



Neogene Climate Evolution in Eurasia

September 7–9, 2021

*Neogene climate evolution
and biotic response(s) in south Asia*



Organised by
Birbal Sahni Institute of Palaeosciences

**PROGRAM
and
ABSTRACTS**

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Birbal Sahni Institute of Palaeosciences, Lucknow, India



Neogene climate evolution and biotic response(s) in south Asia

(September 7–9, 2021)

Neogene period witnessed formation of the mighty Himalaya post-India-Eurasia collision. The Himalayan orogeny greatly affected the climate of South Asia in the form of development and subsequent evolution of the south Asian Monsoon (SAM). In addition, Neogene interval also witnessed intermittent closure(s) and opening(s) of the seaway(s) between the Indian Ocean and the Paratethys. Thus, tectonics and climatic change(s) during the Neogene were instrumental in terms of origin, early evolution of biota (both flora and fauna), and/or development of migration corridor(s) for both marine and terrestrial biota which is reflected in the historical distribution of fossil biota across South Asia during the Neogene.

NECLIME (Neogene Climate Evolution of Eurasia) is a platform organised by the scientists devoted to palaeoclimatic reconstruction(s) including past CO₂ and ecosystem analysis using multiple quantitative methods utilizing various proxies such as plant mega-fossils, pollen, spores, vertebrates (including mammals), invertebrates, isotopes, geological and geochemical signatures. Thus, palaeoclimate data from both terrestrial and marine archives become significant in understanding the dynamics of the global climate system during the Neogene.

Birbal Sahni Institute of Palaeosciences (BSIP), established in 1949, an autonomous institute of the Department of Science and Technology, Government of India, is constantly working to enhance the knowledge about the past ecosystem(s) and climate(s) through multidisciplinary approaches integrating the fossil data with geological, geochronological, geochemical, and geophysical inputs.

To better understand the geological processes, the BSIP is organizing an online conference via NECLIME platform to bring together all researchers on one podium for sharing their scientific ideas toward the Neogene climate evolution and biotic response in south Asia.

Host: Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow, India

Convenor: Dr. Vandana Prasad (Director), BSIP, Lucknow, India

Organising secretaries: Dr. Gaurav Srivastava (Scientist-D), BSIP; Dr. Vivesh Vir Kapur (Scientist-D), BSIP

Conference themes:

1. Age and depositional environment(s) of Siwalik and Siwalik-equivalent sediments.
2. Biotic (flora and fauna) evolution and biogeography during the Neogene.
3. Climatic change(s) during the Neogene.

Note:

- Keynote lectures will be for 30 minutes and 10 minutes for discussion (total 40 minutes).
- Presentations will be for 10 minutes followed by 5 minutes for discussion (total 15 minutes).

General Schedule

Time	Country	Difference to IST	Time Zone
17:30–21:30	Beijing, China	+2.5	China Standard Time (CST)
11:30–15:30	Paris, France	-3.5	Central European Summer Time (CEST)
11:30–15:30	Berlin, Germany	-3.5	Central European Summer Time (CEST)
18:30–22:30	Tokyo, Japan	+3.5	Japan Standard Time (JST)
15:15–19:15	Kathmandu, Nepal	+0.15	-
11:30–15:30	Warsaw, Poland	-3.5	Central European Summer Time (CEST)
11:30–15:30	Bratislava, Slovakia	-3.5	Central European Summer Time (CEST)
10:30–14:30	London, UK	-4.5	British Summer Time (BST)
05:30–09:30	Washington DC, USA	-9.5	Eastern Daylight Time (EDT)

Important Links

NECLIME: <https://www.neclime.de/>

BSIP: <https://bsip.res.in/>

The video recordings of the above-mentioned conference are available online.

Conference Day 1 (7th September 2021): <https://youtu.be/EKI6Z6NeVBg>

Conference Day 2 (8th September 2021): <https://youtu.be/4lqhDLRcuuY>

Conference Day 1 (9th September 2021): <https://youtu.be/qx7kkzNuoo4>

Scientific program

Day-1: September 7, 2021 (Tuesday); 15:00 hours – 18:50 hours (IST)

Theme 1: Age and depositional environment(s) of Siwalik and Siwalik-equivalent sediments

- 15:00 IST Gaurav Srivastava
Welcome and technical instructions
- 15:10 IST Torsten Utescher
Introduction to NECLIME
- 15:20 IST Vandana Prasad
Journey of BSIP and its Platinum Jubilee

Chair: Torsten Utescher

- 15:40–16:20 IST **Keynote:** *Interpreting stories hidden within the Siwalik archives*
Robert A. Spicer
- 16:20–16:35 IST *Mineralogical comparison between Himalayan River sands and Bengal Fan deposits recovered in IODP Exp. 354*
Yoshida Kohki, Lalit Rai Kumar, Subhadeep Kumar, Hakiai Tomoyuki, and Masuda Asako
- 16:35–16:50 IST *Palynological evidence for the Neogene environment change of the Thakkhola Graben, Nepal*
Basanta Raj Adhikari, and Khum Narayan Paudyal
- 16:50–17:05 IST *Signature of high productivity during Tortonian: evidence from biosiliceous microfossils from northeast Indian Ocean*
Amit K. Ghosh, Lopamudra Roy, Stuti Saxena, Arindam Chakraborty, Sarajit Sensarma, and Ajoy Kumar Bhaumik
- 17:05–17:20 IST **Break**
- 17:20–17:35 IST *A review of dated Late Pleistocene environment studies in India*
Parth R. Chauhan and Shashi Mehra
- 17:35–17:50 IST *Timing of collision of India - Tibetan plate and evolution of Himalayas based on fossils from Kasauli and Ladakh*
Ritesh Arya
- 17:50–18:05 IST *WADE ratio of radiolarians: A tool for interpretation on the palaeoecology of Neogene sediments from Andaman and Nicobar Basin*
Rikee Dey, Amit K. Ghosh, and Ajoy Kumar Bhaumik
- 18:05–18:20 IST *Calcareous nannofossil events and sedimentation rate during Tortonian from northeast Indian Ocean*

Lopamudra Roy, Amit K. Ghosh, Sarajit Sensarma and Ajoy Kumar
Bhaumik

- 18:20–18:35 IST *Organic petrographic and geochemical characterization of Neyveli Lignite deposits (Cauvery Basin), Tamil Nadu, India: Insights into the source flora, depositional environment and hydrocarbon generation potential*
Runcie P. Mathews, Vikram P. Singh, **Rimpy Chetia**, Bhagwan D. Singh,
Alpana Singh, and Vinod A. Mendhe
- 18:35–18:50 IST *Oligocene flora and climate of the Halong Bay, northern Vietnam*
Jian Huang, Hung Ba Nguyen, Truong Van Do, and Tao Su

Day–2: September 8, 2021 (Wednesday); 15:00 hours – 19:35 hours (IST)
Theme 2: Biotic (flora and fauna) evolution and biogeography during the Neogene

Chair: Amit K Ghosh

- 15:00–15:40 IST **Keynote:** *Biotic evolution and biogeography during the Neogene in South Asia: Sirenians and Seagrasses*
Daryl P. Domning, Sunil Bajpai, and Vivesh Vir Kapur
- 15:40–15:55 IST *Fossil callimothalloid fungi from India*
Grzegorz Worobiec, and Elżbieta Worobiec
- 15:55–16:10 IST *Remarkable Miocene vertebrate fossils from Kutch, western India*
Ansuya Bhandari
- 16:10–16:25 IST *New micromammals from the middle Miocene of Ramnagar, Udhampur District, Jammu and Kashmir*
Abhishek Pratap Singh, Ramesh Kumar Sehgal, and Ningthoujam Premjit Singh
- 16:25–16:40 IST Documentation of change in diversity pattern of Kutch gastropods, across the Paleogene/ Neogene boundary.
Adrisuta Ghosh, Shiladri S. Das, and Kanishka Bose
- 16:40–16:55 IST *Fossil wood of Cordia L. (Cordiaceae) from the Tipam Sandstone Formation of northeast India*
Harshita Bhatia, Gaurav Srivastava, and R.C. Mehrotra
- 16:55–17:10 IST *First fossil pod record of Mucuna (Papilionoideae, Fabaceae) from the Miocene of Yen Bai Basin, North Vietnam*
Hung Ba Nguyen, Jian Huang, Truong Van Do, Lin-Bo Jia, Hoa Mai Thi Nguyen, and Tao Su
- 17:10–17:25 IST **Break**

Chair: Angela Bruch

- 17:25–18:05 IST **Keynote:** *Changes in plant biogeography during the Eocene–Oligocene Transition (EOT)*
Carina Hoorn
- 18:05–18:20 IST *The rise of herbaceous diversity in southeastern Tibetan Plateau: first insight from fossils*
Yong-Jiang Huang, Hai Zhu, Tao Su, Robert A. Spicer, Jin-Jin Hu, Lin-Bo Jia, and Zhe-Kun Zhou

- 18:20–18:35 IST *Two giant gastropods from the Miocene of Dwarka Basin, Gujarat, India and their paleobiogeographic implications*
Kanishka Bose, Shiladri S. Das, and Sandip Saha
- 18:35–18:50 IST *Fossil amphibians and snakes from the Neogene localities of Kutch (Gujarat), Western India*
Nongmaithem Amardas Singh, Ningthoujam Premjit Singh, K Milankumar Sharma, Rajeev Patnaik, Andrej Cerňanský, Deepak Choudhary, and Ramesh Kumar Sehgal
- 18:50–19:05 IST *Preliminary data on coprolites from the Neogene (Miocene: Aquitanian–Burdigalian) Khari Nadi and Chassra formations, Kutch Basin, western India*
Ramanand Sagar, Vivesh V. Kapur, Kamlesh Kumar, P. Morthekai, Anupam Sharma, Gaurav Chauhan, and M. G. Thakkar
- 19:05–19:20 IST *Diversity of Engelhardia Lesch. ex Blume from the Latest Neogene sediments of eastern India: its biogeographic implications*
Taposhi Hazra, Manoshi Hazra, Sanchita Kumar, Sumana Mahato, Meghma Bera, Subir Bera, and Mahasin Ali Khan
- 19:20–19:35 IST *Two new legume fossil leaves from the Pliocene–Pleistocene sediments of Nepal*
Dhan Bahadur Khatri, Purushotam Adhikari, Khum N. Paudyal, Gaurav Srivastava, Harshita Bhatia, and R.C. Mehrotra

Day-3: September 9, 2021 (Thursday); 15:00 hours – 19:15 hours (IST)

