The Geological Society

Asian Climate, Tectonics & Biodiversity

5-7 September 2022
Hybrid – Burlington House, London or virtual

How do tectonics and climate force surface processes and the evolution of biodiversity in Asia? Join us to unravel the coupled geodynamic and Earth-surface processes that impact environmental conditions and the biosphere across different spatial and temporal scales.

Convened by:
Guillaume Dupont (CNRS - Geosciences Rennes)
Tara Jonell (University of Glasgow)
René Dommain (Potsdam University).
Peter Clift (Louisiana State University).

Website: https://www.geolsoc.org.uk/asianclimate2021

E-mail: **conference@geolsoc.org**.uk #GSLAsianclimates

Image credit: Tara Jonell

Contents

Asian Climates tectonics and biodiversity

HYBRID CONFERENCE PROGRAMME

5 September 2022	
08.00	**Registration, Tea & Coffee**
08.15	**Welcome Address**
Session 1: SE Tibet - Emile Argand session. Tibetan Plateau Geodynamics, Orogenesis and Paleogeography	
08.30	**KEYNOTE: Coevolution of Landscape and Biodiversity in the Hengduan Mountains, SE Asia** Sean Willet *(ETH Zurich)*
09.10	**Inverse analysis of landscape evolution model reveals the southeastern Tibetan Plateau growth** Xiaoping Yuan *(China University of Geosciences)*
09.30	**Inferring the evolutionary history of the Sino-Himalayan biodiversity hotspot using Bayesian phylodynamics** Bethany Allen *(ETH Zürich)*
09.50	**Break**
Flash Posters Talks	
10.20	**Topography and relief development within the Yalong River drainage area, southeast Tibet** Xiong Ou *(Université Grenoble Alpes)*
10.23	**The Hengduan phytodiversity is higher than expected from area and habitat heterogeneity** Yaquan Chang *(Swiss Federal Institute for Forest, Snow and Landscape Research)*
10.26	**No channel flow in the Longmen Shan: evidence from the Maoxian-Wenchuan fault Cenozoic kinematics (SE Tibet)** Chenglong GE *(Université Claude Bernard Lyon)*
10.29	**Plio-Pleistocene paleoclimate analogue reveals global permafrost stability: Circumarctic versus alpine regions** Feng Cheng *(University of Southern California)*

10.32	**Cenozoic spatial-temporal patterns of erosion of the Hengduan Mountains from thermochronometry** Junqing He *(Zhejiang University)*
10.35	**Tectonic reconstruction of the Hengduan Mountains to understand driving mechanisms of exceptionally high regional biodiversity.** Thomas Lucien Alexander Schouten *(Geological Institute, ETH Zurich)*
10.38	**Impact of geological and climate factors on plant biodiversity patterns in the Hengduan Mts, China** Yaquan Chang *(Swiss Federal Institute for Forest, Snow and Landscape Research)*
10.41	**Geomorphic and ecological controls on the biodiversity hotspot in the Three Rivers Region, China** Xianjun Fang *(Eidgenössische Technische Hochschule Zürich)*
10.45	**Monsoon-driven Incision and Exhumation of the Eastern Tibetan Plateau** Mark Allen *(Durham University)*
11.00	**Conclusions from session 1**
11.10	**Posters**
12.00	**Lunch**
Session 2: George Louis Buffon session. The Evolutionary path to Southeast Asia's Present Biodiversity	
13.00	**KEYNOTE: Crossing lines: the complex origins of SE Asian biodiversity** Thomas von Rintelen *(Museum für Naturkunde Berlin)*
13.40	**Changing patterns of diversity in Southeast Asia** Alice C Hughes *(University of Hong Kong)*
14.00	**Javanese Homo erectus on the move in SE Asia ca. 1.8 Ma** Laurent Husson *(ISTerre, CNRS)*
14.20	**The peat swamp forests of Southeast Asia: from a Miocene carbon sink to an Anthropocene carbon source** René Dommain *(Nanyang Technological University Singapore)*
14.40	**Cenozoic Climatic and Environmental Change Reconstructed by Scientific Drilling of the Asian Marginal Seas** Peter Clift *(Louisiana State University)*

14.55	**The Late Eocene-Early Oligocene terrestrial successions of the Cao Bang and Na Duong basins, and the Hoanh Bo Trough (North Vietnam)** Anna Wysocka *(University of Warsaw)*
Flash Poster Talks	
15.10	**How Did Sediments Disperse and Accumulate in the Oceanic Basin, South China Sea** Fei Wang *(Shanghai Jiao Tong University)*
15.13	**No modern Irrawaddy River until the late Miocene-Pliocene** Tara Jonell *(University of Glasgow)*
15.16	**Break**
Session 3: Alfred Wallace session. India-Asia Paleobiogeography, Climate and Tectonism	
15.45	**KEYNOTE: The establishment of Palaeotropical rain forests from Africa to Oceania in relation to plate tectonics and climate change** Robert John Morley *(Palynova Ltd)*
16.25	**Deep-Time Fossil Records suggest the Indian Plate as Source and Refuge area of Tropical Angiosperms** Prasad Vandana *(Birbal Sahni Institute of Palaeosciences)*
16.45	**Evolution of Oligo-Miocene Tethyan seaway and its impact on the marine molluscan biodiversity of western India** Devapriya Chattopadhyay *(IISER Pune)*
	Flash Poster Talk
17.05	**Distribution pattern in tropical angiosperm families driven by deep time Africa-India Floristic Interchange: Evidences from the early Paleogene Indian records of Dipterocarpaceae, Ebenaceae and Euphorbiaceae** Mahi Bansal *(Birbal Sahni Institute of Palaeosciences)*
17.08	**Day one conclusions**
17.20	**Posters**
18.00	**Drinks**
19.00	**Day one close**

6 September 2022	
08.00	**Registration, Tea & Coffee**
08.15	**Welcome Address**

Session 4: Amadeus Grabau session. Central Asian Climate, Environment and Ecological evolution	
08.30	**KEYNOTE: Twilight of the greenhouse world, learnings from the Eocene of the Asian continental interior** Carina Hoorn *(University of Amsterdam)*
09.10	**The Eocene-Oligocene Transition in Central Asia: an evolutionary bottleneck for the steppe-desert taxon Nitraria L. (Nitrariaceae)** Amber Woutersen *(University of Amsterdam)*
09.30	**The simulated evolution of Asia climate from the Early to the Late Eocene: wetter East Asia and drier Asian inland** Xiangyu Li *(China University of Geosciences)*
09.40	**Long-period astronomical forcing on the strength of Miocene westerlies in Central Asia** Silke Voigt *(Goethe University Frankfurt)*
Break	
Flash poster talks	
10.40	**Evolution of Asian dust input to the Japan Sea and its links to tectonic and climatic changes** Shiming Wan *(Chinese Academy of Sciences)*
10.43	**The potential of Poaceae pollen size for past vegetation and climate reconstruction on a global level** Caixia Wei *(University of Amsterdam)*
10.46	**Eocene hydroclimatic evolution recorded in the Xining Basin, NE Tibet** Niels Meijer *(Senckenberg Biodiversity and Climate Research Centre)*
10.49	**Late Neogene East Asian dust source variation linked to global climate changes: multiproxy single-grain provenance analysis from Baode, Chinese Loess Plateau** Katja Bohm *(Uppsala University)*
10.52	**East-Central Asian Climate Evolved with the Northward Migration of the High Proto-Tibetan Plateau** Chenguang Zhu *(China University of Geosciences)*
10.55	**Spatial and temporal provenance variations of the Chinese Loess Plateau over the late Miocene to early Pleistocene: a window into the reorganization of the Yellow River and monsoon activity** Haobo Zhang *(Lanzhou University)*

10.58	**Tropical podocarps from the Early Eocene Climatic Optimum in the Xining Basin, Tibet** Faez Robin-Champigneul *(Maastricht University, Netherlands)*
11.01	**Tibetan Plateau made central Asian drylands move northward, concentrate in narrow latitudinal bands, and increase in intensity during the Cenozoic** Ran Zhang *(Chinese Academy of Sciences)*
11.05	Session 4 conclusions
11.15	**Poster session**
12.00	**Lunch**
Session 5: Emile Argand session. Himalayan Orogenesis, Monsoons and Biodiversity	
13.00	**KEYNOTE: Himalayan tectonic uplift as a driver of lateral biodiversification** Alexander G. Webb *(University of Hong Kong)*
13.40	**Tibetan Plateau uplift, Westerlies evolution, and Asian climate changes** Guangsheng Zhuang *(Louisiana State University)*
14.00	**Early-Middle Miocene Rise of the High Himalaya and the Disruption of Transverse Drainage due to Basal Accretion in the NW Himalaya** Rasmus C. Thiede *(University of Kiel)*
Flash Talks	
14.20	**Contributions of tectonics and climate on sculpting the landscapes of the Himalayas** Yuqiang Li *(China University of Geosciences)*
14.23	**Holocene hydroclimatic variability in South Asia: lessons from lakes and marginal marine sediments** Yama Dixit *(Indian Institute of Technology Delhi)*
14.26	**Hydrometeorological progression of the Himalayan cryosphere: The Karakoram Predicament** Bibhasvata Dasgupta *(Indian Institute of Science Education and Research)*
14.29	**Enhanced chemical weathering in the western Himalaya during the Bølling-Allerød warm period** Gyana jan Tripathy *(Indian Institute of Science Education and Research)*
14.32	**The spatial–temporal evolution of the Asian summer monsoon during the late Miocene** Zhilin He *(Chinese Academy of Sciences)*

14.35	**Petrography and mineralogy of Bengal Fan turbidites (IODP Expeditions 353-354): Himalayan provenance and depositional history.** Mara Limonta *(University of Milano-Bicocca)*
14.38	**Topographic evolution is responsible for diverging South Asian Monsoon rainfall and wind histories during the Neogene** Anta-Clarisse Sarr *(CEREGE/Aix-Marseille University)*
14.41	**Himalayan-Tibetan Erosion is not the Cause of Neogene Global Cooling** Peter Clift *(Louisiana State University)*
14.47	**Dominance of tectonics over climate in sediment accretion at the Himalayan orogenic front** Sambit Ghosh *(University of Alaska)*
15.07	**South Asian C4 vegetation and rainfall – biomarker reconstructions from two megafans** Sarah J Feakins *(University of Southern California)*
15.10	**Break**
Session 6: Alfred Wegener session. India-Asia collision, Climate and Paleogeography	
15.35	**KEYNOTE: New constraints on the India-Kohistan/Ladakh-Eurasia collision and its influence on the global climate** Oliver Jagoutz *(Massachusetts Institute of Technology)*
16.15	**Paleogeography of the Burma Terrane since the Late Cretaceous** Pierrick Roperch *(CNRS, Université de Rennes)*
16.35	**Reconstructing the Paleogeography of the Neotethys with Paleomagnetic Data** Craig R. Martin *(Massachusetts Institute of Technology)*
Flash Poster Talk	
16.57	**Paleogene Paleogeography of the India-Asia collision reconstructed with Terra Antiqua** Guillaume Dupont-Nivet *(Centre National pour la Recherche Scientifique, CNRS)*
17.00	Conclusions for Day two
17.10	Posters
18.00	Day two close

7 September 2022	
08.00	**Registration Tea and Coffee**
08.15	**Welcome Address**
Session 7: Alexander von Humboldt session. The interactions of Earth, Climate and Life	
08.30	**KEYNOTE Understanding Monsoons and Biodiversity Relevant to Landscapes and Livelihoods in Asia (UMBRELLA)** Robert A Spicer *(Chinese Academy of Sciences)*
09.10	**Solving the cold pole problem and its role in Asian climate dynamics** Paul Vades (*University of Bristol)*
09.30	**The rise of the Himalaya using a high-resolution paleoclimate model** Alex Farnsworth *(University of Bristol)*
09.50	**Simulating the Asian vegetation cover evolution from the late Eocene to the late Miocene induced by paleogeography and climate change** Delphine Tardif *(Université Paris-Saclay)*
10.10	**Modelling the co-evolution of life, climate, and landforms** Esteban Acevedo-Trejos *(GFZ German Research Centre for Geosciences)*
10.30	**Break**
Flash Poster Talks	
11.00	**Sedimentary response to the hyperthermal Permian-Triassic mass extinction and Palaeocene-Eocene Thermal Maximum on land** Zhicai Zhu *(University of Bristol)*
11.23	**Impact of Mountains in Southeast China on the Eocene climates of East Asia** Zijian Zhang *(Chinese Academy of Sciences)*
11.26	**Rapid Eocene diversification of spiny plants in subtropical woodlands of central Tibet** Xinwen Zhang *(Chinese Academy of Sciences)*
11.29	**Species diversity of the late Eocene Xiongmei flora in Lunpola Basin, central Tibetan Plateau** Wei-Cheng Li *(Chinese Academy of Sciences)*
11.32	**A modelling study of the tripole pattern of East China precipitation over the past 425 ka** Dai Gaowen *(China University of Geosciences)*
11.35	**Closing Words and Summary**

11.50	**Posters**
12.30	**Lunch**
14.00	**Trip to Natural History Museum**
17.00	**Event Close**

SESSION ONE: Peter Molnar session. Tibetan Plateau Growth, Climate and Biodiversity

KEYNOTE: Coevolution of Landscape and Biodiversity in the Hengduan Mountains, SE Asia

Sean Willett

ETH Zurich

Katrina Gelwich (ETH Zurich), Yaquan Chang (ETH Zurich), Helen Beeson (ETH Zurich), Loic Pellissier (ETH Zurich), Niklaus Zimmermann (WSL)

The Hengduan Mountains represent the tectonically active and topographically complex transition region between the eastern Tibetan Plateau and the lowlands of eastern China and Indochina. The region contains some of the highest biodiversity outside the tropical regions and is expressed across both plants and animal groups and is evident in all species as well as endemics. We posit that this biodiversity has developed in response to the topographic expression of the complex tectonic setting of the region which is characterized by large transverse strain patterns and differential uplift. We address this hypothesis with two approaches. First is an analysis of the spatial patterns and correlations of geomorphic and climate characteristics such as precipitation, temperature, relief, elevation, LGM glacial extent or specific events such as major river captures. We map species richness for seed plants across the Hengduan region and conduct a generalized correlation analysis to identify and remove correlations with climate parameters and to construct maps of general and endemic richness anomalies. This permits comparison with geomorphic parameters, where we find a number of relationships. The second approach we take is process modeling to investigate landscape evolution effects on habitat creation and fragmentation, both of which lead to speciation or extinction. By constructing a model including speciation, dispersion, evolution and extinction linked to a model landscape with habitat distribution, we can investigate the process linkages. These models are still under development, but we construct cases for simple tectonic settings to generate characteristic patterns for both aquatic and terrestrial clades.

Inverse analysis of landscape evolution model reveals the southeastern Tibetan Plateau growth

Xiaoping Yuan

China University of Geosciences, Wuhan, China

Ruohong Jiao, Guillaume Dupont-Nivet, Xiaoming Shen

The Cenozoic history of the Tibetan Plateau topography is critical for understanding the evolution of the Indian-Eurasian collision, climate, and biodiversity. However, the long-term growth and landscape evolution of the Tibetan Plateau remains ambiguous, it remains unclear if plateau uplift occurred soon after the India-Asia collision in the Paleogene or later in the Neogene. As the landscape evolution is controlled mainly by mountain uplift and surface processes, the present-day river profiles and the drainage basin geometries preserve important information that can be extracted to infer the long-term history of mountain uplift with numerical models. Here we focus on the southeastern (SE) Tibetan Plateau where three of the world's largest rivers draining the Tibetan Plateau (the Yangtze, Mekong, and Salween Rivers, i.e., Three Rivers) have incised deep valleys with distinctive geomorphic signatures. We reproduce the uplift history of the SE Tibetan Plateau using a 2D landscape evolution model, which simultaneously solves fluvial erosion and sediment transport processes in the drainage basins of the Three Rivers region. Our model was optimized through a formal inverse analysis with a large number of forward simulations, which aims to reconcile the transient states of the present-day river profiles. Our modeling results were ultimately compared to existing thermochronologic and paleoelevation datasets to help decipher between competing tectonic models that predict contrasting topographic evolutions. The results suggest initially low elevations during the Paleogene, followed by a gradual southeastward propagation of topographic uplift of the plateau margin until present day. Thus, our modeling does not support Paleogene formation of the SE Tibetan Plateau with a major subsequent degradation via upstream fluvial erosion. The quantitative constraints on landscape evolution achieved based on drainage patterns in SE Tibet indicate a powerful tool potentially applicable to other regions to infer important implications for the evolution of Indian-Eurasian collision, Asian monsoons, and biodiversity, as well as the geodynamic forces involved in collisional orogens.

