Himalayan erosion and climate

CHRISTIAN FRANCE-LANORD
CRPG-CNRS, Univ.Lorraine, BP 20, Vandoeuvre-France cfl@crpg.cnrs-nancy.fr

In Himalaya, the monsoon precipitations exert a primary control on the erosion. From its intensity depends on the extension of the glacier cover, landslide activity, river incision and export of sediments towards the floodplain and oceanic basins. The monsoon also exerts a primary control on the chemical erosion as weathering rates are clearly dependent upon river discharge.

In the floodplain, sediment export also is tightly controlled by climate. The seasonality of the monsoon allows to reach high flooding conditions generating efficient river transport to the delta (Lupker et al. 2011). This efficient transport also acts as a limiting factor for weathering as it reduces residence time in the floodplain. The comparison between the Ganga with a large floodplain and the Brahmaputra with a narrow floodplain and comparatively lower residence time confirm that Himalayan weathering is limited by transport.

When looking at sedimentary record of erosion in the proximal Bengal fan, weathering as traced by K/Al or OH/Al however appears lower during the LGM in spite of reduced discharge i.e. slower transport (Lupker et al. 2013). Reduced weathering intensity is, however, consistent with lower precipitation and temperature in the basin.

Recent IODP Expedition 354 in the Bengal fan generated a comprehensive record of Himalayan erosion over the Neogene and Quaternary. Turbiditic sediments have clear Himalayan origin and close mineralogical and isotopic analogy with those of the modern Ganga-Brahmaputra river sediments. This long-term record also reveals that the chemical compositions of turbiditic sediments cored across the transect are relatively stable throughout the Neogene and also during Quaternary. Over the last 25 Ma it appears that weathering was weak, and lower than during modern conditions. This long-term record suggests that the Himalayan erosion has been controlled by rapid physical erosion, with transport processes efficient enough to prevent weathering of the sediment load.

Lupker (2011) JGR 116(F4), F04012.
Initiation and intensification of Indian Summer Monsoon inferred from stable isotopes and trace element geochemistry

Barniita Banerjee*, Syed Masood Ahmad, E. Y. S. S. K. Babu

1 CSIR- National Geophysical Research Institute
2barniita.geology@gmail.com

The Miocene epoch marks the most salient interval in the Cenozoic era, characterized by several major climatic events. An important aspect of Miocene epoch is related to the initiation and intensification of Indian summer monsoon (ISM), believed to have occurred during Miocene. While most researchers agree that the Asian monsoon systems intensified at around 8 Ma [1,2,3], however this view has been contested by few researchers [4,5], who suggested that the intensification occurred during the early Miocene and the late Eocene [6]. Therefore, in order to better understand the timing of ISM initiation and intensification we focused our attention to reconstruct the paleoceanography of the Northeast Indian Ocean through stable carbon and oxygen isotopic ratios of foraminifera and geochemistry of marine sediments. The δ18O and δ13C values on Globigerinoides quadrilobatus (planktonic) and Cibicidoides wuellerstorfi (benthic foraminifera) indicates initiation of ISM at 12 Ma and its intensification at 10 Ma. We have correlated our stable isotopic data with trace element geochemistry of marine sediments. The Ba data shows increased productivity at ~ 12 Ma which bloomed at 10 Ma to give rise to nearly suboxic condition at ~ 10 Ma leading to dissolution of planktonic foraminifera. The Ba geochemistry is supported by Δδ13C27Al for an increased productivity event at 12 Ma and productivity bloom at 10 Ma. The moderately high U/Th ratio at ~ 10.2 Ma also points at near suboxic condition in the study area. Elemental ratios Rb/Al and K/Al also increases at ~ 12 Ma indicating higher concentration of feldspar and illite [7,8]. High concentration of feldspar and illite from ~ 12-8 Ma could be possibly due to intense mechanical weathering [9,10]. Increase in physical erosion is often linked with stronger summer monsoon [11]. Hence our isotopic and trace elemental record from ODP 758 suggests initiation of ISM at 12 Ma and its intensification at 10 Ma.