Theme 2: Climatic change(s) during the Neogene

Chair: Gaurav Srivastava and Vivesh V Kapur

- 15:00–15:05 IST Brief talk by **Vandana Prasad** on BSIPs Platinum Jubilee
- 15:05–15:40 IST **Keynote: *Vegetation and climate change across tropical Asia during the Pleistocene***
Robert J Morley, Harsanti P Morley
- 15:40–15:55 IST *Vegetation dynamics and its response to climate change during the last ca. 8400 cal yrs from central India*
Md. Firoze Quamar*
- 15:55–16:10 IST *Study of plant megafossils from Siwalik group along the Bagmati river section for palaeoclimate implications*
Vikram Shrestha
- 16:10–16:25 IST *Late Pliocene/early Pleistocene fauna and flora of Jammu: their preservation and climatic appraisals*
Som Nath Kundal
- 16:25–16:40 IST *Pollen-inferred climate reconstruction from the palaeo Kathmandu lake sediment (Lukundol Formation), Southern part of the Kathmandu valley*
Maria Maharjan, Sima Humagain, and Khum N. Paudyal
- 16:40–16:55 IST *Plant fossils from the Middle Siwalik of eastern Nepal and their climatic and phytogeographic significance*
Purushottam Adhikari, Harshita Bhatia, Dhan Bahadur Khatri, Gaurav Srivastava, Dieter Uhl, R.C. Mehrotra, and Khum N. Paudyal
- 16:55–17:10 IST *Palaeoclimate reconstruction of the middle Pleistocene palynological assemblage using co-existence approach analysis from the Dharmasthali Formation, northern Kathmandu Valley*
Sima Humagain, Maria Maharjan, and Khum N Paudyal
- 17:10–17:25 IST **Break**

Chairs: Gaurav Srivastava and Vivesh V Kapur

- 17:25–18:05 IST **Keynote: *Stable isotopic data from fossil mammalian enamel recovered from the Late Miocene deposits of Kutch, Gujarat: Implications for Palaeoecology and Palaeoclimate***

Rajeev Patnaik, Ningthoujam Premjit Singh, K. Milankumar Sharma, N. Amardas Singh, Y. Priyananda Singh, and Deepak Choudhary

- 18:05–18:20 IST *Palaeoceanography, Biogeographic, faunal changes and tectonic shifting of Indian plate with rising of the Himalayas special reference: global and regional climatic events in Indian ocean at Neogene time*
Anand Rajoriya*
- 18:20–18:35 IST *Neogene Sea surface temperature derived from calcareous nannofossils of northeast Indian Ocean*
Arindam Chakraborty and Amit K. Ghosh
- 18:35–18:50 IST *Temporal variations in the western Arabian Sea Oxygen Minimum Zone (OMZ) intensity during the last 10,000 years: Insights from benthic foraminifera*
Ekta Jaiswal, Moumita Das, and A.K. Gupta
- 18:50–19:05 IST *Palynological assemblage from the Upper Siwalik sediment of the Triyuga River section, Eastern Nepal and its paleoclimatic implication*
Rabin Dhakal, **Purushottam Adhikari**, Sima Humagain, and Khum N. Paudyal

***Not attended**

Valedictory: Vivesh V. Kapur

Interpreting Stories Hidden Within the Siwalik Archives

Robert A. Spicer^{1,2}

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The Siwalik succession of Neogene sediments records the rise of the Himalaya, the development of the South Asia Monsoon and the evolution of one of Earth's most diverse biotas but these natural archives are not always straightforward to interpret correctly. Initially deposited close to sea level at an elevation <200m in the foreland basin that developed immediately to the south of the rising Himalaya, Siwalik sediments preserve remnants of the biota inhabiting the ancient equivalent of the Gangetic Plain. As the uplift of the Himalaya continues to progress southwards the Siwalik sediments are even today being raised up and exposed for inspection. Here I review some of the recent interpretations of Siwalik fossil assemblages in terms of climate and diversity, compare them to others from northern India, Tibet, and southern China, and highlight issues yet to be resolved in terms of what the Siwalik records may yet tell us about the orographic, climatic and biotic development of what some call Earth's 'Third Pole'.

Mineralogical Comparison Between Himalayan River Sands and Bengal Fan Deposits Recovered in IODP Exp. 354

Yoshida Kohki^{1*}, Lalit Rai Kumar², Subhadeep Kumar³, Hakiyai, Tomoyuki¹, Masuda Asako¹

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The Bengal Fan has the potential to represent detailed record of erosion history links between climate change and tectonics in Himalayan-Tibetan orogeny. To compare with the Bengal Fan deposits recovered at U1451 site of IODP Exp. 354, we examined the heavy mineral assemblage and chemical composition of specific minerals, such as detrital amphiboles, in the recent bed load deposits of Himalayan rivers. The samples from Himalayan rivers were taken from the Kari Gandaki River, in central Nepal, and the upper tributaries of the Brahmaputra River, in eastern India.

In the sands from the Kari Gandaki River, it is revealed that the High Himalaya Crystalline Sequence derives specific amphiboles with Ti- and Al-rich composition, whereas Lesser Himalayan Sequence produces Ti- and Al-poor amphiboles. Though both types of the amphibole were found in the present Himalayan River in the eastern India, Ti- and Al-rich amphiboles were predominated.

In comparison with Bengal Fan deposits, Ti- and Al-poor amphiboles were found, though it was very small amount, in the lower part of the Middle Miocene deposits (17-13 Ma). Then, the Ti- and Al-rich amphiboles suddenly increased with subordinal Ti- and Al-poor amphiboles from 12.9 Ma. The Ti- and Al-rich amphiboles were main amphibole components up to the Quaternary deposits.

The source rock assemblage of the Bengal Fan changed in the Late Miocene period (13 Ma), which describes the intense erosion of the core part of the Himalaya.

Palynological evidence for the Neogene environment change of the Thakkhola Graben, Nepal

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The Thakkhola Graben, a north-south graben, lies in central Nepal Himalayas consisting of Neogene sediments. The presence of pollens in these sediments provides a unique natural laboratory to understand the paleoenvironment during the formation of the graben. This study provides a detailed description of the pollen collected from the Tetang and Thakkhola formations with the help of the Light Microscope and Scanning Electron Microscope. A variety of pollen assemblages from the Thakkhola Graben explains that the sediments contain dominant alpine trees with some steppe vegetation. Presence of evergreen subtropical and temperate deciduous broad-leaved forest, needle-leaved element, and high-altitude taxa show a mixed pollen assemblage in fluvial-lacustrine sediments of the graben. The presence of evergreen subtropical and temperate deciduous broadleaf forest (*Quercus*, *Betula*, *Juglans*, *Alnus*), needle-leaved element (*Pinus*, *Tsuga*) and high-altitude taxa (*Picea*, *Abies*) with *Artemisia*, Chenopodiaceae, Poaceae, Rosaceae show mixed pollen assemblages indicating warm and humid paleoclimate. The coniferous pollen indicates the altitude was higher during the deposition time and the presence of *Betula*, *Quercus*, and *Juglans* suggests temperate forest. Domination of *Artemisia* and Chenopodiaceae shows a strong influence of the Himalayan topographic barrier during the sediment deposition.

Signature of high productivity during Tortonian: evidence from biosiliceous microfossils from northeast Indian Ocean

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The oceanographic scenario of the present-day conditions is reflected by biosiliceous sediments. High surface water productivity of the geological past also can be interpreted by biosiliceous sediments. Productivity by means of biosiliceous organisms in the oceanic realm is contributed by both phytoplankton and zooplankton. Amongst these, in the marine environment the planktonic diatoms contribute huge amount of carbon into the deep ocean. These diatoms play a significant role in maintaining the global carbon cycle as they contribute ~20% of global primary productivity. These marine planktonic diatoms are one of the major components of phytoplankton. It has been evidenced that they are most common in upwelling zones of high productivity regions. Amongst the zooplankton, radiolarians – the biosiliceous polycystina, are one of the best marine microfossils that provide considerable evidence about the palaeoenvironment and are widely used for biostratigraphy. During the course of investigation of the onshore (Andaman and Nicobar Islands) and offshore (NGHP-01-17A) sediments of Andaman and Nicobar Basin in the northeast Indian Ocean, it has been revealed that the Tortonian sediments are rich in both diatoms and radiolarians. The diatom flora is well diversified and the radiolarian fauna is represented by index taxa that can determine the age of the sediments precisely. In addition, the planktonic/benthonic ratio of diatoms indicates the

dominance of planktonic forms that in turn suggests deep water condition. The diatom flora also contains number of upwelling responder species. The study also reflects how diatom diversity has responded to change of global temperature in the past and the change in marine export productivity that may be linked to the changes in global carbon cycle.

A review of dated Late Pleistocene environmental studies in India

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Palaeoenvironmental studies in relation to prehistoric hominin dispersals, adaptations and cultural transitions have been frequently applied to data from Europe, Africa and the Levant. In South Asia, however, very few studies have been carried out to test comparable hypotheses of hominin ecological adaptations. The region's geographical location suggests a corridor for hominin expansions towards Southeast Asia, making it relevant for paleoanthropology. The Late Pleistocene archaeological records of South Asia have been increasingly studied over the last two decades in relation to the number of sites, chronological information, and contextual palaeoenvironmental data available, especially in India and Sri Lanka. This paper presents a general summary of Late Pleistocene environmental studies done till date in South Asia and associated implications derived from different proxies, i.e., sediment, carbonate, ostrich eggshell, pollen, speleothem, and multi-proxy approaches, including some archaeological sites. The records tentatively show that the period from 125-80 ka is predominantly characterized by humid environments and was followed by varied results/changes in climatic conditions at 79-70 ka and arid environments at 69-60 ka. Between 59 ka and 30 ka, South Asia's environmental conditions were again generally humid. The period from 29-20 ka again represents varied results, which was later followed by arid conditions from 19-11 ka, i.e., following the Last Glacial Maximum. Studying archaeological and paleontological records within environmental contexts will help to understand past human-environment relationships and associated behavioral transitions as well as explain specific faunal speciation and extinction events. This general review also demonstrates that many more Quaternary studies are required to fill major geographic, chronological, and methodological gaps in Late Pleistocene environmental research. This paper has been recently published in *Man and Environment*.

Timing of collision of India - Tibetan plate and evolution of Himalayas based on fossils from Kasauli and Ladakh

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Timing of collision between Indian and Tibetan plate has been a matter of concern for all the geologists. Various dates have been proposed by various workers mostly based on radio active dating of the igneous rock samples and many 3D graphic models proposed to show the movement and final collision. And a sort of consensus appears to have been achieved about initial and final collision between 55 million years to 40 million years.

Present paper is based on collection of fossils of plants molluscs from Kasauli-Subathu and Ladakh Tethyan sediments and establishing their role in bio- and litho-stratigraphic correlation which show that they were homotaxial formation. Plant fossils of *Combretum*, *Syzygium*, *Garcinia*, *Gluta* and Palm collected from Kasauli show that today these plants are not found in Himalayas and are confined to Indonesia Malaysia and Andaman Nicobar Island. Paleolatitudinal position of the Kasauli and equivalent formation therefore at the time of deposition must be around 4-11 degrees north of equator. Since Kasauli sediments are Lower Miocene in age. This also implies that Himalayas were not born at that time and it might have taken couple of more million years for Indian plate to reach its present latitude of 33 degrees. The Batholiths (granites) of Ladakh has intruded into these fossiliferous horizons along the present-day suture. Hence the age of the collision which subsequently led to the origin of Himalayas has too much younger than 20 million years. Time of initial collision of the 2 plates has to be definitely less than 18 million years.

