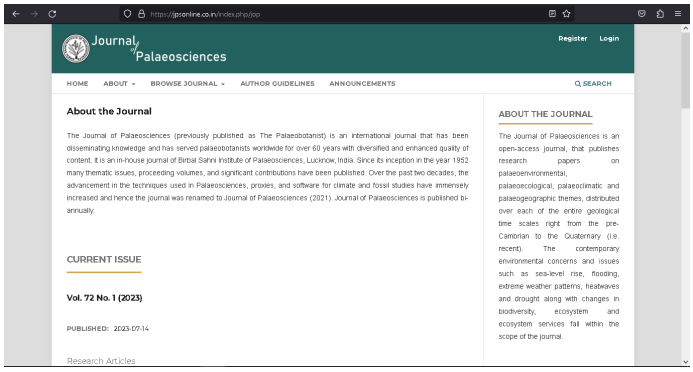
In addition to the journal, the Publication Unit was involved in publishing the bilingual Annual Report of the Institute in Hindi and English. This report contained relevant information related to research work carried out under different research projects during the period of 1st

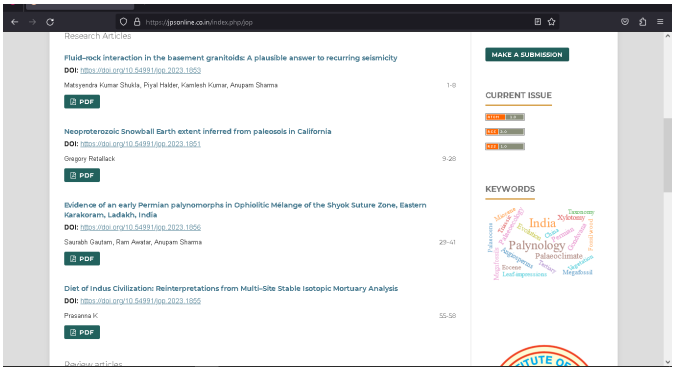


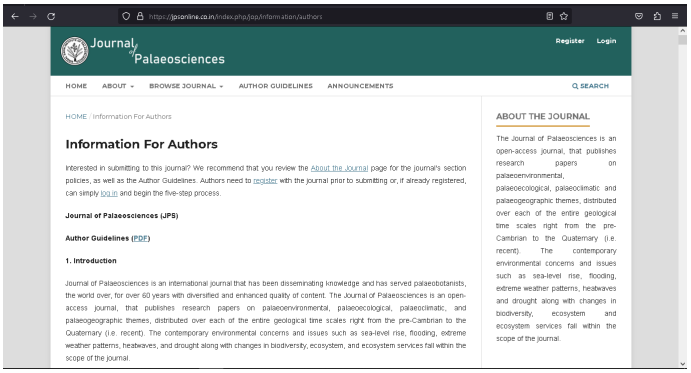
April, 2021 to 31st March 2022. It also included details of conference participation, awards, research papers published / accepted, training / deputation, Foundation / Founder's Day celebration, reports of different units, annual accounts, and related aspects with relevant graphics and photographs.

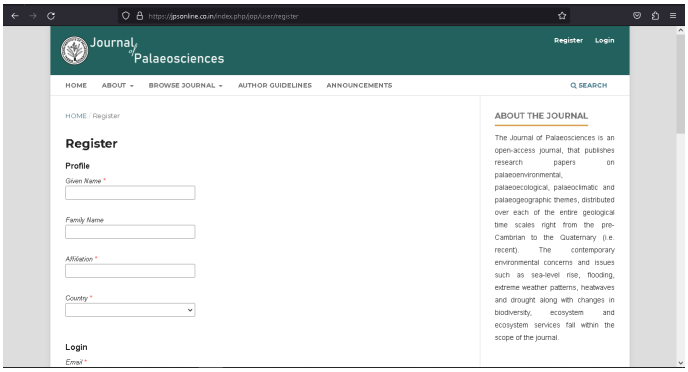
Publication Unit played an active role in handling correspondence work of the journal and printing invitation cards for Foundation Day, Founder's Day, Conference, and other programmes organized from time to time. Biographical profiles and abstracts of lectures given by eminent speakers on various functions were also printed.

Overall, the Publication Unit of Birbal Sahni Institute of Palaeosciences made noteworthy strides in 2022, in its efforts to disseminate scientific knowledge pertaining to the domains of earth and life sciences. The unit remains committed to publishing high-quality research articles, proceedings, and conference reports, and reaching a wider audience through various channels in the coming years.









STATUS OF OFFICIAL LANGUAGE

The Institute continues to pursue the set goals for Official Language implementation. The Institute participated in the meeting of Nagar Rajbhasha Kaaryaanvayan Samiti (Karyaalaya-3) during the year 2022. Scientists and Technical Officers/Employees of the Institute remained active and disseminated science in Official Language through various media platforms.

Hindi Fortnight

Hindi Fortnight was celebrated during 01-14 September ,2022 in the Institute.

During the fortnight, competitions, namely Debate, Hindi Typing, Noting, Dictation (for MTS only), Essay, E-Poster, Lecture by Non-Hindi Speaking Scientist, Antyaaksharee and Kavi Sammelan were organized.

Hindi Workshop

The undermentioned Hindi Workshops were organized. The workshops were followed by lively discussions related to the topics of talks and related terminology:

1. *Vijnaan ko Hindi men Badhaavaa dene ke Sutra* (on-line)
   Sri Kamakhyaa Narayan Singh, Assistant Director (O.L.), DST date: 31.5.2022.
2. *Vijnaan evam Praudyogikee mein Hindi kee Bhumika*
   Dr. Ajay Kumar Sah, Principal Scientist, IISR & Secretary, TOLIC (Karyaalaya-3) date: 01.9.2022.
3. *Madhya Pradesh se Praapt Glossopteris Vanaspati: Antim Parmiyan Aayunirdhaaran*
   Dr. S. Suresh K. Pillai, Scientist 'E', BSIP date: 15.12.2022.
4. Effect of Indian Monsoon on India Ocean Dipole
   Mr. Brijesh Kumar, SRF, BSIP date: 16.3.2023.

Miscellaneous

The computers of the Institute with net facilities have access to multi-lingual software. The annual report of the Institute was published in Hindi also. In the international journal of the Institute, *'Journal of Palaeosciences'* abstracts of all the research papers were published in Hindi. The Convener, Dr. Swati Tripathi and Member–Secretary, Mr. Ashok Kumar of the Official Language Implementation Committee were deputed to DST in view of the ensuing Inspection of the Parliament Committee on the Official Language in the Institute. From time to time internal meetings of the Official Language Implementation Committee were held for discussing and monitoring the progress of the use of Official Language in various sections.

The Institute received an appreciation certificate from the TOLIC (Karyaalaya-3) for its Hindi e-Magazine *Puravijnaan Smaarikaa* (Volume 1 published in September 2022).


बीरबल साहनी पुराविज्ञान संस्थान, लखनऊ
Birbal Sahni Institute of Palaeosciences, Lucknow
हिंदी पखवाड़ा / HINDI FORTNIGHT
01-14 सितंबर


बीरबल साहनी पुराविज्ञान संस्थान
लखनऊ
Birbal Sahni Institute of Palaeosciences
Lucknow


बीरबल साहनी पुराविज्ञान संस्थान, लखनऊ
Birbal Sahni Institute of Palaeosciences, Lucknow
HINDI FORTNIGHT

PERSONNEL

BSIP PERSONNEL

DIRECTOR

Dr (Mrs) Vandana Prasad

SCIENTIST 'G'

1. Dr Anupam Sharma (w.e.f. 01.01.2023)
2. Dr Mukund Sharma (retired w.e.f. 31.12.2022)

SCIENTIST 'F'

1. Dr Rajesh Agnihotri (expired on 17.01.2023)
2. Dr (Mrs) Anjum Farooqui (retired w.e.f. 31.12.2022)
3. Dr Ratan Kar (w.e.f. 01.07.2022)
4. Dr (Mrs) Binita Phartiyal (w.e.f. 01.07.2022)
5. Dr Anil Kumar Pokharia (w.e.f. 01.07.2022)

SCIENTIST 'E'

1. Dr Sadhan Kumar Basumatary
2. Dr (Ms) Ruby Ghosh (w.e.f. 01.01.2023)
3. Dr Pawan Govil
4. Dr Abhijit Mazumder (w.e.f. 01.01.2023)
5. Dr Krishna Gopal Misra
6. Dr Srikanta Murthy
7. Dr S. Suresh Kumar Pillai
8. Dr Parminder Singh Ranhotra (w.e.f. 01.07.2022)
9. Dr (Mrs) K. Pauline Sabina
10. Dr (Mrs) Anju Saxena
11. Dr Santosh Kumar Shah
12. Dr Hukam Singh
13. Dr (Ms) Vartika Singh (w.e.f. 01.01.2023)
14. Sri Veeru Kant Singh
15. Dr Biswajeet Thakur
16. Dr (Mrs) Anjali Trivedi (w.e.f. 01.01.2023)
17. Dr (Mrs) Poonam Verma (w.e.f. 01.01.2023)

SCIENTIST 'D'

1. Dr (Mrs) Abha
2. Dr (Mrs) Neha Aggarwal
3. Dr Shailesh Agarwal
4. Dr (Mrs) Deepa Agnihotri
5. Dr Sheikh Nawaz Ali
6. Dr Arif Hussain Ansari
7. Dr Vivesh Vir Kapur
8. Dr Kamlesh Kumar
9. Dr Manoj M.C.
10. Dr Runcie Paul Mathews (w.e.f. 01.07.2022)
11. Dr P. Morthekai
12. Dr (Mrs) Neelam
13. Dr Santosh Kumar Pandey
14. Dr (Mrs) Shilpa Pandey
15. Dr Mohd. Firoze Quamar
16. Dr Niraj Rai
17. Dr (Mrs) Anumeha Shukla
18. Dr Sunil Kumar Shukla
19. Dr Gaurav Srivastava
20. Dr Jyoti Srivastava
21. Dr (Mrs) Swati Tripathi

SCIENTIST 'C'

1. Dr Sajid Ali (on lien w.e.f. 01.09.2022)
2. Dr Mohammad Arif
3. Dr Ansuya Bhandari
4. Dr Trina Bose
5. Dr Gurumurthy G.P.
6. Dr Niteshkumar Narendra Khonde
7. Dr Prasanna K.
8. Dr (Mrs) Yogmaya Shukla
9. Dr Arvind Kumar Singh

SCIENTIST 'B'

1. Dr Adrita Choudhuri
2. Sri Sanjay Kumar Singh Gahlaud
3. Dr Anurag Kumar
4. Sri Sabyasachi Mandal
5. Dr Divya Kumari Mishra
6. Dr (Mrs) Shreya Mishra
7. Dr Ranveer Singh Negi
8. Dr Suman Sarkar
9. Dr Mayank Shekhar
10. Dr Prem Raj Uddandam

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 (retired w.e.f. 31.05.2022)
6. Sri Yogendra Pratap Singh

(The names are in alphabetical order according to surnames)