Inferring the evolutionary history of the Sino-Himalayan biodiversity hotspot using Bayesian phylodynamics

Bethany Allen

ETH Zürich

Timothy Vaughan, Louis du Plessis, Tanja Stadler (all ETH Zürich)

The Sino-Himalayan region in central Asia is one of the world's most biodiverse, especially renowned for its alpine plant richness. The region also has a complex geological and climatic history, involving the collision of the Indian Plate into Eurasia during the Paleogene (~ 66 to 23 Mya), resulting in the subsequent uplift of the Himalayan and Hengduan Mountains, and the adjacent Qinghai-Tibetan Plateau. However, the relationship between these tectonic events and the development of the biodiversity hotspot is poorly understood, particularly the relative roles of in-situ speciation and immigration. Here, we use the birth-death skyline model, implemented in BEAST 2, to estimate how net diversification and turnover rates changed over the Cenozoic (~ 66 Mya to present), based on a large maximum likelihood phylogeny of Sino-Himalayan angiosperm plants. We estimate piecewise constant rates for both equally-spaced and geological time bins, allowing rates to change between bins. We then relate these results to the timing of regional geological events and their associated changes in geography and climate. Using this model, we show that phylogenies of extant taxa contain sufficient information to estimate changes in species diversification over deep time.

Topography and relief development within the Yalong River drainage area, southeast Tibet

Xiong Ou

Institut des Sciences de la Terre (ISTerre), Université Grenoble Alpes

Anne Replumaz (IsTerre, Université Grenoble Alpes), Peter van der Beek (Institute of Geosciences, Potsdam University)

The Southeast Tibet is characterized by low–relief surfaces at high–elevation with young thermochronological data/strong erosion and the deeply incising valleys of large rivers, such as the Salween, Mekong, Yangtze and Yalong rivers, with old thermochronological ages and very little exhumation since the India-Asia collision. Those relict surfaces are proposed either to inherit a pre–existing flat landscape on a high proto–plateau by or prior to the collision, or to be generated at low altitude and then uplifted and dissected by rivers since middle Miocene. In this study, we applied a landscape modeling (FastScape) in the Yalong River drainage of the Great Bend Region (southeast Tibet) to explore the influence of strong monsoonal precipitation, which destroys the plateau and engraves deep gorges on the plateau edge, and the strong tectonics of the Yalong Thrust Belt (YBT) and its imposed orographic effect on reducing precipitation, which conserve the flat headwater and interfluve surfaces on a high plateau. The results show that a formerly proposed pure climatic forcing on an existing pre–Neogene high plateau, due to either an intensified monsoon since the Mid–Miocene Climate Optimum (~17–14 Ma) or an expansion of upstream drainage since 15 Ma, will strongly destroy the high plateau by regressive fluvial erosion. A southeastward propagating uplift wave from central Tibet has recently been used to generate the peculiar topography in the Three Rivers Region (around the Eastern Syntaxis), combined with strong precipitation but small erosion coefficient. Differently, here we propose that a coupling of strong Miocene uniform uplift on the Muli thrust of the YBT, strong orographic effect on precipitation on the high plateau edge and capture of large upstream paleo–endorheic zone of inland plateau could well reproduce such a similar topography in Great Bend Region (west of the Sichuan craton). Indeed, the capture of paleo–endorheic zone, increasing tremendously run–off in the river networks, ensures sufficient flow–in water in the river channels to efficiently downcut deep gorges as observed on the high plateau edge.

The Hengduan phytodiversity is higher than expected from area and habitat heterogeneity

Yaquan Chang

Ecosystem and Landscape Ecolution; ETH Zürich; Swiss Federal Institute for Forest, Snow and Landscape Research

Katrina D. Gelwick (Geological Institute, ETH Zürich); Sean D. Willett (Geological Institute, ETH Zürich); Zhiheng Wang (Institute of Ecology and Key Laboratory for Earth Surface Processes of the Ministry of Education, Peking University); Yunhong Tan (Southeast Asia Biodiversity Research Institute, Chinese Academy of Sciences & Center for Integrative Conservation, Xishuangbanna Tropical Botanical Garden); Niklaus E. Zimmermann (Land Change Science Research Unit, Swiss Federal Institute for Forest, Snow and Landscape); Loïc Pellissier (Ecosystem and Landscape Ecolution, ETH Zürich, Swiss Federal Institute for Forest, Snow and Landscape Research, Switzerland)

No channel flow in the Longmen Shan: evidence from the Maoxian-Wenchuan fault Cenozoic kinematics (SE Tibet)

Cenglong Ge

Laboratoire de Géologie de Lyon, Université Claude Bernard Lyon 1

Philippe Hervé Leloup (Laboratoire de Géologie de Lyon, Université Claude Bernard Lyon 1); Yong Zheng (Chinese Academic of Geological Sciences); Haibing Li (Chinese Academic of Geological Sciences)

The NE striking Longmen Shan (LMS) mountains are located at the eastern margin of the Tibetan plateau, and towers nearly 5000m above the Sichuan basin, which is considered to be the greatest relief than anywhere else around the plateau. From west to east, three major sub-parallel faults straddle the Longmen Shan: Wenchuan-Maoxian fault (WMF), Yingxiu-Beichuan fault and Guanxian-Anxian fault. Several models have been proposed to explain the Cenozoic uplift of the Longmen Shan. The major two models are lower crustal channel flow and upper crustal shortening, which imply different movement sense on the Wenchuan-Maoxian fault. The former suggests that the LMS were uplifted above a lower crustal flow expulsed from below the Tibetan plateau and would require a normal sense movement on the MWF. The latter implies that a series of upper crustal thrusts controlled the uplift of the LMS, and the WMF should have a reverse sense. Here we present field observations, fault gouge structural analysis and authigenic illite K-Ar geochronology data of fault gouge in the Wenchuan-Maoxian fault, showing that the Maoxian-Wenchuan fault was dextral with a reverse component at ~7Ma. Reconstruction of offsets of river valleys along the Wenchuan-Maoxian fault suggests that the corresponding total horizontal dextral offset is ~25km. Analysis of the thermochronology data acquired on both sides of the fault suggests that reverse faulting started at ~15 Ma, and reactivated in dextral-reverse at ~7 Ma, possibly lasting until today. Our conclusions support the upper crustal shortening model and suggest the channel model maybe not applicable to Longmen Shan uplifting in the later Oligocene.

Plio-Pleistocene paleoclimate analogue reveals global permafrost stability: Circumarctic versus alpine regions

Feng Cheng

Peking University

Carmala Garzione (University of Arizona)

Estimates of the permafrost-climate feedback vary in magnitude and sign, partly because permafrost carbon stability in warmer-than-present conditions is not well constrained. Here we use a Plio-Pleistocene lacustrine reconstruction of mean annual air temperature (MAAT) from the Tibetan Plateau, the largest alpine permafrost region on the Earth, to constrain past and future changes in permafrost carbon storage. Clumped isotope-temperatures (Δ47-T) indicate warmer MAAT (~1.7 °C) prior to 2.7 Ma, and support a permafrost-free environment on the northern Tibetan Plateau in a warmer-than-present climate. Δ47-T indicate ~8.1 °C cooling from 2.7 Ma, coincident with Northern Hemisphere glacial intensification. Combined with climate models and global permafrost distribution, these results indicate, under conditions similar to mid-Pliocene Warm period (3.3–3.0 Ma), ~60% of alpine permafrost containing ~85 petagrams of carbon may be vulnerable to thawing compared to ~20% of circumarctic permafrost. This estimate highlights ~25% of permafrost carbon and the permafrost-climate feedback could originate in alpine areas.

Cenozoic spatial-temporal patterns of erosion of the Hengduan Mountains from thermochronometry

Junqing He

Zhejiang University

Rong Yang (Zhejiang University), Sean Willett (Swiss Federal Institute of Technology)

The Hengduan Mountains, located southeast of the Tibetan Plateau, exhibits distinctive geomorphological features characterized by high elevation and low relief where three major rivers (Mekong, Salween and Yangtze) flow in parallel and deeply incise into the terrain forming steep gorges. The region is also notable for its extremely high biodiversity. This region is of fundamental importance to understand the deformational response to continental collision as it is in the Eastern "corner" of India-Eurasia Plate Collision where crustal strain and stress are concentrated. Two end-member models have been proposed: the block extrusion model where deformation has been accommodated by crustal shortening and transform motion along faults and the lower crustal flow model where partially molten lower crustal material flows outward and results in thickened lower crust and surface uplift without crustal shortening. One of the important characteristics of analysis of the region is the space and time patterns of erosion rates which reflect tectonic uplift and geomorphic processes including river incision. Towards a complete analysis, we compiled over 1000 published thermochronological data (AFT, ZFT, AHe, ZHe and 40Ar/39Ar ages) together with some of our new (U-Th)/He data to reassess the erosion rates across the Hengduan Mountains. We applied a uniform analysis method using pseudo age-elevation profiles taking the relation between erosion rate, crustal geothermal gradient and closure temperature into account. The modern geothermal gradient is determined from surface heat flow and thermal conductivity of a newly-published geophysical finding in this region. We divide the analysis into 95 separate areas to evaluate regional and local signals. We find that the region is dominated by local tectonic events, associated with local faulting superimposed on a near steady background erosion rate. Specific regions are tectonically active at different times with little temporal correlation.

Tectonic reconstruction of the Hengduan Mountains to understand driving mechanisms of exceptionally high regional biodiversity.

Thomas Lucien, Alexander Schouten

Geological Institute, ETH Zurich

Shihu Li (Institute of Geology and Geophysics, Chinese Academy of Sciences), Lydian M. Boschman (Department of Earth Sciences, Utrecht University), Sean D. Willett (Geological Institute, ETH Zurich)

The Hengduan Mountains, east of the eastern syntaxis of the Tibetan-Himalayan orogen, lie at the triple junction between the Eurasian, Indian and Burma plates. It is the geographical and tectonic transition from the Eastern Tibetan Plateau to the tropical lowlands of SE Asia. Moreover, it represents one of the most biologically diverse regions on Earth, outside of the tropics. We posit that the tectonic and topographic history of this region has controlled this biodiversity. Hypotheses at this point regarding different colonization pathways and barriers or different elevation histories requires knowledge of the relative positions of the Eurasian, Indian and Burma plates and the deformation and topographic history of their intensely deformed plate boundary zones. Here we show results of a new kinematic reconstruction of the Tibetan-Himalayan orogen with a focus on the Eurasia-India-Burma triple junction. We compile structural geologic, palaeomagnetic and mantle seismic tomographic data to restore the complex regional deformation. We build our reconstruction in GPlates with deforming networks to predict past surface velocity vectors and strain rates. Our results show that the connection between India, Burma and Eurasia could have been established by 40 Ma, whereas two phases of internal deformation of the Eurasian plate in the Hengduan Mountains occurred from 50 to 20 Ma and 13 Ma to the present. These results provide a tectonic framework for the study of regional biodiversity in the Hengduan. Furthermore, our reconstruction provides the platform for future work to include reconstruction of palaeotopography and palaeoclimate to identify the environmental changes that may have driven the diversification of life in the Hengduan Mountain

Geomorphic and ecological controls on the biodiversity hotspot in the Three Rivers Region, China

Xianjun Fang

Eidgenössische Technische Hochschule Zürich (ETH Zürich)

Sean Willett (ETH Zürich), Yaquan Chang (ETH Zürich), Katrina Gelwick (ETH Zürich)

The Three rivers region (TRR), east of the Tibetan plateau, China, is composed of three major rivers, the Salween, the Mekong, and the Yangtze. The TRR is characterized by extremely diverse topography with deep valleys and low-relief surfaces, complex tectonics, strong climate gradients. The geomorphic complexity is mirrored by high biodiversity and high endemism in multiple taxa. How this landscape formed is controversial with models including strike-slip faulting parallel to the rivers, shortening perpendicular to the rivers, or large river captures associated with drainage basin consolidation. To address these models and to constrain the landscape evolution, we conduct a detailed geomorphic analysis of the TRR. We examine the normalized channel steepness (Ksn) of the three major trunk rivers and compare these steepnesses to the steepness of the major tributaries. We also investigate the importance of precipitation patterns including from paleoclimate proxy data. We make an analysis of the Yuqu river, an exceptionally large tributary to the Salween draining the high elevation region between the Mekong and the Salween. The tributary basin-averaged Ksn are consistent with the trunk Ksn with some important exceptions for the highest trunk Ksn. The Salween is consistently steeper than the other rivers while the Yangtze is the least steep. There are several distinct steep segments on the trunk channels of all three rivers, including at Biqiu in the Salween, at Meli in the Mekong, and at Geyading in the Yangtze, which are not reflected in the tributary channels. Otherwise the rivers are remarkably uniform in steepness, though with the strong west to east variation between rivers. All three rivers flatten in their upper reaches where they reach the Tibetan plateau with its low uplift rate and dry climate. The lower reaches of the Yuqu shows some of the highest Ksn of the region. The planform of the river channel here is unusual with the flow direction changing nearly 180° within 3.5 kilometers. The upper Yuqu shows very low steepness, suggesting a strong transience of the catchment. We interpret the Yuqu as a formerly larger catchment, with the lower reaches offset into narrow bends by strike slip faults. The narrow width of the catchment suggests that it has been tectonically squeezed between the Salween and Mekong. These lower reaches show exceptional biodiversity of endemic mid- and high- altitude plant species. Biodiversity decreases upstream due to the higher elevations. We posit that the strike-slip faulting in the lower reaches results in deep valleys and strong habitat gradients as well as steep rivers and high erosion rates. Together these support speciation and high endemism. The high relief of the lower Yuqu can serve as a refuge for high-altitude plant species during glaciation, also supporting endemism. The Yuqu serves as a model for processes throughout the TRR.

Monsoon-driven Incision and Exhumation of the Eastern Tibetan Plateau

Mark Allen

Durham University

Katharine Groves, Christopher Saville, Stuart Jones (Durham University) Shuguang Song (Peking University), Martin Hurst (Glasgow University)

We analyse the geomorphology of the eastern Tibetan Plateau alongside published data for precipitation, erosion and exhumation, to test alternative hypotheses for the formation of the present plateau structure and landscape. Previous models have suggested either pre-Miocene growth of the Tibetan Plateau via crustal shortening and thickening, or later Miocene surface uplift via lower crustal flow (channel flow). There is a broader question of the relative controls of tectonics and climate on mountain landscapes. We use quantitative geomorphic indices (hypsometric integral, surface roughness and elevation/relief ratio) to identify a spatial transition in the landscape in the central-eastern Tibetan Plateau, along an ENE-WSW trend. The transition zone is typically ~400 km outboard of the present internal/external drainage divide. Subdued landscapes to the north and west change across the transition zone to more youthful, incised landscapes to the south and east. We relate this landscape change to a spatial change in precipitation at the same position in the plateau, which is effectively the limit of the Asian monsoon. Higher erosion and exhumation rates to the south and east indicate a long-term significance to this climatic and landscape transition zone, which we interpret as the effect of Early Miocene intensification of the monsoon system. Our results suggest early plateau growth, followed by monsoon-driven incision and exhumation of the present landscape. The spatial correlation of the incised landscape and the region of post-Oligocene increased exhumation suggests that the western extent of monsoon precipitation has had a similar position over this time.