References


Persistent South Asian Monsoon induced erosion over the past 26 million years

SAJID ALI1,2,3, ED HATHORNE1, MARTIN FRANK1

1GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany (sajid@prl.res.in)
2Physical Research Laboratory Ahmedabad, India
3Birbal Sahni Institute of Palaeosciences Lucknow, India

On geological timescales, CO\textsubscript{2} is removed from the ocean-atmosphere system by silicate weathering and the burial of organic carbon. Increases of both have been attributed to Himalaya-Tibetan Plateau uplift and changes in the monsoon’s erosive power [1,2] with some studies suggesting that uplift initiated the monsoon [3] while others linking tectonics with monsoon controlled exhumation [4]. The timing of Asian monsoon development is, however, still poorly constrained and recent estimates range from the early Miocene (~22 million years (Myrs) ago) [5] to the Eocene (~39 Myrs ago) [6]. Detailed long-term records of South Asian monsoon induced erosion (reflecting its strength) and potential changes related to past warmer climates are lacking. Here we use the Sr, Nd, and Pb isotope compositions of clay minerals transported to the central Bay of Bengal (ODP Site 758) to show that the general spatial pattern of regional erosion, which today is strongest at the location of most intense monsoon rains, persisted throughout the last 26 Myrs. Two periods of stronger monsoon erosion and physical weathering occurred around 20 and 10 Myrs ago. This led to enhanced sediment deposition on the Bengal fan and potentially reduced atmospheric CO\textsubscript{2} thus contributing to global cooling.

Carbonate content of the turbidite in the Bengal Fan: a neogene record of the monsoon’s strength?

A. Galy 1*, C. France-Lanord 1, V. Galy 2, T. Rigaudi 1

1 Université de Lorraine, Centre de Recherche Pétrographiques et Géochimiques (CRPG), Nancy, France (*correspondence: agaly@crpg.cnrs-nancy.fr)
2 Woods Hole Oceanographic Institution Woods Hole, MA USA

Because they correspond to an easily soluble lithology, carbonate weathering is very sensitive to climate change. The IODP Expedition 354 drilled the middle Bengal fan at 8°N and generated a record of Himalayan erosion going back to Late Oligocene. Based on isotopic fingerprint of the silicate fraction, turbiditic sediments have clear Himalayan origin. This record also revealed that the nature of the eroded formation remained remarkably constant throughout the Neogene, in agreement with the previous finding at the distal part of the fan cored by ODP Leg 116. The turbidites’ chemical composition showed virtually no differences with the modern Himalayan river sediments, with no significant variation through time. On the other hand, the shallower water depth at 8°N allowed the studying of carbonate content. Carbonate is persistent through the Neogene and appears to show a maximum of 8%–10% during the Middle Miocene. Stable (δ13C & δ18O) and radiogenic isotopic compositions (87Sr/86Sr) are quite variable and likely the result of a mixture of marine biogenic carbonate and terrestrial detrital carbonate. Unscrambling of the carbonate origin will be performed in order to confirm that the Middle Miocene corresponds to the lowest carbonate dissolution in Himalaya. If this is the case, that period should be characterized by a weaker monsoon.
First evidence of denitrification vis-à-vis monsoon in the Arabian Sea during the last 10 million years

M. TIWARI1*, S. TRIPATHI1, J. LEE2 AND B-K. KIM2

1 National Centre for Antarctic and Ocean Research, Vasco-da-Gama, 403804, Goa, India (*correspondence: manish@ncaor.gov.in) (shubham@ncaor.gov.in)
2 Department of Oceanography, Pusan National University, Busan, 46241, Korea (jimphy123@hanmail.net, bkkhim@pusan.ac.kr)

The new results based on the samples retrieved during the International Ocean Discovery Program (IODP) Expedition 355 yield the first record of denitrification vis-à-vis South Asian Monsoon intensity since Late Miocene (the past 10 million years) in the Eastern Arabian Sea [1]. In the Arabian Sea, South Asian monsoon-induced high surface water productivity coupled with poor ventilation of intermediate water results in strong denitrification within the oxygen minimum zone (OMZ). Denitrification results in N$_2$O production, which is a greenhouse gas that is ~300 times more powerful than CO$_2$. The balance between nitrogen fixation and its release through N$_2$ production is key to carbon assimilation by primary production and CO$_2$ regulation from the atmosphere. Despite the significance of denitrification, no long-term record of its evolution spanning the past several million years existed till now in the Eastern Arabian Sea. This study shows that the South Asian Monsoon was persistently weak from ~10.2 to 3.1 million years ago; it did not intensify at ~8 million years ago in contrast to the previous hypothesis. During the last 10 million years, the first evidence of denitrification and South Asian Monsoon intensification was at ~3.2–2.8 million years ago that coincided with the Mid-Pliocene Warm Period (MPWP), which was a period of global warmth with CO$_2$ levels (400 ppmv) similar to the present. Thereafter, the South Asian Monsoon declined for the next ~1.8 million years concurrent with the Northern Hemisphere Glaciation. The modern strength of the South Asian Monsoon and the OMZ where denitrification is a permanent feature in the Arabian Sea was attained at ~1.0 million years ago.