WADE ratio of radiolarians: A tool for interpretation on the palaeoecology of Neogene sediments from Andaman and Nicobar Basin

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Radiolarians are one of the first-rate proxies in terms of both biostratigraphy and age determination. Presently radiolarians are widely used to determine the changes in productivity in the oceans, using the ratio of surface and deep-water species. Water Depth Ecology (WADE) index is considered as a reliable tool for deducing the past productivity. WADE index has the advantage as it provides a clear model linking productivity to faunal composition. This method is significant because its basic foundation is on much broader taxonomic/ecologic parameters that is applicable in most the ocean environments and over extended geologic time. In the present study an attempt has been made to interpret the palaeoecology based on the WADE index of radiolarians from three outcrops on the Havelock Island belonging to the Ritchie's Archipelago of Andaman and Nicobar Group of islands. The data base on the ecology of radiolarians has been obtained from various published literatures. The data from different Ocean Drilling Program (ODP), Deep Sea Drilling Program (DSDP), and International Ocean Discovery Program (IODP) were available on the website of Pangea (www.pangaea.de) and www.gbif.org has been taken into consideration for the analysis. The preservation potential of most of the radiolarian taxa from the outcrops of the Havelock Island is moderate. In view of this, only those radiolarians which were identified up to species level have been considered for the WADE analysis. For better understanding of the past environment a comparison has been made based on the datasets of the diversity of radiolarians and the WADE index.

Calcareous nannofossil events and sedimentation rate during Tortonian from northeast Indian Ocean

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The calcareous nannofossil represents a major component of oceanic planktonic community and widely used as a powerful tool for regional and global biostratigraphic correlations. For the establishment of biostratigraphy, relative ages of the sediments can be precisely determined by age diagnostic calcareous nannofossils. The present study carried out on calcareous nannofossils from NGHP-01-17A core of northeast Indian Ocean reveals well preserved and index species of calcareous nannofossils. Owing to the first occurrences (FO) or last occurrences (LO) of some significant nannofossil events, viz., LO *Discoaster hamatus* at 9.65 Ma, the Bottom paracme (Bpa) of *Reticulofenestra pseudoumbilicus* at 8.80 Ma and the FOs of *Discoaster berggrenii* and *Discoaster quinqueramus* at 8.20 Ma, the studied sequence of the core is assignable to NN9, NN10 and NN11 zones corresponding to CNM13 to CNM17 zones. Based on calcareous nannofossils, the age of the analysed section of the core has been dated Tortonian. The age-depth model proposed herein based on the significant events (FO, LO and Bpa) of calcareous nannofossils, diatoms and radiolarians which reveals that the average sedimentation rate for Tortonian was ~151 m/Ma. During the late Miocene, the rate of sedimentation was considerably high in the Indian Ocean and South China Sea. However, the sedimentation rate was comparatively low in the equatorial Pacific Ocean. In the present study, abundance of calcareous nannofossils in the late Miocene also indicates enhanced productivity in northeast Indian Ocean.

Organic petrographic and geochemical characterization of Neyveli Lignite deposits (Cauvery Basin), Tamil Nadu, India: Insights into the source flora, depositional environment and hydrocarbon generation potential

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Lignites are mainly composed of huminite (av. 71 vol.%) followed by liptinite (7-38 vol.%), inertinite group (av. 5 vol.%) group of macerals and low mineral matter concentration (av. 3 vol.%). A homologous series of C₁₄ to C₃₆ *n*-alkanes with bimodal distribution is evident. Biomarker composition includes non-hopanoid pentacyclic triterpanes with oleanane, ursane, lupane and fernane structures. Substantial amounts of hopanes were identified with dominance of neohop-13(18)-ene, 17 β (H),21 β (H)-30-norhopane and 17 β (H),21 β (H)-hopane. Copious huminite macerals, pentacyclic non-hopanoid triterpanes, high CPI (av. 2.68), and TAR (av.19.40) indicates a major terrigenous higher plant (angiosperm) source of the lignite deposits and reducing conditions in the paleomire. However, the high content of detrohuminite and P_{aq} values (av. 0.28) suggests the contribution of soft wood/herbaceous vegetation and/or accelerated mechanical, chemical and microbial breakdown; further indicated by frequent funginite, inertinite macerals and hopane compounds. The low TPI and GI values suggests the deposition probably occurred in a swampy/marshy environment with higher level of groundwater.

The lignites are characterized by the moderately higher moisture contents (27.09 and 36.30 wt.%), moderate ash yields (1.17 to 40.16 wt.%), moderate to high volatile matter yields (daf: 54.44-67.82 wt.%), and fixed carbon content 32.18-45.56 wt.% (daf) with low gross calorific values (av. value 3335 cal/g). The studied lignites contains high carbon (av. 44.96 wt.%) and oxygen (av. 41.12 wt.%) contents, while hydrogen (av. 5.89 wt. %), nitrogen (av.1.03 wt.%) and

sulphur (av.1.43 wt.%) contents are low. The H/C and O/C atomic ratios vary between 1.23 and 2.06, and between 0.21 and 0.87, respectively. The atomic H/C vs. O/C plot suggests that the studied lignite contain mixed type III and II kerogen and capable of generating gaseous (mainly) and liquid hydrocarbons with additional heating.

Biotic evolution and biogeography during the Neogene in South Asia: Sirenians and Seagrasses

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Sirenians (herbivorous marine mammals; Order Sirenia) are represented in the Neogene fossil record of the Indo-Pacific region by a significant diversity of recently-discovered taxa of mostly Miocene relatives of the modern dugong. These have been found particularly in the district of Kutch (Kachchh), India, but some also in Madagascar. All belong to the Family Dugongidae, and most represent the Subfamily Dugonginae. However, this Indo-Pacific record has presented two anomalies: so far, no sirenian genera have been found in common between India and Madagascar; and until recently, no members of the Subfamily Halitheriinae (which is the most common sirenian group in the Euro-Mediterranean region) had been identified in the Indo-Pacific. The cosmopolitan halitheriine *Metaxytherium* has now been reported from Madagascar, along with at least two genera of dugongines. The faunal list from Kutch now stands at three genera, all dugongines different from the Madagascan ones. If we assume this geographic difference is an artifact of limited sampling, there still remains the paleoecological question of how these (presumably) sympatric taxa divided the available food resources (seagrasses; marine angiosperms, which are diverse today in the Indo-Pacific but not yet represented there by identifiable fossils). Several ecomorphological characters of sirenians (e.g., body size, rostral deflection, tusk morphology) offer hope of inferring how they minimized feeding competition, once sufficiently complete remains of the sirenians have been collected. A final unsolved problem is: which (if any) of all these Indo-Pacific sirenians gave rise to our modern

dugong? Surprisingly, its closest relative and most likely ancestor appears to be from Florida! But the overall paleontological picture is clear in one respect: contrary to the traditional view of seagrass biologists, it is not normal for most seagrass to become detritus. Rather, the Cenozoic norm has been for a very large fraction of seagrass primary production to be eaten by herds of diverse, large, warm-blooded herbivores: sirenians!

Fossil callimothalloid fungi from India

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Fossil epiphyllous fungi are important as the palaeoecological proxy, however, the determination of their taxonomic position in many cases has led to serious mistakes. We reinvestigated the epiphyllous callimothalloid [having sporodochial, non-ostiolate conidiomata, with a single pore (= conidiogenous locus, aperture) at least in the part of the cells] fungi belonging to the fossil genera *Callimothallus* Dilcher and *Cribrites* R.T. Lange (Worobiec et al. 2020). The common fossil callimothalloid fungus, *Callimothallus pertusus* Dilcher, previously thought to be related to the fungal family Microthyriaceae (Dilcher 1965) or to some modern algae (*Phycopeltis*), was found as near the same as the modern *Mycoleptodiscus disciformis* Matsush. and *Neomycoleptodiscus venezuelense* Hern.-Restr., J.D.P. Bezerra and Crous. A new combination *Neomycoleptodiscus pertusus* (Dilcher) G. Worobiec was made. Contrary to *Callimothallus pertusus*, fossil *Callimothallus quilonensis* K.P. Jain and R. Gupta (Jain and Gupta 1970) from tertiary of Kerala Coast, India, has pores only in the outermost row of cells of the sporodochium and has slightly elevated walls forming collarette around pores. These features suggest taxonomic affinity with species of the modern genus *Muyocopron* Speg. and a new fossil-genus *Muyocopromyces* G. Worobiec was created with a species *Muyocopromyces quilonensis* (K.P. Jain and R. Gupta) G. Worobiec. Both *Neomycoleptodiscus pertusus* and *Muyocopromyces quilonensis* were assigned to the family *Muyocopronaceae* K.D. Hyde. Callimothalloid fungi belonging to the fossil-genus *Cribrites* differ from both *Neomycoleptodiscus pertusus* and *Muyocopromyces quilonensis* in the size and orientation of the pores and in the cell arrangement of the sporodochia. *Ratnagiriathyrites hexagonalis* R.K. Saxena and N.K. Misra from Neogene deposits of Maharashtra, India (Saxena and Misra 1990) shows morphological features typical of the fossil-genus *Cribrites*. Thus, we reconsider *Ratnagiriathyrites hexagonalis*

as *Cribrites hexagonalis* (R.K. Saxena and N.K. Misra) G. Worobiec. *Neomycoleptodiscus pertusus* and *Muyocopromyces quilonensis* are reliable climate proxies of warm climate conditions in the past.

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Remarkable Miocene vertebrate fossils from Kutch, western India

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Late Miocene was an important interval for mammalian evolution; however, mammals from this interval are poorly known from the Kutch region, western India. Palaeontological studies were recently carried out on the Miocene terrestrial biota in central Kutch (Gujarat, India). Numerous vertebrate fossils remain were recovered from Tapar and Pasuda localities of central Kutch that include freshwater fishes, turtles, crocodiles, large- and small-sized mammals (that include bats and rodents). The first record of rodents from the Miocene interval of central Kutch assumes considerable biostratigraphic significance. The rodent assemblage supports an age of earliest Late Miocene (<10 Ma) for the deposits in the Pasuda-Tapar area.

New micromammals from the middle Miocene of Ramnagar, Udhampur District, Jammu and Kashmir

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Ramnagar locality of lower Siwalik India is well known for its diverse mega and microfossil assemblages. The fossil record of tree shrews, hedgehogs, and other micromammals from the Lower Siwaliks of India is very scanty. Here, we describe new fossil specimens of Tupaiinae gen. and *Galerix* cf. *wesselsae*, as well other micromammals (Rodents) from the middle Miocene (Lower Siwalik) deposits surrounding Ramnagar, (Udhampur District, Jammu and Kashmir State). The Tupaiinae specimen from Ramnagar represents the oldest record of fossil tupaiids in the Siwaliks and extends their time range by ~2.5-4 million years in this region. The occurrence of *G.* cf. *wesselsae* is the first erinaceid documented from the Indian Siwaliks. However, more specimens are necessary to confirm the presence of *G. wesselsae* at Dehari to support one of the three possibilities: 1) *G. wesselsae* extends well beyond ~14.1 Ma in the Indian Lower Siwaliks while going locally extinct during this time period on the Potwar Plateau, 2) the deposits at Dehari (and Ramnagar) may extend back in geological age to the equivalent of the base of the Chinji Formation, close to ~14 Ma, or 3) the Dehari 2 *Galerix* specimens represent a previously undocumented species that is distinct from both *G. wesselsae* and *G. rutlandae*.