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. Dr 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 Sonker
2. Sri Shailendra Kumar Yadav

REGISTRAR

Sri Sandeep Kumar Shivhare

ACCOUNTS OFFICER

Sri Ashutosh Shukla

PRIVATE SECRETARY

Mrs M. Jagath Janani retired (w.e.f. 30.04.2022)

SECTION OFFICER

1. Sri Mishri Lal
2. Mrs Swapna Mazumdar
3. Sri K.P. Singh
4. Sri N.U. Kannan
5. Sri Gopal Singh

STENOGRAPHER

Sri Murukan Pillai

ASSISTANTS

1. Ms Chitra Chatterjee (retired w.e.f. 31.12.2022)
2. Sri Shailendra Singh Panwar
3. Sri Rameshwar Prasad
4. Sri Avinash Kumar Srivastava
5. Mrs Renu Srivastava (retired w.e.f. 31.05.2022)
6. Mrs Manisha Tharu
7. Sri Koshy Thomas (retired w.e.f. 30.04.2022)

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
2. Sri Shailesh Kumar
3. Sri Purneshwar Prakash Mishra
4. Mrs Savita Nair
5. Sri Abhishek Sachan
6. Ms Barsha Shah
7. Sri Abhay Shukla
8. Sri Rajat Srivastava
9. Mrs Vijaya Venkateshwari
10. Sri Pushkar Verma
11. Sri Karan Yadav

DRIVER 'IV'

1. Sri Devendra Kumar Misra (retired w.e.f. 30.06.2022)
2. Sri Pushpendra K. Misra

MULTI TASKING STAFF

1. Mrs Bhawana Awasthi
2. Sri R.K. Awasthi
3. Mrs Beena
4. Sri Ram Chander
5. Sri Ram Dheeraj
6. Sri Vishwanath S. Gaikwad
7. Ms Prapti Gupta
8. Sri Palton Ho (w.e.f. 25.04.2022)
9. Mrs Ram Kali
10. Sri Sanjay Kashyap
11. Sri Hari Kishan (retired w.e.f. 31.12.2022)
12. Sri Deepak Kumar
13. Sri Indra Kumar
14. Sri Jitendra Kumar
15. Sri Ramesh Kumar
16. Sri Sunit Kumar
17. Sri Dhan Bahadur Kunwar
18. Sri Manish Mishra
19. Sri Prabhat Mishra
20. Ms Nandani
21. Sri Kailesh Nath (retired w.e.f. 31.05.2022)
22. Sri Mani Lal Pal
23. Sri Lavkush Pandey
24. Sri Puneet Pandey
25. Sri Mathura Prasad
26. Sri Ashik Gyaniram Saryam (w.e.f. 25.08.2022)
27. Sri Ravi Shankar
28. Sri Aquil Siddiqui
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

BIRBAL SAHNI RESEARCH ASSOCIATE

1. Sri Shamim Ahmad (relieved w.e.f. 27.08.2022)
2. Shri Saurabh Gautam (relieved w.e.f. 28.08.2022)
3. Ms Debarati Nag (relieved w.e.f. 06.09.2022)
4. Ms Sandhya Sharma (relieved w.e.f. 17.09.2022)

BIRBAL SAHNI RESEARCH SCHOLAR

1. Sri Pawan Kumar Singh (tenure completed on 26.08.2022)
2. Ms Pooja Tiwari (tenure completed on 26.08.2022)
3. Ms Shalini Parmar (tenure completed on 27.08.2022)
4. Ms Priya Agnihotri (tenure completed on 27.08.2022)
5. Ms Harshita Srivastava (tenure completed on 27.08.2022)
6. Ms Supriya Kumari (tenure completed on 27.08.2022)
7. Ms Divya Singh (tenure completed on 28.08.2022)
8. Ms Kajal Chandra (tenure completed on 28.08.2022)
9. Ms Harshita Bhatia (relieved w.e.f. 04.09.2022)
10. Ms Prachita Arora (tenure completed on 14.09.2022)

APPOINTMENTS

MTS

1. Mr. Palton Ho (w.e.f. 25.04.2022)
2. Mr. Ashik Gyaniram Saryam (w.e.f. 25.08.2022)

PROMOTIONS

SCIENTIFIC STAFF

1. Dr. Anil Kumar Pokharia, Scientist –'F' (w.e.f. 01.07.2022)
2. Dr. Binita Phartiyal Scientist –'F' (w.e.f. 01.07.2022)
3. Dr. Ratan Kar Scientist –'F' (w.e.f. 01.07.2022)
4. Dr. Parminder Singh Ranhotra Scientist –'E' (w.e.f. 01.07.2022)
5. Dr. Runcie Paul Mathews, Scientist –'D' (w.e.f. 01.07.2022)
6. Dr. Anupam Sharma Scientist –'G' (w.e.f. 01.01.2023)
7. Dr. Abhijit Mazumder Scientist –'E' (w.e.f. 01.01.2023)
8. Dr. (Ms) Vartika Singh Scientist –'E' (w.e.f. 01.01.2023)
9. Dr. (Mrs) Anjali Trivedi Scientist –'E' (w.e.f. 01.01.2023)
10. Dr. (Mrs) Poonam Verma Scientist –'E' (w.e.f. 01.01.2023)
11. Dr. (Ms) Ruby Ghosh Scientist –'E' (w.e.f. 01.01.2023)

RESIGNATION / RELIEVED

1. Shri Shamim Ahmad (relieved w.e.f.27.08.2022)
2. Shri Saurabh Gautam (relieved w.e.f.28.08.2022)
3. Ms. Debarati Nag (relieved w.e.f. 06.09.2022)
4. Ms. Sandhya Sharma (relieved w.e.f.17.09.2022)
5. Mr Pawan Kumar Singh (tenure completed on 26.08.2022)
6. Ms Pooja Tiwari (tenure completed on 26.08.2022)
7. Ms Shalini Parmar (tenure completed on 27.08.2022)
8. Ms Priya Agnihotri (tenure completed on 27.08.2022)
9. Ms Harshita Srivastava (tenure completed on 27.08.2022)
10. Ms Supriya Kumari (tenure completed on 27.08.2022)
11. Ms Divya Singh (tenure completed on 28.08.2022)
12. Ms Kajal Chandra (tenure completed on 28.08.2022)
13. Ms Harshita Bhatia (relived w.e.f. 04.09.2022)
14. Ms Prachita Arora (tenure completed on 14.09.2022)

SUPERANNUATION

1. Mrs M. Jagath Janani (retired on 30.04.2022)
2. Sri Koshy Thomas (retired on 30.04.2022)
3. Sri V.K. Nigam (retired on 31.05.2022)
4. Mrs Renu Srivastava (retired on 31.05.2022)
5. Sri Kailesh Nath (retired on 31.05.2022)
6. Sri Devendra Kumar Misra (retired on 30.06.2022)
7. Dr. Mukund Sharma (retired on 31.12.2022)
8. Dr. (Mrs) Anjum Farooqui (retired on 31.12.2022)
9. Miss Chitra Chatterjee (retired on 31.12.2022)
10. Sri Hari Kishan (retired on 31.12.2022)
11. Sri M. Pillai (retired on 31.03.2023)

OBITUARY

1. Dr. G. Rajagopalan, Ex- Scientist-'G' (on 19.06.2022)
2. Sh. Bhagwan Singh, Ex- Section Officer (on 28.08.2022)
3. Sh. J. C. Srivastava, Ex- Junior Technical Officer (on 11.01.2023)
4. Dr. Rajesh Agnihotri, Scientist 'F' on 17.01.2023

OTHER SCIENTIFIC STAFF & PROJECT / RESEARCH SCHOLARS

SPONSORED PROJECT

RESEARCH ASSOCIATE

1. Dr Bandana Shukla, ONGC
2. Dr Lomas Kumar, DAM, Govt. of Gujarat (w.e.f. 16.03.2023)

SENIOR RESEARCH FELLOW

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

JUNIOR RESEARCH FELLOW

1. Sri Deveshwar Prakash Mishra, DST-SERB
2. Sri Ramanand Sagar, DST-SERB
3. Sri Sadanand Pathak, DST-SERB
4. Sri Yogesh Kumar, ONGC
5. Sri Piyal Haldar, MOES
6. Ms Vartika Singh, MOES
7. Ms Nidhi Tomar, SAC-ISRO
8. Ms Trishika Seth, NCPOR (resigned w.e.f. 28.04.2022)
9. Sri Siddhant Vaish, DST-SERB
10. Sri Abhinav Jain, DST-SERB
11. Ms Ayushi Misra, DST-SERB

PROJECT ASSISTANT

1. Sri Ashish Kumar Mishra, ONGC, (resigned w.e.f. 23.02.2023)
2. Sri Raj Kumar, ONGC
3. Sri Sachin Kumar, DST-SERB
4. Sri Vishwadeep Rout, NCPOR (resigned w.e.f. 30.06.2022)
5. Ms Bhawana Ahlawat, DSM, Govt. of Gujarat (w.e.f. 15.03.2023)
6. Stuti Saxena, ONGC
7. Yogesh Pal Singh, ONGC

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

JUNIOR RESEARCH FELLOW

1. Ms Arya Pandey, DST-INSPIRE
2. Ms Deeksha, DST-INSPIRE
3. Sri Hidayatullah, DST-INSPIRE
4. Sri Kishore Katange, DST-INSPIRE
5. Ms Lopamudra Roy, DST-INSPIRE
6. Sri Mohd. Arif Ansari, DST-INSPIRE
7. Ms Pooja Saraf, DST-INSPIRE
8. Ms Sneha Mary Mathews, DST-INSPIRE
9. Ms Stuti Saxena, DST-INSPIRE
10. Sri Vijay Kumar Rathaur, DST-INSPIRE
11. Sri Anand Rajoria, 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 Sarvendra Pratap Singh, CSIR
17. Sri Shirish Verma, CSIR
18. Ms Richa, UGC
19. Sri Kumail Ahmad, UGC (w.e.f. 25.08.2022)
20. Sri Nazakat Ali, UGC
21. Ms Aparna Dwivedi, UGC
22. Sri Faizan Ahmed Khan, UGC (w.e.f. 22.08.2022)
23. Sri Brijesh Kumar, UGC
24. Sri Shubham Mishra, UGC (w.e.f. 23.08.2022)
25. Ms Mitra Rajak, UGC (w.e.f. 14.09.2022)
26. Ms Samiksha Shukla, UGC
27. Sri Lamgingsang Thomte, UGC
28. Sri Arvind Tiwari, UGC
29. Ms Divya Verma, UGC
30. Ms Sadhana Vishwakarma, UGC

DIRECTOR SECTION

Sitting L to R: Puneet Pandey, M J Janani, Madhukar Arvind, P.K. Misra, Dhan Bahadur Kunwar

REGISTRAR SECTION

Sitting L to R: Prapti Gupta, Rahul Gupta, Sandeep K Shivhare, Pushkar Verma, Karan Yadav
Standing L to R: Jitendra Kumar, Prabhat Mishra, Vishwanath S. Gaikwad