Mio-Pliocene Variations of the Indian monsoon recorded in the Bengal Fan (IODP Exp354)

Valier Galy1, Sarah Feakins2, Camilo Ponton3, Albert Galy4, Christian France-Lanord4

1 Woods Hole Oceanographic Institution, Woods Hole, MA, USA (vgaly@whoi.edu)
2 University of Southern California, Los Angeles, CA, USA (feakins@usc.edu)
3 California Institute of Technology, Pasadena, CA, USA (camilo.ponton@gmail.com)
4 CRPG, Université de Lorraine, Nancy, France (agaly@crpg.cnrs-nancy.fr; cfl@crpg.cnrs-nancy.fr)

We present a multi-proxy study of the marine sediments of the Bengal Fan recovered during IODP expedition 354. In turbiditic sediments of Himalayan origin, the late Miocene C4 expansion was found in all three long records recovered during expedition 354 based on stable carbon isotope composition of bulk organic carbon and terrestrial leaf-wax compounds. Cores from site U1455 provide the highest resolution record of the C4 transition, which appears to occur abruptly within a relatively continuous series of turbiditic sequences. The hydrogen isotopic composition of the same leaf-wax compounds reveals a surprisingly small (on the order of 10 ‰) isotopic shift associated with the late Miocene C4 expansion. In contrast, the hydrogen isotope composition shift observed across the last deglaciation is far greater (ca. 40‰; Hein et al., submitted). Cores from site U1451, provide a low resolution record across at least the last 26 Myr and appear to indicate a long term hydrological change from ca. 11Ma to ca. 7Ma, as inferred from progressive D enrichment in the biomarker records. These compound specific hydrogen isotope data will be discussed in the context of changing erosion patterns and attendant variations in the strength of the Indian summer monsoon as well as with respect to the mechanisms that led to the C4 expansion.
Complex astronomical forcing of South Asian monsoon precipitation over the past ~1 million years

D. GEBREGIORGIS1, E.C. HATHORNE1, L. GIOSAN2, S. CLEMENS3, D. NÜRNBERG1, AND M. FRANK1

1GEOMAR Helmholtz Center for Ocean Research Kiel, Wischhofstrasse 1-3, Kiel 24148, Germany,
2Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA.
3Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI, USA.

The South Asian monsoon (SAM) precipitation is vitally important for billions of people yet its controlling mechanisms are still poorly understood. Absolutely dated speleothem records from China [1] record a mixed signal of the amount of precipitation and moisture sources [2] while records of monsoon wind induced upwelling in the Arabian Sea may not be directly related to monsoon rainfall [3]. The core convective region of the SAM is over the Bay of Bengal and Andaman Sea but no records covering many of Earth’s orbital cycles exist for this region. Here we reconstruct Andaman Sea surface seawater temperature and oxygen isotope compositions over the past one million years with measurements of planktic foraminifera. Our new record reveals that SAM precipitation was weakest during all glacial maxima and strong during the interglacials of the last million years. Superimposed on this were higher frequency variations and in the precession band SAM precipitation peaked ~9 kyrs after the Northern Hemisphere insolation maximum, in phase with changes in the Arabian Sea. Nonetheless, the precession band accounts for only a small component (~30%) of the total variance of SAM precipitation and thus cannot be considered the primary driving force. We show that obliquity forcing has played a much larger role and is triggered by Southern hemisphere warming and cross hemisphere moisture transport rather than Northern Hemisphere insolation. This is the first direct evidence that precipitation in the South and East Asian monsoon subsystems responded independently to changes in solar insolation.