In addition to these two new records of micromammal fauna, new specimens of the rodents *Kanisamys indicus*, *Sayimys sivalensis*, and Murinae indet. from Dehari-2 locality help confirm age estimates for the Ramnagar region equivalent to the Chinji Formation of type area in Pakistan, most likely equivalent to the Middle Chinji Formation.

Documentation of change in diversity pattern of Kutch gastropods, across the Paleogene/ Neogene boundary

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In the present endeavour, a preliminary study to document the temporal changes in taxonomic and morphological diversity of the gastropods of the Paleogene and Neogene beds of the Kutch Basin is done. Data comprises of 228 species, belonging to 90 genera and 27 families (Figure 1), - of which 17 families are reported each from Eocene and Oligocene, whereas 26 families are reported from the Miocene. The data reveals that a total of 12 families out of the 17 gastropod families that thrived during Eocene continued to Oligocene. The gastropod families during Oligocene show remarkable similarity with that of Miocene as 16 out of 17 families are seen to cross the Paleogene–Neogene boundary and flourish during Miocene. This overlap in taxonomic composition during the Paleogene–Neogene transition reveals a similar paleoenvironment condition prevailing during the studied interval in the Kutch basin. However, during the Miocene a significant proliferation of gastropod diversity in both family and generic levels is seen with the appearance of 4 new families, recorded from the Kutch Basin.

On studying the morphological diversity of the gastropods, a significant change is observed during the Paleogene- Neogene boundary marked by the dominance of fusiform gastropod shell forms, over obconic shell forms (Figure 2). The shell forms of the gastropods belonging to the Neogene Period are also significantly diverse than those present during the Paleogene. Hence, both taxonomically and morphologically, Neogene is more diverse.

Family	Genus + species	Eocene	Oligocene/Miocene	Family	Genus + species	Eocene	Oligocene/Miocene	Family	Genus + species	Eocene	Oligocene/Miocene	Family	Genus + species	Eocene	Oligocene/Miocene			
Amphilebidae	<i>Ampullipos crassifera</i>			Cymatidae	<i>Epider noma</i>			Naticidae	<i>Coris</i> sp.			Turbellidae	<i>Retra zepora</i>					
	<i>Ampulloneta angulifera</i>				<i>Epider perra</i>				<i>Esagra parviphensis</i>				<i>Retra (Retra) lachensis</i>			<i>Retra (Retra) orbicula</i>		
	<i>Ampulligera</i> sp.				<i>Gyrium blaberrabre</i>				<i>Esagra</i> sp.				<i>Retra subrotunda</i>			<i>Myrtil lachensis</i>		
	<i>Ceratia</i> sp.				<i>Serpytes humosa</i>				<i>Esagra</i> sp. 1				<i>Myrtil orbicula</i>			<i>Stenolis paxoni</i>		
	<i>Cranium</i> sp. 1				<i>Cyanea lutea moris</i>				<i>Esagra</i> sp. 2				<i>Trocha</i> sp. 4			<i>Trocha</i> sp. 4		
	<i>Cranium aff. pseudobalmet</i>				<i>Esora</i> sp. 1				<i>Esagra</i> sp. 3				<i>Trocha</i> sp. 1			<i>Trocha</i> sp. 1		
	<i>Cranium</i> sp. 2				<i>Esora</i> sp. 2				<i>Esagra</i> sp. 4				<i>Trocha</i> sp. 2			<i>Trocha</i> sp. 2		
	<i>Globularia</i> sp. 1				<i>Lymnaea rosata</i>				<i>Natica obtusa</i>				<i>Trocha</i> sp. 3			<i>Trocha</i> sp. 3		
	<i>Globularia</i> sp. 3				<i>Lymnaea prunum</i>				<i>Natica pellagrina</i>				<i>Trocha</i> sp. 4			<i>Trocha</i> sp. 4		
	<i>Globularia carli</i>				<i>Anava varicosa</i>				<i>Sium operis precedens</i>				<i>Trocha</i> sp. 1			<i>Trocha</i> sp. 1		
<i>Globularia</i> cf. <i>sanctiagorani</i>			<i>Cicurena</i> sp.			<i>Tana</i> sp.			<i>Trocha</i> sp. 2			<i>Trocha</i> sp. 2						
Callionastriidae	<i>Globularia (Ampulligera) crassifera</i>			Epuridae	<i>Cicurena</i> sp.			Olividae	<i>Agrotia pupa</i>			Turbellidae	<i>Semula zepora</i>					
	<i>Globularia (Ampulligera) sp.</i>				<i>Cicurena subrotunda</i>				<i>Agrotia pupa</i>				<i>Semula zepora</i>			<i>Perforonema bouet</i>		
	<i>Polypremium bonis</i>				<i>Cicurena operis</i>				<i>Olive indica</i>				<i>Perforonema bouet</i>			<i>Perforonema ripoides</i>		
	<i>Polypremium</i> sp.				<i>Epurium (Vericaria) sp.</i>				<i>Olive (Olive) sp.</i>				<i>Perforonema cili</i>			<i>Perforonema zepora</i>		
	<i>Callionastriella jubbium</i>				<i>Stenophyllis</i> sp. A				<i>Obvolutaria (Agrotia) retulosa</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Callionastriella jubbium</i>				<i>Coneljus</i> cf. <i>ferreoli</i>				<i>Combarus buclardi</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Callionastriella jubbium</i>				<i>Coneljus</i> sp. 1				<i>Combarus erythrostrata</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Callionastriella jubbium</i>				<i>Coneljus</i> sp. 2				<i>Combarus</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Callionastriella jubbium</i>				<i>Fasciola nodulosa</i>				<i>Combarus</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Callionastriella jubbium</i>				<i>Fasciola nodulosa</i>				<i>Combarus</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
<i>Callionastriella jubbium</i>			<i>Fasciola nodulosa</i>			<i>Combarus</i> sp.			<i>Perforonema zepora</i>			<i>Perforonema zepora</i>						
Cecidae	<i>Semiothis (Semiothis) juba</i>			Fasciolidae	<i>Fasciola nodulosa</i>			Pisanidae	<i>Trionda</i> sp.			Turbellidae	<i>Perforonema zepora</i>					
	<i>Semiothis (Semiothis) quibensis</i>				<i>Fasciola nodulosa</i>				<i>Perforonema zepora</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Semiothis</i> sp.				<i>Fasciola nodulosa</i>				<i>Perforonema zepora</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Semiothis</i> sp. 1				<i>Fasciola nodulosa</i>				<i>Perforonema zepora</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Semiothis</i> sp. 2				<i>Fasciola nodulosa</i>				<i>Perforonema zepora</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Semiothis</i> sp. 3				<i>Fasciola nodulosa</i>				<i>Perforonema zepora</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Semiothis</i> sp. 4				<i>Fasciola nodulosa</i>				<i>Perforonema zepora</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Semiothis</i> sp. 5				<i>Fasciola nodulosa</i>				<i>Perforonema zepora</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Semiothis</i> sp. 6				<i>Fasciola nodulosa</i>				<i>Perforonema zepora</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Semiothis</i> sp. 7				<i>Fasciola nodulosa</i>				<i>Perforonema zepora</i>				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
<i>Semiothis</i> sp. 8			<i>Fasciola nodulosa</i>			<i>Perforonema zepora</i>			<i>Perforonema zepora</i>			<i>Perforonema zepora</i>						
Cerambycidae	<i>Cerambium (Pycnozanthum) pseudocorymbium</i>			Meligetidae	<i>Meligete</i>			Rasbilleridae	<i>Tiba</i> sp.			Turbellidae	<i>Perforonema zepora</i>					
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Tiba</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Tiba</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Tiba</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Tiba</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Tiba</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Tiba</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Tiba</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Tiba</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Tiba</i> sp.				<i>Perforonema zepora</i>			<i>Perforonema zepora</i>		
Cerambycidae	<i>Cerambium (Pycnozanthum) rufum</i>			Meligetidae	<i>Meligete</i>			Meligetidae	<i>Meligete</i>			Serpilidae	<i>Terebellum (Terebellum) terebellum</i>					
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
Cerambycidae	<i>Cerambium (Pycnozanthum) rufum</i>			Meligetidae	<i>Meligete</i>			Meligetidae	<i>Meligete</i>			Serpilidae	<i>Terebellum (Terebellum) terebellum</i>					
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
Cerambycidae	<i>Cerambium (Pycnozanthum) rufum</i>			Meligetidae	<i>Meligete</i>			Meligetidae	<i>Meligete</i>			Serpilidae	<i>Terebellum (Terebellum) terebellum</i>					
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
	<i>Cerambium (Pycnozanthum) rufum</i>				<i>Meligete</i>				<i>Meligete</i>				<i>Terebellum (Terebellum) terebellum</i>			<i>Terebellum (Terebellum) terebellum</i>		
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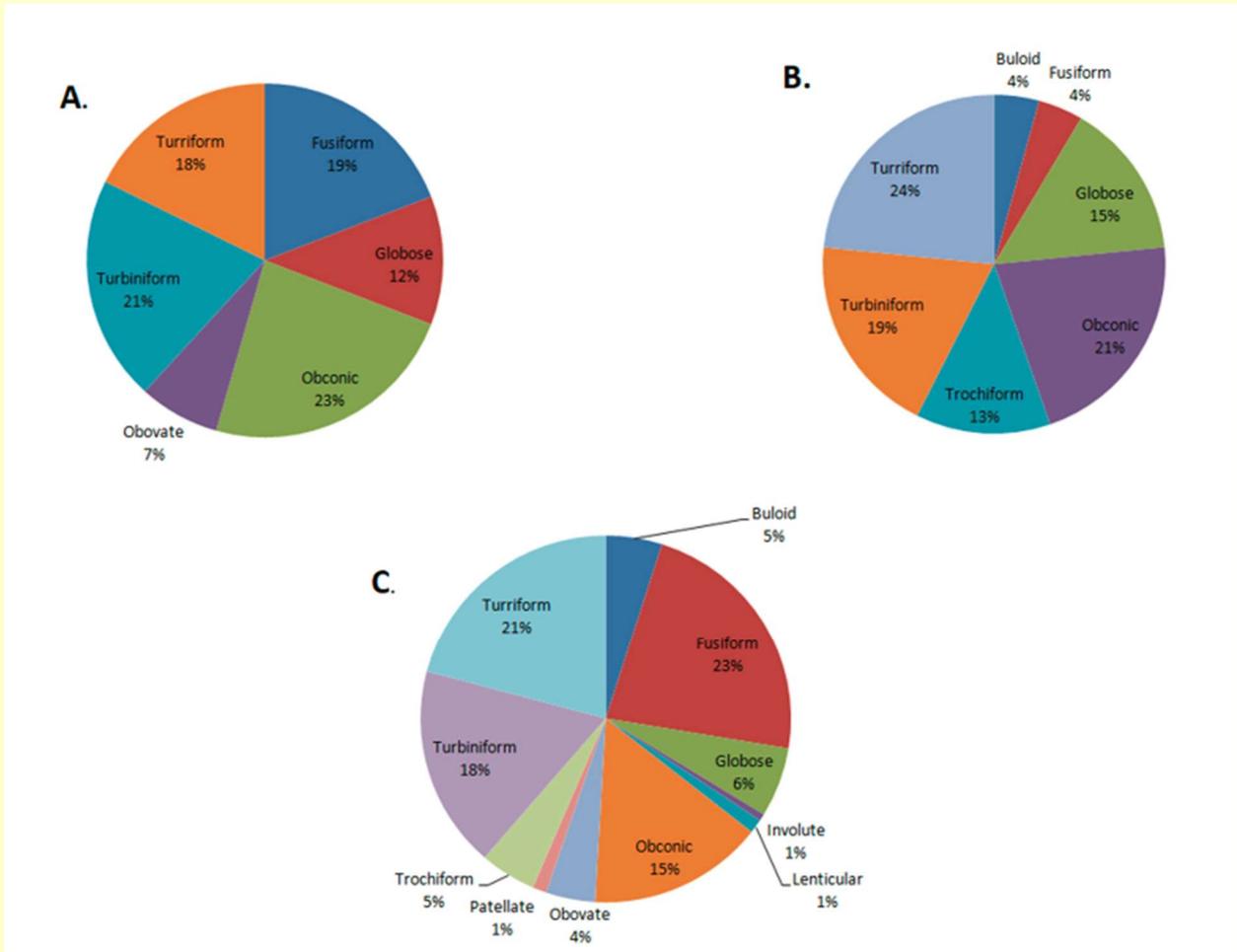


Figure 2: Pie-charts showing different gastropod shell forms (in percentage) during A. Eocene, B. Oligocene, and C. Miocene.