RESEARCH DEVELOPMENT & COORDINATION CELL

Sitting L to R: Prasanna K, Vivesh V Kapur, Anupam Sharma, Vandana Prasad, Anju Saxena, Neha Aggarwal

ACCOUNTS SECTION

Sitting L to R: Rajesh K Mishra, Ashutosh Shukla, K P Singh, Shailendra S Panwar
Standing L to R: R K Awasthi, Abhishekh Sachan, Manoj Singh, Lavkush Pandey, Barsha Shah

ESTABLISHMENT SECTION

Sitting L to R: Akshay Kumar, Ashok Kumar, Swapna Mazumdar, Rameshwar Prasad, Ram Kali

STORES SECTION

Sitting L to R: Savita Nair, Mishri Lal, Shailendra Yadav, Anupam Jain
Standing L to R: Manish Mishra, Purneshwar P Mishra

WORKS & BUILDING SECTION

Sitting L to R: Shailesh Kumar, Madan S Rana, N Unnikannan, Ashok Sharma, Suneet Kumar, Sanjay Kashyap

SCIENTIFIC ACTIVITY SECTION

Sitting L to R: Manisha Tharu, Sudha Kureel, Gopal Singh, Ram Singh

SPONSORED PROJECT SECTION

Sitting L to R: Inder Kumar, Avinash K Srivastava, Sandhya Singh

MUSEUM COMMITTEE

Standing L to R: Abhijit Mazumder, N Unnikannan, Ranveer S Negi, SSK Pillai, Neelam Das, Archana Sonker, Trina Bose

HINDI RAJBHASHA COMMITTEE

Sitting L to R: Sandeep K Shivhare, Poonam Verma, Vandana Prasad, Swapna Mazumdar, Pawan S Katiyar,
Standing L to R: Ashok Kumar, Swati Dixit, Neelam Das, Divya K Mishra, Prasanta K Das

GARDEN COMMITTEE

Standing L to R: Inder K Yadav, Mathura Prasad, Ansuya Bhandari, Shivalee Srivastava, Ashutosh Shukla, Sadhan K Basumatary, Ram Chander, Ram Kewal

STAFF WELFARE COMMITTEE

Sitting L to R: Sabyasachi Mandal, Prasanta K Das, Abha Singh, Divya K Mishra, Nandani, Karan Yadav

COAL QUALITY ASSESSMENT GROUP

Standing L to R: Shivam Yadav, Runci Paul Mathews, Divya K Mishra, Vandana Prasad, Neha Aggarwal, Shivalee Srivastava, Prasanna K, Manoj M C

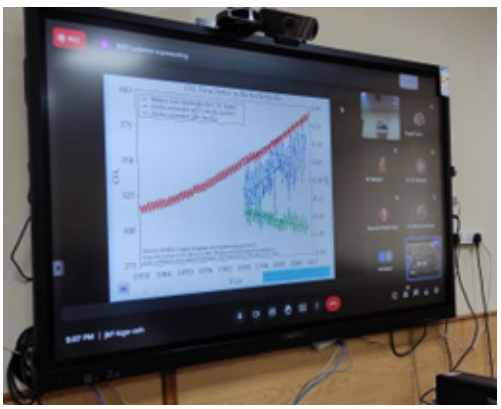
EVENTS

Death Anniversary of Prof. Birbal Sahni: April 10, 2022

Floral tributes were offered to Late Prof. Birbal Sahni at his Samadhi in the Institute premises on the 10th April, 2022 by all the scientific, technical and administrative staff of the institute.

Second Palaeobotanical Society Lecture: April 28, 2022

Professor Kevin McCartney (Director, North Maine Museum of Science, University of Maine, USA) delivered (via online mode) the Second Palaeobotanical Society Lecture titled "Silicoflagellates: skeletal morphology and evolution" on the 28th April, 2022. Dr. Vandana Prasad (Director, BSIP & President of the Society), council members of the Palaeobotanical Society and staff of BSIP attended the lecture.

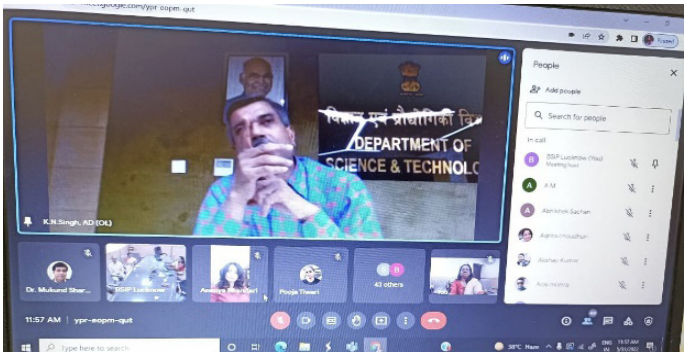


Celebration of Swachhata Pakhwada under Swachhata Action Plan: May 01-15, 2022

Under the *Swachhata Action Plan 2022-23*, a fortnightly celebration of Swachhata Pakhwada with a series of events were conducted from 01st to 15th May, 2022 within the institute premises. These events included Swachhata Pledge, Quiz Competition, Plantation Programme, and a cleanliness drive. All the scientific staff, research scholars, technical and administrative staff members of the institute participated enthusiastically in the event to make it successful.

Hindi Workshop Lecture: May 31, 2022

Shri Kamakhya Narayan Singh (Assistant Director, Official Language Department, DST, New Delhi) delivered a lecture titled “Ways to promote science in Hindi”via online mode.



“Har Ghar Tiranga” Programme: June 14, 2022

As part of the “Har Ghar Tiranga” Programme, BSIP scientists delivered lectures on emphasizing the unsung heroes of freedom movement of India and the historical aspects and significance of the Indian National Flag. The event was followed Poem Recitation ‘Kavita Path’ by staff members and research scholars of the institute.

Building Committee Meeting: June 16, 2022

8th International Yoga Day Celebration: June 21, 2022

The 8th International Yoga Day was celebrated on the 21st June, 2022 with a yoga session conducted in the BSIP premises for all the staff members. The yoga session included Gentle Yoga flow, Surya Namaskar, Pain and stress reliving asanas and Pranayama asanas. The session was attended by BSIP staff members.

Invited Scientific Lecture: July 13, 2022

Dr. Kalachand Sain (Director, Wadia Institute of Himalayan Geology-WIHG, Dehradun) delivered a talk on the topic "Machine learning and its applications to geosciences" on the 13thJuly, 2022 at BSIP premises. Prof. L. S. Chamyal (Chairman, RAC, BSIP) presided over the function and Prof. GVR Prasad (Member, RAC, BSIP) was the Guest of Honour for the event. All the RAC members of the institute, scientific staff and research scholars attended the event.

Independence Day Celebration: August 15, 2022

Flag hoisting ceremony was organized on the auspicious occasion of the 76th Independence Day (15th August 2022) at the BSIP premises. After singing of the National Anthem 'Rashtra Gaan', a short cultural event was also organized with the active participation of institute staff members. Dr Vandana Prasad (Director, BSIP) highlighted the significance of freedom, struggles and efforts of numerous freedom fighters in her speech. Further, she emphasized on the need for concerted research efforts towards further development of the institute in the subject area of Palaeosciences and allied aspects. The event was attended by all the scientific, technical and administrative staff members of the institute.

National Accreditation Board for testing and calibration Laboratories (NABL) awareness program: August 30, 2022

BSIP organized a National Accreditation Board for testing and calibration Laboratories (NABL) awareness program on the 30thAugust, 2022 (via online mode) for all the scientific and technical staff members who are actively involved in the day-to-day successful running of the analytical laboratories at the BSIP. The officials of NABL presented a detailed description of their organization's functioning, testing and calibration standards for various types of scientific laboratories accredited under NABL. In addition, the NABL officials also discussed (in detail) the guidelines and procedures for acquiring a NABL accreditation certificate of testing for various state-of-the-art laboratories at BSIP.

Hindi Fortnight (Pakhwada): September 01-14, 2022

The institute celebrated the Hindi Fortnight (Pakhwada) from 01st to 14th September, 2022. The event was inaugurated by the Director, BSIP (Dr Vandana Prasad) and Dr Ajay Kumar Sah [Principal Scientist and In-charge, Indian Institute of Sugarcane Research (IISR), Lucknow] delivered a lecture titled विज्ञान एवं प्रौद्योगिकी प्रसार में हिन्दी की भूमिका on the 01st September, 2022. Various types of competitions such as Hindi Typing (computer based), Debate Competition, Noting, Poster Competition, Essay Writing, Poem Recitation and 'Antyakshari' were organized in the institute premises during September 01-14, 2022. All the scientific, technical and administrative staff, research scholars of the institute participated in the above-mentioned events with enthusiasm.

Foundation Day Celebration: September 10, 2022

Foundation Day of the Institute was celebrated on the 10th September, 2022 by offering floral tributes to Late Prof. Birbal Sahni by Prof. Nitin R Karmalkar (Chairman, Governing Body, BSIP), Dr. Vandana Prasad (Director, BSIP), Prof. Ashutosh Sharma (Department of Chemical Engineering, Indian Institute of Technology (IIT) Kanpur, Uttar Pradesh), and all the scientific, technical and administrative staff of the institute. On this occasion, Prof. Ashutosh Sharma (IIT Kanpur) delivered a lecture titled "Science and Scientists in the New Millennium: A Short History of the Future". In addition, on the occasion of the Foundation Day, the BSIP released the first issue of the Hindi Magazine "पुराविज्ञान स्मारिका" which contains both general and technical articles contributed by the Institute's staff.

Governing Body Meeting: September 10, 2022

Third Palaeobotanical Society Invited Lecture: September 26, 2022

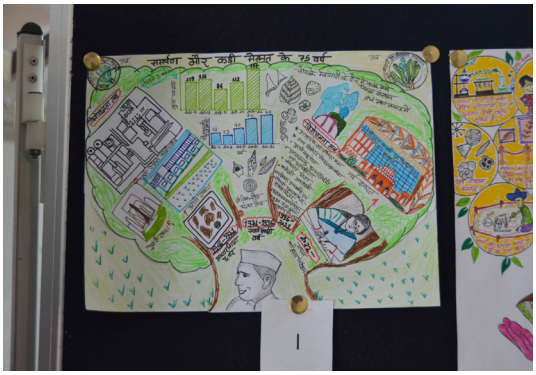
The Third Palaeobotanical Society Invited Lecture titled "Herbarium techniques and digitization" was delivered by Dr. Arti Garg (Scientist-E & Head, Botanical Survey of India, Central Regional Centre, Allahabad, Uttar Pradesh) on the 26th September, 2022 (via Online mode). Dr. Vandana Prasad (Director, BSIP & President of the Society) was the Chief Guest for the event. The members of the Palaeobotanical Society and staff of BSIP attended the lecture.