SESSION TWO: George Louis Buffon session. The Evolutionary path to Southeast Asia’s Present Biodiversity

Crossing lines: the complex origins of SE Asian biodiversity

Thomas von Rintelen

Museum für Naturkunde Berlin

Southeast (SE) Asia has, together with Amazonia, the most diverse terrestrial biota on our planet. In contrast to continental Amazonia, megadiverse SE Asia is largely insular in nature, comprising numerous archipelagos of thousands of mostly smaller oceanic and larger continental islands. The fragmented nature of SE Asia's geography is reflected in the distribution of its extant biota, which is characterized by a high degree of regional and local endemism. Against this background, the origin of SE Asian megadiversity has been given considerable attention. Given the complex geological history of the region, biotic evolution in SE Asia cannot be understood without considering the region's complex geological evolution and climatic changes. Recent advances in both earth and life sciences have provided a much more robust framework for studies on both the geological and biotic evolution of SE Asia. Refined geological and tectonic models provide information on the timing and distribution of various landmasses and islands, which in turn underpin biological models on the distribution of key habitats through time. This has enabled the use of dated phylogenetic studies on extant taxa to identify patterns of diversification, not least the role of vicariance and dispersal events, across SE Asia. I will present results of comparative meta-analyses for the entire region and Sulawesi in particular, as well as from case studies from freshwater invertebrates, and discuss their implications for common hypotheses on the biogeography and diversification of taxa in insular SE Asia.

Changing patterns of diversity in Southeast Asia

Alice C.Hughes

University of Hong Kong

Southeast Asia has been a perpetual challenge for understanding regional changes in biodiversity, with complex biogeographic patterns across the region. Here we examine Southeast Asia's changing shape and climate, and using a combination of approaches we map out changes in regional biodiversity patterns over extended timescales. We examine drivers of biogeographic change across some of the major regional biogeographic divides, and assess current biogeographic zones, how they vary between taxa, and how they may have changed over time. We also assess the importance of high resolution models for facilitating hindcasting, as the complexity of the region, and the impacts on global seaways mean that many climate models may not provide sufficient resolution and accuracy for the hindcasting of distributions. Finally we discuss major data gaps, and priorities for future research in the region, as well as the relevance of such work to assessing priorities and gauging the probable impacts of future climatic changes on species distributions.

Javanese Homo erectus on the move in SE Asia ca. 1.8 Ma

Laurent Husson

ISTerre, CNRS

Laurent Husson (ISTerre, CNRS), Tristan Salles (Univ Sydney), Anne-Elisabeth Lebatard (CNRS), Swann Zerathe (IRD), Regis Braucher (CNRS), Sofwan Noerwidi (BRIN), Sonny Aribowo (BRIN), Claire Mallard (Univ Sydney), Julien Carcaillet (CNRS), Danny H. Natawidjaja (BRIN), Didier Bourles (CEREGE) and ASTER team (CEREGE)

The terminal migration of Homo erectus in Southeast Asia during Early Pleistocene is cardinal to our comprehension of the evolution of the genus Homo. However, the limited consideration of the rapidly changing phys- ical environment, together with controversial datings of hominin bearing sites, make it challenging to secure the robust timeline needed to unveil the behavior of early humans. Here, we reappraise the first appearance datum of Javanese H. erectus by adding the most reliable age constraints based on cosmogenic nuclides 10Be and 26Al produced in situ to a com- pilation of earlier estimates. We find that H. erectus reached Java and dwelled at Sangiran, Java ca. 1.8 Ma. Using this age as a baseline, we develop a probabilistic approach to reconstruct their dispersal routes, coupling ecological movement simulations to landscape evolution models forced by reconstructed geodynamic and climatic histories. We demon- strate that the hospitable terra firma conditions of Sundaland facilitated the prior dispersal of hominins to the edge of Java, where they conversely could not settle until the Javanese archipelago emerged from the sea and connected to Sundaland. The dispersal of H. erectus across Sunda- land occurred over at least tens to hundreds kyr, a time scale over which changes in their physical environment, whether climatic or physiographic, may have become primary forcings on their behavior. Our comprehen- sive reconstruction method to unravel the peopling timeline of SE Asia provides a novel framework to evaluate the evolution of early humans.

The peat swamp forests of Southeast Asia: from a Miocene carbon sink to an Anthropocene carbon source

René Dommain

Asian School of the Environment, Nanyang Technological University Singapore

Insular Southeast Asia harbours ancient rain forests that are unique reservoirs of a rich biota. Since the Miocene peat swamp forests, largely dominated by Dipterocarps, covered large portions of the lowlands of Sundaland and nearby regions. Unique biotic assemblages evolved in these forests in response to prevailing acidic, oligotrophic and waterlogged conditions. Many organisms possess specific adaptions for the survival in these peatlands and often exhibit narrow endemic distributions. The plant-derived organic matter deposited as peat under these forests formed thick coal deposits in the past, contributing to permanent land-based carbon storage during the Late Cenozoic. The Quaternary history of these peatlands was strongly tied to sea-level changes, which is well known for the Holocene but still poorly constrained for the Pleistocene due to the large absence of records from the region, especially the Sunda Shelf. Until about 30 years ago these forests continued to store carbon efficiently – with globally the highest long-term rates of carbon accumulation known for peatlands. Ever since, anthropogenically-driven deforestation, drainage and widespread conversion to industrial-scale plantations of oil palm and Acacia at explosive rates has transferred these peatlands into globally relevant carbon sources. Recurring destructive fires consume hundreds of years of peat accumulation in a single fire event, causing massive haze plumes that result in thousands of premature deaths. The destruction of peat swamp forests also leads to an unaccounted loss of species and thereby unique evolutionary history. This situation is certainly one of the greatest environmental disasters of the 21st century and requires urgent science-based solutions. In this talk I review the history of peat swamp forests, their carbon storage dynamics and their effect on the global climate system in past, present and future and identify research directions that would benefit from synergetic linkages between the geo- and biosciences.

Cenozoic Climatic and Environmental Change Reconstructed by Scientific Drilling of the Asian Marginal Seas

Peter D Clift

Louisiana State University

Christian Betzler (University of Hamburg, Bundesstrasse 55, 20146 Hamburg, Germany), Steven C. Clemens (Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI, USA), Beth Christensen (Department of Environmental Science, Rowan University, Glassboro, NJ, USA, Gregor Eberli (Center for Carbonate Research, University of Miami, Miami, FL, USA), Christian France-Lanord (Centre de Recherches Pétrographiques et Géochimiques, Université de Nancy, CNRS UMR 7358, Vandoeuvre-lès-Nancy, France), Stephen Gallagher (School of Earth Sciences, The University of Melbourne, Victoria, , Australia), Ann Holbourn (Institute of Geosciences, Christian-Albrechts-University, Kiel, Germany), Wolfgang Kuhnt (Institute of Geosciences, Christian-Albrechts-University, Kiel, Germany), Richard W. Murray (Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA), Yair Rosenthal (School of Environmental and Biological Sciences, Rutgers, The State University of New Jersey, New Brunswick, NJ, USA), Ryuji Tada (Department of Earth and Planetary Science, The University of Tokyo, Tokyo, Japan), Shiming Wan (Key Laboratory of Marine Geology and Environment, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China)

International Ocean Discovery Program (IODP) conducted a series of expeditions between 2013 and 2016 that were designed to address the development of monsoon climate systems in Asia and Australia. Significant progress was made in recovering Neogene sections spanning the region from the Arabian Sea to the Japan Sea and southward to western Australia. High recovery by advanced piston core (APC) has provided a host of semi-continuous sections that have been used to examine monsoonal evolution. The records show that humidity and seasonality developed diachronously across the region, although most regions show drying since the middle Miocene and especially since ~4 Ma, likely linked to global cooling. This drying reduced erosion rates in the source mountains but does not control the focus of the erosion which is more determined by tectonically driven rock uplift. A transition from C3 to C4 vegetation often accompanied the drying but may be more linked to global cooling than to weaker monsoon rainfall. Western Australia, and possibly southern China diverge from the general trend in becoming wetter during the late Miocene, with the Australian monsoon being more affected by the Indonesian Throughflow, while the Asian Monsoon is tied more to the rising Himalaya in South Asia and to the Tibetan Plateau in East Asia. The monsoon shows sensitivity to orbital forcing, with many regions having a weaker summer monsoon during times of Northern Hemispheric Glaciation. Stronger monsoons are associated with faster continental erosion, but not weathering intensity which either shows no trend or decreasing strength since the middle Miocene in Asia. Marine productivity proxies and terrestrial environmental proxies are often seen to diverge. Future work on the almost unknown Paleogene is needed, as well as the potential of carbonate platforms as archives of paleoceanographic conditions.

The Late Eocene-Early Oligocene terrestrial successions of the Cao Bang and Na Duong basins, and the Hoanh Bo Trough (North Vietnam)

Anna Wysocka

Faculty of Geology, University of Warsaw

Phan Dong Pha (Vietnam Academy of Science and Technology), Hoang Van Tha (Vietnam Academy of Science and Technology), Nguyen Quoc Cuong (Vietnam Academy of Science and Technology), Ewa Durska (university of Warsaw), Urszula Czarniecka (University of Oslo), Anna Filipek (University of Warsaw), Do Van Thang (University of Warsaw), Radosław Staniszewski University of Warsaw), Daniel Zaszewski (University of Warsaw)(, Adam Baranowski (University of Warsaw)

In northern Vietnam, there are at least a dozen small areas in which Paleogene and Neogene deposits crop out. In most cases, they are paltry erosional patches and constitute remnants of a larger sedimentary terrestrial system. Only some of them are big enough to be treated as basins with fully developed sedimentary patterns. Among them, the Cao Bang and Na Duong basins, and the Hoanh Bo Trough filled with thick series of Late Eocene-Early Oligocene terrestrial deposits deserve special attention. The Cao Bang and Na Duong basins are related to the left-lateral Cao Bang-Tien Yen Fault and interpreted as belonging to an associated extensive terrestrial drainage system. The Cao Bang Basin is filled with a wide variety of immature or submature clastic deposits, from coarse-grained alluvial-fan through sandy fluvial to fine, organic-rich lacustrine deposits. Sedimentation in the Na Duong Basin was initially dominated by fluvial and peat-forming processes (Na Duong Formation), followed by lacustrine deposition (Rinh Chua Formation). These formations were deposited in the Early Oligocene, under a warm temperate-to-subtropical climate. The sedimentary infill of the basin is petrographically mature and was deposited in a relatively long-lasting fluvial-lacustrine sedimentary system. This system is proposed as a main Oligocene feeder system for the Beibuwan Basin (South China Sea). While, the Hoanh Bo Trough is with filled proximal alluvial fan, distal alluvial fan, fluvial alluvial plain with channels, alluvial plain and/or lake margin, and lacustrine facies associations. The sedimentary pattern and interpretation of the Hoanh Bo Trough evolution match well with the rift initiation, rift development, and rift termination tectonic system tracts. It is the nearest well-exposed Paleogene landward basin in relation to the Tonkin Gulf, is unique and crucial for regional interpretations of the sedimentary and structural evolution of the northern Vietnam onshore/offshore transition, especially for the Red River Fault Zone (RRFZ), the Cao Bang-Tien Yen Fault, the northern Song Hong Basin, and even for the Beibuwan Basin. Moreover, the Hoanh Bo Trough could be treated as a landward keyhole for the offshore basins: for instance, for the Kien An Basin in the northern Song Hong Basin.

How Did Sediments Disperse and Accumulate in the Oceanic Basin, South China Sea

Fei Wang

School of Oceanography, Shanghai Jiao Tong University, China (Visiting at Dep. of Earth Sciences, ETH Zurich)

Weiwei Ding (Key Laboratory of Submarine Geosciences & Second Institute of Oceanography, Ministry of Natural Resources, China)

Quantification of the sedimentary accumulation and dispersion process of the South China Sea (SCS) established an important part on the “source-to-sink” process in East Asia. Based on geological interpretations of more than 30 multichannel seismic profiles covering the whole oceanic basin with constraints from IODP Expedition drilling results, we calculated the sedimentary budget of the oceanic basin since the Oligocene on a million-year geological scale. Sediment isopach maps in different geological time were reconstructed to understand the controlling factors dominating the Cenozoic sedimentary accumulation and dispersion process, as well as the possible sedimentary provenances. Results show that the sedimentary budget of the whole oceanic basin increased gradually with time, although the rate has not been consistent over time. It was complicated by regional tectonics, including the spreading of the SCS, the uplift of the Tibet Plateau and the Taiwan, the Asian monsoon, the river systems, and the sea level changes. Submarine channel/canyon systems developed in the continental margin acted as the major conduits for terrestrial sediments discharging into the oceanic basin. Opposite trend occurred in the Southwest Sub-basin during the Late Miocene, and in the Northwest Sub-basin during the Pliocene. The former might be related with the local rifting event in the Mekong Shelf, which trapped most of the terrestrial input. While the later was due to the retreat of the Central Canyon and Pearl River Canyon in the Late Pliocene. Sediment isopach maps indicate that the sediments accumulation mainly focused on the northern flank of the SCS oceanic basin before the Late Miocene, with the depocenters generally distributed at the mouth of the channel/canyon systems and slope foot area near basement highs; but gradually migrated to the southern flank of the basin since Pliocene due to the high sea level and increase of the Mekong River runoff. An exception is the depocenter in the northeast part related with the Taiwan orogeny. Either the thickness or the range increased and spread to the central basin caused by the huge amounts of terrestrial sediment accumulation due to the continuous uplifting and denudation since the Late Miocene.

No modern Irrawaddy River until the late Miocene-Pliocene

Tara Jonell

University of Glasgow

Liviu Giosan (Woods Hole Oceanographic Institute), Peter D. Clift (Louisiana State University), Andrew Carter (Birkbeck College, London), Lisa Bretschneider (GEOMAR, Helmholtz Centre for Ocean Research Kiel), Ed C. Hathorne (GEOMAR, Helmholtz Centre for Ocean Research Kiel), Marta Barbarano (Università di Milano-Bicocca), Eduardo Garzanti (Università di Milano-Bicocca), Giovanni Vezzoli (Università di Milano-Bicocca), and Thet Naing (Pathein University)

The deposits of large Asian rivers with unique drainage geometries have attracted considerable attention due to their explanatory power concerning tectonism, surface uplift and upstream drainage evolution. This study presents the first petrographic, heavy mineral, Nd and Sr isotope geochemistry, and detrital zircon geochronology results from the Holocene Irrawaddy megadelta alongside modern and ancient sedimentary provenance datasets to assess the late Neogene evolution of the Irrawaddy River. Contrary to models advocating a steady post-middle Miocene river, we reveal an evolution of the Irrawaddy River more compatible with regional evidence for kinematic reorganization in Myanmar during late-stage India-Asia collision. Quaternary sediments are remarkably consistent in terms of provenance but highlight significant decoupling amongst fine and coarse fraction $^{87}Sr/^{86}Sr$ and εNd due to hydraulic sorting. Only well after the late Miocene do petrographic, heavy mineral, isotope geochemistry, and detrital zircon U-Pb results from the trunk Irrawaddy and its tributaries achieve modern-day signatures. The primary driver giving rise to the geometry and provenance signature of the modern Irrawaddy River was regional late Miocene (≤ 10 Ma) basin inversion coupled with uplift and cumulative displacement along the Sagaing Fault. Middle to late Miocene provenance signatures cannot be reconciled with modern river geometries, and thus require significant loss of headwaters feeding the Chindwin subbasin after ~14 Ma and the northern Shwebo subbasin after ~11 Ma. Large-scale reworking after ~7 Ma is evidenced by modern Irrawaddy River provenance, by entrenchment of the nascent drainage through Plio-Pleistocene inversion structures, and in the transfer of significant sediment volumes to the Andaman Sea.