Fossil wood of *Cordia* L. (Cordiaceae) from the Tipam Sandstone Formation of northeast India

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The family Cordiaceae has pantropical distribution and consists of three genera (*Cordia* L., *Varronia* Candolle and *Coldenia* L.) and 350 species. The genus *Cordia* envelops 229 species mainly distributed in tropical areas of the world. The majority of its species are found in the American tropics and only 16 species are known to occur in India. The fossil records of the genus are poorly known. The leaf fossil of the genus has been reported from the Paleogene sequence of Russia, however, wood fossils have been reported from late Paleocene of Argentina, Paleogene of Egypt and Miocene of south India. In the present communication we report a new fossil wood of *Cordia* from the late Miocene sediments of Tipam Sandstone Formation of Assam, northeast India. The characteristic features of the fossil wood are indistinct growth rings, diffuse porous wood, simple perforation plates, tylosed vessels either solitary or in multiples and clusters, vasicentric to confluent to more than 3 cells wide paratracheal bands, rays more than 4 seriate, weakly heterocellular with crystalliferous parenchyma and ray cells.

The occurrence of *Cordia* in Diphu, in association with other evergreen to deciduous taxa such as *Canarium* L., *Gluta* L., *Lannea* A. Rich., *Cassia* L., *Cynometra* L. *Terminalia* L. and *Phyllanthus* L. indicates the presence of tropical evergreen to deciduous forests there during the late Miocene. Nowadays there is an increase in deciduous elements due to seasonality in temperature and rainfall. It can be concluded that a tropical warm and humid climate was present in Assam, northeast India during the depositional period.

First fossil pod record of *Mucuna* (Papilionoideae, Fabaceae) from the Miocene of Yen Bai Basin, North Vietnam

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The genus *Mucuna* Adans. (Papilionoideae, Fabaceae) contains approximately 105 extant species widely distributed in pantropical areas, with its diversity center in Asia. Its pantropical distribution and rich species have been explained by the central role of the seeds in the long-distance oceanic dispersal. The genus has been traced back to Oligocene to early Miocene with its origin and early diversification in Asia by molecular evidence. However, its biogeography history is not fully understood because of lacking fossil evidence. Here, we report the first fossil pod record of *Mucuna* from the late Miocene of Yen Bai Basin, northern Vietnam. Based upon examination with all living legumes that have morphological resemblances to the current fossil we assigned the fossil to *M. cf. birdwoodiana* Tutcher, an extant species with large, torulose pods and a pair of robustly marginal wings. The establishment of the late Miocene fossil pod record of *Mucuna* in northern Vietnam provides critical information on our understanding of

the evolutionary history of this leguminous genus. The discovery supports the hypothesis that *Mucuna* might originate in Asia and suggest that the genus had already existed and undergone a divergence from evolution in Asia by at least the late Miocene. Besides, the paleoclimatic implication of the current fossil was discussed. Together with other species from the Yen Bai flora, it presents a tropical vegetation outlook that is similar to the Indochina Peninsula today.

Changes in plant biogeography during the Eocene–Oligocene Transition (EOT)

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The Eocene–Oligocene Transition (EOT) is an important global climate transition that culminated with a drop in global temperature at ~34 Ma. This transition is known as the shift from ‘greenhouse’ into ‘icehouse’ world and thought to be driven by atmospheric CO₂ decline, geographic changes in oceanic passages, ice sheet formation on Antarctica, and was exacerbated through orbital forcing. Evidence from the fossil record indicates that biotic composition was strongly affected by the EOT. In this presentation I will focus on the palynological record and highlight case studies from representatives of three plant groups: palms, conifers, and steppe-desert taxa. A) Recently it was shown that Mauritiinae palm pollen, a characteristic pollen type that can be used as indicator taxon for tropical forest vegetation, was widely distributed during the Paleocene and Eocene extending across South America, Africa, and India. After the EOT, however, this group dwindled and became endemic in South America. B) In the boreal zone, conifer pollen are known to have increased during the Oligocene, suggesting expanding forests. This pattern is echoed in records from NE part of the Tibetan Plateau, where the increase of Pinaceae at the EOT suggests an expansion of the Pinaceae forest following climatic cooling. C) Pollen from steppe-desert taxa in this same Tibetan region dwindled during the Oligocene, a decline that is suggestive of arid-cooler conditions. In summary, further study of palynological records from the EOT can help increase our understanding of the impact of climate cooling on vegetation, and improve models for future scenarios of climate change.

The rise of herbaceous diversity in southeastern Tibetan Plateau: first insight from fossils

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The southeastern margin of the Tibetan Plateau supports a high diversity of herbs, particularly in its subalpine to alpine ecosystems due to high altitude and cool temperate climate. Current understandings on the formation of such herbaceous richness is based chiefly on molecular phylogenies, while direct geological evidence is lacking. In this study, we present abundant fossil fruits and seeds of herbs from the late Pliocene Heqing Basin in the southern Hengduan Mountains region (HMR) at southeastern edge of Tibetan Plateau. Our systematic analysis shows the presence of at least 18 species belonging to 11 genera, i.e., *Ranunculus*, *Corydalis*, *Rumex*, *Polygonum*, *Chenopodium*, *Stellaria*, *Fragaria*, *Astragalus*, *Aster*, *Carex* and *Schoenoplectus*, of which *Polygonum* is most abundant followed by *Astragalus*. This finding throws the first light from fossil evidence on the rise of herbaceous diversity in the southeastern Tibetan Plateau. We interpret the local assembly of these herbs as resulting from rapid pre-Pliocene species diversifications of many herbaceous groups in this region. As nowadays most of these herbs grow primarily in meadows and a few occur as subaquatic plants, we suggest an open meadow hosting some scattered shrubs in the vicinity of a vegetated wetland in the Heqing

Basin during the late Pliocene. This provides the first direct evidence of past treeless open vegetation within the southeastern Tibetan Plateau and thus improves our knowledge of vegetation evolution therein. We suggest that the uplift-induced climate cooling and monsoon-associated precipitation seasonality are potentially the key driving forces for the opening of meadow vegetation.

Two giant gastropods from the Miocene of Dwarka Basin, Gujarat, India and their paleobiogeographic implications

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Herein, we are reporting for the first time two large sized gastropods from Early-Middle Miocene beds of the Dwarka Basin, western India. *Dilatilabrum* sp. belongs to the Family Dilatilabridae Bandel, 2007 and *Conus (Lithoconus) gajensis* Jain, 2014 belongs to the Family Conidae Fleming, 1822). The existence of these giant gastropods has been mentioned by previous workers as a passing reference. Here we report two species with detailed morphological study on them which is lacking in literature.

The temporal range of the genus *Dilatilabrum* was so far recorded from the Middle Eocene to the Early Miocene (Aquitanian). With this new find of the giant Dilatilabriid gastropod range extends up to Middle Miocene.

The spatio-temporal distribution pattern of the genus *Dilatilabrum* indicates that after its origination during Middle Eocene, the genus was quite abundant and widespread in the Tethyan Region. Due to a cooling event in the Tethyan Region, the genus compelled to migrate from west to east during the latest Oligocene and is seen to take refuge in the eastern Tethys. The situation prevailed during the Miocene, and with the closure of the Tethyan seaways the genus remained confined to the Indian subcontinent and eventually become extinct (Fig. 1).

On the other hand, the giant conus i.e., *Conus (Lithoconus) gajensis* is the largest conus species (H is 233 mm, D is 150 mm) reported till now. The species is found only confined to the Dwarka Basin and thus, is considered an endemic fauna to this western Indian basin (Fig. 2).

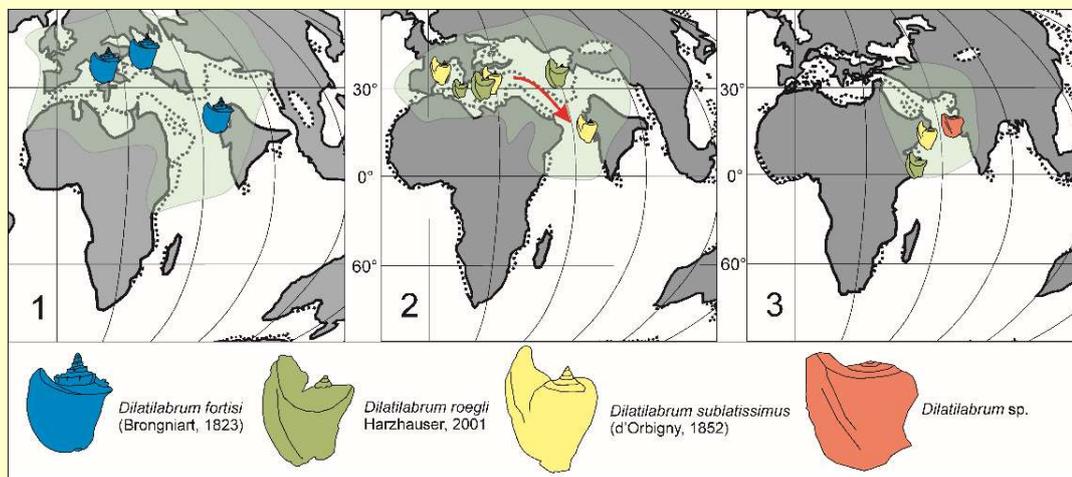


Fig. 1: Segmented paleo-coastline maps of (1) Middle Eocene, (2) Oligocene and (3) Miocene (modified after Smith et al., 1994) focusing on the Tethyan Region and showing distribution of the genus *Dilatilabrum* through time.