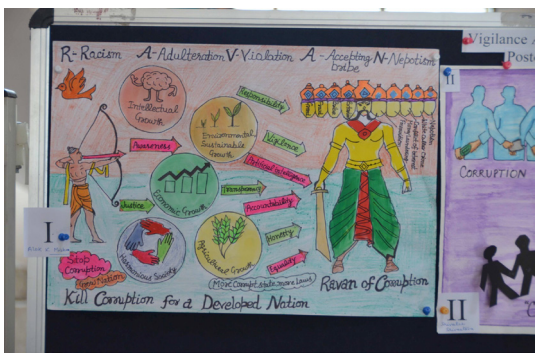
Special Campaign on Cleanliness (DST): October 02-31, 2022

As part of a special campaign on cleanliness from 02-31 October, 2022 on the directives of the Department of Science and Technology (DST), New Delhi, the BSIP scientific and technical staff monitored and cleaned various laboratories in the institute. In addition, a plantation drive was also conducted in the institute premises. All the above-mentioned activities were recorded (photographed) during the cleanliness campaign.

Vigilance Awareness Week: October 31–November 06, 2022

As per the directives of the Govt. of India, Vigilance Awareness Week-2022 was observed from 31st October to 06th November, 2022 at BSIP. An 'Integrity Pledge' both in Hindi and English languages was undertaken on the 31st October, 2022 at 11:00 A.M. by all the scientific, technical and administrative staff members of the institute. Additionally, a Poster Competition on the topic "Corruption free India for a developed Nation; भ्रष्टाचार मुक्त भारत - विकसित भारत" and an Essay Writing Competition on the topic "Role of citizens in eradicating corruption; भ्रष्टाचार उन्मूलन में नागरिकों की भूमिका" were organized in the Institute during the Vigilance Awareness Week-2022. Subsequently, on the occasion of the Founder's Day of the Institute, i.e. on 14th November, 2022, the winners of both the above-mentioned competitions were facilitated with prizes and certificates.





Fourth Palaeobotanical Society Invited Lecture: November 10, 2022

The Fourth Palaeobotanical Society Invited Lecture titled "Hydrocarbon Source Rock Evaluation"was delivered by Dr. Om Prakash Thakur (Assistant Professor, Department of Geology, Kurukshetra University, Kurukshetra, Haryana) on the 10th November, 2022 (via online mode). Dr. Vandana Prasad (Director, BSIP & President of the Society), council members of the Palaeobotanical Society and staff of BSIP attended the lecture.

Founder's Day Function: November 14, 2022

The BSIP celebrated Founder's Day Function on the 14th November, 2022. Floral tributes were given to Prof. Birbal Sahni on this occasion. The Chief Guest of the event was Prof. Alok Dhawan [Director, Center for Biomedical Research (CBMR), Lucknow]. During the event, Dr. Vandana Prasad (Director BSIP) highlighted the legacy and contributions of Late Prof. Birbal Sahni. She also provided an overview of the achievements, ongoing research activities of BSIP and appreciated the institute's contribution in various activities such as Special Cleanliness Drive-2, Hindi Pakhwada and Vigilance Awareness Week-2022. In addition, Prof. Maharaj Krishan Pandit (Dean, Jindal School of Environment & Sustainability, Jindal Global University) delivered the 52nd Prof. Birbal Sahni Memorial Lecture entitled "A unified bio-geo-climatic framework for understanding evolutionary divergence of the Himalayan flora". In his lecture, Prof. Pandit discussed rich diversity of Himalayan flora and its changing dynamics with the effect of climate change. The BSIPs Annual Report (2021-2022) was released and a short-film on institute's contribution in the various events (in particular cleanliness drive) during the year 2021-2022 was showcased on this occasion.

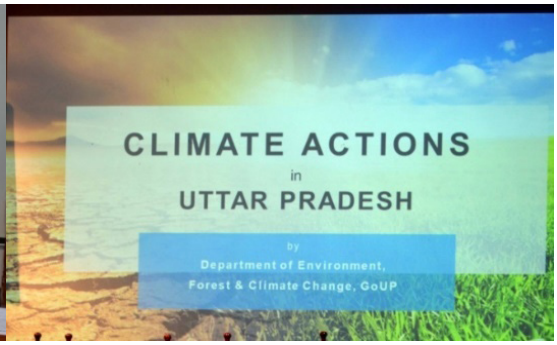
Awareness Program for Women Empowerment and Security: November 25–December 10, 2022

As per the directives of the Ministry of Women and Child Development, Govt. of India, a 16-days (i.e., from 25th November to 10th December 2022) campaign was conducted in the BSIP to raise awareness about the elimination of all forms of violence and discrimination against women to ensure safety, security and holistic empowerment of women. Further, to ensure that the basic human rights of women and girls are respected by all.

In this regard, two events: (1) Debate Competition and (2) Poster Competition were organized at BSIP. The topic of the Debate Competition held on the November 30, 2022 was "Gender Equality in STEM fields in India" in which the contestants presented their "for or against" views on the debated topic. The topic provided for the Poster Competition was titled "Women Empowerment in the Digital Era" and many staff members of BSIP including Research Associates, Research Scholars and Project Staff took active participation.

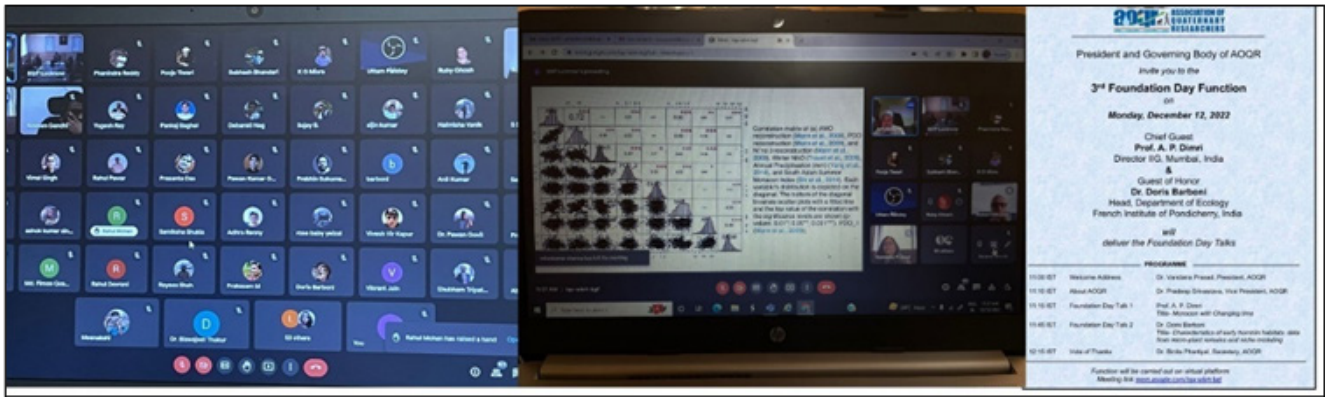
High End Workshop (Karyashala) on "Disaster and Climate-Resilient Pathways: Adaptation, Mitigation and Sustainable Development" as part of the SERB-Accelerate Vigyan Scheme: December 07-13, 2022

A High-End Workshop (Karyashala) on "Disaster and Climate-Resilient Pathways: Adaptation, Mitigation and Sustainable Development" as part of the SERB-Accelerate Vigyan Scheme was conducted from 07th to 13th December, 2022 at BSIP. The salient objectives of the workshop was to foster advance research and education programs focusing on building climate resilience and disaster risk reduction, to bring together young researchers, students as well as disaster risk and climate change experts to strengthen cooperation, links and synergies to address current and future impacts of climate change and disasters on human life, livelihood and to address underlying causes of vulnerability, to sensitize the participants in the potential and scope of nature-based solutions, remote sensing, GIS for holistic disaster risk reduction and climate resilience, to assess the new perspectives and challenges that climate change brings to the disaster risk management field. "Karyashala" was attended by postgraduate students and research scholars from various national institutes, universities and colleges. Additionally, Eminent researchers/academicians from various parts of the country visited the institute and delivered talks on a variety of topics linked to disaster risk management, extreme weather events and its consequences and monitoring and many others. Participants of the workshop also visited all the BSIP's research laboratories and Institute's museum.



The 3rd Foundation Day Function of Association of Quaternary Researchers (AOQR): December 12, 2022

The Association of Quaternary Researchers (AOQR) celebrated its Third Foundation Day on the 12th December, 2022. Prof. A.P. Dimri [Director, Indian Institute of Geomagnetism (IIG), Mumbai] graced the occasion as Chief Guest and Dr. Doris Barboni (Department of Ecology, French Institute of Pondicherry) was the Guest of Honour for the event. On this occasion, Prof. A.P. Dimri delivered a talk titled "Monsoon with changing time" while Dr. Doris Barboni delivered a talk on the topic "Characteristics of early hominin habitats: data from micro-plant remains and niche modelling". The event was attended by scientists, academicians, and research scholars from various institutes across the country including but not limited to Wadia Institute of Himalayan Geology (WIHG), Lucknow University, Kumaon University and French Institute of Pondicherry.



Curtain Raiser for India International Science Festival-2022: January 13, 2023

As part of the Curtain Raising ceremony of the India International Science Festival-2022, a few outreach activities were organized by the BSIP on the 13th January, 2022. A total of 40 students from various institutions across the country visited BSIP and were provided guided tour of the institute's museum, and state-of-the-art laboratories. On this occasion, Dr SSK Pillai (Scientist-E) delivered a talk on the topic "Fossils & BSIP's contribution in the development of Geoheritage parks".

Annual General Meeting of the Association of Quaternary Researchers (AOQR): January 24, 2023

Annual General Meeting of the Association of Quaternary Researchers (AOQR) was conducted successfully on the 24th January, 2023 at the Natural History Museum, Christ College, Thrissur, Kerala. The meeting was attended by several members of the AOQR through both offline and online mode. Vice-President (Dr. Pradeep Srivastava, IIT Roorkee) presided over the meeting and delivered the welcome address. During the event, various activities were carried out such as: delivery of the Secretary's Report, briefing about AOQR activities, a remembrance meet for Professor S N Rajguru, discussions for Indian Quaternary Congress 2024 and delivery of the Treasure's Report.

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Visit of Apex Committee for Establishment of Coal Consultancy Lab: January 24, 2023

Republic Day: January 26, 2023

Brain Storming Session at IIT-Roorkee Noida Center: February 21, 2023

BSIP scientists attended a three-days Brain Storming Session at IIT-Roorkee, Noida Center. Fruitful discussions amongst scientists of 16 institutions across India have led to formulating the key questions & their deliverables for "Integrating Molecular Biology & Geosciences in India.

7th PAMC-Geosciences Meeting: February 23-24, 2023

The 7th PAMC-Geosciences Meeting of the Ministry of Earth Sciences (MoES) was held on the 23– 24 February, 2023 at BSIP. Prof. AK Singhvi chaired the meeting which was attended by the Committee members of PAMC through hybrid (both online and offline) mode.

Research Advisory Council Meeting: February 27-28, 2023

National Science Day: February 28, 2023

BSIP celebrated the National Science Day on the 28th February, 2023 with active participation of the students of the Mahatma Gandhi Institute of Management and Technology (MGIMT), Lucknow. The students from the above-mentioned institute were provided guided tour of the BSIP museum and various state-of-the-art laboratories in BSIP. The students were encouraged to gather information regarding the ongoing research activities of BSIP. Additionally, the scientific staff of BSIP delivered talks to apprise students about the glorious history of the BSIP, its scientific endeavours, importance of National Science Day, scientific endeavours of Sir CV Raman, and an introduction on the Raman Effect.