SESSION THREE: Alfred Wallace session. Paleobiogeography, Climate and Tectonism

The establishment of Palaeotropical rain forests from Africa to Oceania in relation to plate tectonics and climate change

Robert John Morley

Palynova Ltd

How old are tropical rain forests? Old-world rain forests of the Palaeotropical kingdom became established at different times in different regions with changing opportunities for plant dispersals in relation to plate movements and climate change during the Late Cretaceous and Cenozoic. The Palaeotropical and Neotropical kingdoms differentiated in the Late Cretaceous. Maastrichtian records of fossil Dipterocarpus pollen, recently discovered in Sudan, when evaluated in relation to molecular data, lead to the suggestion that canopy-forming dipterocarp genera evolved in Africa by the Campanian. These genera persisted through the K/Pg extinction event. With the Late Cretaceous northward drift of the Indian Plate and its collision with the Kohestan/Lakadh Island Arc during the late Maastrichtian and Paleocene, numerous Dipterocarpoideae and other taxa dispersed to India as part of the Africa-India floristic interchange and replaced earlier low-diversity Indian floras. As the Indian Plate subsequently drifted towards Asia in the Eocene, dispersal opportunities again arose for multiple lineages to disperse 'out of India' during the middle Eocene. Dispersals took place both just before and immediately following the establishment of a direct land connection, from about 48 Ma onward. These elements replaced a depauperate flora of East Asian affinity across Southeast Asia and mark the time of initial establishment of Southeast Asian rain forests. Tectonic models for Southeast Asia are in conflict, and the different models impact strongly on how to interpret the subsequent evolution of rain forests in that area. Palynological evidence for different models will be discussed. The lowland floras of the islands of Eastern Indonesia and Oceania originated due to dispersals mainly from Southeast Asia and became established only after those areas rose above sea level during the Neogene, although there may have been localised older oceanic islands which bore floras of unknown affinity. The oldest rain forests thus likely formed in equatorial Africa during the Campanian, and subsequently became established on the Indian Plate in the late Maastrichtian and Paleocene, followed by Southeast Asia in the middle Eocene and Oceania in the Miocene. The current megadiverse Southeast Asian rain forests are therefore essentially sourced from immigrants.

Deep-Time Fossil Records suggest the Indian Plate as Source and Refuge area of Tropical Angiosperms

Prasad Vandana

Birbal sahni Institute of Palaeosciences

Tropical angiosperms are the main constituents of tropical biodiversity hotspots. Tracing the evolution of tropical angiosperms is arguably a challenging and relevant issue in plant evolution. The dramatic geological history of the Indian Plate puts on view its significant role in shaping the biogeography of tropical angiosperms. Early and Mid-Cretaceous sedimentary records of India have not provided any evidence of angiosperm fossils so far. Ecological opportunities due to latitudinal shift of the Indian plate in the tropical zone during Late Cretaceous-early Paleogene and the formation of dispersal routes with tropical Africa (via KLIA), and through that with Europe and later with Southeast Asia sheds light on the longstanding debate of lack of endemicity of Indian fossil flora despite isolation of Indian plate as an island. KLIA acted as a filter corridor for dispersal of tropical angiosperms from Africa to India. Perhumid climatic setting due to equatorial positioning of Indian Plate under warm climate of early Paleogene provided an ecological release for the rapid diversification and speciation of aseasonal tropical angiosperms. Post-India Asia collision led to the dispersal of the aseasonal tropical angiosperms to the low-lying tropical regions of Southeast Asia where they got an ecological release afresh, helping them speciate again and diversify to finally develop as dense tropical rain forests. These warm and humid climatic conditions were maintained for the sustainability of tropical angiosperms on Indian plate till the initiation of monsoonal climate. Lesser precipitation and long periods of dry climatic conditions with the advent of monsoonal climate led to the retraction of aseasonal tropical angiosperms from larger parts of India and restricted them to the perhumid climate of the Southwestern Ghats of India and Sri Lanka as Gondwana relic forests. The Indian Plate hence acted as both museum and cradle for tropical biodiversity and was the main driver for the emergence of tropical rain forest in Southeast Asia.

Evolution of Oligo-Miocene Tethyan seaway and its impact on the marine molluscan biodiversity of western India

Devapriya Chattopadhyay

IISER Pune

Saurav Dutta (Interuniversity Institute of Marine Sciences of Eilat (IUI), Israel)

Tectonic changes have influenced the evolution of the marine community by changing the land and seaway configuration over time. Two such events during the Oligo-Miocene—the closure of the Tethyan seaway due to the development of the Gomphotherium Landbridge leading to the separation of the Arabian Sea from the proto-Mediterranean Sea (~ 19 Ma) and the significant uplift of the Tibetan Plateau influencing the monsoon (~16 Ma)—represent a classic case of tectonic shift influencing the regional environment of the Indian subcontinent. We investigated the taxonomic and body-size related response of the shallow marine bivalve (molluska) assemblage from 11 time-constrained shellbeds of the Kutch Basin (western India) from three formations—Maniyara Fort (Chattian), Khari Nadi (Aquitanian) and Chhasra (Burdigalian-Langian) representing a time span of ~ 9 Ma (24.4–15 Ma). Our collection of over 2000 individuals represents 15 families and 61 morphospecies. The fossils are predominantly calcitic in nature, indicating a potential adverse effect of diagenesis. However, the taphonomic nature does not vary substantially across shellbeds and hence, less likely to produce a temporal pattern. The five most abundant bivalve species occur in all the formations. The Maniyara Fort Formation species composition is substantially different from the younger formations, implying the possible effect of biogeographic separation. The absence of proto-Mediterranean taxa in Oligocene shellbeds supports limited faunal exchange between the Mediterranean-Iranian Province (MIP) and the western Indian Province (WIP) as early as ~ 24.4 Ma (Chattian). Faunal exchange, however, continued between the WIP and the adjacent Eastern African-Arabian Province (EAAP). Formation-specific evenness shows a monotonic decrease from the Maniyara Fort to the Chhasra Formation. However, shellbed-specific analyses of diversity and body size do not demonstrate a strong directional trend through time and support the stasis model. Although the global comparison shows a change in composition across Oligo-Miocene, the diversity of the marine bivalve fauna of the Kutch Basin demonstrates relatively little response to the Tethyan closure and Himalayan uplift.

Distribution pattern in tropical angiosperm families driven by deep time Africa-India Floristic Interchange: Evidences from the early Paleogene Indian records of Dipterocarpaceae, Ebenaceae and Euphorbiaceae

Mahi Bansal

Birbal Sahni Institute of Palaeosciences

Robert J. Morley (Palynova Ltd., UK), Vandana Prasad (Birbal Sahni Institute of Palaeosciences)

The fragmentation of Gondwana brought a revolution in angiosperm diversity during the Cretaceous. Plate tectonic movements and changes in climate during the Late Cretaceous-Paleogene introduced continental heterogeneity in the distribution pattern of angiosperms, many of which were far more widespread then, than they are today. The underlying causes for the geographic and temporal range shifts of tropical angiosperms can be comprehended by investigating the evolutionary history of tropical rainforest families. The Cretaceous-Paleogene fossil records of the three angiosperm families Euphorbiaceae subfamily Crotonoideae, Ebenaceae and Dipterocarpaceae from the Indian Plate bring prominence to the disjunct distribution of tropical angiosperms. These families are important elements of tropical rainforests. The morphological analyses of the pollen fossil records combined with DNA sequencing of their comparable extant families' species, under a phylogenetic framework, reveal that the three families originated in the seasonally wet regions of Africa during mid-Cretaceous. The biotic corridor of the Kohistan-Ladakh Island Arc connecting the tropical zones of the Indian Plate and northeastern Africa facilitated the dispersal of plant lineages from Africa to India during the Maastrichtian-Paleocene. Similarly, some lineages migrated to South America at the time of, or immediately after the separation of the South American and African Plates. The low temperature gradient across equatorial and polar latitudes during early Paleogene hyperthermal-events promoted the spread of megathermal elements to the mid latitudes via boreotropical routes. However, subsequent Oligocene global cooling with increased aridity resulted in the retreat of these lineages to low latitudes. The paleo-equatorial position of the Indian Plate during early Paleogene further provided an ecological opportunity for the diversification of aseasonal plant lineages in a perhumid climatic setting. Subsequent to the India-Asia collision, aseasonal plant lineages dispersed to Southeast Asia, where they further diversified giving rise to rich tropical lowland rainforests. The advancement of seasonal aridity over the Indian subcontinent during the Neogene further limited the floral exchange between the two regions and led the aseasonal flora to be restricted to the perhumid pockets of the Western Ghats and Sri Lanka. The present Cretaceous-Paleogene Indian fossil records together with the phylogenetic analyses, thus, display footprints of the Africa-India Floristic Interchange in the distribution pattern of tropical angiosperms.

SESSION FOUR: Amadeus Grabau session. Central Asian Climate, Environment and Ecological evolution

Twilight of the greenhouse world, learnings from the Eocene of the Asian continental interior

Carina Hoorn

University of Amsterdam

Faez Robin-Champigneul (Maastricht University, Netherlands), Amber Woutersen (University of Amsterdam, The Netherlands), Niels Meijer (Senckenberg Biodiversity and Climate Research Centre (Bik-F), Germany), Guillaume Dupont-Nivet (CNRS - Géosciences Rennes, France)

The Xining Basin is situated in NW China and holds an excellent and well-dated Paleogene sedimentary record with an exquisite sporomorph (pollen and spores) flora. This record exemplifies the transition from greenhouse to icehouse conditions and can provide valuable lessons for the future as it forms analogue for vegetation response to global warming. Here we focus on the Eocene sediments and evaluate the changes in sporomorph composition through time. We observe that pollen from steppe-desert shrubs such as Ephedraceae and Nitrariaceae are common, but pollen from Podocarpaceae and Pinaceae (conifers) are also found. The podocarps disappear from our record by 40 Ma, followed by a drop in steppe-desert shrubs at the Eocene to Oligocene Transition (EOT, c. 34 Ma). In contrast, high elevation Pinaceae such as Picea and Abies emerge at 37 Ma. These data point at an increase in regional topography, but also a strong effect of global climatic cooling from 40 Ma and peaking at 34 Ma. Together, this evidence suggests that the climatic transition from 'greenhouse' to 'icehouse' conditions that took place in the Eocene, drastically reshaped the phytogeography of the Asian continental interior, with plant taxa experiencing either extinction or extirpation. Such changes in vegetation must also have driven changes in surface processes and ultimately climate and the carbon cycles. Although it remains a challenge to forecast future vegetation scenarios, the sedimentary record can provide us with explanations on past drivers of change from which we can make inferences for our future.

The Eocene-Oligocene Transition in Central Asia: an evolutionary bottleneck for the steppe-desert taxon Nitraria L. (Nitrariaceae)

Amber Woutersen

University of Amsterdam

Phillip E. Jardine (University of Münster), Daniele Silvestro (University of Fribourg; Gothenburg Global Biodiversity Centre), Raul Giovanni Bogotá-Angel (Universidad Distrital Francisco José de Caldas), Hong-Xiang Zhang (Xinjiang Institute of Ecology and Geography), Niels Meijer (Senckenberg Research Institute), Johannes Bouchal (Medical University Vienna), Natasha Barbolini (Stockholm University), Guillaume Dupont-Nivet (Université de Rennes; University of Potsdam), Andreas Koutsodendris (Heidelberg University), Alexandre Antonelli (Kew Royal Botanic Gardens; University of Oxford; Gothenburg Global Biodiversity Centre), Carina Hoorn (University of Amsterdam)

The transformation from a greenhouse to icehouse world at the Eocene-Oligocene Transition (EOT) coincided with a large decrease of pollen from the steppe-adapted genus Nitraria. A coastal origin has been suggested for the genus, which has a geographically widespread fossil record and is now present along the Mediterranean coast, and in Asia and Australia. Fossil palynological records show high abundance and diversity of Nitraria in the Eocene, but molecular records imply diversification of the genus from the Miocene onwards. We investigated the evolution of Nitraria throughout the Cenozoic by combining extant taxa and fossil palynological morphotypes into a unified phylogenetic framework. This framework was based on both DNA sequences and pollen morphological data. Our oldest palynological fossil of Nitraria was at least 51 Myrs old and found in Central Asian deposits. This provides new evidence for its origin in this area. We found that taking extinct taxa into account leads to a distinctly different diversity trajectory of Nitraria, compared to a trajectory derived from extant-only taxa. Coinciding with retreat of the proto-Paratethys Sea, a major global cooling event and a turnover in Central Asian steppe vegetation, the EOT is an evolutionary bottleneck for Nitraria. The genus never regains its Eocene diversity, even though renewed diversification of the modern species occurred in the Miocene. Our study demonstrates it is therefore crucial to apply an integrative approach to fully understand plant evolutionary history.

The simulated evolution of Asia climate from the Early to the Late Eocene: wetter East Asia and drier Asian inland

Xiangyu Li

Department of Atmospheric Science, School of Environmental studies, China University of Geosciences, Wuhan,

Zhongshi Zhang (Department of Atmospheric Science, School of Environmental studies, China University of Geosciences, Wuhan, 430074, China. NORCE Norwegian Research Centre, Bjerknes Centre for Climate Research, Bergen, Norway. Nansen-Zhu International Research Centre, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China) Ran Zhang (Department of Atmospheric Science, School of Environmental studies, China University of Geosciences, Wuhan, 430074, China. Climate Change Research Center, Chinese Academy of Sciences, Beijing 100029, China) Qing Yan (Nansen-Zhu International Research Centre, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China)

Modern Asia is dominated by non-zonal climate pattern, with monsoon climate in the East Asia and arid climate Asian inland. Unlike today, it has been hypothesized the Eocene Asia was dominated by a zonal climate, with broad arid climate belts from west to east China. The transition from zonal to non-zonal climate has been hypothesized to be no later than ~22 Ma and is closely related to the initiation of the East Asian monsoon. Based on the simulations, there was a zonal/zonal-like arid desert/steppe climate band in China in the Early Eocene, but the zonal band very likely disappeared in the Late Eocene due to increased precipitation over East China. It was wetter over East China and direr in Asian inland from the Early to the Late Eocene, broadly consistent with geological evidences. The wetter condition over East China is related to the intensified summer southerlies and the westward extension of the western Pacific subtropical high in the Late Eocene. However, the disappearance of a zonal climate band does not sufficiently indicate the formation of an East Asian monsoon climate in the Late Eocene, since that the simulated wind and precipitation seasonality is still much weaker in the Late Eocene and should be distinguished from the modern monsoonal seasonality. The enhanced aridity in Eocene Asian inland is closely related to the early uplift of Tibetan Plateau and global cooling induced by decrease in atmospheric CO2 concentration. The early uplift of the Tibetan Plateau contributed to the long-term Asian inland aridification during the Eocene, whilst the variations in the atmospheric CO2 concentration are more important in modulating the regional aridity on short timescale.

Long-period astronomical forcing on the strength of Miocene westerlies in Central Asia

Silke Voigt

Goethe University Frankfurt

K. Frisch, R. Petschick, A. Gerdes (U Frankfurt), V. Verestek, E. Appel (U Tübingen), J. Pross, A. Koutsoudendris (U Heidelberg), J. Kley (U Göttingen), T. Voigt (U Jena), S. Nigmatova (Geological Institute K. Satpaeva, Almaty)

The Miocene climate transition (MCT) represents a major global climatic shift towards sustained cooling of our planet. The mechanisms behind this cooling, its regional differentiation and the feedbacks involved are still a matter of debate. Continental settings of Central Asia witnessed increased desertification during this period, but its precise timing and the interplay of tectonics, regional and global climatic factors are not well understood. We will provide insights into the regional climate evolution north of the uplifting Tian Shan Mountains by presenting sedimentary and palynological data from a well-dated, high-resolution terrestrial record of mudflat, playa and saline lake deposits spanning the MCT. The 450-m-thick sedimentary succession exposed in the Aktau Mountains of the Ili Basin, SE Kazakhstan, is representative for a phase of widespread lake formation. Regular depositional cycles represent changes in sedimentary facies and lake level expressing a strong sensitivity to moisture availability under arid to semi-arid climate conditions. Time series analysis of hydrology-sensitive proxy parameters shows the sedimentary cyclicity to be influenced by critical thresholds relative to variations of long-period astronomical forcing. Thereby, the MCT was a period of most intense regional water cycling evident from most extreme oxygen isotope fractionation in carbonates of the Ili Basin’s discharge playa. The later formation of a deep perennial lake accompanied by the spread of the conifer Tsuga between 12.6 – 11.6 Ma represents cool and humid conditions in Central Asia north of the Tian Shan in a period of obliquity dominance during a very long eccentricity minimum. Modulations of precession and obliquity affected the regional strength of atmospheric pressure gradients and westerly winds, which in turn were crucial for the magnitude of moisture transport evaporated from the Eastern Paratethys and Mediterranean seas. Both, the pathway and the intensity of Westerlies controlled the amount of precipitation available for runoff and aquifer/lake recharge in Central Asia.