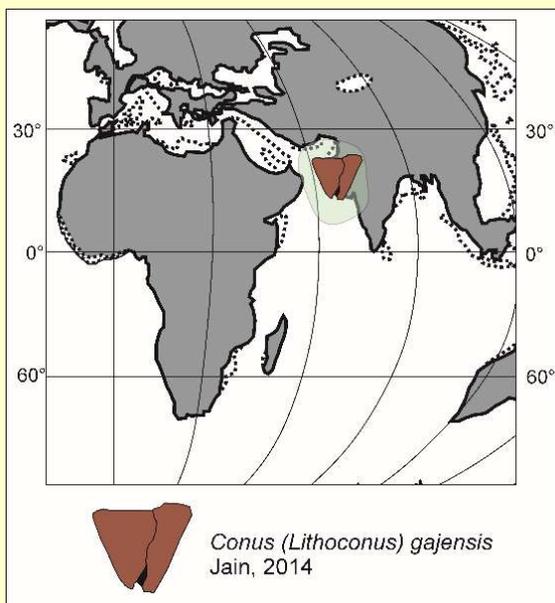


Fig. 2: Segmented paleo-coastline map of Miocene (modified after Smith et al., 1994) showing distribution of the genus *Conus (Lithoconus) gajensis* Jain, 2014.

Fossil amphibians and snakes from the Neogene localities of Kutch (Gujarat), Western India

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The Neogene localities of Kutch in India are famous for its rich assemblages of fossils vertebrates and invertebrate including the well-known record of an extinct ape *Sivapithecus*. Although, a little is known about the fossil herpetofaunal assemblages except a few fossil snakes. During a recent field in the Neogene of Kutch area, we have recovered new and additional fossil remains of amphibians and snakes from the two Miocene localities, the older deposits of Palasava locality which is earlier dated as middle Miocene (~14 Ma), and the younger deposits of Tappar and Pasuda sections which are biochronologically dated as late Miocene (~11-10 Ma). The amphibian fossils consist of ilium, humeri, sacral and presacral vertebrae of *Rana* sp., *Ranidae* indet. And *Anura* indet. The fossil snakes are mainly represented by isolated vertebrae and can be allocated to several taxa including *Python* sp., *Acrochordus dehmi*, *Acrochordus* sp., *Ahaetuliinae* indet. And *Colubroides* indet. The *Rana* sp., *Ahaetuliinae* indet. And *Python* sp. are the first evidence of these taxa from the Neogene of India. The ectothermic faunas are good indicators of palaeoenvironmental conditions. The record of palaeoherpetofauna indicate a very warm, humid/wet, and tropical to subtropical environment condition during the middle and late Miocene in these localities.

Preliminary data on coprolites from the Neogene (Miocene: Aquitanian–Burdigalian) Khari Nadi and Chassra formations, Kutch Basin, western India

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In recent years, the Siwalik-equivalent Neogene (Miocene) sedimentary successions of the Kutch Basin (western India) have gained importance owing to the recovery of a rich assemblage of vertebrates (including terrestrial and marine mammals). However, no or little emphasis has been placed on the associated ichnofossils (particularly cm-sized coprolites) from the Miocene of the Kutch Basin, western India, in terms of deciphering the diet of the producer(s) or linking the coprolites to producer animal(s). Herein, we provide preliminary data on coprolites (associated with vertebrates) from the Miocene (Aquitanian-Burdigalian) Khari Nadi and Chassra formations, Kutch Basin, western India. The coprolites (varying in sizes with the length ranging from ~97 mm to ~24 mm and width ranging from ~46mm to ~11mm) were recovered by surface prospecting in the field and represent at least three morphotypes (elliptical, irregular and ribbed). Scanning Electron Microscopy and Energy Dispersive Spectroscopy confirms the phosphatic character of the coprolite specimens. Scanning electron microscopy of the coprolite specimens also confirms presence of bone matter, walled-microspherulites/spherical cavities (egg-like mineral spheres formed in the presence of gases as a consequence of decomposition of excrement in the presence of sulphur producing bacteria), micron-sized porous structures, and pyrite. Presence of bone matter in the coprolite specimens suggest a dominantly carnivorous diet consumed by the producer (most likely crocodiles) while chelonians are well-known to yield ribbed coprolites. Morphometric and size comparisons (in a statistical framework: PCA analysis)

with previously known coprolites from the Mesozoic-Cenozoic successions of India also assist in providing some clues on the link(s) to producer taxa.

Diversity of *Engelhardia* Lesch. Ex Blume from the Latest Neogene sediments of eastern India: its biogeographic implications

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Here, we report a large number of engelhardioid winged samaroid fruit remains from the latest Neogene (Pliocene: Rajdanda Formation) sediments of Chotanagpur Plateau, eastern India. They are characterized by a tri-lobed wing (oblong-ovate median lobe and two lateral lobes) and a globose nut. The ample occurrences of this taxon suggest that *Engelhardia* Lesch. Ex Blume was established in the region at least by the Pliocene. *Engelhardia* has rich fossil records from the Cenozoic sediments of Europe, North America, and eastern Asia (China, Korea), but its modern analogue, *Engelhardia*, is presently native only to India (eastern Himalaya) and neighboring Southeast Asia. Here, we discuss its possible causes (gradual intensification of monsoonal rainfall seasonality since the Pliocene) of disappearance from the present-day tropical vegetation of Chotanagpur Plateau. In addition, we review in detail its biogeographic history and suggest possible migration routes of this relict taxon.

Two new legume fossil leaves from the Pliocene– Pleistocene sediments of Nepal

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The existing legume fossil leaves account first report from the lacustrine sediments of intermontane Kathmandu Basin, lying on the southern slope of the central Himalaya. Investigation based on morphological characters and comparison to their nearest living relatives (NRLs) shows closer resemblance to the extant genus of *Albizia* Durazz. And *Bauhinia* L. Among them, two *Bauhinia* fossils were recovered from the older fluvio-lacustrine sediments of Lukundol Formation (Pliocene to early Pleistocene) and younger fluvio-deltaic and lacustrine sediments of Gokarna Formation (late Pleistocene). The other genus (*Albizia*) was recovered from the Gokarna Formation. Investigation of the physiognomic characters, habit and habitat of the two fossil taxa with their extant equivalents suggest a warm and humid climate during the deposition of the sediments. The significant expansion of *Bauhinia* spp. is due to prevalence of a warm-temperate climate to warm-humid and *Albizia* sp. due to warm and humid climate during the deposition of Lukundol and Gokarna formations respectively. These fossils existence coincide with, when a major adjustment advance in the paleo-Kathmandu Lake dimension and tectonic activity prompting uplift of the southern Sub-Himalayan zone. Analysis of these legume plants reflect their migration triggering local short-distance dispersal, from the Miocene-Pliocene Sub-Himalayan zone towards the intermontane basin.

Vegetation and climate change across tropical Asia during the Pleistocene

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The climate and vegetation history for tropical Asia is reviewed for the last three million years by comparing the history for India with that for Southeast Asia for the later Pliocene and Pleistocene, paying particular emphasis to the last glacial period. The Pliocene witnessed the demise of humid tropical forests across India, which were replaced at least in the north by open grasslands, whereas closed forests continued to occur widely across much of Southeast Asia. The northern Indian grasslands supported a diverse fauna, elements of this which migrated to Java during the Early Pleistocene. The suggestion that the fauna migrated to Java along a “savanna corridor” is dismissed; it is more likely that there was a corridor of semi-evergreen forests across equatorial Sunda rather than open grasslands. During Pleistocene glaciations, there was an expansion of desert and savanna vegetation at the expense of deciduous and evergreen forests across the Indian subcontinent, whereas in Southeast Asia, perhumid rain forests remained along the equator, with fire-climax pine forest forming a belt at northern subequatorial latitudes, with savanna occurring to the north in Indochina. In contrast seasonal evergreen and deciduous forests expanded to the south, across the emergent Java Sea and Java. It is suggested that widespread Pleistocene megafauna may have considerably modified vegetation across the region compared to today.

Vegetation dynamics and its response to climate change during the last ca. 8400 cal yrs from central India

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Pollen analytical study of a 2.1-m deep lacustrine sedimentary profile from the central India has demonstrated that between ~8400 and 1200 cal yr BP, open, mixed tropical, deciduous forest occurred in the region under a warm and moderately humid climate, probably indicating moderate monsoon precipitation. Subsequently, between ~ 1200 and 500 cal yr BP (AD 750-1450), with the spread of most of the existing forest constituents, the open, mixed tropical, deciduous forest was succeeded by dense mixed, tropical, deciduous forest owing to the prevalence of a warm and humid climate with increased monsoon precipitation, coinciding with the Medieval Warm Period (MWP)/ Medieval Climate Anomaly (MCA) (AD 750-1200). Finally, during ~ 500 cal yr BP (AD 1450) to the Present, mixed, tropical, deciduous forest has been replaced by a relatively denser, mixed, tropical, deciduous forest around the study area under a warm and relatively more humid climate with further increase in monsoon precipitation, which falls within the time-frame of the Current Warm Period (CWP) (AD 1800 to the Present). Moreover, the varying degrees of warming since ~8.4 ka to the Present could be correlatable with the Holocene Climate Optimum (HCO)/Holocene Thermal Maximum (HTM). The present study provides insights into the vegetation dynamics and Indian Summer Monsoon (ISM)-influenced climate since the last ~8.4 ka to the Present from one of the poorly understood areas of the tropics where rainfall is essentially controlled by the monsoon [especially the southwest (summer) monsoon; SWM/SM] variability.

Study of plant megafossils from Siwalik group along the Bagmati River section for palaeoclimate implications

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The Bagmati River Section lies in the Siwalik Group, Central Nepal. The Siwalik zone has been divided into two belts as northern and southern belt by the CCT and the present study centered only in southern belt. The lithostratigraphic units, from bottom to top, are the Nunthar Formation, Bhimangau Formation, Raigau Formation and Majhgau Formation. The estimates age ranges from the Middle Miocene to Early Pliocene. The Siwalik Group represents the fluvial deposits, which in general shows a coarsening upward sequence but individual units display a fining upward sequence. The sediments of the Siwalik occurred from the fine-grained meandering river system to sandy braided river system.

Altogether 9 species of plants fossils belonging to 6 genera and 5 families were identified. They are *Daphnogene* sp. of the family Lauraceae, *Cinnamomum* sp. of the family Lauraceae, *Artocarpus* sp. of the family Moraceae, *Terminalia* sp. of the family Combretaceae, *Grewia* sp. of the family Malvaceae, *Cyclosorus* sp. of the family Thelypteridaceae. These plant fossils are the age of middle to late Miocene. Overall floristic assemblage of the study area indicators a dominance of evergreen condition during Middle Miocene. The physiognomic features of plant fossils suggest the tropical humid climate during middle to late Miocene age. The analysis of the present-day distribution and climate preference of nearest modern equivalent of fossil taxa suggests that the climate of Miocene Epoch to present day relatively humid climate conditions.

Oligocene flora and climate of the Halong Bay, northern Vietnam

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Fossil plant assemblages were found from the Oligocene Dong Ho Formation of the Halong Bay region, northern Vietnam. The flora contains about 40 species, including conifers and angiosperms. The Halong flora mainly comprises Fagaceae, Lauraceae and Dipterocarpaceae, with significant tropical Asian kinship. It has high similarity with other Paleogene floras in southern China, especially those from the Tonkin Gulf region, characterized by Fagaceae, Lauraceae, Dipterocarpaceae, Liquidambar and *Sabalites*. The floral composition shows a tropical-subtropical transition, with zonal vegetation mixed with limestone calciphile taxa. Among them are taxa endemic to tropical lowland rainforests, tropical montane evergreen broad-leaved forests and tropical limestone thickets, which still exist in this area. Reconstruction of the palaeoclimate in the Halong area was made using the coexistence approach based on 21 identified taxa, and, climate leaf analysis multivariate program based on 38 morphotypes of woody dicotyledonous plants. The analysis indicated a mean annual temperature around 20°C, a coldest month mean temperature around 10°C, during which there was almost 2000 mm of precipitation. This and other indicators all suggest a hot and humid marginally monsoonal tropical

environment. Floristic and climatic comparisons between the Halong and other southern China paleofloras reveals long-term environmental and floristic stability in this region.