Goldschmidt2017 Abstract

**Late Quaternary chronology of the Lower Bengal Fan (IODP Expedition 354) – paleoclimate implications**


¹University of Bonn, mike.weber@uni-bonn.de
²San Francisco State University, dekens@sfsu.edu
³Oregon State University, breilly@coas.oregonstate.edu
⁴University of Bremen, lantzsch@uni-bremen.de
⁵University of Washington, paselkin@uw.edu
⁶Presidency University Kolkata, sdas.geol@presiuniv.ac.in
⁷IODP Texas A&M University, trevor@ldeo.columbia.edu
⁸British Antarctic Survey, yasmars@bas.ac.uk
⁹University of Bremen, radhikari@marum.de
¹⁰Tohoku University, gyawali.b@dc.tohoku.ac.jp
¹¹Chinese Academy of Sciences Guangzhou, jiagd@gig.ac.cn
¹²Natural History Museum London, lynedseaoy.fox@nhm.ac.uk
¹³Chinese Academy of Sciences Beijing, gejunyi@ivpp.ac.cn
¹⁴Birbal Sahni Institute of Palaeobotany, manoj.mcm@gmail.com
¹⁵Universidade Federal do Rio Grande do Sul, jairo.savian@ufrgs.br
¹⁶Université Paris, meynadier@ipgp.fr

IODP Expedition 354 drilled seven sites along an east west oriented core transect of 320 km length at 8°N in the lower Bengal Fan (France-Lanord et al., 2015). The sites were recovered to reconstruct the Himalayan uplift, the monsoonal development, and the turbiditic depositional mechanisms.

Here, we concentrate on the hemipelagic sequences that represent a several meter thick top layer of Late Quaternary age. We studied a number of physical, optical, geochemical, stable isotopic, and grain-size properties of the top layer in order to estimate sedimentary properties, and to assess the climate and monsoonal development of the region during the last glacial cycle.

Records of wet-bulk density as well as color reflectance b* and L* show a dominant precession cyclicity. Hence, we are able to provide an insolation-tuned chronology for the last 200 ka (MIS1–7). The records agree well with δ¹⁸O records from Chinese caves. An independent age model is derived from records of relative paleointensity. We compare both chronologies and evaluate their chronological and paleoclimatic implications. Grain-size measurements show in-phase variability with monsoonal strength. In addition, color endmember modeling reveals strong correlation of three color endmembers to monsoonal variability. We will also discuss elemental geochemistry, stable carbon and nitrogen isotopes, and potential sources of organic matter.
Indian Summer Monsoon dynamics during the penultimate deglaciation revealed using multi-proxy records from the northern Bay of Bengal

KERR, K1*, ANAND, P1, LENG, M. J.2, SEXTON, P. F1 AND CLEMENS, S. C3

1School of Environment, Earth and Ecosystem Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, (*correspondence: katrina.kerr@open.ac.uk)
2NERC Isotope Geoscience Facilities, British Geological Survey, Nottingham, NG12 5GG
3Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI, USA

Understanding the sequences of events and interplay between oceanic-atmospheric teleconnections operating during the glacial to interglacial transition is vital in order to constrain the mechanisms that drive major transitions in Earth’s background climate state. The Indian Monsoon, a subsystem of the Asian Monsoon, represents one of Earth’s most dynamic interactions of oceanic-atmospheric-land processes and it is thus essential to understand the role of the monsoon in propagating rapid climate changes across these transitions. Our understanding of the palaeoclimate of the Indian Summer Monsoon (ISM) has been shaped primarily by indirect inference from wind-driven upwelling proxy records from the Arabian Sea. However, a comprehensive understanding of the ISM has been hindered by spatial and temporal gaps in records from the core monsoon regions with a known moisture source.

Here we present sub-millennial scale multi-proxy records from the core convective region of the ISM, the northern Bay of Bengal (IODP Exp. 353, site U1446), capturing variation in precipitation and river runoff sourced exclusively from the ISM across the penultimate deglaciation (~135 ka) and the subsequent warmth of the last interglacial. Bulk sediment elemental composition and the oxygen isotope ratios of surface dwelling *Globigerinoides ruber* (sensu-stricto) are utilised to reconstruct variability in the strength of terrigenous input and river runoff induced by the ISM. We will show the response of the ISM to internal and external climatic forcing during the penultimate deglaciation. Furthermore, comparing our new records with published records provides new constraints on the degree of coupling between the East Asian Monsoon and the ISM.
Evidences of global climatic events for last two millennia and their forcing factors from active mudflats of Western India