National Geoheritage Field Workshop: March 03-04, 2023

A two-day National Geoheritage Field Workshop titled "Zawar Ancient Metallurgical National Geological Monument Jhamarkotra Stromatolite (Fossil Algae) National Geological Monument" was jointly organized by BSIP, Society of Earth Scientists and Janardan Rai Nagar Rajasthan Vidyapeeth University in the Zawar & Jhamarkotra region, near Udaipur District, Rajasthan State. During the two-day researchers, academicians, media personnel, and subject experts from various fields such as geology, archaeology, biotechnology discussed with regards to the action plan for the preservation and conservation of the ancient metallurgical sites of the Zawar region and one of the oldest records of stromatolites (fossil algae) and associated geological structures in the Jhamarkotra region in a Geoheritage-Geotourism perspective.

International School & Symposium (LEM) – 2023: March 13-24, 2023

As part of the International Union for Quaternary Research (INQUA) under the Humans & Biosphere Commission (HABCOM) funded "Landuse-Landcover Mapping and Modelling using Pollen and Isotopic Data in different ecological regions of the monsoon" (LEM) project, BSIP scientists conducted a workshop from 13-24 March, 2023 in western Vidarbha region, Maharashtra State. During the workshop, all the participants were trained in field surveys and landcover mapping by the BSIP scientific staff.

BSIP Friday Lecture Series

BSIP conducted a series of lectures during the year 2022-2023 (detailed underneath) with an aim to provide a platform to early career researchers/research scholars within the institute to showcase their ongoing research work in the field of Earth Sciences and allied subjects and have interactions with subject experts.

S. No.	Speaker	Title of the talk	Date
1.	Dr. Debarati Nag, BSRA, BSIP	Climate variability inferred from the lake deposits in Ladakh region of NW Trans Himalayan range since LGM	08 April, 2022
2.	Dr. Saurabh Gautam, BSRA, BSIP	Permian–Triassic palynofloral transition in Sohagpur Coalfield, South Rewa Gondwana Basin, Madhya Pradesh, India	22 April, 2022
3.	Dr. Adrita Choudhuri, Scientist- B, BSIP	Stratigraphic record: Continuous or discontinuous?	27 May, 2022
4.	Mr. Sabyasachi Mandal, Scientist - B, BSIP	Shallow marine glauconitization in response to the intra-basinal tectonics	03 June, 2022
5.	Dr. Sandhya Mishra, BSRA, BSIP	Archaeobotany: Looking into Green through Black	10 June, 2022
6.	Dr. Prem Raj Uddandam Scientist - B, BSIP	Late quaternary evolution of primary productivity in the northern Indian Ocean	01 July, 2022
7.	Dr. Anurag Kumar, Scientist - B, BSIP	Stable isotopes as a tracer to understand modern environments: a case study from Ganga River Basin	22 July, 2022
8.	Dr. Ranveer Singh Negi, Scientist - B, BSIP	Cambrian Biostratigraphy of the Tethyan Himalaya	29 July, 2022
9.	Mr. Masud Kawsar, SRF, BSIP	Advance insights into grain size interpretation in the context of paleoclimate and paleoceanographic research: Case studies from marine and terrestrial archives	13 January, 2023
10.	Dr. Mahi Bansal, SRF, BSIP	Biotic dispersal between the Indian Plate and other Gondwanan continents and Eurasia during Cretaceous-Paleogene: Testing hypotheses for paleobiogeographic implications	20 January, 2023
11.	Dr. Salman Khan, SRF, BSIP	Late Pliocene pollen-based vegetation record from ODP Hole 91OC, Yermak Plateau, Arctic Atlantic Gateway	27 January, 2023
12.	Dr. Ashish Kumar Mishra, SRF, BSIP	Cretaceous-early Paleogene biostratigraphy & paleoenvironment of the Krishna-Godavari Basin	03 February, 2023
13.	Dr. JC Kuniyal, Scientist G, GB Pant National Institute of Himalayan Environment, Almora	Invited Talk on “Himalaya & Climate Change: Adaptation & resilience building mechanism”	03 March, 2023
14.	Ms. Pujarini Samal, SRF, BSIP	Species distribution models to predict the priority conservation areas (PCAs) for mangrove ecosystem	17 March, 2023
15.	Dr. Divya Kumari Mishra, Scientist-B, BSIP	Technological properties of coal in context to coal quality assessment	24 March, 2023

OUTREACH ACTIVITIES

The Birbal Sahni Institute of Palaeosciences is thankful to the Department of Science and Technology, Government of India for financial support. Since its inception in 1946, the Birbal Sahni Institute of Palaeosciences has established itself in the subject area of palaeobotany (the study of plant fossils) that has aided in understanding the developmental patterns of plant life on our planet.

Various government schemes aim to steer the country's progress in research and development while bridging the gap between the industry and academics, and to enhance public outreach. Further, the younger population of India can shoulder the responsibility to steer the country towards a path of sustainable development. Over the past few years, the Birbal Sahni Institute of Palaeosciences has made tremendous efforts to conduct multidisciplinary research in the field of Geosciences and allied subjects. The institute's transformation has been possible due to active engagement of younger research community into the Institute's outreach activities and research work. Additionally, the institute is actively undertaking initiatives towards promotion of Geoheritage conservation across the country.

BSIP Museum and laboratory visits for Nav Yug Kanya Mahavidyalaya, Rajendra Nagar, Lucknow (May 19, 2022)

BSIP Scientists and Museum Staff provided an in-depth tour of BSIP Museum, and all the state-of the-art laboratories of the Institute to students of Nav Yug Kanya Mahavidyalaya, Rajendra Nagar, Lucknow. The students were introduced to the history of the BSIP and the concepts of good research practices in various types of laboratory environments.

Dr Suresh Kumar Pillai and Dr Vivesh Vir Kapur from BSIP were felicitated on the above-mentioned inaugural event by the Forest Department, Jharkhand. It is expected that the above-mentioned Geoheritage conservation efforts by BSIP and the Forest Department (Jharkhand State) would bring to light the geological and paleontological significance of the Rajmahal Hills and would also encourage geotourism in the region. The "Rajmahal Fossil Museum & Interpretation Centre" hosts a variety of galleries with digital (audio-visual) interactive displays providing basic information on Geosciences (including Palaeontology), the geological significance of the

Conceptualization and Development of Fossil Park at Mandro, Jharkhand: (Inaugurated on the June 30, 2022)

BSIP has conceptualized a fossil park at Mandro (District Sahibganj, Jharkhand) as part of a collaboration with the Forest Department, Jharkhand. The Mandro Fossil Park including "Rajmahal Fossil Museum & Interpretation Centre" was inaugurated by Honourable Chief Minister of Jharkhand (Mr. Hemant Soren) on the 30th June, 2022.


QULTURE
संस्कृति
जीवाश्मः मृत्यु से प्रदर्शक पटल तक
FOSSIL: FROM DEATH TO EXHIBIT
RAJMAHAL FOSSILS

Rajmahal flora and some cultural aspects of the region. Additionally, an auditorium within the “Rajmahal Fossil Museum & Interpretation Centre” has been developed to showcase geoscience related documentaries to the visitors. Further, a Guest House facility is also available in the fossil park for the visitors.

Showcasing BSIPs participation at IISF-2023, Bhopal (January 21–24, 2023)

A team of BSIP Senior Scientists participated in IISF 2023 and showcased various scientific findings as well as scientific practices followed at BSIP to general public. BSIP also showcased its achievement and further appealed for greater scientific collaboration of all stake holders.

Dr Santosh K Shah visited the Department of Geology (Gauhati University, Assam) on 23rd January 2023 and provided a brief about the institute (BSIP) apart from providing the concept of tree rings, an overview of the proxies utilized in palaeoclimatic studies and their applications.

Participation in outreach activities - invited talks/lectures

Dr Nivedita Mehrotra delivered a lecture (via online mode) titled "Aspects of Palaeogeomorphology & its implications in palaeoclimatic studies" in a 3-days International Lecture Series on Applied Geomorphology organized by the Department of Geography, Mahapurusha Sankaradeva Vishwavidyalaya, Assam from 13th to 15th December, 2023.

Dr Santosh K Shah briefed about the subject of Dendrochronology and explained about its application in palaeoclimatology to the students of Department of Forestry Wildlife & Environmental Science, Guru Ghasidas Vishwavidyalaya (Chhattisgarh) on the 16th December, 2022.

Dr Binita Phartiyal delivered an invited talk entitled "The Landscape evolution & climatic variations in Ladakh, NW Trans-Himalaya during Late Quaternary" in the Conference on Geology: Emerging Methods & Applications (GEM-2023) at Christ College, Thrissur, Kerala during 23rd to 25thJanuary, 2023.

On the World Wetlands Day - 2023 (i.e., 02nd February, 2023), Dr Shilpa Pandey visited the Maharana Pratap Inter College (Asti, Lucknow Uttar Pradesh) and delivered a talk on "Importance of the Wetlands & urgent need of Wetlands Restoration".

Scientists of BSIP participated in the India Energy Week - 2023 at the Bengaluru International Exhibition Centre (Bangaluru, Karnataka) from the 6th to 8th February 2023 and showcased the history, purpose, and various aspects of research being carried out at BSIP.

Dr Anju Saxena delivered the Prof. Birbal Sahni Memorial Lecture on the topic "Legacy & vision of Prof. Birbal Sahni: Journey from Palaeobotany to Palaeosciences" on the 13th February, 2023 at the Department of Botany, University of Lucknow, Lucknow, Uttar Pradesh.

Dr Poonam Verma delivered an invited lecture on the topic "Cenozoic Palaeopalynology & its applications" at the KSKV Kachchh University, Bhuj, Gujarat on the 15th February, 2023.

Dr Binita Phartiyal was invited as a 'Chief Guest' by SEUZ India on the occasion of International Women's Day-2023 on the 3rd March, 2023 at Gurugram, Haryana.

Dr Anurag Kumar delivered an invited talk titled "Use of environmental isotopes in water resource management in Ganga River Basin" at the Uttar Pradesh Ground Water Board, Lucknow on the 4th March, 2023.

Dr Vandana Prasad (Director, BSIP) was invited as 'Chief Guest' by Central Groundwater Board (Lucknow, Uttar Pradesh) on the occasion of International Women's Day-2023 on the 3rd March, 2023.

Dr Vandana Prasad (Director, BSIP) was invited as a 'Chief Guest' by the Geological Survey of India (GSI), Lucknow for the 173rd Foundation Day Function on the 4th March, 2023.

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

A J MOHAN & ASSOCIATES

CHARTERED ACCOUNTANTS

Head office: 25, Babar Road, Ground floor, New Delhi -110001

Email- ajmohan@ajmohan.com, ca_abhijitmohan@outlook.com

INDEPENDENT AUDITORS REPORT

To,
The Governing Body,
Birbal Sahni Institute of Palaeosciences,
53, University Road,
Lucknow.