Pollen-inferred climate reconstruction from the palaeo Kathmandu Lake sediment (Lukundol Formation), southern part of the Kathmandu valley

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The Kathmandu intermontane basin covering an area of approximately 650 sq. km., contains well-preserved lacustrine sedimentary deposits of Pliocene-Pleistocene to Holocene age. The basin encloses numerous vertebrate and plant fossils that can be used as proxies to investigate the past vegetation and environment. The present work features the palynological analysis of sediment samples (Upper Pliocene to Lower Pleistocene) acquired from the road-cut section of Lukundol Formation exposed in Pharsidol area. The three pollen assemblage zones viz. Zone I, Zone II and Zone III were divided according to pollen percentage diagram based on CONISS cluster analysis. The palynoflora of the Lukundol formation are characterized into Coniferous tree, broad leaved tree, herb, aquatic plant and fern plant according to the increase and decrease in representative pollen percentage in pollen diagram.

The Zone I indicate that the lake area was dominated by grassland with few trees during deposition period. The Zone II shows diversity in plant species as indication of favorable climate conditions to expand plant community. Increase in *Pinus*, *Picea*, *Quercus* and appearance of *Abies*, *Ulmus* pollen in the upper section of the pollen Zone II, indicates change in climate from warm to cold and moist during the deposition of sediments. The appearance of crop plants such as Apiaceae, Leguminaceae, and Malvaceae in the pollen Zone III, indicates human influence in the natural forest ecosystem. Pollen count was also analyzed by the means of unsupervised pattern recognition technique, PCA (Principal Component Analysis). This analysis was performed for determining variations in pollen assemblages.

Plant fossils from the middle Siwalik of eastern Nepal and their climatic and phytogeographic significance

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The Siwalik foreland basin accumulated a huge pile of molasse sediments since the middle Miocene to early Pleistocene, which host an excellent archive to analyzed paleovegetative and paleoclimate condition of the region during the deposition period of these sediments. The plant mega fossil records particularly from the eastern part of Nepal are meagre. In the present work, we report two new fossil leaves, namely *Pterygota palaeoalata* Srivastava and Mehrotra of the family Malvaceae and *Thelypteridaceophyllum teriarum* Joshi and Mehrotra of the family Thelypteridaceae from the Middle Siwalik (late Miocene–early Pliocene) sediments of eastern Nepal. The presence of these fossils and previous fossil records indicates the occurrence of evergreen forest growing under warm and humid conditions during the deposition of the Middle Siwalik sediments in eastern Nepal. The family Thelypteridaceae probably immigrated to Indian sub-continent after the complete joining of Indian and Eurasian Plates during the Neogene.

Palaeoclimate reconstruction of the middle Pleistocene palynological assemblages using co-existence approach analysis from the Dharmasthali Formation, northern Kathmandu Valley

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Climate is known to be utmost components of the plant diversification and they are mostly influenced by their surrounding environment making them as authentic indicator of climate and ecology. The Kathmandu basin sediment holds huge information of the climate and ecological changes from the Pliocene–Pleistocene–Holocene time period. The coexistence approach (CoA) has been applied to the palynological sample retrieved from the Dharmasthali Formation dated 780 kyrs exposed at the north of the Kathmandu valley in order to reconstruct mean annual temperature (MAT), temperature of the coldest month (TCM), temperature of the warmest month (TWM), mean annual precipitation (MAP), precipitation of the driest month (PDM), precipitation of the wettest month (PWetM) and precipitation of the warmest month (PWM). The CoA is based in the assumption that fossil plant taxa have similar climatic requirements in which they can coexist to their nearest living relatives. The method has been inferred by many researchers in order to quantitatively reconstruct palaeoclimate from fossil taxa around the world. The different climate parameters calculated by CoA from pollen assemblages of the Dharmasthali Formation reveal coexistence interval of MAT 9.3-22 °C, TCM 1.7-12.5 °C, TWM 21.6-28.1 °C, MAP 1122-1577mm, PDM 19-41mm, PWetM 115-323mm and PWM 82-172mm. The palynological assemblages refers to the diverse vegetation during the deposition of the Dharmasthali Formation under favorable environmental condition. The non-arboreal pollen (NAP) shows higher frequency than arboreal pollen (AP) in two different pollen zones of the formation suggesting forest floor rich in various herb and shrub vegetation.

Stable isotopic data from fossil mammalian enamel recovered from the late Miocene deposits of Kutch, Gujarat: Implications for Palaeoecology and Palaeoclimate

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The Miocene freshwater deposits of Kutch have recently yielded an ape *Sivapithecus*, that was earlier known from 12.7 to 8.5 ma Siwalik sediments exposed along the Himalayan foothills. From these sites we have recovered a diverse assemblage of rodents, proboscideans, giraffids, equuids, rhinocerotids, bovids, tragulids and suids and have analysed their dental enamel for stable oxygen and carbon isotopes. The bulk stable $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values of fossil mammals from the Late Miocene of Kutch, ranges between -10.04 to -13.33 and 6.30 to -7.51, respectively. This indicates that all these mammals were predominantly C3 browsers living in a highly seasonal environment. *Deinotherium indicum* consumed dominantly C3 plants and ~4-20% C4 plants ($\delta^{13}\text{C}$ values: -10.87 to -13.33) and acquired its water under dry to wet conditions. In contrast *Gomphotherium* ($\delta^{13}\text{C}$ values -10.25 to -11.05) was a browser with somewhat more grass (20-25 %) in its diet. The tragulid *Dorcatherium* ($\delta^{13}\text{C}$ values -13.18) and the suid *Tetraconodon* ($\delta^{13}\text{C}$ values: -13.23) lived in rather denser and wetter part of the forest. The equid *Hipparian* was a browser ($\delta^{13}\text{C}$ values -10.04 to -12.76) and likely lived in drier areas ($\delta^{18}\text{O}$ values: 2.41 and -3.96). The giraffids were C3 browsers ($\delta^{13}\text{C}$ values -10.74 to -11.62) too but lived in very dry ($\delta^{18}\text{O}$ values 6.30 and -0.93) parts of the region. The rhinos with $\delta^{13}\text{C}$ values of -12.55 and anthracotheres having $\delta^{13}\text{C}$ values of -13.07 were C3 feeder and lived close to the rivers and so did the early bovids ($\delta^{13}\text{C}$: -11.37 to -13.31; $\delta^{18}\text{O}$: -1.14 and -5.53). Overall, the fossil vertebrate assemblage and isotope data on mammals indicate that the Kutch

Sivapithecus lived in a subtropical seasonal forest close to the coast, very different from the present-day arid conditions.

Palaeoceanography, biogeographic, faunal changes and tectonic shifting of Indian plate with rising of the Himalayas special reference: global and regional climatic events in Indian ocean at Neogene time

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Ocean, climatic events and continental landmasses interconnected with each other, changes in any one directly effects the regional as well as global Scenario of marine habitat, Sea level which further influenced by latitudinal T° variability and tectonic configuration of continents.

Neogene was the time of earth history which consists greater climatic events as well as that was the time when earth get its current continental configuration, during this time many changes occur due to opening – closing of ocean gateways, extension of new ocean basin, ocean currents change which further led the change in marine faunal and floral, directly affect the world Biogeographic pattern which can be reconstructed with the help of deep-sea sediments records of Neogene time.

Neogene included the Miocene and Pliocene Epochs this time characterized by gradually declining atmospheric CO₂ levels and cooling of global temperature. This time period also included climatic reversal-MMCT (middle Miocene climate transition) SST Drops, Ocean water gets cools, which has a greater capacity to hold much CO₂, The Himalayas upliftment also drawdown the atmospheric CO₂. Marine diversity culmination around 14 Ma (middle Miocene) warm early middle Miocene abruptly ended with a cooling event that expanded the east Antarctic ice sheets and cold bottom water which surely affect the warm water marine organisms, Cause of this quick cooling, which is controversial although it clearly involved a large drop in atmospheric CO₂ caused by weathering of the rapidly rising Himalayas and Tibetan plateau which absorb the CO₂ In the weathering process. During late Miocene, the Mediterranean dried-up completely and sea level dropped by 2.5 Km (8500 ft) this was the time of Messinian Salinity events.

As we looking in southern Asia, we have the Great Indian Ocean it's unique because of its continental configuration around its water masses in different aspects, which have greater effect on surface circulation, seasonal reversing monsoon system, Tele-connection with The Pacific Ocean, relative absence of eastern boundary currents, lake of North hemisphere circulation system, make it differ from other oceans of the world. Differentiating work of Ocean surface circulation which controls by winds and differential pressure between ocean – continents areas, which further effect the fauna of marine habitat.

Movement of continents have strong influence on southern Asia climate as well. During Neogene, Indo – Pacific passage strength the low latitudinal circulation faunal province, changes in global climatic resulted steeper latitudinal variation in T° which further effect the Faunal provincialization, isthmus of Panama, ice sheet shifting, sea level fluctuation, warming - cooling of the ocean water, NHG, make Neogene time important for further study, in this work we look deep sea sediments work from Indian Ocean from the different DSDP site which marks on the evidence of this climatic events in different aspects.

Neogene sea surface temperature derived from calcareous nannofossils of northeast Indian Ocean

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Neogene is a geological period where, the global climate cooled considerably, but amongst it there were some periods which also witnessed warm climatic events e.g., MCO, Tortonian Thermal maxima. Understanding the climate and the oceanic condition during this period is important. Amongst several microfossils, calcareous nannofossils act as one of the best proxies for inferring the past environmental changes in marine realm and these are useful in determining the precise geologic age. Calcareous nannofossil assemblages were quantitatively investigated from seven sections on Andaman and Nicobar Island, northeast Indian Ocean. These are examined under polarizing light microscope in smear slides; those were prepared using standard techniques. The age of all the sections is clearly demarcated by biostratigraphically important species. In order to understand the climate, we analyzed the sea surface temperature at each study site by Nannofossil Temperature Index (NTI). The mean NTI of Burdigalian - Langhian varied from 78.88 to 84.24, late Tortonian ranges from 94.52 to 98.22 and early Zanclean from 66.55 to 93.73. The values of NTI indicate that the sea surface temperature of northeast Indian Ocean was more or less uniformly warm during Miocene and Pliocene. Amongst the studied sections, the Tortonian sediments of Neil Island has the highest NTI value and this can be correlated to the hot and humid conditions that possibly triggered the intensification of Indian Summer Monsoon. The NTI value of Burdigalian - Langhian is also high but comparatively lower than Tortonian. This may be due to the Miocene Climate Optimum (MCO) event. However, among the two Zanclean sections of Car Nicobar Island the stratigraphically older sequence i.e., Sawai Bay 'A' Section has higher NTI due to the Indian Ocean Warming event that was also identified in the Andaman Sea (as evidenced in Site U1448, IODP 353), whereas, the stratigraphically younger sequence i.e., Sawai Bay 'B' Section shows

low NTI value that is also co-relatable with the negative shift in the Mg/Ca derived temperature curve derived from Andaman Sea (as revealed from Site U1448, IODP 353).