Evolution of Asian dust input to the Japan Sea and its links to tectonic and climatic changes

Shiming Wan

Institute of Oceanology, Chinese Academy of Sciences

Understanding Asian dust cycle and its interactions with the climate–tectonics at the late Cenozoic is the frontier topic of earth science research. Asia is the second largest dust source region in the world and the west Pacific is the major sediment sink of Asian dust. As a semi-enclosed marginal sea in the Asian margin, the Japan Sea/East Sea is located between the Asian dust source region and the North Pacific and thus has the potential to provide an excellent record of the history of Asian eolian dust input. Continuous and high-resolution clay minerals and Sr-Nd isotopic records from the Japan Sea indicate the proxy records of past changes in Asian eolian input to the basin since 15 Ma that highlights the four-step drying of Central Asia, which in turn was controlled by the stepwise uplift of Tibetan Plateau and global cooling. Eolian dust input the deep-sea could potentially exert influence on oceanic biogeochemical cycles through iron fertilization. Palaeoproductivity proxies indicate remarkable increases in productivity at the late Pliocene. We suggest that higher dust-derived iron supply was likely driven by the growth of the Northern Hemisphere ice sheets and could account for enhanced primary productivity and export production in the Japan Sea.

The potential of Poaceae pollen size for past vegetation and climate reconstruction on a global level

Caixia Wei

University of Amsterdam

Philip Jardine (University of Münster), Will Gosling(University of Amsterdam), Carina Hoorn(University of Amsterdam)

Poaceae has been regarded as the most widespread angiosperm family of all and grasslands occupied around 40% of the Earth's land surface. However, big knowledge gaps remain about the history of global expansion of grass-dominated habitats. Poaceae pollen size has previously been suggested as a tool to reconstruct the past vegetation and climates, but it is still controversial if it indeed can be used in broader spatial and deep-time scales. Here we set out to perform a full assessment and test the robustness of this proxy. One hundred and twenty-seven specimens across the Poaceae phylogeny from the Amazon drainage basin (ADB) were prepared for pollen grain size analyses, in order to explore their relationship with six abiotic and biotic variables including vegetation type, soil composition, climate (temperature and precipitation), photosynthetic pathway, and genome size. Phylogenetic generalized least squares (P-GLS) model and linear mixed models (LMM) were applied to assess of the proxy. Our measurement data show that Poaceae pollen size presents a very wide range, not only at genus and species level but also within species. When applying a phylogenetic generalized least squares (P-GLS) model and a linear mixed model (LMM) on our specific dataset, these models confirmed that Poaceae pollen size is not respond to these variables, and also cannot as a useful proxy in palaeoecological research at a global level.

Eocene hydroclimatic evolution recorded in the Xining Basin, NE Tibet

Niels Meijer

Senckenberg Biodiversity and Climate Research Centre

Alexis Licht (Aix Marseille University,), Guillaume Dupont-Nivet (Univ Rennes, CNRS), Pierrick Roperch (Univ Rennes, CNRS), Alexander Rohrmann (Freie Universität Berlin), Aijun Sun (Lanzhou University) Amber Woutersen (University of Amsterdam), Mattia Tagliavento (Goethe Universität Frankfurt), Julia Brugger (Senckenberg Biodiversity and Climate Research Centre (SBiK-F), Carina Hoorn (University of Amsterdam, Gemma Benevento (Senckenberg Biodiversity and Climate Research Centre (SBiK-F), Susanne Fritz (SBiK-F), Goethe Universität Frankfurt), Jens Fiebig (Goethe Universität Frankfurt,), Andreas Mulch (SBiK-F), Goethe Universität Frankfurt)

Central Asian climate is governed by the interplay between northern hemisphere atmospheric circulation, topography and land-sea contrasts. However, their respective roles in driving the hydroclimatic evolution remains debated, especially during the Eocene. Some suggest that a subtropical arid belt covered most of China, while others have proposed that monsoons already existed due to the warmer greenhouse conditions of the Eocene. To resolve these opposing views, we extend the high-resolution magnetostratigraphy of a terrestrial record from the Xining Basin in NE Tibet down to the early Eocene (53.0 Ma; chron 24n), thereby covering most of the Paleogene. We compile sedimentological as well as stable and clumped isotope data to reconstruct the paleo-environmental evolution in the basin. Organic-rich paleosols as well as carbon and oxygen isotopes of vadose-grown and lacustrine carbonates and organic matter suggest a wetter and possibly monsoonal paleo-environment between 53.0 and 51.8 Ma, coeval with the peak greenhouse climate of the Early Eocene Climatic Optimum (EECO; 53-49 Ma). This is followed by drying at 49.7 Ma as evidenced by an increase in the $\delta18O$ values of the carbonates, setting the stage for subsequent aridification steps recorded throughout the middle and late Eocene. The coeval timing with the EECO suggests a dominant role for global climate in driving atmospheric moisture and may have important implications for vegetation cover, dust production, mammal dispersal and weathering in the region.

Late Neogene East Asian dust source variation linked to global climate changes: multiproxy single-grain provenance analysis from Baode, Chinese Loess Plateau

Katja Bohm

Department of Geosciences and Geography, University of Helsinki, Finland; Department of Earth Sciences, Uppsala University, Sweden

Anu Kaakinen (Department of Geosciences and Geography, University of Helsinki), Thomas Stevens (Department of Earth Sciences, Uppsala University), Yann Lahaye (Geological Survey of Finland), Hugh O'Brien (Geological Survey of Finland), Huayu Lu (School of Geography and Ocean Science, Nanjing University, China), Yuan Shang (State Key Laboratory of Estuarine and Coastal Research, East China Normal University, China), Hanzhi Zhang (School of Geography and Ocean Science, Nanjing University, China)

The Neogene-Quaternary aeolian dust deposits (Red Clay and loess) on the Chinese Loess Plateau (CLP) are exceptional terrestrial archives of past climates and environments. Constraining the provenance of these deposits sheds light on the long-term links between Central-East Asian climate, tectonics and desertification. Despite its importance, the CLP dust provenance and its possible changes at the Mio-Pliocene and Plio-Pleistocene global climate transitions remain debated. Because dust provenance changes can result from both global- and regional-scale processes, which also operate on different time scales, interpretation is complicated. Uncertainties in dust provenance also derive from the complex dust cycle of Central-East Asia, where dust is transported stepwise from multiple mixed sources. The mixed nature of the sediments requires single-grain provenance techniques that can distinguish the different source area signals from one another. Additionally, ambiguities in the interpretation of single-grain detrital zircon U-Pb data, the most commonly used single-grain technique, indicate that multiple statistically representative single-grain proxies are needed for reliable provenance reconstructions. In this study, we use a combined single-grain detrital zircon and rutile approach at high sampling resolution to analyse the provenance of the 7–2.6 Ma Baode Red Clay. Located on the marginal northeastern CLP, Baode is closer to the northern dust source areas and likely less influenced by pre-depositional recycling of the dust than the sites on the southern or central CLP. Our data consist of joint detrital zircon U-Pb ages and detrital rutile trace element geochemistry of the Baode Red Clay. As the first comprehensive study using detrital rutile geochemistry in sourcing the CLP dust, we also present rutile data from 14 potential sedimentary source areas. The combined data indicate that dust provenance changed gradually at the Mio-Pliocene and Plio-Pleistocene global climate transitions. We also identify multiple shorter periods of provenance variation, caused by changes in global and/or regional environment. Implications of our results not only shed light on the wider causal mechanisms of dust emission and deposition in the late Cenozoic, but also verify that a multiproxy single-grain approach is needed for reliable provenance analysis of the CLP dust.

East-Central Asian Climate Evolved With the Northward Migration of the High Proto-Tibetan Plateau

Chenguang Zhu

Department of Atmospheric Science, School of Environmental Studies,China University of Geosciences, Wuhan, China

Chenshan Wang, Jun Meng (China University of Geosciences); Yongyun Hu (Peking University); Jian Zhang (Chinese Academy of Sciences)

The evolution of Cenozoic climate patterns in Asia has been linked to uplift of the Tibetan Plateau (TP), retreat of the Paratethys Sea, and global cooling. However, less attention has been placed on the latitudinal change of the TP. Here we report new climate modeling to explore how modern climate changes as a function of topographic growth and spatial migration of the TP. Our results show that the northward displacement of the uplifted proto-TP within the subtropics can significantly affect the wind and precipitation pattern over East-Central Asia. By compiling proxy-based climatic records, paleolatitudinal and paleoelevational evolution models of the proto-TP, and in comparison with previous modeling under a global paleogeography, we suggest that the northward migration of the proto-TP in the Paleogene could have intensified the aridity in Central Asia, but its influence on East Asian precipitation and monsoonal circulation could be dependent on the paleogeography and other boundary conditions.

Spatial and temporal provenance variations of the Chinese Loess Plateau over the late Miocene to early Pleistocene: a window into the reorganization of the Yellow River and monsoon activity

Haobo Zhang

Lanzhou University

Wenbin Peng (Zaozhuang University); Alex Pullen (Clemson University); Maotong Li (Lanzhou University); Baotian Pan (Lanzhou University); Wenjiao Xiao (Chinese Academy of Sciences); Junsheng Nie (Lanzhou University)

The Miocene–Holocene Red Clay, paleosol, and loess sequences composing the Chinese Loess Plateau (CLP) are one of the most complete terrestrial eolian sediment archives on Earth. We present the first large-n detrital zircon U-Pb geochronology dataset for the Miocene–Pliocene sequence from the northeastern CLP. The depositional ages of these samples are like those of other data sets from the central CLP, allowing comparison of spatial-temporal differences. These data show that the CLP had spatially varied provenance over the late Miocene–Pliocene, similar to the Quaternary strata. The data from the northeastern CLP indicate two shifts in dust sourcing around the Miocene-Pliocene and Pliocene-Quaternary boundaries. The shift around the Miocene-Pliocene boundary is consistent with elongation of the proto-Yellow River to incorporate the present-day 'big bend'—allowing sediment transport to and ultimately through the Yinchuan-Hetao graben. The provenance shift around the Pliocene-Quaternary boundary is consistent with increased sediment contributions from the Lüliang Shan and the Cretaceous strata overlying the North China Craton. These interpretations challenge assertions linking eolian sediment accumulation on the CLP over the late Miocene–Pliocene primarily to aridification within the continental interior of eastern Asia, but rather point to the importance of riverine transport, catchment reorganization, sediment storage, and increased climatic fluctuations.

Tropical podocarps from the Early Eocene Climatic Optimum in the Xining Basin, Tibet

Faez Robin-Champigneul

Maastricht University, Netherlands

Amber Woutersen (University of Amsterdam, Niels Meijer (Senckenberg Biodiversity and Climate Research Centre (BiK-F), Roy Erkens (Maastricht University), Guillaume Dupont-Nivet (CNRS - Géosciences Rennes), Carina Hoorn (University of Amsterdam)

Looking at interactions between past climates and palaeoflora allows us to make inferences about future climatic change, which is of particular relevance due to the current trend of anthropogenic global warming. The Xining basin in the Tibetan plateau is a prime location for such studies due to its well-dated sections previously used to study the Cretaceous and Late Eocene. In this study we explore the palynological records of the Early Eocene Climatic Optimum (EECO) in Tibet, focusing on two groups of tropical gymnosperm palynomorphs: Phyllocladidites and Podocarpidites. On a methodological level, we investigated the use of confocal microscopy as a tool for high-resolution imaging in palynological studies, which proved overall successful. However, we also found that Kaiser’s glycerine-gelatine is not a suitable embedding medium for such procedures. We were therefore able to produce high quality images and descriptions of Podocarpidites and Phyllocladidites that adequately confirm the presence of these tropical taxa during the EECO in Tibet, suggesting a once broader range for the genera. Our findings regarding the evolution of the genus Phyllocladus suggest a more diverse lineage with a much larger historical distribution than previously proposed. On the other hand, our findings align themselves with reports of tropical podocarps in more northern regions during climatic optima. Finally, we compare Phyllocladidites with Parcisporites, finding little to no distinguishing features between the two genera, proposing that they could be studied as a single type. We conclude that the palaeobiogeography of Phyllocladidites is a story of expansion and widespread extinctions, and that climatic optima have played an important role in such shifts in vegetation. We furthermore suggest that future climatic changes may similarly affect modern plant distributions.

Tibetan Plateau made central Asian drylands move northward, concentrate in narrow latitudinal bands, and increase in intensity during the Cenozoic

Ran Zhang

Institute of Atmospheric Physics, Chinese Academy of Sciences

The evolution of central Asian drylands during the Cenozoic is a hot topic in paleoclimate research, but the underlying mechanism remains unclear. Here, we investigate this topic with climate modeling based on six key geological periods. Our results indicate that central Asian drylands have existed since the early Eocene, after which they move northward and become narrower. Although changed land-sea distribution and decreased atmospheric CO2 concentration promote the aridification of drylands, they only slightly affect the latitudinal position of drylands. By comparison, the growth of Asian high-topography areas, especially the Tibetan Plateau (TP), makes central Asian drylands move northward, concentrate in narrow latitudinal bands, and increase in intensity. Good model-data qualitative agreement is obtained for stepwise aridification in midlatitude inland Asia north of ∼40°N, and the uplifted main and northern TP by the early Miocene likely forced drylands to form in this region.

SESSION FIVE: Emile Argand session. Himalayan Orogenesis, Monsoons and Biodiversity

Himalayan tectonic uplift as a driver of lateral biodiversification

A. Alexander G.Webb

University of Hong Kong

Hayley Hunt (University of Hong Kong); Fabien Condamine (University of Montpellier); Alice Hughes (University of Hong Kong); Laurent Husson (University of Grenoble Alpes)

Mountains, like islands, are increasingly well-understood as drivers of biodiversification. With increasing uplift, more opportunities for in situ speciation and species migrations occur. Most studies exploring relationships between the tempos of mountain-building and biodiversification examine systems on the scale of an entire mountain region, in large part because of data richness and methodological limitations. However, in settings where a very large mountain system uplifted in a simple, lateral-propagation fashion over several millions of years, it may be possible to elucidate a corresponding wave of enhanced biodiversification along the length of the range. The Himalayan mountains offer an opportunity which may fit this condition. Data sets as various as upper mantle seismic tomographic images, bedrock P-T-t constraints, volcanic and leucogranite crystallization ages, foreland detrital thermochronometric patterns, and motion histories of major orogenic wedge shear zones increasingly indicate lateral growth of the Himalayan mountains, dominantly from the west to the east-central portions of the range, from ~25 Ma to ~12 Ma. The only presently available model to explain this along-strike growth involves a laterally propagating detachment of the subducting slab, which would cause a wave of km-scale uplift traversing ~2000 km over ~13 million years. Here, we present the basic tectonic considerations and explore the use of phylogenetic modeling to examine whether a corresponding wave of biodiversification may be detectable. The work is ongoing: at present, the general findings for most groups are somewhat unclear, in large part because of limited resolution so far back in time. No group yet presents an obvious failure of the biodiversification wave prediction. Results for some groups, like snakes, appear to match the prediction. A further consideration of this work is that if lateral mountain-building can drive lateral biodiversification, then in turn, spatially-propagating biodiversification pulses of biodiversification can provide tests of mountain-building models, particularly in terms of parsing 3D vs. cross-sectional (2D) models.