Report on Audit of the Financial Statements

We have audited the financial statements of Birbal Sahni Institute of Palaeosciences (BSIP) which comprises the Balance Sheet as at 31st March, 2023, the Statement of Income & Expenditure for the year ended 31st March, 2023 and the Receipts and Payments Account for the year ended 31st March, 2023 including a summary of significant accounting policies annexed herewith.

Responsibilities of Management and those Charged with Governance for the Financial Statements

Management is responsible for the preparation of the 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 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; 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 Responsibilities for the Audit of the Financial Statements

Our responsibility is to express an opinion on these financial statements based on our audit.

We have taken into account the provisions of the Act, the accounting and auditing standards and matters which are required to be included in the audit report under the provisions of the Act and the Rules made thereunder.

We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves 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 organization's preparation of the financial statements that give a true and fair view in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on whether the organization has in place an adequate internal financial control system over financial reporting and the operating effectiveness of such controls. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by the organization, as well as evaluating the overall presentation of the financial statements

Basis for Opinion

We conducted our audit in accordance with Standards on Auditing (SAs). Our responsibilities under those Standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the entity in accordance with the ethical requirements that are relevant to our audit of the financial statements, and we have fulfilled our other responsibilities in accordance with these requirements.

Basis for Qualified Opinion

Our opinion with respect to the financial statements is qualified to the extent of the following:-

i. Vide office note dated 04.03.2020 approved by the Director, BSIP it is stated that "As per the new laws proposed by Department of Science and Technology, it is proposed in Chapter No. II (Finance and Accounts) at S. No. 16, - 'The annual accounts of the Institute should be prepared on accrual basis by using uniform format of Accounts for Central Autonomous Bodies'." However, the said office order has not been complied with even in so far as the accounts for F.Y. 2022-23 are concerned. In fact, the summary of accounting policies itself are in deviation to the above office note as under:

   a. As per para 7.2 of the Schedule 24 - 'Significant Accounting Policies' annexed to the financial statements it is stated that government grants are recognized on realization basis. However, we have noticed that the 'Current Assets, Loans and Advances' include Grant Receivables to the tune of Rs. 40.53 lacs, thus, the grants have not been accounted for as per accounting policy mentioned in Schedule 24 and the deviation is of the quantum of Rs. 40.53 lacs. Thus, the accounting treatment is contrary to the accounting policy mentioned above.

   b. As per para 8 of the Schedule 24 - 'Significant Accounting Policies' annexed to the financial statements it is stated that retirement benefits and leave encashment have been accounted for on cash basis. However, we have noticed that provision for pension payable to the tune of Rs. 79.52 lacs has been created on 31.03.2023. Thus, the accounting treatment is contrary to the accounting policy mentioned above.

   c. As per Schedule 7 – 'Current Liabilities and Provisions', provisions have been created for expenses related to salary, pension, retirement benefits, project overhead and audit fees aggregating to Rs. 3,26,43,655.00 as on 31.03.2023. This is a change in accounting treatment as compared to the previous year where these expenses were accounted for on cash basis. Thus, the expenses have been overstated to the extent of Rs. 3.26 crores in the current year on account of change in accounting policy as compared to the previous year and the liabilities have also been overstated by the corresponding amount.

   We have noticed that BSIP has continued to follow the cash method of accounting for the remaining heads of expense and income except for establishment expenses, grants and interest on investments which have been accounted for on accrual basis. This is also in violation to AS 1 – 'Disclosure of Accounting Policies' prescribed by the Institute of Chartered Accountants of India.

ii. BSIP receives grants for various projects for research work undertaken by the scholars and scientists. The grant is sent to BSIP and then paid to the scientists on monthly basis and utilized for expenses related to that project. Thus, the grants are adjusted at the time of payments related to that project. However, as on 31.03.2023 we noticed debit balances in the following project grants i.e., excess expenditure over the quantum of grant pertaining to the following grants:-

S.No.	Project	Debit Balance as on 31.03.2023
1.	Moes (P) Dr. Vandana Prasad Component – 1	2,58,061.78
2.	Moes (P) Dr. Anjum Farooqui Component – 2	1,21,799.68
3.	NHMS/CHEA Project PS Ranhotra	76,382.69
4.	Indo Sri Lankan Project Neerja Jha	25,814.00
5.	DST Project Manoj MC	21,277.17
6.	Contingency CSIR (P) Ms. Shazi	19,962.00
7.	CSIR Project Mr. Harsh Kumar	11,000.00
8.	NPD Project Dr. Rajesh Agnihotri	1,427.67
TOTAL		**5,35,724.99**

We have not been given any explanation under which debits have been made to grant account beyond the quantum of the respective grants. We are of the opinion that proper control deserves to be exercised in charging expenses to any grant account.

Qualified Opinion

In our opinion and to the best of our information and according to the explanations given to us, except for the possible effects of the matters described in the Basis for Qualified opinion paragraph, the financial statements give the information required by the Act in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India, of the state of affairs as at 31st March, 2023 and its Income and Expenditure for the year ended on that date.

Emphasis of Matter

We draw attention to the following Notes to Accounts and financial statements. Our opinion is not modified in respect of this matter:-

i. As per Schedule 9 – 'Investments from Earmarked/Endowment Funds' of the audited financial statements for F.Y. 2021-22, the investments were classified under Government Securities. However, we have noticed that these investments were in FDRs and not in Government securities and thus BSIP has re- classified these investments under Other Approved Securities/FDRs for both F.Y. 2021-22 and F.Y. 2022-23.

ii. The Bank Reconciliation Statement pertaining to account no. 187301000001666 maintained with Indian Overseas Bank, University Road Branch, Lucknow as on 31.03.2023 contains several very old entries pending reconciliation pertaining to many previous financial years. An aggregate amount of Rs. 39.74 lacs pertains to credit entries in the bank which has not been traced since F.Y. 2017-18. Certain cheques issued by BSIP during F.Y. 2019-20, 2020-21 and 2021-22 but not deposited by the parties have been listed in BRS. However, since these cheques are older than 90 days as on 31.03.2023, these cheques should have been treated as stale and accounted for accordingly which is not done. Moreover, there are payments aggregating to Rs. 8.93 lacs during F.Y. 2021-22 and F.Y. 2022-23 for which no entries have been passed in the books on the plea that payment advice for the same is not available. It is a matter of concern that payments have been processed at BSIP which cannot be traced and receipts in bank accounts of BSIP have not been reconciled since F.Y. 2017-18. Necessary steps to streamline the process and for proper reconciliation of these entries need to be taken by BSIP forthwith.

iii. As per para 5 of the Schedule 24 - 'Significant Accounting Policies', depreciation has been charged on fixed assets as per the Income Tax Act, 1961 and full depreciation has been charged on the additions during the year. However, as per Section 32 of the Income Tax Act, 1961, the deduction in respect of such asset shall be restricted to fifty per cent of the amount calculated at the percentage prescribed for an asset if the asset was acquired by the assessee during the previous year and put to use for a period of less than 180 days in that previous year. Thus, the depreciation has been overcharged by BSIP beyond the mandate prescribed by the Income Tax Act, 1961. This has resulted in overstatement of expense and understatement of assets of corresponding amount as on 31.03.2023.

iv. As per para 2 of the Schedule 25 – 'Contingent Liabilities and Notes on Accounts', estimated value of contracts remaining to be executed on capital account has been mentioned as Nil. We have noticed that the contract for the building construction was ongoing as on 31.03.2023. Upon our query, we were informed by BSIP, - "This is ongoing construction and the exact amount of Liabilities on this act is not ascertainable being ongoing costs having several modification or account of specifications. However as per sanction the balance amount of sanctioned grant of Building fund is yet to be released by the Ministry." In our opinion, capital commitments as per para 2 should not be reported as Nil in case of an ongoing project since the contract for such construction work is on record and the work pending completion can be ascertained from the contract.

v. Advances given to the below mentioned parties many years ago are pending for recovery/ adjustment as on 31.03.2023.

Particulars	**Year**	**Amount**	**Remarks**
M/s Alliance Book Suppliers, Delhi	2014-15	Rs. 2,00,883.89	The amount is pending since F.Y. 2014-15 and needs to be adjusted appropriately.
M/s Spem A/c	Several years	Rs. 55,324.00	BSIP has sent a letter for cancellation of misplaced Demand Draft to Indian Overseas Bank. However, the same is not resolved.

vi. Old outstanding balances as on 31.03.2023 in the Advances to Staff are pending since 2017-18. Necessary steps for the recovery/adjustment from salary needs to be done:

Particulars	**Year**	**Amount**
Mr. K.P. Singh	2018-19	Rs. 1,32,640.00
Mrs. Kirti Singh	2017-18 to 2020-21	Rs. 3,150.00

vii. On scrutiny of the Fixed Assets Registers maintained manually, we have noticed that the same does not tally with the assets as per the assets schedule listed in the financial statements of FY 2022-23. This is a matter of grave concern as BSIP has assets worth several crores. Also, RFID tagging is recommended in such situation.

viii. As per Schedule 11 – 'Current Assets, Loans and Advances', advances aggregating to Rs. 53.28 lacs have been reported as advances against expenses. As informed to us by BSIP, these advances have been given to staff for expenses. We are of the opinion that this is a wrong classification; the same should have been classified under Advances to Staff.

ix. BSIP had received COVID Fund Grant of Rs. 1.71 crores in the previous years out of which Rs. 86.73 lacs was unspent and has still not been refunded. As per the records provided to us and explanation given to us, we have learnt that correspondence for refund had been made with the Fund issuing authority, the DM Lucknow; however, the same is not resolved yet. The said amount of Rs. 86.73 lacs is classified under the head – 'Advances Received – COVID Management' of Schedule 7 – 'Current Liabilities and Provisions' in the Balance Sheet as on 31.03.2023.

Report on other Legal and Regulatory Requirements

i. 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.

ii. In our opinion, proper books of accounts have been kept by the Institute so far as appears from our examination of the books.

iii. The Balance Sheet, Income and Expenditure Accounts and the Receipts and Payments account for F.Y. 2022-23 are in agreement with the books of accounts maintained at the head office at Lucknow.