Upasana S. Banerji*, Ravi Bhushan¹ and A.J.T. Jull²

¹Geosciences Division, Physical Research Laboratory, Ahmedabad-380 009, Gujarat
²NSF Arizona AMS Laboratory, University of Arizona, Tucson, AZ 85721, USA

Documenting climate for the last two millennia is essential to evaluate anthropogenic influence and future projection of climate trends but there exists ambiguity in amplitude, synchronicity and spatial extent of last two millennia climatic events. Solar Insolation and Volcanic eruption are the two major forcing factors which essentially controlled the climate and monsoon system of last two millennia. The Indian monsoon system is significantly constrained by the migration of Intertropical Convergence Zone (ITCZ). The paucity of climate records from the Indian subcontinent for last two millennia is a major impediment which reinvigorated us to study the climate and the forcing factors for a region significantly influenced by Indian Summer Monsoon (ISM).

The multiproxy approach on a sediment core raised from the active mudflat of western India suggested warm and humid conditions with enhanced ISM during 2000–950 cal yr BP (Roman Warm Period and Medieval Warm Period) interrupted by Dark Ages of Cold Period during ~1500 cal yr BP. Later, southward shift in the ITCZ triggered by volcanic activity enhanced western disturbances with improved winter precipitation resulting in cool and humid climate between 500–200 cal yr BP (Little Ice Age). Following this, a warm climate persisted since last 200 cal yr BP (Modern Warming period), period well known for both natural and human induced Climate Change.

The present study suggest that volcanic activity played a significant role in controlling the millennia scale climate variability with additional feedback mechanisms. Global climatic events of last two millennia observed in European sub-continent is also documented from the tropical region of India.
Variations in Indo-China Hydroclimate over the last two millennia

JESSICA K. WANG¹, KATHLEEN R. JOHNSON², MICHAEL L. GRIFFITHS³, GIDEON M. HENDERSON⁴

¹Department of Earth System Science, University of California, Irvine, 92697-3100, USA, kkwang1@uci.edu
²Department of Earth System Science, University of California, Irvine, 92697-3100, USA, kathleen.johnson@uci.edu
³Department of Environmental Science, William Paterson University, Wayne, New Jersey, 07470, USA, griffithsm@wpunj.edu
⁴Department of Earth Sciences, Oxford University, South Parks Road, Oxford OX1 3AN, UK, gideon.henderson@earth.ox.ac.uk

The Southeast Asian Monsoon (SEAM), a sub-component of the Asian Monsoon (AM) system, dominates the hydroclimate of mainland Southeast Asian and provides the rainfall necessary to sustain agriculture and food production for millions of people. Meridional migrations of the intertropical convergence zone (ITCZ) coupled with zonal shifts in the Pacific Walker Circulation (PWC) govern variations in hydroclimate across the AM region. However, the impacts of these internal climate variations on Indo-China hydroclimate remains poorly understood, partly due to the scarce paleoclimate records available from this region. Here, we present 2,000-year, high-resolution, absolute-dated stalagmite δ¹⁸O and δ¹³C records from Tham Mai cave in northern Laos, which document changes in monsoon strength and local hydrological conditions, respectively. The moderate correlation between our δ¹⁸O and δ¹³C records suggests a potential linkage between large-scale monsoon circulation and upstream rainout with locally wet (or dry) conditions. The two records share broadly similar patterns from 1200 CE to 1800 CE, which suggest that decreased monsoon intensity and subsequent decreased upstream rainfall correspond with drier conditions in northern Laos. A positive δ¹³C excursion, interpreted as reflecting dry conditions, at ~1300 CE coincides with the approximate transition from the Medieval Climate Anomaly (MCA; 950-1250 CE) into the Little Ice Age (LIA; 1400-1800 CE). Our records suggest multi-decadal drought conditions especially during the 14th and 15th centuries, which are consistent with Vietnamese tree-ring records and the timing of Late Medieval droughts in Cambodia. Our record, however, contradicts the relatively wet conditions in the South China Sea during the LIA revealed in grain sizes of lake sediment and ostracode shells from Dongdao Island.
Influence of particle-released Nd in the seawater $\varepsilon_{Nd}$ signal of the proximal Bay of Bengal during interglacial periods