Late Pliocene/early Pleistocene fauna and flora of Jammu: their preservation and climatic appraisals

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During the last fifteen years, a good number of fossil specimens have been recovered from the Late Pliocene-Early Pleistocene deposits of Jammu Siwalik by the author himself. The fossils specimens include both fauna and flora. The fauna includes Proboscidea (five species), Rodents (thirteen species), Fish teeth (Cyprinids), Lizards (Iacertilian), Ostracodes (sixteen species), Gastropods (four species), Bivalves (two species), Charophytes (six species), Angiospermae seed (one species). All these species have been recovered from the mudstone horizons underlying geochronologically dated bentonitized tuff band exposed in various sites of the Upper Siwalik of Jammu province in between Pakistan in the west and Ravi River in the East (India). Some authors correlate this bentonitized tuff band with Gauss/ Matuyama Boundary or Pliocene/Pleistocene Boundary. Fauna and flora recovered by authors also suggested Pliocene/Pleistocene ages for the fossil yielding mudstone horizon/ash beds. The fauna and flora indicate lacustrine depositional environment and the preservation caused by the volcanic ash layer/bentonitized tuff band. The change in fauna and flora underlying and overlying ash beds also suggests that there is change in climate during late Pliocene-early Pleistocene times.

Temporal variations in the western Arabian Sea Oxygen Minimum Zone (OMZ) intensity during the last 10,000 years: Insights from benthic foraminifera

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The western Arabian Sea hosts intense hypoxic conditions (OMZ) at intermediate depths driven by seasonal reversal of Indian monsoon winds and subsurface ventilation. Previous studies in this region have revealed millennial scale oscillations in past OMZ intensity, making it an ideal region for understanding complex relationship between OMZ variability, monsoon induced oceanic productivity, and ventilation by intermediate waters. In this regard, high resolution sediment archives from the Oman margin provide a unique opportunity to investigate the response of OMZ intensity to Northern hemisphere climatic variability (Dansgaard- Oeschger (DO) oscillations and Heinrich events). Benthic foraminifera morpho-groups have been proven as an important proxy in deciphering bottom water oxygen conditions and organic matter flux in the Arabian Sea. Hence, temporal changes in sensitive benthic morpho-groups would enable us to better understand Arabian Sea OMZ dynamics in the past.

Here, we present a high-resolution record of deep OMZ indicator species spanning the last 10000 years from Oman margin (ODP site 723A at a depth of 808m). This study aims to reconstruct temporal variation in Arabian Sea OMZ and its linkages to North Atlantic climatic perturbations.

Palynological assemblage from the Upper Siwalik sediment of the Triyuga River section, Eastern Nepal and its paleoclimatic implication

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The palynological study of the Upper Siwalik sediment from the Triyuga River section, eastern Nepal revealed in total 117 taxa belonging to 36 families. In the palynomorphs gymnosperm taxa were represented by Pinaceae (*Abies* sp., *Picea* sp., *Pinus* sp. and *Tsuga* sp.). The gymnosperm taxa were represented by Acanthaceae (*Justicia* sp., *Strobilanthes* sp.), Anacardiaceae, Apocynaceae, Betulaceae (*Betula* sp.), Bombocaceae, Combretaceae (*Terminalia* sp.), Compositae (*Artemisia* sp.), Corylaceae (*Coryls* sp.), Fagaceae (*Quercus* sp.), Hamamlidaceae (*Liquidambar* sp.), Leguminosae, Malvaceae, Oleaceae (*Fraxinus* sp.), Salicaceae (*Salix* sp.), Symplocaceae (*Symplocos* sp.), Urticeae (*Urtica* sp.), Arecaceae, Liliaceae, Poaceae, Typhaceae (*Typha* sp.). The pteridophytes spores are belonging to Cyatheaceae (*Cyathea* sp.), Lygodiaceae (*Lygodium* sp.), Perkeriaceae (*Ceratopteris* sp.), Polypodiaceae (*Polypodium* sp.) and Pteridaceae (*Pteris* sp.) are most common palynomorphs. The palynomorph evidence that the tropical-subtropical to lower temperate humid and warm climatic condition with plenty of rainfall. Coexistence Approach (CoA) suggests that the Triyuga River section experienced at the MAT 16.8-21.7 °C, CMT 10.6-14.6 °C, WMT 23.6-26.1 °C and MAP 1122-1682 mm, LMP 19-73 mm, HMP 115-349 mm, WMP 82-172 mm during the deposition time.

Palaeovegetation and palaeoclimate changes during Last glacial recorded from the Sunakhoti Formation, southern Kathmandu valley, Nepal

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The Palaeo-Kathmandu Lake sediments hold immense knowledge of past climate and vegetation change along with its tectonic history and depositional environment. The palynological and sedimentological research is one of the best archives to reveal past environment of the Kathmandu valley. The 14m thick sequence of the Sunakhoti Formation exposed in the southern part of the Kathmandu basin is composed of gravel, silty clay and clay sequence with plant fossils. The palynological samples 8 in number were taken from clay and silty clay sections that helps to disclose the climate and vegetation change since late glacial period. The two pollen zones SZ I and SZ II is divided according to increase and decrease of the certain index pollen. The pollen assemblages show high frequency of tree pollen exceeding 70% then herbs and shrub plant about 20%. *Pinus* and *Quercus* are dominant tree taxa followed by *Podocarpus* and *Tsuga* species. The herbs such as *Poaceae*, *Araliaceae*, *Compositae* contain less than 10% frequency in both zones. The SZ I contain 25% of *Pinus*, less than 5% *Picea*, and *Abies* species and dominantly 45% of *Quercus* indicating expansion of broad-leaved forest. The herb and fern species contain 5% and 10% frequency respectively. The presence of aquatic plant *Trapa* in many samples although less in frequency reveal wet and moist condition. The SZ II zone suggest dominance of gymnosperm trees over angiosperm indicating sub temperate to temperate forest with cold and humid climate during the period. The forest floor was dominated by *compositae*, *poaceae* and fern plants.



REPORT

BSIP-NECLIME Online International Conference

September 7–9, 2021

Convenor: Vandana Prasad

Organizing secretaries: Gaurav Srivastava and Vivesh V. Kapur

The Birbal Sahni Institute of Palaeosciences, Lucknow, India organized an online international conference using the NECLIME platform. The conference took place from September 7–9, 2021. In this conference, 63 participants were registered from 11 countries namely, China, France, Germany, India, Japan, Nepal, Netherlands, Poland, Slovakia, the United Kingdom, and the United States of America. This online conference was very well organized and has proven an effective way to stay connected with each other during the Covid-19 pandemic situation. Besides the senior colleagues, many research students participated and presented papers very well. The basic aim of this conference was to bring researchers on a single platform who are working on a wide variety of topics such as Asian monsoon evolution, Himalayan orogeny, Siwalik and Siwalik-equivalent sedimentary successions in terms of continental as well as marine floral and faunal evolution and diversification, climate change and related research.

The conference program included a total of 34 oral presentations including five keynote lectures and covered a wide variety of topics. Overall, the 34 talks were covered under five sessions that represented the three themes of the conference i.e.,

- Age and depositional environment(s) of Siwalik and Siwalik-equivalent sediments.
- Biotic (flora and fauna) evolution and biogeography during the Neogene
- Climatic change(s) during the Neogene.

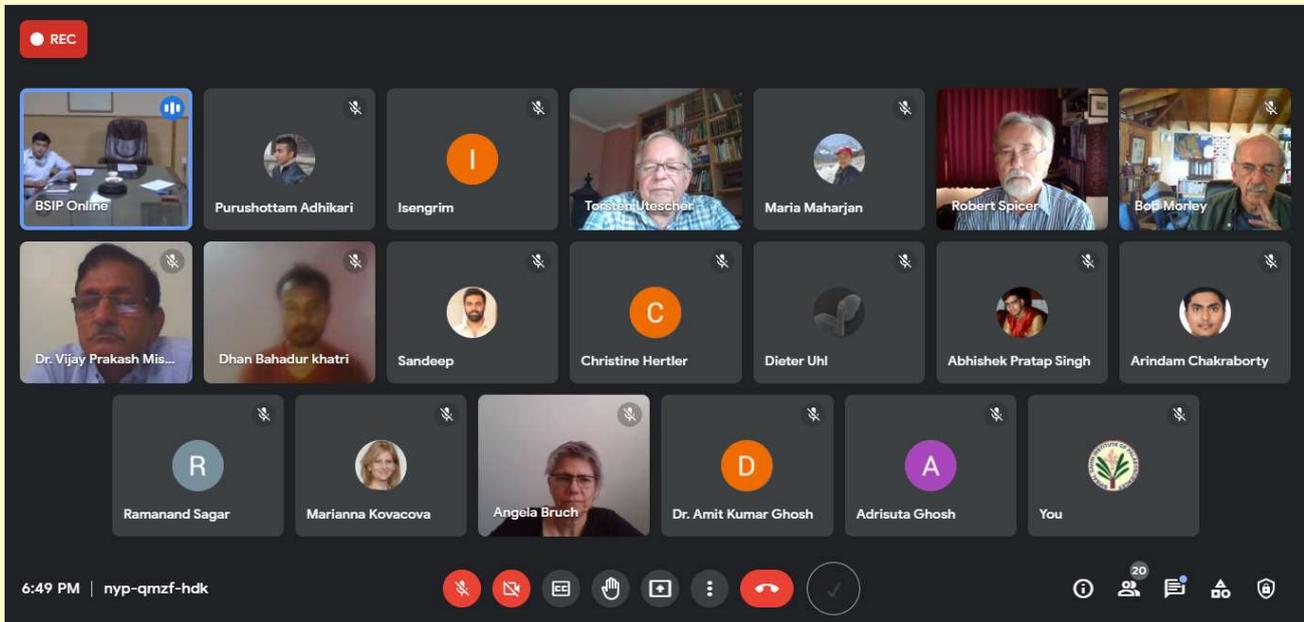
Many future areas of research and gaps in research w.r.t the Neogene of Siwalik and Siwalik-equivalent deposits of the subcontinent were identified during the conference. These include:

- Dating in absolute framework
- Expansion of grasses in the Himalayan Foreland Basin
- Diversity changes in fauna and flora and its linkages to climate change w.r.t orogeny of the Himalaya.
- Evolution of flora and fauna and their palaeobiogeographic implications.
- Uncertainties in measuring palaeo-elevations
- Understanding the global and regional climate change.

We believe that the future research endeavors would continue to incorporate a multiproxy and inclusive approach in filling the gaps of research (mentioned-above) pertaining to the Siwalik and other contemporary sedimentary successions.

The success of this conference could not have been possible without the constant support from NECLIME members especially Torsten Utescher and Angela Bruch.

Some impressions of the BSIP-NECLIME 2021 International conference



Thank you!