For AJ Mohan & Associates

CHARTERED ACCOUNTANTS

(FRN: 002468N)

Sd/-

CA HASAN JAWAID

(PARTNER)

M. No/ UDIN: 468230 / 23468230BHAPFE8013

Date: 18.09.2023

Place: Delhi

Action Taken Report for the F.Y. 2022-23

Audit Observation	Action taken
i. Vide office note dated 04.03.2020 approved by the Director, BSIP it is stated that "As per the new laws proposed by Department of Science and Technology, it is proposed in Chapter No. II (Finance and Accounts) at S. No. 16, - 'The annual accounts of the Institute should be prepared on accrual basis by using uniform format of Accounts for Central Autonomous Bodies'." However, the said office order has not been complied with even in so far as the accounts for F.Y. 2022-23 are concerned. In fact, the summary of accounting policies itself are in deviation to the above office note as under:	Noted for Compliance.
a. As per para 7.2 of the Schedule 24 - 'Significant Accounting Policies' annexed to the financial statements it is stated that government grants are recognized on realization basis. However, we have noticed that the 'Current Assets, Loans and Advances' include Grant Receivables to the tune of Rs. 40.53 lacs, thus, the grants have not been accounted for as per accounting policy mentioned in Schedule 24 and the deviation is of the quantum of Rs. 40.53 lacs. Thus, the accounting treatment is contrary to the accounting policy mentioned above.	Noted for compliance.
b. As per para 8 of the Schedule 24 - 'Significant Accounting Policies' annexed to the financial statements it is stated that retirement benefits and leave encashment have been accounted for on cash basis. However, we have noticed that provision for pension payable to the tune of Rs. 79.52 lacs has been created on 31.03.2023. Thus, the accounting treatment is contrary to the accounting policy mentioned above.	The amount of Rs.79.52 lacs is advanced drawn for payment of retirement benefit of March 2023 and it is not a provision for retirement benefits in true sense. This has been done as per the directions of Department of Science and Technology, GOI vide their e-mail dated 10.12.2022(wherein the directions has been given for charging the Salary and Pension & retirement benefits of the month of March 2023 and to be paid in the next month.

Sd/-
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Accounts Officer

Sd/-
(Sandeep Kumar Shivhare)
Registrar

Sd/-
(Prof. Mahesh G. Thakkar)
Director

c. As per Schedule 7 – 'Current Liabilities and Provisions', provisions have been created for expenses related to salary, pension, retirement benefits, project overhead and audit fees aggregating to Rs. 3,26,43,655.00 as on 31.03.2023. This is a change in accounting treatment as compared to the previous year where these expenses were accounted for on cash basis. Thus, the expenses have been overstated to the extent of Rs. 3.26 crores in the current year on account of change in accounting policy as compared to the previous year and the liabilities have also been overstated by the corresponding amount. We have noticed that BSIP has continued to follow the cash method of accounting for the remaining heads of expense and income except for establishment expenses, grants and interest on investments which have been accounted for on accrual basis. This is also in violation to AS 1 – "Disclosure of Accounting Policies" prescribed by he Institute of Chartered Accountants of India.	The amount of Rs. 3,26,43,655.00 consist of following: 1- Leave Salary Contribution 2- Provision for Overhead (Project) 3-Fellowship Payable 4-Audit Fees Payable 5- Remittances (Salary) 6- Pension Payable 7-Retirement Benefit Payable (M. Pillai) 8-Plan RTF Payable 9- Salary Payable 10-Project Overhead Payable As stated above, the advances for Salary , Pension & Retirement benefits have been drawn as per the email of Department of Science and Technology vide their email dated 10.12.2022. The advances from project for project overhead and audit fees has been drawn to reflect the expenditure in the financial year 2022-23. So that true picture could be shown in the Utilization certificate.
II. BSIP receives grants for various projects for research work undertaken by the scholars and scientists. The grant is sent to BSIP and then paid to the scientists on monthly basis and utilized for expenses related to that project. Thus, the grants are adjusted at the time of payments related to that project. However, as on 31.03.2023 we noticed debit balances in the following project grants i.e., excess expenditure over the quantum of grant pertaining to the following grants:-	The excess amount shown have been correctly reflected in the UCs of the funding agency has been requested for recoupment of the same. All expenses are incurred in the interest of projects. However, the remedial actions will be taken in current financial year 2023-24.

Sd/- (Ashutosh Shukla) Accounts Officer	Sd/- (Sandeep Kumar Shivhare) Registrar	Sd/- (Prof. Mahesh G. Thakkar) Director

S.No.	Project	Debit Balance as on 31.03.2023
1.	Moes (P) Dr. Vandana Prasad Component – 1	2,58,061.78
2.	Moes (P) Dr. Anjum Farooqui Component – 2	1,21,799.68
3.	NHMS/CHEA Project PS Ranhotra	76,382.69
4.	Indo Sri Lankan Project Neerja Jha	25,814.00
5.	DST Project Manoj MC	21,277.17
6.	Contingency CSIR (P) Ms. Shazi	19,962.00
7.	CSIR Project Mr. Harsh Kumar	11,000.00
8.	NPD Project Dr. Rajesh Agnihotri	1,427.67
TOTAL		**5,35,724.99**

We have not been given any explanation under which debits have been made to grant account beyond the quantum of the respective grants. We are of the opinion that proper control deserves to be exercised in charging expenses to any grant account.	
Qualified Opinion In our opinion and to the best of our information and according to the explanations given to us, except for the possible effects of the matters described in the Basis for Qualified opinion paragraph, the financial statements give the information required by the Act in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India, of the state of affairs as at 31st March, 2023 and its Income and Expenditure for the year ended on that date.	
i. As per Schedule 9 – 'Investments from Earmarked/Endowment Funds' of the audited financial statements for F.Y. 2021-22, the investments were classified under Government Securities. However, we have noticed that these investments were in FDRs and not in Government securities and thus BSIP has re- classified these investments under Other Approved Securities/FDRs for both F.Y. 2021-22 and F.Y. 2022-23.	The audit has remarked that Schedule 9 of Balance Sheet "**Investment from Earmarked/ Endowment funds"** were shown in the Balance Sheet as Government securities. However the funds has not been invested in government securities either during the year 2021-22 or 2022-23. When it was pointed out, the classification has been modified to reflect the true nature of investment shown as **" Other approved Securities / Fixed Deposit Receipts"** instead of "**in Government securities"**

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Accounts Officer

Sd/-
(Sandeep Kumar Shivhare)
Registrar

Sd/-
(Prof. Mahesh G. Thakkar)
Director

ii.	The Bank Reconciliation Statement pertaining to account no. 187301000001666 maintained with Indian Overseas Bank, University Road Branch, Lucknow as on 31.03.2023 contains several very old entries pending reconciliation pertaining to many previous financial years. An aggregate amount of Rs. 39.74 lacs pertains to credit entries in the bank which has not been traced since F.Y. 2017-18. Certain cheques issued by BSIP during F.Y. 2019-20, 2020-21 and 2021-22 but not deposited by the parties have been listed in BRS. However, since these cheques are older than 90 days as on 31.03.2023, these cheques should have been treated as stale and accounted for accordingly which is not done. Moreover, there are payments aggregating to Rs. 8.93 lacs during F.Y. 2021-22 and F.Y. 2022-23 for which no entries have been passed in the books on the plea that payment advice for the same is not available. It is a matter of concern that payments have been processed at BSIP which cannot be traced and receipts in bank accounts of BSIP have not been reconciled since F.Y. 2017-18. Necessary steps to streamline the process and for proper reconciliation of these entries need to be taken by BSIP forthwith.	Noted for compliance.
iii.	As per para 5 of the Schedule 24 - 'Significant Accounting Policies', depreciation has been charged on fixed assets as per the Income Tax Act, 1961 and full depreciation has been charged on the additions during the year. However, as per Section 32 of the Income Tax Act, 1961, the deduction in respect of such asset shall be restricted to fifty per cent of the amount calculated at the percentage prescribed for an asset if the asset was acquired by the assessee during the previous year and put to use for a period of less than 180 days in that previous year. Thus, the depreciation has been overcharged by BSIP beyond the mandate prescribed by the Income Tax Act, 1961. This has resulted in overstatement of expense and understatement of assets of corresponding amount as on 31.03.2023.	As per Schedule 24 – Significant accounting policies para no. 5, it has been mentioned that **"Depreciation has been charged on Fixed Assets as the rate prescribed under income Tax Act 1956. Full depreciation is charged on opening balance and the additions during the year"**. From the above Significant Accounting policies it is evident that only the rates prescribed by the Income Tax act 1961 has been adopted for charging the depreciation and not the methodology given therein. It has been clearly stated that **Depreciation will be charged on Fixed Assets as the rate prescribed under Income Tax Act 1956. Full depreciation is charged on opening balance and the additions during the year.** From this it is clear that depreciation has been charged as per statement declared in significant accounting policies.

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iv.	As per para 2 of the Schedule 25 – 'Contingent Liabilities and Notes on Accounts', estimated value of contracts remaining to be executed on capital account has been mentioned as Nil. We have noticed that the contract for the building construction was ongoing as on 31.03.2023. Upon our query, we were informed by BSIP, - "This is ongoing construction and the exact amount of Liabilities on this act is not ascertainable being ongoing costs having several modification or account of specifications. However as per sanction the balance amount of sanctioned grant of Building fund is yet to be released by the Ministry." In our opinion, capital commitments as per para 2 should not be reported as Nil in case of an ongoing project since the contract for such construction work is on record and the work pending completion can be ascertained from the contract.	Noted for compliance.
v.	Advances given to the below mentioned parties many years ago are pending for recovery/ adjustment as on 31.03.2023.	(i) The amount of Rs.2,00,883.89 of M/s. Alliance Book Suppliers has already been submitted for consideration of Governing Body. (ii) The issue (M/s Spem Rs.55,324/-) is being pursued with the bank.

Particulars	Year	Amount	Remarks
M/s Alliance Book Suppliers, Delhi	2014-15	Rs. 2,00,883.89	The amount is pending since F.Y. 2014-15 and needs to be adjusted appropriately.
M/s Spem A/c	Several years	Rs. 55,324.00	BSIP has sent a letter for cancellation of misplaced Demand Draft to Indian Overseas Bank. However, the same is not resolved.

vi.	Old outstanding balances as on 31.03.2023 in the Advances to Staff are pending since 2017-18. Necessary steps for the recovery/adjustment from salary needs to be done:	(i) The advance of Mr. K.P singh Rs.132640/- has been settled in FY 2023-24. (ii) The advance of Rs. 3,150.00 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.

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(Sandeep Kumar Shivhare)
Registrar

Sd/-
(Prof. Mahesh G. Thakkar)
Director

Particulars	Year	Amount
Mr. K.P. Singh	2018-19	Rs. 1,32,640.00
Mrs. Kirti Singh	2017-18 to 2020-21	Rs. 3,150.00

vii.	On scrutiny of the Fixed Assets Registers maintained manually, we have noticed that the same does not tally with the assets as per the assets schedule listed in the financial statements of FY 2022-23. This is a matter of grave concern as BSIP has assets worth several crores. Also, RFID tagging is recommended in such situation.	Noted for compliance.
viii.	As per Schedule 11 – 'Current Assets, Loans and Advances', advances aggregating to Rs. 53.28 lacs have been reported as advances against expenses. As informed to us by BSIP, these advances have been given to staff for expenses. We are of the opinion that this is a wrong classification; the same should have been classified under Advances to Staff.	Noted for compliance.
ix.	BSIP had received COVID Fund Grant of Rs. 1.71 crores in the previous years out of which Rs. 86.73 lacs was unspent and has still not been refunded. As per the records provided to us and explanation given to us, we have learnt that correspondence for refund had been made with the Fund issuing authority, the DM Lucknow; however, the same is not resolved yet. The said amount of Rs. 86.73 lacs is classified under the head – 'Advances Received – COVID Management' of Schedule 7 – 'Current Liabilities and Provisions' in the Balance Sheet as on 31.03.2023.	The unspent amount of Covid grant could not be remitted back to the state government for want of Account number and IFSC Code. However, the issue is constantly being pursued with the funding authorities.