Tibetan Plateau uplift, Westerlies evolution, and Asian climate changes

GuangshengZhuang

Louisiana State University

N/A

In studies of Tibetan tectonics-climate interactions, much emphasis has been placed on the Asian Monsoons governing regional climate and ecology. For example, Asian Monsoons were strengthened in the late Miocene in response to Tibetan plateau uplift and, in turn, drove the C4-grassland expansion with dry hydrological conditions. On the contrary, the Westerlies has not been given equal attention if not ignored. In present-day, the Westerlies splits to the west of Pamir in winter into the south and north branches. The south branch, which circumvents the Himalayan front retreats, joins the north branch, and migrates northward in summer. The present Asian climate is governed by the interactions between the Westerlies and Asian Monsoons. Hence, when such a climatic regime was formed is a key question but has remained underestimated due to the unequal weight given to the Westerlies. In this talk, I am presenting isotopic records from the Westerlies-monsoon boundaries. The isotopic records from the north and south of the Tibetan Plateau reveal that the Asian climate became drier around 10 Ma. The similar timing of drying suggests a regional event rather than a local signal. In comparison, records from monsoonal areas show that the climate remained wet during the same time interval. By examining the uplift history from paleoaltimetry studies, I interpret that the Tibetan Plateau uplift in the late Miocene forced the Westerlies to split. The displacement of monsoonal areas by Westerlies caused the drying in the boundary areas. Thus, the Westerlies-monsoon climatic regime may have been formed by 10 Ma.

Early-Middle Miocene Rise of the High Himalaya and the Disruption of Transverse Drainage due to Basal Accretion in the NW Himalaya

Rasmus C.Thiede

Institut für Geowissenschaften, Christian-Albrechts-University of Kiel, Germany

Dirk Scherler (GFZ - German Research Centre for Geosciences, Potsdam & Free University Berlin), Christoph Glotzbach (University of Tübingen), Germany

The Himalaya is the highest mountain range on Earth and an efficient north-south barrier for moisture-bearing winds. 1D-thermokinematic modelling of new zircon (U-Th)/He bedrock-cooling ages and >100 previously published mica 40Ar/39Ar, zircon and apatite fission track ages from the Sutlej Valley document a consistent rapid decrease in exhumation rates that initiated at ~17-15 Ma across the entire Greater and Tethyan Himalaya and the north-Himalayan Leo Pargil dome. Simultaneous changes in the hanging and footwall of major Miocene shear zones suggest that cooling is associated to surface erosion and not due to tectonic unroofing. We explain the middle Miocene deceleration of exhumation with major tectonic reorganization of the Himalayan orogen, probably coincident with the onset of basal accretion, which resulted in accelerated uplift of the Greater and Tethyan Himalaya above a mid-crustal ramp and the establishment of a new efficient orographic barrier. The period of slow exhumation in the upper Sutlej Valley coincides with a period of internal drainage in the south-Tibetan Zada Basin farther upstream, which we interpret to be a consequence of tectonic damming. Exhumation rates in the upper Sutlej Valley accelerate again at ~5-3 Ma, and allowed the Sutlej River to re-establish external drainage of the Zada Basin at ~1 Ma. Comparison with other data from the Himalaya along strike suggests that by ~15 Ma, southern Tibet was high, located in the rain shadow of the High Himalaya and eroding slowly for at least 10 Ma, before erosion accelerated again by ~5-3 Ma, most likely due to climatic changes.

Contributions of tectonics and climate on sculpting the landscapes of the Himalayas

YuqiangLi

Hubei Key Laboratory of Critical Zone Evolution, School of Earth Sciences, China University of Geosciences, Wuhan, China

Xiaoping Yuan (Hubei Key Laboratory of Critical Zone Evolution, School of Earth Sciences, China University of Geosciences, Wuhan, China)

The Himalayas, the highest mountains in the world, strongly affect the climate, ecology, and biodiversity in Asia. More importantly as one of the most active and largest mountain belts on Earth, the Himalayas serve as a good example to study the interaction between tectonics that usually create topography and climate that lowers topography through river erosion. However, the relative contributions of tectonics and climate on sculpting the landscapes of the Himalayas remain ambiguous. Here we reconstruct the growth of the Himalayas since the Early Miocene (23 Ma) using numerical landscape evolution modeling, taking into account tectonic uplift, fluvial erosion, and sediment deposition processes. We model the tectonic uplift of the Himalayas using the propagating uplift pattern as suggested by various geological evidence. The propagation of mountain belts shows first the increasing trend of steepness index (Ksn, as a proxy of erosion rate) and then decreasing pattern downstream from mountain interior to foreland, and the river profiles are upstream convex and downstream concave. To verify our modeling results, we compare the modeled topographic profiles, river profiles, and erosion rates to the observed datasets of eight rivers in the Himalayas across ~1500 km. The modeled geomorphic characteristics and erosion rates are broadly consistent with the observations by testing various combinations of model parameters, i.e., the stream power erodibility Kf varying between (0.7–1)×10-6 m0.1/yr, the characteristic width of propagating uplift varying between 10–70 km, and the uplifted elevation without erosion in the range of 6000–12000 m. The advantage of our modeling results is able to quantitively compare contributions of tectonic uplift and climatic erosion. Our results indicate that propagating uplift pattern supports the tectonic processes in the Himalayas and controls its landscape evolution more than climatic erosion. In the 23-Myr Himalayan growth, the average best-fit elevation of ~7500 m uplifted by the tectonic process, i.e., the crustal accretion with propagating thrust faults, is lowered to the present-day ~5000 m by climatic erosion. We further quantitatively show tectonic and climatic contributions in the Himalayas based on the established modeling results, and suggest the ratio of erosion to uplift amounts of 15%-30%.

Holocene hydroclimatic variability in South Asia: lessons from lakes and marginal marine sediments

YamaDixit

Centre for Atmospheric Sciences, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India

The Asian monsoon system, including both the Indian and East Asian, is a critical part of the global hydrological cycle. Variations in the intensity of the summer monsoon are likely to have widespread socio-economic impacts in the South Asian developing countries, underlining the importance of examining the variability of monsoon on various timescales. While instrumental record (post-1871) is too short to document the full range of monsoon variability that operates at centennial-millennial scale, paleoclimate records are useful to evaluate past changes in monsoon, both in terms of its cyclicity and intensity, and elucidates its potential societal implications. Continental archives such as lakes and cave deposits present a unique archive for understanding the summer monsoon variability because of their location closed to regions occupied by human civilisations. Marine and marginal-marine archives, on the other hand helps elucidate the local and regional hydrological changes along with the various tropical atmospheric-ocean phenomena such as the El-Nino Southern Oscillation and the Indian Ocean Dipole. The first past of this work will present an overview of lake records from northern India and their contribution to the overall understanding of the Holocene Indian summer monsoon variability on the subcontinent. The second part would deal with early-mid Holocene coastal record from the western Indo-Pacific warm pool region, which has direct implication on the monsoon rainfall on the Indian subcontinent.

Hydrometeorological progression of the Himalayan cryosphere: The Karakoram Predicament

BibhasvataDasgupta

Indian Institute of Science Education and Research Kolkata

The anomalous behaviour of the Karakoram glaciers has been a decade-long discussion. While a lot of effort has been given to understanding this phenomenon, little has been explored with respect to the factors that govern glacier accumulation rates. We performed a time-series analysis of 17 Himalayan glaciers to evaluate the Accumulation Index (AI), examine the ice accumulation/ablation balance of each glacier, and investigate the natural periodicities in regional climatic behaviour. Based on the AI, the Himalayan glaciers have been characterised as 'glacier-positive' and 'glacier-negative'. Glacier-positive behaviour in the Karakoram is favoured by global meteorological and local topographical factors. Analysis of 120 years of meteorological data shows a significant positive trend in winter and annual precipitation in the northwestern Himalayas, linked to surfacial warming and the Indian Ocean Dipole, while local factors such as slope, aspect and supraglacial debris constrain summer ablation. Additionally, the Karakoram precipitation is periodic in nature, demonstrating anti-correlation with decadal-scale precipitation records from the remaining Himalayan glaciers. Both local and global factors explain the anomaly in the Karakoram or the lack of it in other Himalayan glaciers. In a potentially warming planet, glacial accumulation rates are becoming increasingly sensitive to ambient temperatures, where glacier mass budget turns sharply negative at temperatures above 263 K due to accelerated summer ablation which overcompensates wintertime accumulation. This makes the Karakoram more sensitive to global meteorology than local factors. Therefore, it is important to address whether the Karakoram anomaly is an isolated climatic event or will it succumb to global climate change like the remainder of the Himalayan glaciers.

Enhanced chemical weathering in the western Himalaya during the Bølling-Allerød warm period

Gyana RanjanTripathy

Indian Institute of Science Education and Research Pune, India

Anupam Samanta (Indian Institute of Science Education and Research Pune, India), Satyabrata Das (Wadia institute of Himalayan Geology, Dehradun), Santosh Kumar Rai (Wadia institute of Himalayan Geology, Dehradun), Ravi Bhushan (Physical Research Laboratory, Ahmedabad), Suraj K Parcha (Wadia Institute of Himalayan Geology, Dehradun)

Erosion in the Himalayas plays a key role in the global chemical and climatic cycles. To assess climatic sensitivity of this land surface process, chemical and Sr-Nd isotopic compositions of a river section (PDM18) from the upper Zanskar river basin in the western Himalaya have been investigated. This section (length ~ 1.8 m) was collected from the bank of the Tsarap tributary at Padum, which provides a continuous erosional record between 22.4 and 1.4 kyr BP. The PDM18 sediments are composed of high carbonate content (53 ± 11 wt%), which is consistent with appreciable exposure of the Tethyan carbonates in the basin. The average Si/Al ratio of these sediments (4.9 ± 0.6; n = 35) is intermediate to that reported for the Higher Himalaya (HH) and Tethyan sedimentary sequence (TSS). The 87Sr/86Sr ratio (in their silicate fractions) vary from 0.726 to 0.779 (average: 0.737 ± 0.010), whereas the εNd values vary from -19.4 to -13.5 (average: -17.3 ± 0.9). These isotopic values also fall between their possible sources (HH and TSS) compositions. The depth profiles of Sr-Nd isotopes show significant temporal variation, indicating a shift in sediment provenance around the Bølling–Allerød warm period. Additional to these sedimentary source changes, the CaCO3 concentrations were relatively lower (~ 38 wt%) in the lower part of the section (older than ~16 kyr BP) compared to that (~ 64 wt%) in the upper portion (since ~12.8 kyr BP), with an intermediate CaCO3 concentration (52 ± 3 wt%) during ~16 to ~12.8 kyr BP. Further, temporal trends of several erosion indices such as chemical index of alteration (CIA) and K/Si ratios also show significant changes in the chemical erosion intensity. Relatively higher intensity of chemical erosion in the basin is observed during the Bølling–Allerød warm period, which is attributable to enhance rock dissolution during warmer period and also, exposure of fresh minerals during glacial retreat following the last glacial maxima. The observed changes in sediment provenances and chemical erosion underscore strong coupling between the Himalaya erosion and climate.

The spatial–temporal evolution of the Asian summer monsoon during the late Miocene

ZhilinHe

Institute of Geology and Geophysics, Chinese Academy of Sciences

Zhongshi Zhang (China University of Geosciences, Wuhan); Zhengtang Guo (Institute of Geology and Geophysics, Chinese Academy of Sciences); Ning Tan (Institute of Geology and Geophysics, Chinese Academy of Sciences); Zijiang Zhang (Institute of Geology and Geophysics, Chinese Academy of Sciences); Zhipeng Wu (Institute of Geology and Geophysics, Chinese Academy of Sciences); Chunxia Zhang (Institute of Geology and Geophysics, Chinese Academy of Sciences); Chenglong Deng (Institute of Geology and Geophysics, Chinese Academy of Sciences)

The long-term evolution of the Asian summer monsoon and its drivers are important for understanding future Asian summer monsoon variations. Due to inconsistencies among proxy data and/or different interpretations, the long-term evolution and drivers of the East and South Asian summer monsoons (EASM and SASM) during the late Miocene still remain controversial. There are two main viewpoints involving an overall strengthening or weakening trend, which is typically attributed to uplift of the Himalaya–Tibetan Plateau or global cooling. Here, we compiled paleoenvironmental reconstructions for the EASM and SASM during the late Miocene and used numerical simulations to investigate their evolution and potential drivers. The synthesized results indicate that the late Miocene climate: (1) underwent an overall drying trend in northern China, but a wetting trend in the South China Sea and surrounding areas; (2) became progressively drier on the northern Indian subcontinent, but not on the southern Indian subcontinent. The modeling results indicate that: (1) EASM circulation overall weakened, whereas SASM circulation weakened (strengthened) in the northern (southern) part of South Asian monsoon domain; (2) summer precipitation decreased (increased) in the northern (southern) part of East and South Asian monsoon domains, which is roughly agreement with the paleoclimate records. Our results suggest that a decline in atmospheric CO2 may have been a key driver of the evolution of the EASM and SASM during the late Miocene.

Petrography and mineralogy of Bengal Fan turbidites (IODP Expeditions 353-354): Himalayan provenance and depositional history.

MaraLimonta

, University of Milano-Bicocca

Alberto Resentini (Laboratory for Provenance Studies, Department of Earth and Environmental Sciences, University of Milano-Bicocca, 20126 Milano, Italy), Eduardo Garzanti (Laboratory for Provenance Studies, Department of Earth and Environmental Sciences, University of Milano-Bicocca, 20126 Milano, Italy)

The Himalayan Mountain range provides a spectacular example of an orogenic belt produced by continental collision. Provenance analysis of detritus stored in the Bengal Fan, recently cored during International Ocean Discovery Program (IODP) Expedition 354 on an east-west transect at □8°N across the Bengal Fan [1], allows us to reconstruct patterns of Himalayan erosion and weathering and the interplay of climate and tectonics during long-term and short-term fluctuations of the Indian monsoon. Petrographic and heavy mineral composition of 42 turbiditic layers overall, from four shorter cores (Sites U1454, U1453, U1452, U1449) covering the complete terrigenous record of the Himalayan flux over the last 1-2 Ma, and one longer core drilled through the complete fan succession reaching the mid-Oligocene (28 Ma; Site U1451) was analyzed, together with four additional samples from drill site U1444 collected during IODP Expedition 353. Bengal Fan turbidites are mostly feldspatho-quartzose to litho-feldspatho-quartzose and locally feldspar-rich feldspatho-quartzose, with plagioclase > K-feldspar. Sedimentary and low-rank metasedimentary lithics decrease in younger beds whereas high-rank metamorphic lithics increase. Ultramafic lithics sporadically occur and mica sharply increases in finer-grained samples. Turbidites of Pleistocene age contain moderately rich to rich amphibole-dominated tHM suites with epidote, garnet, and minor clinopyroxene, apatite, titanite, sillimanite, tourmaline, zircon, and kyanite. In Pliocene-Miocene turbidites, the heavy mineral concentration decreases, and assemblages are relatively enriched in garnet and epidote at the expense of amphibole. The relative abundance of zircon, tourmaline, and apatite increases progressively in older strata. Compositional variability depends on diverse controls, including provenance, grain size, hydraulic sorting, and diagenesis. Petrographic and heavy mineral composition on silt- and sand-sized sediments of the turbiditic depositional system testifies to long-distance provenance from the Himalayan Range via the Ganga-Brahmaputra fluvio-deltaic-turbiditic system and confirms that the Bengal Fan was a major sink for Himalaya-derived material since the Miocene. Compositional variability of Bengal Fan turbidites allows us to discriminate between pre-depositional and post-depositional processes controlling sediment mineralogy, and to link their depositional history to uplift and erosion of different tectono-stratigraphic Himalayan domains. 1. France-Lanord, C., et al. Bengal Fan: Proceedings of the International Ocean Discovery Program, 354 (2016).