V. Rojas$^{1*}$, L. Meynadier$^1$, C. Colin$^2$, Y. Zhaojie$^2$, R. Joussain$^{2,3}$, F. Bassinot$^4$, A. Cogez$^1$

$^1$IPGP, Sorbonne Paris-Cité, 1 rue Jussieu, 75005 Paris, France [*correspondence: rojas@ipgp.fr]
$^2$GEOPS, CNRS-Université de Paris-Sud, Bâtiment 504, 91405 Orsay, France
$^3$State Key Laboratory of Marine Geology, Tongji University, Shanghai, 200092, China
$^4$LSCE (CEA-CNRS-UVSQ), Domaine du CNRS, Bât. 12, Avenue de la Terrasse, F-91198 Gif-sur-Yvette, France

The factors controlling Nd isotopic variations in the oceans include changes in continental sources and water circulation, along with interactions between dissolved and particulate Nd in the water column [1]. We reconstructed the evolution of the $\varepsilon_{Nd}$ signal in the proximal Bay of Bengal, from glacial stage 6 to the Holocene, based on the analysis of core MD12-3411. The combined study of detrital and authigenic Nd helped us figure out the relative influence of continental vs. oceanic sources in controlling the seawater Nd composition of the bay. REE patterns and seawater $\varepsilon_{Nd}$ indicate important continental discharges in the northern Bay of Bengal, especially during interglacials. By contrast, far from the continental sources, in the equatorial Indian Ocean, seawater is able to acquire its typical REE signal. Comparison with modern water $\varepsilon_{Nd}$ values from the Bay of Bengal [2, 3] suggests that the carbonate fraction in the sediments recorded the bottom seawater composition. Reconstructed seawater $\varepsilon_{Nd}$ values can be explained by the contribution of NIDW and AABW, with an additional contribution from the release of Nd from the settling detrital particles. During glacial periods, the influence of particle-released Nd was reduced and the $\varepsilon_{Nd}$ values mainly reflected the Indian Ocean bottom water circulation.

Evolution of Indian Summer Monsoon dynamics over the Cenozoic: a multi-proxy record from the Bay of Bengal

ANAND, P., HARRIS, N.B.W., AND KEMP, S.J.

1School of Environment, Earth and Ecosystem Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, pallavi.anand@open.ac.uk
2British Geological Survey, Nottingham, NG12 5GG

The evolution of the Indian Summer and East Asian monsoons have been linked to Himalayan Tibetan uplift on tectonic time scales (Ma). A recent paleoflora study [1] has suggested that the uplift of the Himalaya above the Tibetan plateau around 20 Ma intensified the modern Indian Summer monsoon (ISM) by 15 Ma thereby confirming the importance of the orographic effect of the Himalaya indicated by climate models [2]. Oceanic studies of the ISM evolution provides conflicting evidence for the timing of the intensification of the ISM; the Bay of Bengal [3] record suggests 8 Ma and an extended Arabian Sea [4] record suggests 12 to 13 Ma, both periods tentatively linked to the tectonic evolution of the Tibetan plateau. These ISM records are predominantly based on the erosion proxies from the Bay of Bengal and wind-driven upwelling proxies in the Arabian Sea. In this study, we present additional data from the Andaman Sea to test the widely accepted view of initial strengthening of the ISM around 8 Ma or earlier. We will utilise semi-continuous sedimentary succession from the Andaman Sea (sites U1447 0 to 9.5 Ma and U1448 0 to 5 Ma; ~12 to 14 Ma) and the southern Bay of Bengal (site U1443 ~17 to 35 Ma) obtained through recent IODP drilling (expedition 353) to reconstruct ISM evolution.

We will present preliminary results of bulk elemental concentrations and ratios obtained from portable X-ray fluorescence and percent terrestrial, calcium carbonate and total organic fraction data. Together with clay mineralogy data we will evaluate terrigenous flux and marine productivity and evaluate periods of ISM strengthening in the critical period 8 to 20 Ma to distinguish between competing claims for tectonic-climate linkage in southern Asia.