Sd/-
(Ashutosh Shukla)
Accounts Officer

Sd/-
(Sandeep Kumar Shivhare)
Registrar

Sd/-
(Prof. Mahesh G. Thakkar)
Director

Balance Sheet as on 31.03.2023

(Amount-Rs.)

Particulars	Schedule No.	Current Year	Previous Year
		31.03.2023	31.03.2022
CORPUS/CAPITAL FUND AND LIABILITIES			
Corpus / Capital Fund	1	1,00,10,54,630.16	71,06,56,644.15
Reserves and Surplus	2	7,52,77,980.00	7,32,10,903.00
Earmarked / Endowment Funds	3	87,04,45,576.63	76,91,05,386.63
Secured Loans and Borrowings	4	-	-
Unsecured Loans and Borrowings	5	-	-
Deferred Credit Liabilities	6	-	-
Current Liabilities and Provisions	7	7,03,49,522.38	4,38,96,316.84
Total		**2,01,71,27,709.17**	**1,59,68,69,250.62**
ASSETS			
Fixed Assets	8	25,97,67,366.00	25,12,64,025.69
Investments from Earmarked / Endowment Funds	9	87,04,45,576.63	76,91,05,386.63
Investments - Others	10	11,15,57,859.00	12,39,18,709.00
Current Assets, Loans & Advances, etc.	11	77,53,56,907.54	45,25,81,129.30
Miscellaneous Expenditure (to the extent not written off or adjusted)		-	-
Total		**2,01,71,27,709.17**	**1,59,68,69,250.62**
Significant Accounting Policies	24		
Contingent Liabilities And Notes On Accounts	25		

For AJ Mohan & Associates
Chartered Accountants

Sd/-
CA Hasan Jawaid
(Partner)

Sd/-
(Ashutosh Shukla)
Accounts Officer

Sd/-
(Sandeep Kumar Shivhare)
Registrar

Sd/-
(Prof. Mahesh G. Thakkar)
Director

Income And Expenditure Account for the period/year ended 31.03.2023

(Amount-Rs.)

Particulars	Schedule No.	Current Year	Previous Year
		2022-23	2021-22
INCOME			
Income from Sales / Services	12	8,72,873.88	11,82,507.00
Grants/subsidies (OB, Deposit A/C and Transfer from Cap. Fund)	13	87,08,49,039.50	57,25,00,000.00
Fees/Subscriptions	14	-	-
Income from Investments (Income on Invest. From Earmarked/Endow. Funds transferred to Funds)	15	4,40,48,231.00	4,70,67,305.00
Income from Royalty, Publication, etc.	16	-	-
Interest Earned	17	3,04,939.00	4,12,878.00
Other Income/Adjustments	18	22,00,977.94	50,69,870.00
Increase/(decrease) in stock of Finished goods and works-in-progress	19	-	-
Total (A)		**91,82,76,061.32**	**62,62,32,560.00**
EXPENDITURE			
Establishment Expenses	20	40,58,03,351.00	30,58,44,133.00
Other Administrative Expenses, etc.	21	8,52,50,079.12	9,07,82,280.48
Expenditure on Grants, Subsidies, etc.	22	-	-
Interest	23	-	-
Depreciation (Net Total at the year-end-corresponding to Schedule 8)		4,43,60,870.19	4,21,32,271.83
Total (B)		**53,54,14,300.31**	**43,87,58,685.31**
Balance being excess of Income over Expenditure (A-B)		38,28,61,761.01	18,74,73,874.69
Interest Earned on Reserve Fund		20,67,077.00	-
Interest on GPF Fund transferred to GPF Fund		40,64,714.00	45,95,755.00
Interest on Institute Account refundable to DST		-	1,49,12,875.00
Interest on Pension Fund transferred to Pension Fund		3,26,71,088.00	2,40,97,103.00
Interest on Building Fund FD transferred to Building Fund		25,91,936.00	-
Interest on Donated Fund FD transferred to Donated Fund		68,960.00	64,463.00
Transfer to Pension Fund		5,10,00,000.00	13,50,00,000.00
Balance being Surplus / Deficit carried to Corpus / Capital Fund		**29,03,97,986.01**	**88,03,678.69**
Significant Accounting Policies	24		
Contingent Liabilities and Notes on Accounts	25		

For AJ Mohan & Associates
Chartered Accountants

Sd/-
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(Partner)

Sd/-
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Accounts Officer

Sd/-
(Sandeep Kumar Shivhare)
Registrar

Sd/-
(Prof. Mahesh G. Thakkar)
Director

Receipt & Payment Account for the year ended 31.03.2023

(Amount-Rs.)

Receipts	Current Year 2022-23	Previous Year 2021-22	Payments	Current Year 2022-23	Previous Year 2021-22
I. Opening Balances			**I. Establishment Expenses**		
a) Cash in hand	-	-	a) Salaries and Wages	13,07,59,558.00	11,75,92,869.00
b) Bank Balances:-			b) Allowances and Bonus	8,81,18,314.00	6,76,11,754.00
- In Saving Accounts	20,29,65,211.54	42,30,72,825.32	c) Contribution to CPF (Employer's Contribution)	2,50,45,183.00	87,15,452.00
			d) Contribution to Other Funds	-	-
II. Income from Sale & Services			e) Staff Welfare Expenses	-	-
a) Income from Sales	-	-	f) Expenses on Employee's Retirement and Terminal Benefits	16,18,80,296.00	11,19,24,058.00
b) Income from Services	8,72,873.88	11,82,507.00	g) Others (specify)	-	-
III. Grant & Subsidy			**II. Other Administrative Expenses etc.**	8,52,50,079.12	9,07,82,280.48
a) Central Government	67,56,49,039.50	57,25,00,000.00			
b) State Government	-	-	**III. Addition in Fixed Assets**		
c) New Building Grant	19,52,00,000.00	-	(As per Schedule - 8)	5,28,64,210.50	7,40,63,989.60
IV. Fee & Subscriptions	-	-	**IV. Increase in Investments from Earmarked / Endowment Funds**	10,13,40,190.00	17,71,83,118.30
V. Income from Investment			**V. Increase in Investments Others**	-	-
a) Interest	4,40,48,231.00	4,70,67,305.00			
b) Dividends / Rent / Others	-	-	**VI. Increase in Current Assets**	42,18,37,574.99	19,91,48,526.54
VI. Income from Royalty, Publication etc.	-	-	**VII. Decrease in Current Liabilities**	-	2,44,33,939.16
VII. Interest Earned			**VIII. Transfer to Designated Funds**		
a) On Term Deposit	-	-	a) Interest on GPF Fund transferred to GPF Fund	40,64,714.00	45,95,755.00
b) On Saving Deposit	-	-	b) Interest on Institute Account refundable to DST	-	1,49,12,875.00
c) On Loan	3,04,939.00	4,12,878.00	c) Interest on Pension Fund Transferred to Pension Fund	3,26,71,088.00	2,40,97,103.00
d) Interest on Debtors & Other Receivable	-	-	d) Interest on Building Fund FD transferred to Building Fund	25,91,936.00	-
			e) Interest on Donated Fund FD transferred to Donated Fund	68,960.00	64,463.00
VIII. Other Income & Adjustments	22,00,977.94	50,69,870.00	f) Transfer to Pension Fund	5,10,00,000.00	13,50,00,000.00
IX. Increase in Funds (As per Schedule - 3)	10,13,40,190.00	17,71,83,118.30	**IX. Closing Balances**		
			a) Cash in hand	-	-
			b) Bank Balances:-	-	-
X. Increase in Current Liabilities			- In Saving Accounts	10,39,03,414.79	20,29,65,211.54
(As per Schedule - 7)	2,64,53,205.54	-			
XI. Decrease in Investments Others	1,23,60,850.00	2,66,02,891.00			
Total	**1,26,13,95,518.40**	**1,25,30,91,394.62**	**Total**	**1,26,13,95,518.40**	**1,25,30,91,394.62**

For AJ Mohan & Associates
Chartered Accountants

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(Partner)

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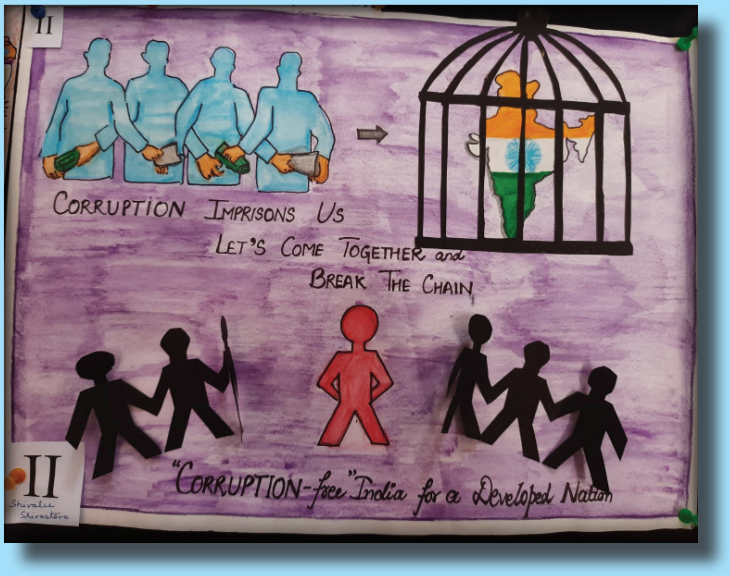

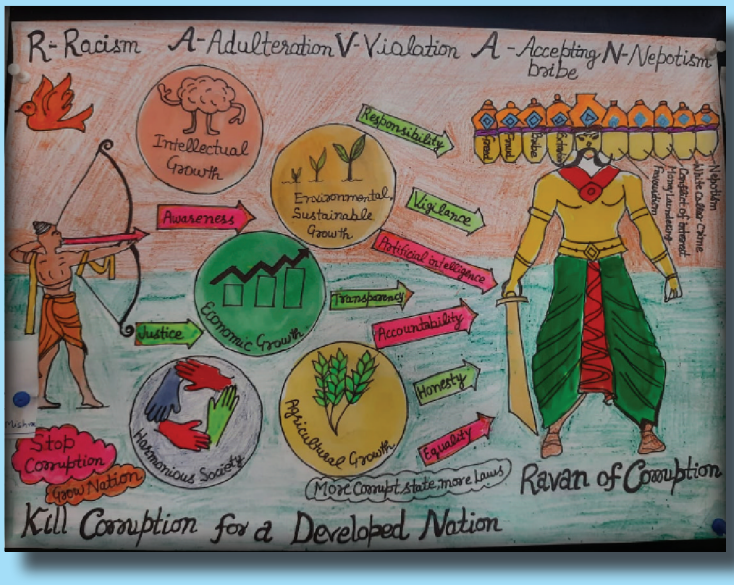

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एक कदम स्वच्छता की ओर

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