Topographic evolution is responsible for diverging South Asian Monsoon Rainfall and Wind Histories during the Neogene

Anta-ClarisseSarr

CEREGE/Aix-Marseille University

Y. Donnadieu (CEREGE), C. Bolton (CEREGE), J-B. Ladant (LSCE), A. Licht (CEREGE), F. Fluteau (IPGP), M. Laugié (CEREGE), D. Tardif (IPGP, CEREGE), G. Dupont-Nivet (Univ. Rennes)

Cenozoic evolution of South Asian Monsoon and mechanisms driving changes recorded in the geological record remain highly debated. An intensification of monsoonal rainfall recorded in sediment archives from the earliest Miocene (23-20 million years ago, Ma) is generally attributed to Himalayan uplift. However, Indian Ocean paleorecords place the onset of strong monsoons around 13 Ma, linked to strengthening of the Somali Jet that forces Arabian Sea upwelling. In this contribution we reconcile these divergent records using Ocean-Atmosphere and ocean biogeochemistry models. Our results show that factors forcing monsoon circulation versus rainfall are decoupled and diachronous : Asian topography predominantly controlled early Miocene rainfall patterns, with limited impact on ocean-atmosphere circulation. Yet the uplift of East African and Middle Eastern topography played a pivotal role in the establishment of modern Somali Jet structure above the western Indian Ocean, while strong upwelling initiate in response to the emergence of the Arabian Peninsula. Our results emphasize a polygenetic history of the South Asian Monsoon with multiple paleogeographic controls: although elevated rainfall seasonality was likely a persistent feature since the India-Asia collision in the Paleogene, the modern-like monsoonal atmospheric circulation was only reached recently, in the late Neogene.

Himalayan-Tibetan Erosion is not the Cause of Neogene Global Cooling

PeterClift

Louisiana State University

Tara N. Jonell (University of Glasgow)

Investigating links between solid Earth tectonics and climate change continues to be a fruitful avenue for geoscience research. In particular, the roles that surface processes play in controlling levels of atmospheric CO2, an important greenhouse gas, have been the subject of much work. Although recent doubt has been cast on whether mantle CO2 degassing rates have remained consistent over million-year timescales, such contributions represent only half of the potential budget. There is continued interest in the role that chemical weathering and breakdown of silicate minerals may play in removing CO2 from the atmosphere as sediments transfer from source to sink. Uplift and erosion of the Himalaya and Tibetan Plateau have resulted in deposition of some of the largest sedimentary masses on Earth, invoking the argument that chemical weathering of these materials was a primary driver of long-term Cenozoic global cooling. To test the 'uplift-erosion-weathering' hypothesis, we estimate changes in chemical weathering fluxes from ~20 Ma for three major river systems (Indus, Mekong and Pearl) draining Asian mountain belts by combining geochemical data from scientific drill sites in the Arabian and South China seas with seismically-constrained sediment mass flux budgets. All weathering calculations are calibrated for the effects of evolving provenance. We find rates of CO2 consumption by silicate weathering decreased by 50% between ~16 and 5.3 Ma, especially in the Indus system, as onshore erosion slowed and less reactive mafic arc material was eroded from the suture zone. No net increase in CO2 consumption and falling chemical weathering fluxes during a period of global cooling refutes the idea that Himalaya–Tibetan Plateau uplift was the sole driver of Neogene global cooling over the last ~20 My. Instead, we surmise that chemical weathering of tropical arcs may have been more important, or that other mechanisms such as enhanced carbon burial and/or reduced mantle degassing drove Cenozoic global cooling.

Dominance of tectonics over climate in sediment accretion at the Himalayan orogenic front

SambitGhosh

Institute of Arctic Biology, University of Alaska Fairbanks, Alaska 99775, USA

Melinda Kumar Bera (Department of Geology and Geophysics, Indian Institute of Technology Kharagpur, West Bengal, 721302, India), Biswajit Roy (Department of Earth Sciences, Indian Institute of Science Education and Research Kolkata, West Bengal, 741246, India), Srinivasan Balakrishnan (Department of Earth Sciences, Pondicherry University, Pondicherry 605014, India), Prasanta Sanyal (Department of Earth Sciences, Indian Institute of Science Education and Research Kolkata, West Bengal, 741246, India)

The topographic evolution of an actively deforming mountain range is governed by the balance between mass accreted through tectonically induced rock uplift and its removal by the climate-driven change in the erosion rate, which varies spatially as well as temporally. Despite a large amount of thermochronological data have been obtained from the Higher and Lesser Himalayan sequences to understand the mutual interactions among tectonics, climate, and exhumations in terms of elevation gain of the orogen, consensus on the relative influences of tectonics and climate on the widening of the orogen is still lacking. The present study, therefore, tried to understand how an orogen widens in response to tectonics and climatic forces by studying the actively accreting marginal foreland sedimentary sequences. Combined sedimentology and sequence stratigraphic analyses, carried out in >4000 m logged sections of the Siwalik Group of NW Himalaya, suggest that both spatially and temporally the foreland basin filling style alternates between high and low accommodation system tracts. The comparison of foreland sedimentary architecture and tectonic and climate proxy data implies that thrusting induced flexural movement of the lithosphere controlled the sediment accumulation and its accretion to the Himalayan orogen margin, thereby increasing the width of the orogen, since the Middle Miocene.

South Asian C4 vegetation and rainfall – biomarker reconstructions from two megafans

Sarah J.Feakins

University of Southern California

A long-standing question has been whether hydrological change drove the expansion of C4 ecosystems during the Neogene. Drilling by the International Ocean Discovery Program has recovered sediments from the margins of the Indian Ocean, including the two largest submarine fans in the world, the Bengal Fan (Expedition 354) and Indus Fan (Expedition 355). These newly recovered sediment cores allow the regional expression of the late Miocene C4 expansion to be sampled, and to assess whether a coincident shift in precipitation occurred. Dual measurements of the carbon and hydrogen isotopic composition of plant debris, provide a powerful means to interrogate the connection between C4 plants and the isotopic composition of rainfall, in the same molecules. Dual C & H isotope analytical work has focused on to two types of plant debris: plant wax biomarkers present in sediments throughout the core and woody debris discovered in the coarse layers of turbidic deposits to gather this information. A raft of other proxies helps understand the larger depositional story. Multi-proxy contextual interpretation is vital to ascertain source-switching in marginal settings - to untangle regional reconstructions of climate, environment and ecological change.

SESSION SIX: Alfred Wegener session. India-Asia collision, Climate and Paleogeography

New constraints on the India-Kohistan/Ladakh-Eurasia collision and its influence on the global climate

OliverJagoutz

Massachusetts Institute of Technology (MIT)

Craig Martin (MIT), Josh Murray (MIT)

The India-Eurasia collision in the Cenozoic profoundly affected global climate and movements of major tectonic plates. Classically, mainly based on studies focusing on the central Himalayas, the collision was thought to be a single-stage process occurring ~50 Ma. However, in recent years it has been proposed that the India-Eurasia collision was a multistage, prolonged event involving multiple plates. The geology in the western Himalayas differs from the central Himalayas. In the west, the Indian plate is separated from Eurasia by the Kohistan Ladakh arc (KLA). This intra-oceanic island arc started in the Neotethyan ocean in the Late Jurassic. Constraining the collision timing between these three plate tectonic units is crucial to understanding the evolution of the broader India-Eurasia collision. In this talk, I will first review the current discussed collision models and present new field and paleomagnetic data from the KLA and the Eurasian margin (Karakoram) that constrain their paleo-latitude in the crucial time interval between 80 and 60 Ma and allow to constrain a possible collision model and the size of ‘greater’ India. Finally, I discuss how our proposed collision model could have affected the global climate.

Paleogeography of the Burma Terrane since the Late Cretaceous

PierrickRoperch

Geosciences Rennes, Université de Rennes1, France

Jan Westerweel (Géosciences Rennes), Guillaume Dupont-Nivet (Géosciences Rennes), Alexis Licht (Cerege), Nathan Cogne (Géosciences Rennes), Fernando Poblete (Universidad de Chile)

Recent paleomagnetic data from early Late Cretaceous and late Eocene rocks from Myanmar demonstrate that the Burma Terrane (BT) underwent an important northward translation alongside India in the Cenozoic. Paleomagnetic results from Paleocene to Eocene sediments confirm the slightly southern to equatorial paleolatitudes during the Paleocene to mid Eocene. Since the middle Eocene, the BT has been oriented mainly NS without major global clockwise rotation. These paleomagnetic results imply a new paleogeography not compatible with the typical view of the geology of Myanmar as an andean-type margin above an active subduction of the Tethys/India oceanic crust below Sundaland. Most previous models proposed an active subduction below Myanmar during the Paleogene but a slab anchored in the mantle would impede the large northward motion of the BT implied by our paleomagnetic data. The northward motion of the BT alongside India also implies that the dextral displacement of India relative to Sibumasu is accommodated mainly on the eastern side of the BT along a proto Sagaing fault rather than within the Indo-Burman ranges (IBR). While the dextral displacement along the Sagaing fault is well established by GPS data, the total displacement and especially its pre-Neogene history is still debated. The BT contains >10km thick Cenozoic Central Myanmar Basins (CMBs) recording the Cenozoic geological evolution of the BT. The Indo-Burman ranges contain also thick late Cretaceous to Eocene sediments that have been deeply buried and exhumed mainly during the Miocene. The Eocene sediments of the CMB, Indo-Burman Ranges in Myanmar as well as those of the Disang Fm in India west of the Naga Hills in the northernmost IBR share a similar source with a significant proportion of mid-Cretaceous to Eocene zircons. This observation supports the hypothesis that the BT and the IBR formed a single terrane, at least during the Cenozoic, tightly linked to India. The very large volume of Eocene CMB & IBR sediments and their provenance signature suggest orogenic material either sourced from Greater Burma now-subducted to the north or from an eventual connection with the Lhasa magmatic arc and the main India-Asia collision zone, with a smaller contribution of the Myanmar magmatic arc.

Reconstructing the Paleogeography of the Neotethys with Paleomagnetic Data

Craig R.Martin

Massachusetts Institute of Technology

Oliver Jagoutz (Massachusetts Institute of Technology)

Utilizing the Himalaya as a case-study to investigate the complex linkages between plate-tectonic processes and the wider hydrosphere, atmosphere and biosphere systems relies on a clear understanding of the paleogeographic development of southern Asian region through time. Unfortunately, progress in this effort has been hampered by conflicting conclusions drawn from paleomagnetic data relating to the latitudinal positions of India, Eurasia and an additional intra-oceanic subduction system in the Neotethys ocean prior to its closure. Recent work has yielded paleolatitudes for the southern edge of Eurasia in the Cretaceous – Eocene ranging between 5 – 25 °N, and estimates for the pre-collisional extent of the Indian continent ranging from <900 km to as much as 3600 km beyond its present-day extent. This spread in reported paleolatitudes partly reflects the well documented challenges inherent in interpreting the magnetic signals in natural rock samples including chemical and thermal overprints, strain-induced magnetic anisotropies, and the effects of inclination shallowing in sediments. However, a more often underappreciated challenge is the possibility of unidentified inclined-axis rotations capable of significantly skewing paleomagnetic results that are an enhanced risk in complex orogenic settings like the Himalaya fold and thrust belt. After filtering the Himalayan paleomagnetic record for these problems, a more consistent picture emerges. The southern margin of Eurasia was situated close to ~20 °N consistently throughout the closure of the Neotethys ocean and India extended no more than 900 – 1300 km beyond its present-day exposure. The first stage of India-Eurasia collision involved the obduction of a trans-Tethyan intra-oceanic subduction system onto the Indian margin at 60 – 50 Ma, followed by the closure of a major oceanic basin and then the initiation of India-Eurasia continental collision at 45 – 40 Ma. The presence of a major ocean basin between India and Eurasia until the Eocene likely affected global ocean circulation, and the drawdown of CO_2 due to the obduction and chemical weathering of mafic and ultramafic material at low latitudes during the Paleocene arc-continent collision explains global cooling throughout the Cenozoic.

Paleogene Paleogeography of the India-Asia collision reconstructed with Terra Antiqua

GuillaumeDupont-Nivet

CNRS

Guillaume Dupont-Nivet1, Diego Ruiz2, Jovid Aminov3, Thomas van der Linden4, Boris Gailleton1, Pierrick Roperch1, Fernando Poblete5, Niels Meijer6, Mustafa Kaya7, Alexis Licht8, Aude Gébelin8, Xiaomin Fang9, Douwe van Hinsbergen4

Paleogeographic reconstructions are the most effective media to integrate and display Earth and Environmental data and their interpretations. They enable to show in simple evolving maps, the overwhelming mass of information stemming from the ongoing surge of paleoenvironmental data and models of Earth System sciences. Scientists working on environmental changes use them as boundary conditions for interpreting their own data and for numerical modelling to infer governing factors of global and regional climate, biotic evolution, surface processes and geochemical cycles. This particularly the case the intensely studied, yet still extremely controversial India-Asia collision with major implication on regional and global climate such as monsoons and the greenhouse to icehouse transition. Ongoing debates argue for radically different end-member models of the collision timing and its configuration, and of associated topographic growth in the collision zone. We present here new global paleogeographic reconstructions at 50 and 30 Ma that complement an existing set at 60, 40 and 20 Ma with updates. These integrate various end-members models of the India-Asia collision and associated topographic patterns and land-sea masks. They are provided online (https://map.paleoenvironment.eu/) in various model-relevant formats with associated database and discussion forums to comment on amelioration of these maps. We also present the latest developments of the user-friendly and open-source Terra Antiqua Q-GIS plugin (https://paleoenvironment.eu/terra-antiqua/) that has been used and specifically developed to making these maps, with new tools including the creation of physically realistic topographic patterns.

SESSION SEVEN: Alexander von Humboldt session. The interactions of Earth, Climate and Life

Understanding Monsoons and Biodiversity RElevant to Landscapes and Livelihoods in Asia (UMBRELLA)

Robert A.Spicer

1. Chinese Academy of Sciences 2.The Open University 3. Chinese Academy of Sciences

Although the exact timing of the onset of India-Eurasia continental collision is still debated, increasing evidence points to an early Paleogene contact, perhaps no later than 60 Ma, with profound consequential impacts on Asian atmospheric and oceanic circulation, flora and fauna. Multiproxy surface height measurements show that the area now forming the Tibetan Plateau already exhibited pronounced topographic relief before India accreted. The Gangdese highlands along the southern margin of Eurasia were separated from the roughly parallel Tanggula uplands by a wide lowland - the Central Tibetan valley. This mountain (>4 km high) and valley (lowland ~1.5 km) complex was the product of earlier Mesozoic terrane collisions. This Paleogene heterogenous relief acted as both a cradle and migration corridor for a rich biota, generating a range of environments related to aspect and altitude. We know this complex relief existed through advances in multiproxy paleoaltimetry, much based on new fossil records mediated by climate modelling, and an accurate and precise chronostratigraphic framework. This approach not only reveals a Paleogene Central Tibetan Valley complex, but also an Eocene transition from desert lowlands (~ 0.6 km) to vegetated uplands (> 3.5 km) in eastern Tibet, altered air flows across the region and the development of a uniquely Eocene monsoon system that delivered increased moisture across east Asia. This in turn led to increased plant biodiversity and the modernization of the biota such that by the Oligocene many of the taxa typical of the region today were in place. Asian Cenozoic monsoon systems evolved gradually from a Mesozoic ITCZ system as the landscape evolved along with secular cooling. The modern monsoon is exactly that - reflective of conditions today. There is no point in the Cenozoic when the modern system suddenly appeared. Interpreting simple geological proxies, typically wet/dry precipitation seasonality is inadequate for tracking of subtle changes in air flows and rainfall seasonality that define monsoon dynamics. This overview summarises recent work of the UK/China UMBRELLA project exploring complex links between Cenozoic landscape evolution of the Tibetan region and Asian monsoons combining geological proxies and modelling.

Solving the cold pole problem and its role in Asian climate dynamics

PaulValdes

University of Bristol

Alex Farnsworth (University of Bristol), R.A. Spicer (Open University), Su Tau (CAS, Xishuangbanna Tropical Botanical Gardens), Shufeng Li (CAS, Xishuangbanna Tropical Botanical Gardens)

Computer climate models have been extensively used to investigate the interaction between Tibetan uplift history and monsoon climates yet until recently all of these models had a severe limitation. Paleoclimatic data shows that most of the Cenozoic had high latitude climates significantly warmer than present, but all climate models have struggled to represent the magnitude of the warming. Errors for the early Eocene could be 20C or larger. This potentially has consequences for the ability of climate models to simulate past monsoons. The strength of the monsoon partly depends on the temperature gradient between the Indian ocean and Eurasian continent and hence errors in the simulation of Eurasian temperature may impact the Asian monsoon. Recently, we have developed a new climate model which significantly improves upon the model-data mismatch. The main changes are associated with clouds which have typically been poorly represented in climate models. The talk will show how the revised model impacts on the simulation of the Asian summer monsoon, and the associated changes in vegetation and biodiversity. Although the first-order response is similar, there are important differences between the old and newly improved models.