Paleoceanographic role of the Tsushima Warm Current in the Hupo Basin of the southwestern East Sea (Sea of Japan)


1Pusan National University, parky@pusan.ac.kr, bkkhim@pusan.ac.kr, jmhpy123@hanmail.net, sddfqwer@naver.com
2Hokkaido University, myama@ees.hokudai.ac.jp
3Korea Polar Research Institute, delongksh@kopri.re.kr, kcyoo@kopri.re.kr, hiyoon@kopri.re.kr

The Hupo Basin, located in the western margin of the East Sea (Sea of Japan), is sensitive to global/regional climate change. To reconstruct paleoenvironmental change in the Hupo Basin and reveal its controlling mechanism, we conducted various geochemical (TOC, TC, TN, CaCO$_3$, biogenic opal and C/N ratio) and biomarker (GDGT, TEX$_{86}$ and U$^{137}$) analyses using a sediment core (ES14-GC02; 6.28 m long) with high resolution (ca. 240 yr interval).

Core ES14-GC02 is divided into two parts: 1) upper part (the uppermost to 5.2 m; present to ~7,000 $^{14}$C yr BP) characterized by high sedimentation rate, constant high values of TOC, TC, TN, GDGT and TEX$_{86}$ and low values of CaCO$_3$ and C/N ratio, and 2) lower part (5.2 m to the core bottom; ~7,000 to ~30,500 $^{14}$C yr BP) characterized by low sedimentation rate, low values of TOC, TC, TN, GDGT and TEX$_{86}$, and high values of CaCO$_3$ and C/N ratio. Meanwhile, values of biogenic opal, U$^{137}$ and TEX$_{86}$ are fluctuated since ~7000 $^{14}$C yr BP.

Our results indicate that the Hupo Basin has well recorded the history of environmental changes during Holocene/glacial periods, interpreted as a fact that, after flowing into the East Sea (Sea of Japan), the Tsushima Warm Current began to affect the Hupo Basin since ~7,000 $^{14}$C yr BP, leading to the increase of marine productivity and seawater temperature.
Insights from the multi climate indexes in the marginal sea of the western Pacific

Li Li, Yanming Ruan, Liang Dong

State Key Laboratory of Marine Geology, Tongji University, Shanghai 200092, China

In the past decades, except for the global warming, increasing of severe floods and droughts, has caused an increase in famine, disease and economic losses. The situation is especially critical in the tropical-subtropical eastern Asia given the large population of this region. Thus, obtaining a comprehensive knowledge of the climatic dynamics in these areas is urgent. The remarkable change in climate since last glacial interval is the best baseline for evaluating future climate change. High-resolution and multi-climate records in the northern South China Sea provide an excellent record for this purpose. Sea surface temperatures derived from the UK37 exhibit a gradual increase from 17kyr to the mid Holocene, and lack the two-step warming noted for southern high latitudes and the typical abrupt YD cooling in the northern high latitudes. Variability of the long chain n-alkanes content is evident in a two-step reduction at 17kyr and 12kyr since the last glacial period, and keeps stabilized in the Holocene. This pattern is similar to that produced by current Antarctic warming and sea level change in the first step, but with the former being more evident. n-Alkane Average chain length (ACL), which had been demonstrated to be controlled by the humidity condition in most regions, has decreased gradually since the last glacial interval with a significant decrease at 13ka. This indicates an extreme increase in precipitation during the Bølling warming. Thus, the multi-climate indexes indicate that millennial patterns are superimposed on the overall glacial-interglacial trends with the hydrological dynamics controlled by northern hemisphere influences while terrestrial deposition was more related with southern hemisphere factors. The continual increase in precipitation and temperature until 5kyr implies a tropical influence which is tightly coupled with the ENSO variability as shown by the zonal SST gradient observed since the last deglaciation. The present study indicates the complex of the climate change since the last glaciation and the necessity for multi climate indexes.
Late Cenozoic climate and carbon-cycle dynamics from the Arabian Sea (IODP 355)

K. E. NEWTON¹*, J. BENDLE¹, K. EDGAR¹, H. M. LIDDY², S. J. FEAKINS², P. D. CLIFT³, L. TAUXE⁴, D. K. KULHANEK⁵, G. SCARDIA⁶, S. WARNY⁷, P. ANAND⁷ AND IODP EXPEDITION 355 SCIENCE PARTY

¹University of Birmingham, Birmingham, UK, (*correspondence: ken155@student.bham.ac.uk)
²University of Southern California, Los Angeles, CA, USA
³Louisiana State University, Baton Rouge, LA, USA
⁴Scripps Institution of Oceanography, La Jolla, CA, USA
⁵Texas A&M University, College Station, TX, USA
⁶Sao Paulo State University (UNESP), Rio Claro, SP, Brazil
⁷The Open University, Milton Keynes, UK

The Indian Summer Monsoon is one of the most significant features of the climate system. Its evolution has been linked to large scale changes in the solid earth throughout the Cenozoic, associated with extensive impacts on climate and vegetation.