The rise of the Himalaya using a high-resolution paleoclimate model

AlexFarnsworth

University of Bristol

Paul Valdes (University of Bristol), Robert Spicer (Open University), Lui Jia (Xishuangbanna Tropical Botanical Garden Institute), Leyi Li (Institute of Loess and Quaternary Geology), Su Tao (Xishuangbanna Tropical Botanical Garden Institute), Shufeng Li (Xishuangbanna Tropical Botanical Garden Institute), Ding Lin (Institute of Tibetan Plateau Research)

The Himalaya are the highest real-estate on Earth today stretching nearly 3000 km along the vast swathes of central Asia borders with around 100 peaks exceeding 7.2km. Its formation began around 60 million years ago with the docking of the Indian sub-continent with Eurasia. By the mid-Eocene most of the Himalaya was at or above sea-level. The Himalaya would subsequently go through different rates of rapid uplift to such that by the mid-Miocene the Himalaya began to exceed the then highest peaks of the adjacent Gangdese mountains and eventually rise above above them to their current heights in the Pliocene. The climate impacts of the rise of the Himalaya have been extensively theorised. However, uncertainties in available data have rendered a comprehensive regional and global assessment on the environment (e.g. monsoons, atmospheric dynamics, biodiversity) problematic. Although paleoclimate models have the potential to simulate the large-scale impact, low resolution (~ 250km grid) and complexity constraints in resolving the Himalaya have further complicated the overall picture. Here, we investigate a new configuration of the Hadley centre paleoclimate model that now resolves the 'cold pole' bias inherent in most models within a new high-resolution framework (~60km grid) that better resolves Himalayan elevation and complexity to simulate the impact of the rise of the Himalaya through the Miocene-Pliocene on the Asian environment.

Simulating the Asian vegetation cover evolution from the late Eocene to the late Miocene induced by paleogeography and climate change

DelphineTardif

(Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, 91191 Gif-sur-Yvette, France)(IRD, DIADE, University of Montpellier, Montpellier, France)

Pierre Sepulchre (Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, 91191 Gif-sur-Yvette, France), Fabien L. Condamine (CNRS, UMR 5554 Institut des Sciences de l'Evolution de Montpellier, Place Eugène Bataillon, 34095 Montpellier, France), Thomas L.P. Couvreur (IRD, DIADE, University of Montpellier, Montpellier, France), Anta-C. Sarr (Aix Marseille Université, CNRS, IRD, INRAE, CEREGE, Aix-en-Provence, France)

Paleogeographic change is a major driver of climate change on multi-million-years time scales. In response to these changes, vegetation can show drastic variations. In Asia, the fossil record – although fragmentary in some regions- shows that the uplift of major landforms in the course of the Cenozoic, coeval with the development of monsoonal climate and inland aridification, lead to the spreading of steppe and monsoon-adapted biomes. Additionally, phylogenies have shown the important role played by abiotic factors on tropical species diversification and on the establishment of modern diversity patterns. In this respect Earth system models including land surface models with dynamical vegetation are promising tools to constrain these influences. Here we take advantage of multiple paleoclimate simulations from the IPSLCM5A2 earth system model and ORCHIDEE land surface models, including the state of the art of current knowledge on the evolution of paleogeography, from the late Eocene to the late Miocene. As the geologic history of some major Asian landforms is still debated, alternative paleogeographic configurations are tested, to clarify the role played by a given region on climate. We explore the impact of different incipient Tibetan Plateau configurations in the Eocene, as well as the orographic evolution of eastern Africa, Iran and Mongolia in the Miocene. We compare the simulated vegetation cover with available data and discuss it within the scope of global Asian biosphere evolution throughout the Cenozoic. Finally, we explore means of using temperature and precipitation values extracted from these simulations, in order to constrain birth-death diversification models. Indeed, although the use of regionally-averaged abiotic parameters seem a potentially considerable step-forward from current methods based on global climate indicators, this methodology presents some technical challenges and uncertainties that need to be tackled.

Modelling the co-evolution of life, climate, and landforms

EstebanAcevedo-Trejos

Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences

Jean Braun (Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences)

The interplay of ecology, tectonics, landscape evolution and climate is known to impact the evolution of life and the patterns of biodiversity we observe on Earth's surface such as, for example, the distribution of present-day biodiversity across elevation or latitude. Many plausible explanations have emerged to explain such biodiversity patterns, but there is little agreement on their causal determinants. Numerical models are an ideal tool to investigate the plausibility of the proposed causal links, in particular, those that couple speciation and landscape evolution. In our contribution, we will describe such a tool that we recently developed to explore the causal links between biodiversity and environmental variation through space and time. Our mode for adaptive speciation is based on the adaptive dynamics of traits that can potentially mediate ecological competition for resources, and includes dispersal and mutation processes. The speciation model is coupled to a landscape evolution model (FastScape) that predicts topographic relief based on the stream power law for river incision and hillslope diffusion and considers the effects of orographic precipitation on both erosion rate and the biota. We will also illustrate the behavior of the coupled model using an example to demonstrate how tectonics, climate and ecology have the potential to co-evolve to produce distinct patterns of biodiversity and its evolution on geological time scales.

Sedimentary response to the hyperthermal Permian-Triassic mass extinction and Palaeocene-Eocene Thermal Maximum on land

ZhicaiZhu

a Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China; b School of Earth Sciences, University of Bristol, Bristol, BS8 1RJ, UK

Yongqing Liu (Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China); Hongwei Kuang (Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China); Andrew J. Newell (British Geological Survey, Maclean Building, Wallingford OX10 8BB, UK); Michael J. Benton (School of Earth Sciences, University of Bristol, Bristol, BS8 1RJ, UK)

The palaeoenvironmental perturbations related to two well studied hyperthermal events of different magnitude, the Permian-Triassic mass extinction (PTME, ~252 Ma; 90–95% species loss) and the Palaeocene–Eocene Thermal Maximum (PETM, ~56 Ma; 5–10% species loss), are still debatable even though massive volcanism is commonly accepted as the prime culprit. Concomitant with sharp carbon dioxide injection into the atmosphere, the climate heated rapidly by 15°C and 5°C in low-latitude areas across the PTME and PETM, respectively. Severe biotic loss/turnover and drastic environmental changes are identified worldwide, both on land and in the oceans. Previous investigations have focused on the response and impact in the ocean, but less is known about the consequences on land, which is the subject of this study. Intriguingly, independent studies are beginning to identify common features of the two events, including similar basin-wide fluvial pattern changes from meandering to braided river systems, with extreme climate crises (e.g. mass wasting and wildfire). Terrestrial sedimentary records show significantly protracted transmission of catchment responses to distant depositional systems as a feature of large-scale basin stratigraphy. They are tightly connected with palaeoclimate conditions and palaeoecosystems. The sedimentary response under a regime of warming, aridity and intermittent heavy precipitation on land may not only accumulate or amplify the signals of abnormalities and consequences in shallow marine settings, but also connect the land and ocean. Similar scenarios are also detected in other deep-time hyperthermal events. Therefore, exploring the similar sedimentary responses and associated climatic perturbations across these two hyperthermal events may test the idea that there is a 'hyperthermal blueprint' or common pattern of such events, but at different magnitudes, that could inform our understanding of the current, Anthropocene climate crisis.

Impact of Mountains in Southeast China on the Eocene climates of East Asia

ZijianZhang

Institute of Geology and Geophysics, Chinese Academy of Sciences

Zhongshi Zhang (China University of Geosciences)

Several previous proxy reconstructions suggested an arid zonal band in mid-latitude China, but others showed a humid climate in the same region. Moreover, previous climate models can simulate both scenarios in China under Eocene conditions. The cause of this model spread is still unclear. We conducted a series of experiments using NorESM1-F and examined the impact of two mountains in southern China (Gangdese and Southeast Mountains) on the simulated Eocene climate. Our results reveal that the Southeast Mountains play the dominant role in controlling the simulated precipitation in Eastern China during the Eocene and mainly contribute to the previous model spread.

Rapid Eocene diversification of spiny plants in subtropical woodlands of central Tibet

XinwenZhang

Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences

Uriel Gélin (Chinese Academy of Sciences); Robert A. Spicer (The Open University; Chinese Academy of Sciences); Feixiang Wu (Chinese Academy of Sciences); Alexander Farnsworth (University of Bristol; Chinese Academy of Sciences); Peirong Chen (Chinese Academy of Sciences); Cédric Del Rio (MNHN - Sorbonne Université - CNRS); Shufeng Li (Chinese Academy of Sciences); Jia Liu (Chinese Academy of Sciences); Jian Huang (Chinese Academy of Sciences); Teresa E. Spicer Chinese Academy of Sciences); Kyle W. Tomilinson (Chinese Academy of Sciences); Paul J. Valdes (University of Bristol); Xiaoting Xu (Chinese Academy of Sciences); Shitao Zhang (Kunming University of Science and Technology); Tao Deng (Chinese Academy of Sciences); Zhekun Zhou (Chinese Academy of Sciences); Tao Su (Chinese Academy of Sciences).

Spinescence is an important functional trait possessed by many plant species for physical defence against mammalian herbivores. The development of spinescence must have been closely associated with both biotic and abiotic factors in the geological past, but knowledge of spinescence evolution suffers from a dearth of fossil records, with most studies focusing on spatial patterns and spinescence-herbivore interactions in modern ecosystems. Numerous well-preserved Eocene (~39 Ma) plant fossils exhibiting seven different spine morphologies discovered recently in the central Tibetan Plateau, combined with molecular phylogenetic character reconstruction, point not only to the presence of a diversity of spiny plants in Eocene central Tibet but a rapid diversification of spiny plants in Eurasia around that time. These spiny plants occupied an open woodland landscape, indicated by numerous megafossils and grass phytoliths found in the same deposits, as well as numerical climate and vegetation modelling. Our study shows that regional aridification and expansion of herbivorous mammals may have driven the diversification of functional spinescence in central Tibetan woodlands, ~24 million years earlier than similar transformations in Africa.

Species diversity of the late Eocene Xiongmei flora in Lunpola Basin, central Tibetan Plateau

Wei-ChengLi

CAS Key Laboratory of Tropical Forest Ecology, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Mengla 666303, China

Jian Huang (a), Jia Liu (a), Zhe-Kun Zhou (a, b), Tao Su (a, b, c) a) Chinese Academy of Sciences, b) Chinese Academy of Sciences*

Recent paleobotanical investigation sheds new light on our understanding for the plant diversity history of the Tibetan Plateau. Here, we report a new late Eocene flora from Xiongmei, Lumpola Basin, central Tibetan Plateau. 269 fossil specimens in forms of leaf, flower, and fruit were collected from the same layer of the Upper Eocene (~35 Ma) Niubao Formation in the Lunpola Basin, central Tibetan Plateau, China. Through detailed morphological study, 60 plant fossil taxa including 13 genera and 19 families were classified, including Cannabaceae, Fabaceae, Ulmaceae, Arecaceae, Anacardiaceae, Rhamnaceae, Araceae, etc. Among them, Cannabaceae is one of the earliest fossil records around the world to our knowledge, and Podocarpium is the first fossil record of this genus in central plateau. Plant composition analysis showed that Jianglang (~47 Ma), Dayu (~39 Ma), and Xiongmei floras in the Lunpola Basin share similar floristic characteristics, some genera were discovered in all these floras, e.g., Koelreuteria, Limnobiophyllum, and Cedrelospermum. However, there are some genera disappeared in Xiongmei flora, e.g., Lagokarpo, IlligeraI, and Ventilago. Therefore, the Xiongmei flora evidences the development of the plant diversity in central Tibet Plateau, which correlated to the paleoenvironmental changes on the plateau. Keywords: Late Eocene; Xionogmei Flora; Paleobotany; Lunpola Basin; Biodiversity

A modeling study of the tripole pattern of East China precipitation over the past 425 ka

DaiGaowen

China University of Geosciences

Zhongshi Zhang (China University of Geosciences); Odd Helge Otterå, Petra M. Langebroek (NORCE Norwegian Research Centre); Qing Yan, Ran Zhang (Institute of Atmospheric Physics, Chinese Academy of Sciences)

The traditional palaeoclimatological view suggests that monsoonal China was overall wetter when the East Asian summer monsoon (EASM) was strong. However, this view is at odds with the understanding of modern climate, which demonstrates an analogous "tripole precipitation pattern" in monsoonal China. Little is known about the spatial pattern of paleo-precipitation in monsoonal China, particularly during the past glacial-interglacial cycles. Here, we provide evidence for a potential tripole precipitation pattern in monsoonal China over the past 425 ka using climate modeling, and compare the results with paleoclimate records available from China. Our simulations illustrate that more (less) precipitation in North China and South China, and less (more) precipitation in the Central-East China during strong (weak) EASM periods associated with high (low) boreal summer insolation. Our results agree with the present understanding of modern East Asian climate, and furthermore confirm that the boreal summer insolation is the dominant forcing for the intensity of EASM and the response of subtropical high pressures is fundamental in modulating the precipitation pattern in monsoonal China on orbital timescales. This temporal and spatial variability of precipitation, as revealed in our simulations, shows the potential high complexities in hydroclimatic conditions in monsoonal China throughout the past glacial-interglacial cycles. Nevertheless, whether the tripole precipitation pattern in monsoonal China over the past 425 ka is robust enough still should be tested, preferable by taking advantage of existing and new well-dated and explicit indicative precipitation archives in Central-East China.

Day 3 AM: Afternoon visit of the Natural History Museum

GSL CODE OF CONDUCT FOR MEETINGS AND OTHER EVENTS

INTRODUCTION

The Geological Society of London is a professional and learned society, which, through its members, has a duty in the public interest to provide a safe, productive and welcoming environment for all participants and attendees of our meetings, workshops, and events regardless of age, gender, sexual orientation, gender identity, race, ethnicity, religion, disability, physical appearance, or career level.

This Code of Conduct applies to all participants in Society related activities, including, but not limited to, attendees, speakers, volunteers, exhibitors, representatives to outside bodies, and applies in all GSL activities, including ancillary meetings, events and social gatherings.

It also applies to members of the Society attending externally organised events, wherever the venue or online platform (virtual event).

BEHAVIOUR

The Society values participation by all attendees at its events and wants to ensure that your experience is as constructive and professionally stimulating as possible. Whilst the debate of scientific ideas is encouraged, participants are expected to behave in a respectful and professional manner - harassment and, or, sexist, racist, or exclusionary comments or jokes are not appropriate and will not be tolerated.

Harassment includes sustained disruption of talks or other events, inappropriate physical contact, sexual attention or innuendo, deliberate intimidation, stalking, and intrusive photography or recording of an individual without consent. It also includes discrimination or offensive comments related to age, gender identity, sexual orientation, disability, physical appearance, language, citizenship, ethnic origin, race or religion.

The Geological Society expects and requires all participants to abide by and uphold the principles of this Code of Conduct and transgressions or violations will not be tolerated.

BREACH OF THE CODE OF CONDUCT

The Society considers it unprofessional, unethical and totally unacceptable to engage in or condone any kind of discrimination or harassment, or to disregard complaints of harassment from colleagues or staff.

If an incident of proscribed conduct occurs either within or outside the Society's premises during an event, then the aggrieved person or witness to the proscribed conduct is encouraged to report it promptly to a member of staff or the event's principal organiser. Once the Society is notified, staff or a senior organiser of the meeting will discuss the details first with the individual making the complaint, then any witnesses who have been identified, and then the alleged offender, before determining an appropriate course of action. Confidentiality will be maintained to the extent that it does not compromise the rights of others. The Society will cooperate fully with any criminal or civil investigation arising from incidents that occur during Society events.