The role of the Indian Monsoon in driving the late Miocene C₄ plant expansion is a key outstanding question. This vegetation shift was globally widespread, recorded at various sites across Asia, Africa and the Americas. However, identifying the key driver of this shift is still uncertain, with transitions to either warmer and more arid conditions, or declining pCO₂ being potential candidates.

Sediments recovered from Site U1457 (IODP 355) include expanded and well-dated sections across this C₄ expansion interval, containing well preserved marine microfossils (foraminifera and nannofossils), algal biomarkers (alkenones) and plant-wax biomarkers (n-alkanoic acids). δ¹³C of plant-waxes indicate a clear positive excursion over this C₄ plant expansion interval. Thus comparison of these new data with parallel proxy records for temperature, hydrological conditions and CO₂ provides an opportunity to directly compare the inferred C₄ shift with potential drivers.

Here we present new alkenone sea-surface temperature and δ¹³C records from sites U1457 and U1456, giving an initial insight into climate and carbon-cycle dynamics over the past 10 Ma. Alkenone δ¹³C is hypothesised to predominantly reflect changing pCO₂.
Tropical Soil Activity on Socotra Island, Arabian Sea, since the LGM: Evidence from Speleothem $^{14}$C

S. THERRE$^1$*, J. FOHLMESTER$^2$, D. FLEITMANN$^3$, S.J. BURNS$^4$, J. ARPS$^1$, A. SCHRÖDER-RITZRAU$^1$, R. FRIEDRICH$^5$, N. FRANK$^1$

1. Institute of Environmental Physics, Heidelberg University, Germany (*stefen.therre@iup.uni-heidelberg.de)
2. Institute of Earth and Environmental Science, Potsdam University, Potsdam, Germany
3. Department of Archaeology and Centre for Past Climate Change, University of Reading, RG6 6AB Reading, UK
4. Department of Geosciences, University of Massachusetts, Amherst, MA, USA
5. Curt Engelhorn Center for Archaeometry gGmbH, Mannheim, Germany

The Indian monsoon is one of the largest tropical weather systems and provides the majority of rainfall to the Arabian Peninsula and Indian Subcontinent. Global climate changes are manifested in the (sub)tropics by monsoonal precipitation variability impacting vegetation and soil carbon dynamics. $^{14}$C in stalagmites is closely coupled to soil activity (i.e. carbon cycling) and subsequent host rock dissolution with strong carbonate dissolution in a closed system leading to high reservoir effects. In contrast, open carbonate dissolution conditions cause much lower reservoir effects, when soil CO$_2$ exchanges with the dissolved C species. Other contributions to the reservoir effect can be introduced by soil CO$_2$ from decomposing old soil organic matter. Hence, $^{14}$C can serve as a tracer of carbonate dissolution, soil activity and vegetation.

Here, we present a $^{14}$C record of stalagmite M1-5 from Moomi Cave, Socotra Island, in the western Arabian Sea. An improved U/Th-chronology confirmed a high average growth rate of 132 $\mu$m/yr over an approximate time span from 27 - 11 kyr BP. $^{14}$C results reveal a very high overall reservoir effect expressed as dead carbon fractions (dcf) of 30-57%: After an enduring phase of very high reservoir ages during the LGM (dcf >50%) before 18 kyr BP, a decreasing trend to ~35% is observed during the deglaciation. The monotonic decrease of dcf is interrupted twice, just prior to the start of the Boelling/Allerod warming of the northern Hemisphere and during the Younger Dryas manifested by elevated dcf (44.3 ± 3.1).

We interpret this unique record as a dramatic change of soil activity and thus deduce an enhanced vegetation growth, starting ~18 kyr BP synchronous to global warming of termination I. Hence, a direct long term influence of the polar warming is evident in the (sub)tropical soil carbon cycling.